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TILE FLOOR PROFILING
CAN WE LEVEL THE PLAYING FIELD ?

by
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For many years, the traditional methods of tile installation relied on secondary mortar beds placed over underlying concrete slabs to provide a level and smooth profile for ceramic tile installations. Unfortunately, mortar bed skills have become a lost art due to the popularity and cost effectiveness of the thin-set method of tile installation. As a result, there is a renewed focus on methods and standards for constructing and remedying concrete slabs so that they are sufficiently flat and level to allow direct adhesion of tile. Building owners are also increasingly emphasizing the importance of measurably level and flat tile floors, not only to improve appearance and reduce interior construction and maintenance costs, but also to protect against claims arising from hazardous conditions caused by sudden changes in overall floor elevation, or excessive lippage of tile edges.

Measurement and assessment of the profile of a tile floor assembly, however, is a controversial topic. Current methods used by the tile industry to judge the levelness and flatness of the finish tile surface or the substrate are subjective at best, and open to wide variations in interpretation, often leading to disputes. Compounding the problem are concrete industry standards, which often confuse and conflict with those standards recommended by the tile industry, resulting in unanticipated and costly remedial repairs that often become the burden of the tile contractor.

In order to "level the playing field", tile contractors need to understand the differences between the tile and concrete industry standards for floor level and flatness profiling, understand the significance of the problem in interpretation and execution of standards, and develop proactive bidding / execution strategies to reduce disputes and improve coordination between the design professional and other construction trades.

TRADITIONAL METHODS FOR FLOOR PROFILING

The traditional straightedge method has been used by both the tile and concrete industries for over fifty years to judge floor surface irregularities. This procedure determines floor profile by measuring and limiting the gap under either a level or freestanding metal straightedge over a 10 foot (3 m) distance. This method, however, has always had several significant deficiencies:

- inconsistency in the (interpretation of) procedure and results
- difficulty in testing large areas
- difficulty in random sampling
- failure to provide for assessment of roughness and local irregularities
- inability to evaluate levelness (consideration of acceptable levelness tolerances)

To illustrate some of these deficiencies, ask yourself some simple questions about the current tile industry standard for substrate level and flatness profile. How do you interpret the profile requirement of a maximum ¼ inch (6mm) deviation from the required plane in 10 feet (3 m) ? Does it mean plus or minus ¼ inch (6 mm) in each direction from the required plane for a total ½ inch (12 mm) horizontal envelope, or plus or minus 1/8 inch (3 mm) for a total ¼ inch (6 mm) horizontal envelope ? How do you interpret the term "required plane" ? Is the required plane determined on a localized basis with a levelled or unleveled straightedge, or over a broader area with a laser level ? Who determines the required plane ? Most owners and architects interpret "required plane" as true level, unless a specific slope is specified. The reality is, that as much as we would like to have a perfectly true level plane by which to judge the quality of floor finish, it is impractical to expect a concrete slab or tile surface to have no tolerance for deviation from a true level plane. So what is, and who determines, a reasonably level (required) plane ? The most practical method is known as the statistical mean deviation from true level associated with the concrete industry's F-Number system, a concept discussed later in this article. This method of determining levelness addresses the realities of construction and reduces disputes.

The issue of determining the standard for "required plane" on suspended concrete or wood structures subject to permanent dead load deflection is even more controversial (dead load deflection meaning the allowable deviation from a level plane due to the cumulative weight of construction materials). While it is beyond the scope of this article, this issue is discussed briefly later in this article.

Another controversial issue is using the straightedge method to assess local irregularities and roughness of a concrete slab as well as a finished tile surface. The three conditions depicted in Figure 1 all satisfy the tile industry ¼ inch (6 mm) in 10 foot (3 m) tolerance, but they each are significantly different in terms of the effect on a tile installation, and the degree of remedial preparation that may be required, even though the concrete profile complies with the tile industry standard for both flatness and levelness.

