If These Walls Could Talk

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Learning Objectives

1. Define a high performance wall.
2. Consider the “control layers”: managing moisture, air, and heat.
3. Identifying and managing risk in wall assemblies.
4. Understand that there isn’t a “one size fits all solution”: different conditions require critical thinking and a suite of solutions.
5. Identify appropriate solutions for new construction.
6. Identify appropriate solutions for retrofits.
7. Let your walls talk: monitoring, learning, sharing data.

Walls are Inherently Complicated

- They connect to foundation, floor, and roof.
- We cut holes in them.
- We attach things to the outside of them.
- We attach things to the inside of them.
- They may contain MEP systems.

What Makes a High Performance Wall

1. Provides structure.
2. Keeps the elements out.
3. Helps maintain indoor comfort.
4. Durable.
5. Able to be repaired without reducing quality.
6. Functions in a variety of conditions.
7. Can “reasonably and affordably” be built.

Consider The Control Layers

- Water Control Layer
  - Manages bulk water
- Vapor Control Layer
  - Manages water vapor
- Air Control Layer(s)
  - Manages air leakage, both interior and exterior
- Thermal Control Layer
  - Manages heat loss and heat gain

Not surprisingly, these things often work together.

Water Control Layer

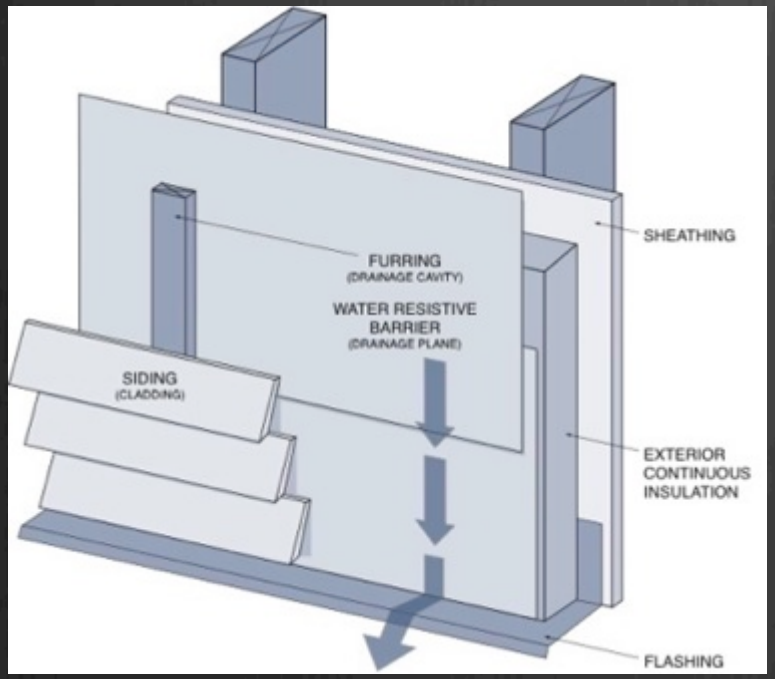


Photo from wbdg.org

- ✓ Waterproof protection close to grade
- ✓ A drainage gap between siding and sheathing
- ✓ A defined drainage plane
- ✓ A water resistive barrier (WRB)
- ✓ Flashing at windows, doors, sills of all kind
- ✓ A strategy for drying when the wall gets wet

Managing Water Vapor

A vapor “barrier” is not as important as an air barrier.
A vapor retarder is needed in most assemblies, but the level depends on the likelihood of condensation occurring.

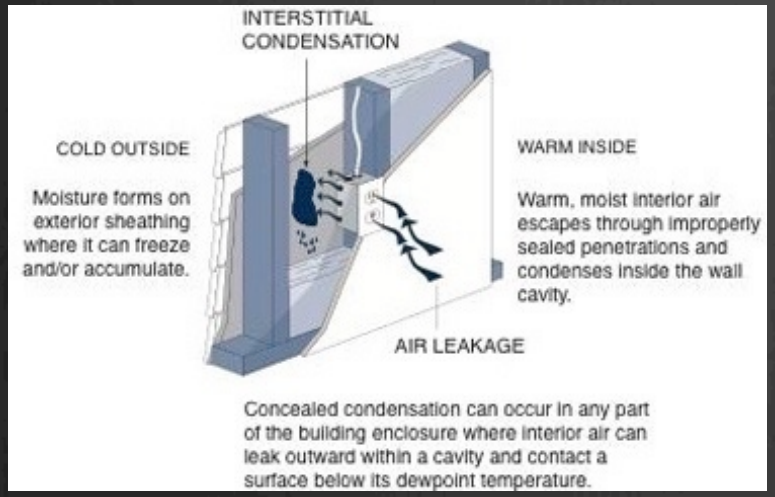


Image from wbdg.org

- If it can’t condense, it’s not really a problem.
- If it can condense, give it a path to dry by diffusion or evaporation
- Water vapor can impact the assembly from the outside or the inside. Know where/when/how the assembly is vulnerable.

Moisture Management

- Assemblies get wet.
- Moisture comes from the interior and the exterior.
- Too much accumulated moisture can cause damage.
- Strategies to minimize the risk of moisture damage:
  - Control of moisture entry
  - Control of moisture accumulation
  - Removal of moisture
- Assemblies should be able to remove the moisture,
  - By draining
  - Or by drying.

Paraphrased from the Builder's Guide to Cold Climates by Joe Lstiburek

Air Control Layer

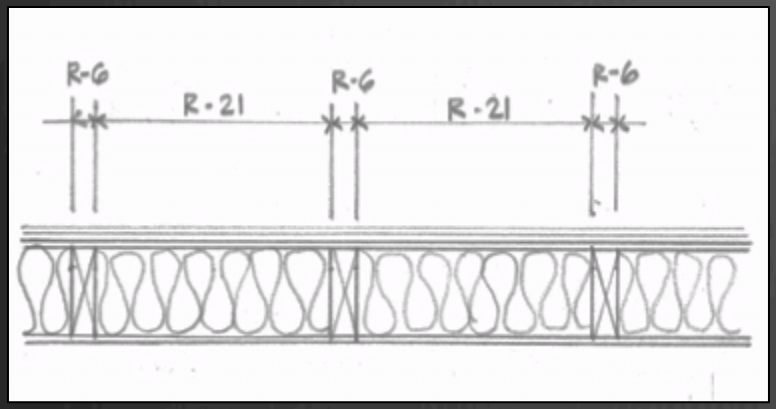
Air Barrier systems should be:

- Impermeable to air flow
- Continuous over the entire building enclosure
- Able to withstand the forces that may act on them during and after construction
- *Durable over the expected lifetime of the building.*

Thermal Control Layer

In a high performance wall, the thermal control layer helps maintain indoor comfort as well as the durability of the structure.
Thermal control layers can be inside, outside, or both.

