DAY THREE – Week One

- Homework – Quiz - Review
- Framing systems & why we care
- DTL & the CAZ test
- BTL & MVG (formerly BTLa)
- ASHRAE 62 & 62.2
- Costing natural air change

Sample House #2

- 20’x30’ ranch on full concrete basement
- Average 2’ exposed concrete basement wall
- 7500 HDD - Open, rural area
- Garage, boiler, washer & drier in basement
- 8’ Ceilings - main floor & basement
- 1000 gallons #2 fuel oil – $4.00/gallon
- 3.5” Fiberglass walls
- 6” Fiberglass attic
- Continuous ridge & soffit venting
- DHW by immersion coil in boiler

Homework:

- Assume 10% wall area = R-2 windows & doors.
  - 800 sq' – 80 sq' = 720 sq' (1st floor only)
  - 200 sq' exposed basement wall
- What is the home's annual surface heat loss in BTU?
  - (600 x 7500 x 24)/17 = 6,352,941 (Ceiling)
  - (720 x 7500 x 24)/10 = 12,960,000 (Walls)
  - (80 x 7500 x 24)/2 = 7,200,000 (Windows)
  - (200 x 7500 x 24)/1 = 36,000,000 (Basement walls)
  - Total 62,512,941 BTU/year
- What is the annual surface heat loss cost?
  - 62,500,000 BTU/100,000 BTU/gallon = 625 gallons/yr
  - 625 gallons @ $4.50/gallon = $2,812.50

Homework:

- What is the volume of heated space?
  - 20’ x 30’ x 8’ = 4,800 cu’
- Assume 1 ACH.
  - 4,800 x 1 x 0.0182 x 7500 x 24 =15,724,800 BTU/yr
- What is the annual cost to heat the air moving through the house?
  - 15,724,800 BTU/100,000 BTU/gallon = 157 gallons
  - 157 gallons @ $4.50/gallon = $706
- If the house were airsealed to .35 ACH what would the annual savings be?
  - 4800 x .35 x 0.0182 x 7500 x 24 = 5,503,680 BTU/yr
  - 15,724,800 – 5,503,680 = 10,221,120/100,000 x $4.50 = $460.

Totals

Surface heat loss =	625 gallons
Air transported HL =	157 gallons
Domestic hot water =	180 gallons
Total	962 gallons
Reported use	1,000 gallons

Close Enough!

Today's Terms

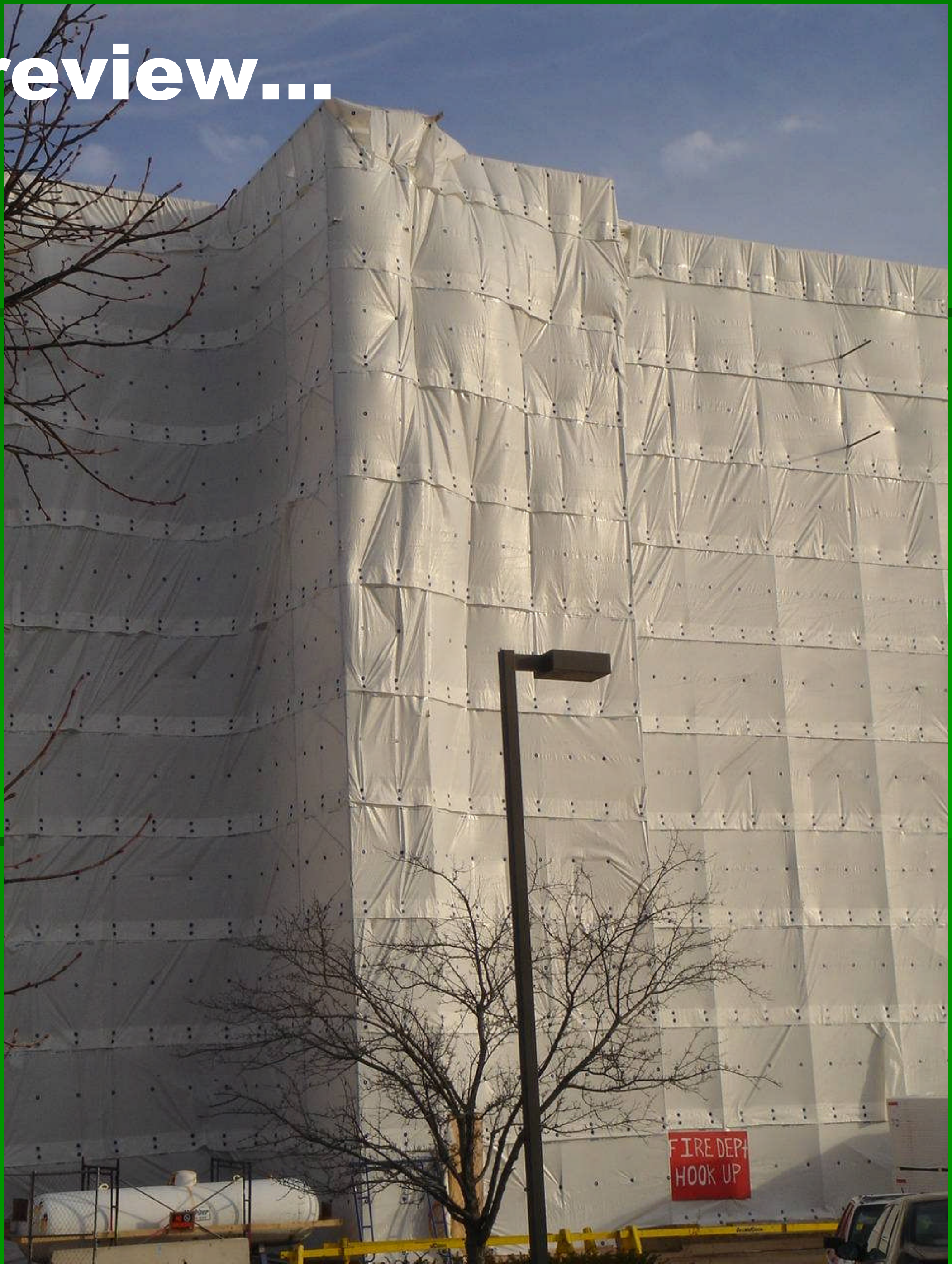
- Header
- Plate
- Shoe
- Cripple stud
- Pier & Post
- Footer
- Frost wall
- Floating slab

Today's Quiz

- What are the three types of heat transfer?
- How does each work?
- What is the perm rating of 6 mil poly?

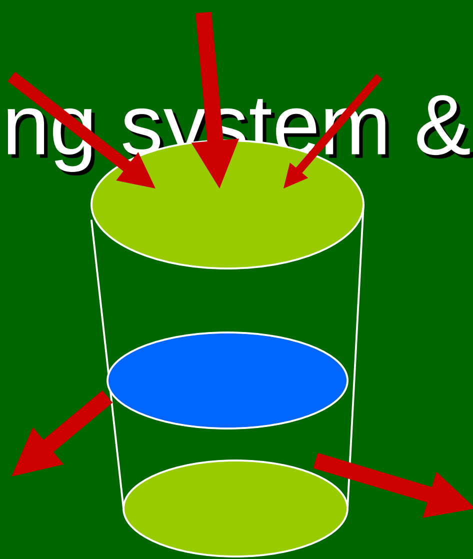
  (Krigger pp273)
- What is a Building Envelope made up of?

A little review…



The Bucket !

- Think of the building as a bucket of water with holes.
- The sun, heating system & internal gain fill it.



- Surface & air transported heat loss empty it
- Your job is to find & plug the holes !

The Building Envelope….

- The building envelope is the dividing line between conditioned & unconditioned spaces.
- The building envelope must have a thermal boundary or barrier, an air leakage retarder (sometimes called an air barrier) and a moisture barrier)
- All must be:
  - continuous
  - at the same plane
  - in contact with each other

Assembly R values

- Most audit protocols reduce any calculated assembly R-value by some percentage – the well known fudge factor – to bring it more into line with real world & laboratory test results.
- For auditing purposes it's generally acceptable to <u>assume</u> an un-insulated wall is ≈ R-3 while a ceiling is R-2 if there is an attic floor & R-1 if there is none.
- An insulated wall or ceiling will have an overall R value ≈ equal to the manufacturer's rated value of any properly installed insulation minus 10% to 15%*.

* Unless it's exposed – no attic floor – fiberglass in a vented attic.

What you should know about BTU !

A BTU = the amount of heat required to raise 1 lb of H^2O 1º F (Note: it's 1 <u>lb</u>, not 1 gallon)

BTU content of fuels:

- #2 Fuel oil – 139,000BTU/gallon
- Kerosene – 134,000BTU/gallon
- Natural gas – 1,000BTU/ cubic foot
- Propane (LPG) – 91,000BTU/gallon
- Electricity – 3412BTU/kWh

Energy Flow & the Building

- Basic Construction Types
  - Post & Beam

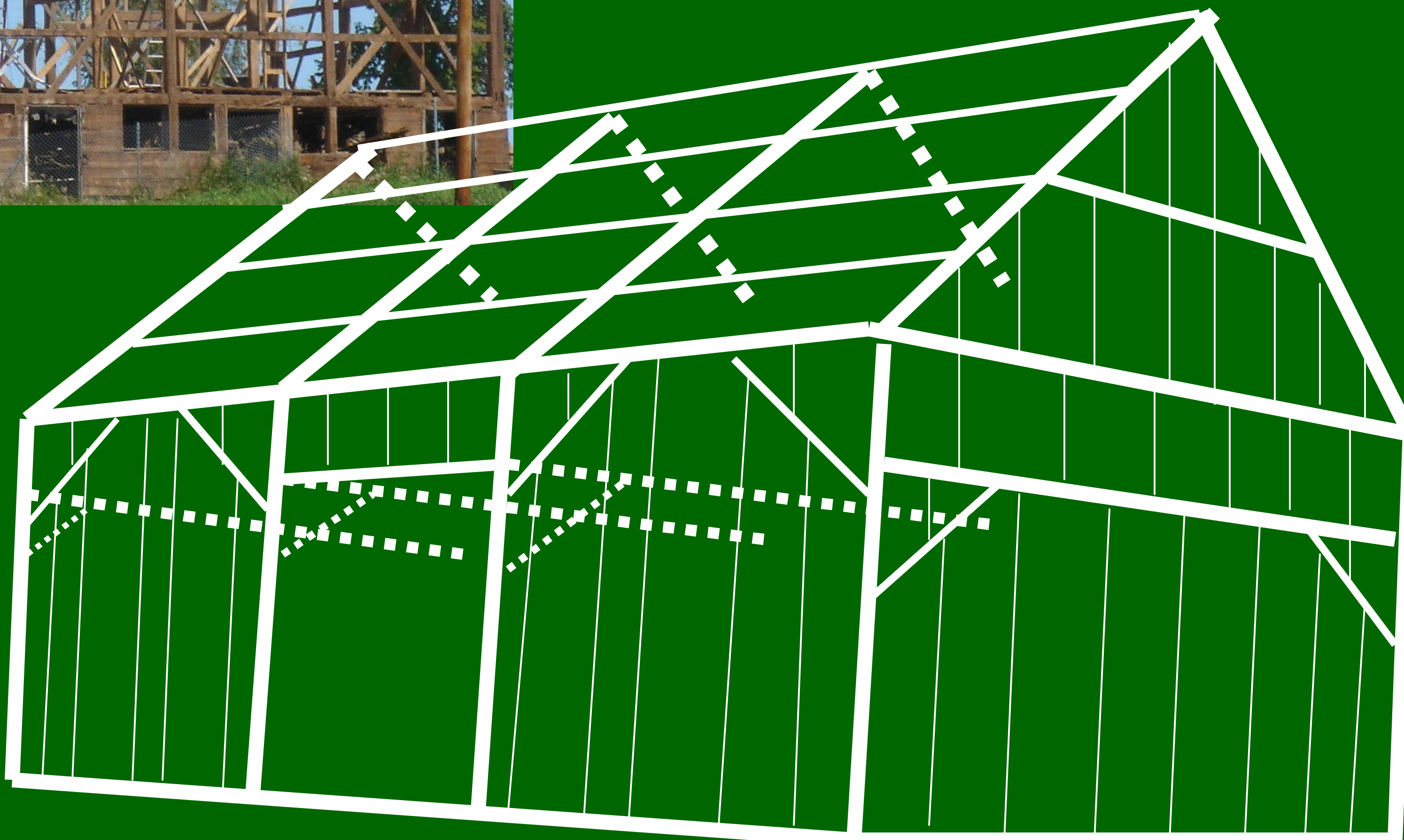
    (or - for you history buffs - Post & Girt)
  - Balloon
  - Platform
  - Some combination thereof.
- Manufactured housing &
- the (sometimes not so) lowly mobile home.

