Wood-frame homes continue to be the dominant choice for both home buyers and home builders in the U.S. Tens of millions of homes have been constructed with wood framing. Even with this long history of wood-frame construction, there are some framing practices that should be monitored carefully to avoid problems.

This guide is intended to help builders avoid common framing errors that not only cause problems with building inspectors, but may create other difficulties within the structure. These recommendations have been developed through years of work by WWPA with framers, contractors and building code officials.

Frame Openings

One common problem occurs after the basic framing is completed. Subcontractors may cut through floor joists to make room for plumbing runs, ductwork, electrical or other mechanical elements. But often, the load-carrying joists are cut without properly transferring the load to other joists by adding headers.

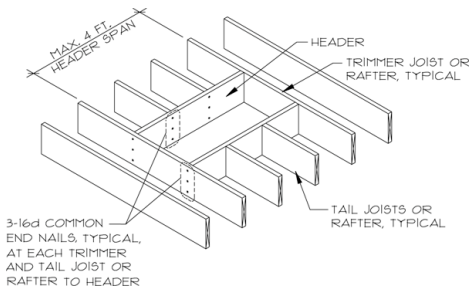

Figure 1A: *Basic floor framing for openings*

Some openings can be accommodated during the initial framing. Consult the blueprints to see where openings might go and header off any joists that might be in the way in advance. This is often much easier than working from underneath the subfloor later.

Once the framing is up and openings are cut, header joists should be added by end nailing a header across the cut ends of the interrupted joists and to the trimmer joists. This will transfer the load to the adjacent trimmer joists.

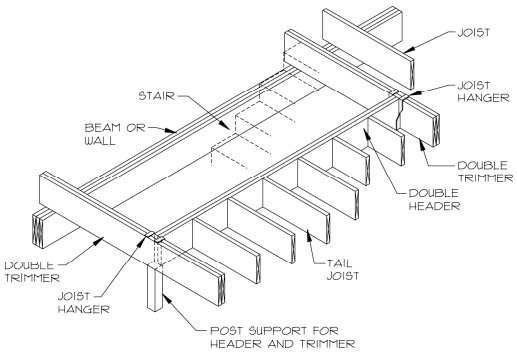

Figure 1B: *Opening perpendicular to floor joists*

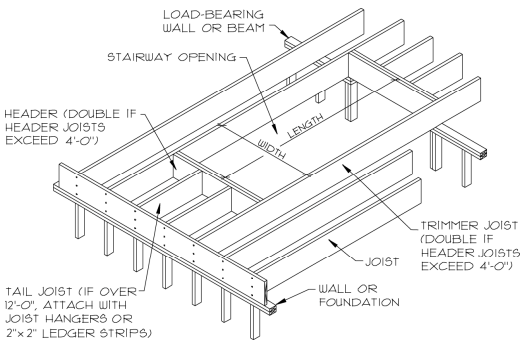

Figure 1C: *Opening parallel to floor joists*

A single header nailed to the tail and trimmer joists will work for openings less than 4 feet. If the header must span more than 4 feet, both the header and the trimmer joists should be doubled, or of lumber of equivalent cross section. The doubled trimmer and header joists must be nailed together properly (with spaced pairs of 16d nails every 16 inches) so that they act like beams. The doubled header joists can be attached by end nailing for spans up to 6 feet. For spans longer than 6 feet, headers must be supported by joist hangers or framing anchors. Any tail joists over 12 feet long should also be supported at the header by framing anchors or on ledger strips of not less than 2 inches by 2 inches.