Thermal Bridges, or When an R-21Wall Isn't R-21



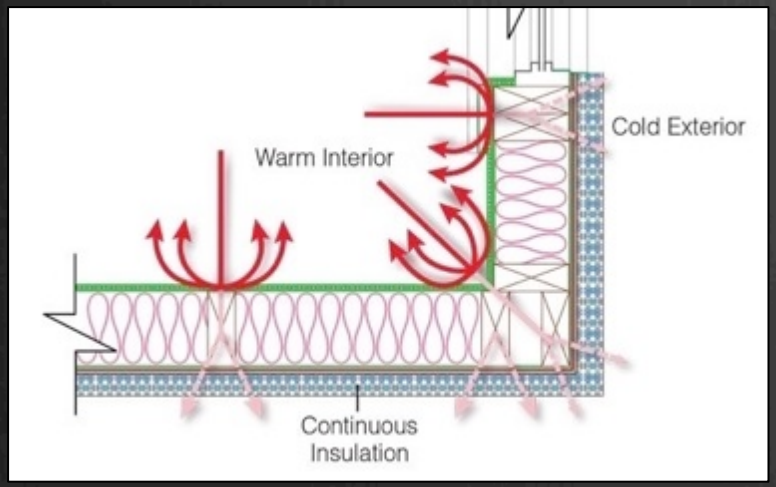


Image from Dryvit Systems

Whole wall R-values of single stud walls with cavity insulation only will be 15-25% less than the R-value of the cavity insulation.

2 x 6 studs at 16" O.C. with R-21 batts as cavity insulation: Actual wall R-value will be between R-15 and R-18, or U-value about 0.064.

Burn that Thermal Bridge:

A 2 x 4 wall with R-11 cavity insulation and R-10 continuous insulation has a U-value of 0.047, or about R-21!

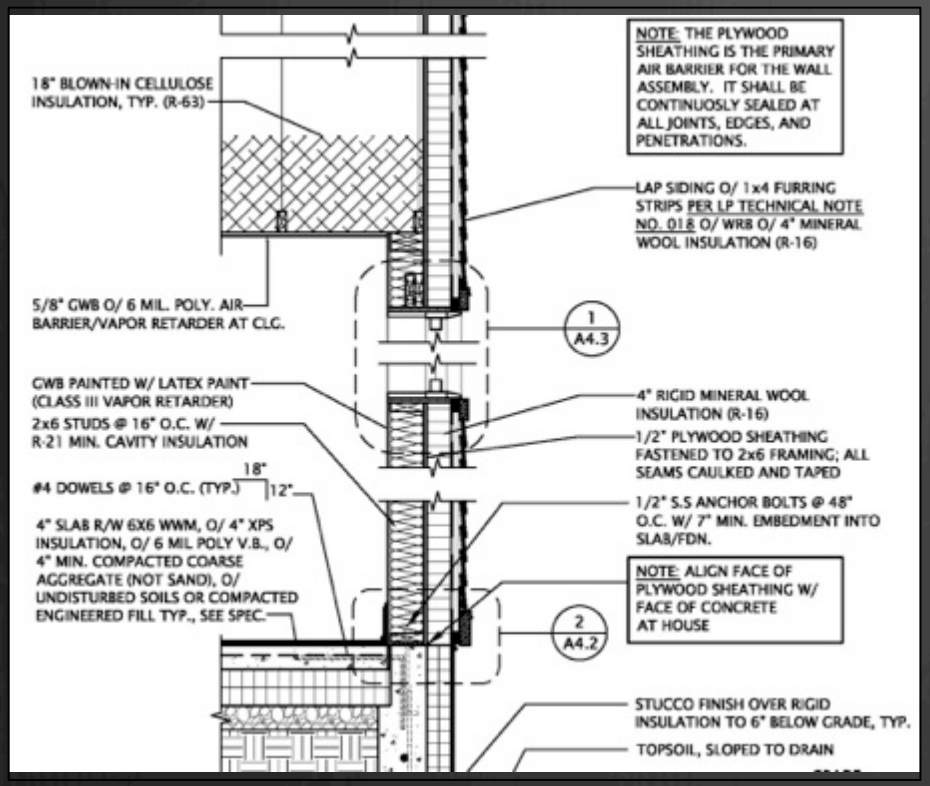
Risk Management

- If you don't manage bulk water you can damage the entire assembly, as well as affect indoor environmental quality.
- If you don't manage water vapor you can damage the assembly, as well as affect indoor environmental quality.
- If you don't manage air, you can end up with moisture transport, which can damage the assembly.
- Air leakage can also reduce the effectiveness of insulation.
- Thermal bridges reduce the effectiveness of insulation and can create cold spots where condensation may form.

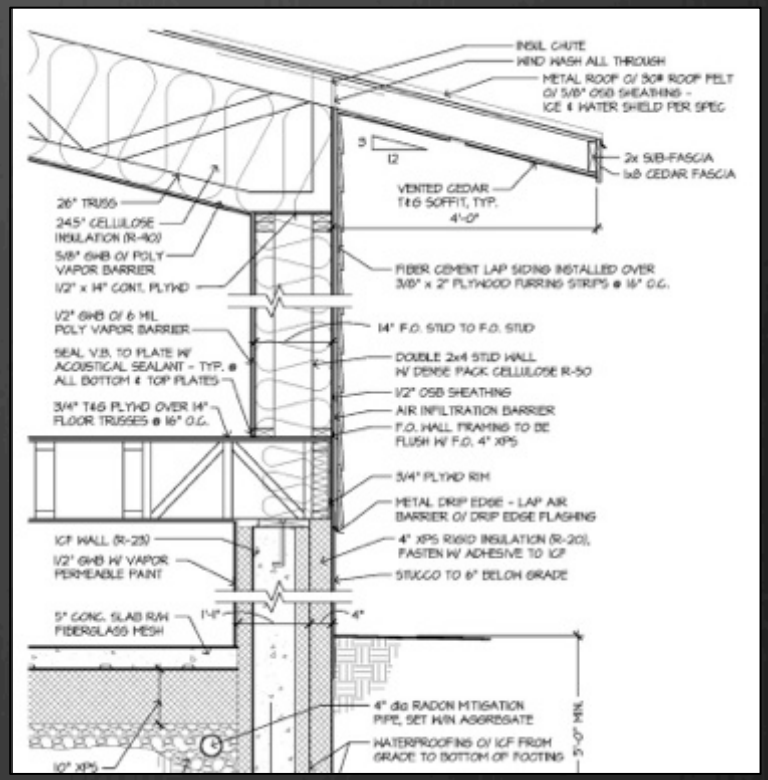
What's the Best Wall?

1. (Good) flashing details.
2. A continuous, durable (rigid) connected air barrier.
3. Minimal thermal bridging.
4. Vapor control.
5. The assembly can connect to everything else without compromising the above list.

