A Guide to CONSTRUCTION ADHESIVES

by Stephen Smulski

AMERICAN PLYWOOD ASSOCIATION

For the best long-term performance, use an adhesive that's made for the materials you're joining

If you've been building for any length of time, you've probably used your share of construction adhesives. These synthetic bonding agents have become as familiar a sight as galvanized nails. They're used for joining everything from wood, metal, and concrete to gypsum board and rigid foam (see "Matching Mastic to the Job," next page). Adhesives make floors stiffer, minimize nail pops and squeaks, let you decrease the number of fasteners in finish materials, and double as a sealant.

But while construction adhesives may be common, not all adhesives are appropriate for all situations. At the same time, some site conditions inhibit an adhesive's ability to do its job. Understanding how an adhesive works will help you choose the right one for the job and use it correctly.

Adhesive Formulation

Though the blend of ingredients used in construction adhesives is proprietary, all construction adhesives are what chemists call *elastomer-based extrudable mastics*. Mastics are a class of high-viscosity adhesives that can be made to flow under pressure. Elastomers are rubbery in nature, which means construction adhesives remain somewhat flexible indefinitely. This permits any materials joined with them to shrink and swell with changes in temperature and moisture content.

The ingredients in an adhesive are dissolved or dispersed in an organic solvent or water. When exposed to the air, the liquid evaporates, and the adhesive starts to cure. (Curing time depends on the product.) If the label says that the adhesive is

Matching Mastic to the Job

	Drywall and Paneling	Plywood	Lumber	Treated Lumber	Metal	Concrete and Masonry
Foam	PL 3 Hen 3 DAP 5 Mir 3 DAP 7 Rus 1 Fra 3 Rus 3 Fra 4 Fra 8	DAP 5 Mir 3 DAP 7 OSI 2 Dar 1 Rus 3 Fra 4 Mac 2 M-D 1	PL 3 Fra 3 Mac 2 PL 7 Fra 4 Mir 2 DAP 5 Fra 8 Mir 5 DAP 7 Hen 2 Rus 1 Dar 1 Hen 3 Rus 3 Fra 2 Mac 1	Fra 2 Hen 2 M-D 2	PL 3 Fra 8 Mir 3 PL 7 Hen 2 Mir 5 DAP 5 M-D 1 DAP 7 M-D 2 Dar 1 Mir 2	PL 3 Fra 3 M-D 2 PL 7 Hen 2 OSI 2 DAP 5 Hen 3 OSI 6 DAP 7 Mac 1 RUS1 Dar 1 M-D 1 Rus 3 Fra 2
Plywood			PL 4 Hen 2 Mir 5 PL 5 Mac 1 OSI 3 PL 6 Mac 2 OSI 4 DAP 4 Mac 3 OSI 7 Dar 1 M-D 2 Rus 2 Fra 4 Mir 1 Sur 1 Fra 6 Mir 2	PL 5 M-D 2 DAP 4 Mir 1 Fra 9 OSI 4 Hen 2 Rus 2 Mac 2	PL 5 Hen 2 DAP 4 M-D 2 Dar 1 Rus 2 Fra 9 Sur 1	PL 5 M-D 1 DAP 4 M-D 2 Dar 1 Rus 2 Hen 2 Sur 1
Drywall & Paneling		DAP 1 M-D 1 DAP 2 Mir 2 DAP 4 Mir 5 Dar 1 OSI 2 Fra 4	PL 1 Fra 4 Mir 5 PL 2 Fra 5 OSI 1 PL 7 Hen 3 OSI 2 DAP 1 Mac 1 OSI 6 DAP 2 M-D 1 Rus 1 DAP 4 M-D 2 Rus 2 Dar 1 Mir 2 Sur 1 Fra 1 Mir 4 Sur 2	Fra 9 M-D 2 Rus 2	PL 1 Fra 1 Mir 5 PL 7 Fra 9 OSI 1 DAP 1 M-D 1 OSI 6 DAP 2 M-D 2 Rus 2 DAP 4 Mir 2 Sur 1 Dar 1 Mir 4 Sur 2	PL 7 M-D 1 DAP 1 M-D 2 DAP 2 OSI 1 DAP 4 OSI 2 Dar 1 OSI 6 Fra 1 Rus 1 Hen 3 Rus 2 Mac 1 Sur 1
Plastic and Tub Kits	PL 9 DAP 1 DAP 6 Fra 8	DAP 1 DAP 6 M-D 1 M-D 2	DAP 1 M-D 1 DAP 6 M-D 2 Fra 8 OSI 6	M-D 2	DAP 1 M-D 1 DAP 6 M-D 2 Fra 8 OSI 6	DAP 1 M-D 2 DAP 6 OSI 6 M-D 1
Viny/Rubber Cover	DAP 8 Hen 1	DAP 8 Hen 1	DAP 8		DAP 8	DAP 8 Hen 1
Clay/Cement Roof Tiles		PL 8 OSI 5	PL 8			PL 8