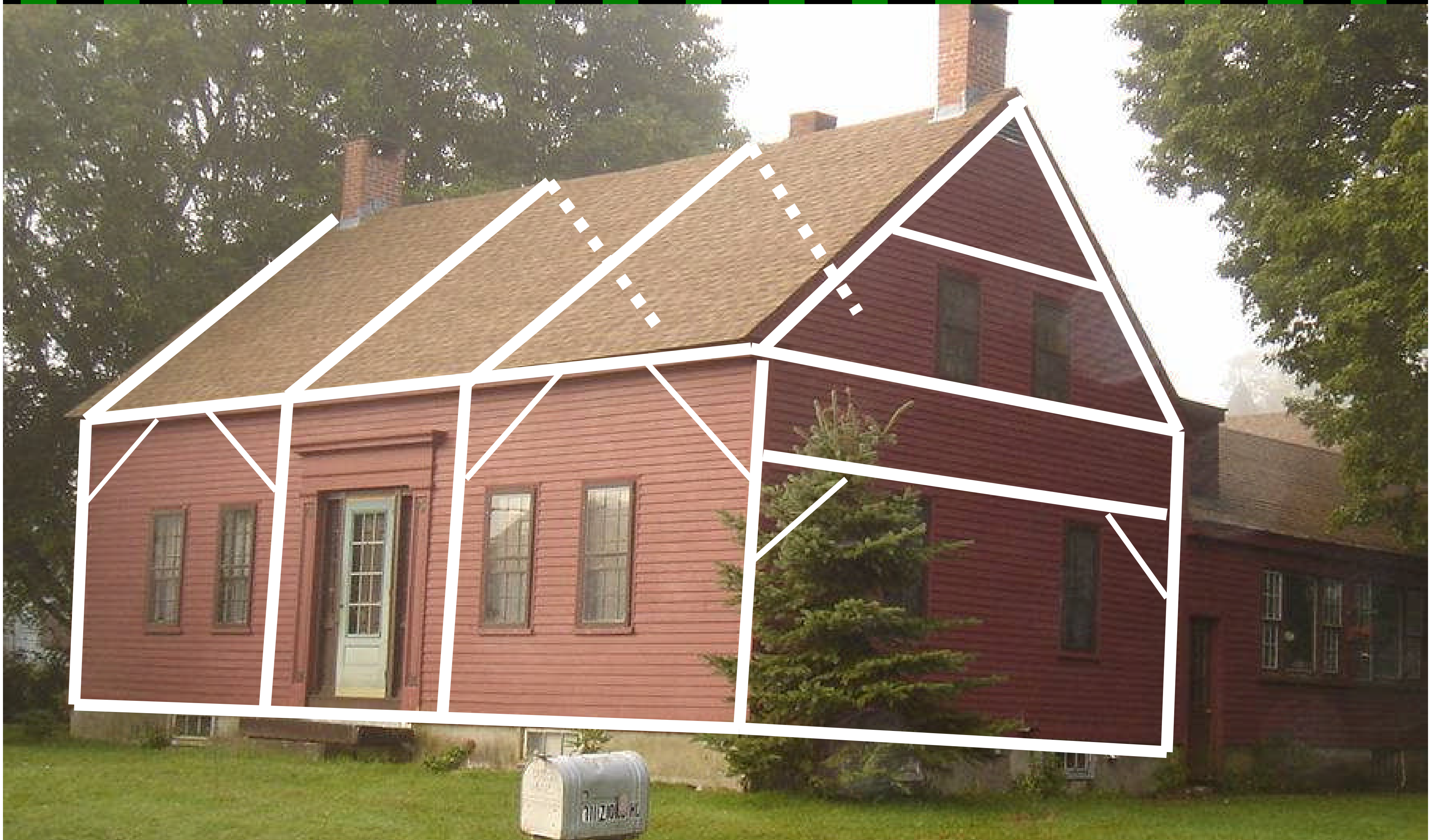
Building types

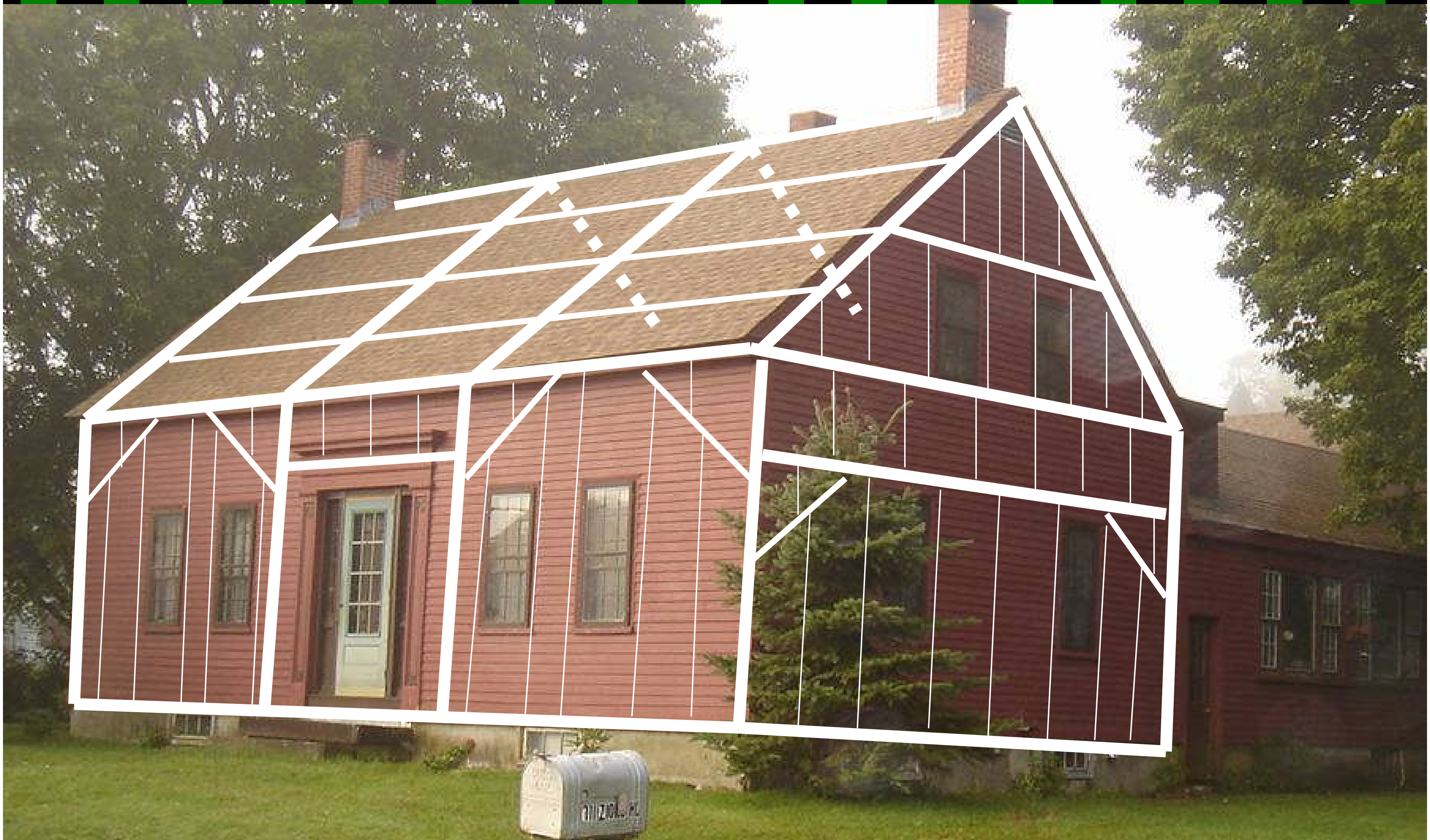
Post & Beam Framing

Barn

House



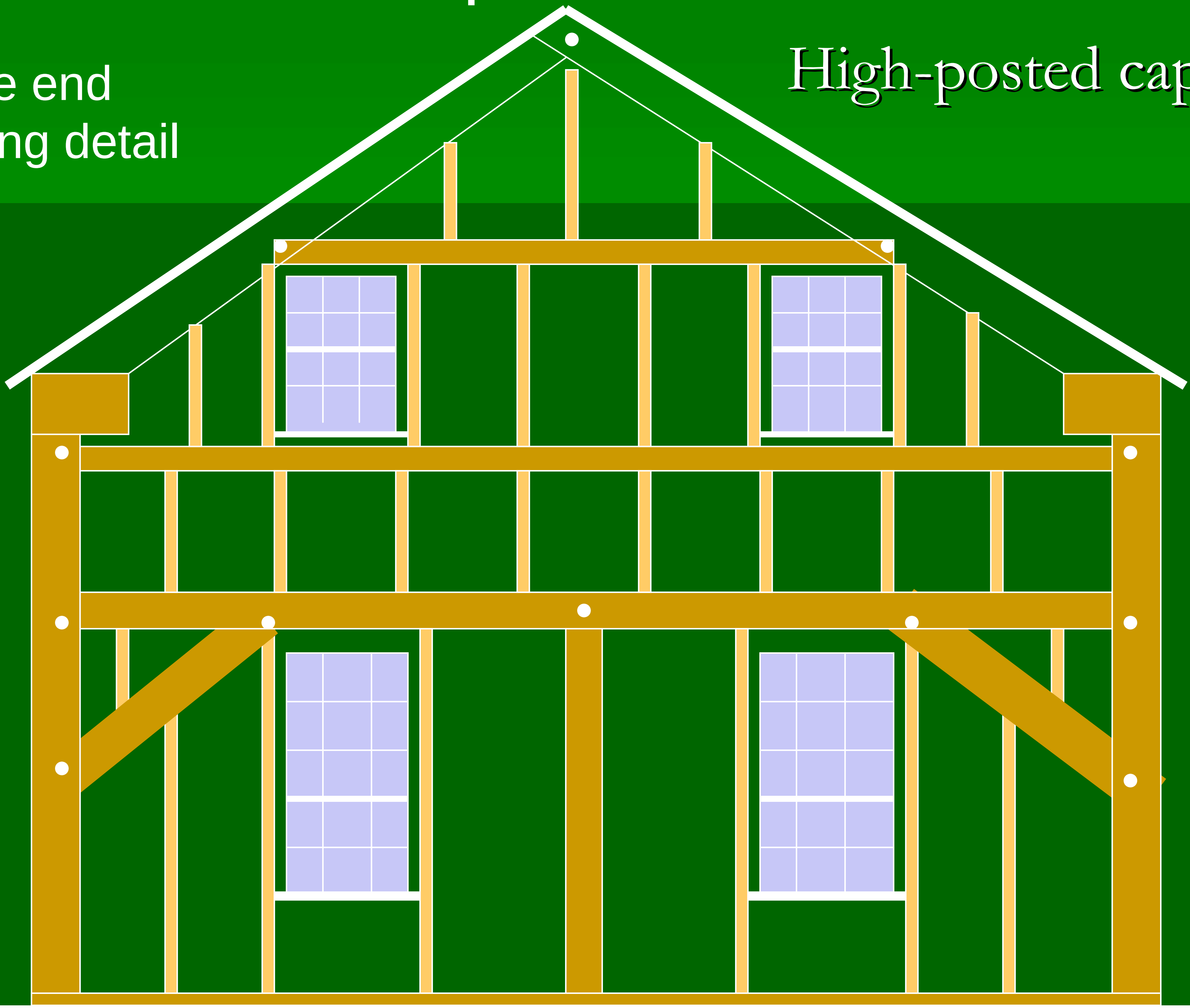




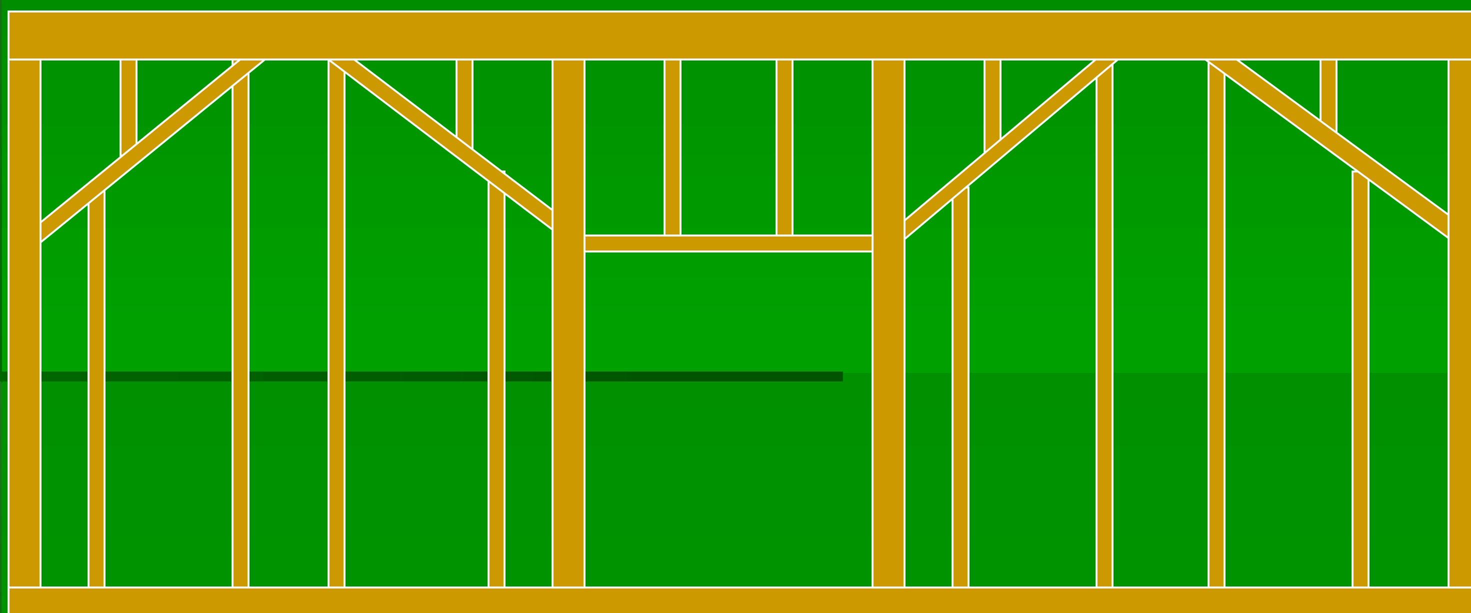
Post & Beam Cape

Gable end framing detail

High-posted cape

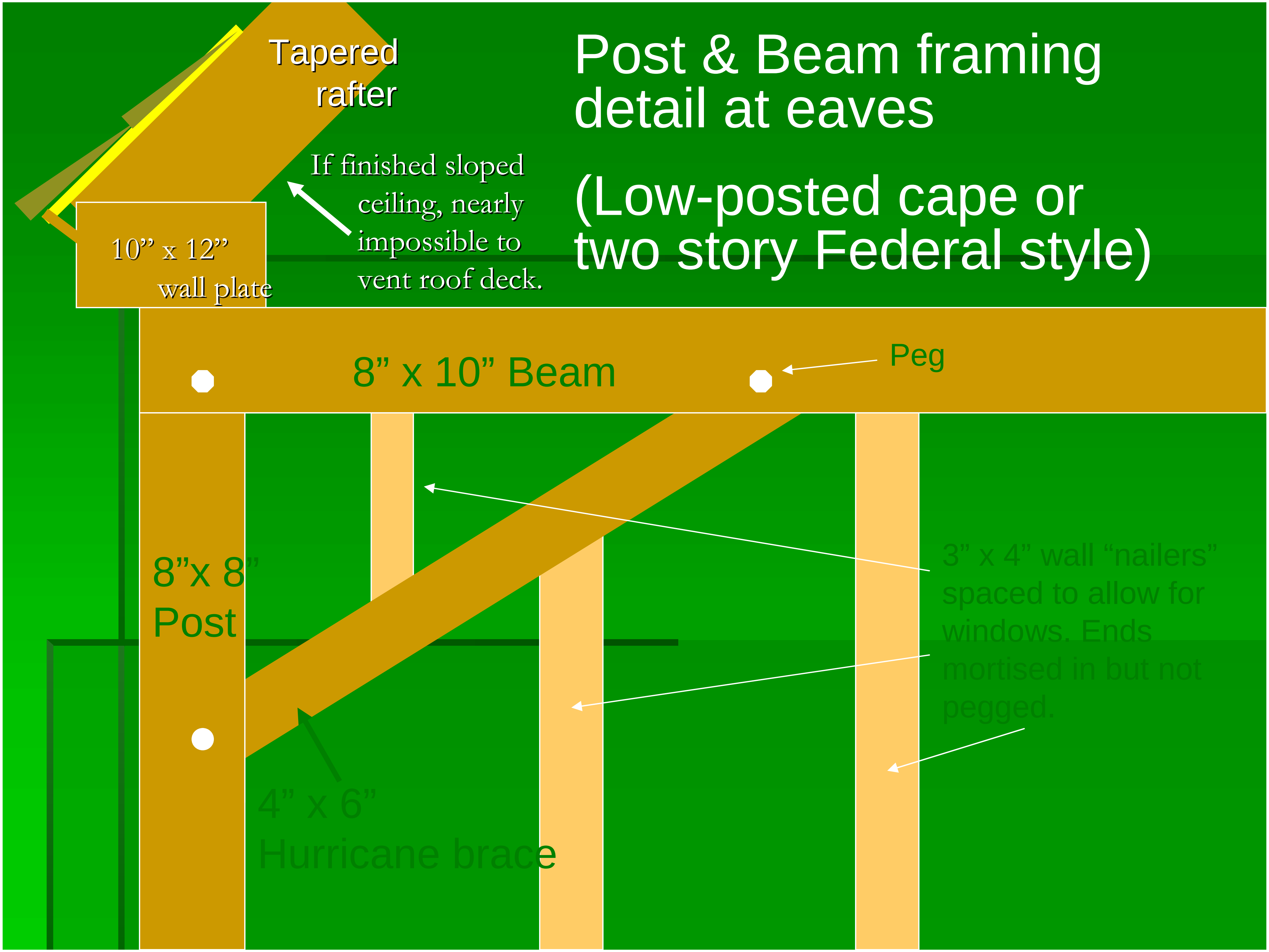


Post & Beam Cape
Eaves side framing details



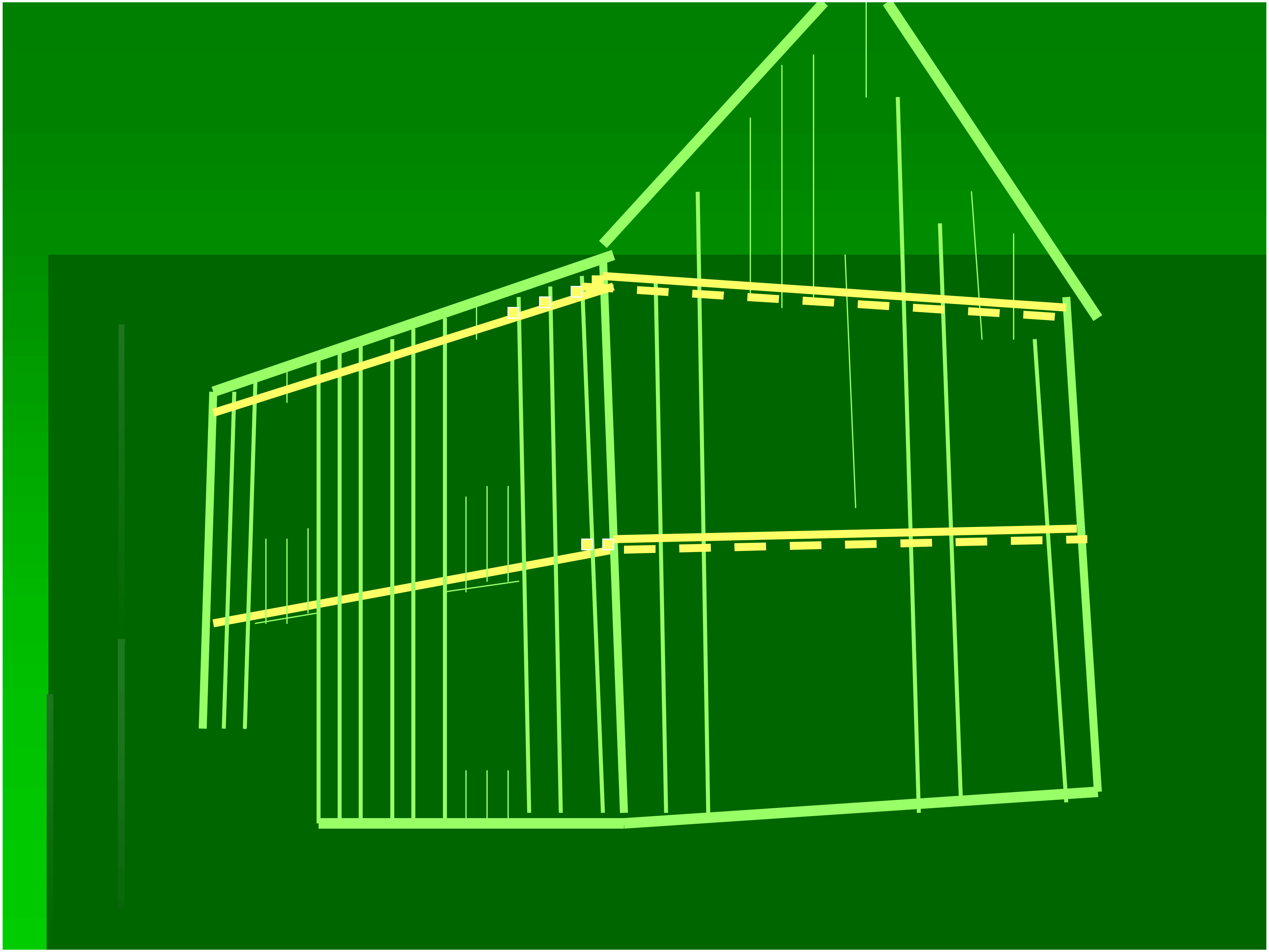
Post & Beam framing detail at eaves

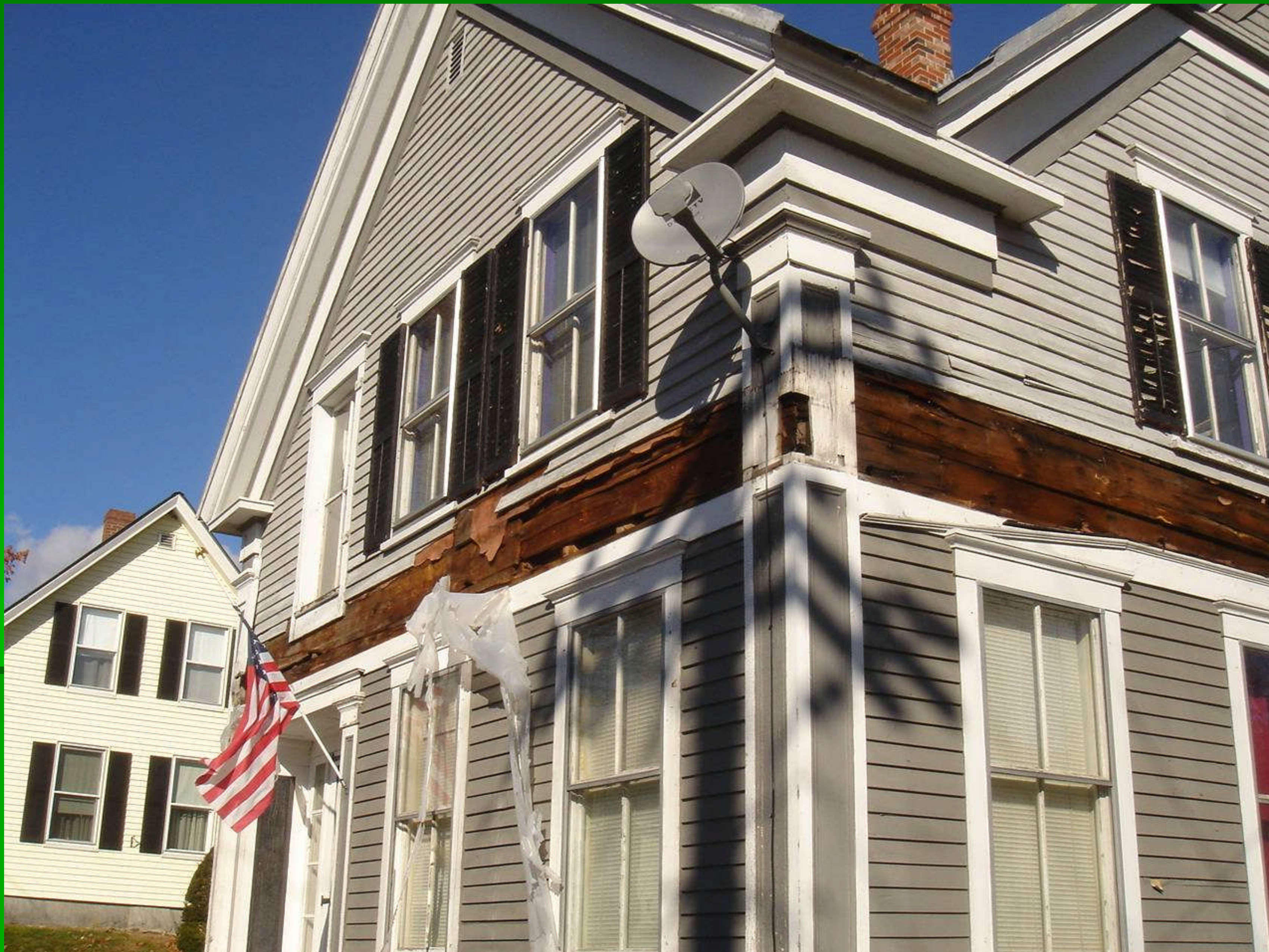
(Low-posted cape or two story Federal style)



Victorian Style

Balloon framing

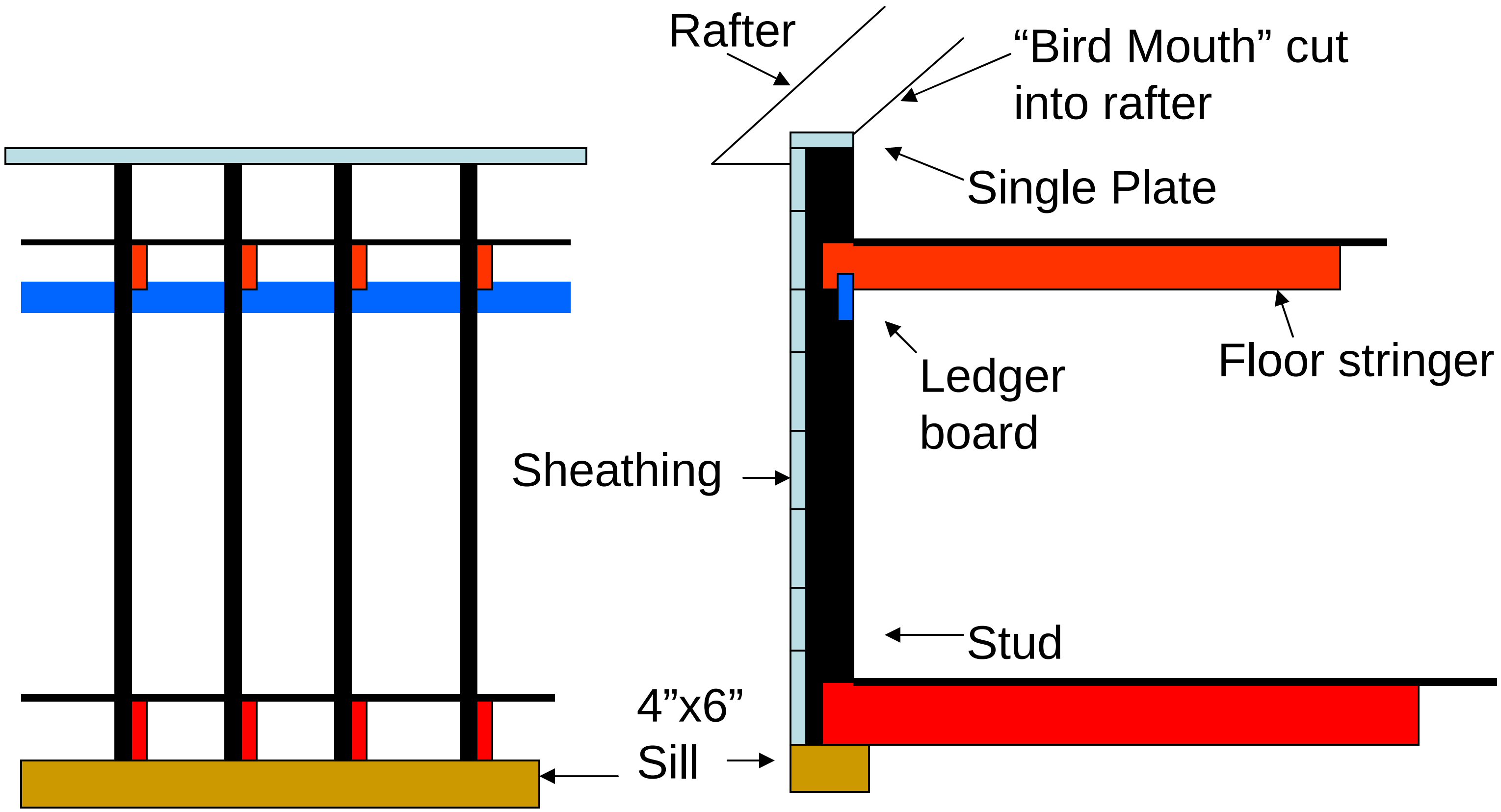




Balloon Framing – typical sidewall detail

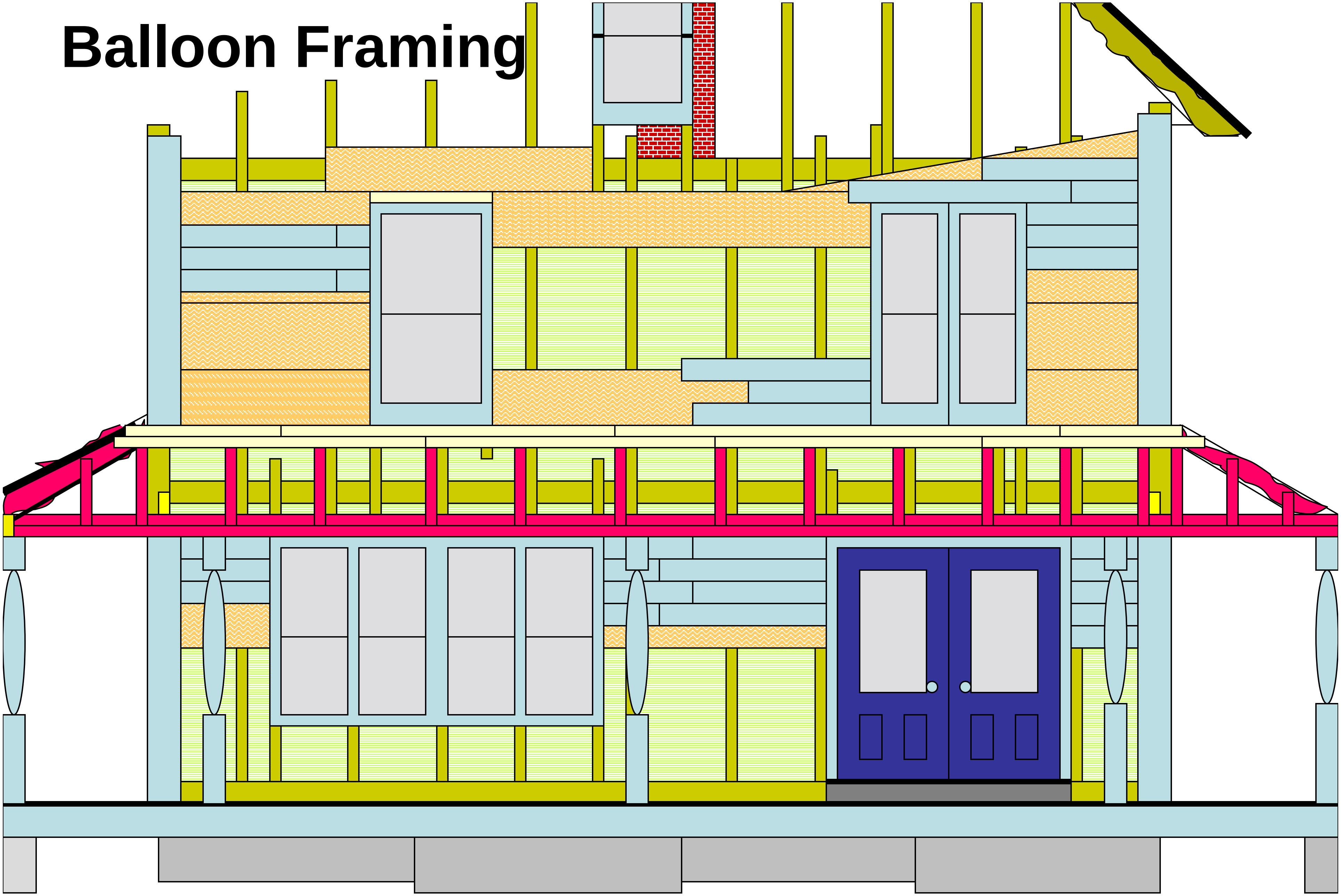
Sill to plate studs with floor stringer ledger board “let in”@ upper floors.

“Letting in” gives wracking strength & provides a flat surface for wall finish



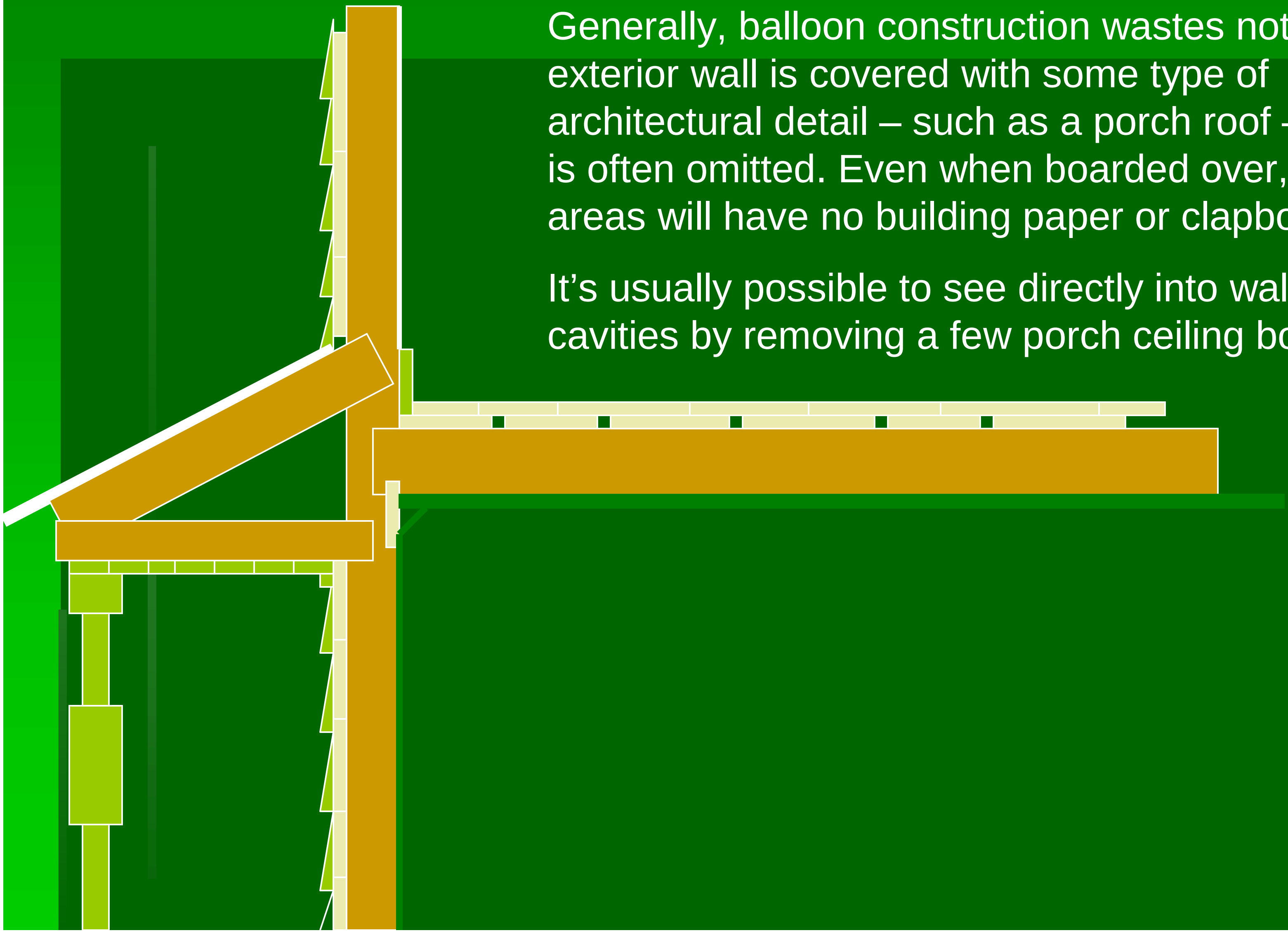
Balloon Framing

Balloon Framing



Balloon Framing

Typical porch or bay window detail

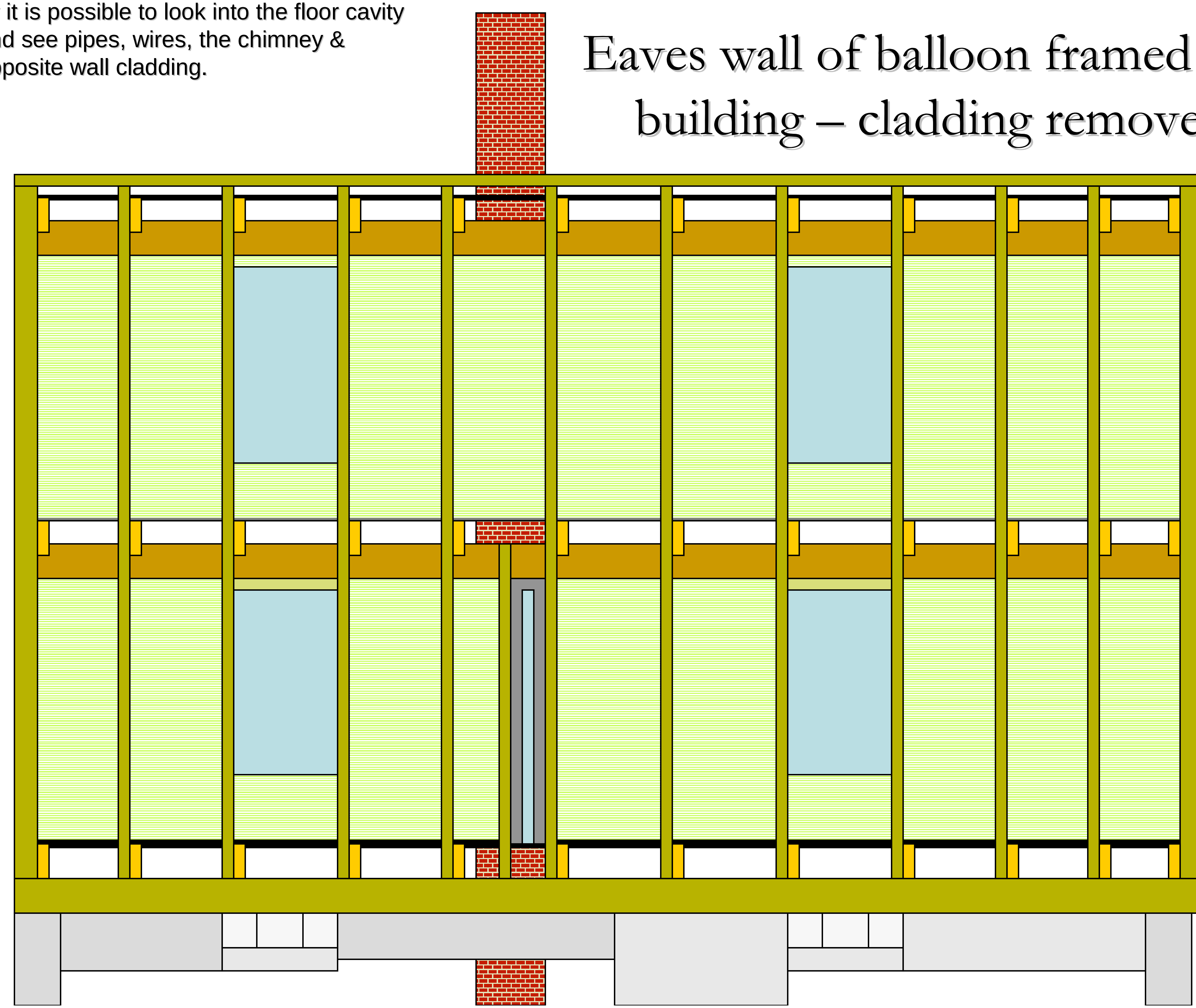


Generally, balloon construction wastes nothing. If an exterior wall is covered with some type of architectural detail – such as a porch roof – cladding is often omitted. Even when boarded over, these areas will have no building paper or clapboards.

It’s usually possible to see directly into wall & floor cavities by removing a few porch ceiling boards.

Usually it is possible to look into the floor cavity and see pipes, wires, the chimney & opposite wall cladding.

Eaves wall of balloon framed building – cladding removed.



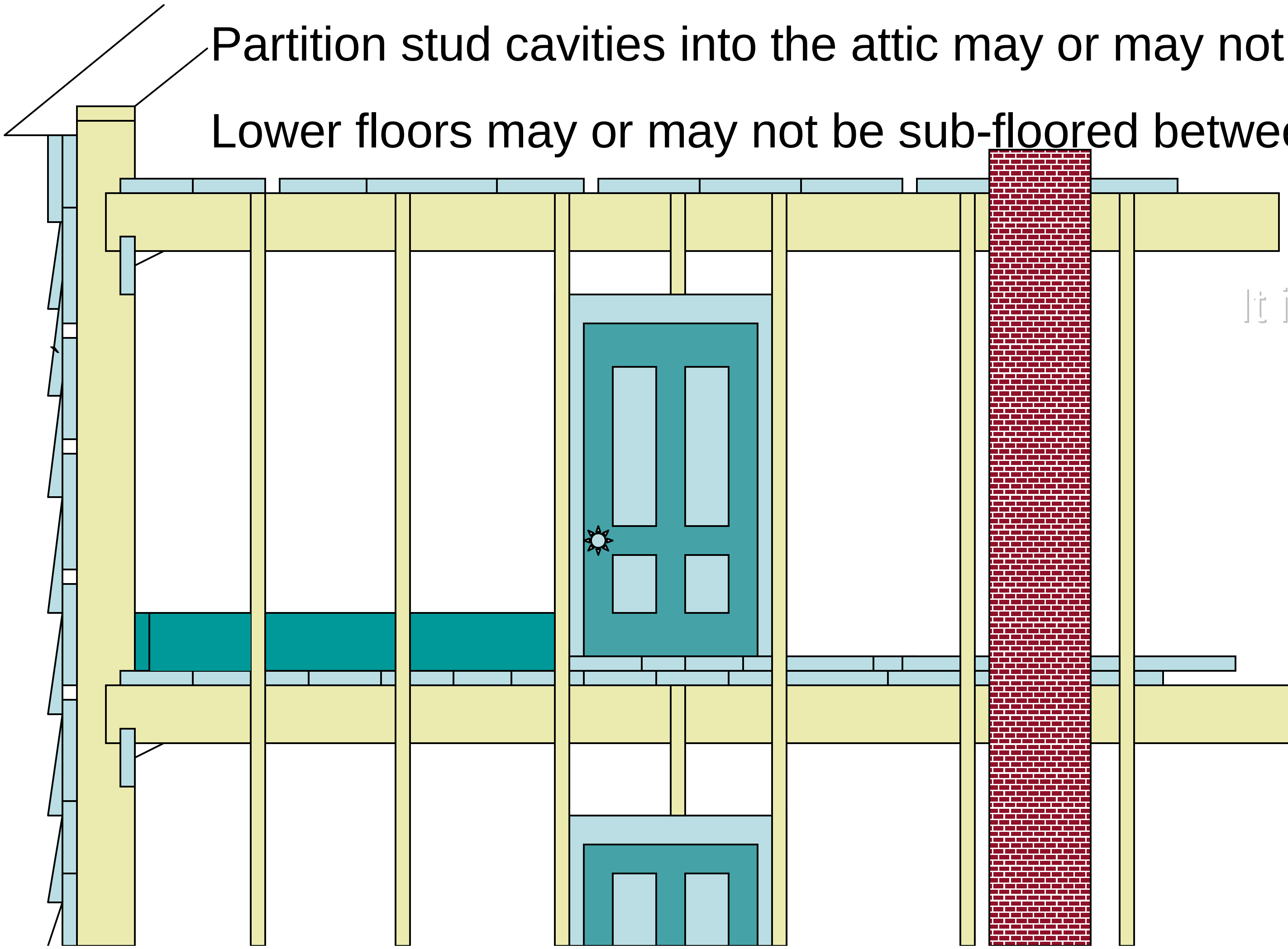
Balloon Framing – typical interior partition detail

Interior partitions generally align floor to floor.

Partition studs are generally nailed to the sides of floor stringers.

Partition stud cavities into the attic may or may not be floored over.

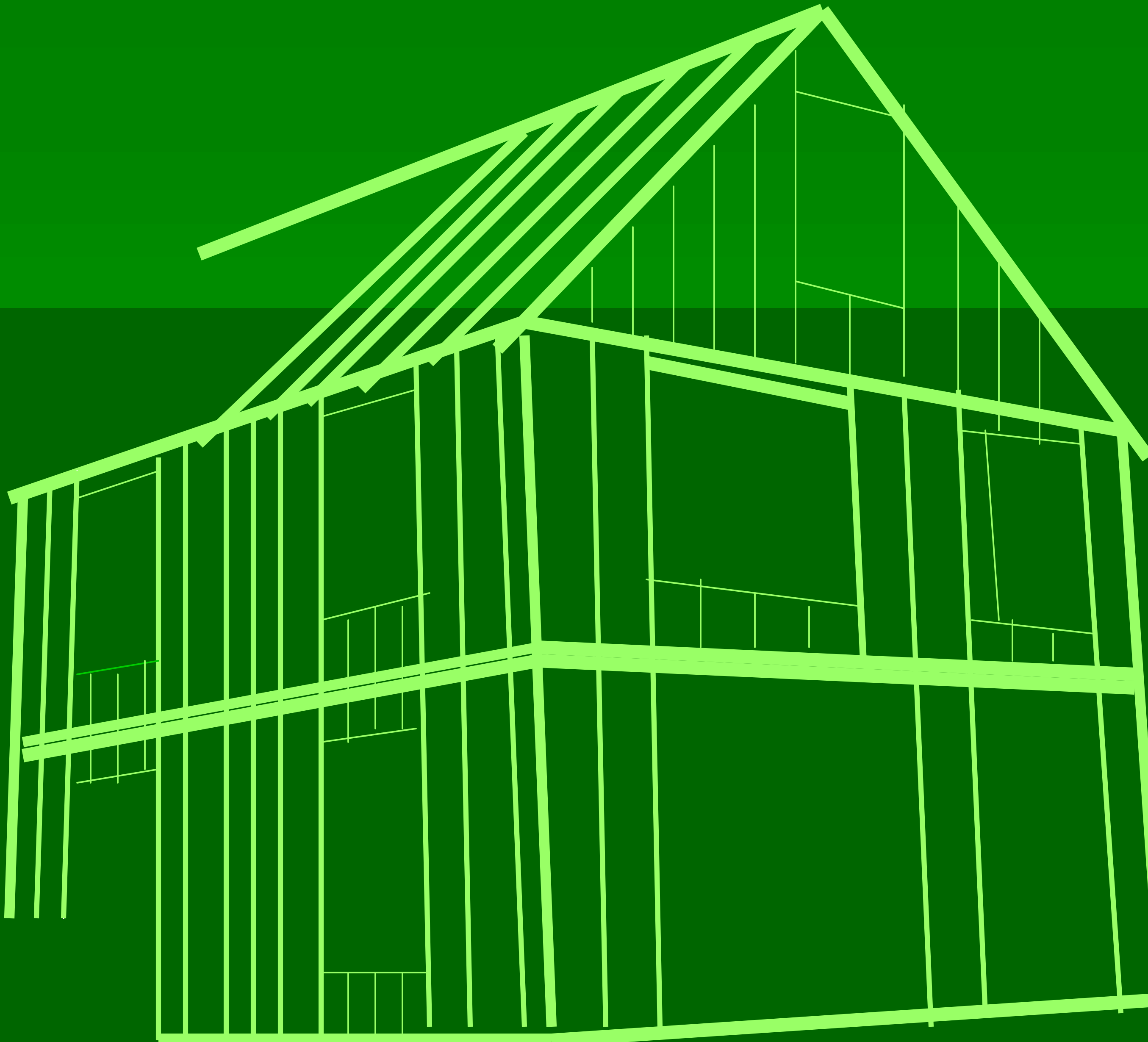
Lower floors may or may not be sub-floored between partition studs.



