



Integrated Design Strategies and Quality Control

Duluth Energy Design Conference

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Learning Objectives

1. Understand the concept of integrated design.
2. Define four key strategies to employ in the Integrated Design Process.
3. Learn how to recognize (and employ) the four key strategies in an Integrated Design Process for high performance housing.
4. See how quality control factors into all aspects of integrated design in order to achieve the goals and targets set.

"When we try to pick out anything by itself, we find it hitched to everything else in the Universe."

- John Muir (1838-1914), engineer, naturalist

Not just about *Design*

- **BEFORE DESIGN**
 - Define who will be involved
 - Set goals, priorities and expectations
- **DURING DESIGN**
 - Communicate with all involved
 - Organize, Manage, Evaluate and Verify
- **BEFORE CONSTRUCTION**
 - Communicate with all involved
 - Set goals, priorities and expectations
- **DURING CONSTRUCTION**
 - Organize, Manage, Evaluate, Verify
- **DURING OCCUPANCY**
 - Educate the homeowner
 - Learn how things are working and if they're not

Design Implications

- The **SUN** matters
 - It can help, it can hinder
 - It shouldn't be ignored
- **SITE** matters
 - Climate, topography, geology
- **SIZE** matters
 - Smaller is usually better energy-wise
 - Smaller can make it harder to integrate elements
- **FORM** matters
 - Thermal bridges, air tightness, and water management
 - Integrating mechanical systems

Construction Implications

- **Health and safety**
 - Combustion safety
 - Ventilation and indoor air quality
 - Moisture management and mold
- **Building Systems – conflict or complement**
 - Domestic hot water delivery
 - Heating, ventilation and cooling distribution
 - One exhaust appliance affects another
- **Function follows form**
 - Thermal bridges
 - Air Tightness/a continuous air barrier
 - Where might the water go?
 - Delivering fresh air, water, and heat

Code Implications

- Integrated assemblies, not always integrated requirements (but sometimes)
 - Insulating sheathing
 - The Air Barrier
 - Vapor retarders
 - Furring strips, rain screens, and siding
 - Fastening over foam
 - Mechanical systems
- And more...
- 2009 IRC
- 2012 IRC coming to a theater near you

Accomplishing Integrated Design



It is straightforward but not necessarily quick or easy

Strategy 1: Make fewer assumptions

I used to go away for weeks in a state of confusion.

Albert Einstein

Strategy 2: Seek Understanding



A Pattern Language How Buildings Learn Building Science Corp The Passive Solar Design Book Peak Everything PHPP The Long Emergency

Strategy 3: Use Critical Thinking

Get the habit of analysis - analysis will in time enable synthesis to become your habit of mind.

Frank Lloyd Wright

Strategy 4: Play as an Ensemble*



*Ensemble: A unit or group of complementary parts that contribute to a single effect

1. Make Fewer Assumptions

- Architects are arrogant ...
- Builders don't read plans ...
- The engineer did the math ...

Make Fewer Assumptions

We can figure that out later ...



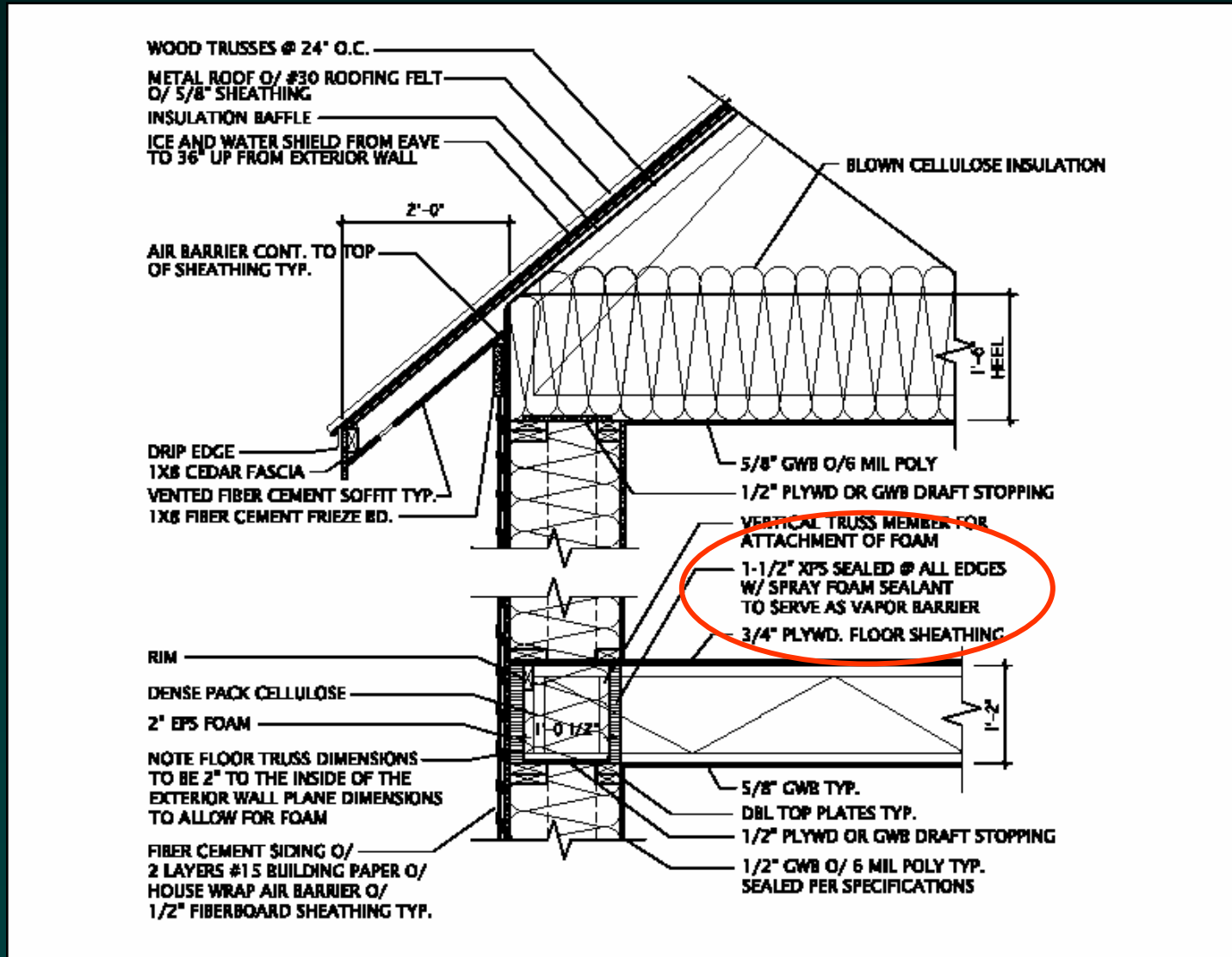
Can you? Know when.