To use the chart: *Find the list of product codes at the intersection of the row and column for the two materials to be adhered. The product code key for each manufacturer appears in the list to the right of the chart, along with general information about the manufacturers. Some boxes are empty to avoid redundant entries.*

Note: *The products are listed according to their best use. Most adhesives are compatible with a wide variety of materials and substrates. (Foam adhesives, however, may work with either polystyrene or polyurethane, but not both). For complete information, check manufacturer literature and product labels.*

PL
Contech Brands, 889 Valley Park Dr., Shakopee, MN 55379; 800/828-0253
1 PL 100 5 PL 500 9 PL Tub & Shower
2 PL 200 6 PL Pro
3 PL 300 7 Nail Pro 10 PL Premium
4 PL 400 8 PL Landscape

DAP
DAP, P.O. Box 277, Dayton, OH 43401; 513/667-4461
1 Panel Wall 5 Big Stick
2 Drywall 6 Beats Nails
3 2000 7 Beats Nails VOC
4 4000 8 Cove Base

Dar
Darworth Company, P.O. Box 639, Simsbury, CT 06070; 800/624-7767
1 Polyseamseal

Fra
Franklin International, 2020 Bruck St., Columbus, OH 43207; 800/347-4583
1 Titebond† 6 Subfloor
2 Titebond Solvent Free† 7 Weatherproof
3 Multibond 8 Tub Kit
4 Panel 9 Metal Framing
5 Drywall

Hen
W.W. Henry Co., P.O. Box 789, Huntington Park, CA 90255; 800/231-5592
1 440, 140, & 595 2 217*‡ 3 238

Mac
Maaco Adhesives, 925 Euclid Ave., Cleveland, OH 44115; 800/634-0015
1 Liquid Nails for Projects & Constr.
2 Liquid Nails for Subfloor & Decks
3 Liquid Nails for Heavy Duty Constr. & Remodeling

M-D
Macklenburg-Duncan, P.O. Box 25188, Oklahoma City, OK 73125; 800/654-8454
1 MD-200 2 MD-400*‡

Mir
Miracle Adhesive Corp., 250 Pettit Ave., Drawer D, Bellmore, NY 11710; 800/647-2253
1 Lumber Lock* 3 Panel & Foam
2 Panel Lock 4 Drywall 5 All-Purpose

OSI
Ohio Sealants, 7405 Production Dr., Mentor, OH 44060; 800/999-8920
1 Formula 38 4 SF-450 6 QB-350
2 QB-300 5 RT-600 7 SF-475
3 SF-400

Rus
W.J. Ruscoe Co., 485 Kenmore Blvd., Akron, OH 44301; 216/253-8148
1 Plio-Nail Panel, Foam & Constr. Adhes.
2 Plio-Nail Constr. Adhes.
3 Pan-L-Bond
4 High Tack Mastic

Sur
Surebond, 500 E. Remington Rd., Schaumburg, IL 60173; 708/843-1818
1 PS800‡ 2 SB-2001

