Laying a Tile Floor

Epoxy mastic on a plywood subfloor is a durable alternative to the traditional mortar-bed method

by Michael Byrne

Of all the finish floors available to the builder, none is more permanent than ceramic tile. Tile floors hundreds of years old attest to the durability of the materials, and today ceramic tiles are available in almost limitless colors and patterns. Because ceramic tile can resist the ravages of water (see p. 74), it is often chosen as the finish floor in wet locations like bathrooms, kitchens and mudrooms. But regardless of how durable and pretty the tile is on top, its useful life depends on things that can't be seen: a sturdy subfloor, high-quality mastics or mortar, an accurate layout and sound installation.

This article describes a typical tile installation in a small bathroom. The job was a remodel, but the procedures are the same for new construction. The tools are the same, too (photo below left). Except for the snap cutter, which you can rent from most tool-rental centers, tile-laying equipment isn't expensive.

Preparing the subfloor—The floor in this bathroom had been covered by wall-to-wall carpeting that extended from the neighboring living room. Years of careless splashing in the shower had rotted a corner of the rug, and the subfloor was about to follow. Fortunately the joists weren't damaged, so I didn't have to perform any framing surgery. I just had to remove the toilet and tear out a rotten rug.

The original subfloor was 1x6 T&G planking over joists 16 in. o. c. This is a satisfactory substrate for a finish floor that can flex, like vinyl or carpet, but a tile floor requires a stiffer base, or it will crack. I won't install a tile floor unless the subfloor and the underlayment are at least 1¼ in. thick, so I covered the planking with ⅝-in. CDX plywood and fastened it down with 2-in. ring-shank nails driven into the joists every 6 in. At the walls, I left a ¼-in. expansion gap.

I never use particleboard as an underlayment because it's not as strong as plywood and it swells if it gets wet. Exterior grades of plywood, when properly fastened, can stand up to the occasional tub oveflow without swelling and popping the tiles loose.

I left a gap of about 1/16 in. to ⅛ in. between the pieces of plywood for a glue joint. By edge-gluing the plywood sheets with the epoxy thinset, the underlayment becomes an integral layer that won't move in isolated spots as a result of a water spill. If individual pieces are allowed to move, the result can be cracked tiles or broken grout lines. Unless the subfloor needs a lot of surface preparation, glue the plywood edges as the tiles are set. Adjacent pieces of plywood shouldn't be more than 1/32 in. above or below each other, and for a larger floor, the edges of the plywood sheets should be staggered.

Traditionally, floor tiles are set in a 1-in. thick bed of mortar. This is still the best method for wet locations, but it's also messier and trickier than using epoxy tile adhesives. The epoxy thinset used on this job (Latapoxy 210, manufactured by Laticrete International, 1 Laticrete Park North, Bethany, Conn. 06525) is acceptable for use in wet locations. Epoxy is really the best choice where raising the level of the floor with a layer of mortar is out of the question. Its water resistance, compressive strength and holding power allow it to stand up to daily bathroom use.

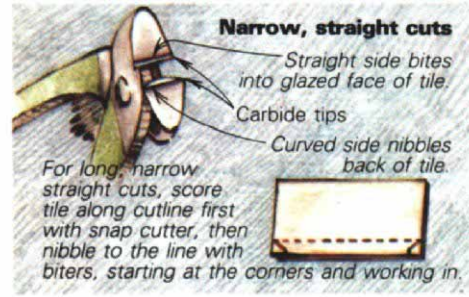
I would never use an organic mastic for this installation for two reasons. (Organic mastics were originally made from rubber-tree extracts. The term now describes a general class of ready-to-use thinset mastics that cure by evaporation.) First, water will eventually get through it to the subfloor and the tiles will loosen. Second, organic mastics don't get hard enough to support floor tiles, so the tiles in the high-traffic area will eventually move, and the grout will crack.

