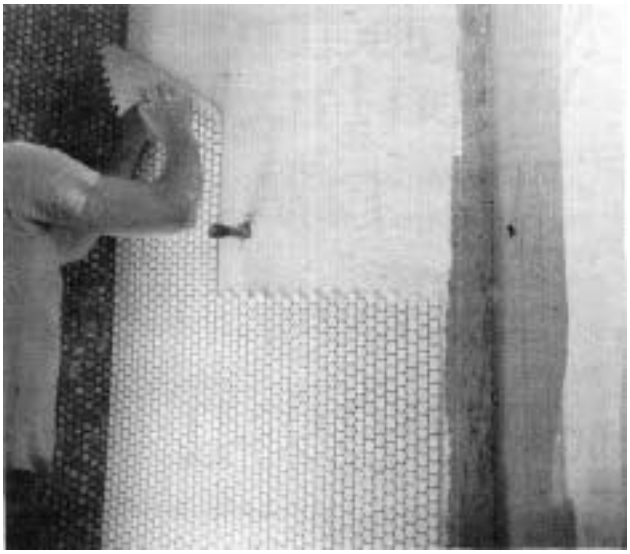
New Ceramic Tile Technologies

Promises and Problems

by Joe A. Tarver



This shower stall (also shown on this month's cover) uses felt paper and asphalt as waterproofing and an insolation membrane between a float mortar bed and gypsum wallboard. The tile are thin-set to the hardened mortar bed.

Ceramic tile has had a glorious past, and predictions for the future are even more rosy. The total U.S. ceramic tile market in 1975 was, in round figures, $214 million. In 1986 it topped $900 million and by 1995 that figure is expected to double.

While the rapid growth was good news for the tile industry, it caused problems for old-line craftsmen, who had a difficult time keeping pace with demand. In response, the industry began developing innovative "thin-bed" methods and materials as alternatives to the traditional "thick-bed" installation. Thin-bed installations, including mastics and dry-set mortars, now command over 90 percent of the market. (Thin-bed mortars are called "dry-set" because the tiles don't need to be soaked in water.)

When these products first came out in the 1950s no one could predict how well they would perform and how long they would last. But over time, they have demonstrated good stability and longevity. Thin-bed installations, following all applicable specifications, compare favorably to the old methods. Some products, such as cementitious backerboards, have proven equal to, or even better than, the old methods.

Substrates

One factor affecting tile installations is the general movement by architects and engineers, away from traditional "over-building," toward smaller and smaller tolerances in construction. This is economical for the owner and developer, but creates some difficulty for the tile contractor. In high-rise construction, for example, thick slabs have been replaced by thinner, pre-formed and/or post-tensioned concrete. The thinner slabs are designed to be slightly convex with no load, returning to level or slightly concave under a load of tile, furniture, and people. Thin-bed installation of ceramic tile on a substrate of this type, using today's products and methods, will probably fail.

This is only one example of how a substrate can affect the performance of a ceramic tile installation. Needless to say, ceramic tile installations will never be any better than the substrates to which they are applied. Further, tile setters must pay strict attention to the compatibility of the tile, the setting material, and the substrate. It is imperative that you follow the specs for the particular substrate you are dealing with.

Some suitable backings for dry areas include gypsum board, glass-mesh mortar units, gypsum plaster, portland cement mortar, formed concrete, and masonry. Suitable backings for wet areas include portland cement mortar, formed concrete, and masonry; and for walls only—glass-mesh mortar units or water-resistant gypsum board.

Plywood, particle board, and cement asbestos board are dimensionally unstable and are therefore *not* ideal backings for ceramic tile. Plywood may be used, however, on horizontal surfaces when installed in accordance with ANSI specifications. If you do use plywood, it must be at least 5/8-inch thick and the joist spacing cannot exceed 16 inches on-center with maximum deflection of 1/360th of span. Plywood must be nailed every six inches along panel edges and every eight inches throughout the panel. But plywood subjected to moisture can delaminate. The expansion and contraction rates of wood and tile are vastly different, especially when wet, and most thin-set materials cannot withstand the resulting movement. Anything from cracked grout joints to a total loss of bond can occur. Deflection of the subfloor is always a potential problem.

Concrete substrates, as mentioned above, can deflect beyond the accepted tolerance of 1/360th of span, with the same results as a wood substrate deflection. Concrete substrates should be checked for curing compounds, oil, grease, and other contaminants, including dust, that would act as a bond breaker. They should be level to 1/8-inch in ten feet, except as required for drainage.

Concrete slabs should be placed at least 28 days prior to tile installation. Give careful attention to the plans, specification requirements, and locations for expansion joints, control joints, and cold pour joints.

All joints in the structure should continue through the tilework. The tilework joints should be directly over structural joints, and must never be narrower than the structural joint. It is the responsibility of the architect to specify the location and details of expansion and control joints. The Tile Council of America's *Ceramic Tile Handbook* (see resource list at end of article) lists requirements for expansion joints. They are generally required every 24 to 36 feet in each direction for interior work. For interior tilework exposed to direct sunlight or moisture, however, they may be required 12 to 16 feet in each direction. And regardless of distances, they are needed where tilework abuts restraining surfaces (such as walls, curbs, or columns) and where changes occur in backing materials.