New Construction: Our 2 Approaches
No “One Size Fits All”

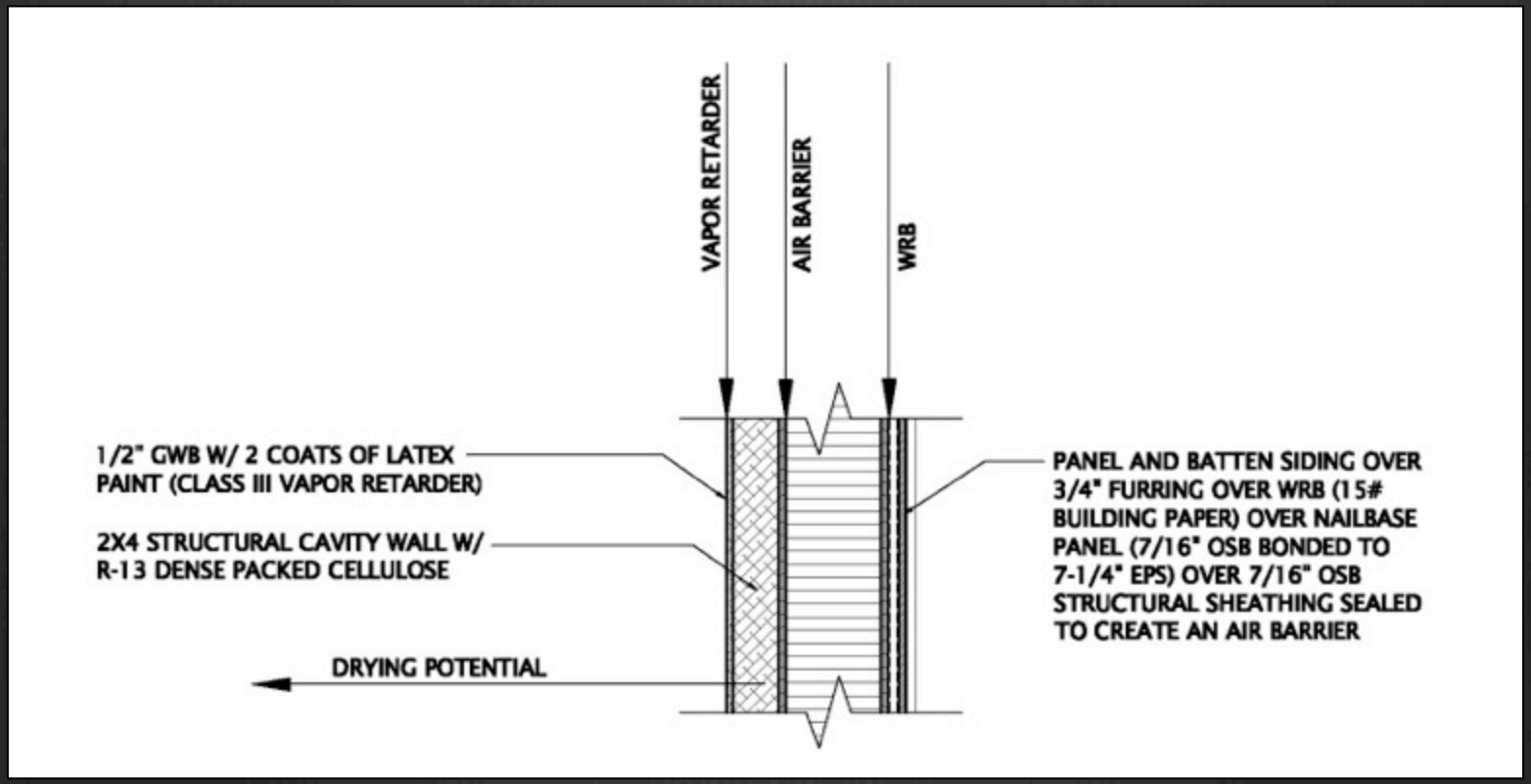


Single Stud Wall+ Continuous Insulation



Double Stud Walls

Single Stud Wall + Continuous Insulation (c.i.)



Theory vs Practice

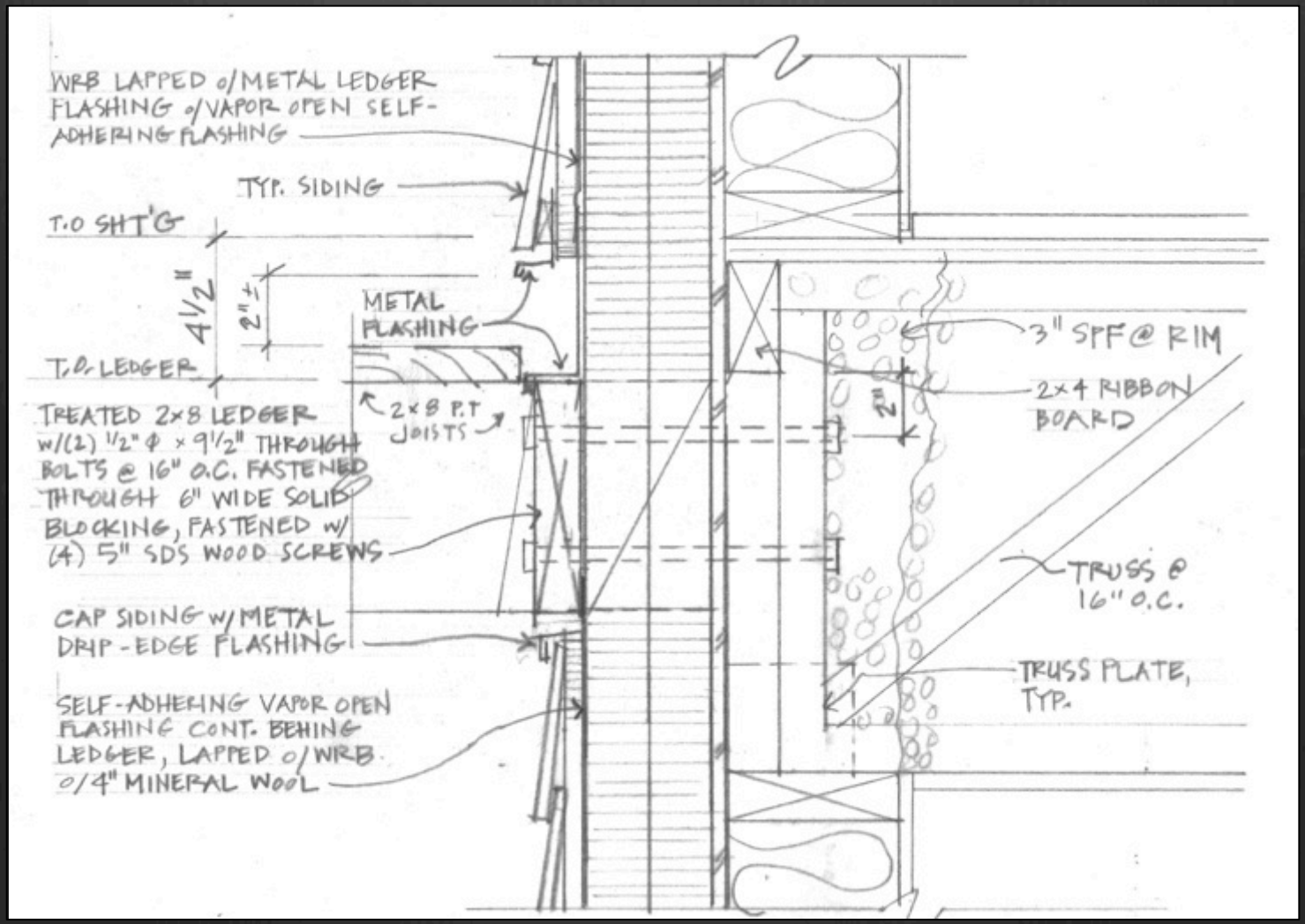
Is this the “Perfect Wall?”