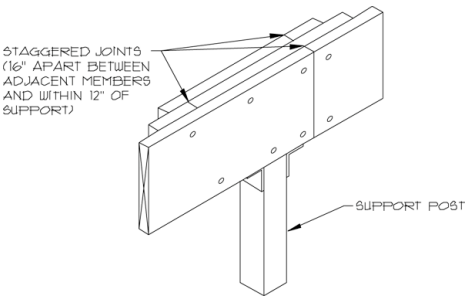

Figure 1D: *Staggered joints*

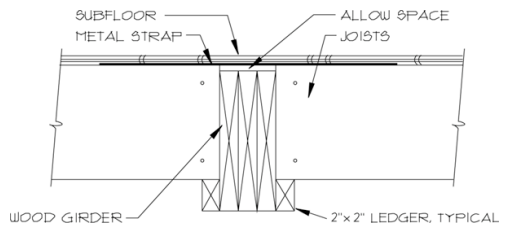

Figure 1E: *Supporting joists using ledgers*

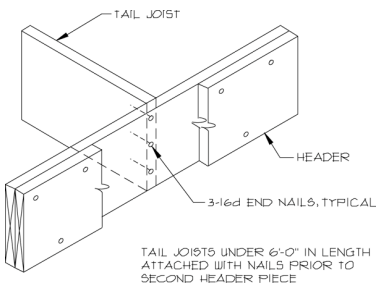

Figure 1F: *Nailing tail joists under 6 feet in length*

Joist Hangers and Nails

The use of joist hangers has improved the speed and performance of wood-frame construction. For these hangers to work properly, however, they must be correctly sized for the joist they are supporting.

Selecting the right size for a joist hanger is important because of the nailing required for the hanger to support the load. Deeper joists usually carry higher loads and hangers for these joists have more holes for nails. It is the shear strength of the nails that carries much of the load on the hangers, so more nails means a higher load-carrying capacity.

Nail size is important for attaching the hangers. The smallest nail that should be used with joist hangers is a 10d common wire nail. There are specialized nails for attaching joist hangers, which are only 1-1/2 inches long and perform similar to 10d common nails.

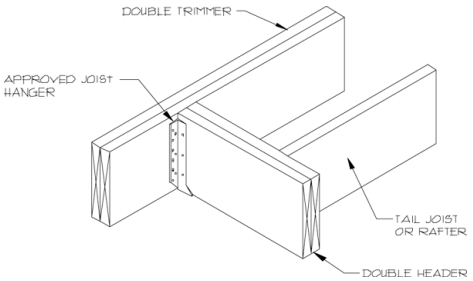

Figure 2a: *Joist hanger*

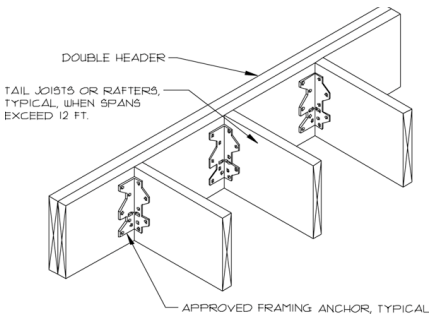

Figure 2b: *Framing anchor*

For double hangers, use 16d common wire nails. Do not substitute 16d sinker nails for attaching hangers; nail withdrawal strength is also important for attaching hangers and sinker nails can pull out too easily.

Blocking

Incorporating blocking between joists at supports is important – so important that it's required under building codes. The load on any structure must be transferred to the foundation. Joists provide that transfer, as long as they remain upright to receive the loads. Blocking ensures that the joists do not rotate under the heavy loads they are carrying.

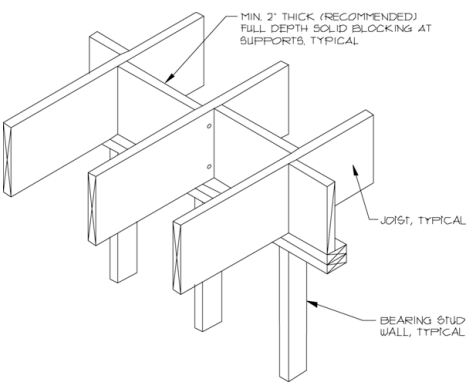

Figure 3: *Solid blocking to keep joists from rolling*

Holes and Notches

While cutting into a load-bearing member should be avoided, there are times when it may be necessary to cut a notch or drill a hole in a joist. Whenever holes or notches exceed the limitations listed below, the lumber is weakened and a portion of the load supported by the cut member must be transferred properly to other joists.

Specifically for floor joists, holes should not be bored closer that 2 inches from a joist edge, nor should they be larger than 1/3 the depth of the joists.

