Code-Compliant Guardrail Posts

by Mike Guertin

Use hardware for fast, solid, cost-effective connections

Though there has been little change to the guardrail requirements in the International Residential Code (IRC) in the past 10 years, guardrails have nonetheless received increased attention from code officials, and enforcement is changing. This may be largely due to research done at Virginia Tech that highlighted two key points. First, the code actually requires guardrails to be much stronger than most of us thought it did. And second, most traditional methods of mounting posts don't meet those strength requirements.

In this article, I'll show a number of post mounting details that do meet code requirements. Many of them are based on supporting materials from industry associations and manufacturers. (Supporting documents generally allay inspectors' concerns and give me peace of mind that I'm using the best practices available.) But there aren't supporting documents for every post-to-frame detail. In those cases, I draw on what I know of load paths and hardware and get my designs okayed by a building official before starting construction. Alternatively, I have a registered engineer design the connection.

It's ultimately up to your building official to decide whether your guardrail complies with the code, and you may not have to go to the measures I'll explain here. Still, it may be a good idea from both a sound construction and a risk management point of view — a structure's passing inspection does not entirely relieve you of liability.

The Case for a Stringent Code Interpretation

Guardrail posts act as levers when a force is applied along the top rail. The weak link isn't where the bolts hold the post to the rim joist but rather where the rim joist attaches to the joists. Nails and screws typically fasten the rim joist into the end grain of the joists, but they don't hold well enough to resist the posts' leverage. In fact, according to some experts, it's impossible to achieve a code-compliant post-to-joist connection on a wood frame without using special metal connectors to transfer the force on the

Figure 1. Once a standard engineering safety factor is applied, specialized hardware may be the only practical way to mount guardrail posts capable of withstanding the code-required 200-pound load.

posts directly to the joists (**Figure 1**). Sometimes the hardware is used to connect the post and rim joist directly to a joist; other times the hardware reinforces the connection of the rim joist to floor joists on either side of the post.

Much of the recent discussion about deck railings originated with an article in *PDB*'s sister publication, *The Journal of Light Construction* ("Strong Rail-Post Connections for Wooden Decks," February 2005, jlconline.com; portions republished in *PDB*'s *Question & Answer* department, May/June 2007, deckmagazine.com). That article detailed testing done at Virginia Tech of several typical post-to-joist connections (**Figure 2**). To design the test, the researchers first looked to IRC Table R301.5 (Minimum Uniformly Distributed Live Loads) and footnote "d," which require the guard to support a 200-pound concentrated load at any point along the top. Then they applied a safety factor of 2.5 — required by IBC section 1714 (Preconstruction Load Tests) for any tested assembly — and came up with a 500-pound test load.

Figure 2. In testing done at Virginia Tech, every traditional wood-to-wood post-mounting detail failed. It wasn't the post-to-rim-joist connection that failed, but the connection of the rim to the deck framing.

Since the *JLC* article appeared, I've heard a lot of discussion among deck professionals about whether guardrails need to be able to support a load of 200 pounds or 500 pounds. I've adopted the higher standard because other code provisions, referenced standards, and International Code Council Evaluation Service (ICC-ES) test criteria for manufactured guardrail systems all seem to support it.

For example, IRC section R317.4 calls for wood-plastic composites used in guardrail systems to comply with ASTM D7032. Several parts of ASTM D7032 apply here. First, Note 10 states that the requirements are based on the building code and a safety factor of 2.5. Then there is this test criteria: *Concentrated test load for guards - A 500-lbf [pounds per foot] load shall be applied ... at critical locations ... such as midspan of top rail, top rail alongside a post and at the top of a post.*

Additionally, the ICC-ES has two Acceptance Criteria that address manufactured guardrail systems: AC273 and AC174. Both criteria use the same load requirements and similar language as the ASTM standard.

Even though ASTM D7032 and the two ICC-ES acceptance criteria apply to manufactured guardrail parts and systems, it is reasonable to assume that the intent of the code would require field-built guardrails to be equally strong. And in no cases are 4x4 posts notched. Notched posts are no stronger than their narrowest cross-section.

Figure 3. Most manufactured railing systems require posts mounted inside the rim. That requires both a bracket to resist the outward force at the top of the rim, and blocking to resist the inward force at the bottom of the post.

Securing Blocking

Many post-to-frame details require blocking between or alongside joists. The blocks and how well they are fastened are critical to the connections because the hardware is screwed to them. Hardware-manufacturer instructions and good framing practice guide how I nail blocking.

Blocks nailed to the side of joists or rim joists get a minimum of 24 10d (3 inches by .148 diameter) hot-dipped-galvanized or stainless steel nails (left). The nails are arranged in three lines 2 inches down from the top, 2 inches up from bottom, and in the center. A 16-inch-long block will have three rows of eight nails spaced about 2 inches apart. An additional benefit of placing the nails 2 inches from the top is that doing so centers them on the bracket and ensures the nails won't get in the way of the bracket's screws.

Blocks between joists are fastened together with 12 10d nails. Four 16d nails driven through the joist or rim into the butt end of each block secure it to the joists.

