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THE MECHANICS OF HOME BUILDING

Nails

BY DEBRA JUDGE SILBER

Considering how critical nails are to holding wood-frame houses together, it's surprising that we don't pay more attention to them. The fact is, nails and the connections they make are critical to managing building loads and ensuring a safe, durable structure. Although there are many types of nailed connections used in home building, the three basic wood-to-wood connections here illustrate how nails perform.

In service, nails must resist withdrawal forces and shear (lateral) forces; they must also be resistant to pull-through and to combined (off-axis) forces. How well they perform is dependent on the characteristics of the nail, the wood, and the angle in which the nail is driven. Altering these factors—such as using a ring-shank nail or driving the nail at an angle—has a much greater effect on withdrawal resistance than on shear resistance, which is more dependent on the bending strength of the nail and the bearing capacity of the wood surrounding it. Penetration is also important. The rule of thumb is that at least two-thirds of the nail should extend into the base material. So a 1x3 should be fastened to a 4x4 with a 2½-in. (8d) nail, with ¾ in. of the nail going through the 1x3 and 1¾ in. going into the 4x4.

So the next time you swing a hammer, consider this: There's a lot riding on that nail. Here's how it works.

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ANATOMY OF A NAIL

Head Head size and structure vary with a nail's type and purpose: to avoid overpenetration of the nailed material (such as the broad thin head of a roofing nail) or to embed the head in it (such as the barrel-shaped head of a finishing nail). Embossed nail heads enhance paint adhesion. Head shape has little bearing on withdrawal, but a small head can result in pull-through under force.

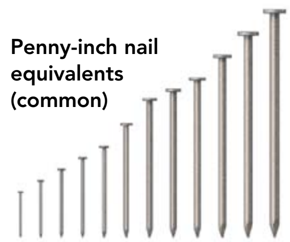
Gauge/diameter Gauge is a measure of nail-shank diameter most commonly associated with collated nails. The larger the diameter, the lower the gauge. In general, nails with a large diameter have greater resistance to withdrawal and lateral loads.

Shank Smooth-shank nails drive into and pull out of most woods more easily than deformed-shank nails, but those deformations—for example, annular rings or helical threads—can improve holding in certain materials such as hardwoods or plywoods. Ring-shank nails can have up to twice the withdrawal capacity of smooth-shank nails.

Coating Sacrificial galvanized (zinc) coatings delay corrosion of steel nails. Hot-dipped galvanized nails are immersed in molten zinc to produce a durable coating; other processes include mechanical galvanization and electrogalvanization. Polymer coatings increase initial withdrawal resistance by increasing friction between the nail and the wood. Driving into hardwoods can remove this coating, however.

Size The size of nails for wood-to-wood applications is commonly referred to by pennyweight. The term is attributed to the original price per hundred nails and is designated with a "d" (for the Roman coin denarius). Pennyweight identifies nails by size on an established but somewhat arbitrary scale (below) and is not considered the best method of specification. Both shank length and diameter can vary slightly among different nails of the same pennyweight: For example, an 8d common nail measures 2½ in. with a 0.131-in. dia., an 8d box nail measures 2½ in. with a 0.113-in. dia., and an 8d sinker nail measures 2⅜ in. with an 0.113-in. dia.

Penny-inch nail equivalents (common)



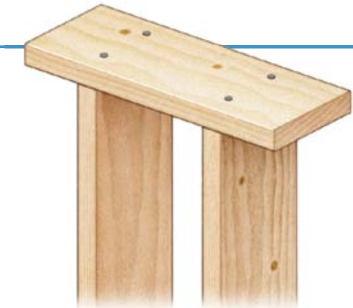
2d = 1 in.	9d = 2¾ in.
3d = 1¼ in.	10d = 3 in.
4d = 1½ in.	12d = 3¼ in.
5d = 1¾ in.	16d = 3½ in.
6d = 2 in.	20d = 4 in.
7d = 2¼ in.	30d = 4½ in.
8d = 2½ in.	40d = 5 in.