Exposing these deficiencies in the traditional straightedge method is not a conspiracy to further reduce acceptable levels of quality for flat and level tile floors. The intention is to raise awareness that a tile contractor will not prosper using a subjective and inconsistent floor profiling technique in an increasingly objective and technologically vigilant construction environment. Most important, though, is the need for tile contractors to understand the differences between current tile industry's standards and the concrete industry's standards, as well as the concrete industry's more progressive and objective floor profiling techniques. This information will allow the tile contractor, as well as the design professional, to take a more informed, proactive position on the issue of floor profiling, in order to avoid disputes and protect from liability for costly remedial repairs.

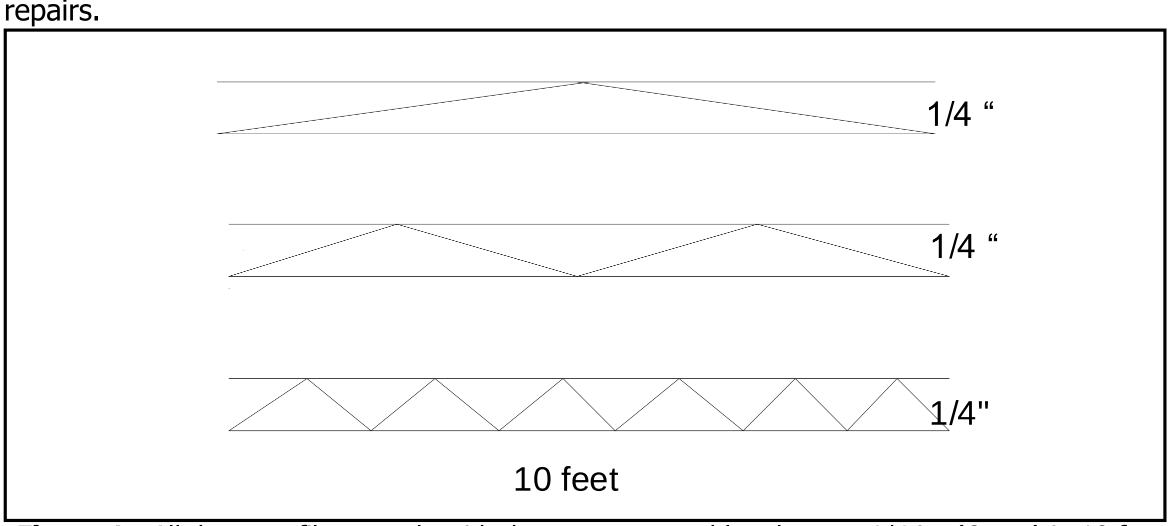

Figure 1 - All three profiles comply with the same acceptable tolerance 1/4 in. (6 mm) in 10 ft. (3 m) using the straightedge method (diagram is not to scale and exaggerated for clarity)

TILE INDUSTRY METHODS

The standard flatness and levelness tolerances used by the tile industry for concrete slabs are simple and straightforward. However, these standards are based on the traditional straightedge method, and are subject to the pitfalls described above. The tile industry standards are contained in the American National Standards Institute (ANSI) A108-99 "Standard Specification for the Installation of Tile", and in the Tile Council of America (TCA) "Handbook for Ceramic Tile Installation" (current edition). Both of these standards generally recommend a maximum variation from the required plane of ¼ inch (6 mm) in 10 feet (3 m) for *both* levelness and flatness, unless specified by the owner or architect to a more stringent tolerance.

CONCRETE INDUSTRY METHODS

For years, the concrete industry standard for flatness and levelness of a concrete slab was a 1/8 inch (3 mm) maximum horizontal envelope deviation in 10 feet (3 m) measured by the straightedge method. While this appears more stringent than the tile industry standard (depending on your interpretation), many considered both standards the same, and the accepted interpretation was that a total ¼ inch (6 mm) maximum horizontal envelope deviation in 10 feet (3 m) was acceptable. Billions of square feet of concrete were specified and installed using this subjective standard, and in reality, the average concrete slab flatness was probably closer to a total 5/8 to 3/4 inch (15-18 mm) horizontal envelope deviation. This reality was also the underlying cause of thousands of disputes and claims by and against tile contractors.