Posts for Manufactured Guardrail Systems

While manufactured deck railing systems have specific instructions about assembling rails, balusters, and post sleeves, most rely on standard 4x4s for posts, and the instructions don't say much about post installation. Railing manufacturers require or recommend that the posts be "installed according to the building code," "approved by the building official," or "designed by a professional engineer," or that they meet some other qualification. In short, most instructions leave us to install the posts the same ways we do with site-built rails.

One difference is that manufactured deck railing systems usually require guardrail posts to be mounted inside the rim joist so post sleeves and base trim rest flat on the decking (**Figure 3, page 2**). But in most cases posts are easier to install outside of the rim joist. There is a way to use outside-the-rim mounted posts with manufactured railing systems — just add a 2-by skirt board outside the posts. You can either mount such a skirt board using the same bolts that mount the posts to the rim and the metal connectors, or fasten it with structural screws after bolting the posts. I find screwing the skirt on afterwards faster than bolting, even though I have to bore out the back of the board for the bolt heads.

The Hardware

The only configuration that resisted a 500-pound load in the Virginia Tech testing used Simpson Strong-Tie HD2A anchors (800/999-5099, strongtie.com) to connect the post to the joists. The HD2A was originally intended as a heavy-duty hold down for resisting seismic or wind loads on walls. It requires three $\frac{5}{8}$-inch-diameter bolts; two through the joist and one through the rim and post. When I used the HD2A hardware, it was often hard to find hot-dip-galvanized $\frac{5}{8}$-inch bolts — especially the $2\frac{1}{2}$-inch-long ones used through the joist. Locally, the HD2A and the bolts cost $18.49.

In 2009, Simpson Strong-Tie introduced the DTT2Z and USP the DTB-TZ (800/328-5934, uspconnectors.com). Another connector, the DeckLok Bracket (deck-lok.com), is also claimed to work for mounting guard posts, but it's been unavailable for about a year. Its inventor, Michael Morse says that it will be back on the market this spring.

Both the DTT2Z and the DTB-TZ (**Figure 4**) are designed and tested to create post-to-joist connections that meet the 500-pound load requirement, and both mount to the joist with eight structural screws (included). The only hole you have to bore is the one through the

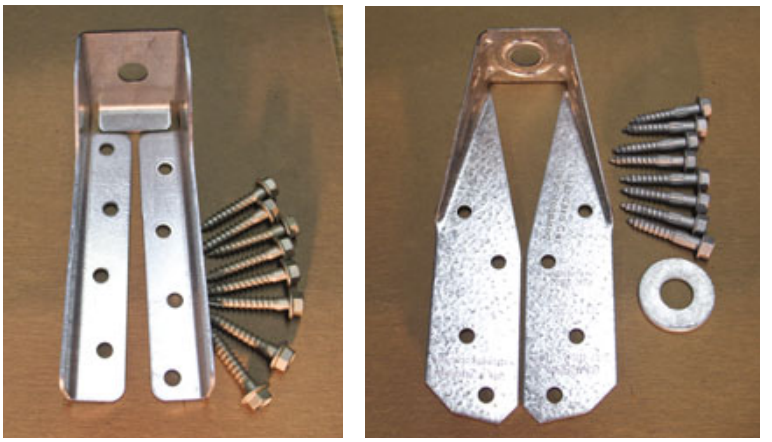

Figure 4. USP's DTB-TZ (left) and Simpson's DTT2Z (right) are two connectors that can provide IRC-required strength to a guardrail post. In addition to the structural screws shown, both require a $\frac{1}{2}$-inch hot-dip-galvanized bolt to complete the connection.

post and rim. I have a hard time finding the USP hardware locally, so I can't quote a price for it, but the Simpson DTT2Z and a single 6-inch-by-1/2-inch bolt costs me $10.05. Plus, because both Simpson and USP substitute structural screws for the two bolts used to connect an HD2A to its joist, installation labor is much lower. Bolts are still used to connect the hardware to the post and the rim. The length of the bolts will vary with the conditions; in some cases, you may have to use threaded rod. (One source for hot-dip-galvanized threaded rod is Jamestown Distributors; 800/497-0010, jamestowndistributors.com.)

One caveat: Although the IRC calls for the top of guards to resist force in "any direction," common sense holds that the outward direction is the highest priority, so the metal connector hardware is installed at the top bolt location where it best resists outward force. The bolts are placed 2 inches down from the top of the joist except at corners where two bolts cross one another. In those cases, I locate one bolt 2 inches down and the other 2 1/2 inches down.

None of the hardware mentioned above will provide the required strength if the joists are smaller than 2x8. With shallower joists, the post-lever is too long relative to the distance below the fulcrum (the point where the bolt joins the hardware to the post), and there's no way that I know of to meet the 500-pound load requirement using 2x6 joists. And if you use a railing much higher than 36 inches, the longer lever arm may also put you out of compliance (See *Question & Answer,* this issue).

Figure 5. A small drill press set up with a plank to support the posts makes for fast, accurate, and nearly effortless boring.

Figure 6. A site-built jig ensures accurate hole placement. The author marks the hole locations with a nail set.

