A Contractor's Guide to Concrete Anchors

by Don Best

A new breed of anchor eliminates tedious hole spotting — and supports even the heaviest loads

Many contractors are baffled when it comes to choosing the right concrete or masonry anchor. With so many products on the market and a lack of easy-to-use performance data, a lot of builders cling to the old standbys — even when they're not the best choice.

Concrete and masonry fasteners fall into three broad categories: *mechanical*, *powder-actuated*, and *chemical*. Each type has its strengths and weaknesses, and certain applications where it excels.

The mechanical types all rely on the same working principle: When the anchor is struck with a hammer or tightened down with a screwdriver or wrench, it expands inside the hole, compressing against the concrete or masonry around it.

Early-day anchors were typically made of lead and zinc — malleable metals that would conform to the rough, sometimes crumbly surface of the masonry. The descendants of those ancient anchors — including wood-screw anchors, lag shields, and single and double expansion anchors — remain popular in the trades today. While all of these, properly installed, can be useful in many light-duty applications, they all have generic weaknesses that make them unfit for heavier work.

To begin with, lead and zinc can't begin to match the holding power of modern steel. Being malleable, they're also more likely to work their way loose when there's vibration in the load.

Another disadvantage with all of the anchors listed above — and with steel drop-in anchors as well — is that they all require the laborious process of *spotting* holes and predrilling for the anchors. In other words, because the anchor is much larger in diameter than the screw or bolt that fits it, you have to hold in place the item you're attaching to the concrete or masonry, mark the holes, remove the item, switch bits, then drill the masonry — hoping the holes don't drift off their marks.

Three modern alternatives — concrete screws, sleeve anchors, and wedge anchors — offer builders the added strength of steel and eliminate hole spotting.

CAROLYN BATES

A carpenter drills through a bottom plate into a concrete stemwall to install a wedge anchor — a fastener strong enough to serve as an anchor bolt.

Concrete Screws

Since ITW Buildex first introduced the concrete screw in 1975 under the name Tapcon, several other manufacturers have introduced their own versions.

Concrete screws are made out of super-hardened steel so they can cut their own thread into concrete or masonry (see Figure 1). While they do require a pilot hole — and a precise one, at that — concrete screws can be fastened right through the fixture or lumber you're mounting into formed concrete, concrete block, or brick masonry. (With block or brick masonry, the preferred placement for concrete screws is into the horizontal mortar joint.)

Available in $^{3}/_{16}$-inch and $^{1}/_{4}$-inch diameters, and in lengths ranging from $1^{1}/_{4}$ to 5 inches, concrete screws are a good choice for all kinds of light-to-medium loads, such as affixing nailers to a basement wall or tying formwork to an existing foundation (see "The Right Anchor for the Job," page 19). They come with a flat Phillips head, which screws in flush, or with a slotted hex head. Both types can be removed with an ordinary screwdriver and then reseated in their original hole, though they do lose some of their anchoring power the second time in. If you know in advance that you're going to be removing and replacing a fastener more than once, you'd be better off choosing a sleeve or wedge anchor, or a PAF threaded fastener, as discussed below.

Sleeve Anchors

Another type of anchor that's strong, versatile, and doesn't require hole-spotting is a sleeve anchor (Figure 2). Only one hole — precisely matching the diameter of the anchor — needs to be drilled. The anchor is then tapped into place with a hammer. As it is tightened, the sleeve expands, wedging the anchor in place.

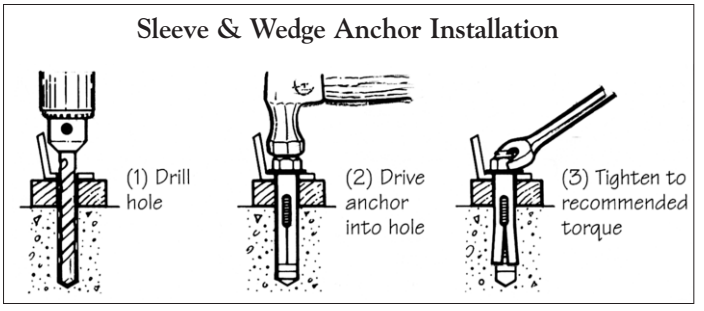
Sleeve anchors work equally well in formed concrete, hollow concrete block, or brick masonry (in the horizontal mortar joint). They come in four styles: slotted flat head, slotted round head, hex head nut, and acorn nut — so you can match the head to the application.