It is generally possible to drop an object through interior & exterior wall cavities from the attic to the first floor sub-flooring.

Partition: Balloon construction

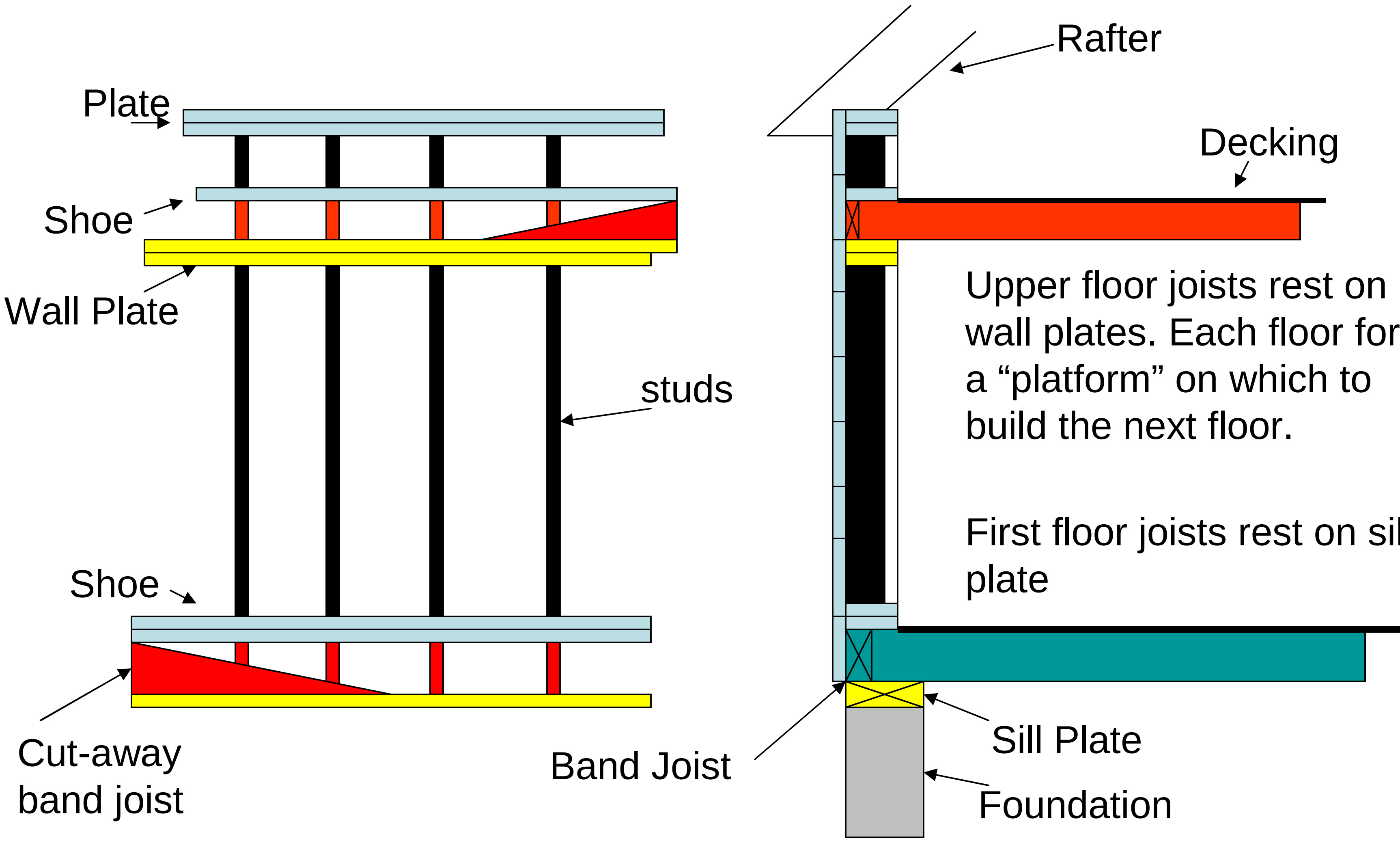
Platform Framing



See Krigger: pp50

Platform Framing

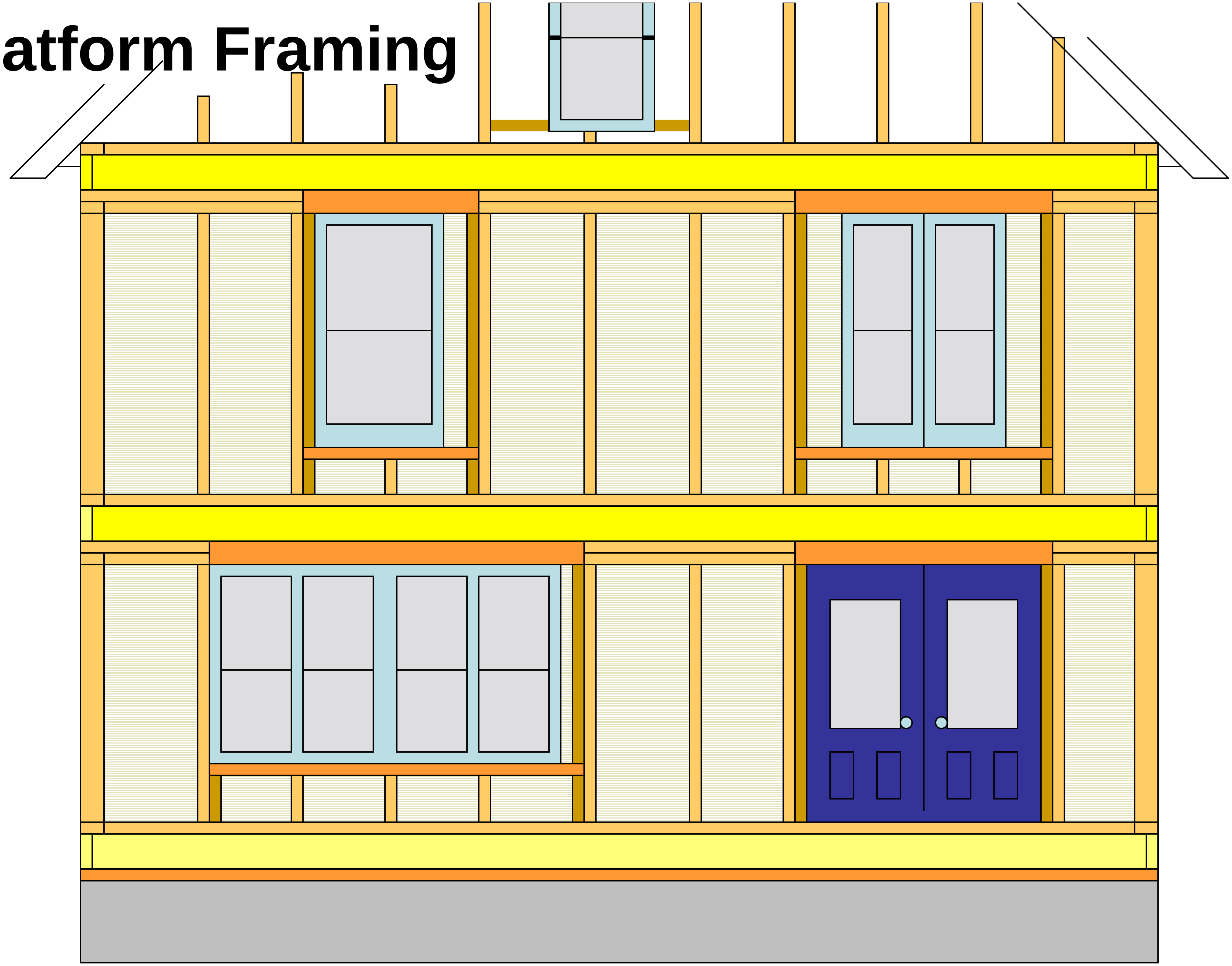
Typical exterior wall framing detail



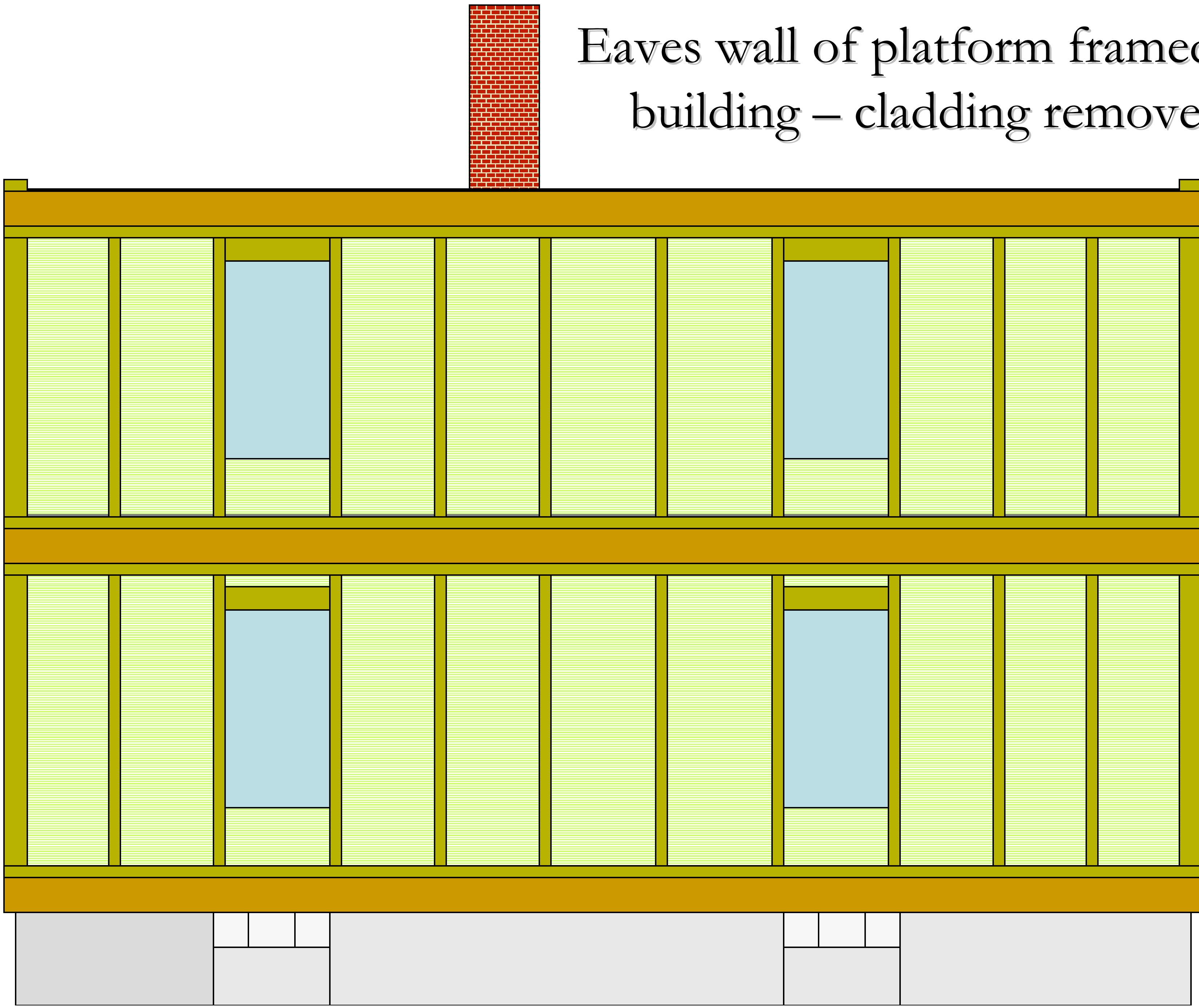
Upper floor joists rest on wall plates. Each floor forms a “platform” on which to build the next floor.

First floor joists rest on sill plate

Platform Framing



Eaves wall of platform framed building – cladding removed.



Trusses vs. Rafters

Framing for
vertical siding.

A real house !

Main house = post & beam – timber/purlined roof system

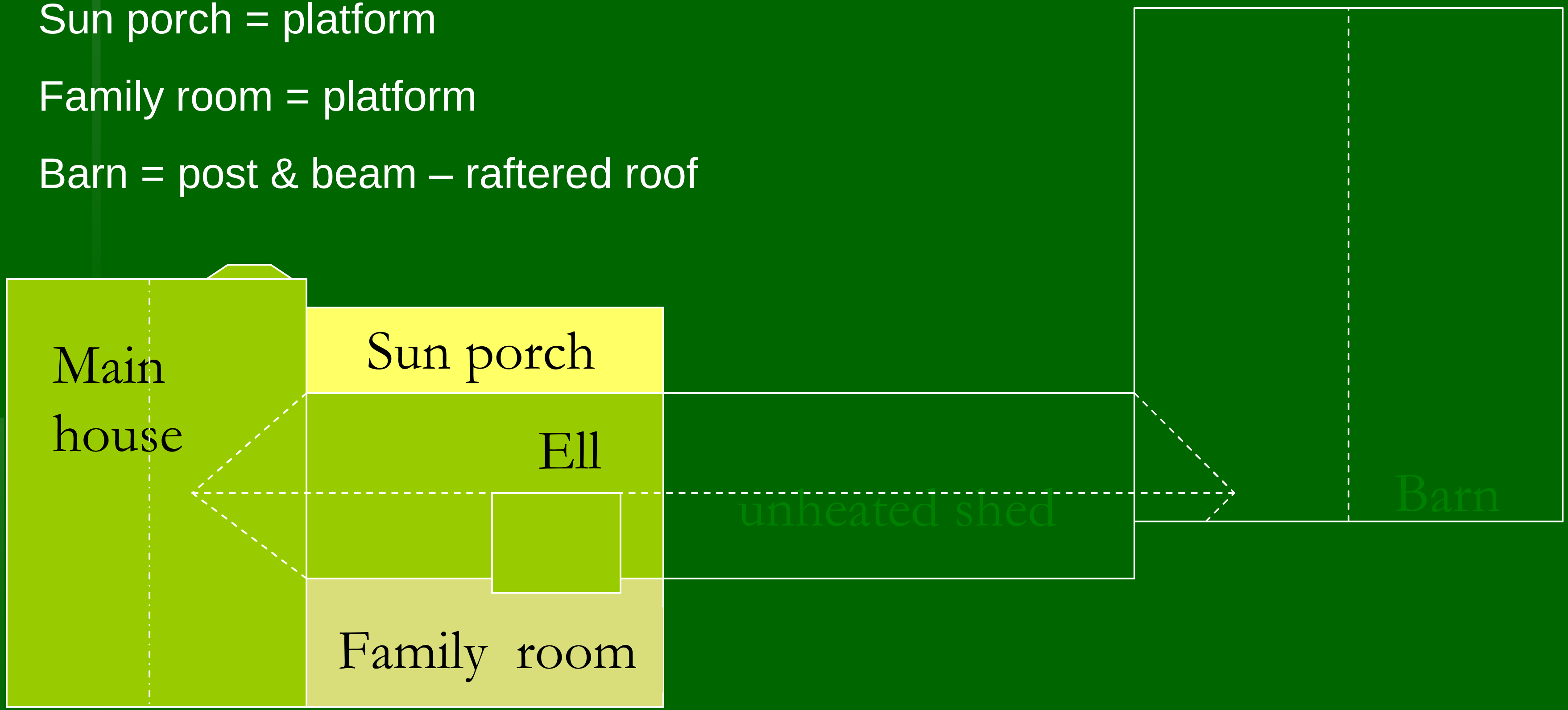
Ell (heated section) = balloon

Ell (unheated shed) = post & beam – raftered roof

Sun porch = platform

Family room = platform

Barn = post & beam – raftered roof



Manufactured housing

Construction details are very similar to platform.

The industry suffers from a “Bad Rep”.

In reality, because units are built in a factory under strictly controlled conditions quality is often higher than site built.

Surviving “road trips” requires strong wracking strength.

Modular design requires some “doubling up” of interior walls, further strengthening the final assembly.

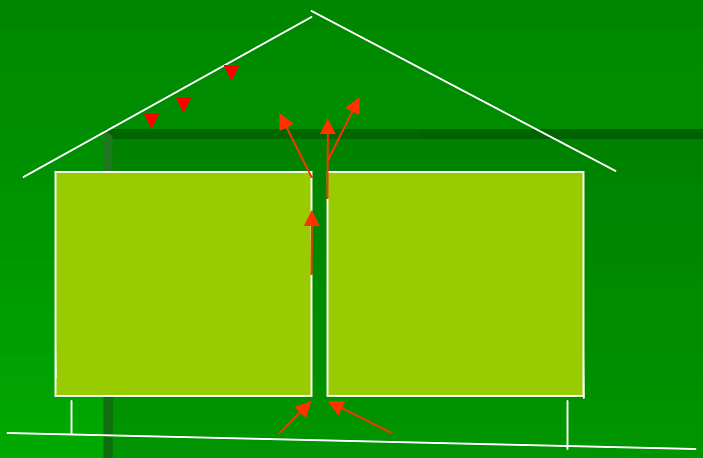
Manufactured housing

Downside…..

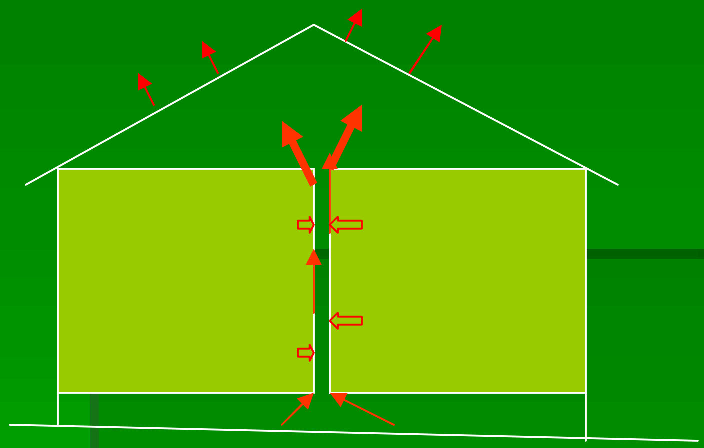
Because they are built in a factory & then brought to the sight they typically have “marriage walls” where the pre-built sections meet. (Think arranging railroad box cars side by side)

The space between the abutting walls is frequently open at the top & bottom allowing air to move freely between them from the basement to the attic.

Manufactured housing



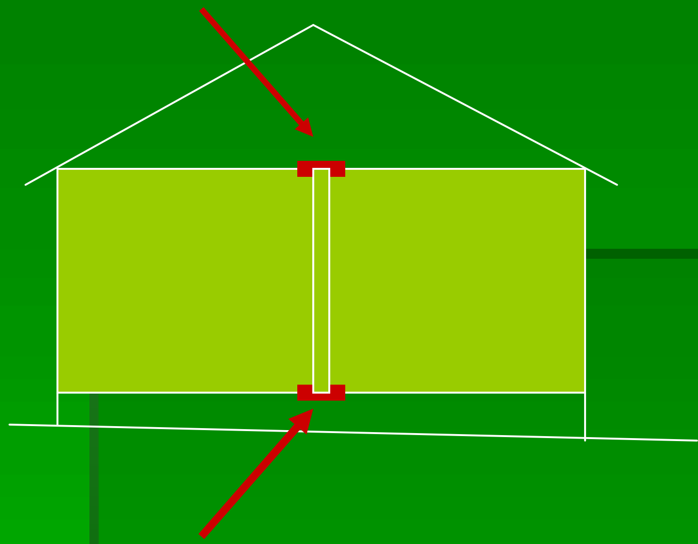
Stack effect moves air from the basement or crawl space to the attic, carrying moisture from below which will condense on the underside of the roof deck resulting in mold & rot.



Heat is also “scrubbed” from the walls as the air passes between them.

[Remember, Conductive heat loss = (A x ΔT x t)/R.]

If we allow unconditioned air to pass between the modules, we’re exposing interior walls to outside temperatures, vastly expanding the “A” in the formula & consequently the heat loss.



What’s the fix?

Carefully airsealing the top & bottom of the marriage wall is all it takes !

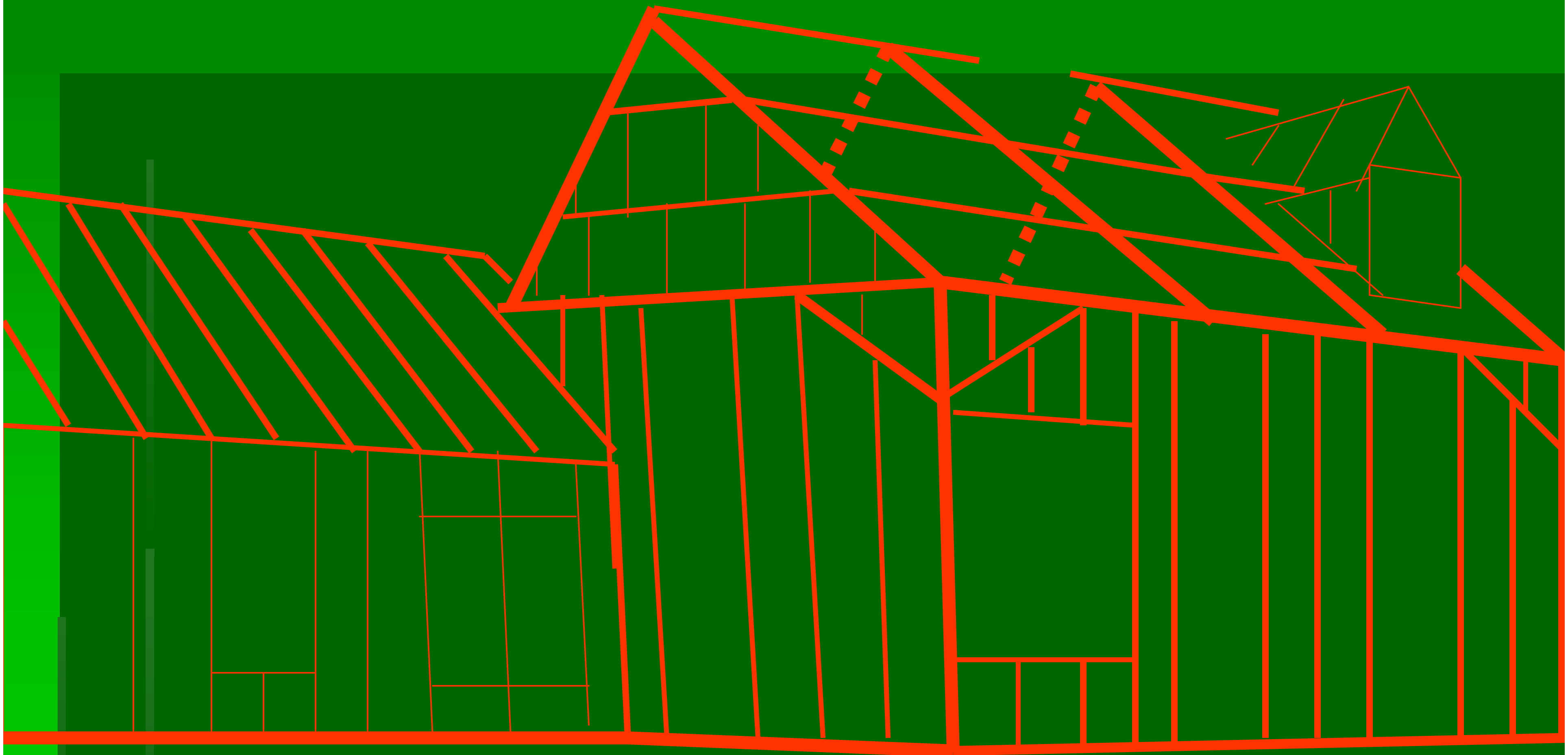
Construction details

- Why do we care?
- The building dictates how we address it !
  - Insulation products
  - Installer techniques

Appearances can be deceiving !

WHICH FRAMING TYPE IS IT ?

POST & BEAM



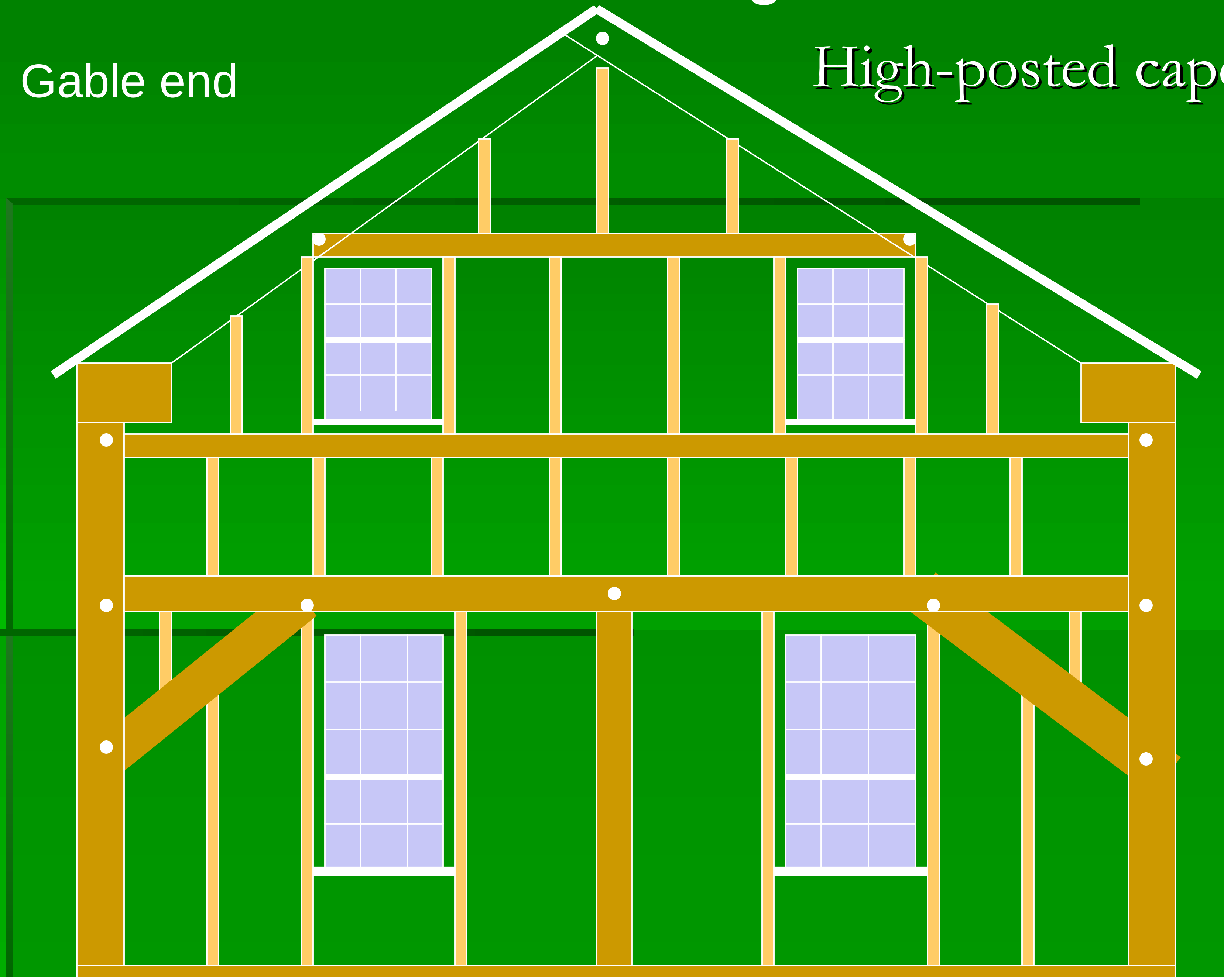
BALLOON

PLATFORM

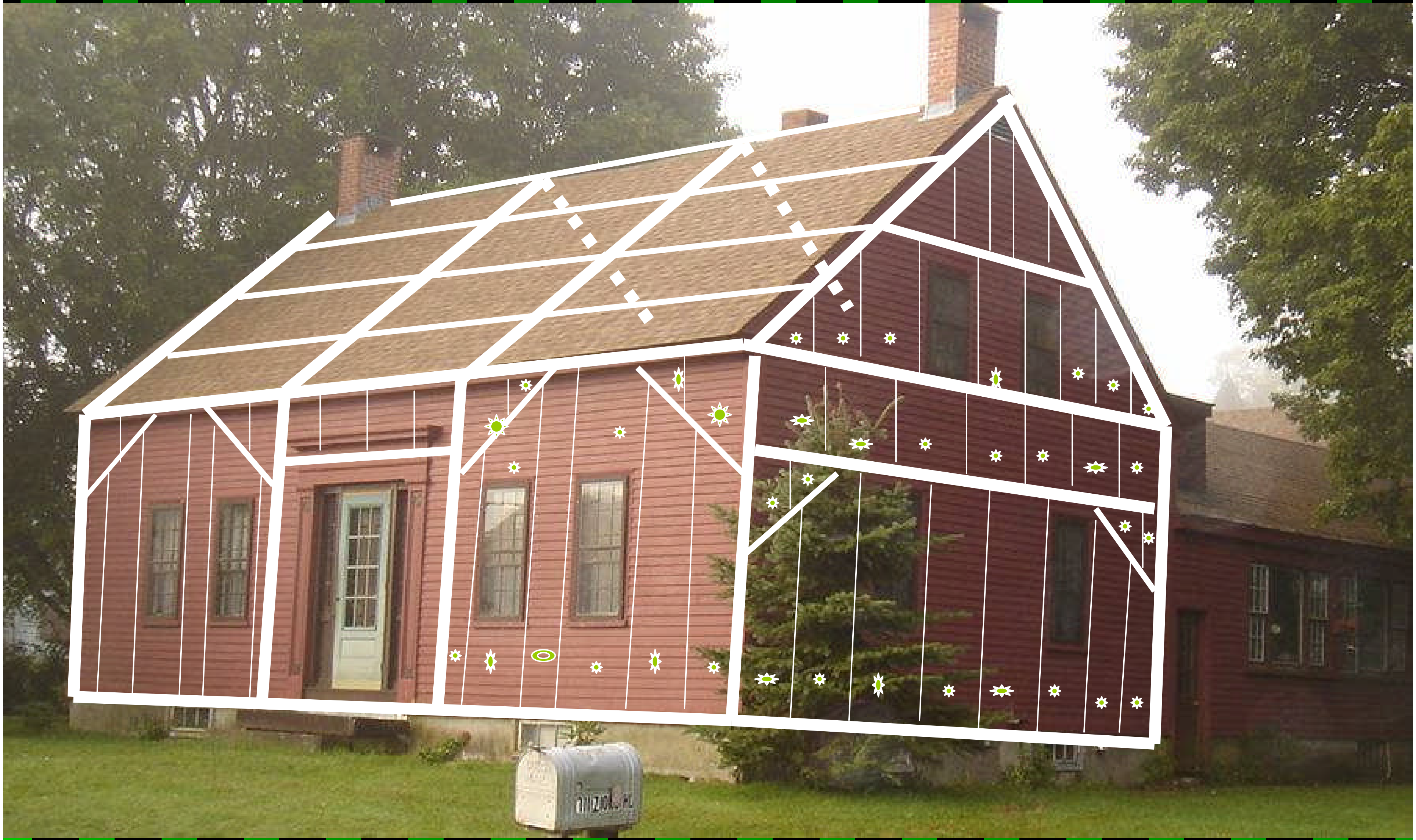
Auditor/Installer "tricks" by framing style

