



the Construction Specifier

Tile Uncoupled

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Installation methods and their overall impact

by Sean Gerolimatos

For millennia, earthenware tiles have been crafted in different shapes, sizes, and colors. The technology has progressed from the ancient practice of baking clay in the sun to firing earth materials at thousands of degrees in sophisticated, modern kilns. From intricate mosaics to the largest formats, earth tones to bright colors, metal finishes to convincing ‘wood’ surfaces, ceramic tiles facilitate boundless design options for both residential and commercial applications.

When used for flooring, tile’s desirability goes beyond aesthetics. Tiled surfaces do not trap dirt and dust, making them an easy-to-clean and hygienic flooring solution. The durability of ceramic allows it to be used in areas subjected to heavy loads and high levels of traffic. Further, ceramic tile is

not sensitive to moisture (making it suitable for use in wet areas) and its low thermal resistance promotes energy efficiency when used in conjunction with radiant floor heating systems.

As is the case for most applied flooring materials, the performance of ceramic tile largely depends on the installation method used. Since the tiles represent only one component of the overall composite flooring assembly, it is important to understand the physical characteristics of tile and the dynamics of such assemblies in general. This empowers design professionals to specify installation methods that allow the tile to perform its function as the veneer component.

Ceramic tiles, like bricks and other fired-clay products, are very strong in compression, but also stiff and brittle. Even small deformations can produce high levels of stress.



Uncoupling membrane application at Providence Park Hospital. The system's specification helped yield the necessary flexibility for placing movement joints.

Consequently, the tile floor is quite sensitive to movement, and its performance depends on the dimensional stability of the other materials in the assembly—particularly the structural base or substrate.

Relative to ceramic tile, most substrates are dimensionally unstable. In other words, these materials tend to expand and contract with changes in temperature and relative humidity (RH) or moisture content at a different rate from the tile. For example, concrete has a coefficient of thermal expansion nearly twice that of typical ceramic tile. Thus, as temperatures increase, the concrete slab expands more than the ceramic tile, resulting in a discontinuity between the materials.

There are various other examples of similar behavior between tile and its substrate. Plywood subfloors can expand and contract significantly with changes in moisture; suspended floors bend and deflect when loaded. All these differential movements have the potential to produce stress in the tile assembly.

Tile installation throughout history

There are tile floors in European cathedrals installed centuries ago that remain intact to this day. (Some applications date back nearly 2000 years.) A common thread in these applications was the placement of a layer of tamped sand (*i.e.* 25 to 152 mm [1 to 6 in.] thick) on the structural base

prior to the installation of the tiles in a relatively thin (*i.e.* 3.2 to 6.4-mm [$\frac{1}{8}$ to $\frac{1}{4}$ -in.]) bed of mortar.

The sand strata effectively distributes loads from the tile-covering to the structural base, which enables the tiles to sustain high traffic levels. The relatively low cohesive strength of the sand also makes the strata a forgiving shear interface within the assembly, effectively 'uncoupling' the tile-covering from the base.

This prevents lateral movement in the structural base from producing damaging stresses in the tiles. Thus, the combination of uncoupling and vertical support within the composite assembly provides the appropriate framework for success of the ceramic tile as the floor-covering material.

Mortar bed method

Another important tile installation method to understand is the mortar bed method. In these applications, a slip sheet or cleavage membrane is laid over the structural base before placement of a relatively thick (*i.e.* 32 to 51 mm [1.25 to 2 in.]) wire-reinforced mortar bed. While the mortar is still fresh, the tiles are bonded to the mortar bed with a neat coat of portland cement and water.

The mortar bed method functions on principles similar to the sand strata method. The cleavage membrane uncouples the tile-covering from the structural base, while the mortar bed distributes the loads to support traffic. It is also important to note the mortar mix design is very dry and lean (*i.e.* typically a 5:1 sand/cement ratio). Just enough water is used to enable the tile installer to compact and screed the mortar easily. In addition to excellent workability, this mix design minimizes potential for excessive shrinkage and curling.

