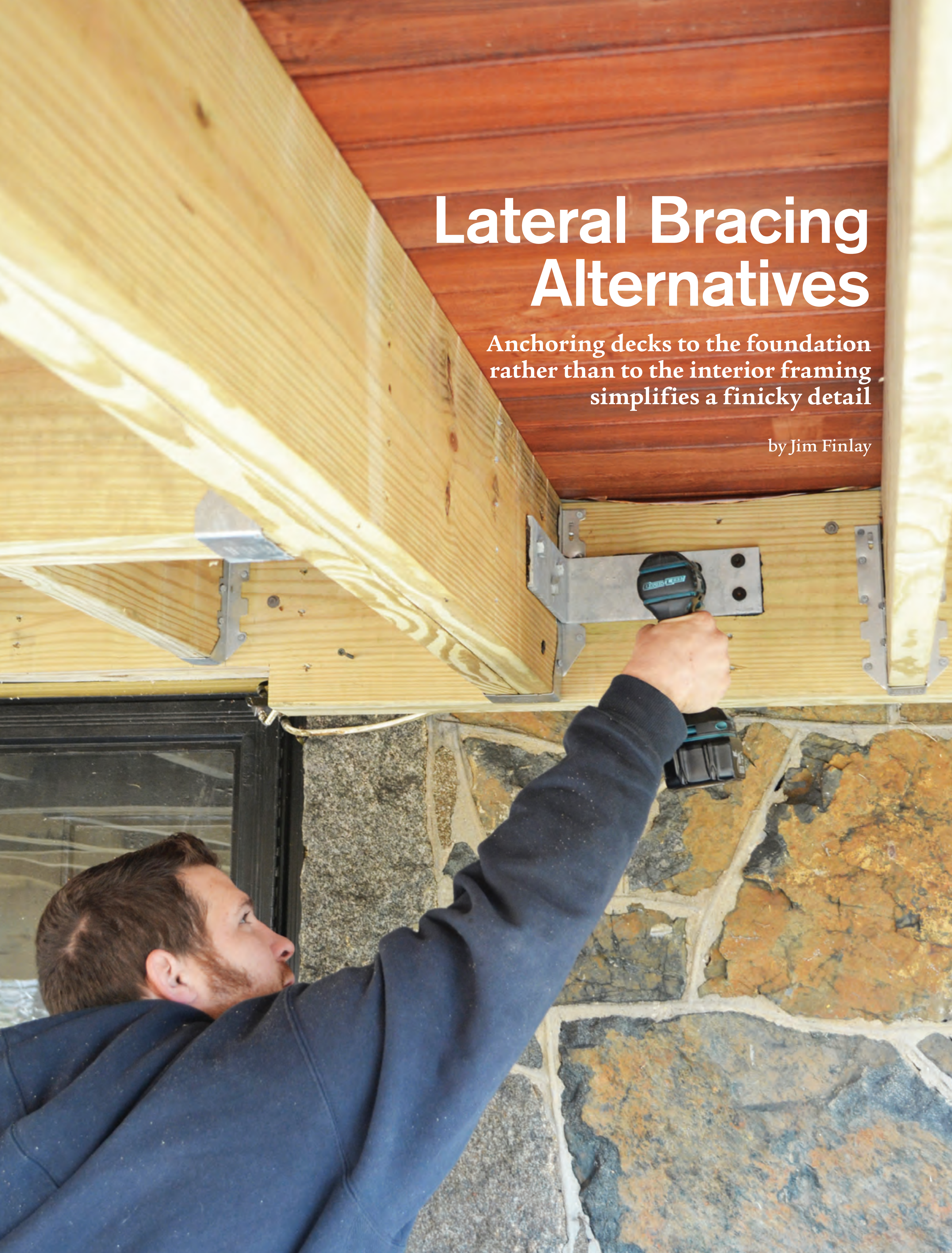

Lateral Bracing Alternatives

Anchoring decks to the foundation rather than to the interior framing simplifies a finicky detail

by Jim Finlay

The 2009 IRC, which is the building code in my area, requires that a deck connected to and supported by its primary structure be "designed for vertical and lateral loads as applicable" (2009 IRC, R502.2.2).

The IRC's vertical load requirement is clear: 50 pounds (40 live plus 10 dead) per square foot. Using a deck's dimensions, you can easily calculate its vertical load on the connection between the deck ledger and the house band, and then refer to the code to find connection details and attachment configurations.