- Post & beam
- Balloon
- Platform
- Manufactured housing
- Mobile homes
- Special situations:
  - Cathedral ceilings
  - Amateur remuddles

Post & Beam wall framing details



Post & Beam drill pattern

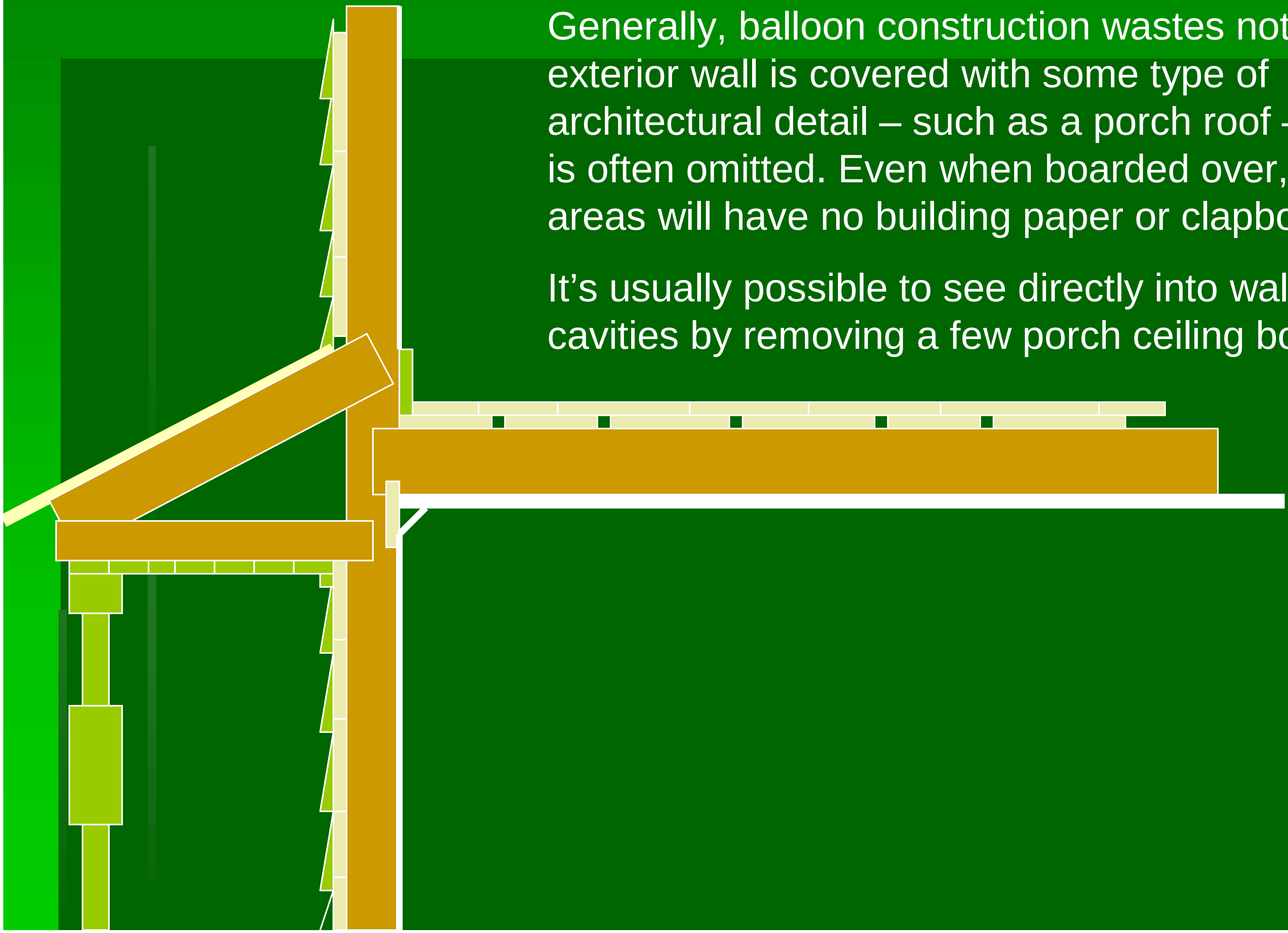


Balloon Framing

Because studs are arbitrarily placed wherever needed, all cavities must be probed left & right

Balloon Framing

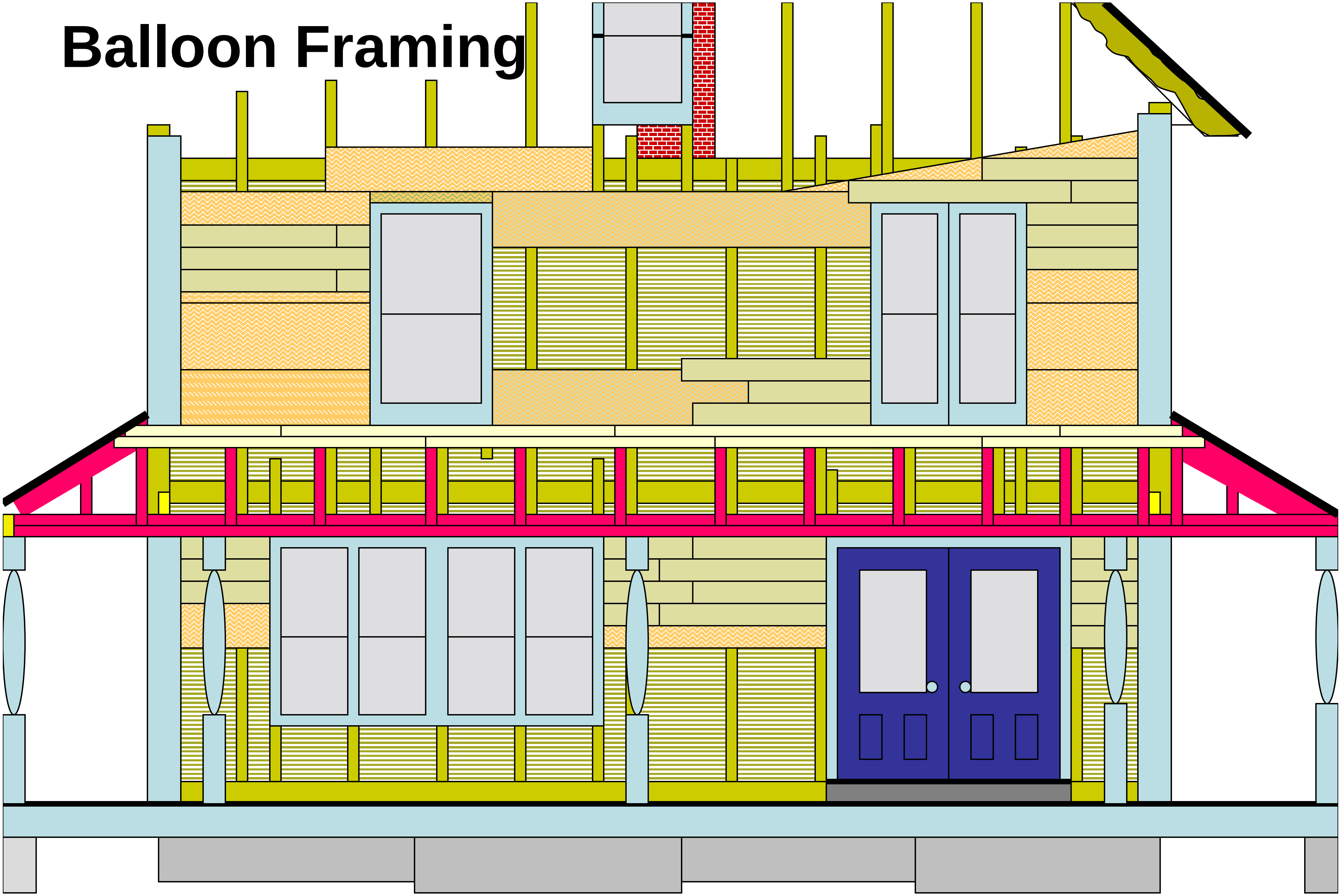
Typical porch or bay window detail



Generally, balloon construction wastes nothing. If an exterior wall is covered with some type of architectural detail – such as a porch roof – cladding is often omitted. Even when boarded over, these areas will have no building paper or clapboards.

It's usually possible to see directly into wall & floor cavities by removing a few porch ceiling boards.

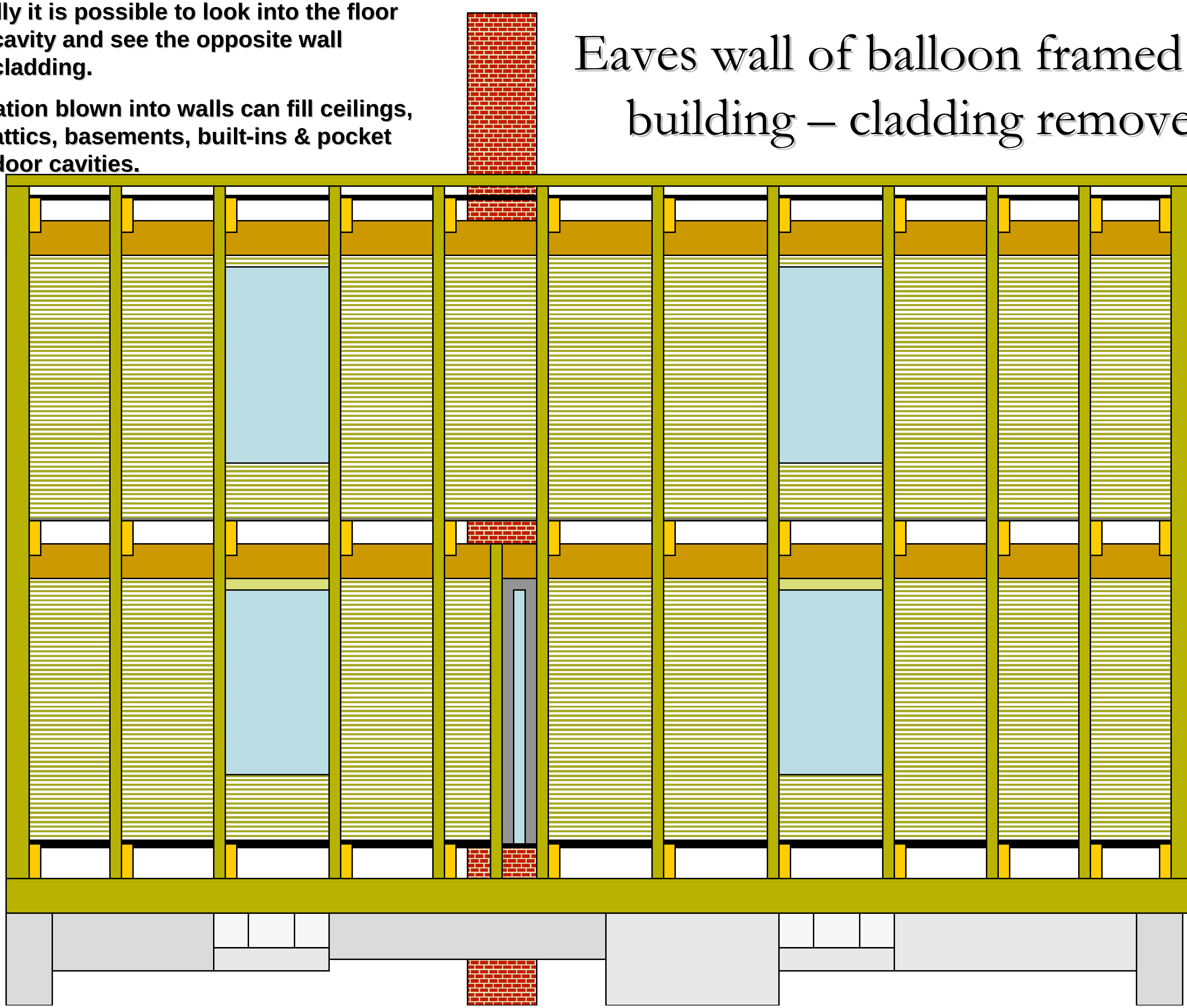
Balloon Framing



Air sealing walls over porches & bay windows is necessary.

Eaves wall of balloon framed building – cladding removed.

- Usually it is possible to look into the floor cavity and see the opposite wall cladding.
- Insulation blown into walls can fill ceilings, attics, basements, built-ins & pocket door cavities.



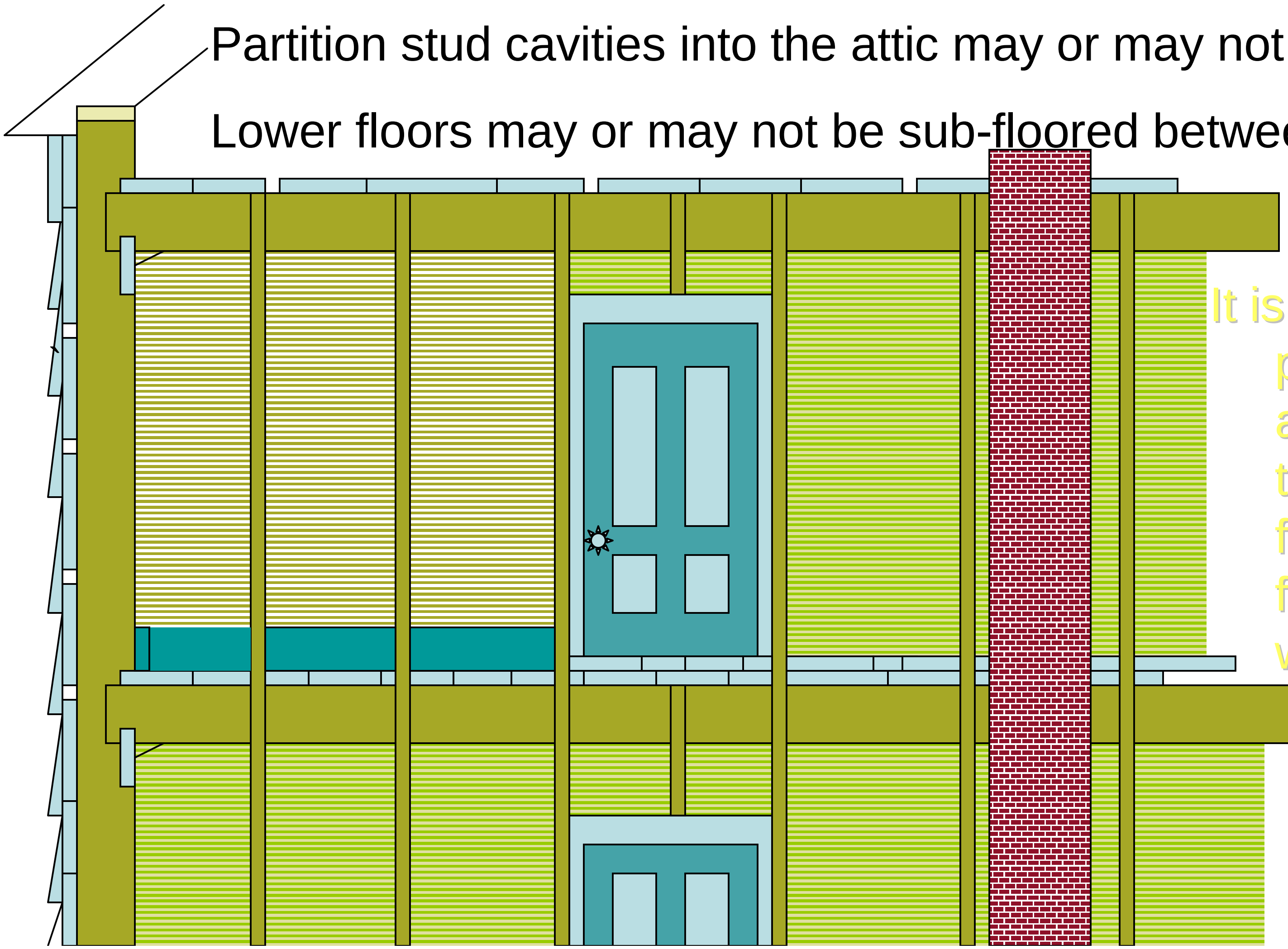
Balloon Framing – typical interior partition detail

Interior partitions generally align floor to floor.

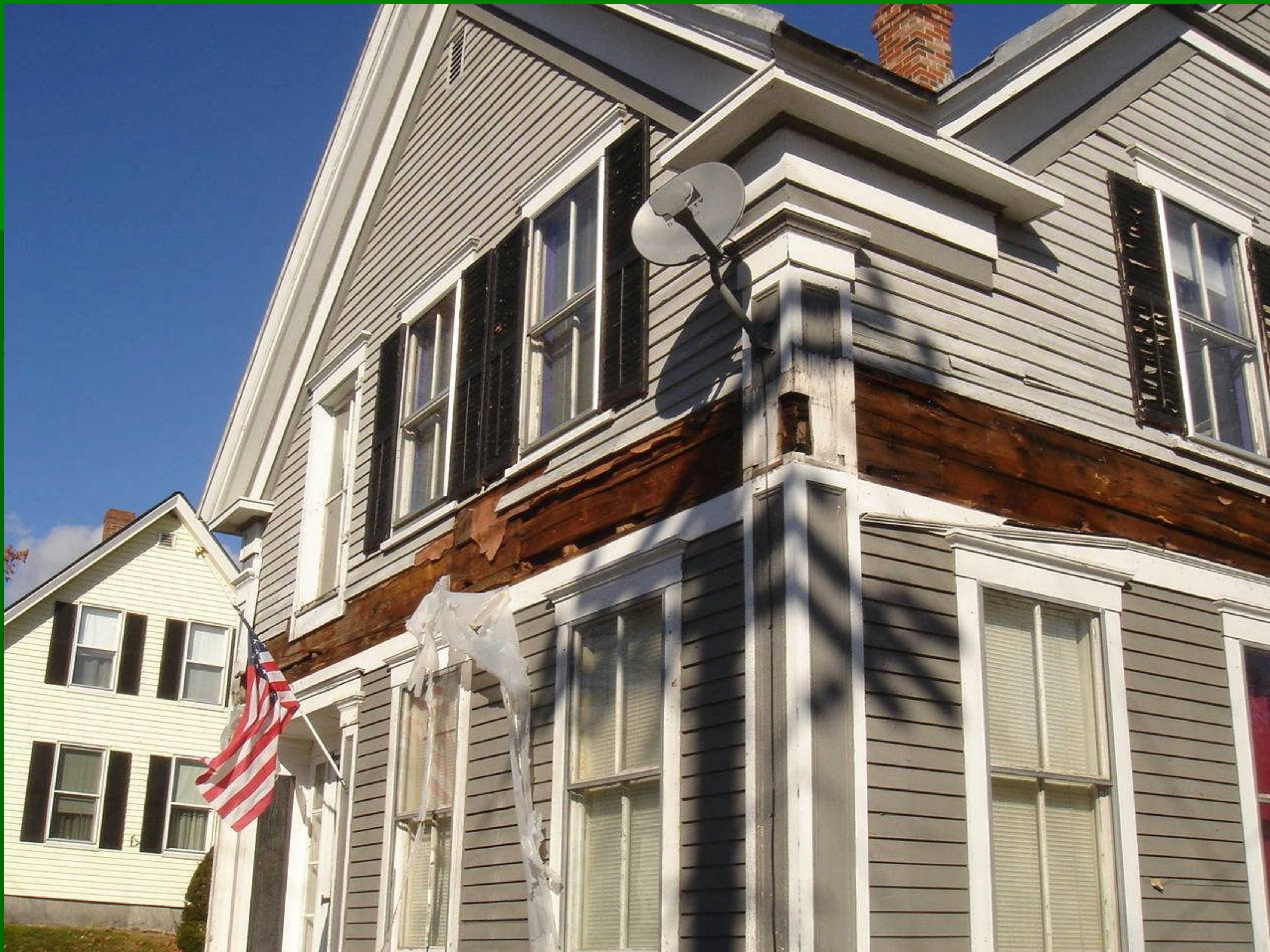
Partition studs are generally nailed to the sides of floor stringers.

Partition stud cavities into the attic may or may not be floored over.

Lower floors may or may not be sub-floored between partition studs.



It is generally possible to drop an object from the attic to the first floor sub-flooring in the wall cavities.



THE BAG TRICK !

All pictures taken through removed floor register

THE BAG TRICK !

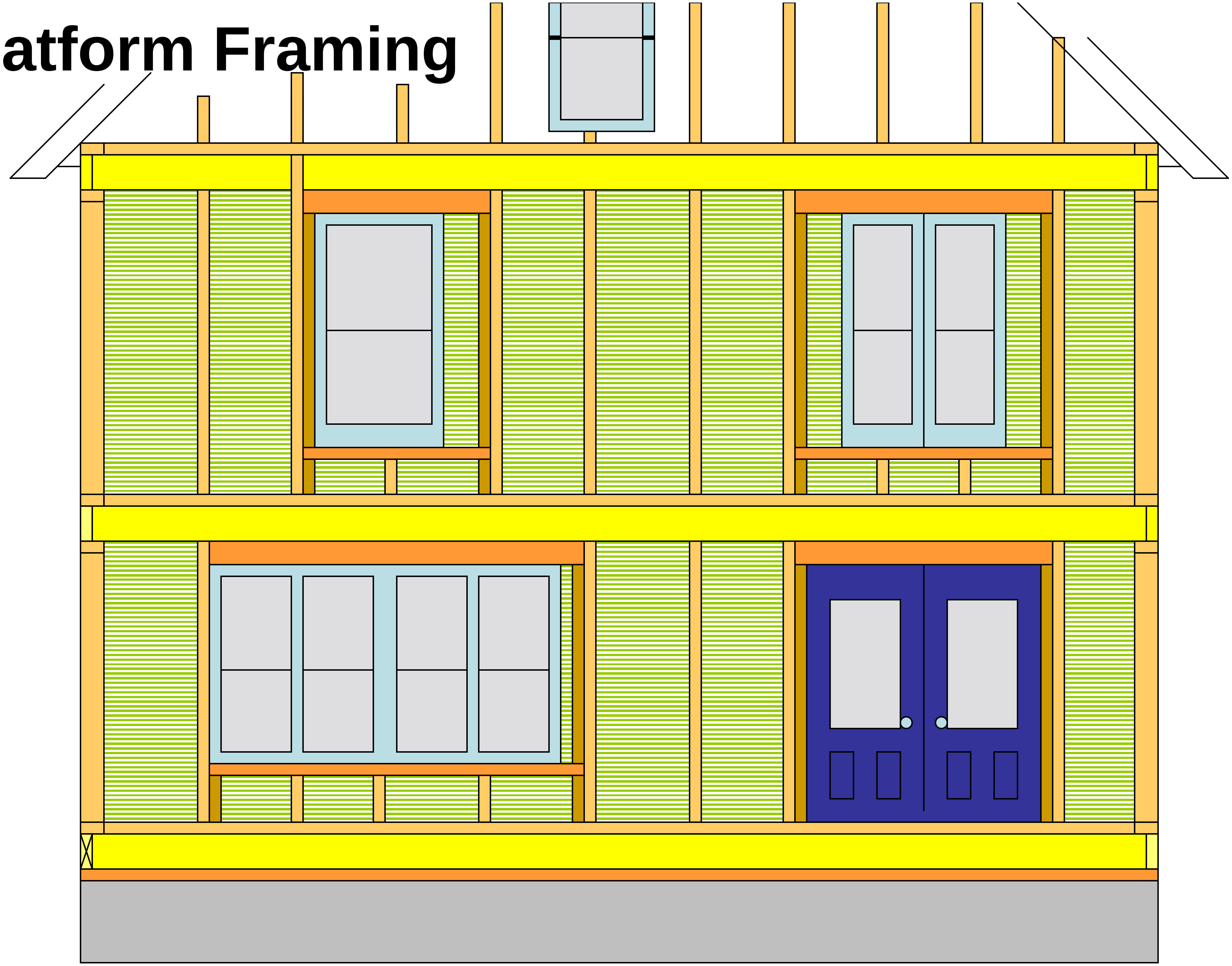
THE BAG TRICK !

THE BAG TRICK !

THE BAG TRICK !

THE BAG TRICK !