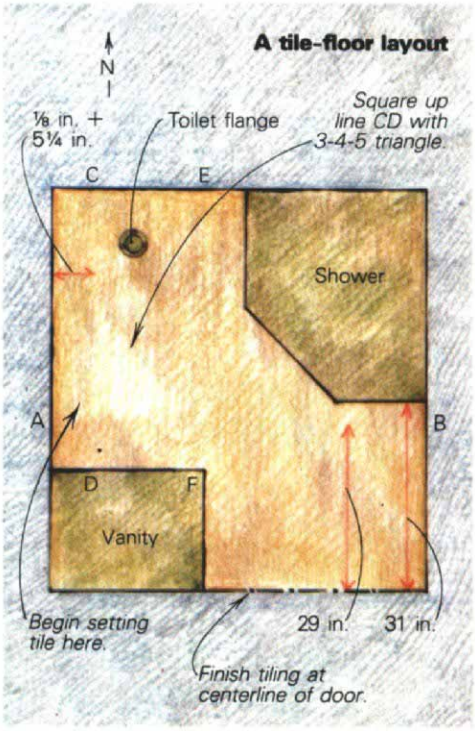
To make sure that the tiles will sit on a flat plane, I knock down any high spots in the subfloor with a disc sander and I fill in the low spots with epoxy mastic. Even slight irregularities can make for wavy grout lines once the tiles are in place. Small tiles look especially bad on uneven surfaces.

To find the low spots, I use a straightedge. I make pencil marks at the edges of the depression just where the light begins to appear under the straightedge. I draw around each depression until an outline defines the low spot. I thoroughly vacuum the floor so that a layer of dust doesn't prevent adhesion between the mastic filler and the subfloor. Then I mix a batch of mastic and trowel it into each low spot with a side-to-side motion of the trowel (this will pick up any remaining dust on the floor), and I screed off excess mastic with a straightedge. Once the mastic has set up, I remove ridges with an abrasive stone.

Laying out the tile—Rather than provide a line for each sheet or piece of tile, it's more convenient to divide a small floor like this one into workable parts. By projecting the location of a few grout lines onto the floor with chalkline or a pencil, I can visualize the alignment

Tools for tiling and cutting **include (below left, clockwise from top) heavy aluminum straightedges for marking layout lines and aligning rows of tile, a snap cutter and assorted tile spacers and shims, a sponge, two margin trowels, biters for cutting tile, three notched trowels for spreading mastic, a sliding bevel, abrasive stones for smoothing cut edges, a chalkline. The snap cutter, below center, is used for straight cuts. Here the tile has been scored by the cutter wheel, and the wings are in position to complete the break—a downward push of the handle will do it. Taping the wings keeps them from marking the tiles, which are semivitreous pavers with cast-in spacing lugs on their edges. For narrow cuts, use biters (drawing, below).**





Layout. **After the newly laid plywood subfloor has been leveled, it is divided by layout lines into sections that will be set in sequence, beginning with the quadrant farthest from the door and ending with the section around the door. As shown in the drawing above, the layout is square to the door opening, emphasizing the most visible lines in the room.**

of the finished floor. I make each section large enough to give me space for ray tools and materials, yet small enough so that I can reach the entire area without straining—it's surprising how easy it is to lose one's balance and fall onto the finished work.

To establish the layout, I usually start at the centerline of the door, directly over the threshold. The most visible portion of the floor is usually just inside the door, so it's important to make sure that the grout lines are straight, and parallel or perpendicular to the threshold. The centerline of the closed door marks the edge of the tile.

The distance between the door centerline and the shower in this bathroom is 31 in. Since the tiles for this job measure 3 in. by 6 in. including the grout lines, there's enough room for 10 full rows of tile plus one row made from pieces about 1 in. wide. But a row of 1-in. wide tiles among 3-in. wide neighbors wouldn't look very good, so I decided to cover the 31-in. width with nine rows of full tiles and two rows of tile trimmed to 2 in. This meant that a grout line would fall at 29 in. from the threshold, so I marked line AB on the subfloor (drawing above).

The distance from A to B is 64½ in. Since 11 rows of tile set lengthwise take up 66 in., I had to trim away 1½ in. from the total. Again, I split the difference by trimming ¾ in. from the tiles that fall at the margins. Whenever possible, plan your layout so that the snap-cut edges of the tiles face the wall. This way, they'll be covered by the trim tiles. On line AB, I measured out 5¼ in. from the edge of the subfloor to allow for the trimmed margin tiles, and then added another ⅛ in. for a grout line. Then I laid my carpenter's square along line AB, and drew line CD. I checked it with the 3-4-5 triangle method to make sure that line CD was perpendicular to line AB. From line CD, I measured over another 18 in. to mark the grout line for another three rows of tile, and scribed line EF on the plywood. These three lines gave me workable sections that were square to the threshold, and took the most visible tile cuts into consideration. The subfloor was ready (photo above).

