

INTERIORS CERAMIC TILE

Success with ceramic and natural stone tile in floor, wall and countertop applications depends on careful surface preparation, layout and detailing.

Tile Types

TILE TYPES

Wear Ratings

Most manufacturers use the Porcelain Enamel Institute (PEI) guide to rate the durability of tile (**Figure A**).

FIGURE A: PEI WEAR RATINGS FOR CERAMIC TILES

Group I	Tiles suitable for residential bathrooms only where softer footwear is worn, or on walls.
Group II	Tiles suitable to general residential traffic, except kitchens, entrance halls, and other areas subject to continuous use.
Group III	Tiles suited for all residential and light commercial areas, such as offices and reception areas.
Group IV	Tiles suited for medium commercial and light institutional applications, such as restaurants, hotels, hospitals lobbies, and corridors.
Group V	Tiles suitable for heavy traffic and wet areas where safety and maximum performance are a major concern. These include walkways, food service areas, shopping centers, building entrances, and around swimming pools.

The Porcelain Enamel Institute (PEI) wear ratings are derived from tests on physical wear of the glaze surface, which evaluates the appearance of the glaze surface after the test. These group ratings are typically listed on tile labels and product literature.

Water Absorption

The capacity of a tile to absorb water is determined by its firing temperature, duration of firing, and composition of the clay. Ratings range from non-vitreous (porous) to impervious (**Figure B**). Do not use highly absorptive tile, such as quarry tile, in wet areas. If this can't be avoided, install waterproofing under the tile and add a latex additive to both the thinset adhesive and grout. Avoid mastic set tile in wet areas.

FIGURE B: WATER ABSORPTION OF TILE

Tile Type	Water Absorption	Application
Impervious	less than 0.05%	Hospitals, sanitary installations
Vitreous	0.5% to 3.0%	All residential applications, good for floors
Semi-Vitreous	3% to 7%	All residential applications except outdoors in cold climates. Mist before grouting.
Non-Vitreous	over 7%	Best in dry application. Mist before grouting.

Glazed and Unglazed Tile

Glazed tiles have either a glossy or a matte waterproof surface glaze. Nonskid tiles have an abrasive grit baked into the glaze.

Mosaic tiles have the color added to the clay itself, so it goes all the way through the tile. They're suitable for nearly any surface.

Quarry tiles are usually deep red and unglazed. They're porous, and are mostly used for interior floors. They must be sealed after installation or they will be easily stained. Install with thinset (see Setting Tile).

Paver tiles are also used for floors and are usually unglazed, requiring sealing. The machine-made types are typically vitreous and non-vitreous. The hand-made type is non-vitreous. Install with thinset.

Tile Types

Floor vs. Wall Tile

Tile Substrates

FLOOR VS. WALL TILE

Glazed wall tiles come in a wide range of colors and designs, and are easy to clean. However, they can get scratched when used on countertops or floors since the glaze is relatively soft. Glazed floor tiles come in fewer colors but are tougher and often have a slip-resistant surface.

TILE SUBSTRATES

Tile may be laid over concrete, plywood, drywall, plaster, or cement backerboard. The substrate must be dimensionally stable.

Floor Substrates

Floors should have a maximum deflection of no more than $L/360$ of the span and they should be level to within $1/8$ in. in 10 ft. A wall plane may vary up to $1/8$ in. in 8 ft. With thinset installation, however, surface variations should not exceed $1/32$ in.

Mortar beds. A Portland cement mortar bed can range from $3/4$ to 1 in. thick on walls, and from $3/4$ to $1 1/4$ in. thick on floors. It smooths out irregularities in the substrate and can be used nearly anywhere.

Concrete slabs. A concrete slab that will be covered with tile should be steel-troweled and fine-broomed to a smooth finish. Thinset or mortar-bed installations are acceptable. The slab should include expansion joints to prevent cracking (see **Expansion Joints** in Setting Tile).

Plywood. Plywood subflooring for tile should be nailed to framing spaced no more than 16 in. o.c. While $3/4$ -in.-thick T&G plywood is preferred, a mortar bed installation can be applied over $5/8$ -in. plywood; thinset applications require an additional $1/4$ -in. underlayment of cementitious backerboard (see **Cementitious Backerboard**, below). When using two layers of plywood, glue and screw the two layers together to stiffen the substrate and reduce the chance of cracking the tile or grout line. Make sure all butt joints fall over joists; do not gap plywood sheets.

Wall Substrates

For walls, $1/2$ -in. cementitious backerboard (see **Cementitious Backerboard**, below) is the best option in wet areas, such as bathrooms, though plywood can work if care is taken to support edges and protect against moisture.