Notches are not allowed in the middle third of the span, where the bending forces are the greatest. Notches should be no deeper than 1/6 the depth of the joist, except at the ends where it can be no deeper than 1/4 the depth. Limit the length of a notch to 1/3 the joist depth.

At times, a notch may be cut so long that it becomes a rip. Unfortunately, ripping wide dimension lumber lowers the grade of the material and is unacceptable under all building codes. When a sloped surface is necessary, a non-structural member can be ripped to the desired slope and fastened to the structural member in a position above the top edge.

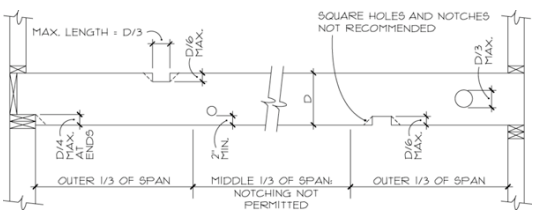

Figure 4: *Permitted holes and notches*

More information on notching and holes can be found in the WWPA TIP sheet A-11, *Notching & Boring Guide*.

Cantilevers

There is often confusion on how far a conventional cantilever can extend and still support a bearing wall. The old rule of thumb used by builders is to have twice as much joist length anchored in the building as is cantilevered. This rule, however, only applies to non-load bearing walls.

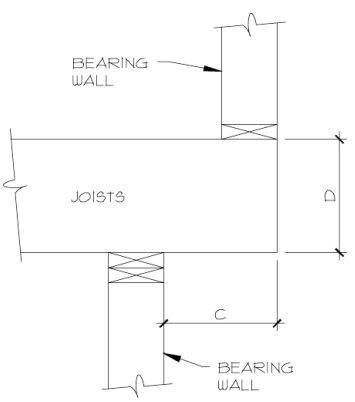

Figure 5: *Cantilever limits*

For load bearing walls, the maximum distance that joists can be cantilevered (C) without engineering is a distance equal to the depth of the joist (D), see Figure 5. Thus, for a 2x10 joist, the maximum cantilever for a load bearing wall is 9-1/4 inches, the net width of the lumber. Beyond this distance, shear forces and the bending moment at the support can become a problem, eventually causing splitting of the cantilevered joist.

Load Paths

All loads start at the roof and transfer vertically through the building to the foundation. If theses loads are not transferred properly, it can result in the cracking of interior finishes, sagging framing or crushed joists.

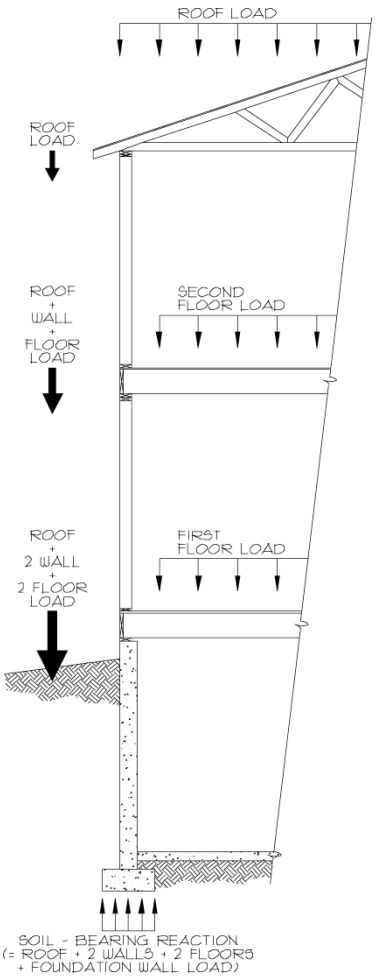

Figure 6A: *Vertical load path for gravity loads*

Building inspectors pay close attention to broken load paths and will red tag a job when they are encountered in a structure. Problems in transferring loads can be avoided by

aligning load bearing walls over supporting beams or walls, proper placement of roof framing and corresponding support struts and transferring column loads directly to the foundation.