After structural sheathing, often two more times around the house for insulation.

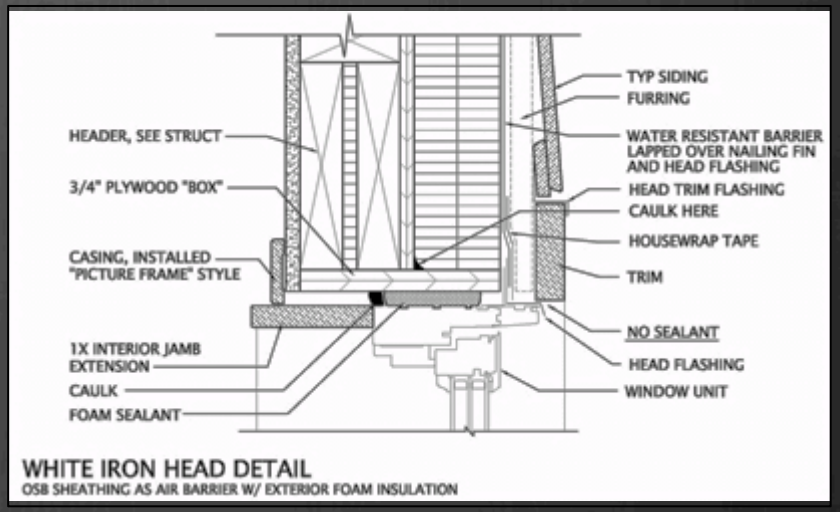
Long screws must fasten into framing. Exterior elements need blocking.

In practice, this wall system is best for simple building forms.