Plywood can be used as the substrate on walls. Use minimum 3/8-in.-thick panels if running them perpendicular to the studs. If the sheets must run parallel to the studs, use 1/2-in. panels. Solid blocking should be added beneath unsupported edges. Nail 6 in. o.c. along the edges and 12 in. o.c. in the field. In bathrooms and other moist areas, seal the panel edges with an exterior primer before installation.

Drywall should be installed in the longest lengths possible. Cover taped joints and fasteners with two coats of mud before installing tile. Do not install tile over drywall in wet areas (not even over moisture-resistant drywall).

Plaster should be steel-troweled to a smooth finish with no trowel marks. Ridges should be no more than 1/32 in. in height. Do not install tile over drywall in wet areas.

Cementitious Backerboard

Cementitious backerboard consists of a sand and cement core with either a woven fiberglass skin or a fiber-reinforcing mixed into the core. Both types come in a variety of thicknesses and types, some (but not all) of which are suitable for exterior use. Although these materials are unaffected by water, they do not provide waterproofing since moisture can pass through them. In wet applications, such as a shower pan, a waterproof membrane is also required.

Floors. Use 1/4-in. backerboard over a 5/8-in. plywood subfloor (3/4-in. preferred). Joists should be minimum 16 in. o.c. and level to within 1/8 in. over 10 ft. Embed backerboard panels in a layer of latex-modified thinset mortar spread evenly with a notched trowel. Do not use a thick layer of the thinset to correct an out-of-level floor; this will create a weak spot. Instead, use a self-leveling compound made specifically for tile.

Most cementitious products require a 1/8-in. gap between panels (check manufacturer's instructions). Also, panel joints should be offset with plywood joints, and no more than two panel corners should meet in one spot.

Fasten boards with either galvanized roofing nails or special corrosion-resistant screws made for backerboard, which can cut their own countersink. Do not use drywall screws, which are too weak and susceptible to corrosion.

Fill the joints between panels with thinset mortar and then cover with 2-in. open-weave fiberglass-mesh tape.

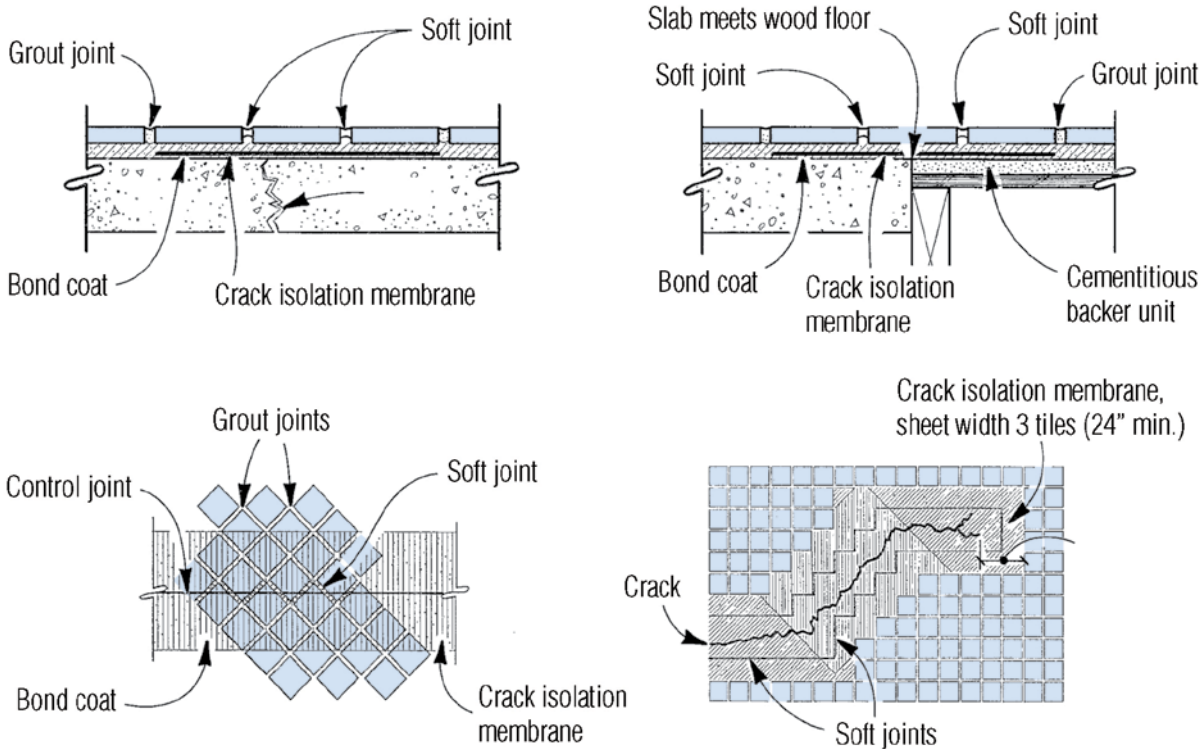
Walls. For wall installations, attach 1/2-in. cement backerboards to studs with galvanized roofing nails or special screws (as for floors). For tub surrounds and shower enclosures, install the panels over 4-mil poly or #15 asphaltic felt hung from the studs. Wall tile installations require 16-in. o.c. stud spacing with horizontal blocking to support panel edges. Steel studs should be 20-gauge or heavier.