For Accuracy, Use a Drill Press

I bore enough holes through the posts on even a medium-sized deck that it's a time savings to systemize the task. Also, holes bored with a hand-held drill can drift off line, which is fine if you don't have to hit a target on the other side, but when mounting hardware, you can't be off much. And when bolts cross over one another inside a post as they do on some corners, there's no room for error. I address all these conditions by marking the posts with a pattern jig and boring the holes with a small drill press (**Figure 5**).

The pattern jig is a piece of 1/4-inch plywood with bottom and side stops made from scraps (**Figure 6**). The bolt holes in a post should be 2 inches above the bottom of the joist and 2 inches below the top of the joist. In the jig, I drill a 1/8-inch hole 2 inches up from the bottom stop, and then others at 5 1/4 inches for 2x8s, 7 1/4 inches for 2x10s, and 9 1/4 inches for 2x12s. I drill two sets of holes in the jig, one 1 3/4 inches in from the side stop so they center on the post, and the other 2 3/8 inches off-center for bolts in blocked-out brackets. This dimension might differ if you use USP or DeckLok brackets.

I mark the posts through the jig with a nail set and a hammer. It's faster than a pencil, and a deep dimple is easier to see than a tiny pencil dot. Also, the drill point centers on the hole nicely. When marking posts with cross bolts, I simply tack a 1/2-inch block to the bottom stop and the holes are automatically adjusted. A jig lasts a whole deck building season (or until it gets lost).

The advantages of boring with a drill press more than make up for the effort of hauling it from the truck. The holes are square to and straight through the posts, and later will become the guides for boring through the rim joists. A production boring station takes five minutes to set up and I can drill through post after post in no time. Working at a comfortable level and letting the machine do the work is a whole

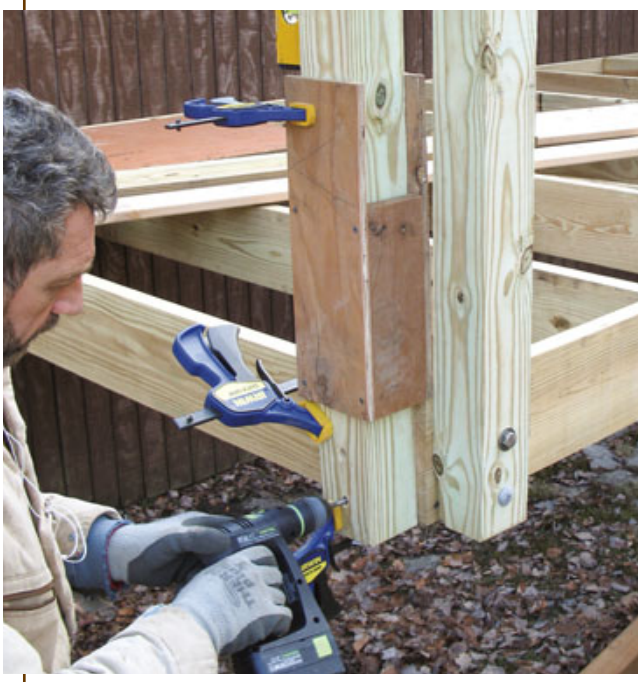

Figure 7. A box made from scraps clamped to the post acts as a positive stop to hold the post at the right height. Additional clamps secure the post to the rim, whose bolt holes are then drilled using the holes in the post as guides.

lot easier than contorting and pushing to bore holes by hand. I set the drill press downstream from the miter saw so a couple of guys can work a production line for efficiency.

Another set-up makes drilling through the rim joists a breeze too. While you could just clamp a post to the rim joist, it's faster and easier to have a positive stop that sets the post at the proper height. For that, I make a 3¾-inch ID box tube out of wood scraps (**Figure 7**). Two opposite sides of the tube are about a foot long and the others are 16 inches. The long sides are the squeeze point and the bottom serves as a positive stop.

To use it, I mark a line on all the posts 37 inches down from the top. Then I slide the box tube down the post, align the tube's bottom with the line, and squeeze the long sides tight to the post with a clamp. When I first set the post on the rim, its weight is borne by the box tube. This allows me to loosen and tighten the clamps I use to hold the post to the rim without losing the height position. Another clamp holds a level to the post so the whole operation becomes a fast, one-person job.

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Post Attachment Details

The following illustrations are grouped based on whether the posts attach outside or inside the rim joist. Though it seems like a simple difference, the connection details differ. The reason is that when the top of an exterior post is pushed outward, the resulting inward force at its base is resisted by the framing. Interior posts require additional blocking to resist that inward force.

For each detail, I've noted my source or sources. I draw from the American Wood Council's *DCA6-09* (awc.org/publications/DCA/DCA6/DCA6-09.pdf), Simpson Strong-Tie's technical bulletin *Code-Compliant Guardrail Post Connections,* and USP's *Professional Design Manual and Product Catalogue.* When there are no published details for a configuration, I extrapolate from tested designs. My designs (labeled "MG") are not tested, however. Before using them, check with your local building official or an engineer.

Some configurations with wide post spacing depend on the railings' cantilevering past the posts to the corner. Use these only when the rails are mounted to the posts' faces, never when they are set between posts. Top and bottom rails must span at least two posts in order to support the free ends at the corner.