Planning for Durable Exterior Elements



Water Management

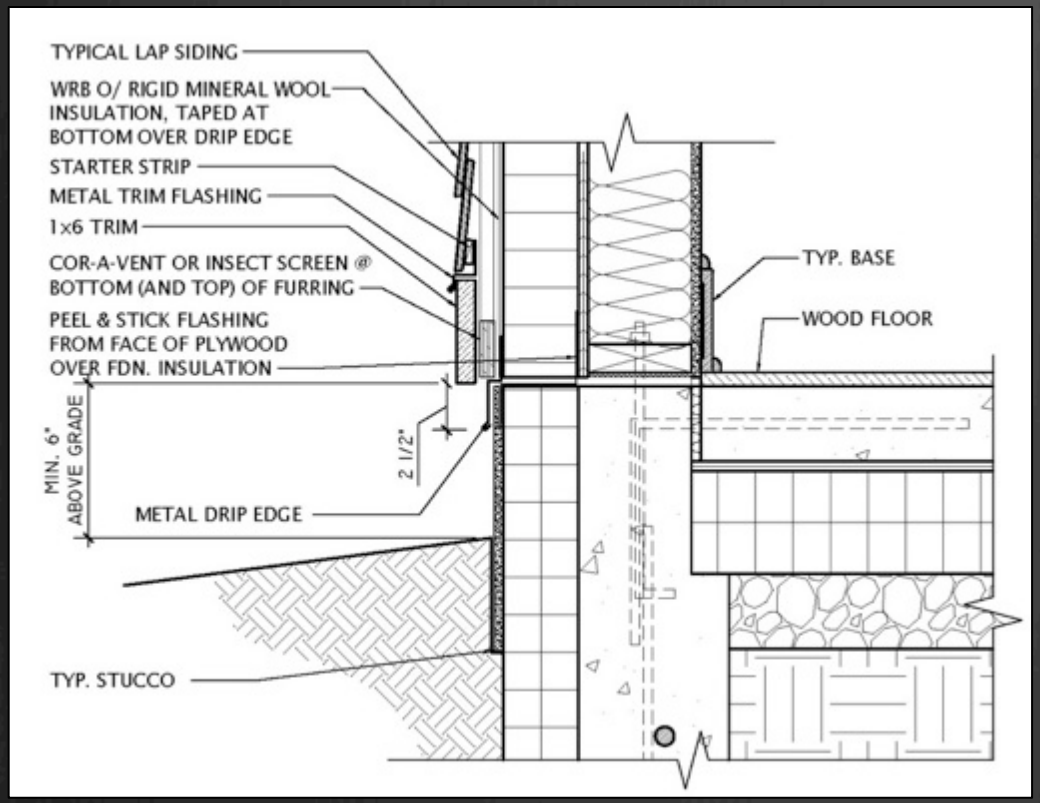


Order of assembly can vary

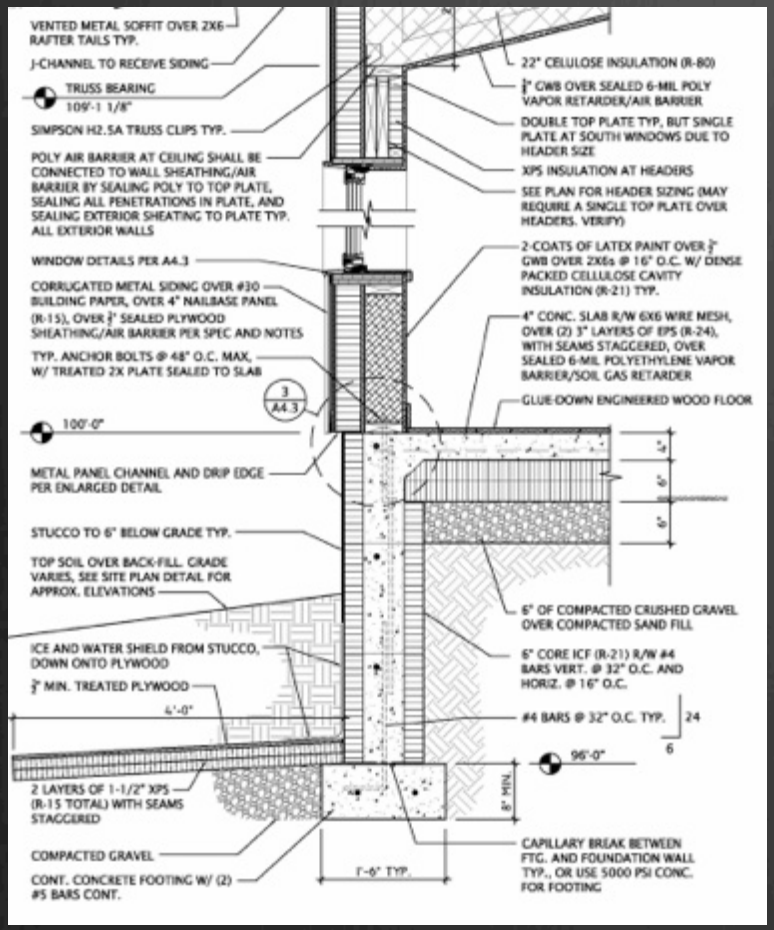
Blocking above for balcony ledger

Planning ahead for WRB installation

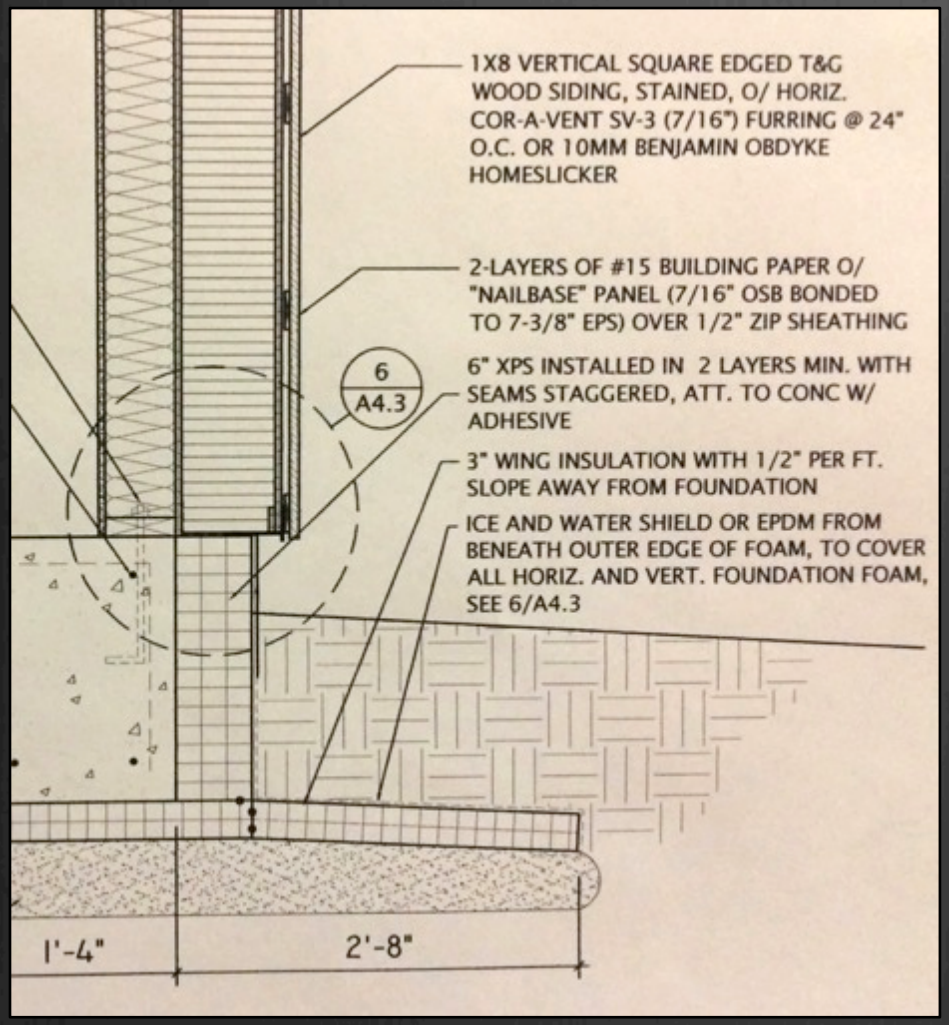
Single Stud Wall + C.I. Variation: Mineral Wool



Single Stud Wall + C.I. Variation: Nail base



Nailbase panels solve some things



To minimize the risk of accumulated moisture, use enough foam on the exterior.

Zone	Class III vapor retarders permitted for:
Marine 4	Vented cladding over OSB Vented cladding over plywood Vented cladding over fiberboard Vented cladding over gypsum Insulated sheathing with R-value >= 2.5 over 2x4 wall Insulated sheathing with R-value >= 3.75 over 2x6 wall
5	Vented cladding over OSB Vented cladding over plywood Vented cladding over fiberboard Vented cladding over gypsum Insulated sheathing with R-value >= 5 over 2x4 wall Insulated sheathing with R-value >= 7.5 over 2x6 wall
6	Vented cladding over fiberboard Vented cladding over gypsum Insulated sheathing with R-value >= 7.5 over 2x4 wall Insulated sheathing with R-value >= 11.25 over 2x6 wall
7 and 8	Insulated sheathing with R-value >= 10 over 2x4 wall Insulated sheathing with R-value >= 15 over 2x6 wall

2 x 6 wall with 1” rigid insulation?

If you don’t use enough continuous insulation to keep the sheathing above the dew point…

Adapt/Adjust your strategy to minimize risk!

- Don’t’ Use OSB sheathing

AND

- Include 1/4” minimum gap behind siding, to aid drying.

- Use cavity insulation that is not vapor or air permeable.

OR

- Use vapor permeable continuous insulation AND put an air barrier and Class II vapor retarder on the warm side, preferably a “smart” vapor retarder.