Because my epoxy adhesive has such a short pot life (about 30 to 40 minutes, depending on the weather), I like to have all my tools, a sponge and a bucket of clean water nearby before I start setting the tiles. I also cut the first row of tiles to size before I mix up the goo. From experience, I've learned that in spite of everyone's best intentions, walls run out of square and out of parallel a little here and there, and bathroom fixtures like tubs and shower stalls frequently have slightly irregular surfaces. So even though I've allowed 5¼ in. for the first row of tiles, chances are that the actual measurement will vary a bit. Cutting the first row before I mix the adhesive lets me check the tiles in place for fit without having to think about $40 worth of epoxy turning to stone in my best bucket while I'm fiddling with the tile cuts.

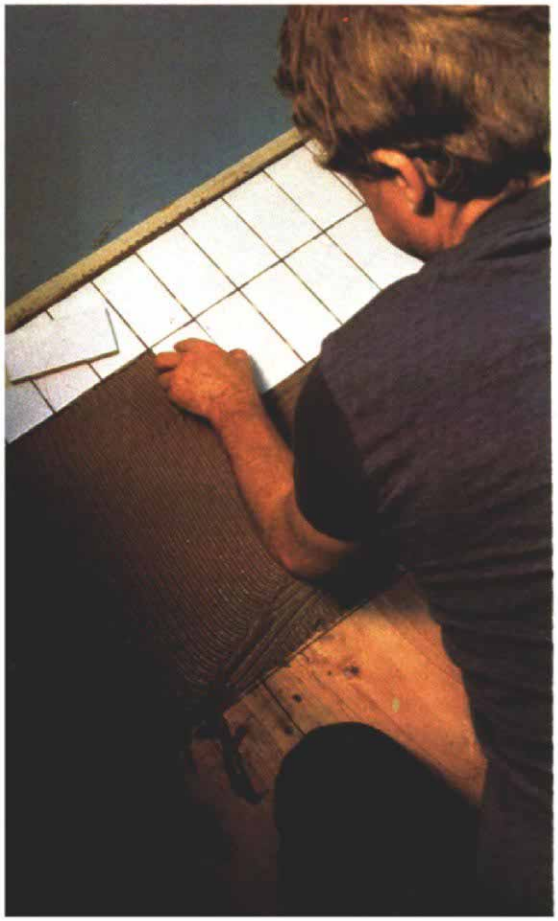
The snap cutter—This is the tool you'll need to make straight cuts in tiles. A snap cutter costs about $40, but most tile shops or tool-rental shops rent them out. The cutter (photo facing page, center) consists of a metal base covered with a rubber pad that helps to hold the tile in place while it's scored. An adjustable fence braces the tile for 90° and 45° cuts, and a track over the base holds and guides the cutter wheel.

To make a cut, mark the cutline on the tile (I use a fine-point, felt-tip pen for this) and line it up with the cutter wheel. Hold the tile in place with one hand and the cutter handle in the other. Lift up on the handle so that the wheel touches the glazed surface of the tile, and pull the handle toward you. Try to score the glaze along the cutline in a single pass with the cutters. Making more than one pass will usually result in a bad break.

To break the tile, hold it in place with one hand, position the cutter handle over the tile and hit the handle firmly with the heel of your other hand. If you've done it right, the wings at the base of the handle will push down on the tile, causing it to break along the scored line. If you haven't ever used a snap cutter before, practice on a few scrap pieces of tile to get the technique right.

