Light Wood Framing #1

References

• Graphic Guide to Frame Construction, Rob Thalon, Taunton Press, 29.95
• APA Guide to Residential Construction, APA - The Engineered Wood Association
• International Residential Code, ICC

A Revolution...

• The hand hewing of tree trunks into columns, beams and bents making up a heavy timber frame has been the standard for construction since 2500 B.C.

• But in 1795 Jacob Perkins was issued a patent, and by 1800 the water powered circular saw was producing sawn lumber quickly and cost effectively...the patent? An automated nail making machine.
Old Nails

- Nails had been handmade since before Rome.
- The Romans mass produced nails by casting molten metal into square rods, nail stock.
- Up through the colonial era, nail stock was reheated, cut, and hammered into tapered shapes and flattened at one end (head it off - to end it).

Nails...a precious resource

- In 1795 nails cost the astronomical sum of 25 cents a pound. This high price kept the "fastener free" - joinery intensive heavy timber frame and masonry construction as the dominant method in the housing construction industry.
- This also meant after a fire, the charred remains of the building would be carefully searched for the nails, which would be straightened and recycled.

Cheap nails

- By 1869 nail costs had fallen below 5 cents a pound, the Civil War had ended and a construction boom was following the homesteaders into the opened Western territories. The balloon frame was the construction method of choice for the fast developing towns of the West. Framing lumber from the Great Lakes region was being shipped along the fast developing railroads was being transformed into commercial and residential structures with a speed not possible with joinery-dependent timber frames or masonry construction.
Pennies per nail

Nails are graded (measured) in a system that refers to their size. The unit is called a "penny." The larger the number, the larger the nail. A 3-penny (3d) nail is much smaller than a 16-penny nail.

This dates back to 15th century England, when the "penny" size determined what one paid a blacksmith to forge a hundred nails of that size of nail (one paid three pennies to get a hundred nails of the size called the "3-penny" nail).

This price became obsolete before 1500, but has continued to be so entrenched in convention, that its use persists to this day. Now we use it primarily as a measure of length (approximate, at least).

We abbreviate the "penny" with the symbol "d", which came from the "denarius", an early Roman coin.

Nails on schedule

- Building codes today specify how many nails, at what spacing and size of the nail for each structural application in light wood framing
**International Residential Code**

Nail schedule table R602.3(1)

1. Sole plate to joist or blocking: 16d @16" o.c.
2. Top or sole plate to stud, end nail: 2 - 16d
3. Stud to sole plate, toenail: 3-8d or 2-16d
4. Doubled studs, face nailed: 10d @ 24" o.c.
5. Double top plates, face nailed: 10d @ 24" o.c.
6. Sole plate to joist: 3-16d@16" o.c.
7. Blocking at braced wall panels: 3-16d@16" o.c.
8. Double top plates, face nail @ 4" offset ends: 8-16d
9. Blocking between joists or rafters: 3-8d
10. Rim joists to top plate, toenail: 8d@6"o.c.
11. Top plates lap at corners and intersections face nail 2-10d

**Typical nails for Light Wood Framing**

- For formwork, scaffold, temporary nailing
- For trim and millwork
- For most of the framing
- For utility millwork
- For braces to concrete slab
- For exterior window casing that won't be put up

**Wood**

1. During this revolution, many species of wood were used for wall framing and floor/roof framing, some worked...some didn’t.
2. Over time, we’ve learned that Spruce, Pine, and Fir (SPF) work well for studs and vertical framing elements, while Douglas Fir and Larch (DFL) work well for spanning members.
3. Both SPF and DFL fall into the Structural Light Framing category of wood materials.
Stress grade lumber... Studs and Verticals

• "Light Framing & Studs" (SPF)
  - "Construction" grade: used for general framing purposes, graded for strength and serviceability... not appearance
  - "Standard" grade: used for general framing purposes, graded for strength and serviceability... not appearance
  - "Utility" grade: used for general construction purposes (studding, blocking... for NON-LOAD BEARING USES ONLY)
  - "Stud" grade: usually for wall framing, may be precut to stud length