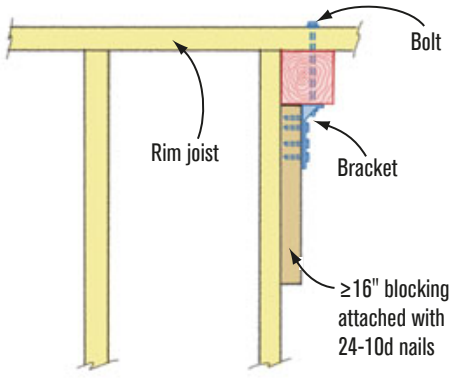
ALL ILLUSTRATIONS BY CHUCK LOCKHART

POSTS INSIDE THE RIM JOIST

A. Post Alongside Joist

Reinforce the post by nailing a 16-inch or longer block to the side of the joist, and mount the hardware on that block. If uniform post spacing doesn't correspond to the proposed joist layout, either change the joist layout to match the post layout or add extra joists at post locations. It's okay if the bolt isn't centered on the post.

SOURCE: SIMPSON STRONG-TIE

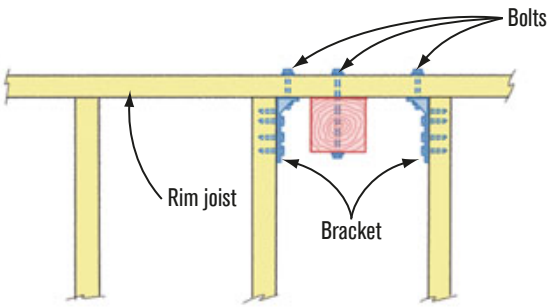


POSTS INSIDE THE RIM JOIST (continued)

B. Post Not Aligned to Joist

Though this solution uses two pieces of hardware, it may be cheaper than adding a joist to mount the post as in (A). Mount hardware to the sides of the two adjacent joists and bolt the post to the rim joist. Hardware can mount to either side of the joists.

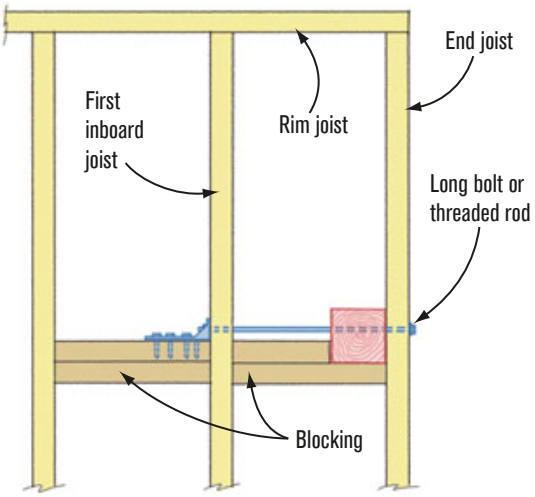
SOURCE: MG

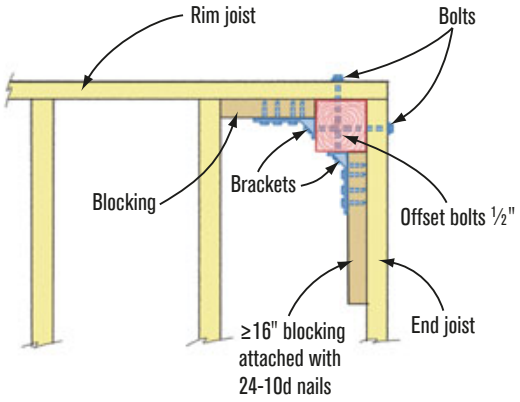


C. Post at End Joist

When an interior post is attached to an end joist, transfer its load back into the floor system with two sets of double blocks. Install one block alongside the post and between the end joist and first inboard joist, and the next tight between the post and the first inboard joist. Install a second set of blocks between the first and second inboard joists. Connect the bracket on the second pair of blocks to the post with a long bolt or threaded rod.

SOURCE: SIMPSON STRONG-TIE

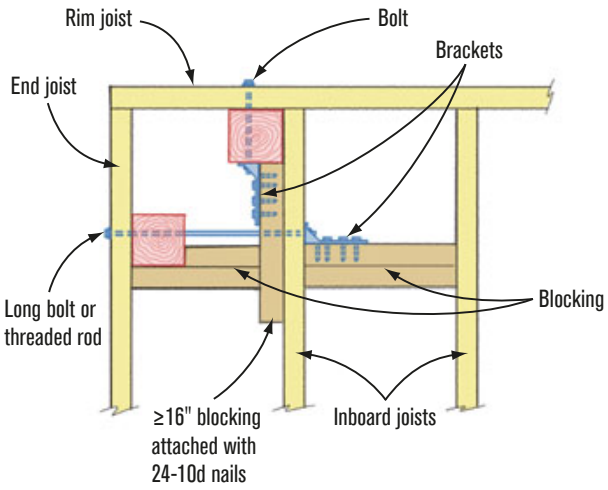




D. Post at 90-Degree Outside Corner

Block tight to a single corner post and run connectors in two directions. Position one connector and bolt 2 inches down from the top of the rim or end joist, and the second 2½ inches down on the other joist.