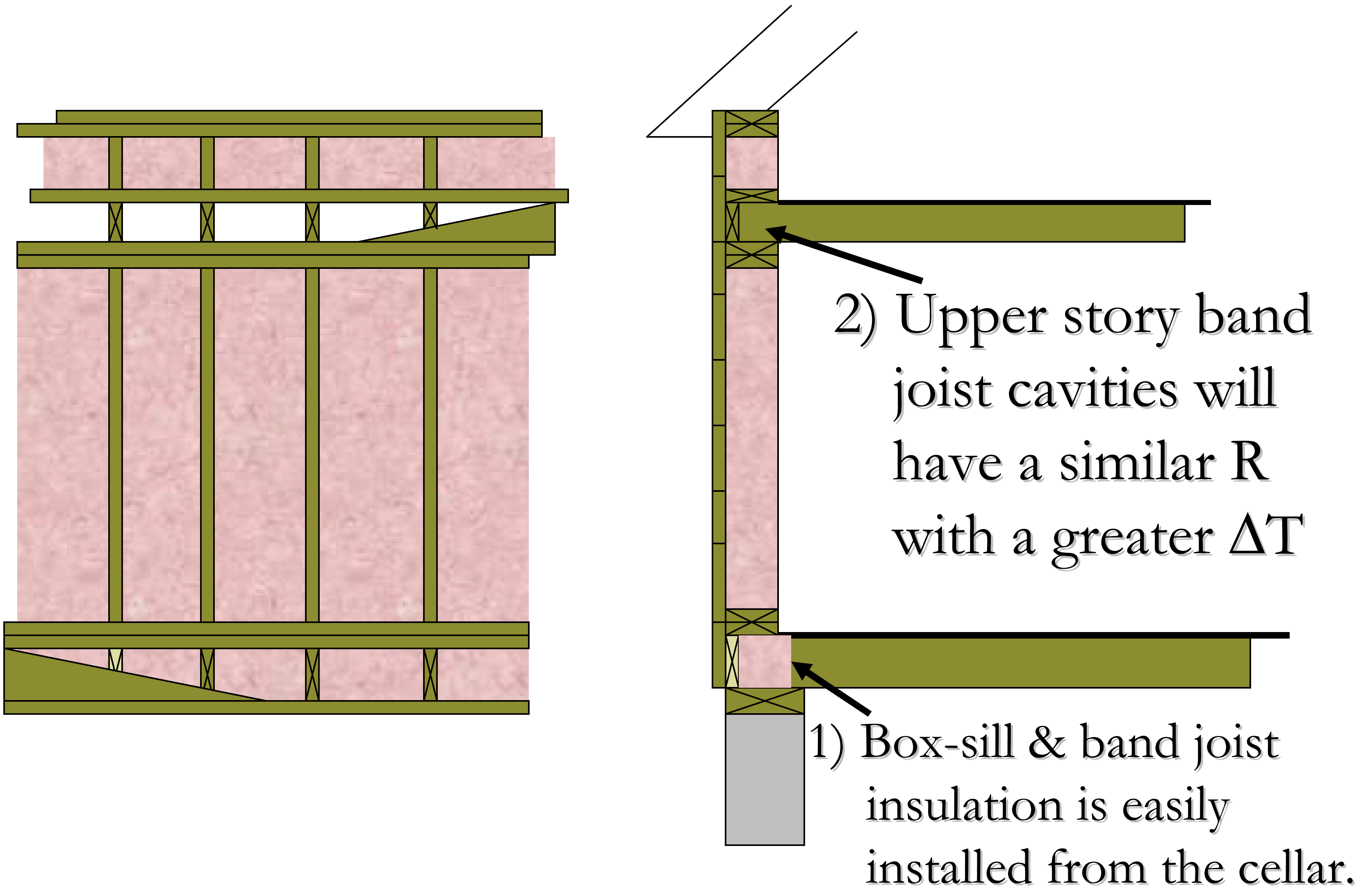
Platform Framing



Typical gable end details – Eve side similar

Platform Framing

Upper story band joist or box sill



Upper story band joist

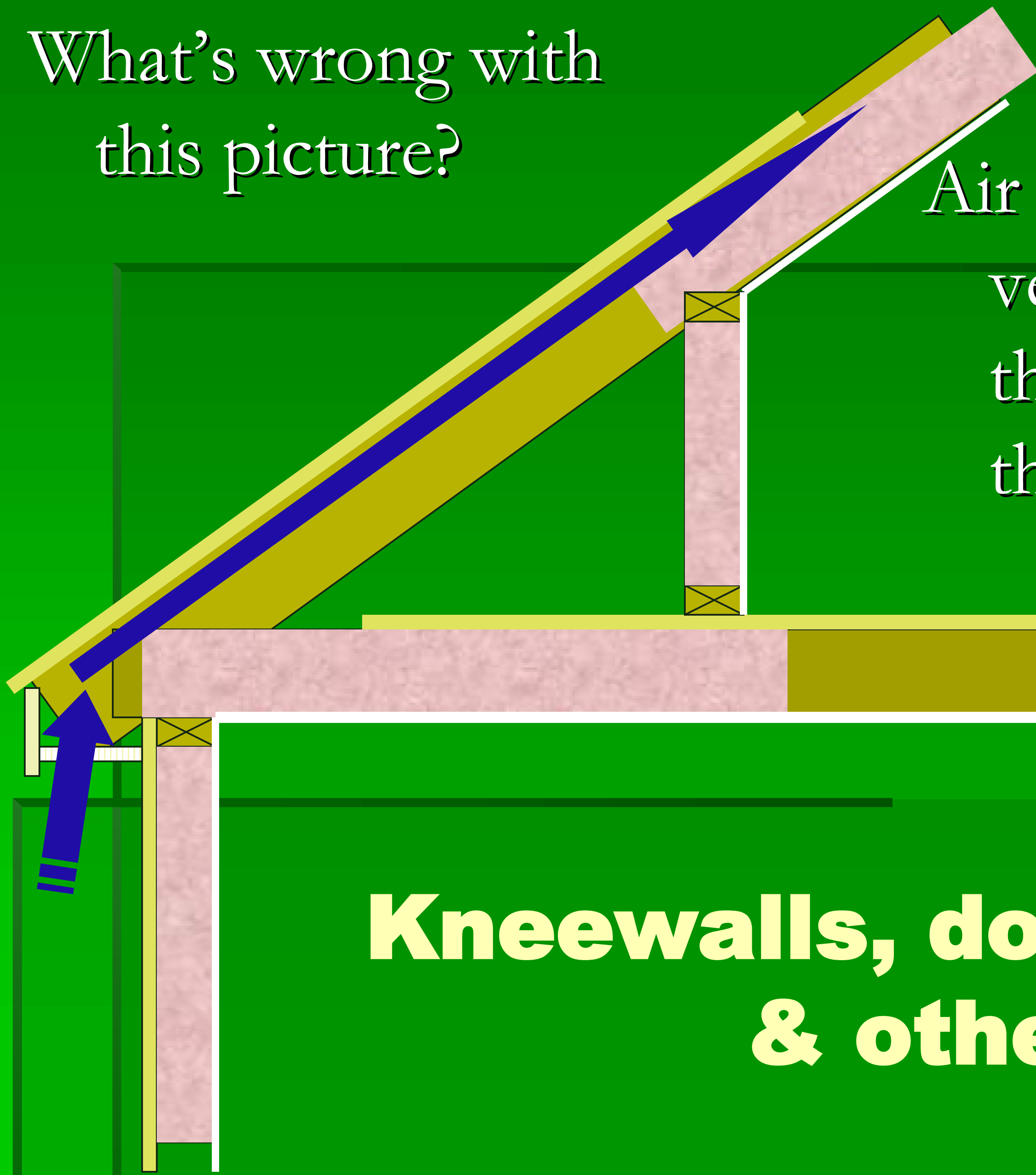
- 2” framing member, cladding & siding ≈ R-3
- Usually band joist “talks” to entire floor cavity
- Access to cavity is the key
  - Unzip siding
  - Remove baseboard or cove molding
  - Lift carpet or inlay
- Dam if possible
  - Bag trick
  - Run low air until bay blocks, then dense-pack
  - Two part foam

Mineral surface siding

- From the outside…
  - Grind a sharp edge onto a short 2” steel pipe.
  - Using pipe & mallet, cut circles through siding.
  - Drill cladding & blow
  - Glue circles in place with matching color silicone.
- If absolutely no exterior access
  - Drill inside behind molding, through casings, etc.
- Remember, every cavity has <u>six</u> sides.
- NEVER allow absorptive insulation to contact brick cladding!

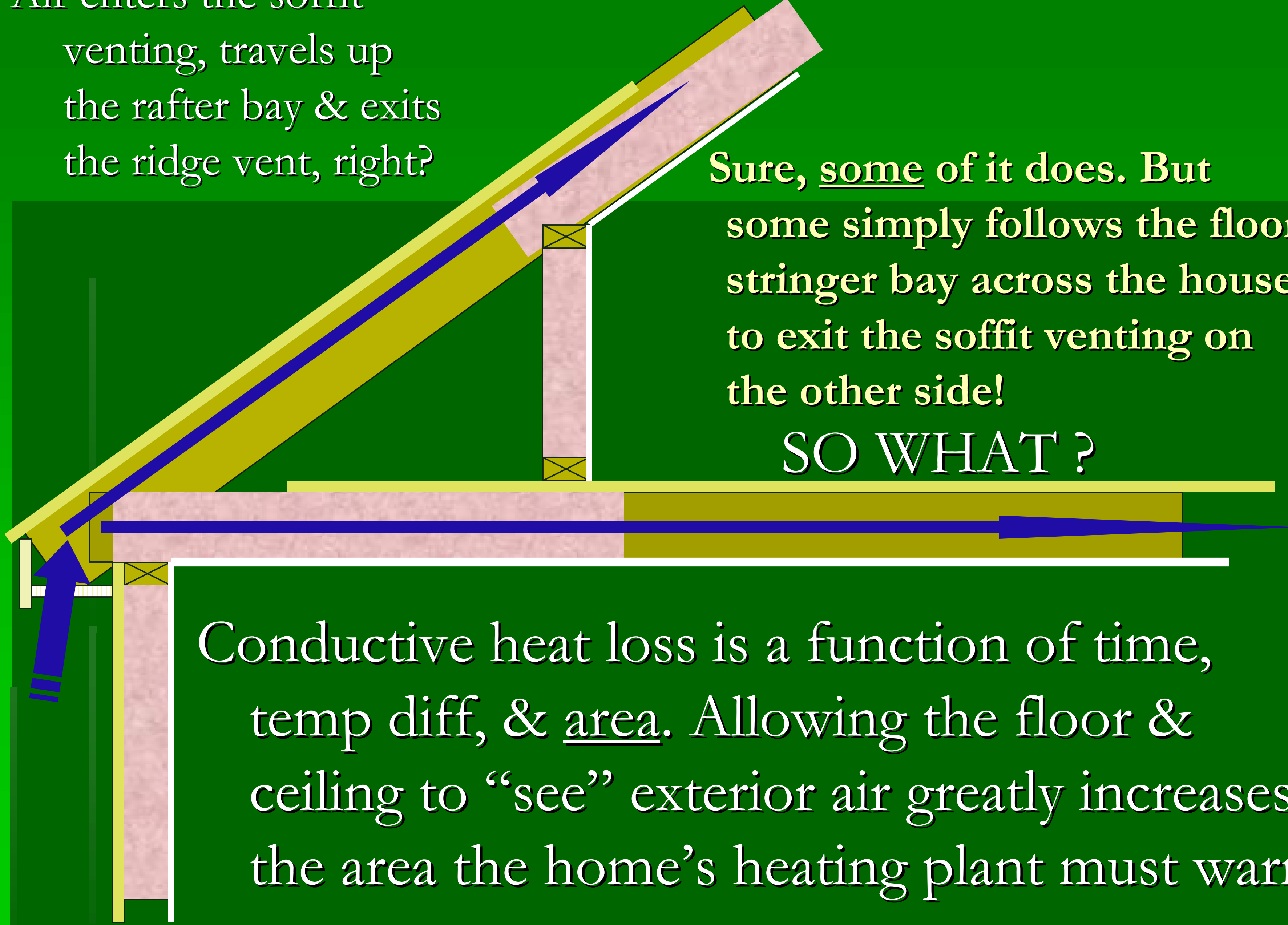
What's wrong with
this picture?

Air enters the soffit venting, travels up the rafter bay & exits the ridge vent, right?



Kneewalls, dormers & other fun stuff!

Air enters the soffit venting, travels up the rafter bay & exits the ridge vent, right?

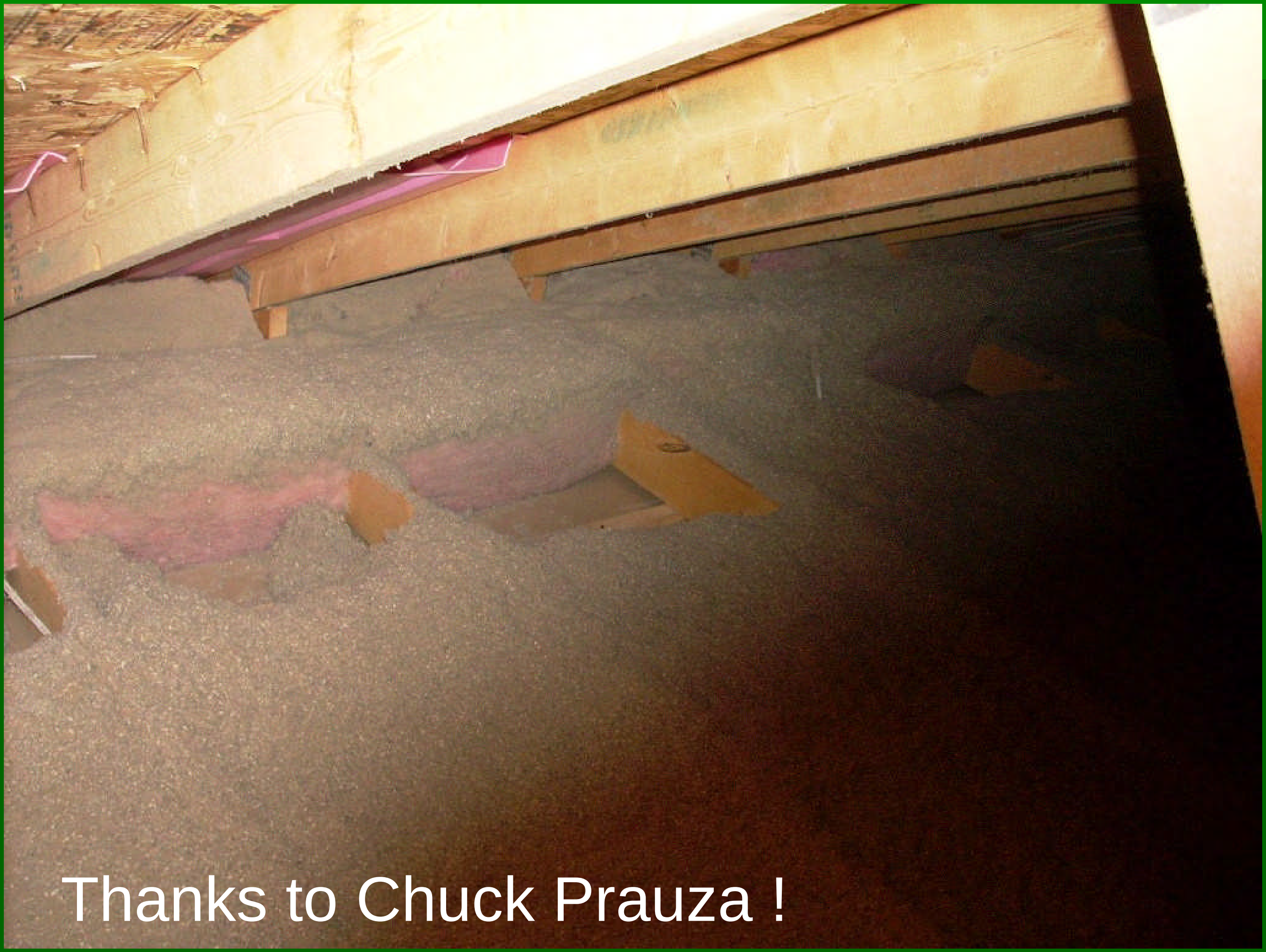


Sure, some of it does. But some simply follows the floor stringer bay across the house to exit the soffit venting on the other side!

SO WHAT ?

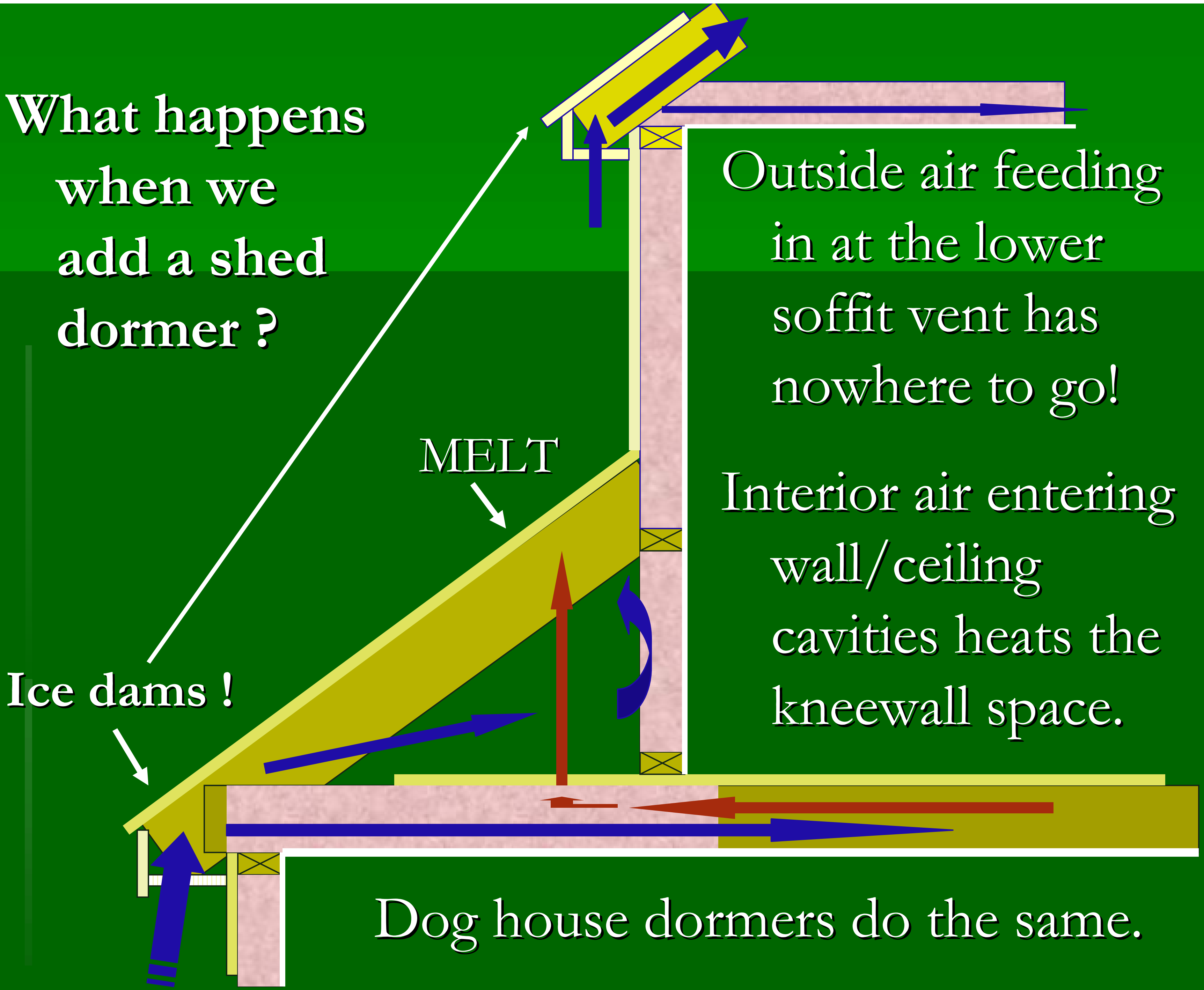
Conductive heat loss is a function of time, temp diff, & area. Allowing the floor & ceiling to "see" exterior air greatly increases the area the home's heating plant must warm.

Seeing is believing!




That's not all !
Houses have chimneys !
(& vent pipes & wires & etc.)
Heated air from the basement or other openings into the floor cavity rises up & out.

What happens when we add a shed dormer ?



Outside air feeding in at the lower soffit vent has nowhere to go!

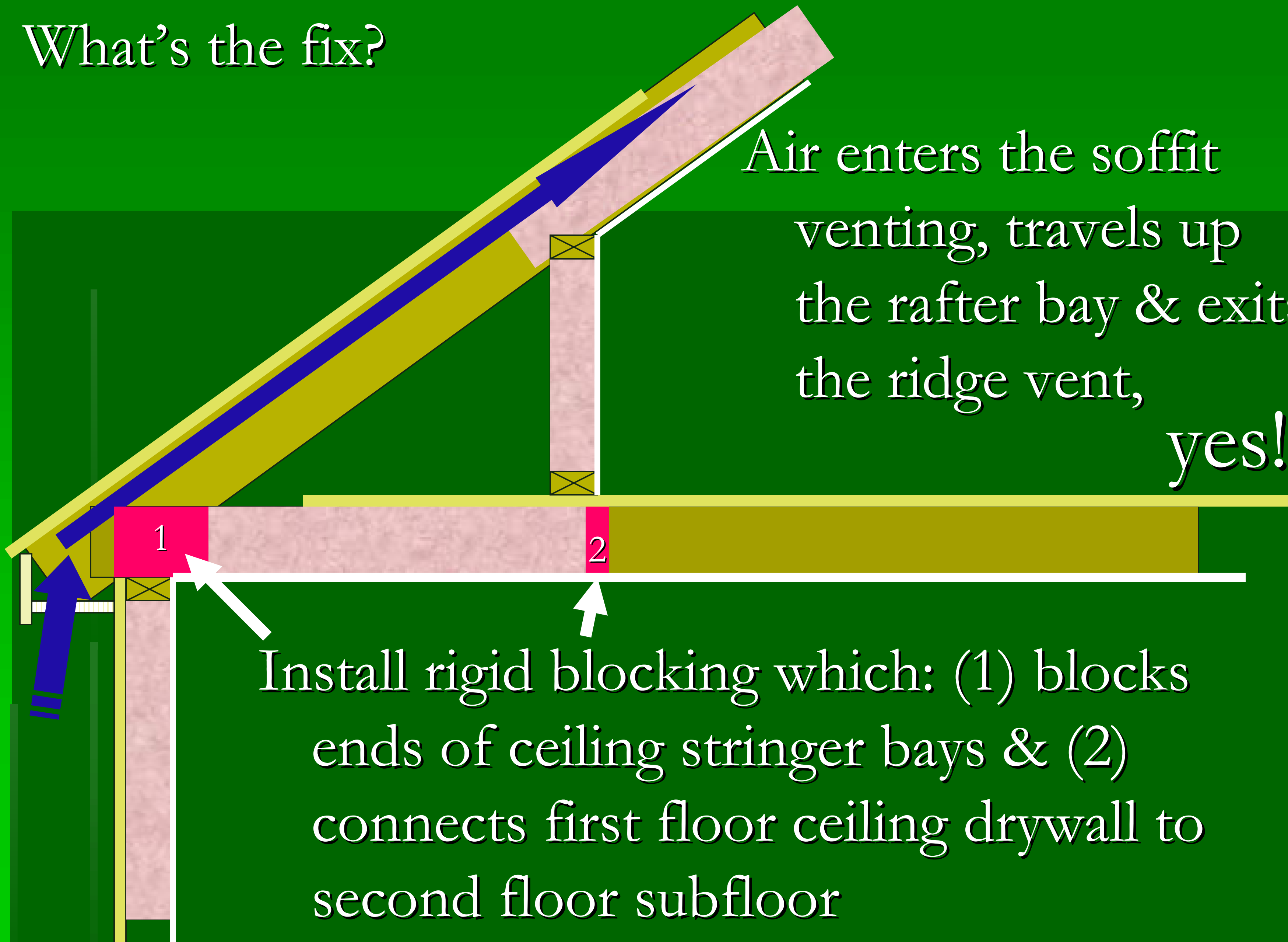
Interior air entering wall/ceiling cavities heats the kneewall space.

Dog house dormers do the same.

What's the fix?

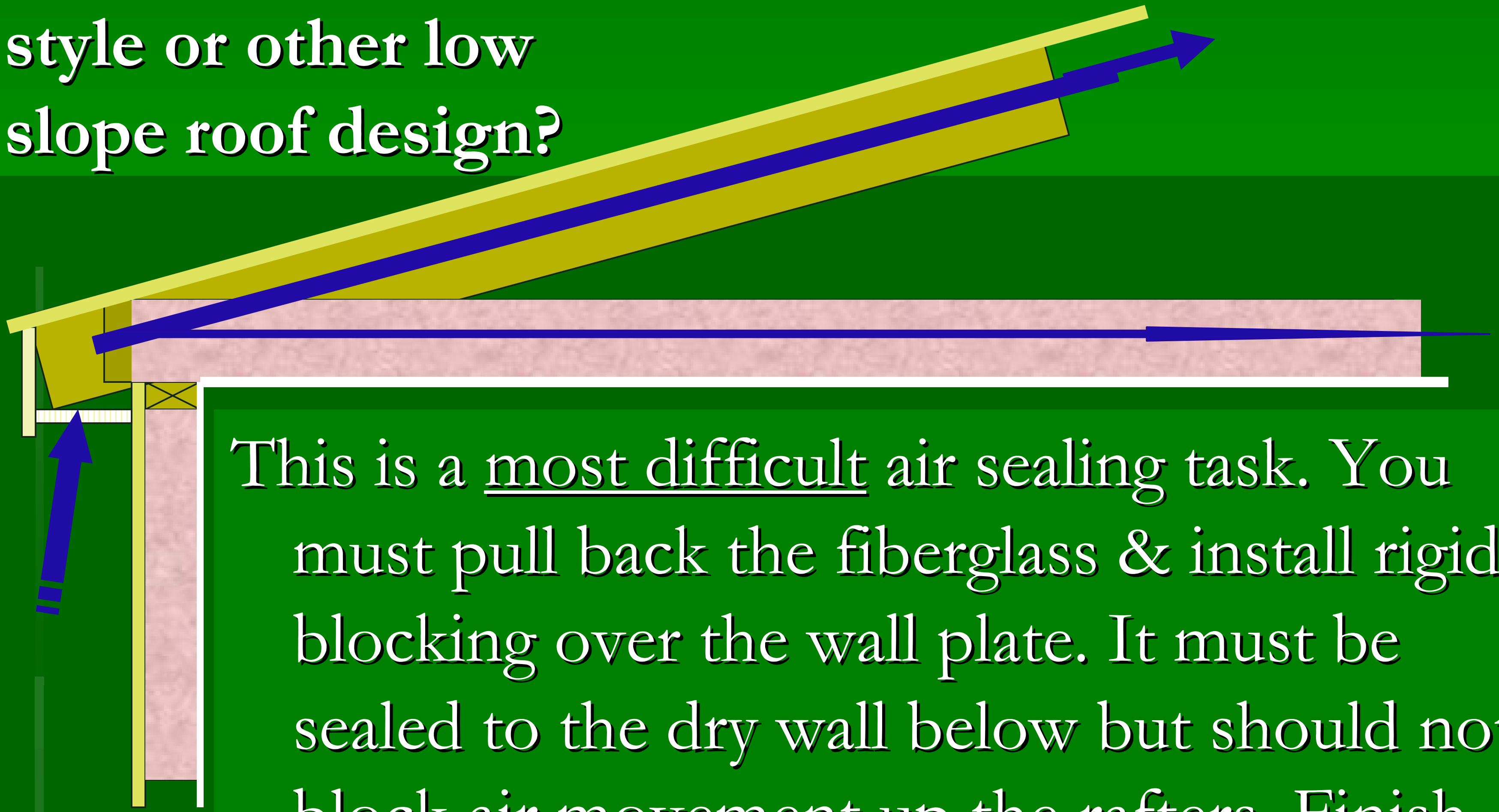
Air enters the soffit venting, travels up the rafter bay & exits the ridge vent,

yes!



Install rigid blocking which: (1) blocks ends of ceiling stringer bays & (2) connects first floor ceiling drywall to second floor subfloor

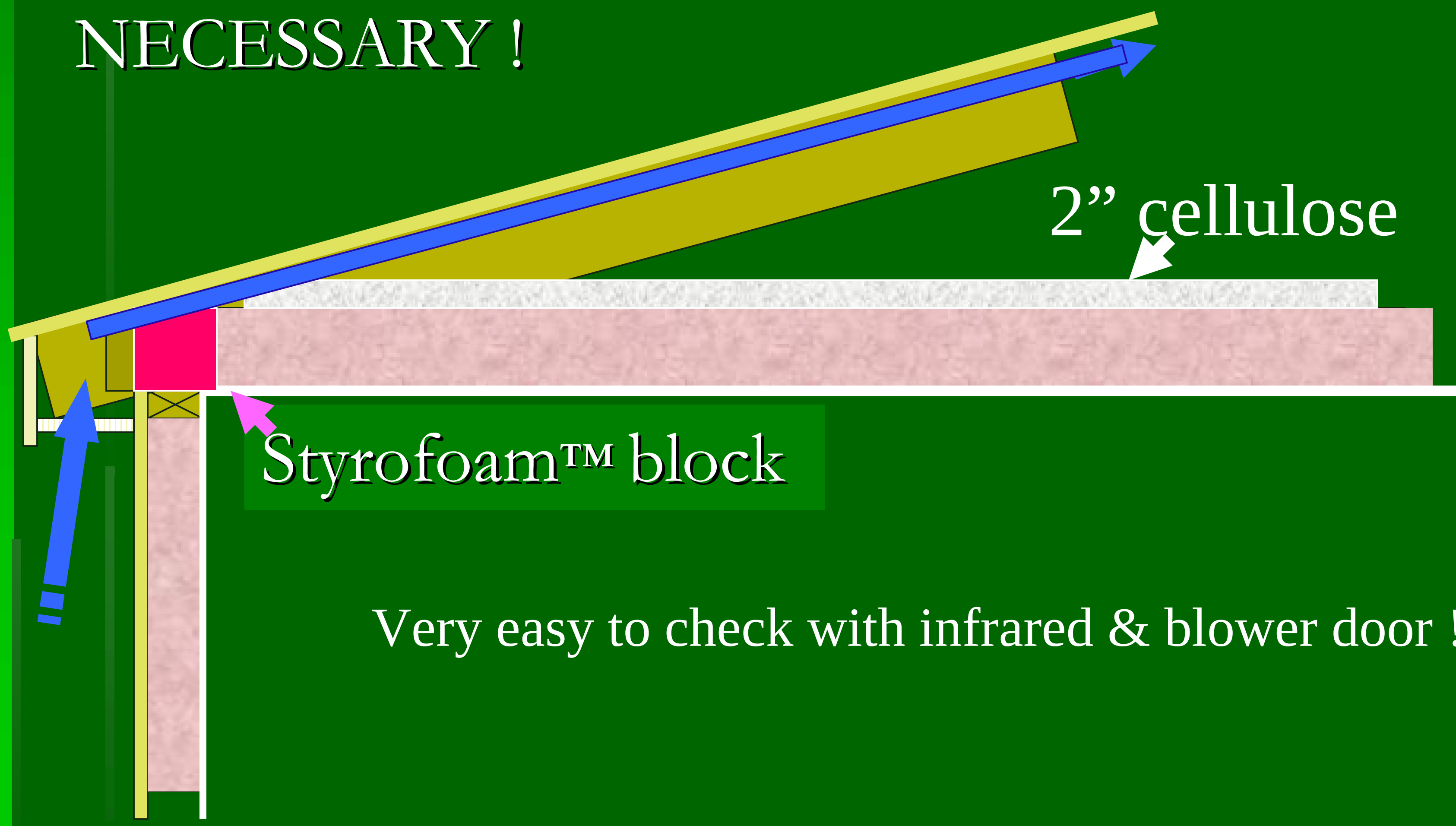
How about a ranch style or other low slope roof design?



This is a <u>most difficult</u> air sealing task. You must pull back the fiberglass & install rigid blocking over the wall plate. It must be sealed to the dry wall below but should not block air movement up the rafters. Finish by blowing ≈ 2" cellulose over all to prevent wind-washing.

Very difficult…

VERY
NECESSARY !