* Bonds to wet & frozen surfaces
† Not for plastic or foam
‡ Not for polystyrene

Figure 1. *You can recognize solvent-based adhesives by the warning that they're flammable or a statement that they contain petroleum distillates.*

flammable or that it "contains petroleum distillates" then it's solvent-borne (see Figure 1). Most solvent-borne adhesives form waterproof bonds, while the bonds formed by most (but not all) water-based adhesives are only water-resistant. Still other adhesives — polyurethanes like Contech's PL Premium, for example — are virtually free of volatile liquids. At nearly 100% solids content, they cure by chemical reaction and form a waterproof bond. Manufacturers will supply technical literature and material safety data sheets that spell out uses, application procedures, properties, and precautions.

Bonding Properties

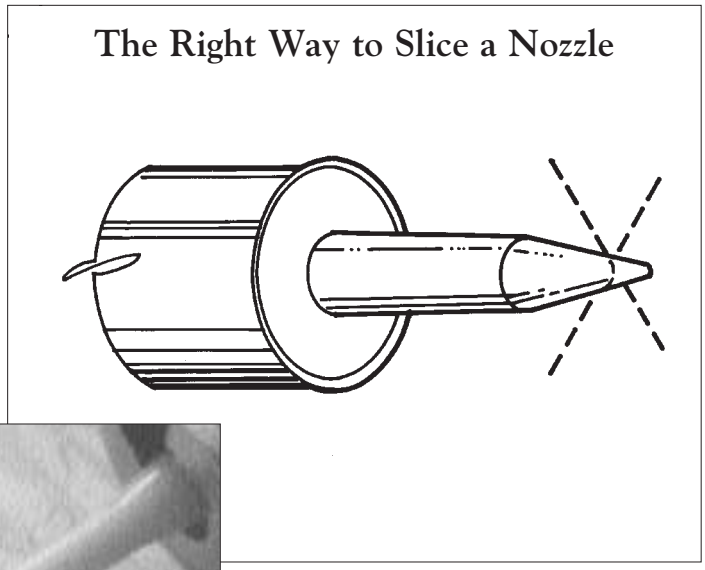
Construction adhesives are formulated to tolerate the often adverse conditions found on the job site. Manufacturers have created adhesives that will bond to sun-baked and rain-soaked lumber, and to surfaces with temperatures below freezing. But adhesion is a surface phenomenon. Ice, standing water, dew, dirt, dust, grease, and other contaminants may interfere with adhesion or create a weak boundary layer. They must be removed before applying adhesive.

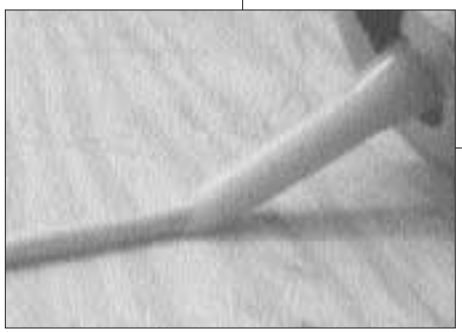
Adhesion is strongest when the chemistries of the adhesive and the materials being joined are compatible. That's why most adhesives are designed to mate specific materials (Figure 2). Check out the adhesives display at your building materials dealer. You'll find products for bonding untreated and preservative-treated wood, concrete and masonry, steel and aluminum, rigid foam, and gypsum board. The industry is trying to develop multipurpose adhesives that will stick to most building materials under most conditions, but that's easier said than done. The polyurethanes come closest to this ideal, but you'll still get the best results by using an adhesive made specifically for the materials you want to join.