Direct-bond method

In the 1960s, a new type of bonding mortar was developed to set tiles in conjunction with the mortar bed method. This cementitious mortar included water-retention agents, which allowed tile-setters to install absorptive tiles in the mortar bed method without needing to soak the tiles in advance. Consequently, the new product was called 'dry-set' mortar. Eventually, dry-set mortars were used to bond tiles directly to the structural base. They became more commonly known as 'thin-set' mortars since the bond coat is only about 3.2 mm ($\frac{1}{8}$ in.) thick, with the installation process referred to as the 'thin-bed method.'

This direct-bonding has become the most common tile installation practice in North America because of its convenience—not only does it allow thinner and lighter tile assemblies, but it also requires less skill to execute than the mortar bed method. Unlike the sand strata and mortar bed methods, direct-bond does not offer the benefits of uncoupling.

When the tile is rigidly connected to the structure, movement in the structural base can produce damaging stresses in the tiles.

Uncoupling membranes

Approximately 20 years ago, a new tile installation method was developed to incorporate uncoupling within a thin-set assembly. The method was based on a configured polyethylene membrane with an anchoring fleece laminated to the underside. The membrane is bonded to the substrate by embedding the anchoring fleece in thin-set mortar. The top of the membrane features a grid of cutback cavities that provide a mechanical lock for the thin-set mortar used to set the tiles. Support for the tile is ensured by the column-like mortar structures formed in these cavities, which carry the loads from the tile to the structural base.

Uncoupling membranes are configured to provide lateral flexibility and allow for independent movement between the tile and substrate. This effectively limits transfer of differential movement stresses and protects tiles from damage. Thus, the uncoupling membrane method bridges the gap between the ancient wisdom of the sand strata method and the modern convenience of the direct-bond method by providing a forgiving shear interface and thereby improving the performance of thin-set assemblies. Uncoupling membranes range in thickness from 3 to 8 mm ($\frac{1}{8}$ to $\frac{5}{16}$ in.) (This uncoupling membrane method is recognized in various details in the Tile Council of North America's *TCA Handbook for Ceramic Tile Installation*.)¹

Movement joints

In addition to movement in the structural base, it is important to consider movement of the tile-covering itself. Tiles expand and contract with changes in temperature, relative humidity, and loading. This expansion and contraction produces stresses that can lead to grout cracking and tile buckling. Such stresses can be mitigated by providing movement joints at any restraining surfaces and at regular intervals in the field.

The *TCA Handbook for Ceramic Tile Installation* includes guidelines for movement joint placement in Method EJ-171. Recommendations for movement joint spacing vary with environmental conditions. Tighter spacings are recommended for wet areas, floors incorporating radiant heat, areas exposed to direct sunlight, etc. This is because the higher temperatures and moisture levels result in increased expansion of the tiles.

Movement joints are created by keeping joints free of grout and instead filling them with flexible materials. Options include field-applied sealants and prefabricated movement joint profiles typically installed in conjunction with the tile. Movement joint profiles consist of anchoring legs embedded in the tile bond coat to secure the joints and protect edges of

the adjacent tiles. The anchoring legs are connected by flexible materials (e.g. chlorinated polyethylene [CPE] or thermoplastic rubbers) that accommodate movement. Aside from protecting tile edges, movement joint profiles also offer the advantage of not requiring maintenance over time. Sealant joints typically need replacement periodically.