TILE MEMBRANES

Water can penetrate any tile system through the grout joints. Membranes can protect the structure from water leakage and protect the tile from structural movement. Membranes are typically applied beneath tile in wet areas, over cracks and control joints in concrete slabs, as well as at the juncture of dissimilar substrates. When used over a crack or control joint, the grout joints on either side of the crack should be replaced with “soft joints” of foam backer rod and high-quality silicone caulk (Figure C).

Tile Membranes

FIGURE C: INSTALLING AN ISOLATION MEMBRANE



Install an isolation membrane over slab cracks and control joints (top left), and at the juncture of dissimilar materials (top right). In the case of diagonal tiles (bottom left), use a zigzag caulk line, or “soft joint,” as shown. For random cracks (bottom right), soft joints should be located on both sides, following the direction of the crack.

Membranes come in liquid and sheet varieties:

One-part membranes are liquid coatings that are poured, brushed, or troweled on. They will work fine for a floor that gets occasional spills, but not for a shower stall.

Two-part membranes are composed of ready-to-use or site-mixed liquids and a fiberglass or polyester fabric (Figure D). They are the most practical choice for waterproofing a complex area like a set of stairs leading into a tub.

FIGURE D: TWO-PART MEMBRANES

Tile Membranes



A two-part membrane starts with a thick liquid (left), which is poured on the tile backerboard and troweled into place (center). This is followed by a fiberglass or polyester reinforcing fabric (right), which is lapped up the walls and around corners, and then smoothed into place with a trowel. This will be followed by a second coat.

CPE membranes are sheet membranes available in rolls of different sizes and thicknesses (**Figure E**). One type that can be used as a water barrier on walls, floors, and countertops is reinforced with spun polyester. The unreinforced type can be used in shower pans and sunken tubs.

FIGURE E: CPE MEMBRANES



After troweling a thinset adhesive onto the tile backerboard (left), roll out the flexible waterproof sheeting (center). Then use a trowel to work out any bubbles and achieve a good bond to the substrate (right). Another layer of thinset will go on top to bond the tile.

TILE ADHESIVES

Tile may be installed with mastic or thinset adhesives (**Figure F**).

Tile Adhesives

FIGURE F: TILE SETTING MATERIALS AND APPLICATIONS

Adhesive Type	Application	Pros	Cons
Organic Adhesive	Plywood, drywall, plaster, backerboard	Best used on walls in dry areas. Economical. Comes ready mixed. Easy to use.	Low compressive strength. Degrades with exposure to heat and water. Some types react with cement backerboard.
Dry-Set Mortar	Concrete, masonry, mortar beds, plaster, backerboards	High compressive strength and bond strength. Economical. Easy to mix and use. Good over concrete or mortar beds.	Not recommended over plywood or drywall, or with large porcelain tiles. Not flexible
Latex or Acrylic Portland-Cement Mortar	Concrete, plywood, backerboard, drywall, plaster	High compressive strength. Flexible. Good for kitchen and bath floors, showers, and tub surrounds. Water-resistant.	Problems with plywood installations reported with some products. More expensive than dry set.
Modified Epoxy Emulsion Mortar	Concrete, plywood, backerboard, most substrates	Very high compressive strength and bond strength. Water-resistant. More economical than epoxy mortar.	Cleanup can be difficult after setup.
Epoxy Mortar	Concrete, plywood, backerboard, most substrates	Highest compressive strength and bond strength. Water- and chemical resistant.	Expensive. Requires precise mixing. Short working times. Difficult cleanup.

Both are spread with the straight edge of a trowel and then combed with a notched trowel (**Figure G**). Use a square-notched trowel for large tile and a V-trowel for small tile. The thicker the tile, the larger the notches should be. To test the size of the combed ridges, as well as the consistency of the adhesive mix, press down on a test tile, remove it, and inspect the back. The back should be fully covered with adhesive.