It's difficult to snap-cut strips narrower than about ¾ in. Usually the tile breaks in the wrong place. Instead, score the tile with the snap cutter, then nibble to the line with a pair of biters (drawing, facing page), specialized

Illustrations: Barbara Smolover



Epoxy mastic **mixed to a stiff consistency is spread out along the first layout line (top photo) with a notched trowel. Notch depth should be about two-thirds the thickness of the tile. Frequently checking alignment with a straightedge, Byrne seats each tile with firm hand pressure (left). A light tap with the wooden handle of the trowel will seat the occasional proud edge. Pull up a freshly set tile occasionally to make sure the mastic coverage is correct, as in the photo above.**

cutters that have a straight cutting edge on one jaw and a curved one on the other. Use the straight jaw on the glazed side, or face, of the tile.

Epoxy mastics—These adhesives were originally developed for industrial applications that required high bonding strength and resistance to chemicals. A tile-setting epoxy is composed of three separate components that are mixed together just before use. Part A is a resin of oxygen, carbon and hydrogen molecules suspended in a water solution. When combined with a hardener (part B) the resin molecules polymerize into long chains that form a resistant skin with high bonding strength. Part C is a mixture of portland cement and very fine sand. It is blended into the concoction of parts A and B to add body and compressive strength.

There are several brands of epoxy mastic, and they all do basically the same thing. They are sold by the unit, half-unit or in bulk. A full unit, enough to do a floor of about 50 sq. ft., costs about $40. I use Latapoxy 210 chiefly because the liquids are packaged in wide-mouthed containers that are easy to use, and they're mixed at a one-to-one ratio.

The two liquids have to be thoroughly mixed in their own containers before they are blended together. Although it's tempting to use a beater mounted on a drill for mixing, don't do so unless you have a very slow drill. High-speed mixing will whip air bubbles into the liquid, and they will weaken the mastic's bonding and compressive strength. I use a stick or a margin trowel for mixing.

Once the individual liquids are homogenized, pour them into a bucket in the proportions specified by the manufacturer, mix thoroughly, and slowly add the cement and sand while you keep stirring. I like to use my margin trowel for this because I can scrape the sides and bottom of the bucket with the trowel's straight sides and broad nose. There should be no lumps in the final mix, and it should be the consistency of very thick syrup. Never add water to thin the blend; it will render the bond useless.

I've found that the ideal temperature for working with epoxy mastics is between 70°F and 85°F. On hot days, the epoxy sets up faster. Conversely, a cold day slows the stuff down. I've laid floors on cold concrete slabs that have taken three days to set up, and others on plywood that are ready to grout three hours later. But on the average, it takes 24 hours before you can walk on the floor.

Setting the tile—Depending on the size of the section I'm about to set, I either pour the adhesive onto the floor or scoop it out of the bucket with my notched trowel. I spread out a skim coat using the flat side of the trowel, and then work it back in the other direction with the notched edge (photo top left). The depth of the notch should be about two-thirds the thickness of the tile. Spreading the mastic in several directions ensures good adhesion.

For this job, I started setting the tiles

against the wall beginning at the intersection of lines AB and CD. I pressed each tile down until it met solid resistance (photo facing page, bottom left), and if a tile corner stood a little proud, I tapped it down with the handle of my trowel.

Each tile should be completely embedded in the adhesive, and from time to time I pull up a freshly set tile to make sure the coverage was correct (photo facing page, bottom right). The bottom of the tile should be completely coated with adhesive, and the adhesive has to be wet enough to stick. If the epoxy mortar starts to set up, it has to be thrown out—its pot life can't be extended by adding water. If there isn't enough epoxy on the bottom of the tile I check, I use a trowel with a larger notch.

It's also important to make sure that there isn't too much adhesive because it will squeeze up between the tiles, and fill the gap that has to be occupied by the grout. Trenching out clogged grout lines is a wearisome task. If there's too much epoxy, I turn to a tool with a smaller notch. And if I get some mastic on top of a tile, I wipe it off right away with a wet sponge while it's still easy to remove.