However, the IRC's lateral load provision—intended to prevent a deck from being pulled away from its supporting structure—is anything but clear, as most deck builders know.

Instead of quantifying general lateral load requirements, the code offers a single solution with a specific design capacity: You are "permitted" to install the mechanism drawn in IRC Figure 502.2.2.3—two Simpson Strong-Tie DTT2s (strongtie.com) connected by a threaded rod, with one fastened to a deck joist and the other to a house joist (**Figure 1**). Two of these mechanisms, each resisting 1,500 pounds, must be installed, regardless of the deck's size or shape.

Note that the IRC does not require this detail, nor does it set a lateral load requirement of 1,500 pounds. That load is merely what the allowed "hold-down device" should resist.

Unfortunately, installing this device poses numerous difficulties, especially after a house is built. Not only is it labor-intensive, it's arguably unnecessary for many decks (see Bad Solution to a Non-Existent Problem, page 40). In fact, lateral load requirements are slated for revision in upcoming versions of the IRC (see *Structure*, page 16).

More Than One Option

If you dislike the lateral-load anchor currently permitted by the IRC, what are your options? The code allows alternatives, but offers none. In this article, I'll describe a few solutions for resisting lateral loads that my deck-building company has successfully employed on our projects.

In my area, and probably in yours too, enforcement of the lateral brace provision is inconsistent. Of the 21 towns where I build decks, only one requires the code-specified bracket or an engineer-stamped solution. Four of the towns want "something reasonable," and the rest ignore the provision altogether. So I've organized my alternative solutions into two categories: "engineered solutions," which have been formally tested or stamped by an engineer; and non-engineered "informal solutions," which are versatile details we've been able to use when the inspector doesn't require

Figure 1. The lateral-load anchor "permitted" by the current IRC requires access to the interior house framing. In an existing house, it's impossible to verify that the subfloor attachment meets requirements without removing finished flooring.