Regardless of formulation, all construction adhesives have excellent gap-filling ability. This makes them appropriate for both smooth and rough surfaces. A typical yellow wood glue has a bond line a scant .005 to .015 inch thick — fine for woodworking, but too thin to mate imperfectly fitting pieces like studs and drywall, or joists and subflooring. Construction adhesives, on the other hand, form

Figure 2. *Choose a construction material that is formulated for the specific materials you are joining. Shown here, from left to right, are adhesives for bonding subflooring to wood joists, treated to untreated wood, rigid foam to concrete, and plastic tub surrounds to drywall.*

Figure 3. *To ensure that an adhesive extrudes properly, slice the nozzle tip twice from opposite directions. Turn one facet of the nozzle to the board to apply the adhesive (below).*





bond lines up to 1/4 inch thick, so they can easily bridge the gap between ill-fitting pieces.

Adhesive Strength

What about the strength of joints formed with construction adhesives? It's not possible to make a blanket statement about strength except to say that each adhesive is strong enough to perform in its intended application. This means that when evaluated under an industry-accepted standard test procedure — APA's AFG-01 for subflooring adhesives, for example, or ASTM C557 for fastening drywall to framing — the joint strength exceeds the required minimum. When wood-to-wood joints are tested to destruction, they typically fail either by rupture within the adhesive layer (cohesive failure) or by separation of the adhesive from the wood (adhesion failure). There are exceptions to this rule. For instance, in tests done with Surebond's PS-800 Super Bond adhesive, wood and concrete both failed while the adhesive remained intact.

Temperature and humidity. The age of an adhesive, the temperature at which it's stored before use, and the air temperature and relative humidity during application all play a role in how well an adhesive bonds. An unopened container has a shelf life of about a year, and retains its adhesive properties best when stored at temperatures around 60°F. You should never allow a water-based adhesive to freeze, as this can cause it to lose its adhesive properties.

Air temperature and humidity influence the rate of solvent evaporation. This, in turn, controls the rate at which the adhesive hardens and develops strength. High temperatures and low humidity hasten hardening, while low temperatures and high humidity slow it down. Some construction adhesives can be applied in ambient temperatures as low as 10°F, but they won't develop their full strength unless the temperature rises to 40°F within one week of application. Warming the adhesive before application makes it more spreadable on a cold day, but air temperatures still need to rise in order for it to cure properly.

Long-term strength. Many factors influence an adhesive bond's long-term performance. Just as an elastic band can stretch out from use over time, molecular slippage called "creep" can occur in some elastomer-based adhesives when they're subjected to prolonged stress. The adhesive can lose its ability to return to its original shape after deformation, resulting in misalignment or failure of the joint.

An adhesive bond can also be weakened by moisture. Liquid water from plumbing and roof leaks, as well as condensation within walls, can cause water-borne construction adhesives to peel from some surfaces. The biggest potential problem is in glue-nailed floor systems over wet basements or bare-earth crawlspaces. The adhesive may let go, causing squeaks to develop. If you anticipate high relative humidity, be sure to use a waterproof adhesive.

Heat can also cause problems. When subjected to the elevated temperatures measured in poorly ventilated attics or in south-facing walls, some construction adhesives may soften and weaken slightly. A problem might arise, for example, where metal windows are adhesively bonded to bricks in a wall opening. The bond could weaken as the materials heat up in the sun. The solution is to use an adhesive that's classified as "heat resistant." No one adhesive brand has consistently superior heat resistance — it's highly dependent upon the individual formulation. Ask the manufacturer.

Application Tips

One reason construction adhesives are so popular is that they're easy to use. Most come in nozzle-tipped cartridges that fit into an ordinary caulk gun. (For caulk gun options, see "High-Performance Caulk Guns" on the next page.) An 11-ounce cartridge delivers about 50 linear feet of adhesive when applied at the recommended 3/16-inch diameter ribbon width. Nails, screws, or staples are the usual means of holding the mating surfaces together while the adhesive cures, but if fasteners are objectionable or impossible — as with wall paneling — you can also use a roller or hand pressure.

To open a tube of adhesive, most builders simply chop off the end with a utility knife or use the nozzle cutter found in the handle of some caulking guns. This leaves a simple beveled cut that forces you to hold the gun at an uncomfortable angle to get a proper bead. A better way to make sure that the adhesive extrudes properly is to slice the nozzle tip twice from opposite sides, making an "X" with your knife blade, as in Figure 3.