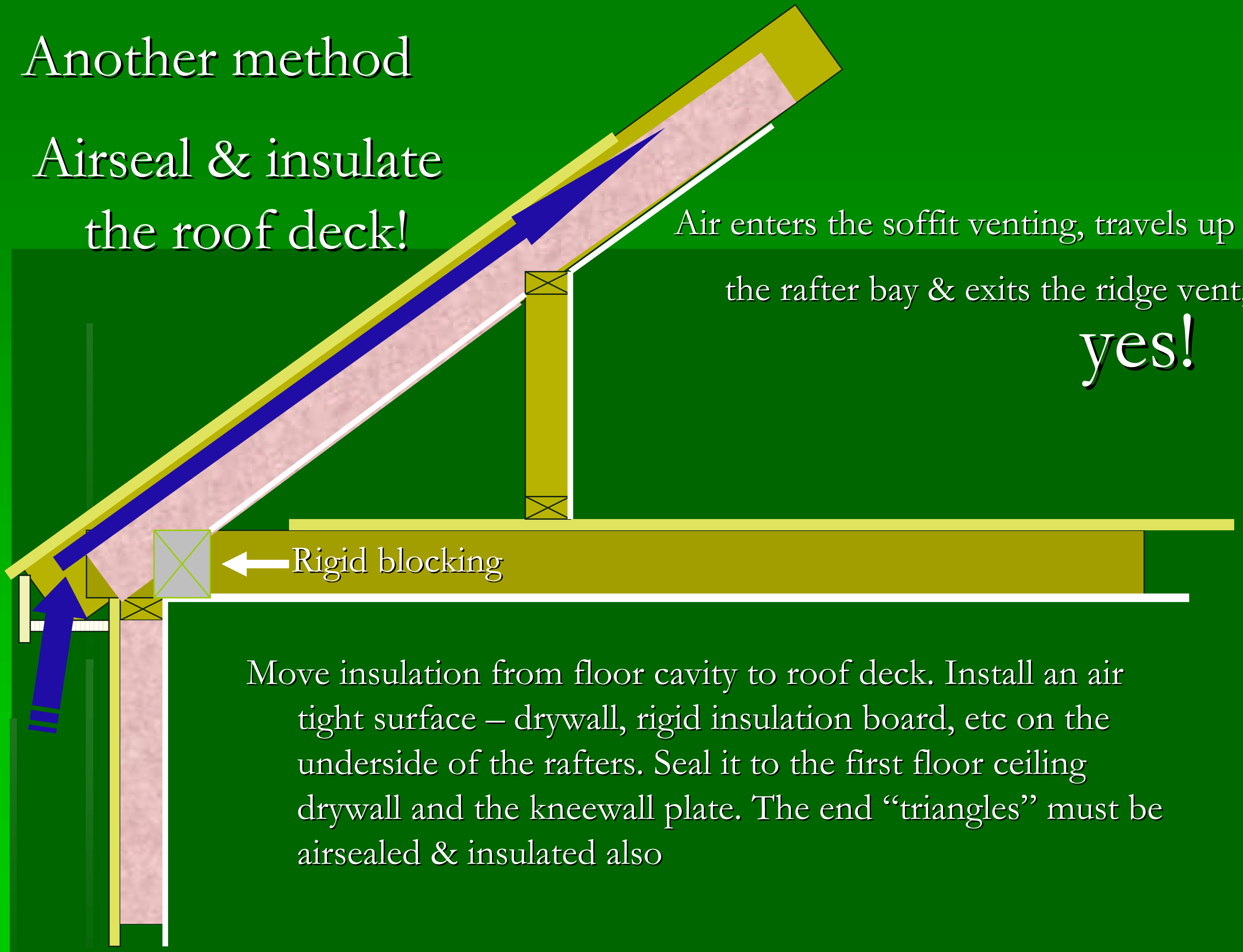


Very easy to check with infrared & blower door !

Tight fit !

Another method

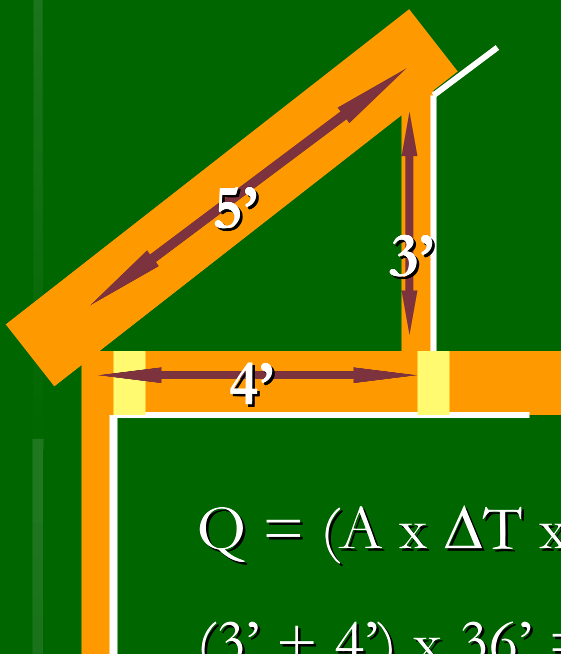
Airseal & insulate the roof deck!



Move insulation from floor cavity to roof deck. Install an air tight surface – drywall, rigid insulation board, etc on the underside of the rafters. Seal it to the first floor ceiling drywall and the kneewall plate. The end "triangles" must be airsealed & insulated also

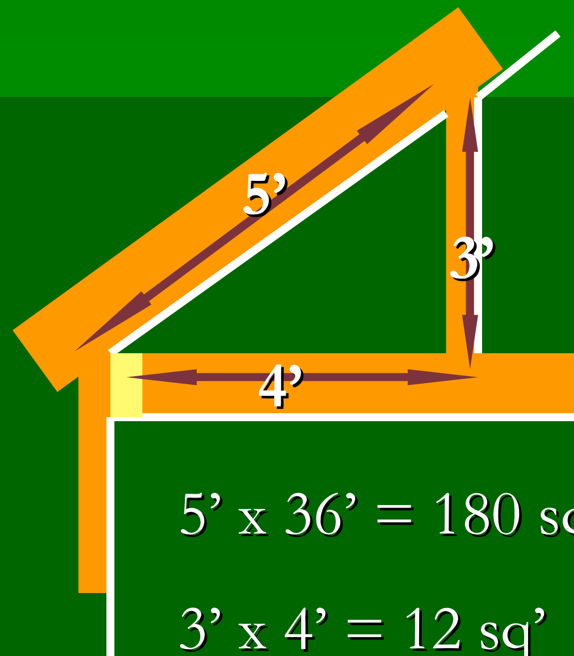
Which is preferred?

24’ x 36’ Cape



Q = (A x ΔT x t)/R

(3’ + 4’) x 36’ = 252 sq’



5’ x 36’ = 180 sq’

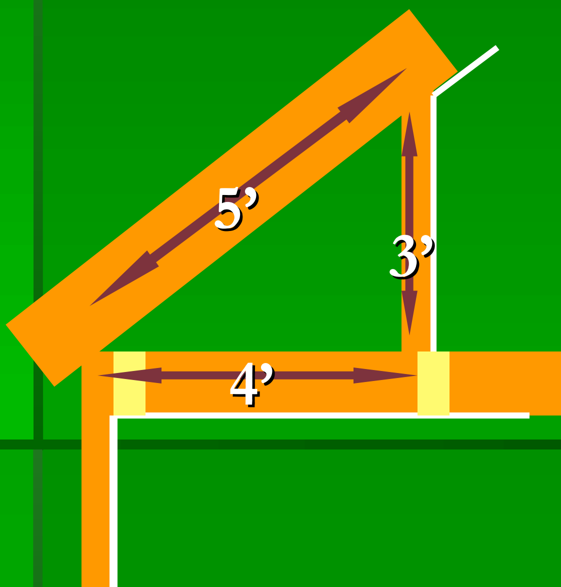
3’ x 4’ = 12 sq’

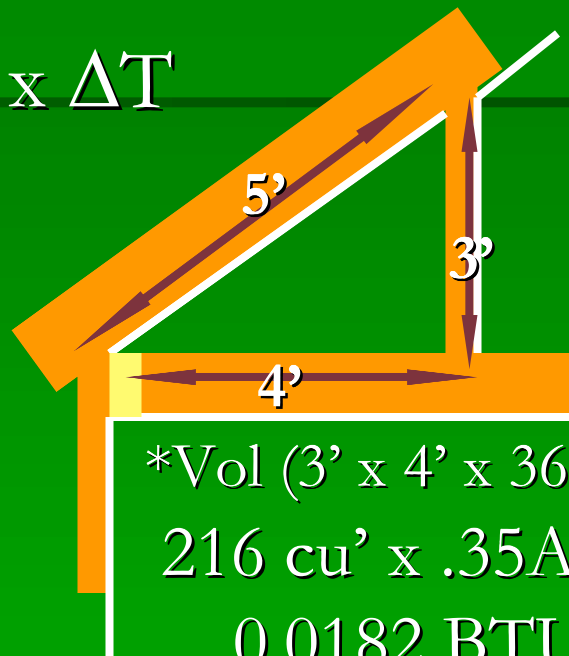
Total = 192 sq’

The conductive heat loss will be about 20% less doing the slope.

What about air transported heat loss?

$$*\text{Vol} \times \frac{\text{AC}}{\text{H}} \times \frac{0.0182\ \text{BTU}}{\text{sq'},\ ^\circ\text{F}} \times \Delta T$$





*Vol (3’ x 4’ x 36’)/2 = 216 cu’

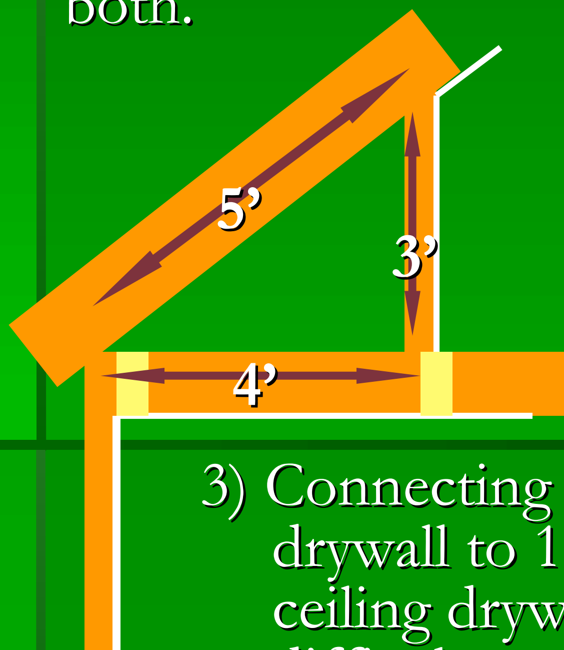
216 cu’ x .35ACH x
0.0182 BTU/sq’,hr x
7500 HDD x 24 hrs =
238,000 BTU/year

Given equal quality airsealing, the air transported heat loss attributable to the enlarged volume will be about $11/yr.

So…Which is preferred?

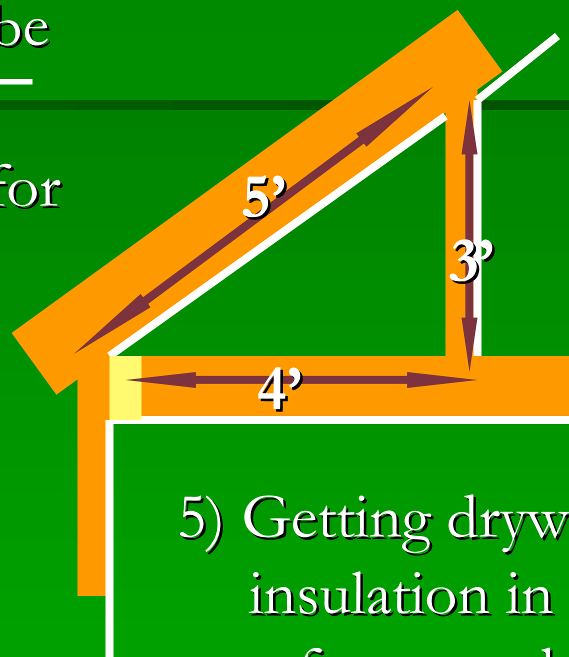
1) Insulation & air barrier must be in contact.

2) Blocking at eaves is required for both.



3) Connecting kneewall drywall to 1st floor ceiling drywall often difficult.

4) Kneewall insulation voids are common

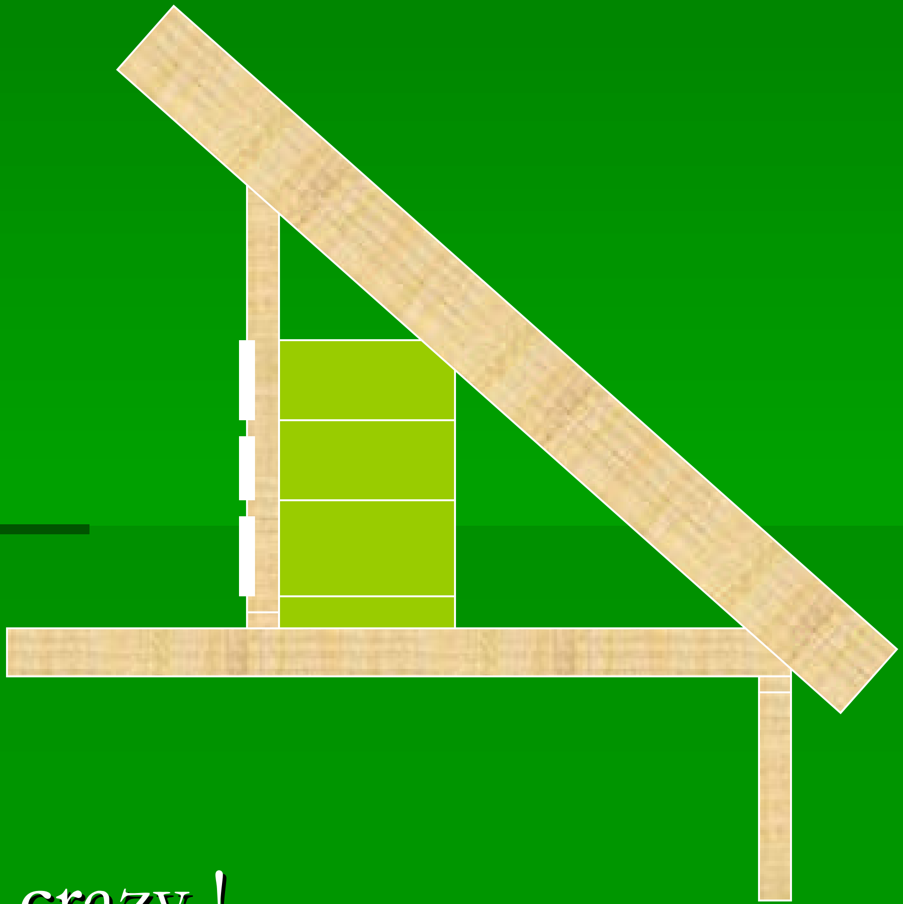


5) Getting drywall or rigid insulation in place on rafters may be difficult.

It Depends !

6) Pick the most advantageous method in each house.

Another consideration



Built-ins can make you crazy !

Built-ins can make your life miserable !

- Bureaus, cubbies recessed into knee walls
- Medicine cabinets
- Fold out ironing boards
- Dumbwaiters
- Heat ducts
- Plumbing chases
- Folding attic stairs

The “Coffin”

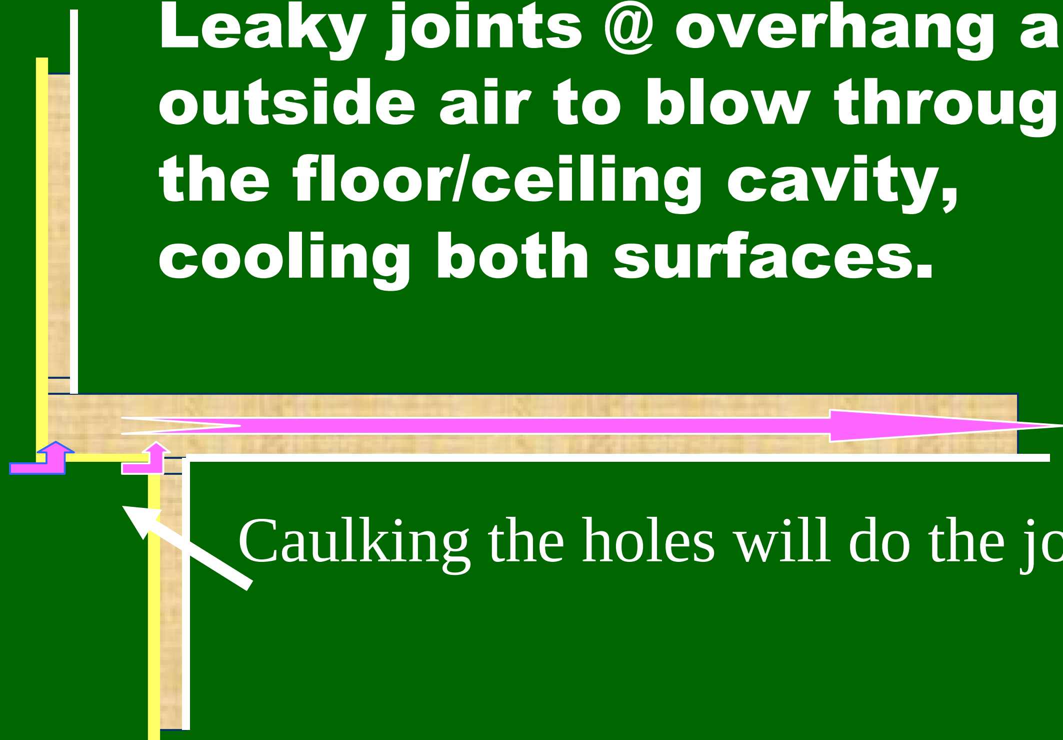
The Coffin

- Sides airsealed to the ceiling
- Collar of 1” x 3” at top for rigidity
- ¾” plywood lid, hinged & counterweighted
- Two layers of 2” polystyrene board

What's the problem? How do we deal with it?

Garrison style

Leaky joints @ overhang allow outside air to blow through the floor/ceiling cavity, cooling both surfaces.



Caulking the holes will do the job.

Window types

- Least to most air tight:
  1. Double Hung
  2. Single hung
  3. Casement – hopper – awning
  4. Fixed

Treatments

- Storm windows
- Weatherstrips
- Caulking
- Unit replacement

Window replacement ?

- There are many good reasons to replace windows:
  - Esthetics
  - Convenience
  - Lead paint mitigation
  - Noise reduction
- Generally speaking, replacing them can not be justified as an energy conservation measure.
  - Cost vs. savings

2'- 6" x 4' DH window & storm

- 10 square feet @ R-2
- $\frac{10\ sq' \times 7200HDD \times 24hrs}{2}$ = 864,000 BTU/yr

  Install R-5 window @ $300
- $\frac{10\ sq' \times 7200HDD \times 24hrs}{5}$ = 345,000 BTU/yr
- Savings = 864,000 BTU/yr - 345,000 BTU/yr = 619,000BTU/yr ≈ 6 gallons #2 x $4.00gal = $24/window/yr = 12.5 yr simple payback.
- 15 yr window life = 1.2 SIR

Multi-Family Weatherization

- Insulate & airseal attics.
- Insulate walls.
- Minimize stack effect.
- Evaluate indoor air quality.

Multi family structures

- Energy movement in big buildings is more driven by building height than any other factor.
- ASHRAE codes & texts generally segregate building treatments at three stories.
- Stack effect.
- Air handlers.
- Typical multi family designs.
- Impact on air quality & energy conservation.

Air sealing

- Blower door basics
- Attic hatches
- Chimney chases
- Plumbing chases
- Wire penetrations
- Basement bulkheads
- Perimeter wrap
- Spray foam

The Blower Door

- A blower door very accurately measures the size of total hole in the envelope.
- With multiple tests @ varying pressures a BD can <u>*guess at*</u> the type of hole.
  - Clean vs. ragged edges
  - Big/round vs. long/narrow
  - Tunnel through depth vs. thin material
- Multiple tests establish the slope of the line – the flow exponent – which is *assumed* to be .65 with a 50 PA BD test

Blower Door test

- House in “winter condition”
  - Exterior windows & doors closed
  - Interior doors open
- “Zero” gauges
- Bring pressure (gradually) to 50 PA
- Read CFM @ 50 PA (CFM50)
- If > 50PA remove ring(s)
- If > 50 w open fan, use “can’t reach 50” chart
- Get CFM50 with cellar door open & shut

Find & seal those leaks!

- Set the door at 30PA. (some use 50PA)
- Walk through the house looking for leaks
  - Two finger test
  - Smoke
  - Cobwebs
- Note problem areas
- Determine airsealing methods

At the top…& at the bottom

- Fold- down attic stair
- Insulated cover
- Weatherstrip

•Sandwich door with weatherstrip

•Wall drape sealed at bottom

•Box sill insulation

Perimeter wrap & box sill insulation

Bulkheads

Bulkhead door, foam caulk, box sill

Perimeter wrap & ground cover

Spraying two-part foam

Perimeter wrap & bulkhead

Perimeter wrap & ground cover

Hatch under construction

Hatches

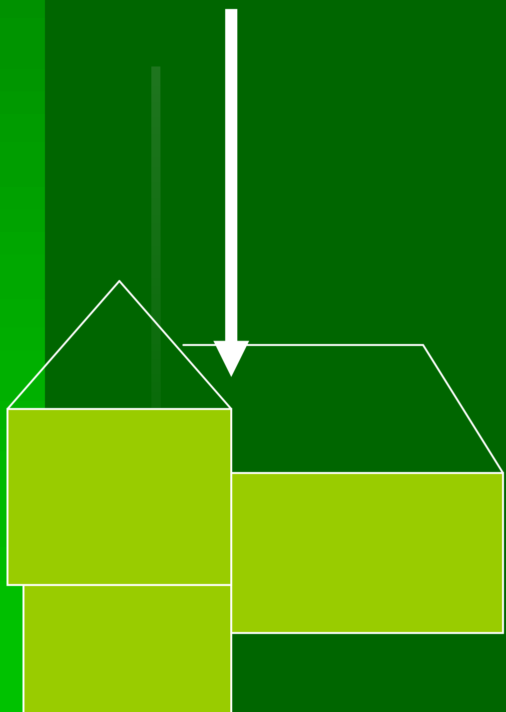
Attic hatches - good

Attic hatches – better!

By-passes are everywhere!

- Insulation is not an air-seal

Tri-level

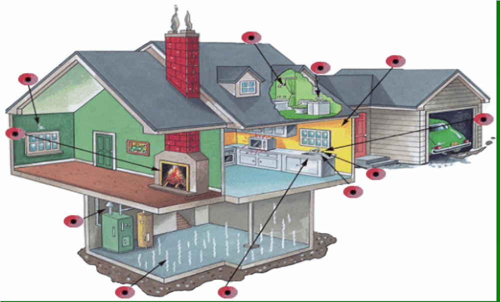


Chimney seal

Chimney Seal

Plumbing stack

Air leak !



Indoor Air Quality

- Moisture
- Stored Toxic Materials
- Carbon Monoxide (CO)
- Radon
- Sewer Gas
- Other

DTL

- Depressurization Tightness Limit
  - (How tight can I make a house before I risk causing backdrafting?)
- Neil Moyer Chart
- Combustion Appliance Zone (CAZ) test

Depressurization Tightness Limit (DTL)

- Atmospheric (natural draft) chimneys operate by warm air rising.
- The buoyancy of heated air above the fire caries the smoke & combustion byproducts up the chimney.
- Draft strength depends on chimney height and the difference between stack & outside temps; i.e. the taller & hotter the chimney and colder the outdoors, the stronger the draft pressure.

Pressures

- Typically, draft is measured:
  1. Over the fire
  2. At the breech
- Manufacturer’s specifications control.
- Most units require - 0.02” water (-10PA)
- Any natural draft appliance will back-draft if it is exposed to negative pressures exceeding the chimney’s draft strength.
- < - 5PA CAZ to outside gives margin of safety

Combustion Appliance Zone (CAZ) Test

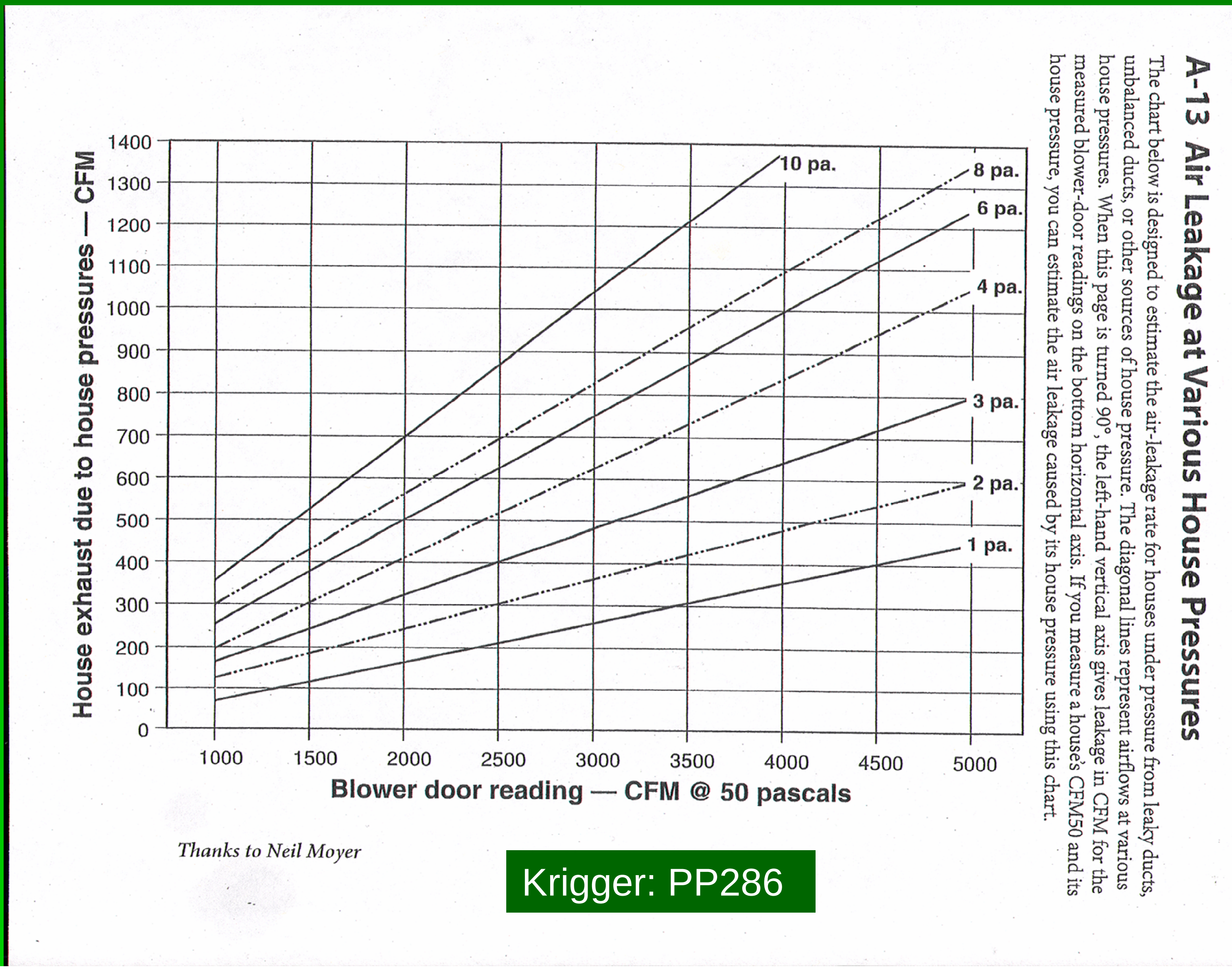
- Manometer set heating appliance area in reference to exterior
- House closed up
- All exhaust appliances running
- Open & close interior doors to determine greatest depressurization in CAZ.

0-4PA  5-9PA  10+PA 

- Fire appliance & check (for) draft

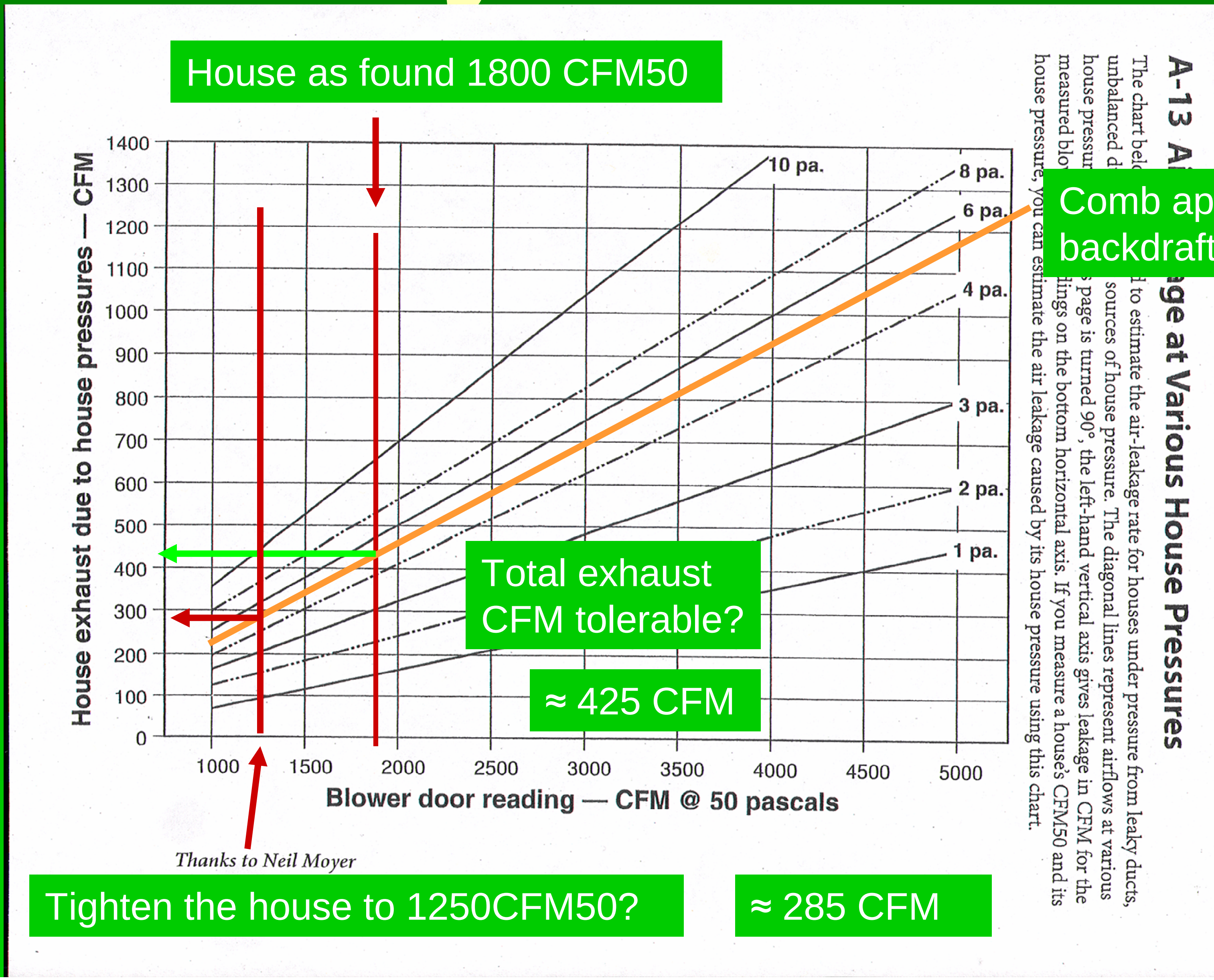
Must meet manufacturer’s specifications.