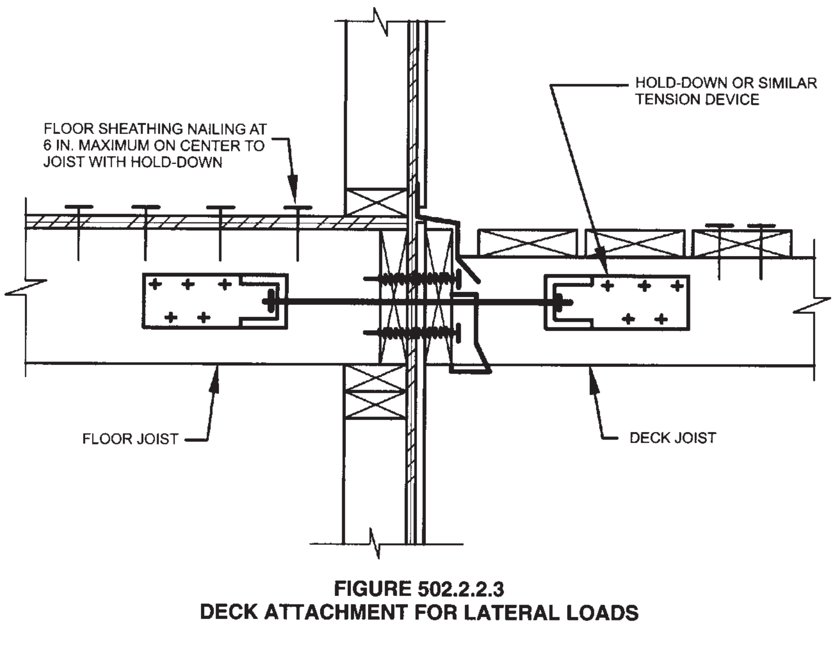

FIGURE 502.2.2.3
DECK ATTACHMENT FOR LATERAL LOADS

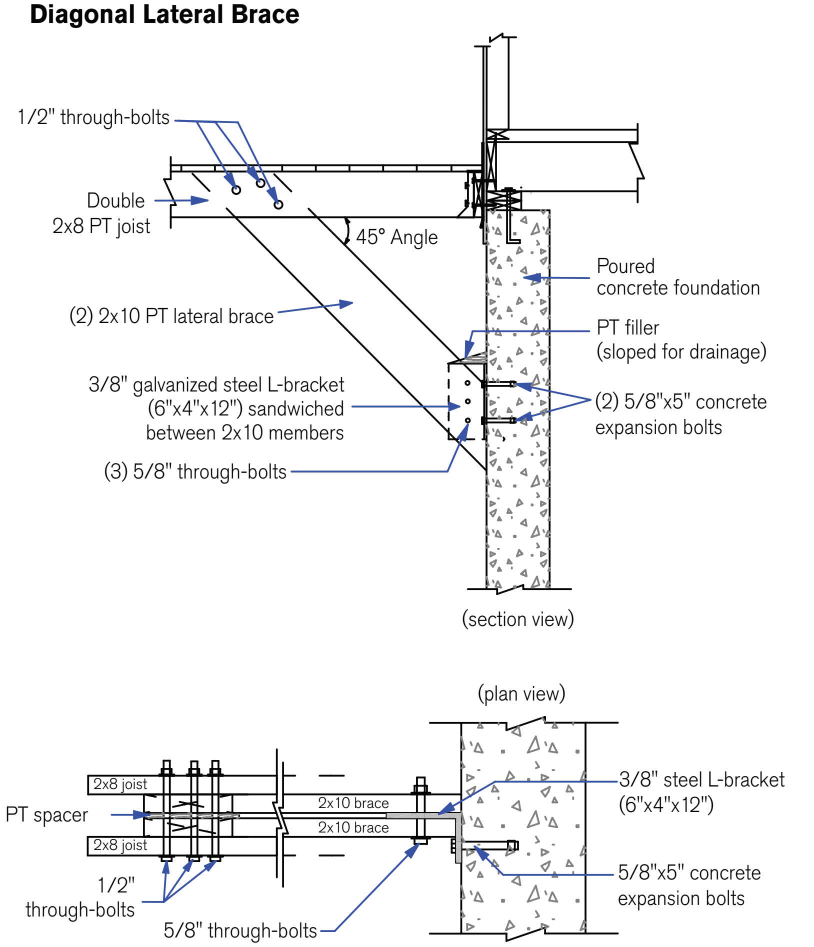

Figure 2. This engineered brace provides 1,500 pounds of resistance to lateral loads and can be installed from the exterior. The diagonal brace is installed at a 45-degree angle and measures 5 feet from long point to long point, requiring that the deck be more than 3½ feet above grade.

Figure 3. The author designed a second custom L-bracket for use without a 2-by brace. It's fabricated from ¼-inch-thick steel plate, with each leg measuring 3 inches by 9 inches. The brackets are hot-dipped galvanized for corrosion protection, and when installed, are isolated from treated framing with self-adhering flashing.

an engineer's stamp—but that may or may not be approved by your building inspector or engineer.

Engineered Solutions

Diagonal foundation brace. The first alternative lateral-load anchor for a deck I ever designed consisted of a double 2x10 diagonal brace anchored to the deck framing with ½-inch through-bolts and to the foundation wall with a beefy 6-inch by 4-inch by 12-inch-long L-bracket fabricated from ⅜-inch steel (**Figure 2**). My engineer approved it—and I expect yours would too. It's well-suited to larger decks. Unlike the code-approved solution, this anchor can be installed without accessing the building's interior. Not only that, it allows the deck to be installed 6 or 7 inches below the elevation of the house floor, a common detail in wet or snowy climates.

Materials for one diagonal brace cost about $72 (since two are needed, total cost is $144). Installation labor is roughly one hour per brace, depending on the age and density of the concrete foundation. Once installed, each brace will resist 1,500 pounds of lateral force, just like the "permitted" hold-down device.

L-bracket. To further simplify anchor installation, I've also designed an L-bracket that doesn't require the diagonal 2-by brace (**Figure 3**). My local steel fabricator cuts 3-inch by 18-inch strips from standard ¼-inch-thick steel plate and bends them 90 degrees into L-brackets with two 9-inch legs. After drilling the holes, he has the brackets hot-dipped galvanized. Because of the set-up time involved, the more I buy, the lower the unit cost; so I order three dozen at a time, which brings my cost down to about $20 per bracket.

To connect a bracket to a doubled joist, I use six 4½-inch HeadLOK (fastenmaster.com) screws (**Figure 4**). The screw manufacturer has formally tested this configuration in shear, parallel to the grain of wet #2 pressure-treated SYP, for a double 2x8 joist. In testing, the connection exceeded 1,500 pounds in shear, even after factoring in a 3x safety margin. Though the brackets are galvanized, we isolate them from treated joists with a piece of Bituthene or Vycor (graceresidential.com) or a similar self-adhering membrane.