Make Fewer Assumptions

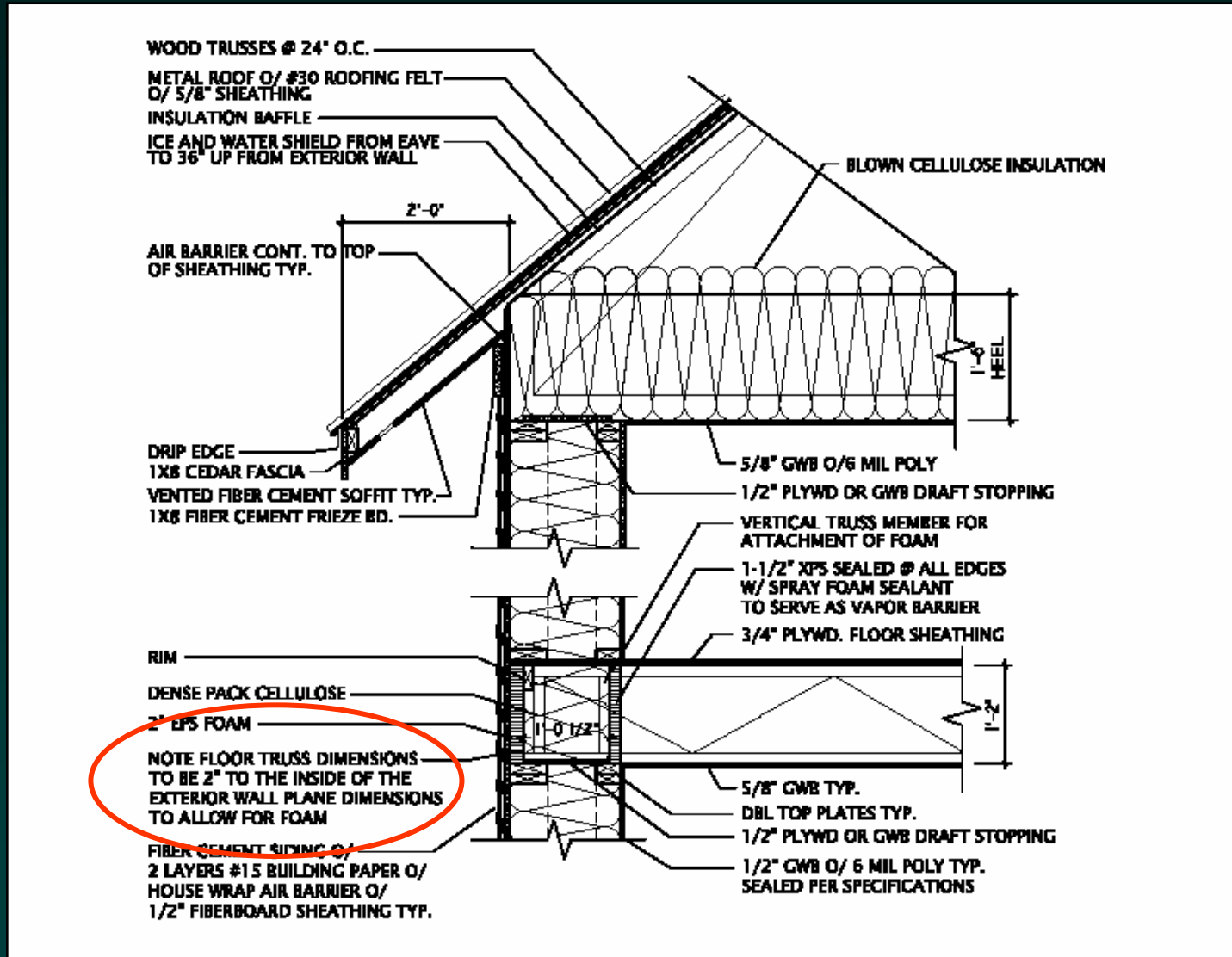
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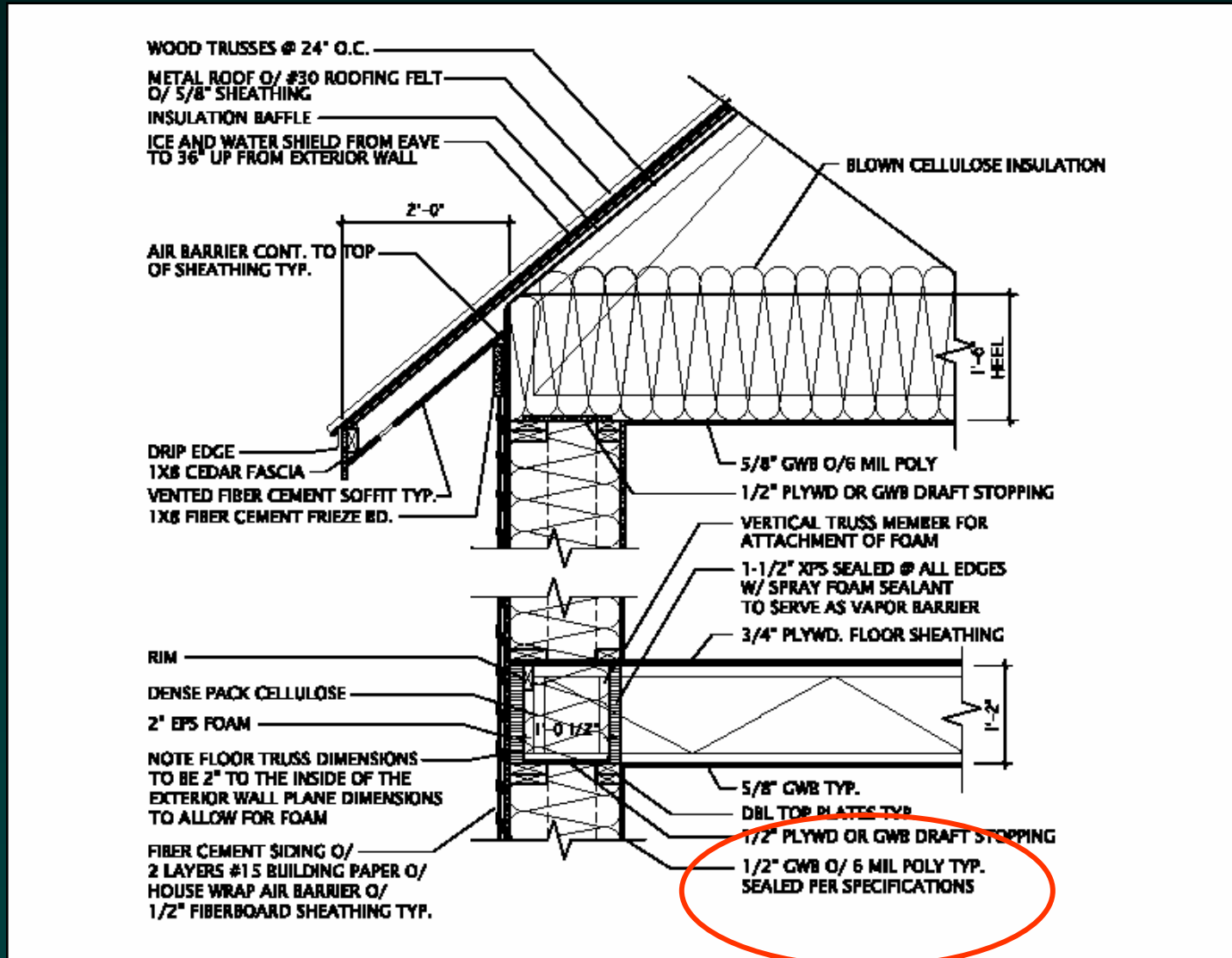
Want it? Put it in the drawings