Stress grade... Spanning grades

• "Structural Light Framing" (DFL) For Engineered (spanning) applications
  - Select Structural used where highest strength (67% of allowable fiber bending stress for clear lumber) and stiffness & good appearance are required.
  - No. 1 high strength (55% of allowable fiber bending stress for clear lumber) and stiffness and good appearance
  - No. 2 (45% of allowable fiber bending stress for clear lumber) and stiffness... recommended for most general construction uses
  - No. 3 25% of allowable fiber bending stress for clear lumber and stiffness... recommended for most general construction uses where appearance is not a factor

Dry

• S-Dry: indicates lumber dried to 19% moisture content, then surfaced
• MC15 lumber dried to 15% moisture content... below this the lumber will pick up moisture from the air, a little less stable
• Green lumber: lumber not dried, dimensional changes should be expected, details must compensate for shrinkage, nail schedules are different as wet wood does not have the strength dry wood does.
Balloon Frame

- The Balloon Frame emerged in the Midwest in the early 1830s.
- It features all dimension lumber construction, 2x and 1x material.
- The vertical loads are carried by continuous 2x4 vertical members called studs.
- Diagonal forces are carried by the 1x6 which are notched into the studs as wind bracing.
- The stud frame gets additional rigidity from the horizontal 1x wall and roof sheathing.

Balloon problems

- Second floor joists are carried on a horizontal 1x member notched into the studs called a ribbon or rib band.
- By the time of the great fires of the 1870s, many balloon frame houses had been constructed in and around growing American cities.
- The balloon frames burned quickly as flames spread from lower levels to the attic between the studs... the continuous studs made a continuous path for flames and smoke.
Fire blocks

- Even though we don’t balloon frame much today, any place in the light wood frame where a horizontal space between framing meets a vertical space between framing, there must be at least 1 1/2 inches of solid wood cut to precisely fit between the framing and prevent smoke and fire from moving through continuous vertical or horizontal spaces between framing.
- The code requires fire blocking in framing spaces at least every 10 feet, either horizontally or vertically.

Platform Challenger

- By 1900, the balloon frames hungry habit for 19 foot long straight 2x4’s was straining some lumber producers, and some builders developed a way of framing small houses to address the flamespread problems of the wood frame.
- The platform frame, depended on studs to carry vertical loads, diagonal let in 1x6’s to resist wind loads, and 1x6 horizontal sheathing to stiffen up the frame.

Platform framing process

1. Build floor
2. On sill plate
1. Build walls on floor.

2. Tilt up walls.


Platform framing process.
Platform framing process

1. Build floor on sill plate
2. Build walls on floor
3. Tilt up walls
4. Build second floor on walls
5. Build walls on second floor
6. Build roof
The big difference was the studs weren’t continuous. This allowed builders to prefab walls on the floor platform and tip them up into place. The floor platform became a work surface, eliminating much of the ladder work that was required for the balloon frame, and putting four and one half inches of wood between the first and second floor to stop the spread of flames.

Anatomy
• This version of the platform frame uses all solid sawn lumber except for the plywood at the roof.
• It is still in use today although many builders have introduced truss elements, I joists, and other composites to reduce costs while holding performance.

Beginnings
• The platform frame begins with a rigid piece of sheet metal (the termite shield) being turned down over the top of the foundation wall.
• This termite shield makes the termites leave the foundation, build a spit/mud tube around the shield, and into the wood above.
Seal and Sill

- Next and (first in northern states without a termite problem) is a strip of closed cell foam to seal out drafts between the shield and the sill plate.
- The sill plate MUST be rot resistant wood, and is bolted to the foundation wall at 4 to 6 feet on center. Usually, the sill is a 2x6.
- What wood should be used? A: Cedar, B: Redwood, C: CCA-SYP, D: ACQ-SYP or E: Teak

Bands & Joists

- Next, the Rim joist is installed at the outside face of the sill plate.
- The Rim joist is usually the same depth as the floor joist and holds the floor joists upright before the joists stabilized by the subfloor.

Subfloor

- The next element to be installed is the subfloor.
- In our time, plywood and OSB are the common structural panel product used as the structural subfloor.
- Usually these panels are tongue and grooved on all edges to make firm connections on all edges of the panel.
- Frequently this panel is screwed to the joists and also glued to the joists to minimize floor squeaks in the future.
Next layer at 90 degrees

- Structural panels (3/4 t&g plywood or OSB) installed for subflooring always span perpendicular to the joist span.
- The plywood is cut in half to make sure the next set of panel joints don’t line up...
- It makes a stronger floor and the plywood joints don’t show through the vinyl flooring as easily.