FIGURE G: APPLYING TILE ADHESIVE



Both mastic and thinset can be spread with a straight edge and bottom of a trowel, then combed into a setting bed with a notched trowel held at a 45-degree angle.

Once the adhesive sets on a floor, no one should walk on the tile for 24 hours.

Mastics

These are expensive and come ready to use, but aren't as strong or flexible as thinsets. They're suitable for light-duty floors and walls only, but should not be used around fireplaces or in wet areas. They require a smooth backing.

Thinset Adhesives

These come in three types:

Dry-set mortar. This consists of Portland cement, sand, and additives, which are mixed with water at the job. It is often used over mortar beds and concrete slabs, as well as on backerboards, and provides good bond strength and compressive strength.

Latex and acrylic thinsets. These are stronger, more flexible, and more water-resistant than water-based thinsets. They can be used over most tile substrates, but only some are recommended for use on plywood. The additives may be part of the dry mix or may be added as a liquid. Bond strengths and set-up times vary. Check label for specific substrates and applications. Clean up immediately after use.

Epoxy mortar and modified epoxy emulsion mortar. These are suited for high bond strength or chemical resistance. They are well-suited to plywood substrates but will work with any setting surface. Combine with epoxy grout when water and chemical resistance are needed. Careful and precise mixing is required; working times can be short, and cleanup is difficult.

Tile Adhesives

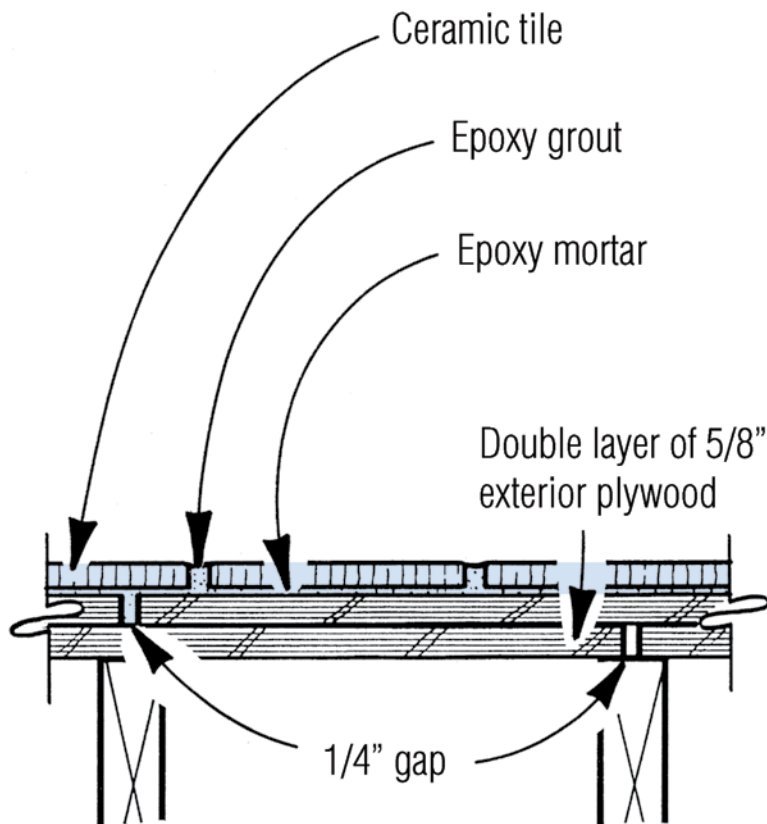
Setting Tile

SETTING TILE

Floor Installations

On light residential floors under dry conditions, mastic over plywood is acceptable. For better quality with some water resistance, upgrade to a latex-modified thinset approved for use on plywood, or an epoxy mortar and epoxy grout (**Figure H**). For still better quality and improved water resistance, use a cement backerboard with a dry-set or latex/acrylic-modified mortar (**Figure I**). Always use a membrane in wet areas, or where substrate movement is expected.