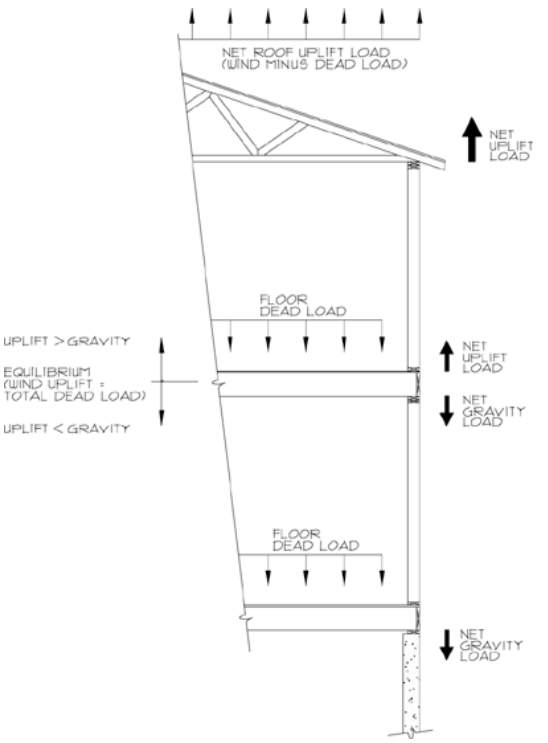

Figure 6B: *Load path for wind uplift*

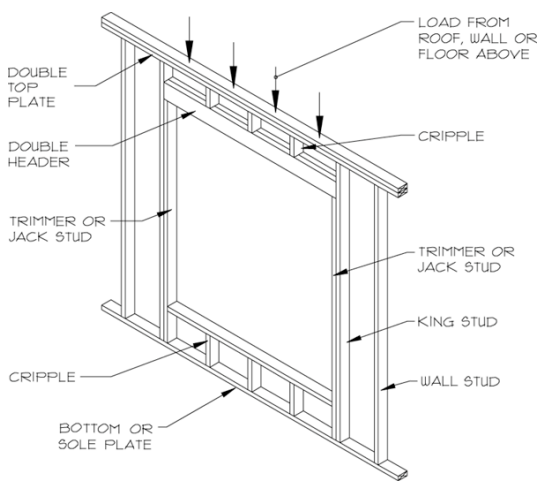

Figure 6C: *Load path*

Loads carried by bearing walls or posts must be transferred through the floor system. If a bearing wall does not line up with a bearing wall, post or beam below, the floor joists in between can be overstressed and cause severe deflection.

Load bearing walls can be offset from supports below, but only by a distance equal to the depth of the joists. For engineered wood I-joists, the codes require the loads to line up directly over each other and solid blocking or vertical squash-blocks are required to transfer the load around the web of the wood I-joist.

Specific engineered designs of either solid-sawn lumber or I-joists may allow placement of loads at other locations, but discontinuous load paths should not be attempted without consulting an engineer.

Struts are often used to support roof rafters when their lengths exceed the recommended clear spans. These struts should be supported by load bearing partitions or braced to a purlin running across the rafters and should form an angle not less than 45 degrees. Rafter struts should not land on non-load bearing walls or rest on "strong backs," the 2x bracing that runs across ceiling joists.

Columns must bear on elements that can support them. Resting a column on a floor or rim joist without extra blocking or support underneath can crush the underlying joists.

All columns should run continuously to the foundation. If that is not possible, the column should be supported by a beam or header designed to transfer the load to other columns or bearing members. To support a column on a rim joist, add full-depth vertical blocking inside the rim joist to the full depth and width of the column base.

Tapering Joists and Beams

It is sometimes necessary to taper the ends of a beam or joist to keep it under the slope of the roof. But reducing the depth of these members also reduces their load bearing capacity.

If joists must be tapered, make certain the length of the taper cut does not exceed three times the depth of the member and the end of the joist or beam is at least 1/2 the member's original size.

When taper cutting beams, it's also wise to consult a design professional to insure the beam's strength has not been severely reduced. If the tapered beam can't meet the criteria, it will have to be lowered into a beam pocket so that enough cross section can be left, after taper cutting, to carry the applied load.