Unless the instructions say to do otherwise, apply the adhesive to one surface only. The best way to get a properly sized bead is to pull the gun toward you, rather than pushing it away (as you should with a caulk or sealant). The bead pattern depends on what you're gluing. When gluing the narrow edge of framing members, draw a single, continuous ribbon

High-Performance Caulk Guns

Most construction adhesives come in 10-ounce or 1-quart cartridges that fit into a standard caulking gun. But all caulking guns are not alike. Manual guns vary in price from $2 to $30, depending on their design and capacity, and in some respects you get what you pay for. A cheapie model gets the job done, but for a few extra dollars you can get a gun that lasts longer and is easier to use. Some guns' pistol-grip handles include a spout cutter and a seal-puncture tool — basically a long, thin spike. To open a tube of adhesive, insert the spout in the cutter hole and squeeze the handle to snip off the end, then use the puncture tool to break the tube's inner seal. In some models, the end of the plunger is bent into a U to serve as a belt or ladder hook.

Figure A. *The Goo Stick lets you spread adhesive on a set of joists while standing safely on a sheet of plywood. It includes a guide to keep the adhesive centered on the joist.*

Regardless of gun design, bending over to glue a large expanse of subfloor while balancing on a set of joists can be both tiring and dangerous. But the Goo Stick from ToLS Inc., makes the job quicker, easier, and safer (Figure A). The gun's 42-inch-long handle lets you stand on the sheet of plywood you just installed while spreading glue for the next one. A guide at the tip of the gun wraps around the sides of the joist to support the gun's weight and keep the adhesive centered on joist. The Goo Stick retails for around $54.

If you use lots of adhesive, a power gun might be a worthwhile investment. Power guns come in pneumatic and drill-driven varieties. Pneumatic guns include Roean Industries' Caulk Master and Ridge Tool Company's Rigid PowerPush (Figure B). Both come in 10-ounce and 1-quart capacities. Caulk Master models range in price from $49.95 to $216, run at pressures as low as 20 psi, and can be used with any standard compressor. The Power-Push ranges in price from $117 to $177. It will do the job at 40 psi and includes a pressure control that lets you vary the size of the bead. All pneumatic guns release the pressure on the tube when you let go of the trigger, minimizing post-adhesive drip.

Of course, you won't find a compressor on every job site. That's where a drill-driven gun comes in handy. The Prazi Drill-Mate (Figure C) looks like an assault weapon and chucks onto the end of a standard 1/4-inch drill (though the company makes an adaptor for larger drills). The 10-ounce capacity model sells for $69 and quart-capacity size for $79. The Drill-Mate works best with a variable-speed drill. For instance, my 10mm Makita emptied a 10-ounce tube of PL-200 adhesive in about 15 seconds at maximum speed (about 1,800 rpm). Throttling back on the drill's speed slowed delivery of the adhesive, but it also gave me more control.

— Charles Wardell

Figure B. *Pneumatic guns, like the Rigid Power-Push, come in 10-ounce and 1-quart models and can be used with any compressor. Pressure is applied to the tube when you squeeze the trigger.*

Figure C. *The Prazi Drill-Mate chucks onto the end of a standard electric drill.*

Caulk Gun Manufacturers

Manual Guns

Cox North America
8181 Coleman Rd.
Haslett, MI 48840
800/822-8114

Newborn Brothers
P.O. Box 128
Jessup, MD 20794
800/638-3983

Specialty Guns

Goo Stick
ToLS Inc.
651 W. 8th Ave.
Milan, IL 61264
800/448-9316

Pneumatic Guns

Caulk Master
Roean Industries
12970 Branford
Suite C
Pacoima, CA 91331
800/447-6326