There are several options for bolting the bracket to the concrete. For example, a galvanized ½-inch-diameter by 4¼-inch-long Red Head Trubolt wedge-type expansion anchor bolt (itwredhead.com) embedded 3⅜ inches into concrete can safely resist more than 1,900 pounds of withdrawal force, or more than 2,900 pounds in shear. Other concrete fastening options include sleeve anchors (available in stainless steel), strike anchors (available in yellow-dichromate-plated steel only), and epoxy-bolt systems.

The size of the anchor depends on the density of the concrete. Since that is virtually impossible to test, I generally assume (in the absence of visual deterioration) that foundation concrete has a compressive strength of 2,500 psi, the weakest allowed by code (2009 IRC, Table R402.2).

It's also critical not to install the anchor bolts any closer to the edge of the concrete than the manufacturer recommends. When the upper hole of the L-bracket would be too close to the top edge of a foundation (within 3¾ inches for ½-inch-diameter Red Head Trubolts, for example), I use a 2x4 PT spacer to lower the bracket, and I upgrade the joist-attachment screws to 6-inch HeadLOKs (**Figure 5**).

Materials for this anchor cost about $41, including the $20 bracket and the second joist. Installation usually takes less than 30 minutes. As a bonus, this L-bracket provides vertical support in addition to lateral strength.

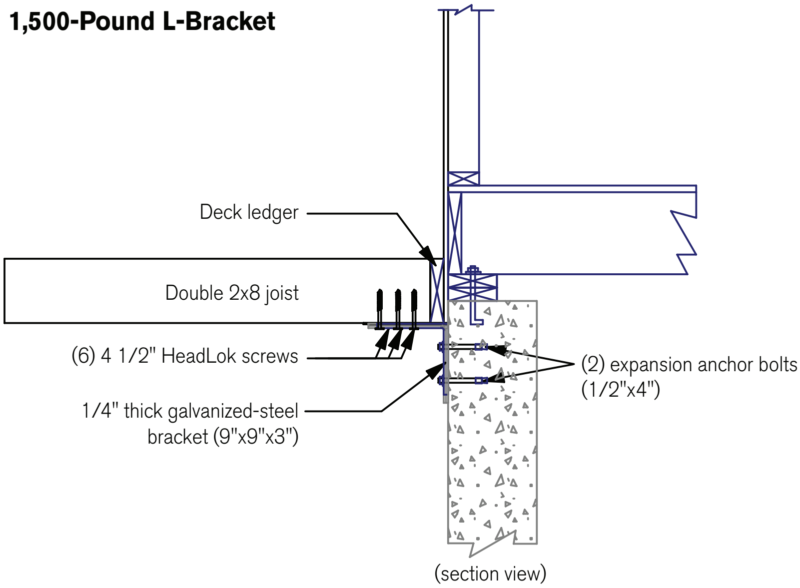

Figure 4. When installed as shown above, the author's custom-fabricated ¼-inch-thick steel brackets provide 1,500 pounds of resistance to lateral loads.

Figure 5. Sometimes blocking is required to avoid installing concrete anchors too close to a foundation edge. In those cases, the author uses 6-inch instead of 4½-inch-long HeadLOK screws to attach the bracket to the doubled joists. The bracket in the photo was fabricated from ½-inch-thick angle iron (the steel was manufactured as a 16-foot-long angle bar with two 8-inch flanges). While the steel is much thicker than necessary, it was readily available, and the fabricator could just cut off 3-inch-wide pieces of the angled steel.

Figure 6. When the deck framing is aligned with the house framing, a simple metal strap can provide sufficient strength to meet lateral load requirements. On existing construction, the siding and sheathing must be temporarily removed to gain access to the framing.