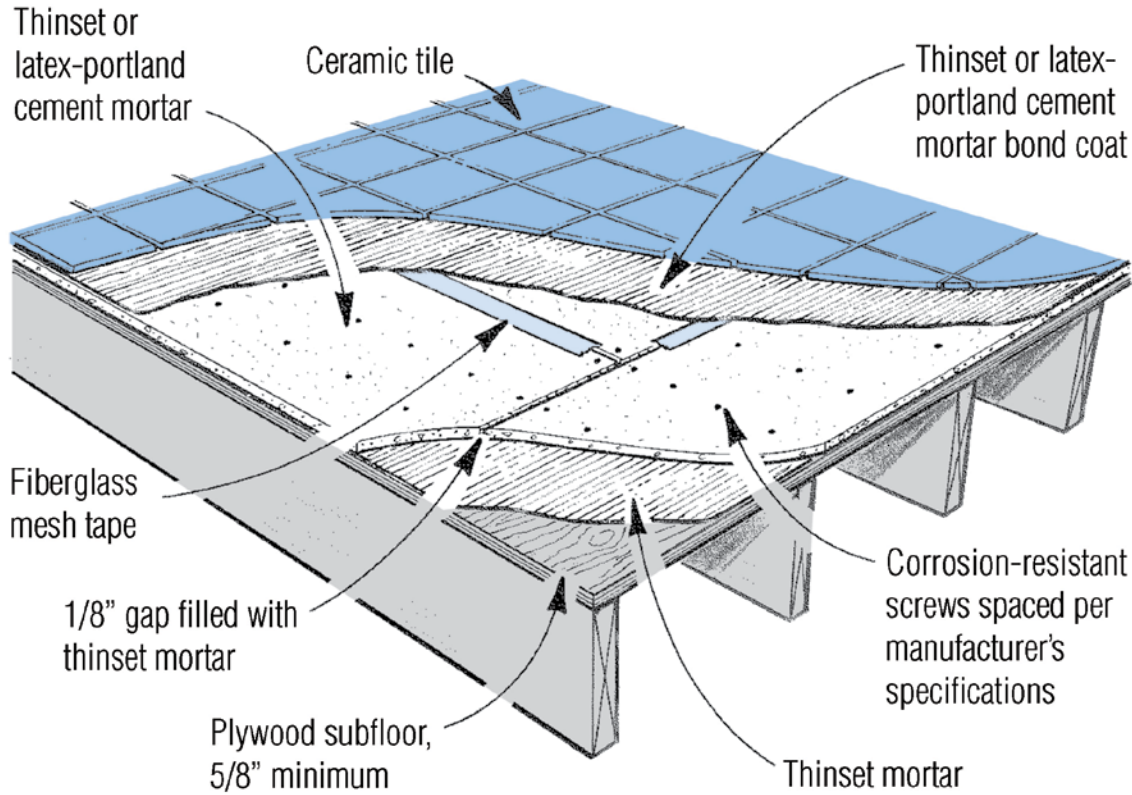
FIGURE H: TILE FLOOR: MODERATE APPLICATIONS



For dry installations, exterior-grade plywood is an acceptable underlayment for tile. Use an epoxy mortar and epoxy grout in areas that will see moderate levels of moisture, such as a kitchen floor.

FIGURE I: TILE FLOOR: WET APPLICATIONS

Setting Tile



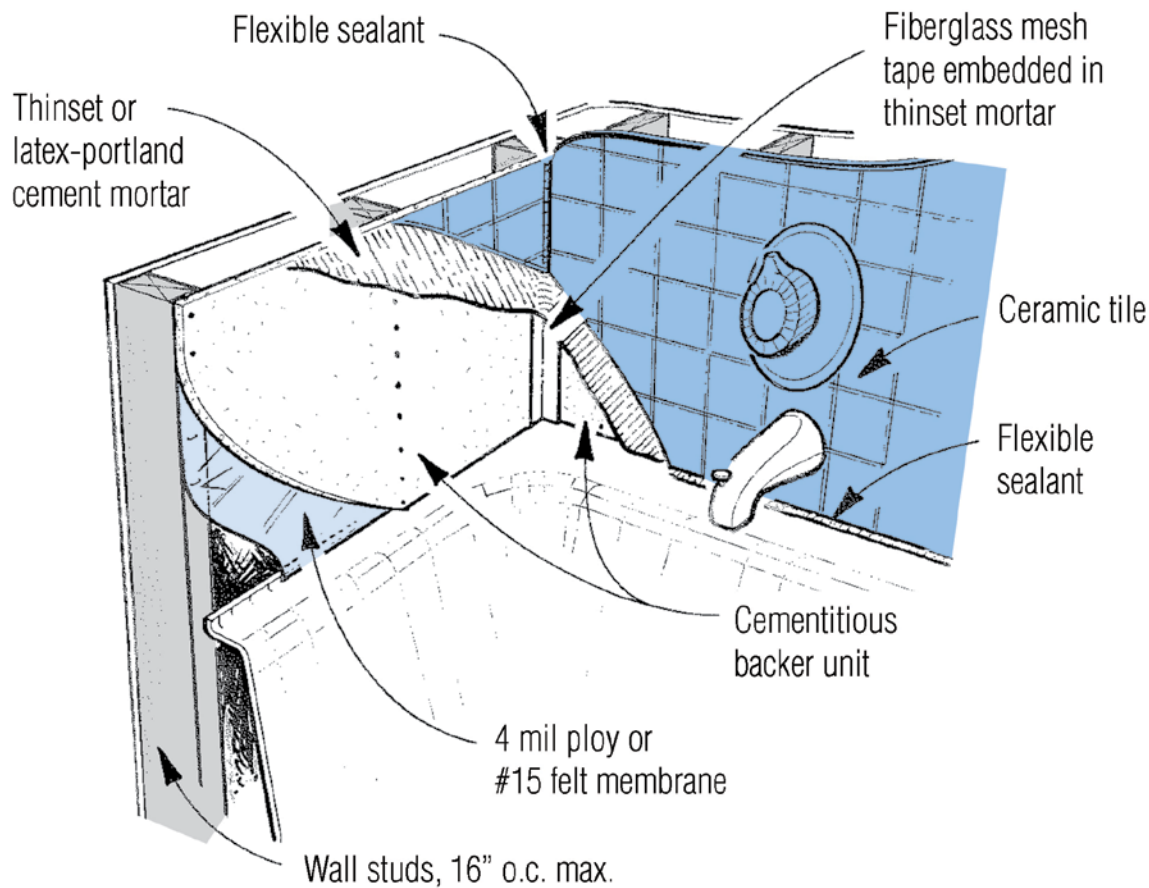
Floor framing for tile must be level to within 1/8in. in 10 feet. Space joists no more than 16 in. o.c., and make sure deflection is limited to L/360. Leave 1/8-in. gaps between plywood subfloor panels (1/4 in. at walls). Install the backerboard over a thin setting bed of thinset mortar, making sure that none of the CBU edges align with the plywood joints.