Want it? Put it in the drawings



Want it? Put it in the drawings



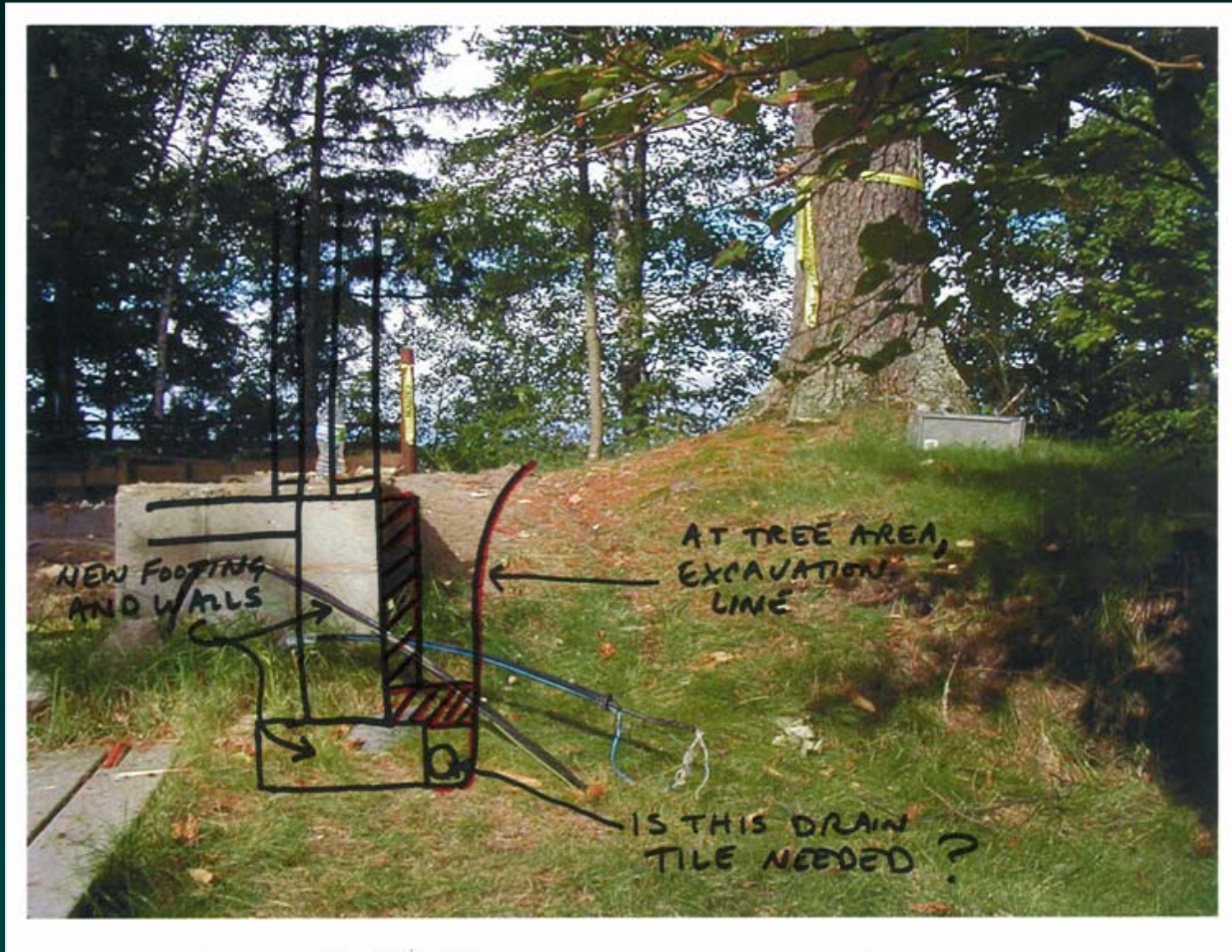
Want it? Put it in the specs



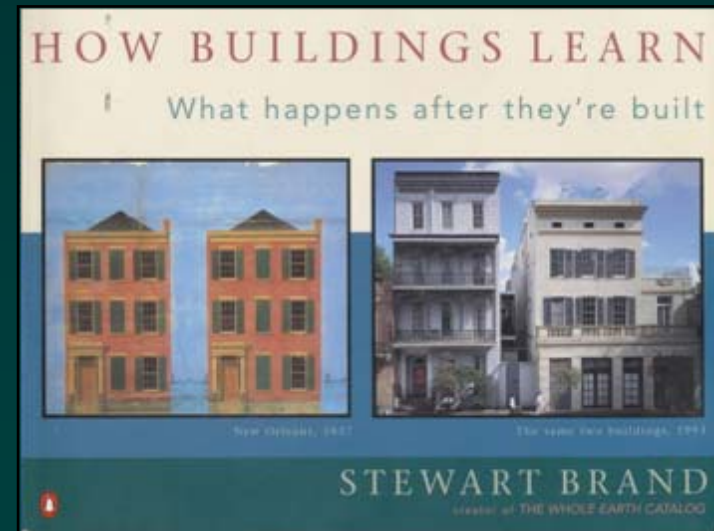
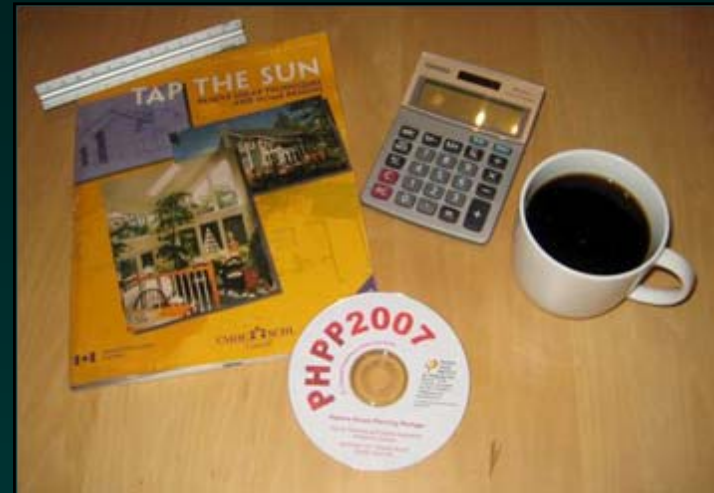
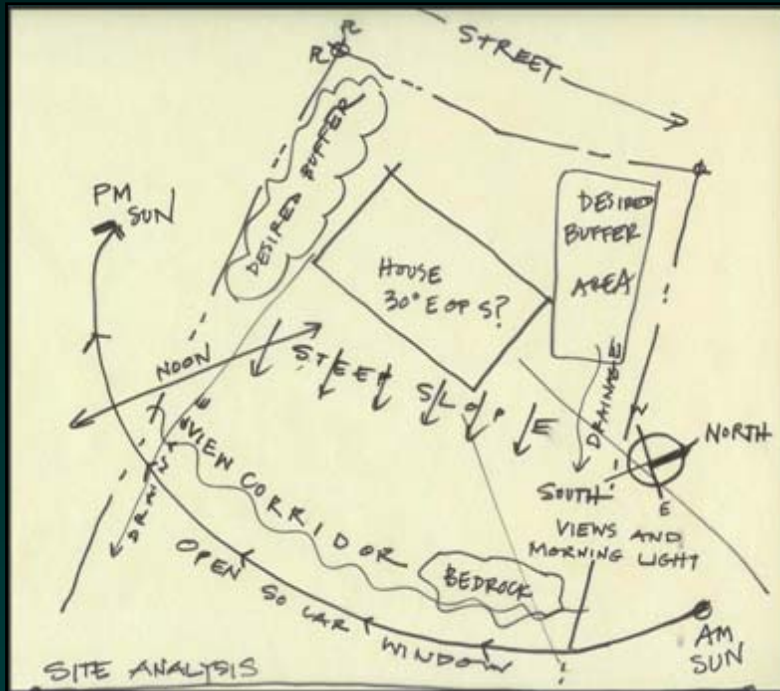
Performance Specifications

- Materials
- Assembly Methods
- Order of Assembly
- Express Intent
- Testing Requirements
- Referenced Details

Ask if it isn't clear. Don't assume.

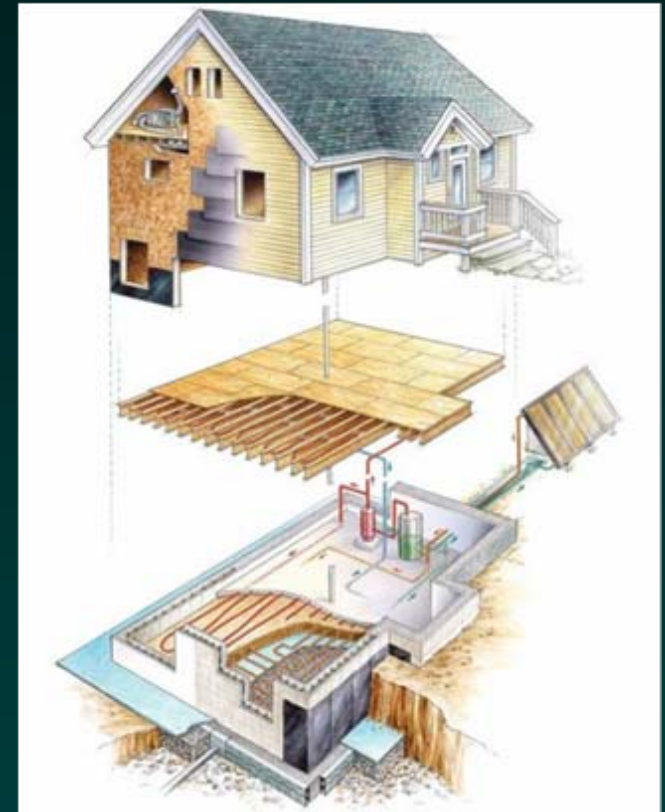


2. Seek Understanding



Define what you need to understand.
Know where to search.
Use the tools.

Seek Understanding (and make fewer assumptions)



Source: www.greenbuildingadvisor.com

- Admit what you might not understand.
- Use the expertise of others.
- Read, investigate, probe.
- www.greenbuildingadvisor.com
- www.buildingscience.com
- Be Willing to Ask Questions:
 - Why do you want it done this way?
 - What is important here?

Seek Understanding

- Understand options, impacts, each other
- Building Science figures mightily
- Low energy can be a complex equation
- High Performance comes from understanding
- Thinking long-term (life of the building) is key

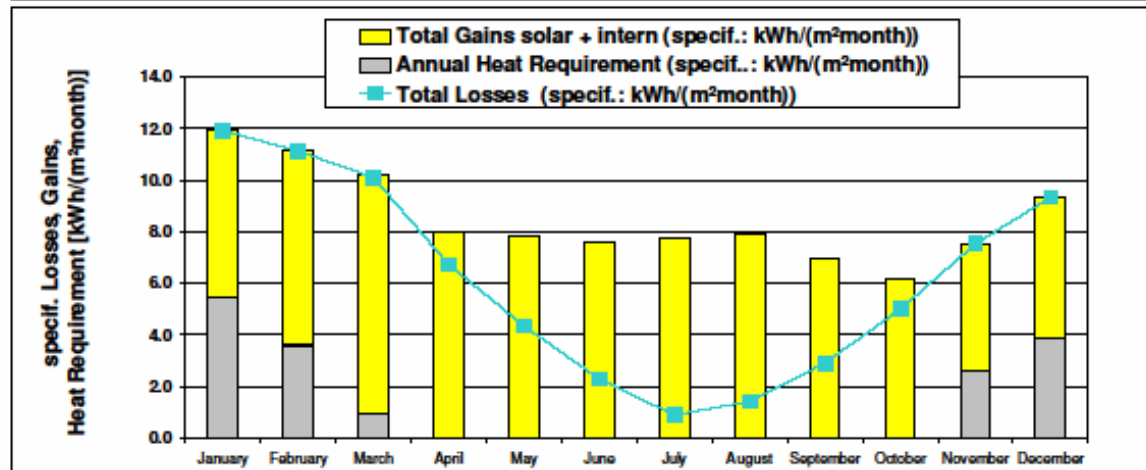
- Quantify and Qualify as you evaluate and select

Understand solar gain and heat loss

PASSIVE HOUSE PLANNING SPECIFIC ANNUAL HEAT REQUIREMENT MONTHLY METHOD

Climate:
 Building:
 Location:
 Interior Temperature: °C
 Building Type/Use:
 Treated Floor Area A_{int}: m²
 Standard Occupancy: People

	January	February	March	April	May	June	July	August	September	October	November	December	Year	
Heating Degree Hours - B	25.2	23.3	20.3	12.5	7.2	3.0	0.2	1.9	5.7	10.4	16.1	19.6	146	KKh
Heating Degree Hours - G	14.5	14.7	16.7	15.2	13.4	10.3	8.0	6.2	5.6	6.8	8.8	11.9	132	KKh
Losses - Exterior	2451	2260	1974	1218	701	294	22	188	553	1012	1561	1909	14143	WWh
Losses - Ground	347	352	400	362	321	245	190	148	133	163	209	284	3155	WWh
Total Losses (specif.: kWh)	11.9	11.1	10.1	6.7	4.4	2.3	0.9	1.4	2.9	5.0	7.5	9.3	73.6	WWh/m ²
Solar Gains - East	67	95	153	140	197	219	208	179	124	86	48	47	1563	WWh
Solar Gains - South	1011	1242	1518	1267	1134	1061	1112	1171	1054	918	696	813	12996	WWh
Solar Gains - West	62	79	106	92	99	99	100	97	79	63	43	48	967	WWh
Solar Gains - North	15	21	32	28	39	45	42	36	24	18	11	11	322	WWh
Solar Gains - Horiz.	0	0	0	0	0	0	0	0	0	0	0	0	0	WWh
Internal Heat Sources	367	332	367	355	367	365	367	367	355	367	355	367	4323	WWh
Total Gains solar + intern	6.5	7.5	9.3	8.0	7.8	7.6	7.8	7.9	7.0	6.2	4.9	5.5	85.8	WWh/m ²
Degree of Utility - Solar	100%	100%	99%	84%	56%	30%	12%	18%	42%	81%	100%	100%	67%	
Annual Heat Requirement	1277	844	219	3	0	0	0	0	0	1	617	907	3868	WWh
Annual Heat Requirement	5.4	3.6	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	3.9	16.5	WWh/m ²