Next layer at 90 degrees

- If a underlayment (high density particle board) were to be added above the structural panel floor sheathing
- The subfloor would be laid perpendicular to the plywood.
- And its joints would be staggered to avoid falling on top of the plywood joints.

Crawl spaces

- In cold climates, this first floor above grade must be insulated to prevent heat loss from the first floor from escaping.
- The bigger problem is moisture, from the ground condensing on the cold framing in winter, making it wet, increasing the chance for rot to begin.
- It’s a similar problem in warm humid climates, AC cools the framing, making condensation of moisture in the air likely.
- The code requires the floor framing be 18 inches above crawl space floor to protect it. This can be reduced to 3'–6” if the earth is covered with polyethylene to minimize moisture migration.

So all crawl spaces are ventilated to the outside, to dump excess moisture.

- The ratio of vent area to the area of the crawl space is 1/150.
- If a vapor barrier is installed near the exposed earth, and when the vents are located within 3 feet of the corners, this can be reduced to 1/300.
Crawl Spaces...to vent or not to vent

- But this requirement for ventilation could make some problems in warm-humid climates.
- It's a similar problem, water condensing on a cool wood surface making conditions right for mold and decay fungi.
- Air conditioning cools the framing, making condensation of moisture in the air likely

Vented Crawlspace and A/C

- In air conditioned houses, a crawl space vented to the outside is likely to fill with air that is warmer, and wetter than the air in the ductwork, and space above

Given the high 82 degree dewpoint, it is likely the duct, insulation, even floor joists will be cool enough to be condensing surfaces
IBC 2000 recommends

- 1202.3.1 The minimum net area of ventilation openings shall not be less than 1 square foot for each 150 square feet of crawl space area.

Except...

- Where warranted by climatic conditions, vents to the outside are not required if vents to the inside are provided...(conditioning the crawlspace)
- Total vent area can be reduced to 1/1500 where the ground is covered with an approved vapor retarder material and required openings provide cross ventilation

Exceptions...

- Ventilation openings are not required when the ground surface is covered with an approved vapor retarder, the perimeter walls are insulated, and the space conditioned in accordance with the International Energy Conservation Code
Dry before sealing

- North Carolina practices:
  - Cover exposed earth with a Class I vapor barrier
  - Insulate over
  - Insulate walls
  - Exhaust at 1 cfm per 50 s.f. (on inside/outside differential humidistat)

Studwall

- The studwall is built on top of the subfloor surface.
- Ultimately it is tipped up. And stands vertically on the first floor platform.

Stud Wall basics
How long do you want that stud?

- A long time, I’m going to build a house with it

- Because the stud sits on a plate
- And is nailed to another plate on top
- Which has one more plate to tie the sections of wall together,
- And if the finished ceiling height is to be 8 feet with 1/2” drywall
- The stud is
  - 8 - 0 1/2” feet (96 1/2”) minus 2 wall plates @ 1 1/2” minus the top plate @ 1 1/2” = 92”
- A standard precut stud is 92 5/8”.
  The 5/8” is tolerance for the gypsum wallboard installation, usually left at the base of the wall

Tying walls together at the top

- Overlapping Plate
- Wall assembly

How many nails of what size are used at corner splice of the top plates?

- (2-10d face nail through the top)

Tying walls together

- Stud walls are tied together at intersections and corners as well as with an additional top plate.
- In making a corner or intersection, remember to leave framing accessible for attaching the finish materials.
Wind and studs

- Since the wood stud is usually only nailed to the top plate with 3 nails, and to the bottom plate with 3 nails, it is pretty flexible parallel to the long axis of the wall.
- Wind bracing prevents this but must be installed in both the long and short axis of the house.

1x4 let in bracing

- Wood 1x4 notched into (let into) the studs and nailed to each stud.
- Labor intensive but common in houses built from 1830 to 1950!
Metal Let in Bracing

- ‘T’ shaped cross section
- Place in saw cut kerf in stud
- Nail through face to anchor to stud

- This is fast and effective.
- Snap a chalkline from corner to corner.
- Run a circular saw over the chalkline to cut the kerf
- Pop the brace in place and nail thru the tee to each stud.