Rigid Power-Push
Ridge Tool Company
400 Clark St.
Elyria, OH 44036
216/323-5581

Drill-Powered Guns

Drill-Mate
Prazi USA
118 Long Pond Rd.,
Unit G
Plymouth, MA 02360
800/262-0211

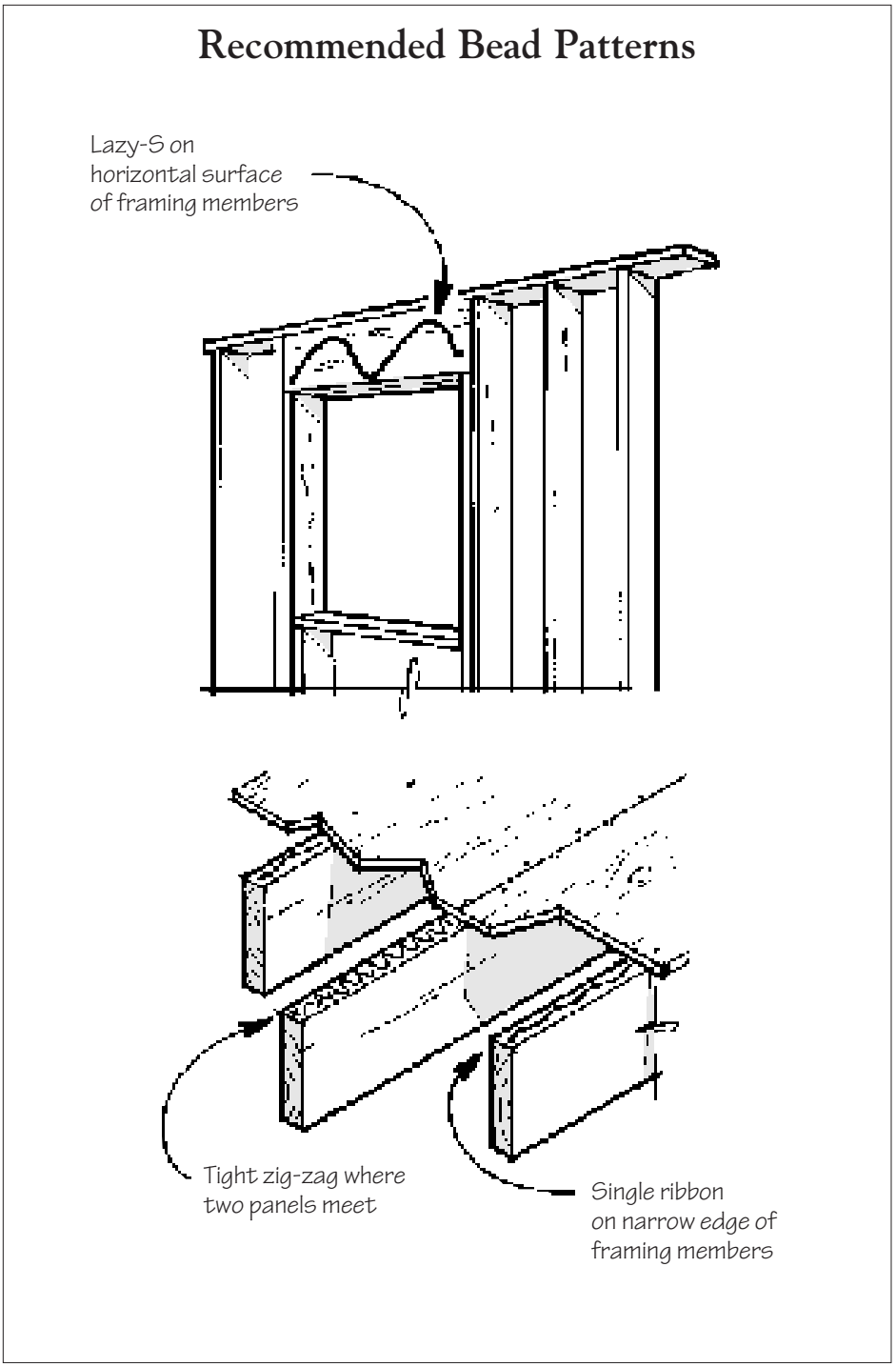


Figure 4. *You'll get better adhesion with a proper bead pattern. Use a zigzag or lazy-S pattern on the wide face of framing members such as window headers (top). Draw a single, continuous ribbon on the narrow edge of framing members and a double ribbon or tight zigzag pattern where two panels meet (above).*