Sleeve anchors are available in larger sizes than concrete screws — up to $^{5}/_{8}$ inch in diameter, and in lengths up to $6^{1}/_{4}$ inches — which makes them good candidates for heavier loads.

Be forewarned that sleeve anchors are *not* removable. However, by choosing a sleeve anchor with a removable hex head or acorn nut, you can remove and remount the fixture later without compromising the anchor's strength.

Wedge Anchors

Wedge anchors are the unrivaled heavyweights among mechanical concrete and masonry fasteners. They're often specced in bridge construction and nuclear power plants where only the strongest anchor will do. In home building and commercial construction, they're often used to anchor sill plates to foundation walls or to attach ledger boards. Once installed, they're virtually impossible to remove.



To install sleeve or wedge anchors drill through the fixture into concrete, tap the anchor into place, and tighten. For removable installations use a hex head or acorn nut and stud.

Wedge anchors are available from 1/4 inch to 1 1/4 inches in diameter, with lengths ranging up to 12 inches.

Strong as they are, wedge anchors generally aren't as good as sleeve anchors when used in masonry or soft concrete, or in any material with voids or irregularities. Sleeve anchors are better in softer material because they offer a larger bearing surface, gripping along most of the fastener's shaft, whereas a wedge anchor holds only at a single point towards the end of the fastener (Figure 3).

If you're going to use any of these mechanical anchors outdoors or in other environments that are humid, corrosive, or briny, it's worth paying the extra money for galvanized or stainless steel.

Powder-Actuated Fasteners

For hanging drywall track, furring out a basement, or other light-duty anchoring jobs, nothing compares with the economy and speed of a powder-actuated fastener, or PAF. Using a range of color-coded power loads, PAFs can drive a shank *pin* or threaded *stud* directly into a concrete wall without any predrilled holes. The power load you use will depend on the stability of the concrete you are driving into. Start with a low-power load and work up until the fastener sets to the proper depth. PAFs can also be used on some masonry walls, provided the surface isn't too soft or brittle. Generally, the best place to drive pins in a masonry wall is into the horizontal mortar joints.

PAFs are available in single-shot, semiautomatic, and fully automatic models (Figure 4). To operate the single-shot type, a fresh load and pin must be hand-loaded for each discharge. Semiautomatic PAFs use a 10-shot disc or strip of loads, but you must still load the pins individually. For fully automatic capability, you need to add a *magazine*, which holds a number of fasteners at the tip.

There are other powered drivers that function similarly to a fully automatic PAF. Erico makes a pneumatic driver similar to a framing nailer, but with enough power to drive a collated strip of pins into concrete. Another option is Ramset/Redhead's new TrakFast, a heavy-duty version of the Paslode Impulse nailer, which is powered by a gas fuel cell and a 6-volt nicad battery.

With any type of PAF or powered driver, safety is a prime concern. The high-velocity models that were sold in the 1970s and early '80s aren't being manufactured in the U.S. anymore because of the serious accidents — and even deaths — linked to their use.

The low-velocity, piston-type PAFs that are now on the market are many times safer, but still require proper training and careful use. In fact, the Occupational Safety and Health Administration (OSHA) requires builders and contractors to participate in a short training course — usually offered by the product's local distributor — that includes safety instructions, hands-on practice, and detailed maintenance information. The trainee is then issued a lifetime license to operate the tool.

Hammer Anchors

If you don't have ready access to PAFs, a new type of hammer anchor provides a good alternative for light-duty applications, such as fastening conduit or strapping to concrete (Figure 5). These fasteners, which look like a nail with a crook or split near the end, include Rawlplug's *Rawl Spike* and *Rawl Drive*, Ramset/Redhead's *Hammer-Loc*, and U.S. Anchor's *Split Fast*. Like concrete screws, they require predrilling but no hole spotting. Once you have a hole, hammer anchors set quickly and hold fast, provided you are fastening to sound concrete or mortar.

A related type of anchor with somewhat less strength includes Hilti's *Metal Hit Anchor*, Rawlplug's *Zamac Nailin*, and U.S. Anchor's *Hammer Drive Anchor*. Each includes a pin and integral zinc-alloy shield. You predrill and drive the pin with a hammer. Hole spotting is unnecessary.

Chemical Anchoring Systems

Though epoxy systems have always shown major league promise, on-site problems with hand mixing and dispensing the chemicals have until recently limited their use. A new generation of products, however, eliminates the guesswork and waste associated with mixing epoxy by hand.