SOURCE: MG

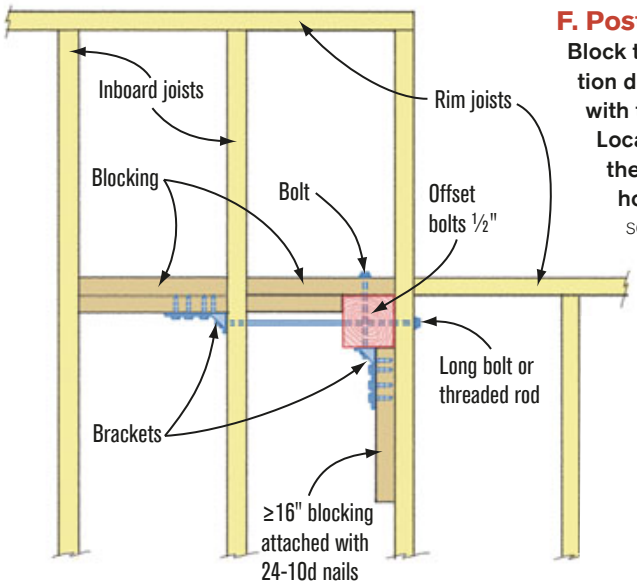


E. Paired Posts Set Back at Outside Corner

Locate one post alongside the first inboard joist and nail a 16-inch block to the joist with one end tight against the post as in (A). Block back two joist bays from the post on the end joist, and secure the hardware with threaded rod as in (C).

SOURCE: SIMPSON STRONG-TIE

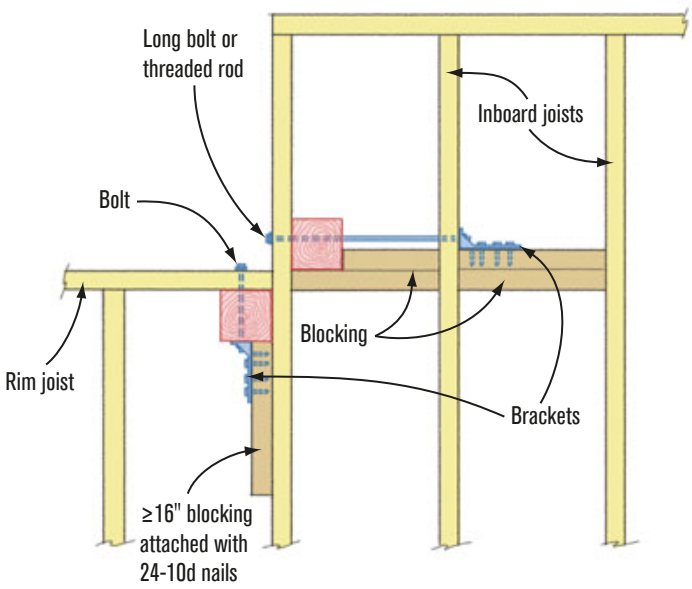
POSTS INSIDE THE RIM JOIST (continued)



F. Post at Inside Corner

Block the post in two directions using the installation details for (A) and (C). Align one set of blocks with the rim joist of the narrow deck section. Locate one bracket and hole 2 inches down from the top of the joist, and the other bracket and hole 2½ inches down.

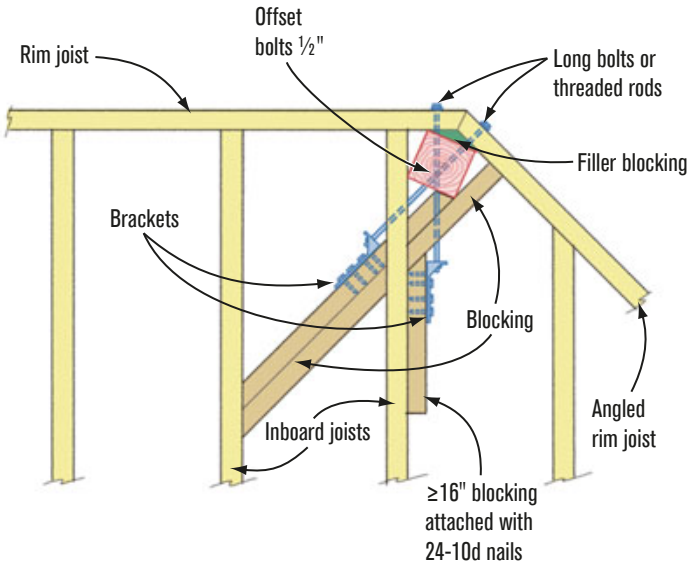
SOURCE: MG



G. Paired Posts at Inside Corner

Bracket the post inside the narrower deck section to a block on the joist as in (A). Block the second post back two joists into the deck frame as in (C). Align the block between the rim joist and the first inboard joist with the rim joist of the narrower deck section.