(Figure 4). Where a seam between panels falls on a member, use a double ribbon or tight zigzag pattern. On the wide face of framing members, a zigzag or "lazy-S" pattern is best. When gluing one panel to another — attaching wall paneling to gypsum board, for instance — use a continuous ribbon around the perimeter, then draw parallel ribbons 16 inches apart or draw an X along the diagonals. On a 4x8 panel, the parallel pattern uses 40 lineal feet; the X, 42 lineal feet.

As soon as a construction adhesive exits the tube, the solvent or water it contains starts to evaporate. (Polyurethanes begin to harden when water vapor in the air contacts the adhesive.) The surface of an extruded bead will usually stay tacky for only about 15 minutes, though some adhesives remain tacky for up to an hour. This is called the open assembly time. If you don't mate the materials during this time, the surface will "skin over," preventing the adhesive from making a bond. But all is not lost. If the surface has begun to skin over, you can slit it with a utility knife to expose the uncured adhesive inside. While this is admittedly a pain, it's the only way you'll get a bond to form once the open assembly time has passed.

Tackifiers in construction adhesives cause bonds to form as soon as the materials are mated. These initial bonds are weak, of course — just strong enough to hold the materials in place while letting you reposition them before applying fasteners. The interior of a thick bond line hardens slowly, and doesn't develop its full strength for about 30 days. The exception is the polyurethanes, which cure within 24 hours. Either way, you'll need to finish all mechanical fastening or rolling shortly after mating. Goofs with solvent-borne adhesives can be cleaned up with mineral spirits, while water is usually sufficient for cleaning waterborne adhesives.

Glue-Nailed Floors

Perhaps the most widespread use of construction adhesives — gluing plywood subflooring to joists — owes its popularity in part to the acceptance of the APA Glued Floor System by the major model building code organizations: BOCA, ICBO, and SBCCI. In fact, APA tests have shown a glue-nailed floor to be substantially stiffer (more resistant to bending) than an otherwise identical nailed-only floor. Why? A nailed-only floor is only as stiff as the supporting joists, but in a glue-nailed floor, the joists and panels work together as a system, sharing the load between them. The adhesive imparts a partial, but significant composite T-beam action between joists and panels that is absent in nailed-only floors. The adhesive distributes structural loads over a wide area rather than concentrating them at the fasteners, in effect letting the various sheets of subflooring function as a monolithic panel.

To illustrate the point, APA tested full-size floor sections framed with

air-dried Douglas-fir 2x8s spaced 16 inches on-center. When 19/32-inch T&G Douglas-fir plywood was nailed to the joists, the floor's measured stiffness was no greater than the stiffness of the supporting joists. But when the same plywood was glued and nailed in place, the floor was 25% stiffer than the joists alone.

When APA also glued the tongue-and-groove joints between panels, the results were even more dramatic, with stiffness increasing by 48%. An added benefit of gluing the tongue-and-groove joints is that it reduces the infiltration of air and the passage of sound between floors. I glued the tongue-and-groove panels on my home for all these reasons. Gluing the grooves didn't complicate installation, either. We simply laid the adhesive in the groove and coaxed the tongue of the next sheet into place with a 2x4 and a sledge.

Can the increased stiffness of a glue-nailed floor system translate into reduced material costs? Yes. Building codes recognize that glue-nailed floors are stiffer than nailed-only floors. In many cases the depth of joists can be reduced or their on-center spacing or span increased. Take, for example, a floor constructed with 19/32-inch T&G rated Sturd-I-Floor plywood and No. 2 southern pine 2x8s spaced 16 inches on-center. In a nailed-only assembly, the maximum allowable joist span is 12 feet 10 inches. But when the plywood is glued and nailed, the span can be increased to 13 feet 10 inches without increasing deflection.