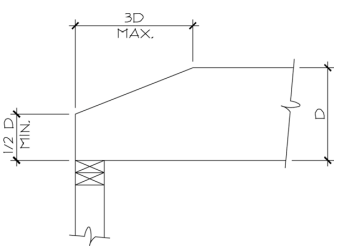

Figure 7: *Proper cutting of tapered joist ends*

Cutting Birdsmouths

Like tapering, cutting a birdsmouth into a rafter reduces the load-carrying capacity of the member. A common error with low-slope rafters is excessive cutting of the rafter seat. This leaves the rafter bearing not on the heel of the seat, as it should, but on the toe. This reduces the effective size of the rafter, producing stresses that can create splits at the bearing point, and eventually, a sagging rafter.

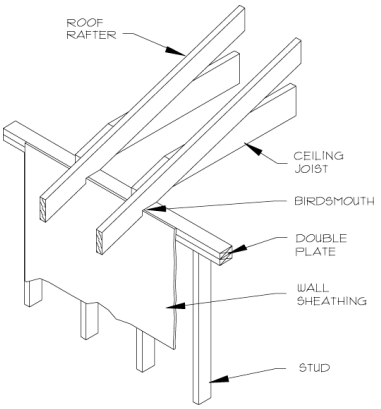

Figure 8: *Avoid sagging rafters by properly cutting birdsmouths*

Cut the rafters so the heel of the joist becomes the bearing point on the plate. Not only will this maintain the integrity of the joist, it will provide extra inches between the top of the exterior wall and the roof sheathing. This translates into more room for attic insulation to extend over the outside wall, reducing cold spots that can cause condensation or ice dams at the eaves.

Transferring Roof Loads

In today's large houses, the complexity of some roof structures makes it difficult to properly support some of the members. Too often, hips and valleys are unsupported or tied into lower ridges that are also unsupported.

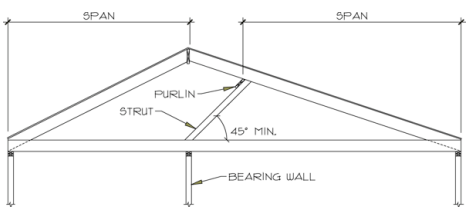

Figure 9: *Transfer roof loads using purlins and struts*

Hip and valley rafters need to be supported by headers or doubled-up rafters to handle the loads. Headers around openings such as skylights, up to 4 feet long, can be put in square with the rafters. Headers over 4 feet should be put in plumb and its members stepped to follow the slope of the roof. Header rafters more than 6 feet long should be supported by framing anchors. Roof loads are also transferred by the use of purlins and struts that will reduce long rafter spans. Specific requirements for the size and span of purlins, and the size and maximum unbraced length of struts can be found in the conventional construction provisions of the building code.

Rafter Ties and Ridge Beams

Cathedral ceilings are a popular addition to many homes today. But they pose special problems in dealing with the downward force of the rafters that push the exterior walls out. Proper placement of rafter ties and use of structural ridge beams can solve these potential problems, which often result in cracked walls or ceilings and walls out of plumb.

In a conventional wood roof truss, the bottom chord creates a tension tie between the outside walls. For a cathedral ceiling, open rafter ties, or collar ties, can serve the same purpose, provided the ties are placed within the lower 1/3 of the rafter span. The higher the ties go, the less leverage is available to counteract the forces pushing out.