The material costs of profiles generally exceed the costs of sealants (approximately \$1.50 to \$10 per lineal foot for profiles, compared to \$0.50 to \$1 per lineal foot for sealant), but labor costs bring the two options closer in price. Profiles offer maintenance-free performance and are relatively straightforward to install. Sealants can produce lasting joints, but installation requires more attention to detail. For example, if sealant joints are installed without bondbreaker tape or backer rod, the joints will require periodic replacement (*i.e.* every few

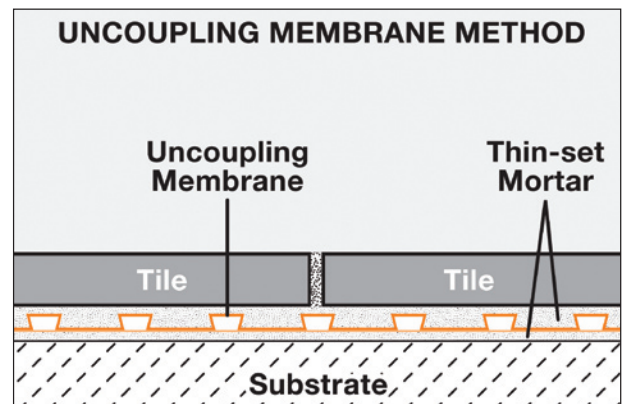
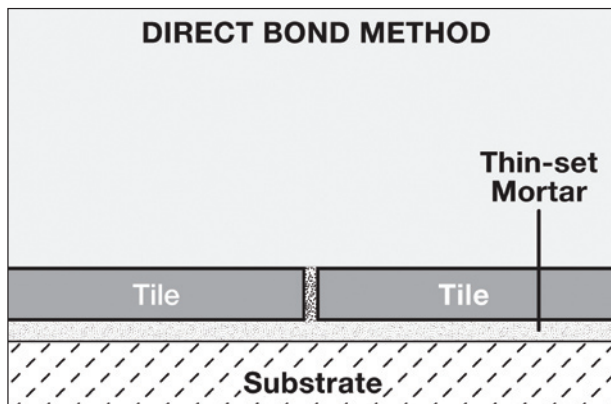
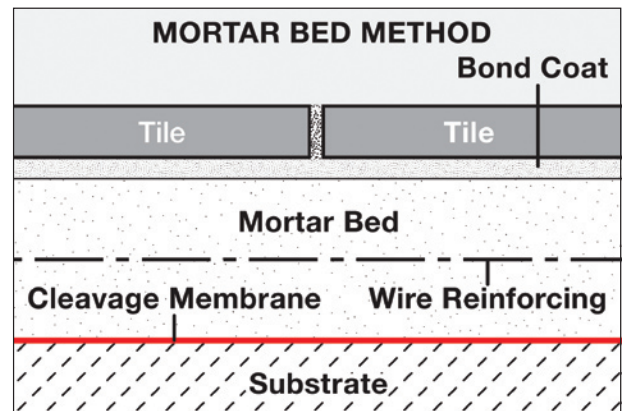
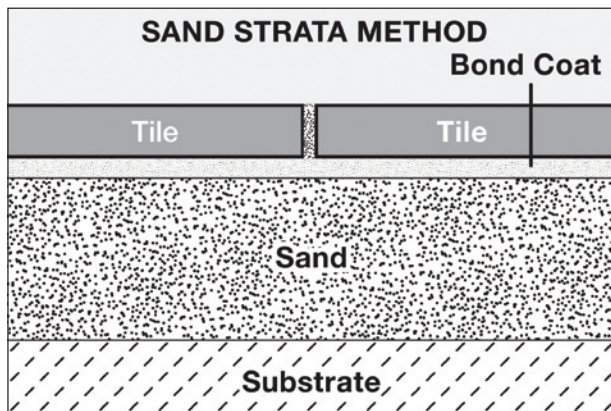
Flexibility in Layout Design

The new Providence Park Hospital and Medical Center in Novi, Michigan, is the first phase of the development of the Providence medical campus designed by NBBJ Architects. The 37,161-m² (400,000-sf), 200-bed facility opened in September 2008.

Tile installers were faced with a challenge in some of the hospital's public areas, including a lobby and large waiting room. The project designer had selected 305 x 610-mm (12 x 24-in.) porcelain tiles in cream, beige, and gray tones to be laid in attractive patterns across the floor. In some areas, the pattern included long, sweeping curves where different colored tiles were to be set on either side of the curve.