ITW RAMSET/RED HEAD

Figure 1. *Concrete screws.* *Hardened-steel concrete screws cut their own threads into concrete or masonry. If the pilot hole is even slightly oversized, however, the screw is prone to strip out the hole.*


HILTI

Figure 2. *Sleeve anchors.* *These work well in formed concrete, masonry mortar joints, or brick. Because of their large bearing surface, they are less affected by voids and irregularities in the base material than are wedge anchors.*


HILTI

Figure 3. *Wedge anchors.* *Often used in industrial construction, high-strength wedge anchors are also useful for attaching sills and ledgers. With soft substrates, however, a sleeve anchor or epoxy fastener is better.*


ITW RAMSET/RED HEAD

Figure 4. *Powder actuated fasteners.* *For furring out a wall or other light-duty work, PAFs are often the fastest, most economical choice. Current models are much safer than older high-velocity drivers, but safety is still a big concern. A variety of pins is available for different applications (insets).*

Epoxy anchors fall into two general categories: *capsule* and *dispenser* systems (Figure 6). With capsule systems, you insert a glass capsule filled with epoxy into a predrilled hole (first cleaned with a wire brush). Next, you drive the fastener — either a threaded sleeve, threaded rod, or rebar dowel — into the capsule with a hammer drill, which breaks the capsule and mixes the epoxy. Care is needed with these to ensure proper mixing of the chemicals.

Dispenser systems, on the other hand, use a dual-cartridge — either hand-pumped or pneumatic — that mixes the resin and hardener and injects the mixture. The hole is pumped half to three-quarters full before inserting the threaded stud or other fitting.

To make a stud removable, you can use either a threaded sleeve, or spray a threaded rod with Teflon before setting it into the epoxy. After the epoxy has set, the rod can be unscrewed.

A unique advantage of epoxy is its good performance in masonry substrates that are crumbly or have gaps. Here you can insert a plastic or wire-mesh sleeve into the hole before the epoxy goes in. When you insert the threaded stud, it forces the epoxy through the sleeve, giving it more surface area and a consistent internal wall to anchor into. For horizontal or overhead applications, a slotted cap keeps the epoxy from running out of the hole until the stud is set.

At the end of the job, any leftover resin and hardener remain separate and stable in their cartridges. Some manufacturers claim a three-year shelf-life without deterioration.

Advances in epoxy chemistry have made these the strongest anchoring systems in the world. Moreover, formulations are now available for different temperatures and curing times — from quick to extended. Here are some other advantages that make chemical anchors worth considering:

- Chemical anchors retain their strength when there's vibration in the load, which tends to loosen mechanical anchors.
- Chemical anchors can be placed close to an edge or corner where a mechanical anchor might crack the concrete or masonry. Similarly, they can be placed close together without stressing the concrete or masonry between the holes.
- Chemical anchors allow builders to custom-cut rods when the specs call for nonstandard sizes.

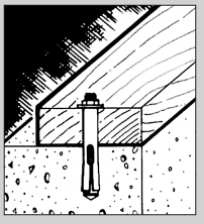
Some modern epoxy formulations — but not all — have done away with the noxious odors and high toxicity associated with earlier blends. Be sure to read the instructions carefully and talk with your distributor about safety and health issues. Extra ventilation and gloves may be required.

The Right Anchor for the Job

Below are anchor recommendations for common residential and light-commercial applications. These recommendations assume poured concrete foundations with a compressive strength of 2,500 psi, residential garage and basement slabs at 3,000 psi, and commercial tilt-up construction at 4,000 psi. We're also assuming that the material is in good condition without spalling, crumbling, or excessive crazing. If you are uncertain that the concrete or masonry is in good shape, choose an epoxy anchor, which will help bind the base material together.

Check with the manufacturer or catalog for the appropriate embedment depth and design load of each fastener — especially for any structural connections.

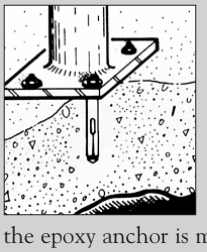
Sill plate to foundation for bearing wall. If you've left out one or two



anchor bolts, a few PAFs should do the job. If the slab is uneven and you need to draw the plate down, use a sleeve anchor. If you've left out all the anchor bolts for a bearing wall, you're best off with sleeve, wedge, or epoxy anchors.

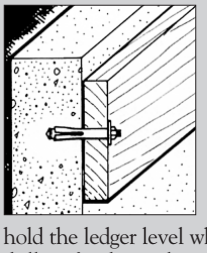
Sole plate to slab for non load-bearing partition. A PAF is the fastest way to connect interior partition plates (wood or steel) to a slab. If you don't have access to a PAF, hammer anchors are a good alternative.