Solar Design Strategies

- Roof overhangs or awnings to let in winter sun and keep out summer sun
- Minimize north and west windows
- Place windows to facilitate cross ventilation
- South glazing with a relevant SHGC
- There is no “all climate” glass!
- The solar gain from glazing must exceed the heat loss from that glazing – *in our climate this means triple pane glazing.*

Integrated design: Solar gain and heat retention



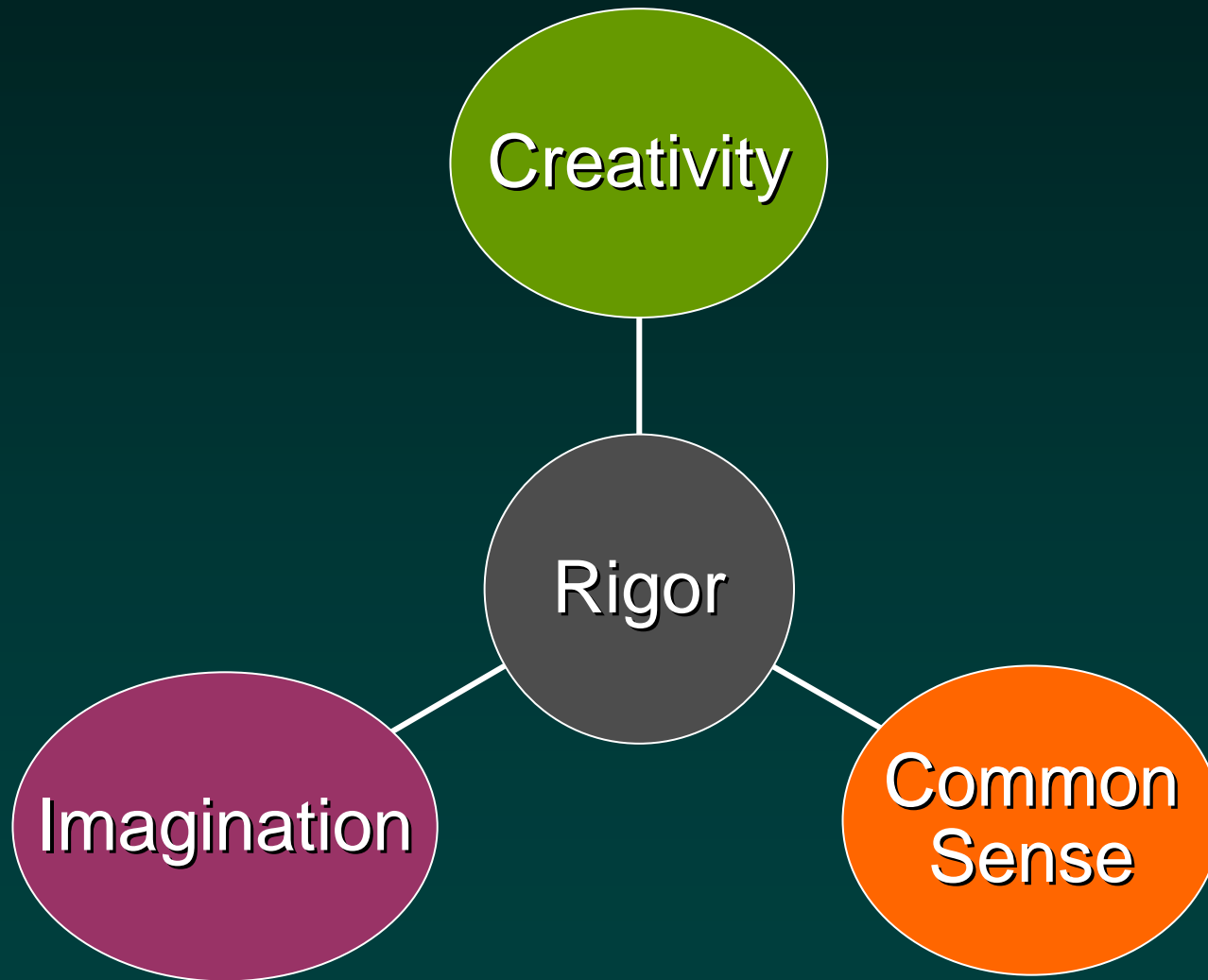
Seek Understanding



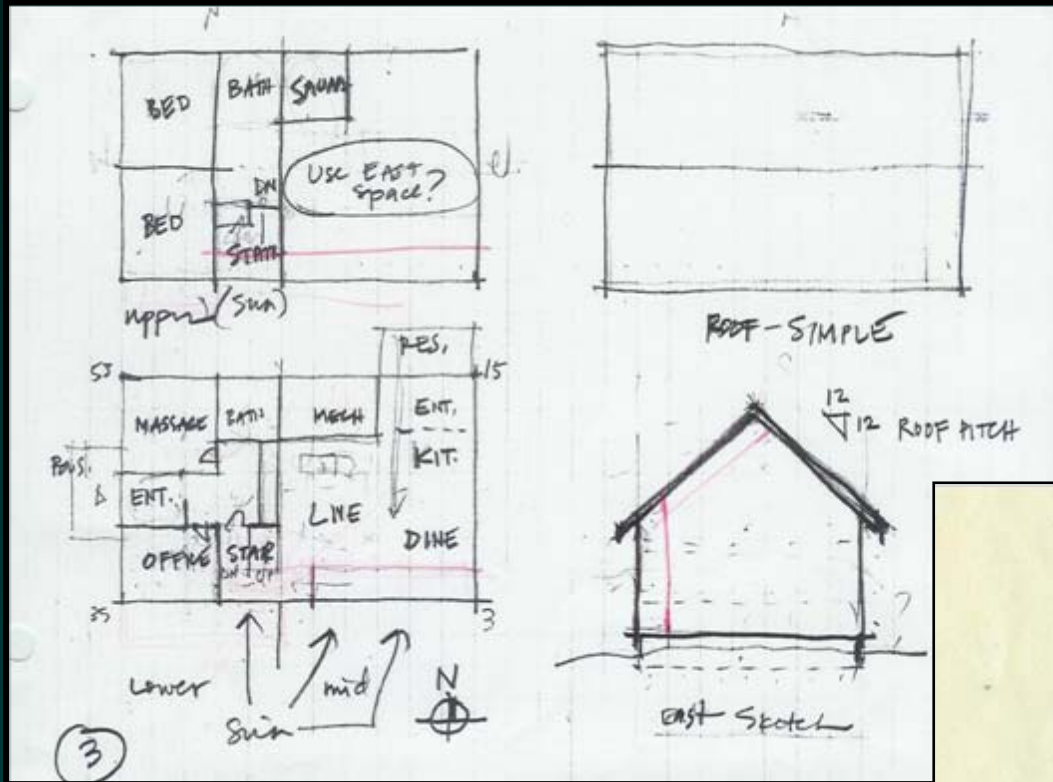
“Disintegrated Design”

- The designer (me) didn't understand the consequences of placing the main exhaust at the soffit on the north side.
- The Contractor asked repeatedly NOT to do it this way.
- The Designer neglected to ask WHY the Contractor wanted to change it, or to seek deeper understanding of the suggested alternate.

3. Use Critical Thinking



Critical Thinking Early in Design



Critical Thinking



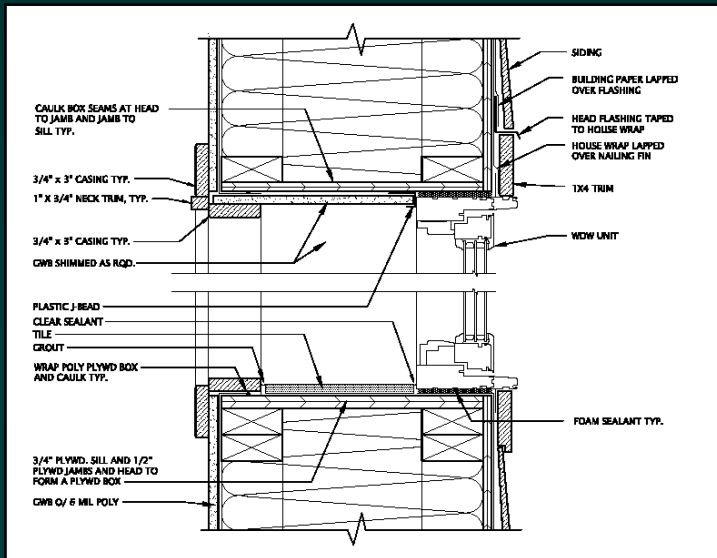
“Disintegrated Design”

- The designer had been taught not to place ducts in unconditioned spaces (like all “rules,” there are exceptions).
- The Contractor wanted to run the main exhaust out through the attic to the gable end.
- The Designer didn’t think critically about this option.
- Now the duct runs through the attic and out the gable end.