Wall Installations

In dry areas, use standard drywall (not MR board) with either mastic, dry-set, or latex/acrylic-modified mortar. In areas subject to wetting, such as a tub surround, use a cement backerboard instead of drywall and use a dry-set or latex/acrylic-modified mortar (**Figure J**).

Setting Tile

FIGURE J: TYPICAL BATH SURROUND



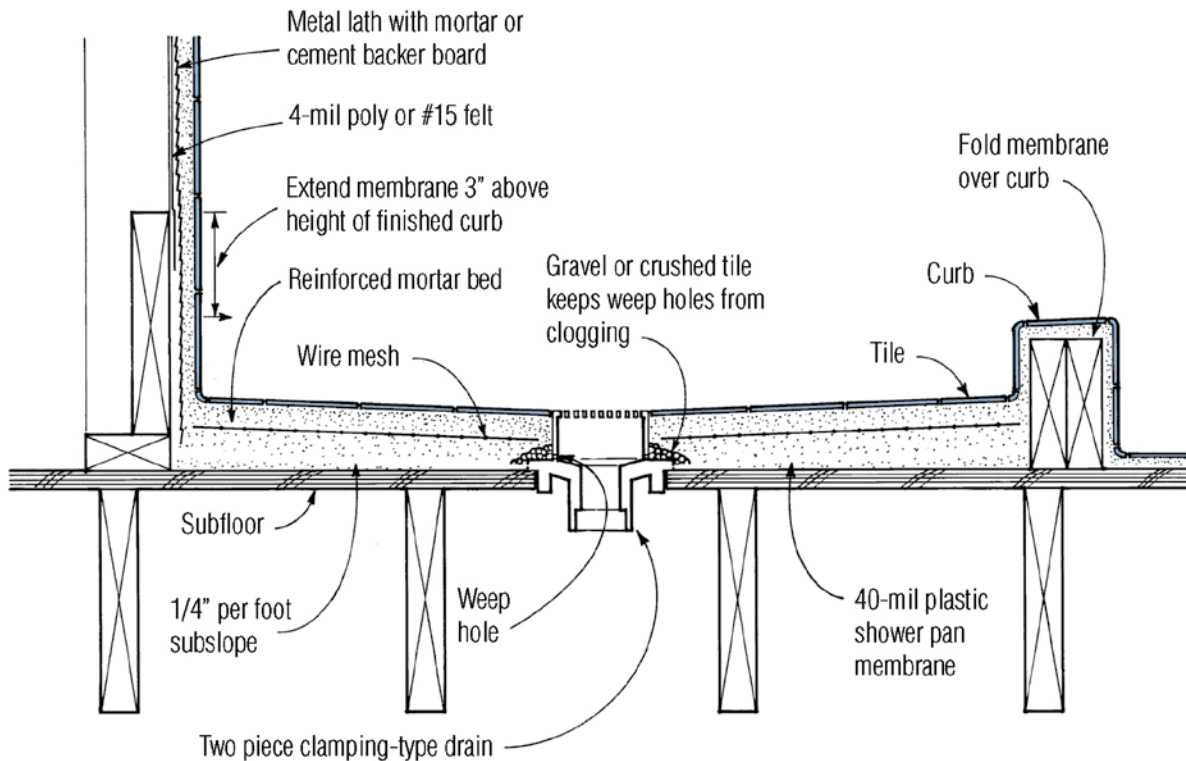
Because tile and cement backer are moisture-permeable, the framing in a bath or shower surround must be protected with a membrane of 4-mil poly or 15-pound felt. Reinforce backerboard joints and corners with thinset mortar and mesh tape. Tile corners, perimeters, and penetrations should be protected with a flexible-sealant expansion joint.