SOURCE: MG



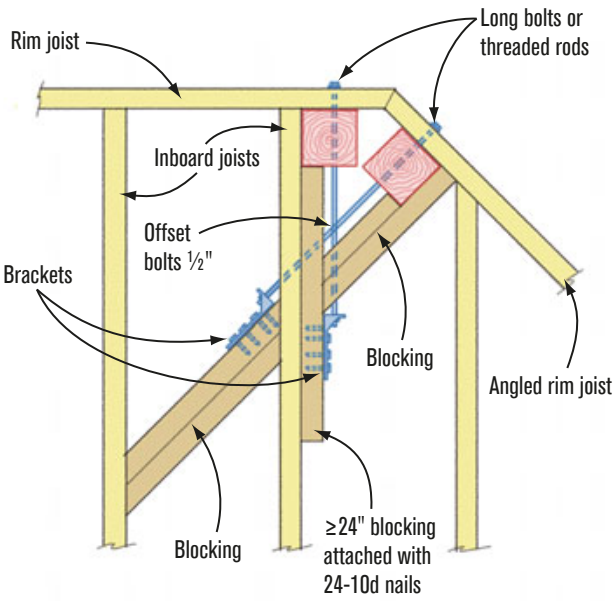
H. Single Post at Outside 45-Degree Corner

This arrangement of blocks secures the post in two directions. The installation sequence and hole alignment are critical.

Cut a 22½-degree block to fill between the post and the outside corner. Install a joist to the primary rim joist, alongside the post. Install a block on the other side of the post, 90 degrees to the angled rim joist and 45 degrees to the inboard joist. Install a second block inside the first, between the post and the floor joist. Continue double-blocking back one additional joist bay. Mount a bracket to the second set of blocks and bolt through to the angled rim joist. Bore the hole 2½ inches down from the top of the joists. Next, install a 16-inch-long block to the side of the joist, butted to the first set of blocks. Mount a bracket to the block; bore the bolt hole 2 inches down from the top of the joists. Use a long bolt or threaded rod.

SOURCE: MG

POSTS INSIDE THE RIM JOIST (continued)

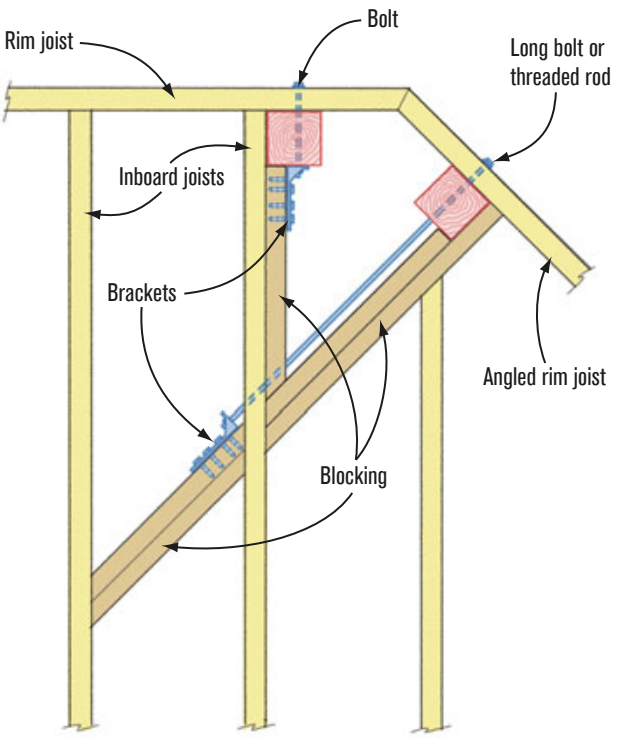


I. Paired Posts at Outside 45-Degree Corner

These posts fit to the inside of each rim joist and touch one another on the inside corner. The installation sequence and hole alignment are critical.

Position the posts and install a floor joist to the primary rim joist alongside one post. Butt a 24-inch-long block to the back of the post and nail it to the joist. Double-block back two joist bays from the angled rim joist. Mount one bracket so its bolt hole is 2½ inches down from the top of the joists, and the other so its bolt hole is 2 inches down. Use threaded rod. The face of the brackets won't rest flat against the floor joist or blocks; just butt the edge to the joist or blocking.

SOURCE: MG

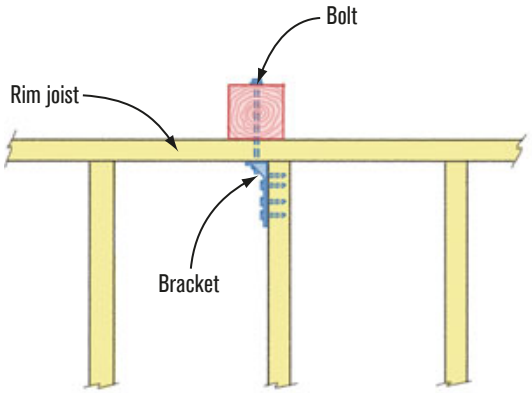


J. Set Back Paired Posts at Outside 45-Degree Corner

When the posts are spaced 6 to 12 inches from a 45-degree corner, installation is similar to (I). The face of the bracket at an angle to the floor joist will not nest tight to it; position the bracket so the edge touches the joist. It may be necessary to shorten a joist to accommodate the blocking.