Critical thinking can lead to integrated solutions



4. Play as an Ensemble



Ensemble:

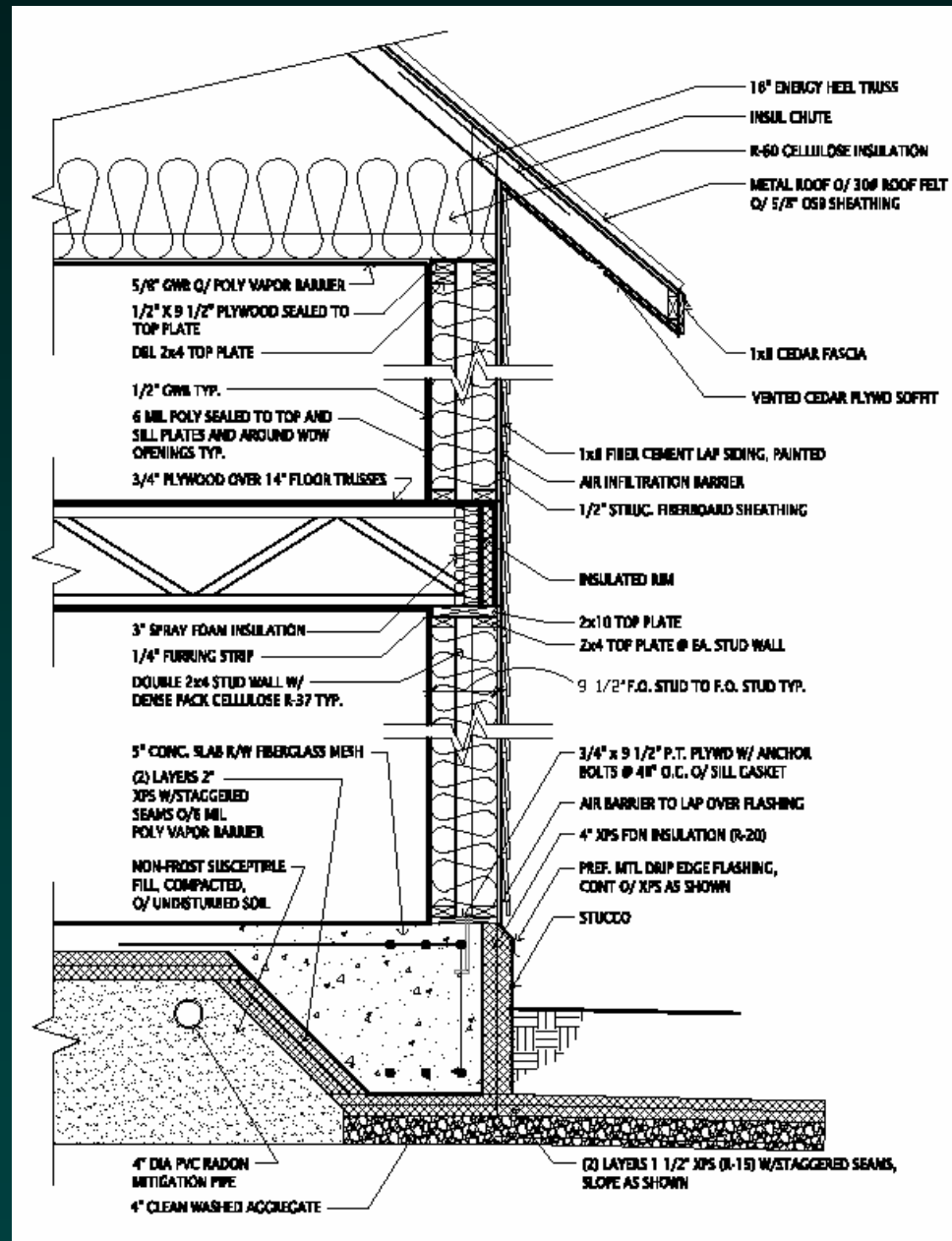
A unit or group of complementary parts that contribute to a single effect

This means coordination and cooperation between:

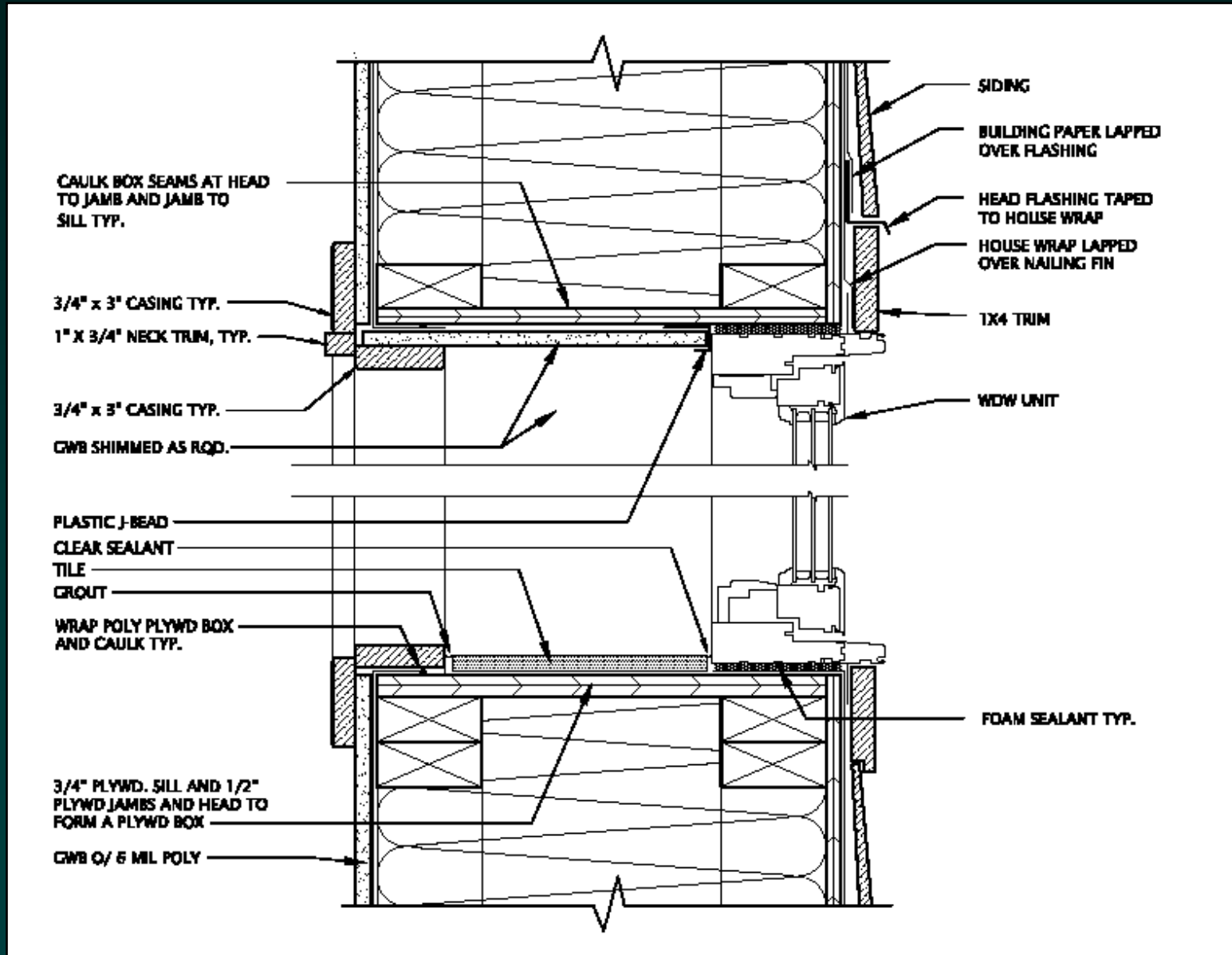
- Owner
- Designer
- Contractor
- Consultants: energy, engineering, building performance
- Subcontractors: excavators, concrete, electricians, plumbers, HVAC contractors ...
- Vendors

The “single effect” can be good or bad. Choose GOOD.