Single Stud + c.i.: Pros and Cons

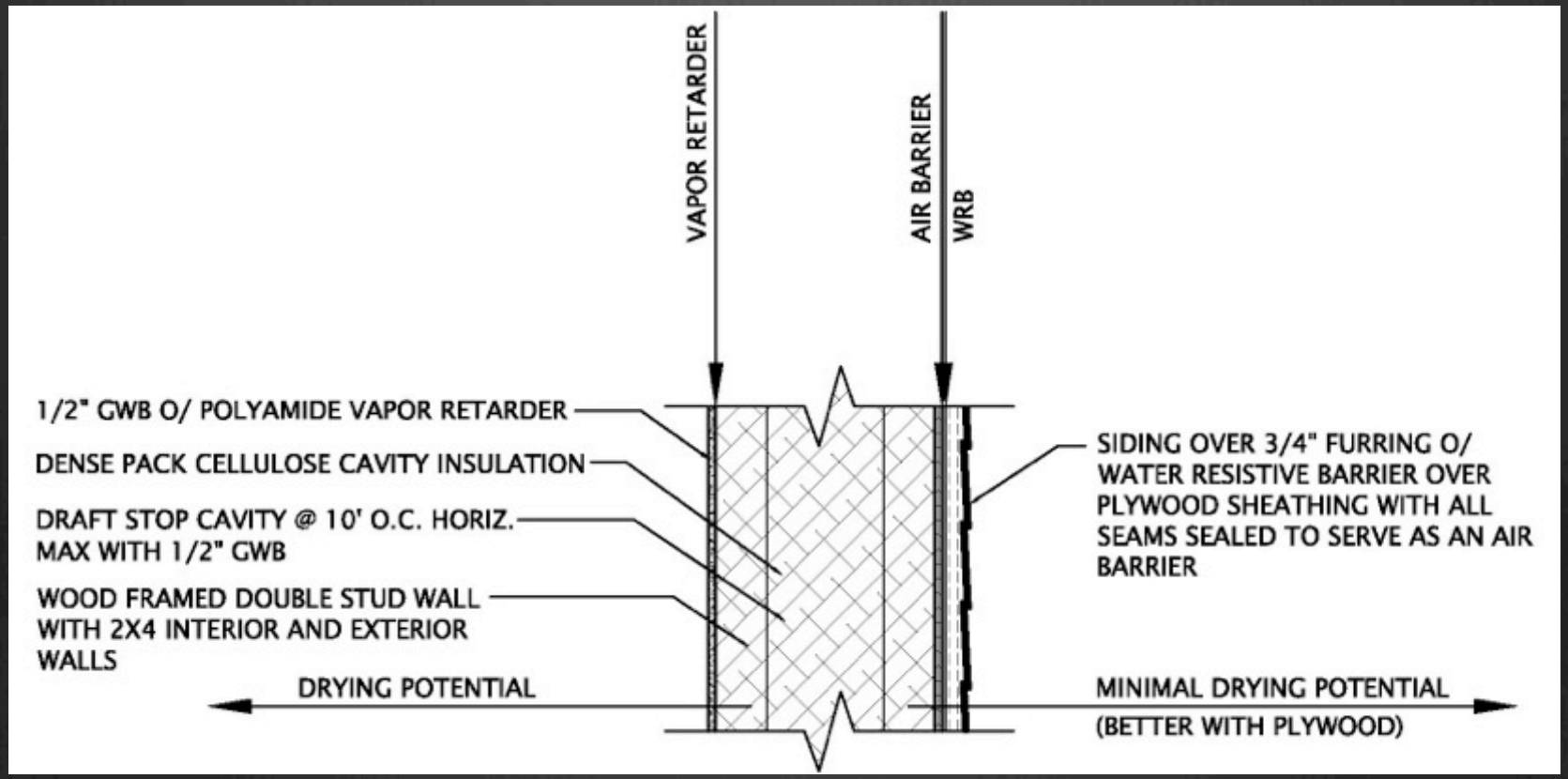
PROS

- Ideal air and vapor control
- Integrates well with foundation insulation
- Easier MEP retrofit
- Least thermal bridging
- Probably most durable air barrier and vapor retarder
- Also good for retrofits

CONS

- More expensive
- Difficult transitions with complex building form
- Long screw attachment
- Blocking for decks, etc
- Harder to integrate good water management
- Layers of exterior assembly, harder in winter

Double Stud Walls

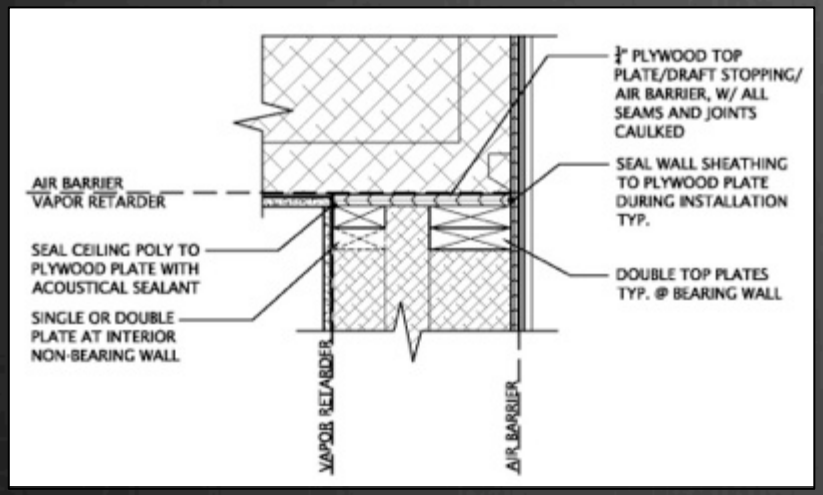


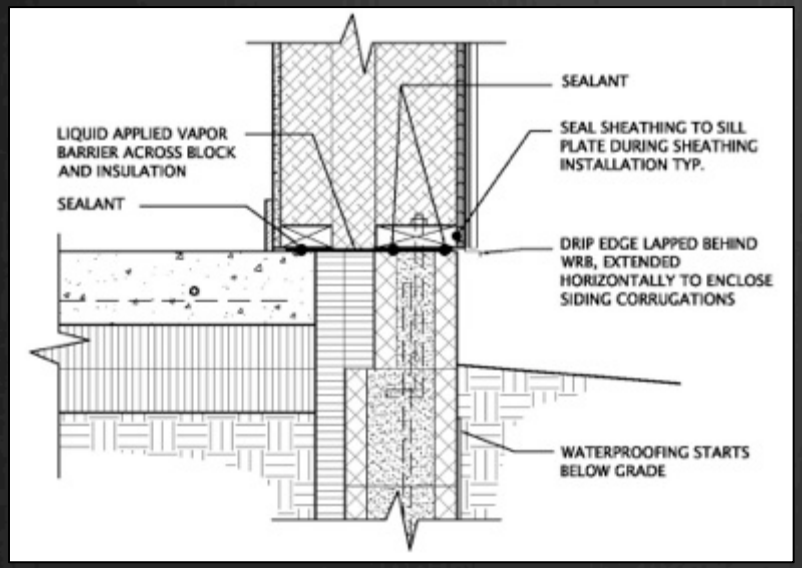
Thermal bridging addressed with the gap between framed walls
Colder sheathing means that an interior vapor retarder is needed
We now seal the exterior sheathing as our air barrier, always.

Double Stud Walls

- Familiar assemblies, common materials
- Usually filled with blown in insulation
- Exterior attachments and drainage plane are straightforward.