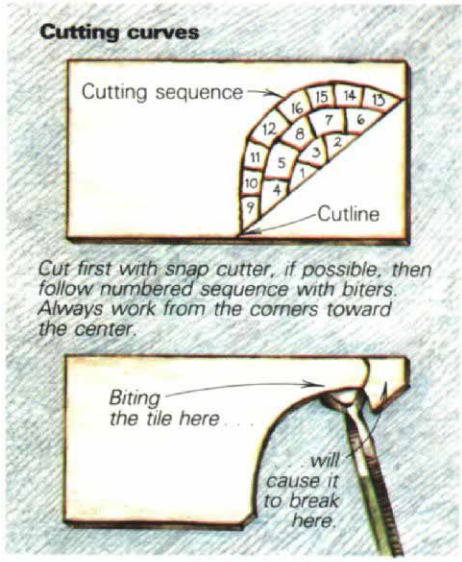
On this job, I continued setting the trimmed tiles along the west wall, carefully aligning them with the layout, and then set in as many full-size tiles as possible around the toilet flange. This left some gaps, and I had to cut some tiles with curves to fit.

Cutting curves—This is where the biters come into play. With them I can shape a tile to fit almost any peculiar gap in the floor, but the tile has to be cut slowly and in the correct sequence (photos and drawing at right). To cut the curve in the tiles around the flange, I first drew the curve on the tiles. Because they will be covered by the toilet, these cuts don't have to be very precise. So I drew freehand guidelines. For radius cuts that are visible, I use a compass. Once the cutlines were drawn, I marked concentric lines about ¼ in. apart and extending to the edge of the tile. The drawing at right shows the sequence for removing the waste bit by bit. Start at the edge of the tile, and always work toward the middle, as shown. This is the best way to shape your cuts and avoid breaks.

Angular cuts—Seven rows in from the north wall of the bathroom, the shower stall takes a 45° jog across the floor, and this change of direction occurs in the center of a tile. To shape this five-sided piece (photos far right), I marked my cutlines with the aid of a sliding bevel and removed most of the waste with the snap cutter, nibbling from the corners toward the center. When I'd finally cut to the line, I smoothed the nibbled edges with my abrasive stone. The stone is also very useful for tile-shaping work that's too minute for the biters or snap cutter.

Trim tiles—The trim tiles where the wall and floor meet can be set as the job proceeds or after all the floor tiles have been placed and the adhesive has set. I used a bullnose base

Cutting curves. **Concentric lines leading to the final line mark the sequence of cuts (drawing, below). To trim tiles to fit around the toilet flange, first mark the tiles with the outline of the curve, then nibble away the bits with the biters, starting from the edges and working in (photos below). Two tile shards used as shims under one of the tiles (bottom photo) compensate for an uneven subsurface. The long bolts allow for the thickness of the new floor.**



Cutting angles. **The shower-stall angle is transferred to the tiles with a bevel gauge (top). To make a pair of angular cuts, begin by removing as much waste as possible with a snap cutter. Then work slowly with the biters from opposite corners to the middle (center). When you reach the line, smooth the raw edges with an abrasive stone (above).**

Trim tiles. **It's easier to apply the epoxy to individual trim tiles, left, than it is to comb the mastic onto the wall. Trim tiles are temporarily held in place by plastic spacers, below, while the mastic sets up. Notice that the trim tile on the left has been shortened to match the width of the field tiles adjacent to the shower enclosure, so that the grout lines on floor and trim align.**

Ceramic tiles

All tiles, even the most elegant, start out as the earthy ooze that lines the bottom of a streambed. As upstream mineral deposits slowly erode, particles are washed downriver where they mingle with organic materials to form sediments known as clay. This is the same soil that expands and contracts as it gets wet and dries out, and it's famous for giving builders fits. But if the mineral particles (primarily aluminum silicates) are removed from the soil, molded into flat pieces, dried and heated to high temperature, the resulting tile is as hard as flint.

Water absorption—The purity of the clay and the temperature at which it's fired determine how much water the tiles will absorb. This is a factor in choosing the right tile for a particular job. Impervious and fully vitrified (made glasslike) tiles are made from highly refined clay (the bisque), and have been fired at temperatures as high as 2,345°F. At this temperature the clay particles begin to fuse, becoming very dense and almost glasslike.

An impervious tile won't absorb more than 0.5% water. This rating means that a tile will absorb no more water than 0.5% of its dry weight after being boiled for five hours. Fully vitrified floor tiles won't absorb more than 3% water; a semivitreous floor tile won't take on more than 7% water while nonvitreous (soft-bodied) tiles absorb more than 7%.