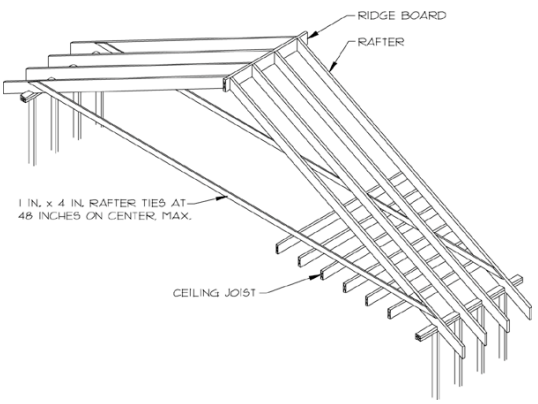

Figure 10A: *Ceiling joists perpendicular to rafters*

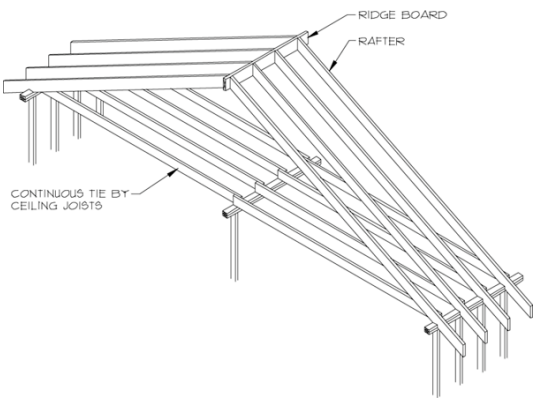

Figure 10B: *Ceiling joists parallel to rafters*

Placing a rafter tie in the middle of a rafter also causes complications. Hanging a drywall ceiling from the rafters will add dead load to the rafter at its maximum bending point. This additional load can cause the ceiling to sag and creates more outward thrust on the exterior walls.

The most effective way to reduce outward thrust is to use a structural ridge beam. The ridge beam must be supported on both ends (and, if necessary at intermediate point(s), along its length) and must be sized to carry the load that will be imposed on it.

Properly connecting the rafters to the structural ridge beam is critical. Given the forces at work, a toe-nailed connection is not adequate. Joist hangers, attached with proper nails, provide a strong connection. Or, cut a birdsmouth notch in each rafter and attach them as they rest on the top of the ridge. Remember, for a birdsmouth, cut no deeper than 1/4 the depth of the rafter.

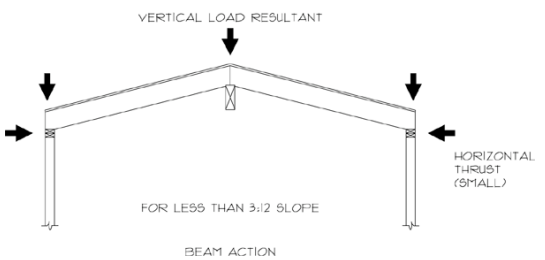

Figure 11: *Ridge beam load*

Trusses

Metal-plate connected wood trusses offer many advantages on the job site. But since trusses are engineered components, they should be treated differently from standard framing lumber.

Field alteration of trusses on the job site should be avoided. Cutting any truss will destroy the structural integrity of the truss. If it becomes necessary to cut a truss, a truss engineer should be consulted before any cuts are made.

Conventional wood trusses are designed to bear on the outside walls and clear span everything in between. The bottom chord of the trusses should not be attached to interior partitions. Attaching a truss to an inside wall can cause the web members designed for tension to become compression members.

Nailing the top plate of an interior wall to a truss can lead to cracked interior finishing in the wall and ceiling. During winter months, the uninsulated top chord picks up moisture from the surrounding air, causing the wood to expand. As it expands, it arches and pulls the bottom chord up with it. If the chord is nailed to the wall plate, it can either pull loose or pull the wall off the floor, opening a gap at the baseboard.

Special truss clips can be used to attach trusses to interior walls. These clips tie the two elements together, but allow the truss and wall to move independently.

Temporary bracing should be installed according to standard procedures outlined by the Wood Truss Council of America (**www.woodtruss.com**). Diagonal bracing at the ends and lateral bracing of the top and bottom chords can keep the trusses in place safely. Most truss makers include instructions for bracing with the specification sheets and other documents when the trusses are delivered.

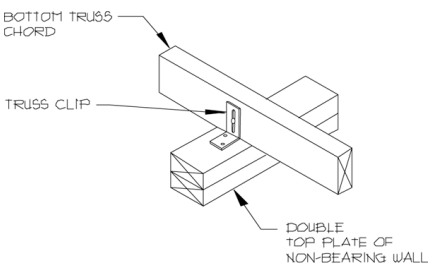

Figure 12: *Using truss clips*

Additional Information

Technical information on Western lumber products manufactured by WWPA mills is available through the Association's web site at **www.wwpa.org.**

Western Wood Products Association
1500 SW First Avenue, Suite 870
Portland, OR 97201-5861

503-224-3930
fax: 503-224-3935
e-mail: info@wwpa.org
web site: www.wwpa.org

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