Connecting the Air Barrier



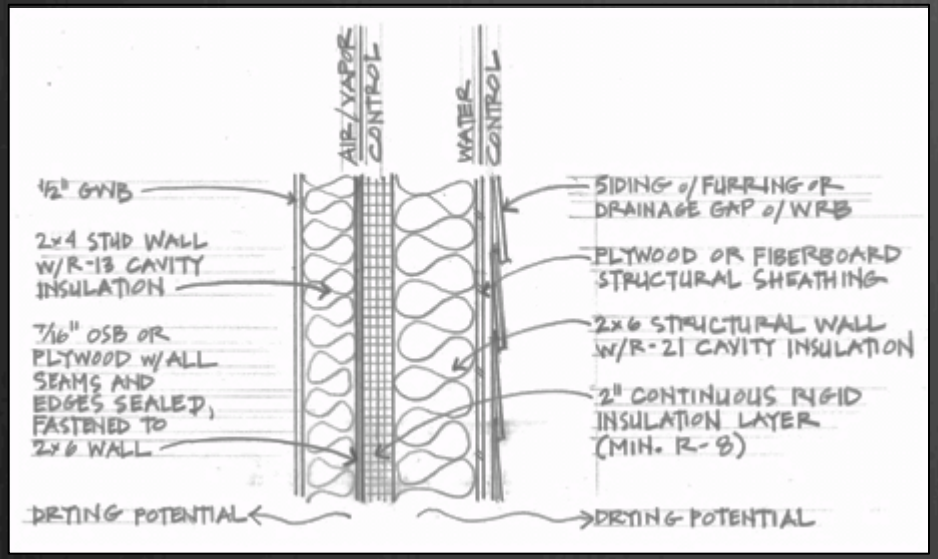


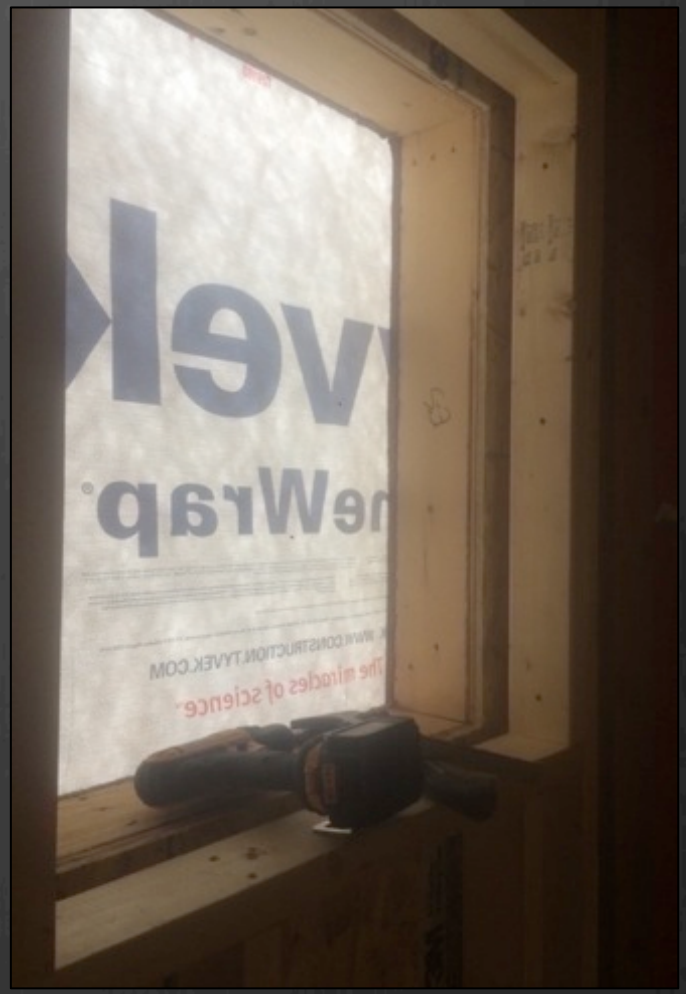
Familiar Exterior Order of Assembly

Straightforward integration of water management details and air barrier.

Considerations:
Durability of air barrier, future modifications

Variation: Double Stud Hybrid





Gets the air barrier inside the wall to reduce the risks associated with cold sheathing.

Double Stud Wall: Pros and cons

PROS

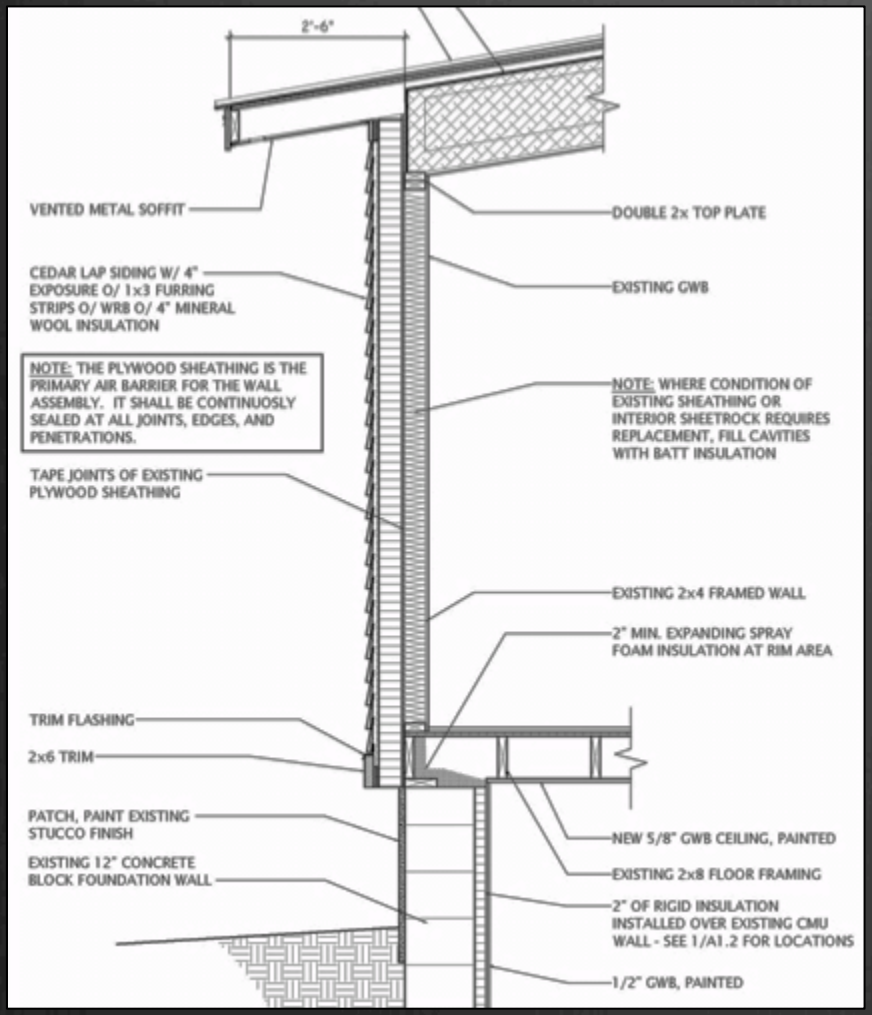
- Most similar to “standard” construction
- Easy siding attachment
- Structure and sheathing readily accessible for exterior attachment
- Easier water management
- Easier winter construction
- Less expensive