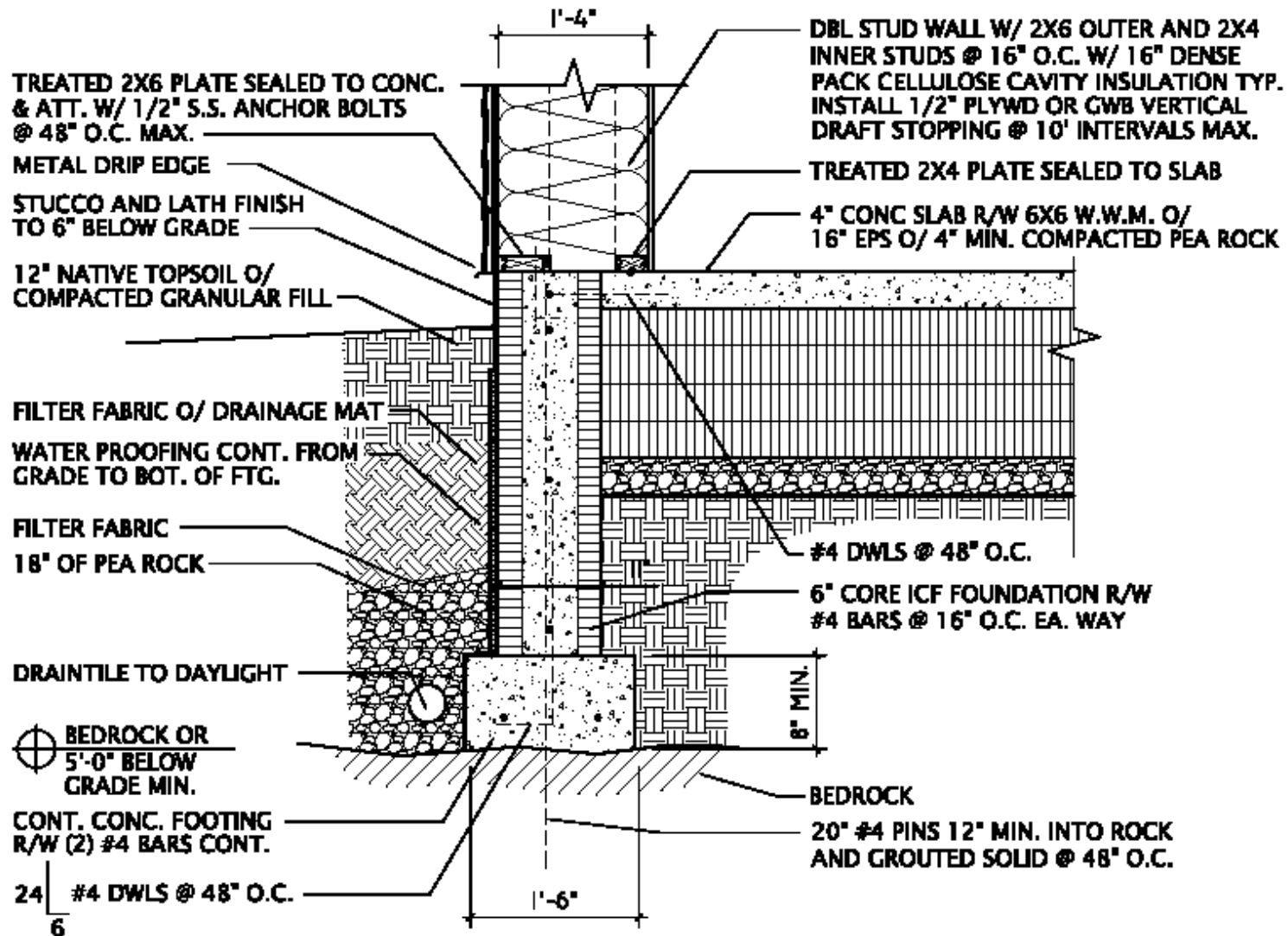
Integrated Design in Drawing



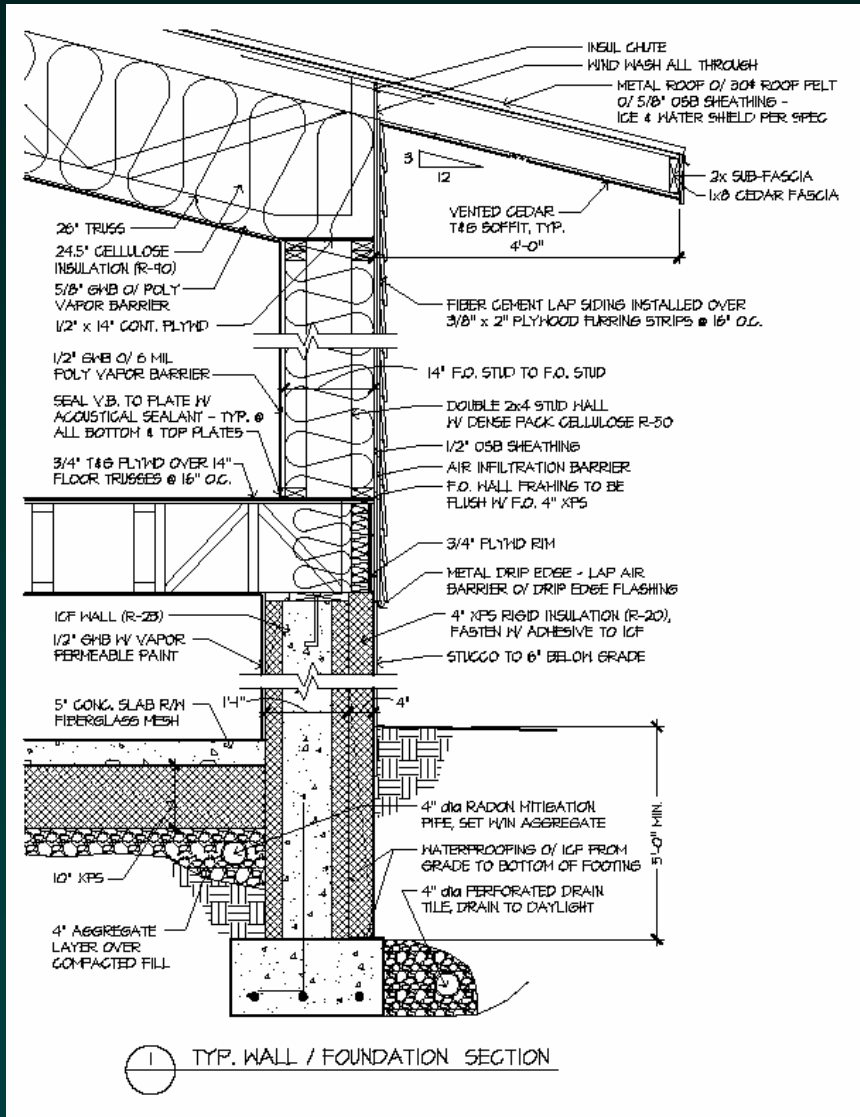
Integrated Design in Detail



Integrated Detail in Design



Thermal bridging, moisture, and air



- A wall should be able to dry to either the interior or exterior
- Understand the integrated nature of the wall assembly
- Might moisture in the cavity reach the dewpoint and condense on the sheathing?
- If there is moisture, will it be able to dry out of the assembly?

Air barrier according to Rosenbaum*

An air barrier needs to be

- (a) impermeable to air;
- (b) continuous;
- (c) strong enough to resist the forces acting on it; and
- (d) durable.

* Thanks to Marc Rosenbaum, an integrated thinker.

Integrated Design, Integrated Assembly:



air sealing, vapor barrier, lighting, ventilation, plumbing

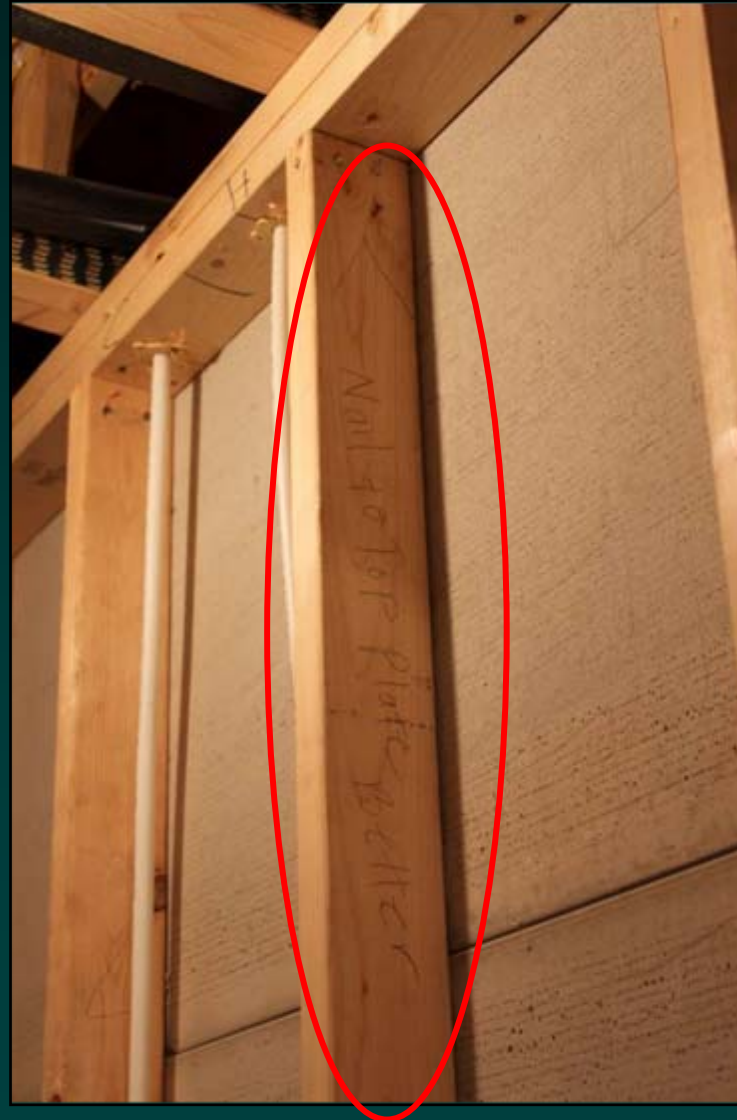
Play as an Ensemble



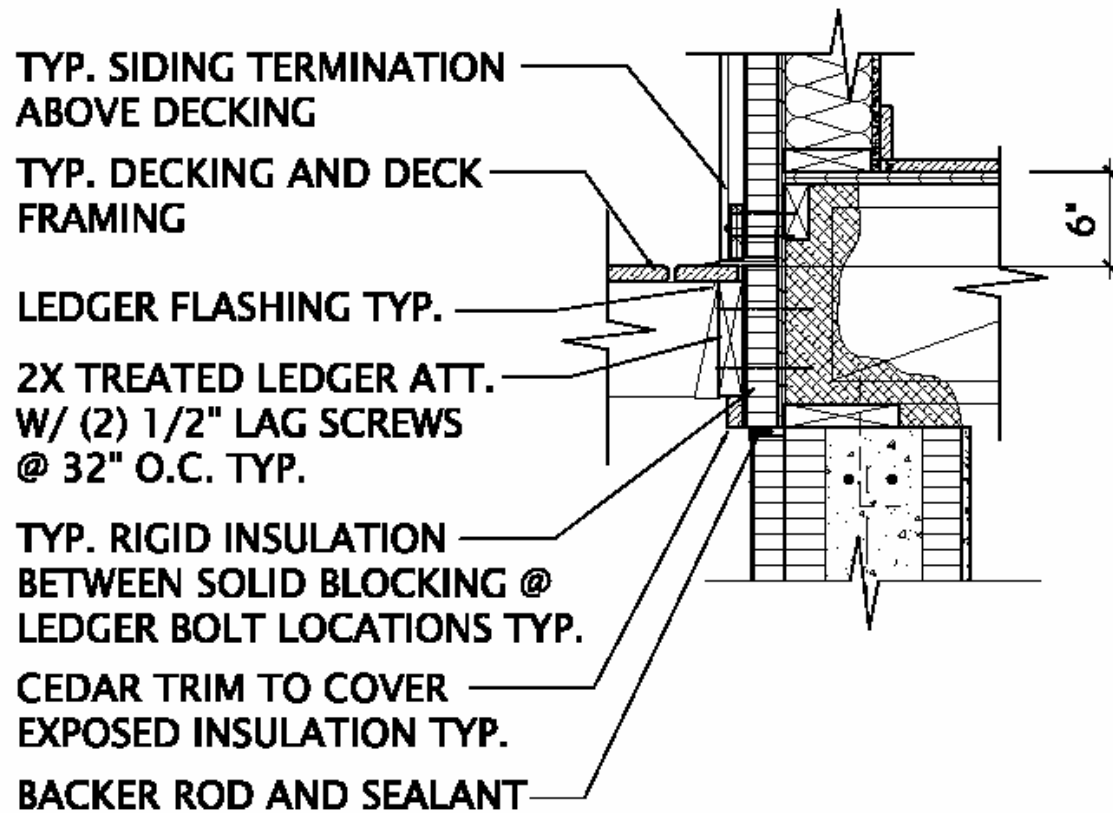
Integrated Water Management

Site/grading choices, building form, roof form, intersections, details, execution

Integrated Design at Work: Quality Control



Can it be drawn?

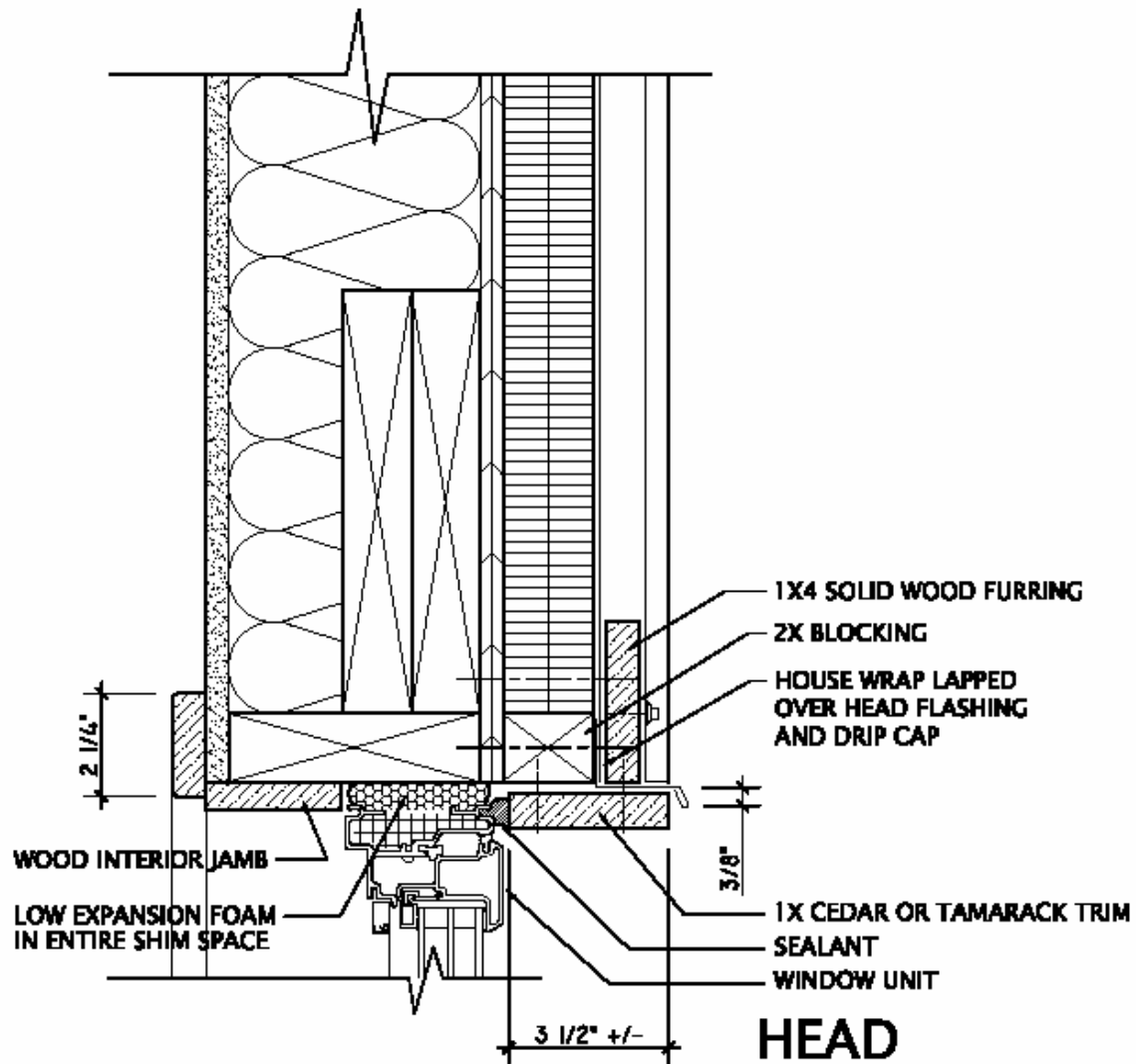


2
A3.1

DECK LEDGER DETAIL

3/4" = 1'-0"

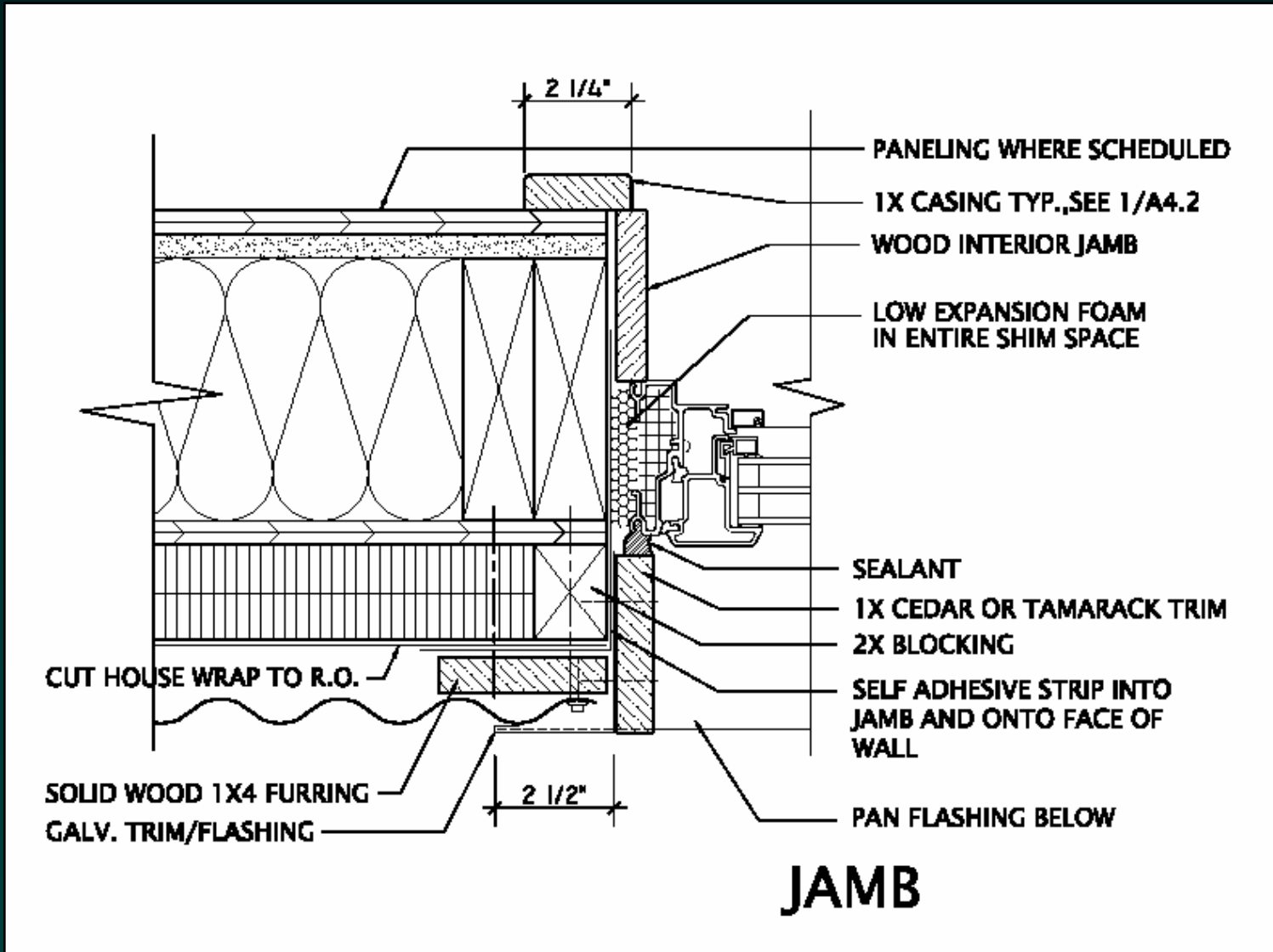
Can it be assembled?