Neil Moyer chart



Krigger: PP286

Neil Moyer chart



House as found 1800 CFM50

Comb appliances can backdraft @ - 5PA.

Total exhaust CFM tolerable?

≈ 425 CFM

Tighten the house to 1250CFM50?

≈ 285 CFM

How many CFM? (What is it, anyway?)

MVG* & ASHRAE 62

- ASHRAE 62 – 15 CFM/person or .35 ACH *whichever is higher.*
  - *The Oalf*
- The Minimum Ventilation Guideline
  - Attempt to relate CFM^{50} to natural air change
  - Lawrence Berkley "n" number
    - Climate Zone (ΔT)
    - Exposure (wind)
    - Number of stories (stack)

*Formerly BTLa

See Krigger PP 79 & 284

Based on the BTL

- Concept “stolen” from the Wisconsin Wx
  - 1500 CFM 50 Wisconsin
  - 1200 CFM 50 Minnesota
- Minimum BD number below which a house must not be air sealed for IAQ.
- Not intended for use elsewhere.
- George Tsongas used Max Sherman’s climate zone concept, adding factors for wind, stack & number of occupants to develop a more site specific threshold.

BTLa factors

- Climate zone (Krigger PP 286)
- Conditioned square footage
  - Must correspond to BD envelope
- Number of occupants
  - # BR + 1 or actual – (whichever larger)
  - Five is minimum
- Exposed height of building
  - 1 – 1.5 – 2 – 2.5 – 3 stories
- Shielding
  - Well shielded – normal – exposed
- LBL number (Krigger pp 286)
- Volume of heated area

BTLa & Zip-Test Pro software

- Developed by Rick Karg - R.J. Karg Assoc.
- Requires graphing calculator (TI-86)
- Provides:
  - Effective Leakage Area (ELA) = area of nozzle shaped hole which would leak = to the bldg @ 4PA ΔP (LBL Laboratory)
  - Equivalent Leakage Area (Eqla) = area of sharp edged hole which would leak = to the bldg @ 10 PA ΔP. (Canadian Nat'l Research Council)
  - Estimated Natural CF<u>M</u> (Cubic feet per MINUTE)
  - Estimated Natural AC<u>H</u> (Air change per HOUR)
  - Estimated Natural CFM per occupant
  - ELA minimum = area of nozzle shaped hole <u>below which</u> mechanical ventilation would be required in the building.
  - Minimum CFM
  - Minimum CFM 50
  - CFM of mechanical venting needed
- You can do the math yourself !

BTLa formula

- BTLa (in CFM50) = 15CFM x #/occ* x LBLn
- Example:

*** 5 is minimum**

  - 1.5 story cape - 4 bed rooms – in town – 2,700 sq’
  - LBLn = 16.7 (Krigger pp 284)
- BTLa = 15 x 5 x 16.7 = >1252CFM50
- The theory is, if this house isn’t tightened below 1252CFM50, natural ventilation will provide enough outside air for good IAQ.

So what's the MVG ?

- Assuming natural ventilation is providing a known CFM allows us to make up the difference between the naturally provided CFM and the ASHRAE 62 required CFM mechanically.
- The MVG is the required mechanical CFM.

How much faith can I have in the MVG (BTLa) ?

- The concept relies on random type & size holes being randomly distributed over random types of surfaces that are being acted upon by random drivers to determine the CFM of natural ventilation.
- Estimating average natural CFM over a spread of “as found” buildings with it is acceptable.

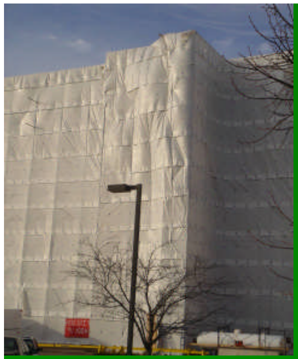
Here’s how it works

Air leakage

- A hole & a pressure differential are necessary.
- The amount of leakage is dependent on:
  - Hole size
  - Hole type –
    - Long/narrow vs. big/round ┐ ┌ turbulent vs.
    - Thick vs. thin surface ├ ┤ linear flow
    - “Hairy” vs. smooth bore ┘ └ “drag” or friction
  - The pressure differential

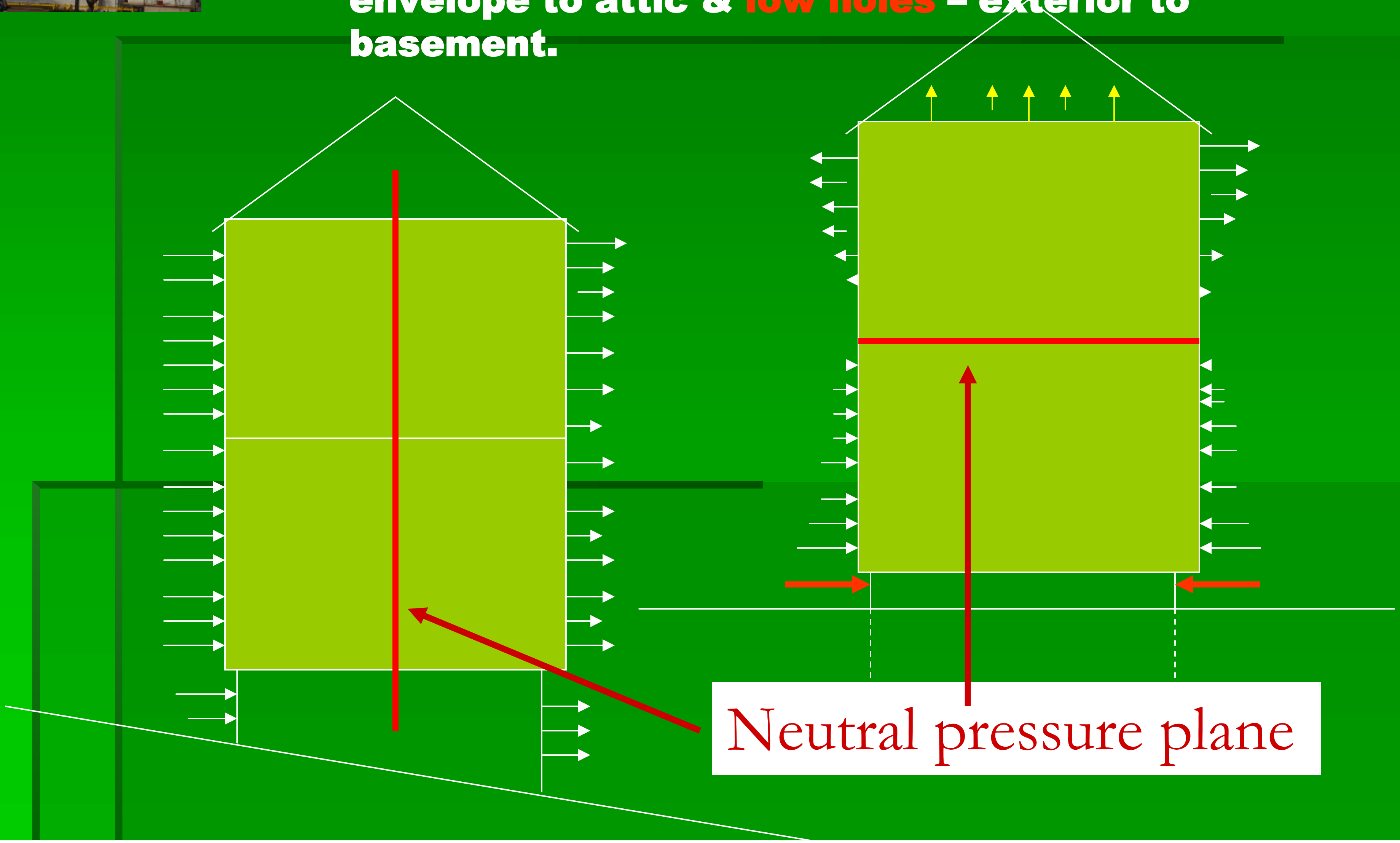
Random hole type ?

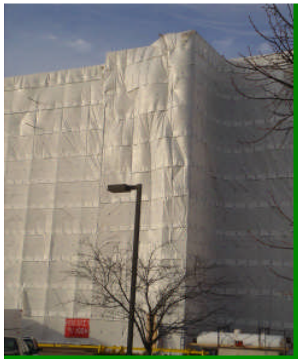
- A five point blower door test can somewhat differentiate the type of existing holes (linear vs. turbulent flow - the ELA vs. the Eqla.)
- We don't do 5 point tests.



Random distribution ?

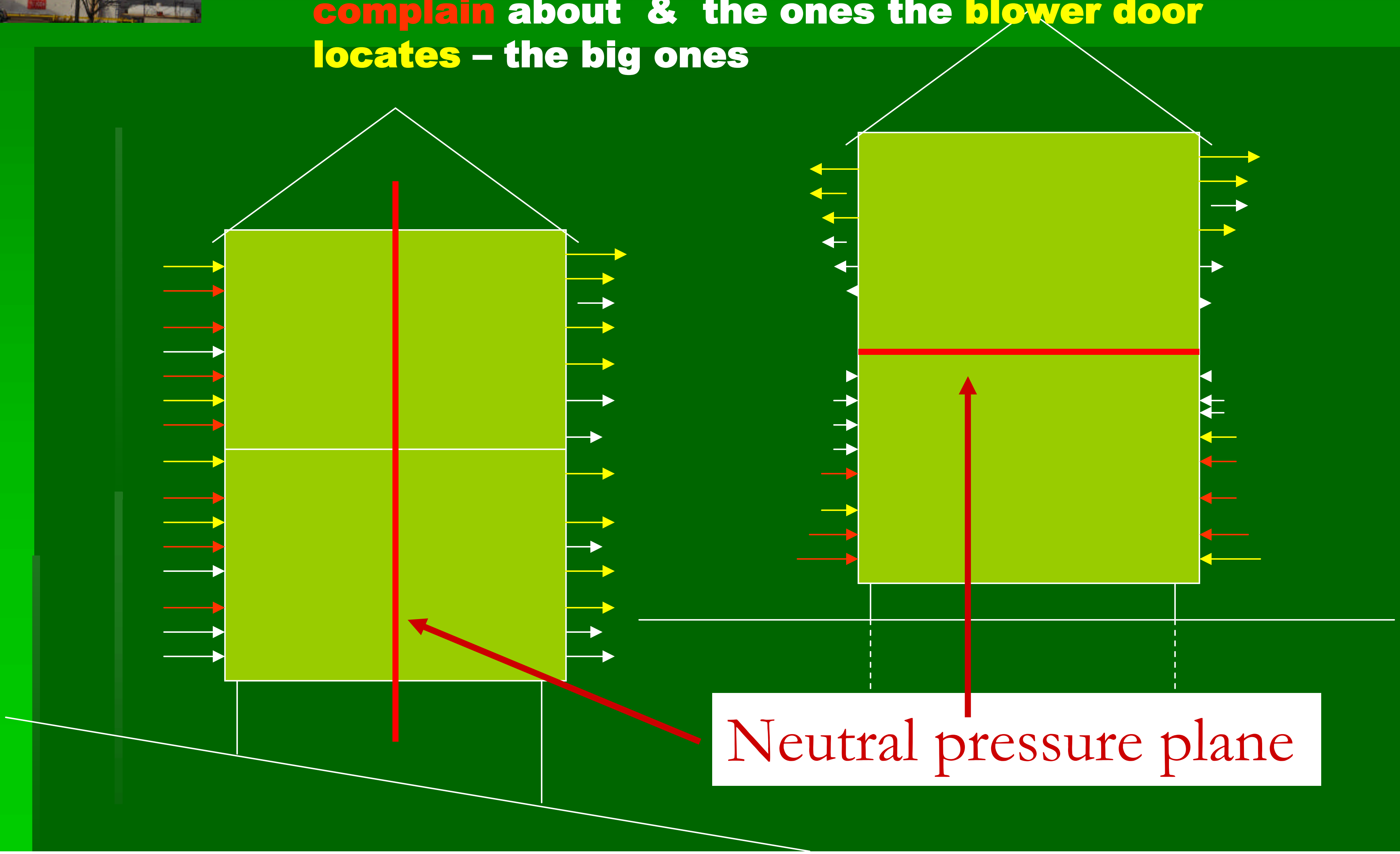
Weatherization stresses blocking high holes - envelope to attic & low holes – exterior to basement.

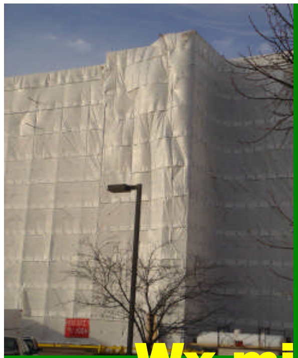




Random Size ?

Wx blocks noticeable holes – the ones occupants complain about & the ones the blower door locates – the big ones

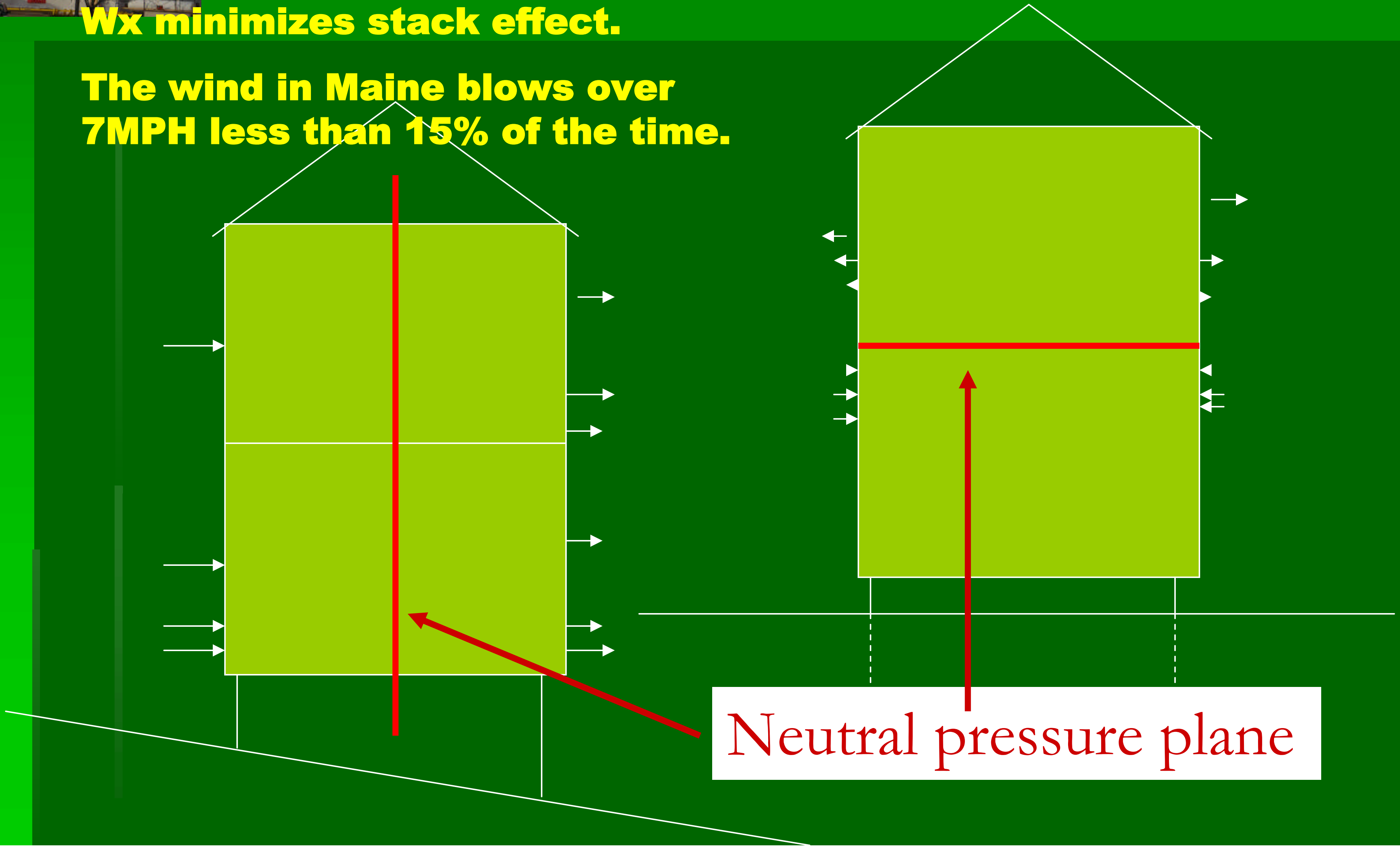


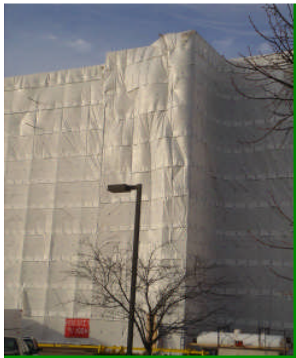


Random Pressure Difference / Random Drivers ?

Wx minimizes stack effect.

The wind in Maine blows over 7MPH less than 15% of the time.





What do we have left?

Tiny, deep bore , crack type holes through multiple layers located where stack effect is minimal !

Air sealing <u>done right</u> eliminates “randomness”!

So what's the MVG/BTL good for ?

1. Estimating air change driven heat loss in existing buildings
2. Setting a realistic "target" for the air sealing contractor.
3. Calculating potential savings from air sealing.

What isn't it good for?

- Setting a threshold CFM50 number above which natural drivers will maintain good IAQ!

- Estimating a building's natural air change rate after air sealing activities are completed!

ASHRAE 62.2 - 2004

- This newer IAQ standard applies to single-family and multifamily residential buildings of three stories or fewer above grade, including manufactured and modular houses.
- Performance Standard

Courtesy of R.J. Karg of R.J. Karg, Assoc.

ASHRAE 62.2-2004

- Whole building ventilation:
  - "A mechanical exhaust system, supply system, or combination thereof shall be installed for each dwelling unit to provide whole-building ventilation. . ."
  - Ventilation based on the table on next slide.
    - These CFM requirements are for whole building continuous ventilation.

Source: ASHRAE 62.2-2004, page 4

Courtesy of R.J. Karg of R.J. Karg, Assoc.

ASHRAE 62.2-2004, Table 4.1a

Minimum Ventilation Air Requirements, CFM, New Buildings

Floor Area (ft^2)	Bedrooms				
	0 - 1	***2 - 3***	***4 - 5***	***6 - 7***	***>7***
<1500	30	45	60	75	90
1501 – 3000	45	60	75	90	105
3001 – 4500	60	75	90	105	120
4501 – 6000	75	90	105	120	135
6001 – 7500	90	105	120	135	150
>7500	105	120	135	150	165

Courtesy of R.J. Karg of R.J. Karg, Assoc.

ASHRAE 62.2-2004

- **Or**, use $\boxed{Q_{fan} = 0.01A_{floor} + 7.5(N_{bedroom} + 1)}$
  - Assumes two occupants in master bedroom and one in the other bedrooms. Over this density, increase ventilation by 7.5 cfm/person.
  - Whole building, intermittently operating ventilation may be used under some conditions for compliance.
  - Ventilation air must come directly from the outdoors.
  - Credit is allowed for envelope air leakage in some cases, based on ASHRAE 62.2 and 136.

A = conditioned floor area; "the part of the building that is capable of being thermally conditioned for the comfort of occupants." (ASHRAE 62.2, p.3)

Courtesy of R.J. Karg of R.J. Karg, Assoc.

ASHRAE 62.2-2004

- Local exhaust fans must be installed in bathrooms and kitchen.
  - Bathrooms
    - 50 CFM on-demand, or
    - 20 CFM continuous.
  - Kitchen
    - 100 CFM on-demand*, or
    - 5 ACH, based on kitchen volume.
      - 12’ x 14’ x 7.5’ kitchen requires 105 CFM.

*Vented range hood required if exhaust fan flow rate is less than 5 kitchen air changes per hour.

Courtesy of R.J. Karg of R.J. Karg, Assoc.

ASHRAE 62.2-2004

- Dryers must be vented out of building.
- When occupiable space adjoins a garage, the design must prevent migration of contaminants.
  - Zone pressure diagnostics helps here.
- Continuous fans must be rated at one sone or less.
- Local, on-demand fans must be rated at three sones or less.

Courtesy of R.J. Karg of R.J. Karg, Assoc.

Minneapolis Blower Door™

The Minneapolis Blower Door™ is a calibrated fan system capable of accurately measuring:

- the pressure it creates across a building envelope &
- the volume of air being exhausted to create that pressure.

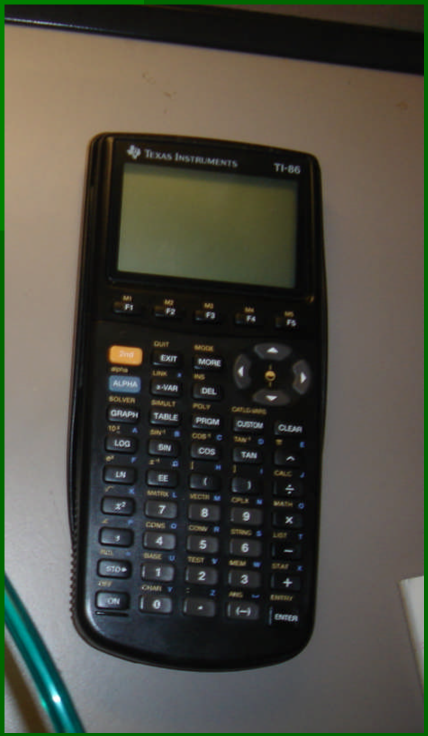
Knowing the pressure & volume of air gives us the total square inches of hole in the building surface(s) resisting the air flow.

Exhaust Fan Flow Meter™

The Energy Conservatory Exhaust Fan Flow Meter™ connected to a manometer – in this case an EC DG-700 Pressure & Flow Gauge™ - will determine the actual air flow through an installed exhaust ventilation set-up – real world as opposed to theoretical numbers.

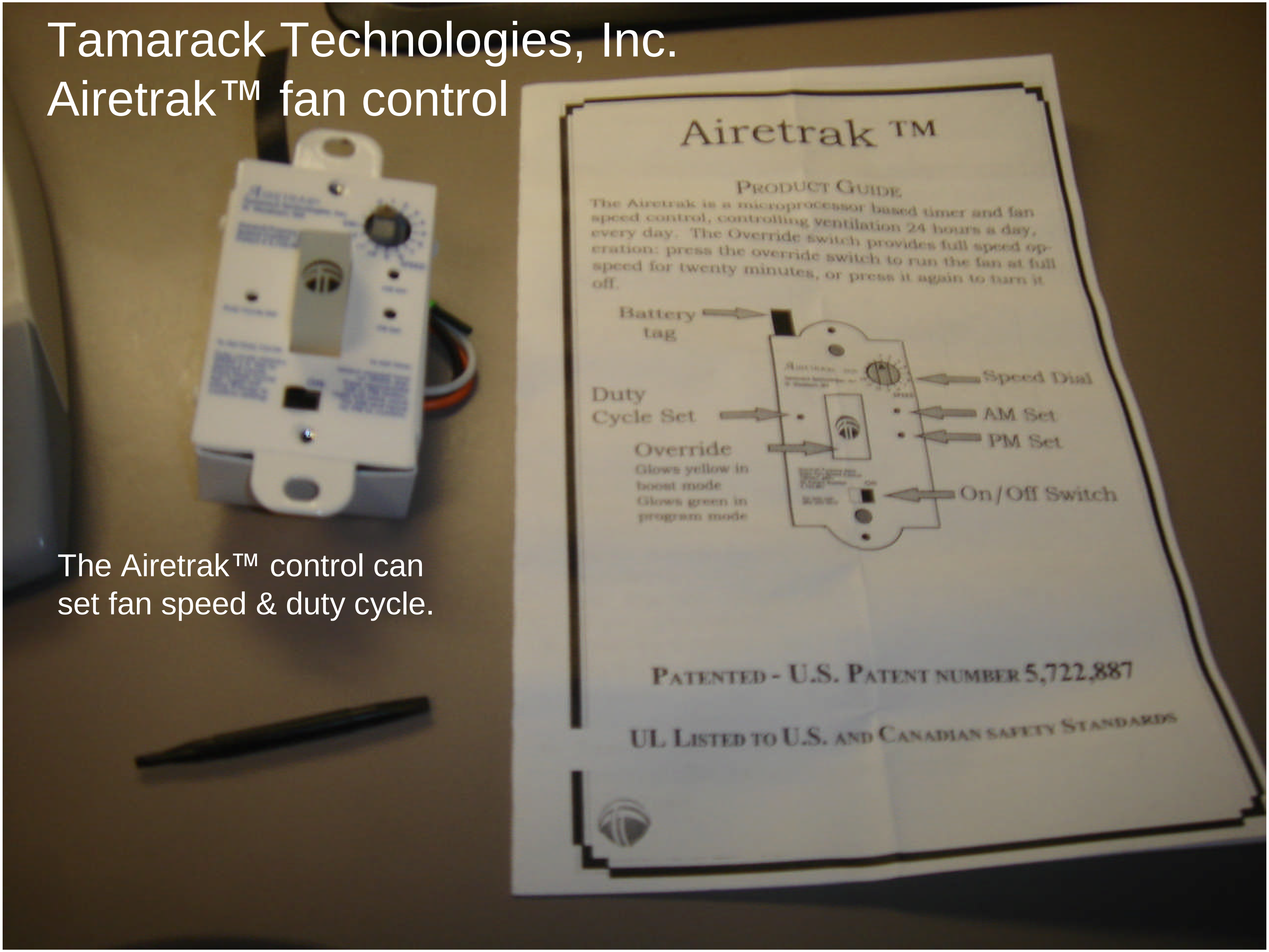
TI-86 graphing calculator with WxWare© software

Rick Karg of R.J.Karg Assoc in Topsham has developed a software program for the Texas Instruments TI-86 which, by use of blower door test results, produces house specific cubic feet of air per minute (CFM) numbers needed to meet the ASHRAE 62.2 standard.



Texas Instruments TI-86 calculator loaded with WxWare© software

Tamarack Technologies, Inc.
Airetrak™ fan control



The Airetrak™ control can set fan speed & duty cycle.

WHAT DOES THIS MEAN?

Any completed single family home can be "real-world" evaluated for a tailored, inexpensive exhaust only ventilation system which will provide the exact amount of fresh air needed to ensure good indoor air quality while maintaining building durability. Normally the incremental expense will be the fan control.

- Homeowner complaints about smells & mold will vanish.
- Window condensation, wet attics and rotting roof decks won't happen.
- Because outside air is introduced through existing cracks & holes, air inlets aren't needed.

An Application

BENTON,MAINE

February, 2006

Home is 22’ x30’. It has three rooms, kitchen/dining/living combo across the front, bath/utility & bedroom in the rear.

Constructed in the fall of 2005.

Heat is by kerosene fired Monitor™ wall heater.

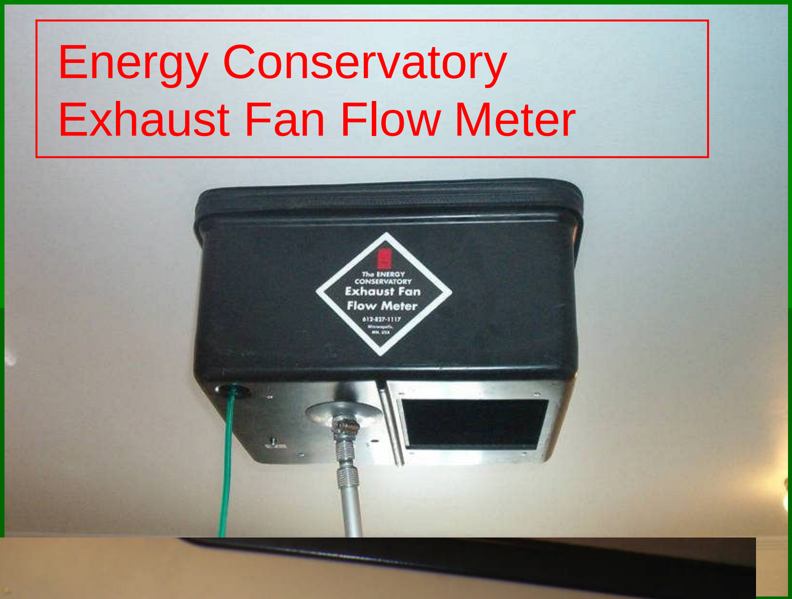
There are two elderly occupants.