As a rule, 5% and below is considered an acceptable absorption rating for tiles in wet locations; so impervious, vitreous and some semivitreous tiles make good countertops and bathroom floors. Other considerations are acid resistance, resistance to abrasion, slip resistance and glaze hardness. Nonvitreous tiles can also be used in wet places, but they should be secured to a mortar backing over a moisture barrier to prevent water from seeping through and damaging the framing. Never use nonvitreous tiles in wet locations where they might freeze—the moisture in them will expand and pop them loose.

Glazes—Many tiles have color built right into them—terra cotta is a good example. These unglazed tiles range in earth tones from yellow to deep red. Other tiles are finished with a baked-on surface of glass (a glaze) that can take on nearly any color and that's easy to clean.

When you're choosing a floor tile that's glazed, make sure its finish isn't so slick it's dangerous to walk on. And be sure the glazed tile is rated for floor use. Wall tiles are too soft to hold up to foot traffic, their glazes will scratch fairly easily, and they are very slippery.

Some glazed tiles are called "button backed" because of the little feet cast into their backs. These feet allow the tiles to be stacked in the kiln without the use of kiln furniture—tiny, high-fire shims that keep the tiles from fusing together. Integral button shims keep manufacturing costs down without affecting quality. Button-backed tiles must be embedded in a high-compression mastic so foot traffic won't snap off their unsupported corners and edges.

Types of tile—*The* various types of tile are manufactured in different ways and are suitable for different uses.

Quarry tiles are hard-bodied, with color throughout the clay. They are usually a deep red, but black and off-white are also available. They have a water-absorption rating of 5% or less.

Quarry tiles are made by an extrusion process that squeezes a moist body made from natural clay or shale through a die. This shapes a constant cross section, which is cut at intervals with a wire. Quarry tiles range from 3 in. by 3 in. up to 12 in. by 12 in., their dimensions are reasonably accurate, and they're modestly priced—around $2 to $3 per sq. ft.

Paver tiles can be glazed or unglazed, porcelain or natural clay. The unglazed varieties are less expensive, about $2 per sq. ft.

Most pavers are formed by a process called the dust-press method. Depending on the type or color desired, various clay bodies are mixed together, and the wet mix is squeezed through a filter to remove excess moisture. The resulting crumbly mix is allowed to dry almost completely, then it's poured into steel molds mounted on hydraulic presses and compressed into tile shapes. This method is especially good for making precisely sized tiles.

Ceramic mosaic tiles are either porcelain or natural clay. They range from ¾ in. by ¾ in. up to 4 in. by 4 in. These tiles come arranged on fabric or paper sheets to make them easier to handle and set. Ceramic mosaics can be either glazed or unglazed, and some contain an abrasive additive to make them a better walking surface. They're made by the dust-press method or by plastic pressing, which uses a die to form wet clay body into tile shapes by direct pressure. Ceramic mosaics come in a mind-boggling variety of colors and designs, and usually cost more than quarry or paver tile—$3 per sq. ft. and up.

Mexican paver tiles are the fat handmade tiles from south of the border. They are rolled out like pastry with a rolling pin. Frequently they are formed directly on the ground, and their backs show the irregular imprint of some faraway courtyard. Their faces sometimes show the tracks of chickens and other barnyard creatures, giving them a quality called "distressed" in the trade. Mexican pavers readily absorb water, and their surfaces will dust with heavy use. They should be coated with a protective sealer (available at any tile store) to create a durable surface. They're not recommended for bathrooms.

Mexican pavers are cut out with big cookie cutters and the fresh tiles are set aside to dry in the sun. They are usually large (12 in. by 12 in.) square tiles, but interlocking shapes like octagons and ogees are also made. These pavers are made of a soft-bodied clay of varied earth tones that is fired at a low temperature and sometimes under primitive conditions. Some small outfits even use old cars as kilns. The sun-dried tiles are arranged inside the car and its trunk. To fire them, old tires are piled around and on top of the car and set ablaze.

For more on tile specifications and installation, see ***The Ceramic Tile Manual.*** It costs $21 plus $2 shipping (Calif. residents add 6%) from the Ceramic Tile Institute, 700 N. Virgil Ave., Los Angeles, Calif. 90029. ***—Charles Miller***

tile for trim here, and made sure that the trim-tile grout lines lined up with the floor-tile grout lines. I back-buttered each tile and pressed it in place, then shimmed each one from below (photos facing page).