Steel column to a slab. To secure the bearing plate of a structural



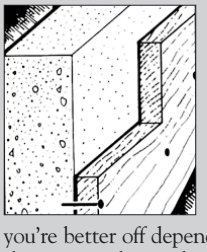
post to a concrete slab, use a wedge or epoxy anchor. If the concrete is at all soft or crumbly, the epoxy anchor is more reliable.

Ledger for exterior deck or porch. To attach a framing ledger to a



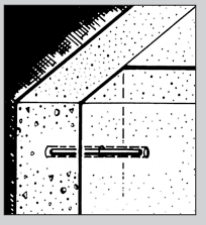
poured concrete or masonry wall, use a wedge anchor for strength. You may want to use a PAF to hold the ledger level while you're drilling for the wedge anchors.

Stair stringer in concrete bulkhead. A PAF is sufficient if you can



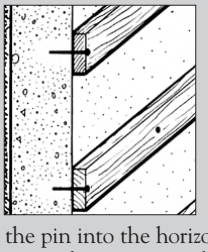
fasten every 16 inches or so along the stringer. If you have to hang the stairs from one end of the stairwell, you're better off depending on a sleeve or wedge anchor.

Rebar dowel. To make a structural dowel connection to concrete —



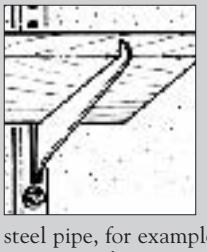
for example, to tie in a foundation for an addition — use an epoxy anchor. In a masonry foundation, you may have to use a screen insert to hold the epoxy if the dowel does not land on a block web, mortar joint, or filled core.

Strapping to foundation wall. If you need to fasten nailers for dry-



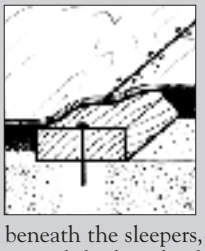
wall or siding to a poured-concrete or masonry wall, PAFs are the fastest method. Be sure to drive the pin into the horizontal mortar joint of a masonry wall. If you don't have a PAF, concrete screws or hammer anchors are a good choice.

Shelf standards or cabinets to basement wall. Concrete screws



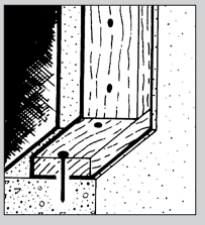
are often your best choice, unless the fixtures will be supporting a lot of weight (lumber or steel pipe, for example). In this case use a sleeve or a wedge anchor. You can use acorn nuts inside the cabinets if a clean look is important.

Sleepers for wood flooring over a slab. A PAF will work well,



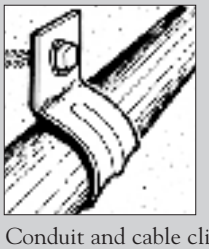
unless the slab is way out of level (if it slopes towards a drain, for example). In this case, with shims beneath the sleepers, you may exceed the length of a PAF and need to use a wedge or sleeve anchor in the deepest areas.

Wood frame around basement window or door. To box out a



door or window with pressure-treated wood, PAFs are the quickest option. If you don't have a PAF, use concrete screws or hammer anchors.

Electric or DWV lines to foundation wall. To secure an electric

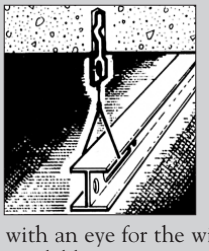


panel, switch box, or conduit to a concrete or masonry wall, a PAF is the fastest option. Conduit and cable clips are available with integral pins for PAFs. Or use hammer anchors with conventional conduit clips. PAFs or hammer anchors are also sufficient to hang a horizontal DWV line from a foundation wall.

Sprinkler connection to concrete ceiling. When hanging sprinkler

lines you need a connector that will accept a threaded pipe holder. Use a hammer anchor, such as Rawlplug's *Pipe Spike*, or a drop-in steel expansion anchor.

Acoustical ceiling tie to concrete ceiling. For suspended acoustical



ceilings use a PAF or hammer anchor. Ceiling clips with PAF pins, or hammer anchors with an eye for the wire tie, are available.

— Clayton DeKorne

The Hole Story

The most important detail in installing any type of mechanical or chemical anchor is to drill the hole according to the manufacturer's specs. If the diameter of the hole is too large, concrete screws won't tap and hold properly while sleeve and wedge anchors may spin in the hole. The holding power of sleeve and wedge anchors may also be compromised if you overtighten them, so take care to follow the manufacturer's instructions regarding torque.