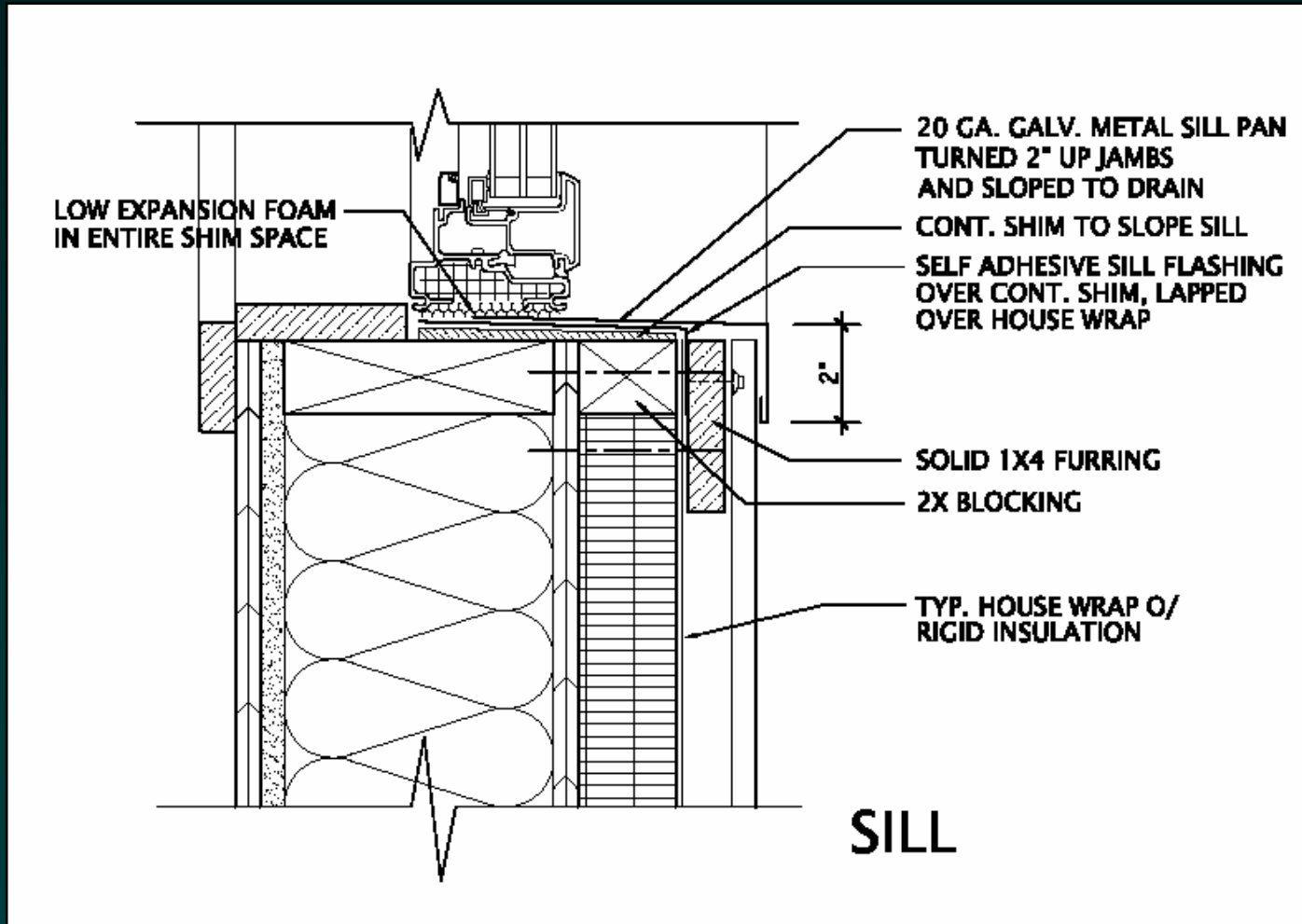
It can be assembled



Is it durable?

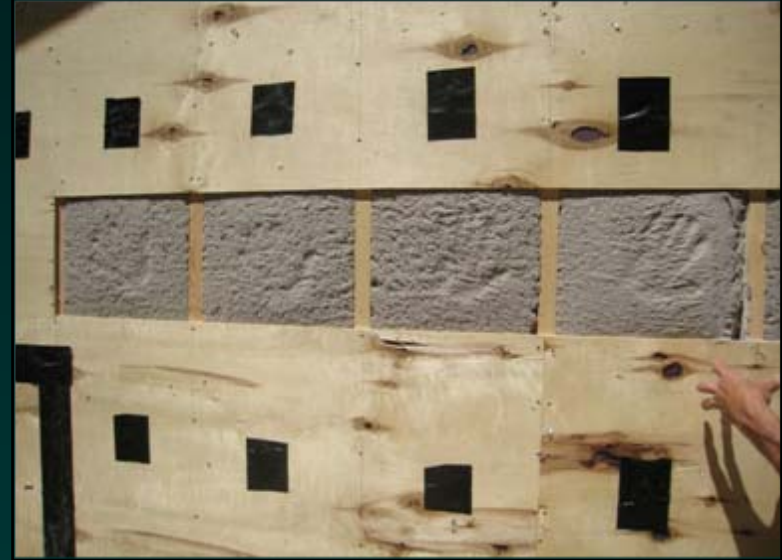


Can it be maintained?



A window may need replacing before the cladding needs replacing. Plan for this.

Quality Control can require investigation



Testing as part of Quality Control

0.7 ACH@50 Pa



0.4 ACH@50 Pa



Passive House air tightness requirement is 0.6 ACH@50Pa
2009 IECC requires 7 ACH@50 Pa

Skyline House



2660 ft² living space

Passive solar design

Integrated heating, hot water, and ventilation systems

Stacked form and services

\$195 to heat in 2009

(natural gas)

Follow up as Quality control:
ask for data on energy use
learn how the house is performing



40 Million Btu/year site

Esko House



2690 ft² living space

Small footprint

Passive solar design

Simple building forms

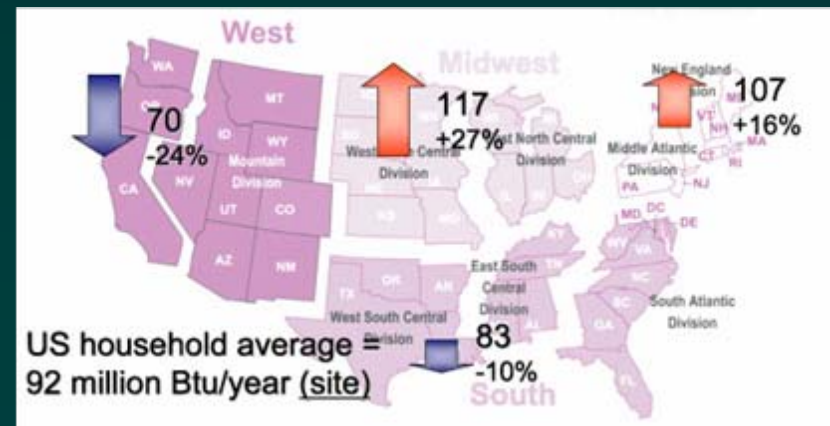
\$303 to heat in 2009

(dual fuel electric)

54 Million Btu/year site

(the first year had a few glitches...)

looking forward to next year's data)





“Well (said Pooh)... we keep looking for Home and not finding it, so I thought that if we looked for this Pit, we’d be sure not to find it, which would be a Good Thing, because then we might find something that we weren’t looking for, which might be just what we were looking for, really.”

- A.A. Milne

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