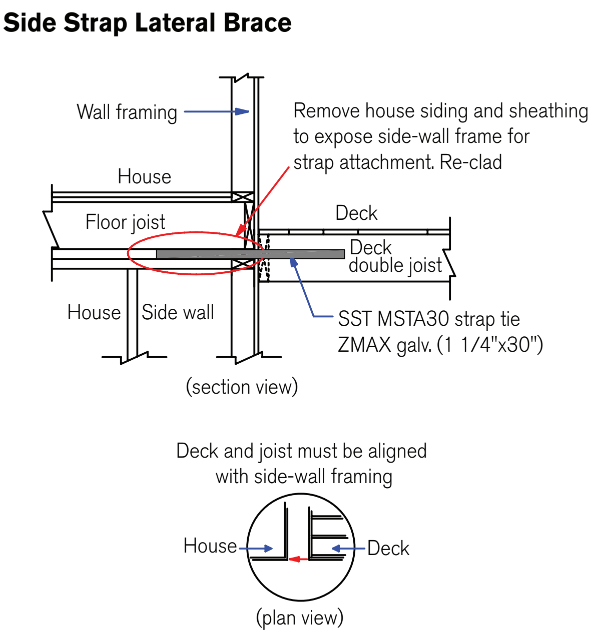

Figure 7. When installed as shown above, Simpson's MSTA30 strap ties offer 1,820 pounds of allowable tension loads in SPF framing, more than enough to meet the IRC's 1,500-pound lateral load requirement for permitted devices.

Note that the diagonal-brace and L-bracket details connect to poured concrete foundations, which are common in my area. Hollow concrete-block foundations, however, pose a challenge, because their thin walls offer considerably less withdrawal strength. For instance, Simpson Strong-Tie's ETSP plastic screen tubes provide only 300 pounds of withdrawal strength and require 8-inch spacing. I suppose that threaded rods could be used as through-bolts, with a 2x6 PT block mounted inside as a big "washer," but that, of course, would require access to the inside of the house.

Side strap. When the deck is aligned with the edge of a house, significant lateral loads can be resisted with a simple strap that connects the deck's outside joist to the house frame (**Figure 6**). We've used Simpson's 1¼-inch by 30-inch MSTA30 straps nailed to the deck and to the second story of a house, a solution that has been stamped by my engineer.

To ensure that the strap is fastened to solid house framing, some siding and sheathing has to be temporarily removed during installation. But once installed with 11 hanger nails in the house frame and another 11 in the deck's double joist, this connection resists more than 1,800 pounds of tension in SPF framing, according to the manufacturer's specifications (**Figure 7**).

The cost of materials for this solution is modest, just a few dollars for the strap and nails. Of course on existing construction, labor can run two hours or more, depending on the house siding.

Figure 8. While this lateral load anchor hasn't been stamped by an engineer, it may be an option that would be approved by your building inspector. Here, a single 2x8 diagonal brace is through-bolted to a joist and fastened to the foundation with a joist hanger attached to blocking.

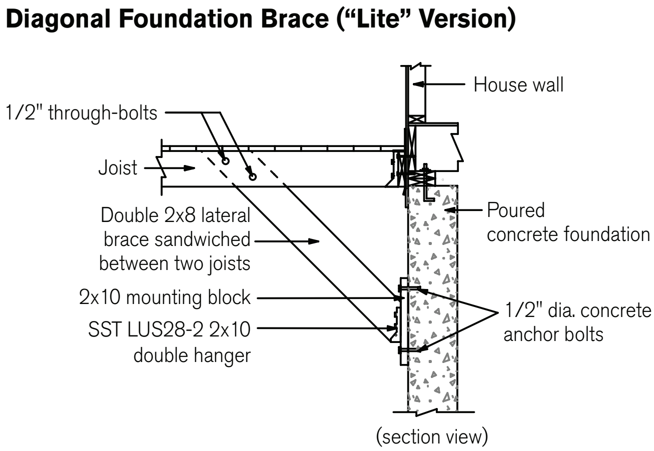

Figure 9. Joist hangers (shown here) or angle brackets can be used to anchor diagonal bracing to a poured concrete foundation wall. Like all of the lateral-brace options shown in this article, this detail would need approval from your building inspector.

Informal Solutions

Because my engineer is known for being very conservative, some of the building inspectors we work with will accept scaled-down and unstamped versions of his engineered brackets and braces.

Simple diagonal brace. In the "lite" version of our diagonal foundation brace (**Figure 8**), we've substituted joist hangers or pairs of 16-gauge angle brackets for the more robust—and more expensive—3/8-inch and 1/4-inch steel L-brackets used in our stamped designs. This detail can be built with either a single or a double 2x8 diagonal brace, which is through-bolted to a doubled deck joist and anchored to the concrete foundation as shown (**Figure 9**). Materials cost about $32 for each brace, and it takes about 45 minutes to install one of them.

While we've had two or three inspectors accept this brace as "reasonable" without asking to see any engineering data, the weak link in the design is the metal hardware. We typically use Simpson LUS28-2 double-joist hangers—which have a 1,315-pound allowable load capacity—or Simpson L70 angle brackets, which have a load capacity of 445 pounds each (for a total capacity of 890 pounds for a pair of brackets) in treated lumber, though the load capacity may need to be reduced since the brace is configured diagonally. If a lateral load requirement of, say, 750 pounds is added to future versions of the building code, this alternative configuration using off-the-shelf hardware would probably meet that lower standard.