Before the installers from Boston Tile & Terrazzo arrived at the site, control joints had been cut in the concrete slab in a grid pattern typical of many commercial and institutional projects. The challenge arose because placing movement joints in the tile-covering directly above the saw cuts in the slab would compromise—or outright ruin—the desired tile pattern. Important design features and proper installation methods appeared to be in conflict.

To create the necessary flexibility in the placement of movement joints in the tile-covering, an uncoupling membrane was installed over the concrete slab. Using the membrane allowed the installers to place the tile movement joints in locations other than directly above the control joints in the concrete slab. The movement joint profile was placed along one of the curves to create a natural-looking break between the two different tile colors. ♥



Tile installation methods throughout the ages. The floorcovering has been used for centuries, but technological improvements have made its application more efficient. Membranes can incorporate uncoupling within thin-set assemblies.

years). Further, joints that are not kept free of mortar or grout will be unable to effectively accommodate movement.

Another consideration for movement joint placement in the tile-covering is the type and location of movement joints in the concrete substrate below. Various types of joints are incorporated in slabs. Expansion joints permit both horizontal and vertical differential movements by providing a complete separation for the full depth of the slab to allow free movement between adjoining parts of a structure or abutting surfaces. They are typically placed at columns, walls, and any other restraining surfaces.

Structural expansion joints must be continued through the tile-covering. Control joints are designed to induce shrinkage cracking at pre-selected locations in the slab and prevent random cracking throughout. Uncoupling membranes can accommodate in-plane lateral movement at control joints. Thus, it is not necessary to place movement joints in the tile-covering directly above control joints when uncoupling membranes are used. This can provide a degree of freedom in determining tile layout.

Thinking big

Tile formats continue to get larger. Most manufacturers now produce units 457 x 457 mm (18 x 18 in.), 610 x 610 mm (24 x 24 in.),

610 x 1219 mm (24 x 48 in.), and larger. These large-format tiles bring exciting design opportunities, but they also mean challenges that must be considered by both the design professional and the tile setter. Larger tiles result in fewer grout joints, which are at least somewhat forgiving compared to the tile itself. Therefore, use of movement joints to relieve stress in the tile-covering due to expansion and contraction of the tile becomes even more critical.



For this lobby, a membrane allowed installers to place tile movement joints in locations other than directly above control joints in the slab. The joint profile was placed along one of the curves to create a natural-looking break between the two different colors.

Ironically, employing these large-format tiles can make it more challenging to address movement joints. Given fewer grout joints, the tile pattern is less likely to align with joints in the substrate. Further, tile pattern can be a very important element of the overall design of the space, which the designer and/or owner may not want to compromise with tile cuts to accommodate movement joint placement.

The uncoupling membrane method can help in these situations by allowing the tile-covering to bridge joints that exhibit only in-plane movement. However, the design professional must acknowledge movement joints are an essential component to successful tile installations and make provisions for them accordingly.

Regardless of the tile sizes involved, accurate construction documentation is essential for a successful project. For example, movement joint profiles are available for a wide range of service conditions. It is important the specifications correctly identify the materials/products that match the expected traffic, chemical exposure, etc. Further, references should be made to follow manufacturers' instructions for both profiles and uncoupling membranes, as requirements can vary between one provider and another. ♥

Notes

¹ For more on the handbook, visit www.tileusa.com/publication_main.htm.

Additional Information

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publications, and presented seminars at tile industry events, including Qualicer and Surfaces. Gerolimatos' academic background is in civil engineering, earning a bachelor's degree from Clarkson University and a master's from Cornell University. He can be contacted at (888) 472-4588.

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Abstract

As with most flooring solutions, the performance of ceramic tile is significantly determined by the installation techniques employed. Understanding the

physical qualities and dynamics of tile assemblies can help specifiers select proper installation methods that enable tile to perform its role as the veneer component.

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