Shower Pans

A tile shower is best built on a mortar-bed floor. Use a heavy 40-mil plastic pan liner. Wrap it over the curb and seal it in place at the drain with a two-part subdrain assembly, as shown in **Figure K**.

Setting Tile

FIGURE K: RECESSED MORTAR-BED SHOWER PAN



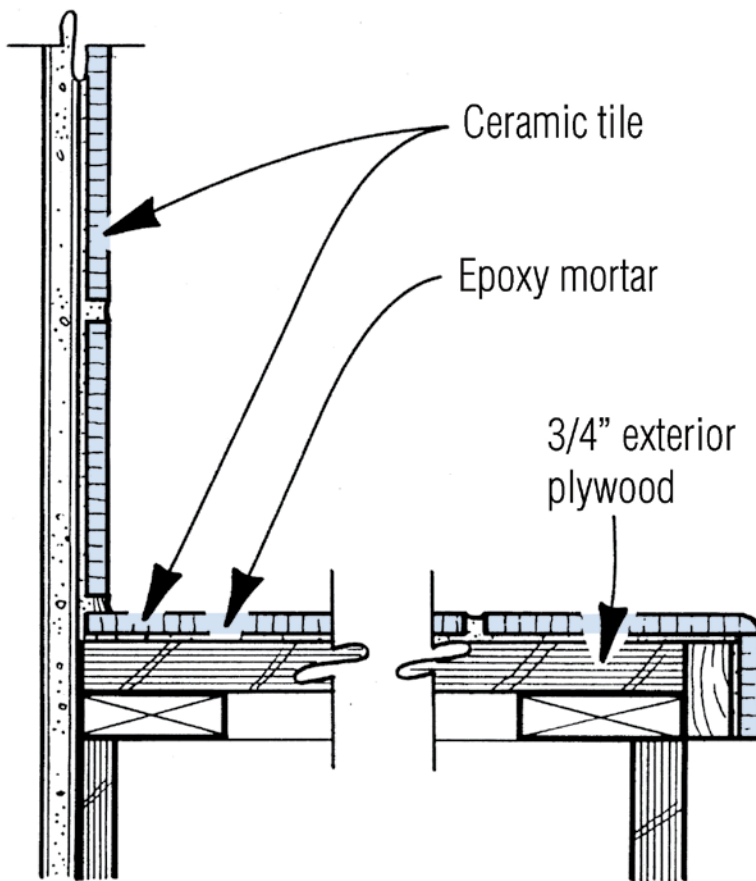
In a typical tiled shower, the pan liner extends above the curb height on walls and is sealed in place by the two-part subdrain assembly. Any moisture that penetrates the tile floor and accumulates will exit through weep holes.

Countertops

A light-duty countertop that won't see much moisture can be made using a mastic- or epoxy-based mortar applied directly to 3/4-in. plywood (**Figure L**). Leave a 1/8- to 1/4-in. gap between sheets and screw a 1x batten under each joint.

Setting Tile

FIGURE L: LIGHT-DUTY COUNTER



For dry, light-duty counters, 3/4-in. exterior-grade plywood will work as a tile underlayment. Avoid pine plywoods; the pitch may act as a bond breaker.

Expansion Joints

Expansion joints are needed wherever a tiled surface meets another material or at a change in plane. In residential work, expansion joints are rarely needed within the fields of a tile surface, but are needed where a tile floor meets a wall, where counter tiles meet a backsplash, or at corners in a shower enclosure or tub surround. Fill these joints with a flexible sealant, not hard grout. Use urethane sealants for maximum durability, and sanded, colored caulks to match the color and texture of the grout.