Grout—Grouting tiles is both an art and a science, and while there's no substitute for experience, knowing a little of the science can make the art happen a lot easier. Grout doesn't just fill the spaces between the tiles. It should be packed in from the setting bed to the surface of the tile. Sometimes a tile won't be completely supported by mastic, with a gap that may undercut its edge. These gaps have to be filled with grout, so the grout has to be viscous enough to flow into the voids.

Before I mix the grout, I dampen the entire floor with a sponge. This makes it easier to spread the grout, and it keeps water from being sucked out too quickly by a dry setting bed or highly absorbent tiles. Premature drying weakens the grout.

There are many grouts on the market, but for this floor I mixed my own with equal parts of standard portland cement and 30-mesh sand. A few years ago I started using latex additive in my grout, and I wouldn't do a job now without it. The latex makes the grout easier to spread, and it also speeds curing. Latex additives are made by Custom Building Materials (6511 Salt Lake Ave., Bell, Calif. 90201), Upco (3101 Euclid Ave., Cleveland, Ohio 44115) and by Laticrete International; these companies also make epoxy thinset.

Without a latex admix, a freshly grouted floor has to be kept moist and covered for at least 72 hours. With the latex, the floor is ready to use in 24 hours, and it doesn't have to be covered, unless it's especially hot and dry. I haven't had any problems with corner cracks or grout shrinkage. And when used full strength, the latex reduces mold and mildew growth on tiles in damp spots.

Follow the directions on the package if you use a latex admix. The procedure usually amounts to slow machine or hand mixing until the grout is smooth and lump free, and about the consistency of drywall joint compound. After letting it sit about five minutes, you mix the grout again, and it's ready to use.

I remove any standing water from the floor, and if any areas have dried out (a problem on hot days) I remoisten them with my sponge. Then I dump enough grout on the floor to cover about 10 sq. ft. With my rubber trowel at about a 30° angle, I force the grout into the voids (photo above center). I go over each area a few times with a side-to-side motion until the gaps are packed and then I scrape off the excess grout with the edge of the rubber trowel. Next I thoroughly wring out a sponge and I go over the freshly packed area to remove any grout that stands above the level of the tiles (photo top right). The pressure on the sponge determines how quickly the excess is removed.

I avoid bullying the grout, and if it seems a little too soft, I spread and pack another portion of the floor, and then come back. But it's important not to get too far ahead of the cleaning process—it takes a lot longer than the spreading. During this stage of the job, I remix the grout about every 10 minutes to keep it from setting up in the bucket.

When the joints have been formed and all the sand is gone from the surface, I make parallel sweeps with the sponge to complete the wet cleaning (photo center right). I use one clean side of the sponge per wipe. The rest of the cleanup is done dry.

After about 10 or 15 minutes a cement haze begins to form on top of the tiles. I remove it with cheesecloth, making sure not to distort the grout lines by pressing too hard. If some of the haze won't come off, I rub the area with a moist sponge. Then I remove with a margin trowel any grout that may have found its way into the expansion gap between the plywood underlayment and the wall.

Once the grout has hardened (about 24 hours), I vacuum the dust and grit from the floor, and I apply a bead of silicone caulk to the tile where it abuts the tub or shower stall, and to the trim tiles at the margins of the floor (photo and drawing, right). The caulk keeps the water out and allows the floor to expand and contract without damaging itself. ❑

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Grouting. **After excess epoxy is removed from between the tiles, grout is forced into the spaces with the sharp edge of a rubber trowel, below. It takes several passes from different directions to fill the voids. Most of the excess grout is scraped away with the trowel. As the grout begins to set up, the grout lines are brought down and made slightly concave with a sponge, right. The sponge is worked in parallel strokes, and rinsed out frequently to remove the sand and cement that it picks up. The last cleaning, below right, is with a nearly dry sponge that is rinsed out after each pass.**

Caulking and finishing. **Before the grout sets up, it is squared with a margin trowel along the edges of the shower (below), and excess grout is removed from expansion joints. Once it sets, a bead of silicone caulk is applied.**