Material Typically made from carbon-steel wire, nails also can be made from aluminum, brass, nickel, bronze, copper, and stainless steel. These materials have different friction values and bending strengths, influencing withdrawal and shear capacity.

Point Most nails have a four-sided diamond point to make driving easier. Sharp points enhance withdrawal resistance, but they can cause wood to split. Blunt points prevent splitting but lessen withdrawal resistance.

Drawings: Christopher Mills

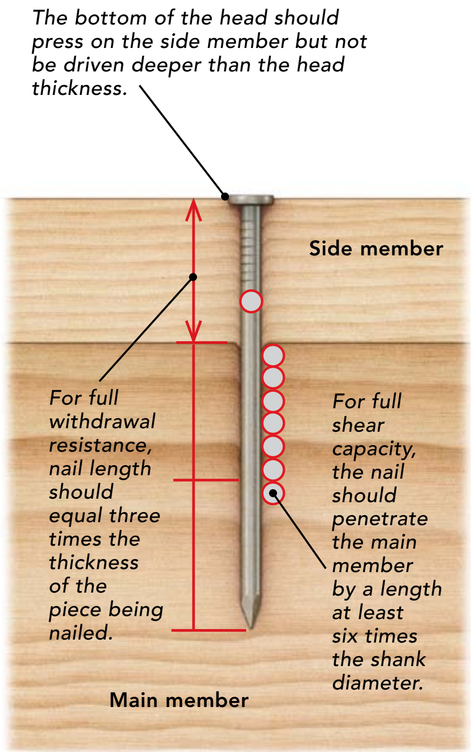
THREE BASIC CONNECTIONS

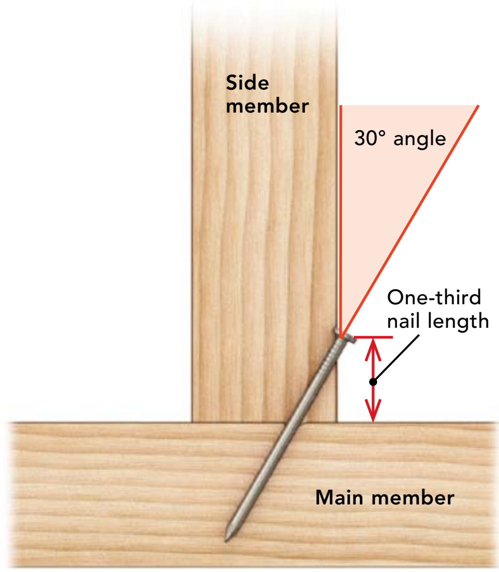


End-nailed connections join two wood members whose grain direction is perpendicular. These connections are easy to make, but they offer little withdrawal resistance (up to 75% less than a nail driven perpendicular to the grain) and effectively resist only shear (lateral) forces.

Face-nailed connections join wood members with the grains parallel. In this application, the nails resist withdrawal, shear, and sometimes off-axis forces.

Toenailed connections offer both withdrawal and shear resistance regardless of the grain direction of the members being nailed. Tests show that these connections are made strongest by using the largest nail that will not cause splitting, by inserting the nail one-third of its length from the joint, by driving the nail at a 30° angle, and by burying the full shank of the nail without causing excessive damage to the wood. When driving several nails, cross-slant driving is somewhat more effective than driving the nails parallel.





Other common connections

Dovetail nailing
Nails are driven at an angle through the face of a board to clamp the boards together and to provide better withdrawal resistance than perpendicular face-nailing.

Blind nailing This connection is used with tongue-and-groove boards. Nails are driven at a 45° angle, enabling the groove of the adjacent board to fit over the nail.

Clinch nailing
An extralong nail is driven through the wood members being joined, and the tip is then bent and nailed flush for extra withdrawal resistance.