SOURCE: MG

POSTS OUTSIDE THE RIM JOIST

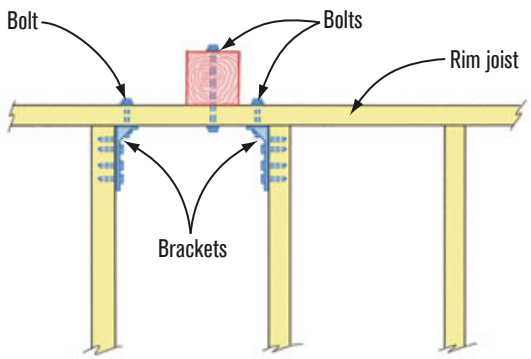


K. Post Aligned With Joist

Hardware mounts to the joist and bolts through the rim and the center of the post. If post spacing doesn't correspond to the proposed joist layout, either change the joist layout to match the post layout or add extra joists at post locations.

SOURCE: DCA6-09, SIMPSON STRONG-TIE, USP

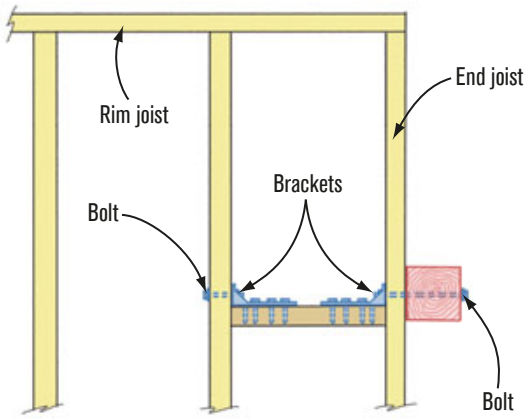
POSTS OUTSIDE THE RIM JOIST (continued)



L. Post Not Aligned to Joist

Hardware bolted through the rim joist can be mounted on either side of the two joists adjacent to the post. The post bolts to the rim joist.

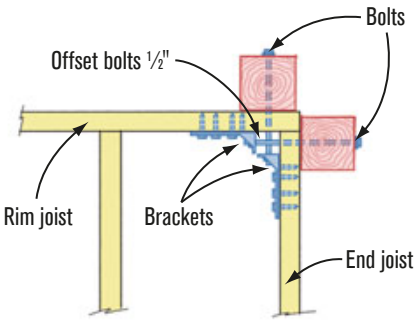
SOURCE: DCA6-09



M. Post at End Joist

Posts attached to end joists require solid blocking with hardware on each end to tie the post back into the inboard joist. To ease installation, bore bolt holes through the post and end joist, orient the connector, and align the block to match.

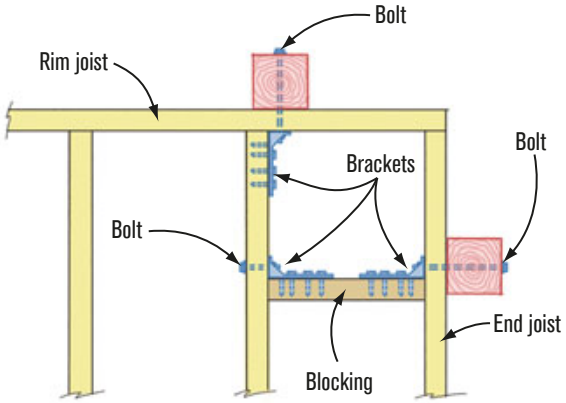
SOURCE: DCA6-09, SIMPSON STRONG-TIE



N. Paired Posts at Outside 90-Degree Corner

The posts are about 1 inch apart and centered on the connector bolt holes. Hold the connector faces away from the opposite rim joists for clearance and use 8-inch bolts to accommodate the backset. Offset the bolts by positioning one 2 inches down from the top of the rim joist, and the other 2½ inches down.

SOURCE: MG



O. Paired Posts Set Back From Outside Corner

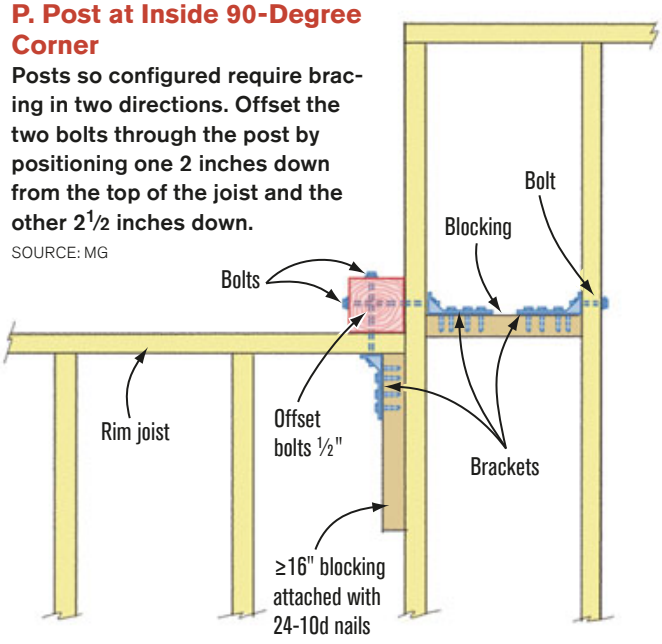
When posts are held back 12 to 16 inches from an outside corner, the post along the rim joist is bracketed to a joist as in (K). The post along the end joist is blocked and bracketed as in (M).