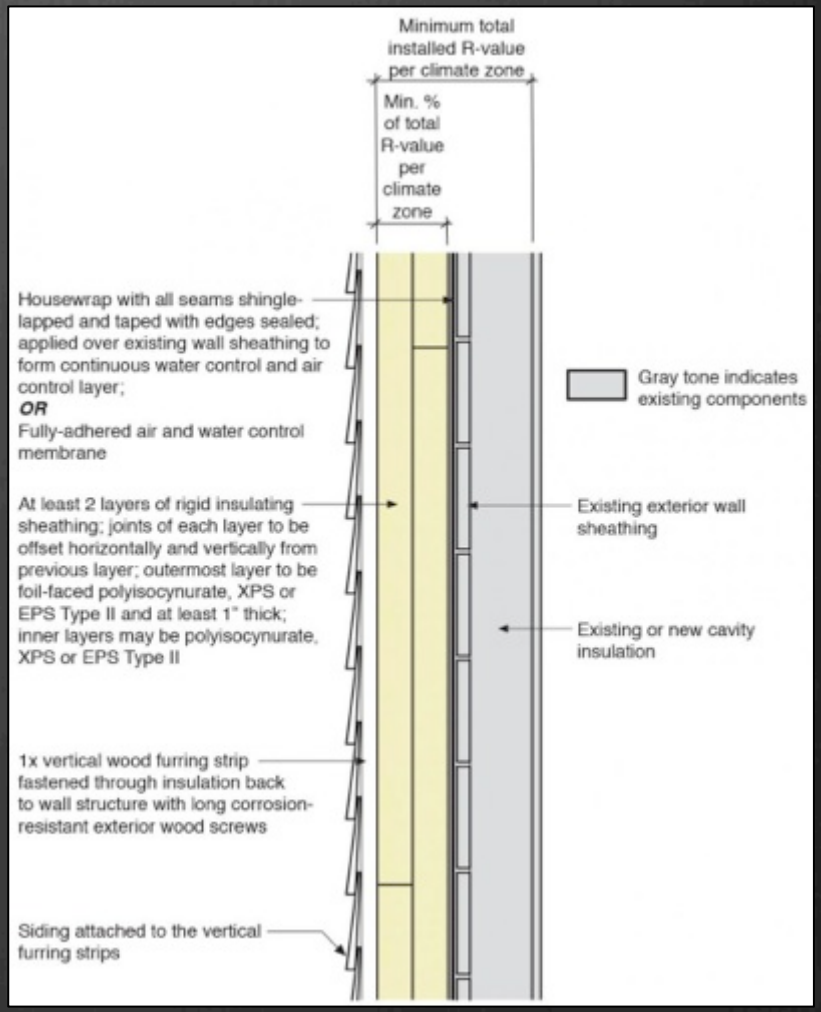
CONS

- Cold exterior sheathing
- Requires Class II interior vapor retarder
- Harder to integrate with foundation insulation
- Building gets smaller
- Harder MEP retrofit
- Rarely appropriate for retrofits

Retrofits are Special

What looks good on paper …





Assessing Risk

- Identify the assemblies.
- When existing walls have polyethylene on the interior, the drying has to be to the exterior.
- Analyze water management.
- Plan new assemblies with identification of management plan for water, air, and thermal control.

Vapor open integrated retrofit

- Self-adhering vapor permeable continuous air barrier covered by EPS c.i. and tar paper

Options: Defining the Air Barrier

Existing plywood sheathing used as the air barrier
Sealed with a combination of tapes, liquid applied air barrier and expanding foam; separate WRB added later

Self-adhering membrane, vapor open, as air barrier and drainage plane, can be integrated with flashing details

Retrofit + Addition: more complicated

New plywood sheathing used as the air barrier
Sealed with a combination of tapes, caulk and expanding foam.

AND

Self-adhering membrane, vapor open, as air barrier over existing fiberboard sheathing, lapped over waterproof membrane at rim/foundation.

Sealed rigid insulation as the Air Barrier

Multiple sheathing conditions. Self-adhering sheet might have worked.

Water Management and Durability: Details, Details, Details

Ask Your Walls These Questions

1. Where will water originate?
2. Where will water go?
3. How will a wet wall dry?
4. How will air try to get through?
5. How will air stop getting through?
6. Where are the thermal weak points?
7. Will the assembly be fragile if someone adds a light fixture later?

Current Takeaways

1. The “Perfect wall” doesn’t exist.
2. Thermal bridges matter.
3. Mineral wool is promising, but it ain’t cheap.
4. Double stud walls usually cost less than single stud with continuous insulation.
5. Exterior continuous insulation is probably the “better wall” in theory.
6. In theory and in practice, managing risk matters the most.

Maybe these walls can talk

If we listen, we can avoid the photo on the left, and achieve the photo on the right.

Resources

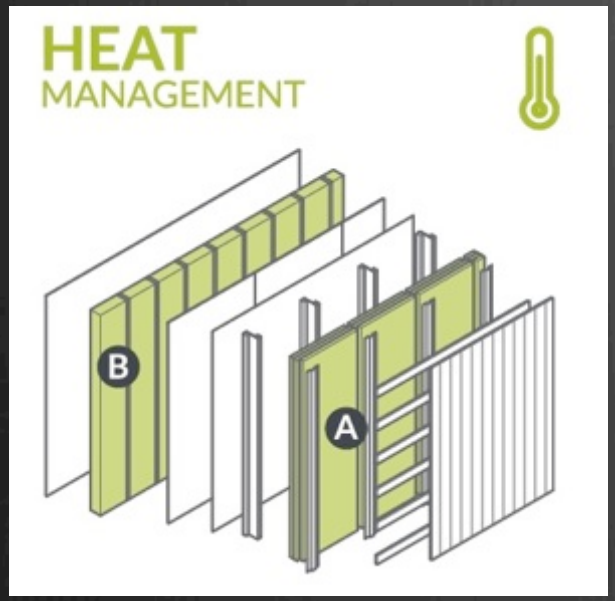


Image from hammerandhand.com

Best Practices Manual- An online guide from a high performance construction company:

- hammerandhand.com/best-practices/manual/

Current Research and Publications from the Building Science Corporation:

- buildingscience.com

RDH Building Science Laboratories

- buildingsciencelabs.com/technical-library

Green Building Advisor

- greenbuildingadvisor.com

Whole Building Design Guide

- wbdg.org

Thank you.

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