Inadequate or no expansion and control joints can cause numerous problems, from cracked grout joints to total bond failure. Floors with no perimeter expansion joints have "heaved" as much as six to eight inches from the substrate in the middle of the room. The pressure was so great in one particular job, that quarry tile literally exploded and shards of tile were embedded in the acoustical ceiling.

Where drywall is the substrate, all joints should be taped and free of voids. Corner beads should be left off at corners that are to be wrapped with tile. Inside and outside corners should be square. Drywall should be stopped a minimum of 1/4-inch and a maximum of 1/2-inch above the floor or where the vertical surface intersects with horizontal surfaces, such as tub rims.

Dry-set installations over gypsum-based substrates in wet areas are not durable because gypsum and lime putty are both very sensitive to moisture. Even the small amount of water contained in dry-set mortar during application can deteriorate gypsum board.

It would be impossible to cover all potential substrate problems here. But the tile contractor must be constantly aware of the potential for structural movement, deflection, expansion, and contraction, whether working with commercial or residential design.

Waterproofing

A ceramic tile installation does not necessarily constitute a waterproof barrier against water penetration. Consequently, waterproof membranes are available for use under both thin-bed and thick-bed installations (see accompanying story starting on page 20), although no industry ANSI/ASTM specifications are recognized at this time. Depending on the system, the waterproofing membrane may be applied under the substrate or between the substrate and the tile. Like most products, some require a great deal of skill to install, while others can be applied by workers with average mechanical skills.

There are several different types of waterproof membrane systems on the market. Most are either one-, two-, or three-component materials applied in a liquid/paste form at a thickness of 20 to 125 mils. They cure into a continuous membrane, some with load-bearing capabilities. Some of the systems have integral reinforcing fabrics for tensile

The Twelve Steps of Thin-Set

Robert T. Young, CSI, one of the industry's leading consultants, recommends the following "Twelve Steps" for thin-set tile installation. All twelve are good information for the novice and journeyman.

1. Mix thin-set and grouting materials at as slow a speed as possible to prevent air entrapment (150 rpm recommended).

2. Allow thin-set and grouting materials to set (slake) for 10 to 15 minutes after mixing, then remix. Consistency should be stiff enough to stick to bottom side of trowel without falling off. Do not add more liquid after material has slaked.

3. Clean surface before applying bonding material. Dampen if dry but do not saturate.

4. Apply mortar with flat side of the trowel, pressing firmly to key into the substrate. Then select the appropriate notched trowel and comb the mortar to give a thickness of approximately 3/32-inch after tiles have been beat in.

5. Set tile with a sliding, twisting motion as quickly as possible to insure the bond coat does not "skin over" before tile is applied and beat in. (In hot, windy, dry climates it may be necessary to work nights or use cold water and materials to prevent "skinning over.")

6. Beat or twist tile into fresh bonding material with a block and hammer. Pull up tile occasionally to be sure that trowel marks are compressed to provide a minimum of 80 percent average coverage on interior and 95 percent on exterior applications.

7. Allow 48 hours after setting the tile before grouting.

8. Mix the grout at slow speed to as stiff a consistency as can be worked. Allow to set (slake) for 10 to 15 minutes and remix.

9. Dampen the surface of the tile before applying the grout.

10. Press the grout firmly into the joints, clean with a minimum amount of water.

11. Cover immediately after grouting. Wet the following day and re-cover in hot, dry, windy climates.

12. *Do not clean with muriatic acid.* If acids are required, use sulfamic acid or products recommended for the particular surface.

strength and minor crack-bridging properties. Some elastomeric products are designed to be used as a one-step waterproofing and setting bed.

Similar anti-fracture membranes are also on the market, designed to eliminate surface cracking due to sub-surface failures, such as cracks in a slab. They are not necessarily designed to waterproof the installation.

Setting materials

Setting materials are the mortars and adhesives used to bond the tile to the substrate. The modern setting materials are referred to as "thin-set." These include dry-set portland cement mortars, furan mortars, organic adhesives, and epoxies. Generally, a thin-bed of *adhesive* should be 1/32-inch thick after the tile has been beaten into place. Thin-set *mortar* installations should be 3/32-inch-thick. In both cases, two-thirds of the joint depth must be kept open for grouting.

A variety of compounds can now be added to portland cement mortars (and grouts) to improve performance. The four main types of latices or emulsion additives are:

Polyvinyl acetate emulsions (PVAs): Excellent bond strength, good resiliency, fair color retention, high water absorption, limited water resistance. Interior use recommended only.

Styrene butadiene rubber (SBRs): Excellent bond strength and resiliency, fair color retention, low water absorption. Recommended for interior or exterior use.

Acrylic resin: Excellent bond strength, resiliency, and color retention, low water absorption. Recommended for interior or exterior use.