Some anchors are also sensitive to the depth of the hole. Concrete screws, for example, require that the hole be 1/4 inch deeper than the screw itself to leave room for displaced material. Drop-in anchors — sometimes called flush anchors — may fail if the hole isn't drilled to the precise depth required.

The secret to drilling into concrete and masonry is to use a good quality, sharp carbide bit with a hammer drill. Look for a drill with variable speed, a "drill-only" mode, and a side handle and depth gauge.

Gauging Strength

The holding power of concrete anchors is characterized in two ways: *pullout strength*, which is the weight required to pull the anchor directly out of the hole, and *shear strength*, which is the force across the face of the wall required to shear the anchor.

Most manufacturers' catalogs include the laboratory-tested ratings for various anchor types as well as recommended embedment depths and hole diameters. Unfortunately, the concrete you're working with in the field may not neatly match the psi (pounds per square inch) values listed in the catalogs. Also, laboratory installations never suffer from irregular holes, overtightening, or other installation problems.

For that reason, it's standard practice to provide a minimum four-to-one safety margin on pullout values for mechanical anchors and an eight-to-one margin for PAFs.

In the final analysis, one of the most valuable tools in choosing the right anchor is an experienced and well-informed person who can give you advice. If you look hard, you have a good chance of finding one of these through your local tool distributor or hidden away in the customer service department at one of the anchor manufacturing companies. ■

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Typical Anchor Costs & Specs

Anchor Type	Size (in.)	Minimum Embedment Depth (in.)	Price Ea.	Pullout Strength (lbs.) (3,000-psi concrete except as noted)
Hammer (sleeve type)	1/4 x 2	3/4	22¢ (box of 100)	800
Hammer (nail type)	1/4 x 2 1/4	1 1/4	17¢ (box of 100)	1,100
PAF	.140 x 2 1/2	1 1/4	17¢ (box of 100, including load)	1,400
Concrete screw	1/4 x 2 3/4	1 1/2	30¢ (box of 100)	1,500
Sleeve	3/8 x 3	1 5/8	50¢ (box of 25)	2,400
Wedge	3/8 x 4	3	60¢ (box of 50)	4,000 – 5,000 (4,000-psi concrete)
Epoxy (dispenser type)	3/8 x 4	3 1/2	70¢ (does not include cost of dispenser)	5,000 – 7,000 (4,000-psi concrete)
Epoxy (capsule type)	3/8 x 4	3 1/2	$1.50	5,000 – 7,000 (4,000-psi concrete)

Note: *The sizes chosen are typical for the type of fastener, although many other sizes are available. Prices are average retail to the trade. For hot-dipped galvanized fasteners, expect to pay about 20% more; for type-306 stainless steel, 100% more; and for type-316 stainless, 120% more per fastener. Pullout values and embedment depths are typical only for the size listed and should be checked for the specific fastener and substrate. Also, note that values listed are "ultimate" pullout strength. In actual design, a safety factor of 4:1 to 8:1 is typically used.*

Figure 5. ***Hammer anchors.*** *The small crook or split at the end of a hardened-steel hammer anchor (left) gives these simple devices good holding power as long as the substrate is sound and hard. A different type of hammer anchor (right) uses a pin in an integral zinc-alloy sleeve to develop similar holding strength.*

Figure 6. ***Chemical anchoring systems.*** *Installed correctly, epoxy systems make the strongest anchors, and are ideal for joining foundations with rebar dowels. Unlike mechanical systems, they will work close to concrete edges (left), and can work in marginal substrates if reinforced with a wire-mesh sleeve. Modern dispenser systems (top right) have made the mixing process nearly foolproof. Capsule systems (bottom right) may be preferable if you're installing only a few anchors, but installation instructions must be closely followed to guarantee a good epoxy mix.*

For More Information

The major manufacturers of anchoring systems listed below all publish extensive catalogues with ample product and technical information.

Ackerman Johnson Fastening Systems
136 Official Rd.
Addison, IL 60101
708/543-2797

Hilti Inc.
P.O. Box 21148
Tulsa, OK 74121
800/879-8000

ITW Ramset/Red Head
1300 North Michael Dr.
Wood Dale, IL 60191
708/350-0370

Rawlplug Co. Inc.
200 Petersville Rd.
New Rochelle, NY 10802
914/235-6300

U.S. Anchor Corp.
1371 S.W. 8th St., Bldg. 7
Pompano Beach, FL 33069
800/872-3330