GROUTING TILE

Grout comes sanded and unsanded. For joints 1/8 in. or smaller, unsanded grout is appropriate. For joints larger than this, sanded grout is recommended. Use a coarser sand for joints over 3/8 in. wide. The sand adds strength and reduces shrinkage (**Figure M**). Don't use sanded grout on shower and tub enclosure walls, since it is difficult to clean and may feel rough.

Grouting Tile

FIGURE M: GROUT TYPES AND APPLICATIONS

Grout Types	Application	Pros	Cons
Commercial Portland-Cement Grout	Wall type used for wet-set mortar-bed installations. Floor type used for mosaic, quarry, and paver tiles.	Water-resistant, dense, and uniformly colored. Easy to mix and clean.	Damp-curing required. Low stain resistance. Absorptive wall tile must be soaked.
Dry-Set Grout	Glazed wall tile and mosaic tile on walls, floors, and countertops.	Easy to mix and clean.	Low stain resistance.
Latex- or Acrylic-Modified Grout	All normal ceramic tile.	Increased bond strength, flexibility, and water resistance. Reduced curing time.	Moderate stain resistance. More difficult cleanup.
Modified Epoxy Emulsion Grout	Floors, walls, and countertops requiring high bond strength and water resistance.	Good stain resistance and water resistance. Little or no shrinkage.	Expensive. Requires special application skills and cleaning procedures.
Epoxy Grout	Floors, walls, and countertops requiring high bond strength and water resistance.	Very strong. Water- and chemical-resistant. Very stain-resistant. Little or no shrinkage.	Expensive. Requires special application skills and cleaning procedures.

Tile Grout

Additives. Many installers use latex- or acrylic-modified grouts, or add acrylic or latex additives to standard grout. These additives increase bond strength, water resistance, and flexibility. However, cleanup may be more difficult.

Epoxy grouts are also available for special applications. These are very resistant to chemical staining, making them a good choice for kitchen floors and countertops. However, they require special application skills. A more economical alternative with many of the same benefits is modified-epoxy emulsion grout.

Joint width. This is largely an aesthetic decision. In general, the larger the tile, the wider the joint. A 1/8- to 1/4-in. joint works well for most tile that's 4x4 in. and bigger. Larger joints look better with irregular tile, but joints larger than 1/2 in. are prone to cracking.

Grout color. Grouts are available in a wide array of colors, and a close match to the tile is usually possible. Gray mortar-colored grouts are a safe choice for most applications. Avoid white grout on floors.

Prep Work for Grouting

Tile-sealing. Acrylic- or latex-modified grout may stain some tile that ordinary grout wouldn't. Test a soupy mixture of modified grout on the tile surface and, if necessary, seal the tile with a water-based sealant before grouting. All unglazed tile should be sealed before grouting to prevent staining.

Clean joints. Before grouting, remove spacers and adhesive remaining between the tiles. This will prevent discoloration caused by variations in joint depth.

Misting. When working with a non-vitreous tile, dampen the surface and the sides of each tile with a sponge or garden sprayer to keep the grout from drying too fast. In dry, hot weather, do this on all tile. Do not create puddles, however, as they can weaken or discolor the grout. Keep direct sunlight off fresh grout to prevent uneven drying.

Applying Grout

Mix the grout according to the manufacturer's instructions and apply to a small area at a time using a rubberized grout trowel (not a steel trowel).

The consistency of the grout mix should be stiff enough to hold its shape but fluid enough to fill joints when pressed into place with a rubber trowel. Mix subsequent batches in a clean bucket to keep the old grout from causing the fresh batch to set up too fast.

Work the grout forcefully into the joints, densely packing it before scraping away the excess. Force the grout into joints by holding the rubber trowel at a shallow angle as you sweep it over the tile from several directions. To scrape away the excess, hold the trowel on edge and stroke the surface on a diagonal to the joint direction.

Cleaning. Once the grout starts to set, use a dull knife or the tip of a trowel to slice it out of expansion joints, which will later be filled with caulk. Begin cleaning by wiping the tile with a clean, damp sponge, using a light circular motion, and then make a final pass with the sponge, using long, straight strokes. After the tile dries, remove any grout haze from the surface with a soft cloth or towel.

Clean the face of the tiles before the residue hardens — or you may need to use a special “grout-haze” cleaner later. Avoid using acids or other harsh chemicals since these can harm some glazes.

Curing. Keep the grout moist and loosely covered with kraft paper or plastic sheeting for as long as is recommended — typically several days for grout with latex additives. Also, once the grout sets, no one should walk on the floor for 24 hours.

Expansion joints. Never grout expansion joints, cove-tile-to-floor-tile joints, or joints between tile and another material, such as wood, porcelain, or metal (including the tub lip-to-tile joint). Instead, use a resilient caulk to seal these joints.