House-frame bracket. On older homes with fieldstone foundations, lateral braces can't be fastened to the foundation. But on a recent project—a classic New England house with solid 4x6 sills—the inspector suggested I anchor our custom L-bracket lateral braces to the sill.

I rotated the brackets so that they were oriented horizontally instead of vertically, and drilled another hole through

Figure 10. At the suggestion of his building inspector, the author rotated one of his custom L-brackets horizontally and fastened it to a solid 4-inch by 6-inch sill with HeadLOK screws. The bracket needed to be fastened to the doubled joist with three bolts instead of two, which required an additional hole drilled through the bracket.

each bracket for a third through-bolt (**Figure 10**). After flashing the brackets with Vycor, I fastened each one to doubled 2x10 PT joists with three ½-inch-diameter galvanized-steel through-bolts. The brackets are anchored through the deck ledger and house sheathing into the sill with six 6-inch HeadLOK screws per bracket.

Is this anchor strong enough? According to my calculations, each of the three through-bolts holding my bracket to the double joist will resist 620 pounds of shear—more than 1,800 pounds total. According to the screw manufacturer's ESR (Evaluation Services Report 1078), the withdrawal strength of a HeadLOK screw embedded 2 inches into a hem-fir sill is 360 pounds; therefore, six such screws should resist 2,160 pounds of withdrawal (6 x 360 = 2,160).

Including the bracket and the second joist, materials for this detail cost about $48. Installation takes about 30 minutes.

Faster and Cheaper

Both the engineered and "informal" devices I've described in this article have several major advantages over the lateral brace "permitted" by the IRC. Installation is easier and less expensive, since my details require no access to the interior flooring, basement ceiling, or floor joists. And they allow us to set our decks 6 or 7 inches below the interior house floor, a practical detail that helps keep rain and snow outside.

Are all my lateral anchors as strong as the code-permitted solution, which depends on special hardware, extends deep into the house, and attaches to the floor framing? Some of them are and some of them aren't, but I'm not too worried that my decks would experience an arbitrary 1,500-pound lateral force on the ledger that would pull the rim joist or sill away from the framing, through the house sheathing, and onto the ground. ❖

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Bad Solution to a Non-Existent Problem?

The reason I developed the alternative lateral braces described in this article is that installing the code-permitted device is disruptive and complex, especially when house joists are perpendicular to deck joists. Because it requires the house subfloor to be attached to the joists with nails 6 inches on-center (rather than the standard 12 inches on-center), the finished floor would have to be removed in order to verify that or remediate it. But the biggest problem for me is that the deck has to be level with the house floor in order to install the device, a bad practice where rain and snow is common.

Often overlooked in discussions about lateral loads is that the lag bolts and ledger screws used to transfer a deck's vertical load to the house also resist withdrawal forces: 582 pounds for each 1/2-inch-diameter lag bolt, and 420 pounds for each LedgerLOK screw embedded 2 inches into an SPF house-framing member. This means that a 16-foot-wide deck with two ledger screws per 16-inch joist bay would have more than 10,000 pounds of lateral resistance.

One explanation I've heard for the lateral-load connection requirement is that it prevents a deck from pulling the band joist or sill away from the house under a severe lateral load. But I've never heard of this actually occurring, except when the deck ledger has been fastened to an overhanging cantilever. And in those cases, the issue is vertical rather than lateral loads.

Recent testing at Washington State University confirms this. There, people moving in unison on a sample deck were able to create a maximum total lateral load of only 1,750 pounds—875 pounds at each end of the deck. Even under artificially-created lateral loads of 7,000 pounds, the joists split and failed massively but the lag screws at the ledger held firm—without any lateral braces. There was no observed damage to the house frame (see the online series *Lateral Loads on Decks* by Don Bender et al., originally published in *Wood Design Focus* (Summer 2013) and reprinted with permission at deckmagazine.com/structure/measuring-lateral-loads-on-decks_o.aspx).

This testing suggests that real-world lateral loads are relatively small, and shows that even artificially created loads that are four times real-world scenarios are easily handled by standard deck attachments that follow IRC connection requirements. Hopefully, common sense and recent tests of actual lateral loads on decks will result in a modification of future building code requirements—and perhaps even eliminate the "permitted" device drawing.