2” x 6” framing
Bio-based two-part foam insulation in wall and rafter bays.
2” Styrofoam & 6 mil poly under floating concrete slab

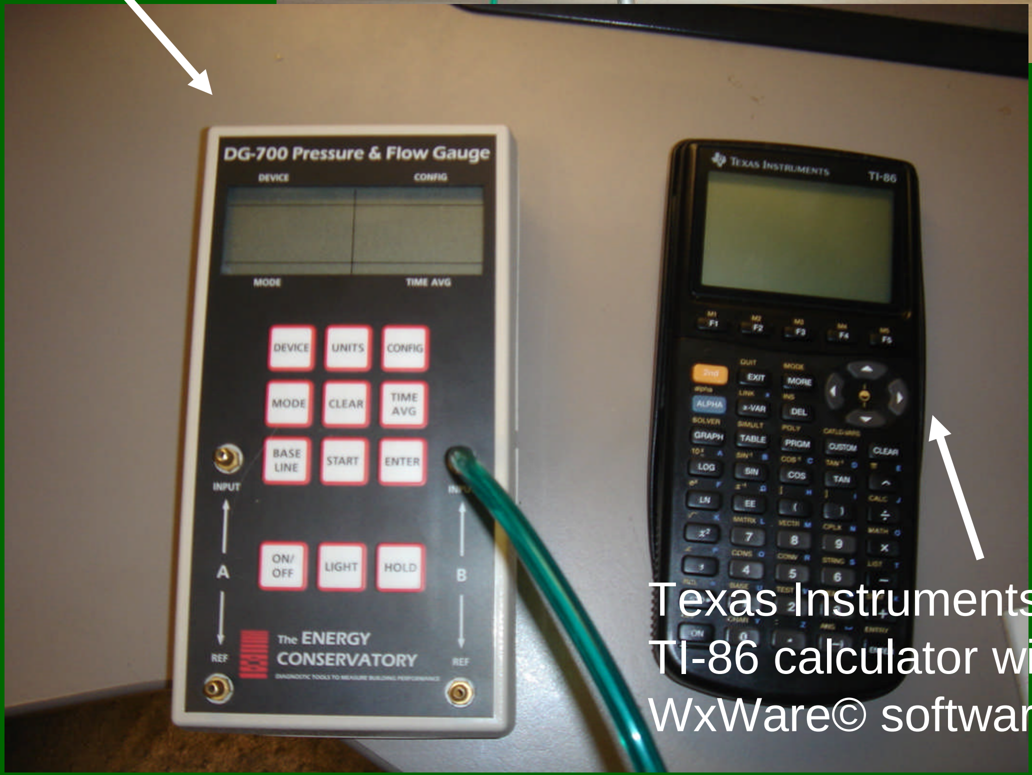

The attic is included in the heated space.
4” – 6” foam in rafter bays

The Test Equipment !

Energy Conservatory Exhaust Fan Flow Meter

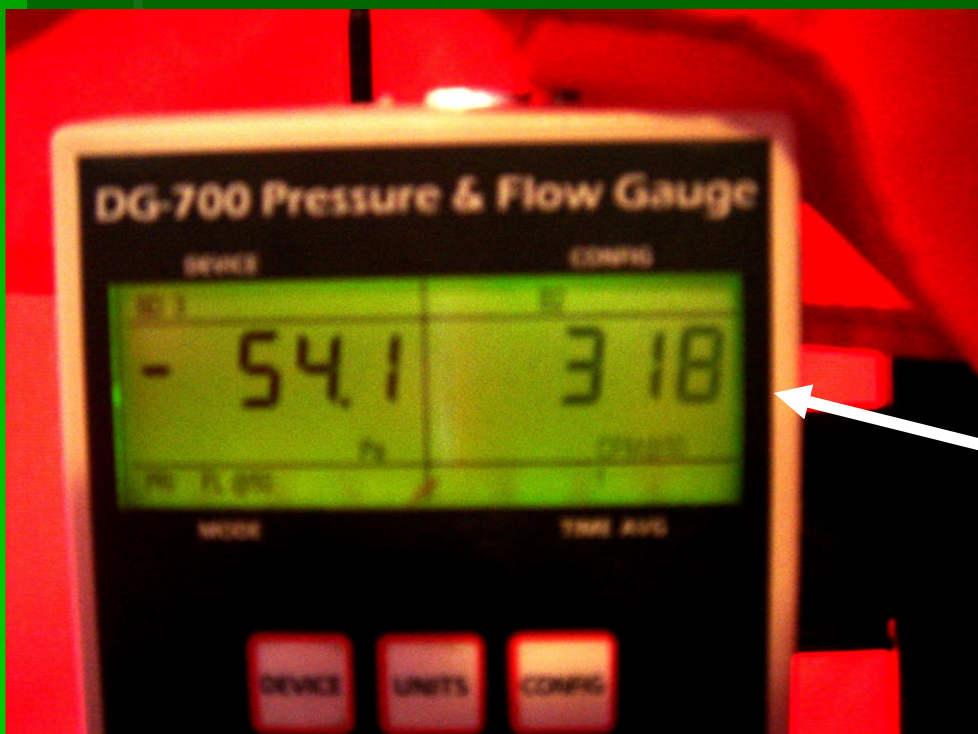


Energy Conservatory Blower Door and DG 700 Pressure & Flow Gauge

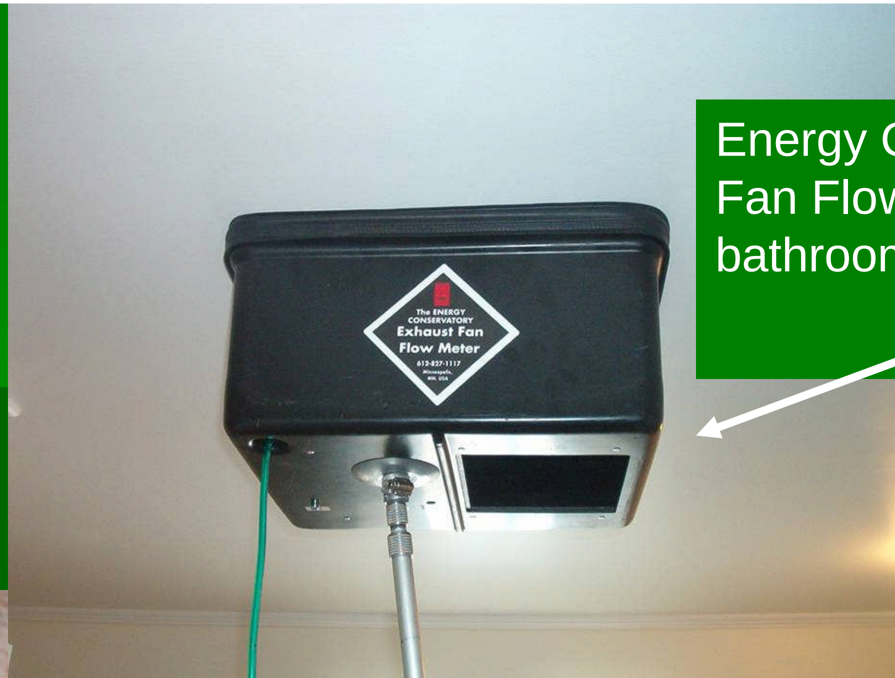


Texas Instruments TI-86 calculator with WxWare© software

Blower door in operation

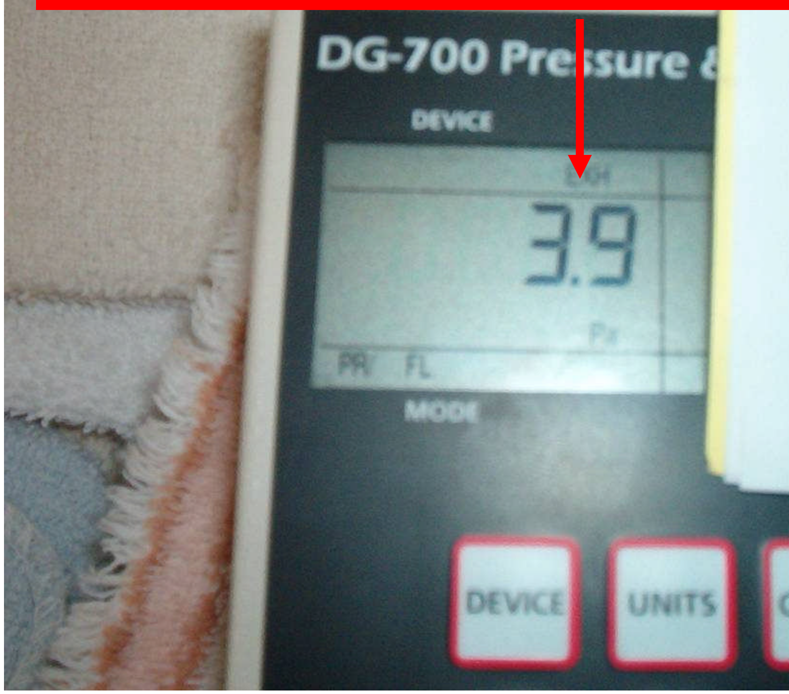


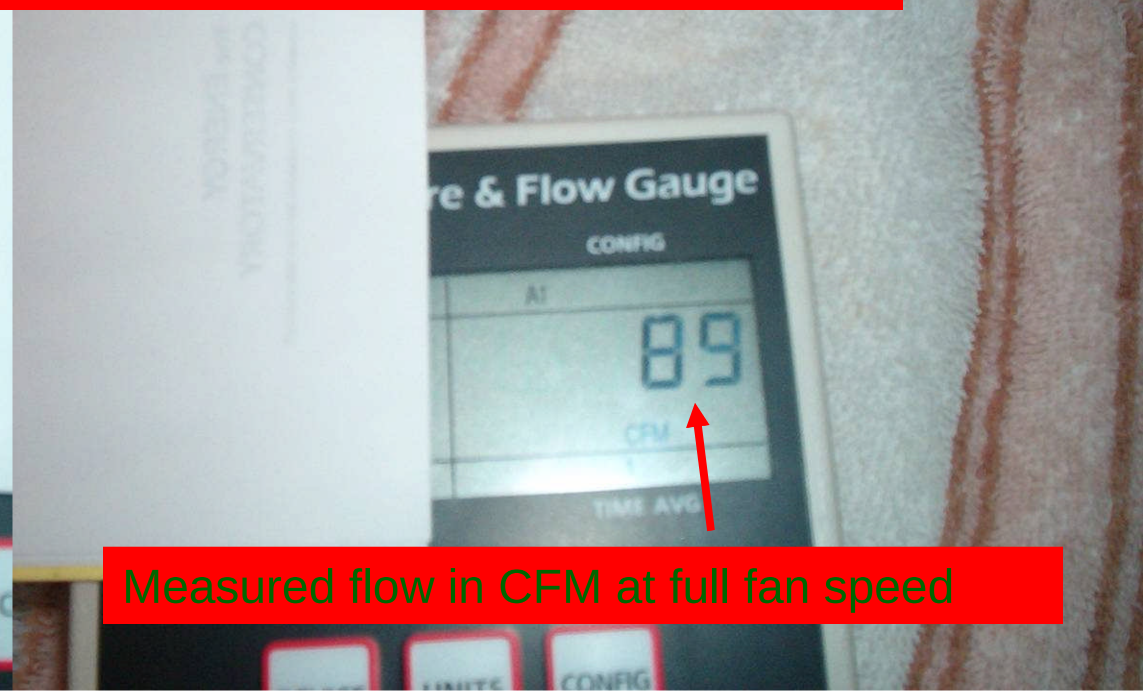
DG 700 showing blower door test readout



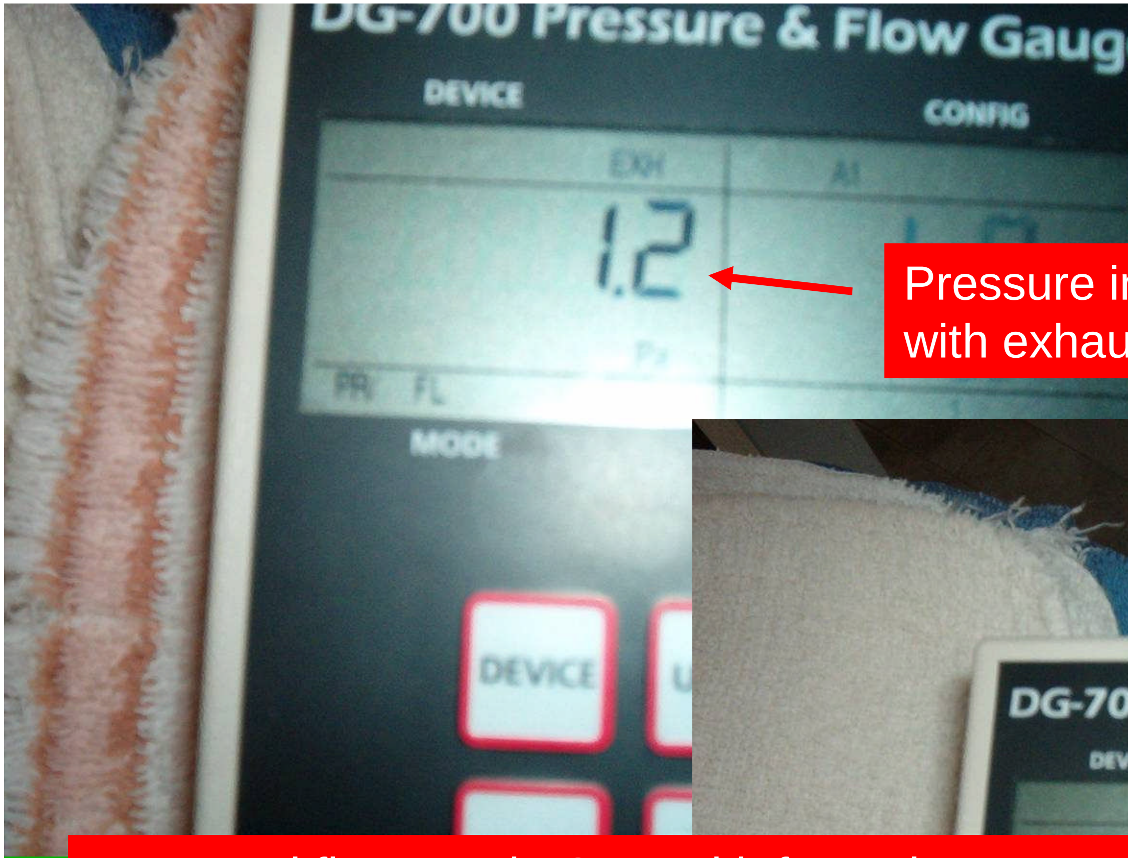
Energy Conservatory Exhaust Fan Flow Meter in place over bathroom ceiling exhaust fan.

Pressure in Pascals created in Flow Meter box by exhaust fan at full speed

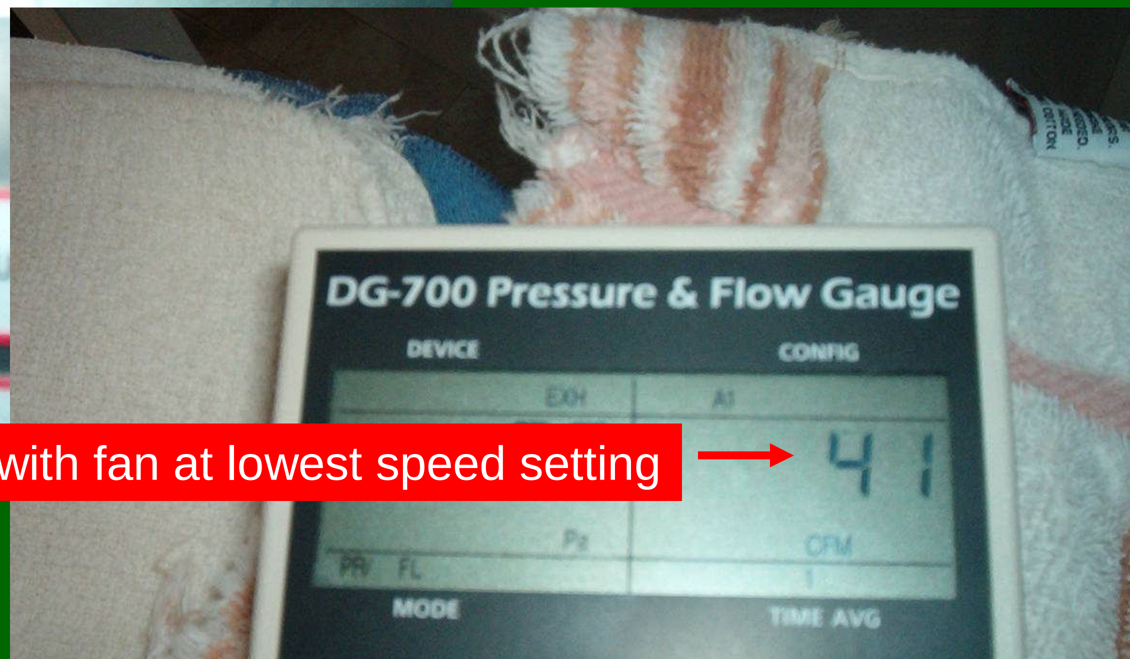




Measured flow in CFM at full fan speed



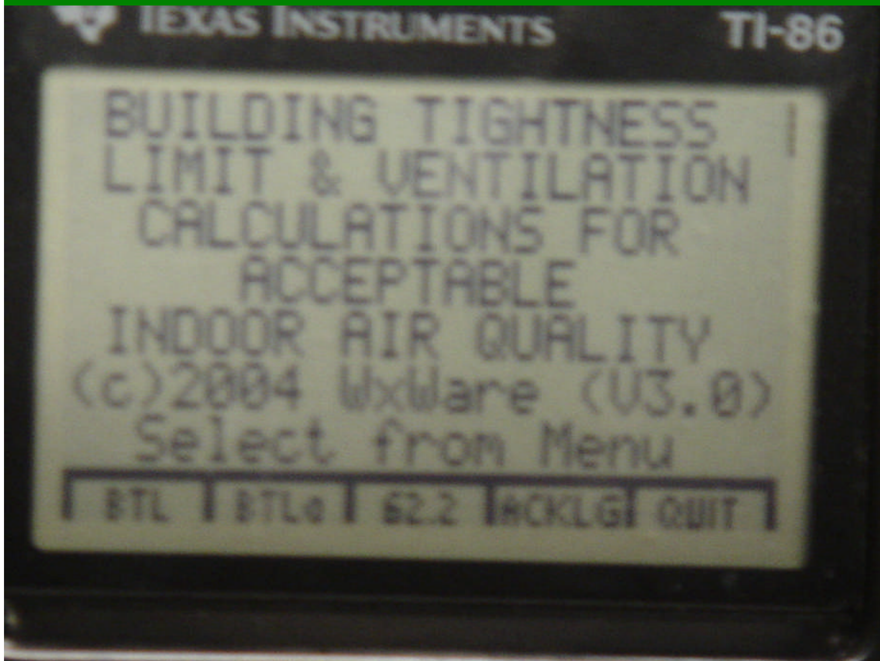
Pressure in Pascals created in Flow Meter box with exhaust fan set at lowest speed setting.

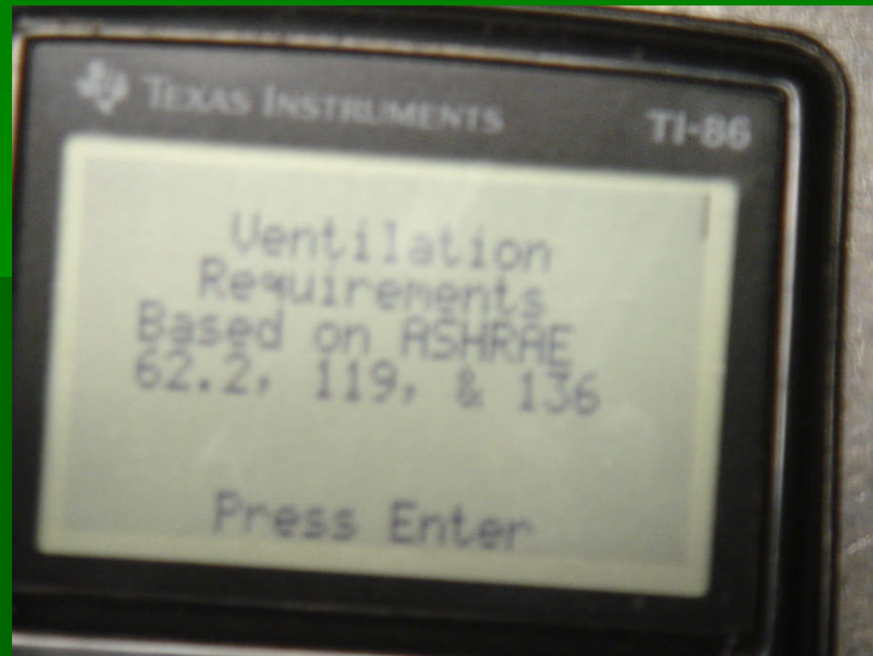


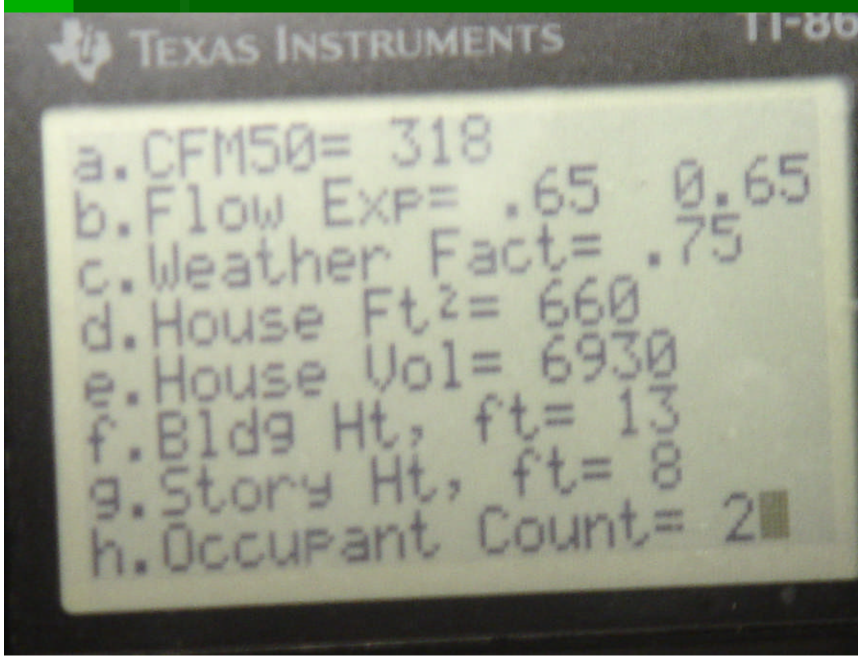
Measured flow rate in CFM with fan at lowest speed setting

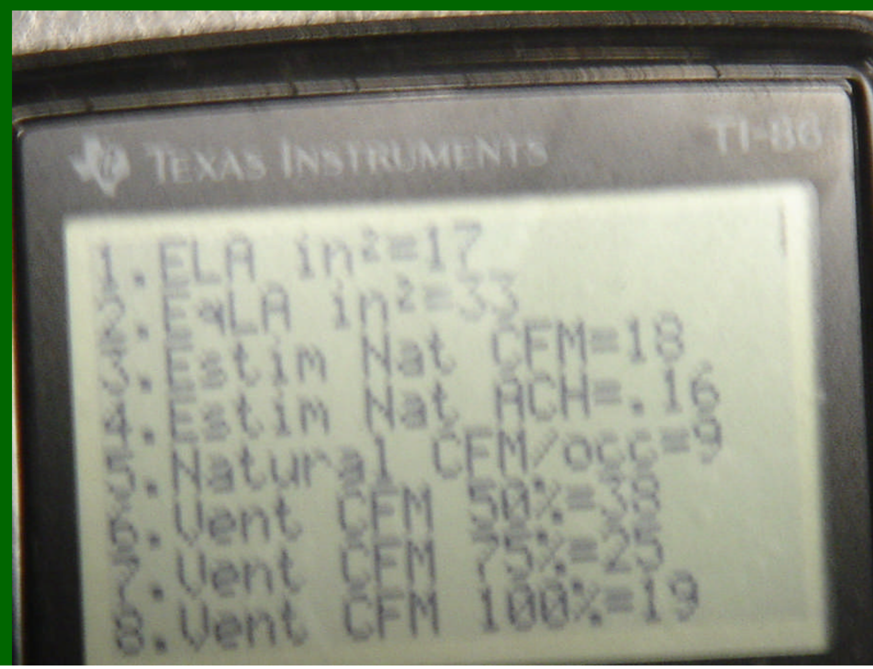
This is the actual measured amount of air moved into & out of this specific home by this specific fan when all operable openings in the entire structure are closed. While opening windows or doors could allow more air flow, at no time when the fan is running will the air flow through the home be less than 41 CFM.

TI-86 & WxWare© software









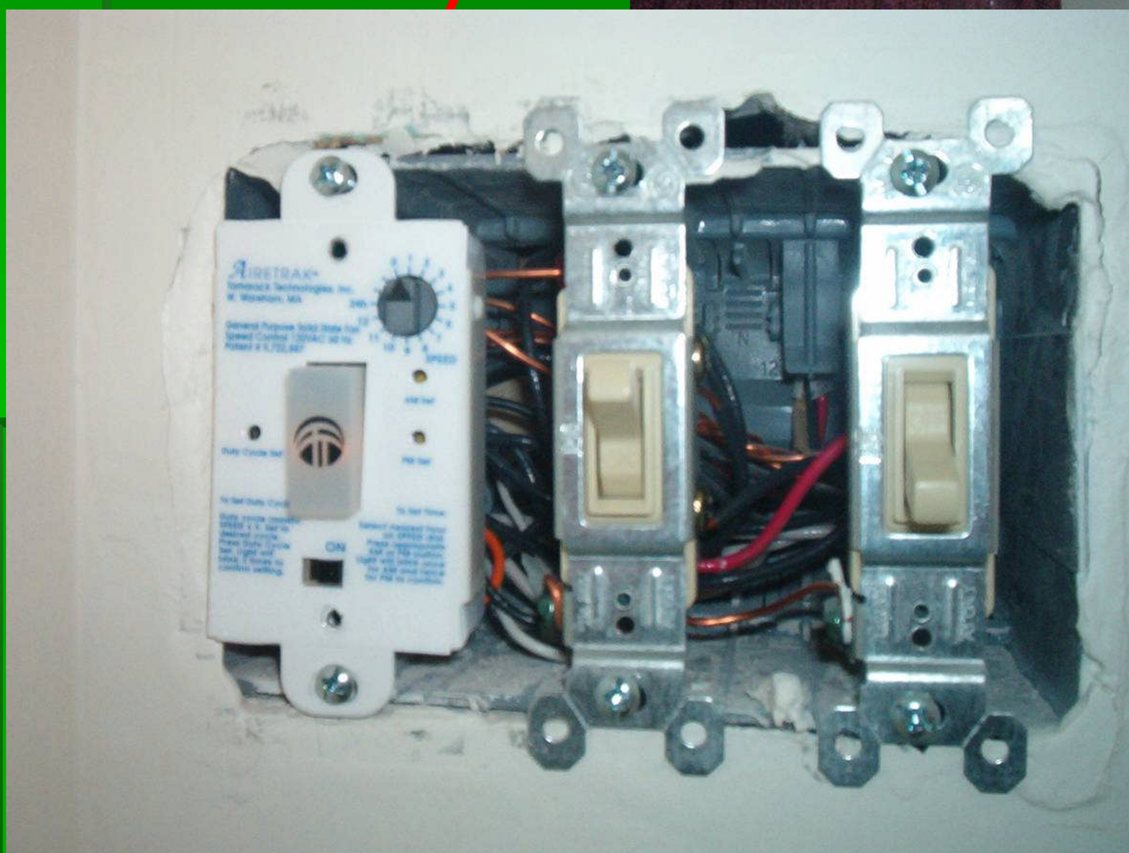
Per the WxWare© software, in this specific home ASHRAE 62.2 calls for one of the following:

- 38 CFM 50% of the time,
- 25 CFM 75% of the time or
- 19 CFM 100% of the time.

- As the lowest fan speed possible delivers 41 CFM, the fan will be set to cycle ½ hour on & ½ hour off 24/7.
- The annual electrical cost to operate the fan at this setting will range from \$6 to \$8 depending on kWh cost & the fan model chosen . The installed model operates under 1.5 sones and, at \$.14/kWh, will consume ≈ \$6.40 annually.

Tamarack Technologies, Inc

Airetrac™ fan control



Technician setting fan control

RESULTS !

- The air moved through the house by the fan is the *exact* code mandated minimum amount needed for the house to “breathe”.
- Using this system will reduce the air change driven heat loss to the <u>absolute minimum</u> required to maintain good IAQ while insuring building durability.
- If this strategy works in a tight house, it will work anywhere!

Important Considerations !

- The heating system in this <u>extremely</u> small, tight house is sealed combustion. In a dwelling using atmospheric combustion appliances, testing for & possibly providing adequate combustion air would be necessary.
- The fan & control are subject to wear and eventual failure. (The expected life is ten years.) The homeowner must be made aware that maintenance and eventual replacement will be required.

Contact Information

- Airtrack™ control

Tamarack Technologies, Inc.

320 Main St. P.O. Box 963 Buzzards Bay, MA 02532

(800) 222-5932

- Texas Instruments TI-86 &
- WxWare© software

R. J. Karg, Assoc

220 Meadow Road

Topsham, ME 04086

(207) 725-6723

- Minneapolis Blower Door
- DG-700 Pressure & Flow Gauge
- Exhaust Fan Flow Meter

The Energy Conservatory

5158 Bloomington Ave. S.

Minneapolis, MN 55417

(612) 827-1117

- Tony Gill

Maine State Housing Authority

353 Water Street, Augusta, ME 04330

(207) 626-4671

Homework !

Homework !

24' x 36' cement block home with 4 occupants – 2 adults & 2 children – 7500HDD. It has a kitchen, utility room, living room, bath room & two bed rooms over a full dirt floored basement. The CFM50 = 2647. There is an electric water heater and warm-air furnace in the basement. The only access to the basement is from the exterior through a metal bulkhead door. The attic has 6" of unfaced fiberglass batts. There is no other insulation. The attic has one 12" X 16" gable vent. There is no other attic venting. There is a bath vent that dumps into the attic. There is no kitchen vent. The main floor ceiling is 1 foot sq. block fiberboard tile. The exterior walls are cement block, painted on the exterior, plastered directly on the block & wallpapered on the interior. There are 2 doors, 2 casement & 7 double hung windows, all with storms. The homeowner has just installed a direct vent condensing warm air furnace to replace the baseboard electric heat which cost more than $4,000 to partially heat (½ @ 65°F- ½ @ 45°F) the house last winter.

WHAT SHOULD BE DONE ?