From Thallon
**Plywood wind brace**

- Often at the corners of a house or small building, one sheet of plywood nailed on each face of the corner will make a vertical shear diaphragm resisting the racking forces of the wind.

**Structural corners**

- Without an engineer's analysis and design, the International Residential Code won't allow a window closer than 4 feet from the corners of the wood frame.
- The code assumes every light wood frame needs to have structural panels at least 4 feet on each side of each corner.

**Plywood Sheathing / siding**

- In many cases, an exterior grade plywood having either a cedar veneer or a medium density face (MDF) can act as both the structural (wind) sheathing and the finished siding.
Dealing with Liquid Flow

• "Face sealed"

• Historic assumption: "we'll keep all water out of the wall" turns out to be pretty much impossible.

Rain Screen

• The face sealed approach is being replaced by a "rain screen" approach
• Assumes water will enter the wall
• Includes a carefully detailed drainage plane to prevent trapping the water.

Cavity Wall - Masonry Drain Plane
Building Paper Drain Plane

- Not all “tar paper” is created equal.
- “15 pound felt” now called “number 15”
- May only weigh 4 to 7 pounds per 100 s.f. not as durable
- 30# roofing felt preferred by building scientists for siding-contact drain plane

Is Tape and Housewrap enough?

Housewrap as Drain Plane needs Drain Space

For Housewrap to function as a drain plane, it must face a drain space of at least 3/8” width

Can be accomplished with firring strips, mesh...
Avoiding chemical dependency

- Sealants, tapes, adhesives are wonders of modern construction chemistry
  - If surfaces are properly prepared
  - If conditions are appropriate
  - If the formulation was correct
- Mechanical flashing, even with building paper can “back-up” the tapes, sealants and adhesives for a fail-safe opening
Belt & Suspenders

• Housewrap and tape at the nailing flange can make an effective water seal
• If there are no fishmouths
• If it is done perfectly
• If the window itself doesn’t leak

1. Install housewrap below window
2. Install sill pan flashing with end dams at jambs
3. Install jamb flashing over sill pan
4. Install cap flashing over tops of jamb flashing
5. Install housewrap over cap and jamb flashing, tape to nailing flange
Chimney Enclosures

Frequently constructed as uninsulated boxes

No insulation or vapor barrier

What is first condensing surface when the fire is not burning/raising enclosure temp?
• From the point of view of the framing, openings in the wood frame are pretty easy, double the framing member on each side of the opening and proceed.

• Windows and doors have their own frame which is shimmed to level and plumb between the doubled studs.

• The frame is anchored to the double studs by nailing through the frame and shims.

• A piece of molding is applied to the exterior of the frame to close the gap between frame and the double studs, often this is called the brickmolding.

• Contemporary windows are often covered with vinyl or metal cladding to prevent deterioration of the wood frame... and end maintenance.

• This cladding layer has a projecting fin which overlaps the joint between frame and double stud closing the gap like the brick molding did.

• This is called a nailing fin, and is a primary way of attaching a window to a wall.
At the top of the opening (called the head) the trim or nailing flange makes a place to trap water.

To prevent the entry of water, the head of the window is usually FLASHED with building paper, metal, or flashing tape to keep out water.

Then the trim is installed, it too makes a horizontal shelf that would hold water, so it gets flashed with metal called CAP FLASHING.

Finally, the siding is installed, which closes off the top of the cap flashing, preventing water from leaking into the window.
Notching, Drilling, Cutting

- Plumbers, Mechanical Contractors, & Electricians take the almost completed wood framing and begin to modify it to accept their systems. Notching, Drilling, Cutting are all done to the framing. In the proper amounts and locations this doesn’t hurt solid sawn lumber.

Joist Notches

RAFTER / CEILING JOISTS

- Max distance = Joist depth from point of support
- Max depth = 1/3 Joist depth
- Length /3
- No Notches Permitted

FLOOR JOISTS

- Max depth = 1/6 Joist depth
- Length /3
- No Notches Permitted

Stud Notches, holes...

EXTERIOR & BEARING WALL

- Max hole dia. < 40% of Stud width
- Min dist To edge 5/8
- Max notch < 25% of Stud width
- No bored holes in cross section of notch

- Max hole dia. < 60% of Stud width
- Min dist To edge 5/8
- Max notch < 40% of Stud width, No bored holes in cross section