Epoxy: Two-part epoxy emulsion and hardener combined with a portland cement sand blend. Excellent bond strength, good resiliency, improved chemical resistance, fair color retention, low water absorption. Recommended for interior or exterior use.

Furan and Furnan are also available for setting and grouting tile where resistance to chemicals and prolonged high temperatures are required.

All of these products have been developed to improve the thin-bed method of installing and grouting ceramic tile, pavers, thin brick, and thin marble and granite tiles.

The unfamiliar-sounding names are listed merely to stress the degree of chemical involvement in the tile industry. When you go to purchase grouts and dry-set mortar the best approach is to use products from the same manufacturer. Mixing one manufacturer's dry-set mortar with another manufacturer's latex additive could void warranties from both.

It is important to use latex additives with portland cement mortars and grouts because they improve adhesion, frost resistance, color retention in grouts, flexural and impact strengths, retention of water in grout when grouting high-absorption tiles (for proper hydration), resistance to staining, and easier cleaning and maintenance due to increased density.

The small cost for additives is far outweighed by value and performance. Most of these additives along with thin-set mortars and grouts can be purchased from local area distributors. Make your selection on the basis of the job requirements and use each in strict adherence to the manufacturer's recommendations regarding suitability, mixing, and application.

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Grouting

This is the last, and perhaps most critical aspect of a tile installation. The choice of grout and how professionally it is installed will largely determine the client's satisfaction. The most beautiful tile in the world can't overcome a sloppy grout job.

The most common mistake with portland cement grouts is the use of too much water, both in mixing and in cleaning. Pigmented, or colored grouts, are particularly affected by too much water in cleaning. The pigments, prior to hydration or curing of the grout, float free. Excessive water simply washes them away. Discolored grout joints are the end result. The MMSA Grout Guide shown above can help in selecting grouts.

In all cases, users should refer to the manufacturers for information on how to prevent grout problems. Another good resource is ATTMCSA's *Problem-Solving Guide for Ceramic Tile Grout Installations* (found in the ATTMCSA Reference Manual). This covers in detail such problems as efflorescence, low grout joints, pinholes in grout joints, and powdery or soft joints.

Know-How

The best defense against tile installation problems is knowledge of the products and systems you are using. See the list of resources at the end of the article. The Ceramic Tile Handbook and the ANSI Standards are a must.

Most new products are not difficult—they are just different. Use common sense. If you are installing products that are unfamiliar, seek help. Avail yourself of every educational opportunity: attend seminars, workshops, conventions, and expositions. Talk to factory reps, distributors, and contractor personnel. Demand answers about how to use the products and tools you buy. And lest you forget, the best and most immediate help is right at hand—on the instruction labels of the bag or bucket.

For more information:

Ceramic Tile: The Installation Handbook by the Tile Council of America, Inc., P.O. Box 326, Princeton, NJ 08542; $1.

American National Standard Specifications for the Installation of Ceramic Tile, by the Tile Council of America; $3.

Bulletins 1 through 15 from the Materials and Methods Standards Association, 315 South Hicks Road, Palatine, IL 60067

ATTMCA Reference Manual. Association of Tile, Terrazo, Marble Contractors & Affiliates, P.O. Box 13629, Jackson, MS 39236. (available to non-member tile contractors for $125) ■

GROUT GUIDE

		GROUT TYPE								
		Commercial Portland Cement		Sand-Portland Cement	Dry-Set	Latex Portland Cement (3)	Epoxy (1) (4)	Furan (1) (4)	Silicone or Urethane (2)	Modified Epoxy Emulsion (3) (4)
		Wall Use	Floor Use	Wall-Floor Use	Wall-Floor Use					
Tile Type	Glazed Wall Tile (5) *(More than 7% absorption)*	●			●	●			●	
	Ceramic Mosaics	●	●	●	●	●	●		●	●
	Quarry, Paver & Packing House Tile	●	●	●		●	●	●		●
Areas of Use	Dry and intermittently wet areas	●	●	●	●	●	●	●	●	●
	Areas subject to prolonged wetting	●	●	●	●	●	●	●	●	●
	Exteriors	●	●	●	●	●	●	●		●
Performance	Stain Resistance	D	C	E	D	B	A	A	A	B
	Crack Resistance	D	D	E	D	C	B	C	A (Flexible)	C
	Colorability	B	B	C	B	B	B	(Black Only)	(Restricted)	B

Performance ratings—Best to Minimal (A B C D E).

(1) Mainly used for chemical-resistant properties.

(2) Special tools needed for proper application. Silicone, urethane and modified polyvinyl chloride used in pregrouted ceramic tile sheets. Silicone grout should not be used on kitchen countertops or other food preparation surfaces unless it meets the requirements of FDA Regulation No. 21, CFE 177.2600.

(3) Special cleaning procedures and materials recommended.

(4) Epoxies are recommended for prolonged temperatures up to 140F, high temperature resistant epoxies and furans up to 350F.

(5) Use a rubber-faced trowel when grouting glazed tile with sanded grout.

Courtesy of the Materials & Methods Standards Association

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