SOURCE: SIMPSON STRONG-TIE

P. Post at Inside 90-Degree Corner

Posts so configured require bracing in two directions. Offset the two bolts through the post by positioning one 2 inches down from the top of the joist and the other 2½ inches down.

SOURCE: MG

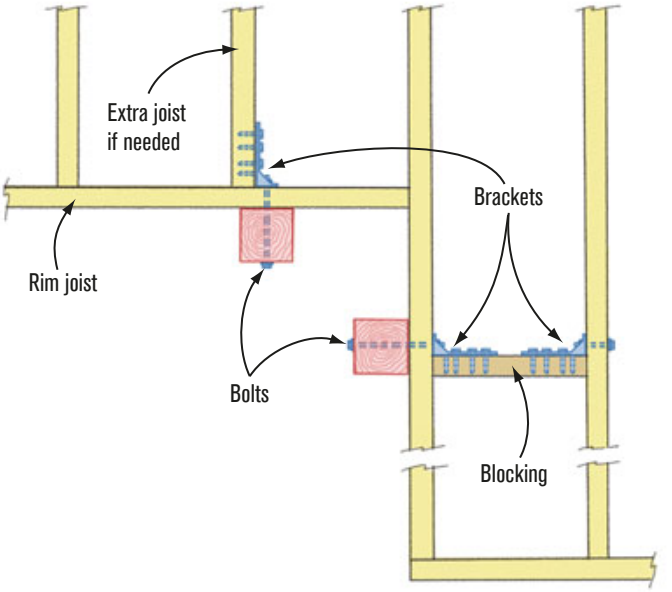


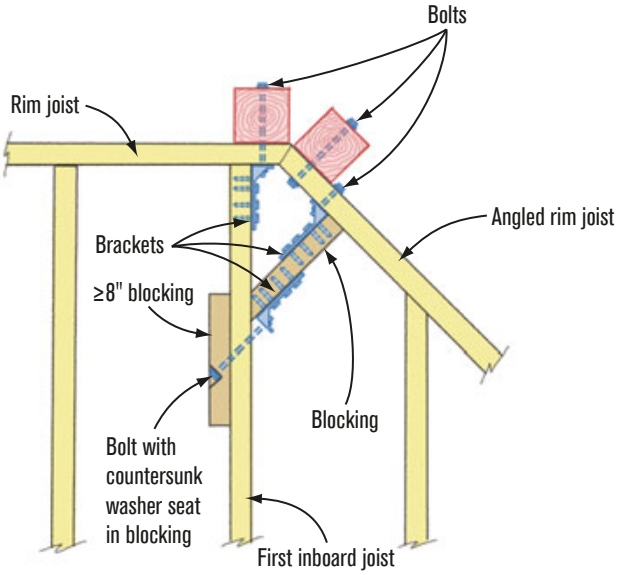
POSTS OUTSIDE THE RIM JOIST (continued)

Q. Two Posts at Inside 90-Degree Corner

When rails will cantilever to an inside corner, the posts are set back 8 to 16 inches. Installation is similar to (O). An extra joist can be added in the narrow deck section to align with the desired post position. The posts should be spaced equally from the inside corner for symmetry.

SOURCE: MG

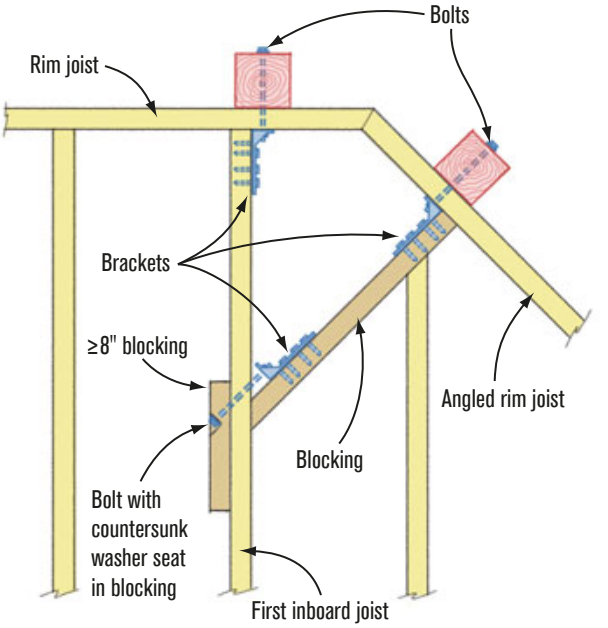




R. Paired Posts at Outside 45-Degree Corner

Secure the first post to the main rim joist as in (K), installing a joist if needed so the bolt through the hardware will center on that post. Bolt the second post to the angled rim and reinforce it with a block that extends to the first inboard joist, tying it in with hardware at each end. Fasten an 8-inch block on the opposite face of the first inboard joist. Bore a 45-degree pocket in that block for the bolt head and washer to seat into. The face of the bracket will not nest tight to the floor joist; just position it so the edge touches the joist.

SOURCE: MG



S. Paired Posts Set Back From Outside 45-Degree Corner

Posts spaced 8 to 16 inches from a 45-degree corner are configured as in (R), except that the hardware on the angled blocking bolts directly to the post, not just to the angled rim. It may be necessary to shorten a joist to accommodate the blocking. ❖

SOURCE: MG