Another advantage of glue-nailed floors is that they require fewer fasteners than nailed-only floors. For example, APA recommends a 6-inch edge and 10-inch intermediate spacing when 19/32-inch Sturd-I-Floor plywood is nailed with 6d ring nails to joists 16 inches on-center. When the same construction is both glued and nailed, the maximum edge and intermediate nail spacings are increased to 12 inches. Glue-nailing also virtually eliminates nail pops and squeaks — two frequent causes of callbacks — because a gap never opens between subflooring and framing. When gypsum board is both glued and screwed, the maximum on-center screw spacing is increased to 16 inches. Besides reducing the number of fasteners, glue-screwed gypsum board walls and ceilings have improved racking strength, more resistance to air leakage, and better sound deadening. To make ceiling joists easy to reach without stilts or scaffolding, special long-barrel applicator guns are available.

Other Uses

Floors aren't the only use for construction adhesive. No-squeak stairs are a reality if you apply a ribbon of adhesive to the stringers before fastening the treads and risers. Where framing members are absent or fasteners objectionable, finish trim can be fixed in place with an adhesive. If you glue interior wall paneling in place, you need fasteners only at the top and bottom where trim will hide their heads. This also lessens the chance that you'll mar finish paneling or trim with an errant hammer blow. Gluing horizontal lap siding, or the battens on vertical siding, means fewer nails and better sealing against wind-driven rain. Thanks to new formulations, you can even glue brick, stone landscape blocks and pavers, retaining wall caps, slate flooring or roofing, and clay roof tiles.

Construction adhesives can also ease the marriage of dissimilar or hard-to-fasten materials. The aggravation of bent masonry nails when attaching wood furring to concrete is lessened because you need fewer nails. But before applying adhesive, make sure concrete and masonry surfaces are thoroughly dry and brushed free of grit. The same rule applies when bonding rigid foam insulation to concrete. Some construction adhesives will also dissolve rigid foam. Check both the foam and the adhesive manufacturers' recommendations to make sure the two are compatible. Also, give the foundation a week or so to dry. Otherwise, moisture coming out of the concrete can interfere with adhesion. Even some cement-based damp-proofing compounds can prevent the adhesive from sticking to the wall. (However, many adhesives will adhere to *asphalt*-based damp-proofing compounds.)

Steel and aluminum framing members present yet another challenge. Oily residues deposited on metal surfaces during fabrication can interfere with adhesion. Visibly contaminated surfaces should be cleaned with alcohol, mineral spirits, or a degreaser before being coated with adhesive. For wood foundations, manufacturers make special construction adhesives that adhere to preservative-treated wood. Future uses for construction adhesives will undoubtedly arise hand-in-hand with the advent of new building materials. ■

Stephen Smulski is president of Wood Science Specialists Inc., in Shutesbury, Mass., a consulting firm specializing in solving wood performance problems in light-frame structures.

Using Adhesives Safely

Construction adhesives contain strong chemicals and, accordingly, you should observe certain precautions when using them. For instance, the vapors from solvent-borne adhesives are flammable and harmful when inhaled. Even water-borne adhesives contain small amounts of volatile organic co-solvents. When working inside, cross-ventilate your work area to dilute and carry away any vapors. Also be careful with sparks and open flame, including pilot lights on gas appliances. It's obvious that you don't want to get adhesive in your eyes, but be aware that the most likely route to the eyes is via a contaminated finger. (You can remove uncured adhesive from your skin with soap and water.) If you get adhesive in an eye, flush it with water and visit a doctor. If you somehow swallow some adhesive, do not induce vomiting. See a doctor immediately. The best protection against accidents is to read and understand the manufacturer's instructions before using the adhesive.

— S.S.