The real conflict began about 15 years ago when the concrete industry developed a more reliable and accurate method for measuring the flatness and levelness of concrete slabs, known as the F-Number System. This method was formalized as ASTM standard E1155-87 "Standard Test Method for Determining Floor Flatness and Levelness Using the F-Number System". This standard has only recently gained wide acceptance for all building types. This is due not only to the functional requirement of superflat floors in certain facility types, but also to the renewed focus on the liability and cost of correcting floor profile problems, and the greater availability and familiarity with measurement methods and equipment.

While the details of the F-Number System are beyond the scope of this article, this system could be summarized as based on a statistical analysis of floor elevations measured at 1 foot (300 mm) intervals to determine flatness, and 10 foot (3 m) intervals to determine levelness. The realities of this new measurement method prompted the American Concrete Institute (ACI) to issue new, more realistic tolerances for concrete slab construction in ACI standard 117-90. This standard gave the specifier the option to use *either* the F-Number System or the freestanding (unleveled) straightedge method for measurement of concrete slab on-grade flatness. More important, the concrete industry standards allowed for a range of acceptable tolerances commensurate with the building type and use, and gave the specifier the flexibility to select the degree of acceptable levelness and flatness deviation. This is an often overlooked issue in resolving claims made by or against tile contractors for floor profile problems.

An understanding of concrete industry standards is crucial to the tile contractor, as ACI 117-90 and the ASTM E1155-87 F-Number System allow, in most cases, much greater levelness and flatness tolerances than current tile industry standards. If a tile contractor is not familiar with these differences when bidding a project, they may unknowingly accept significant concrete substrate preparation work in order to meet the specified tile tolerances, or simply to meet the high level of quality and finished appearance that most professional tile contractors and owners expect. Similarly, design professionals must do a better job in recognizing these potential conflicts, and implement better coordination in project specifications. Accepting and making provisions in the project specifications for the reality of substrate preparation is a more reasonable solution than the traditional (and unreasonable) specification boilerplate excuse that the tile contractor be responsible for "whatever it takes" to prepare and execute the work to industry standards, and that "commencing work constitutes acceptance of the substrate" and all its deficiencies.

To illustrate the problem, review the floor profiling performance standards for concrete slabs contained in ACI 117-90. The acceptable tolerance for level alignment of concrete slabs on-grade is ¾ inch (18 mm). For suspended, formed slabs, the level tolerance is also ¾ inch (18 mm), measured only before supporting shoring is removed. Once shoring is removed, the dead load weight of the concrete will cause the concrete slab to deflect slightly, further adding to the potential deviation from level. It is for this reason that the F-Number System is only used to specify suspended concrete slab flatness, and does not apply to suspended concrete slab levelness after shoring removal. Deviations of 1 inch and greater from true level alignment at structural mid-spans are not uncommon once shoring is removed from suspended concrete floor slabs.

What is frightening and of significant concern to the tile industry, though, is that this degree of levelness deviation is acceptable under current concrete industry standards ! So unless the project specifications contain provisions (in the concrete, tile or other finish flooring section specifications) for more stringent levelness tolerance, or specific remedies to correct substantial levelness deviations, it is the duty of the tile contractor to recognize this potential conflict before submitting a bid. It is a common mistake for the tile contractor to assume entitlement to a change order increase or backcharge for additional substrate preparation during construction. As a result, the tile contractor may be saddled with a lose-lose situation in having to choose between absorbing substantial additional preparation costs, or rejection of the finished appearance of ceramic tile when the concrete meets applicable industry standards, but the finish floor fails to meet current tile industry standards, as well as the owner's quality expectations.

CONCLUSION

The increased awareness and vigilance of tile floor profiling issues by owners and architects, together with significant changes in profiling standards and techniques, make this a priority continuing education topic for tile contractors. If you want to "level the playing field" and be more competitive and profitable on your next project, take action on the following recommendations:

- Understand the differences between the tile and concrete industry standards for floor level and flatness profiling (example resources - ANSI A 108-99, TCA Handbook, ACI 117-90, ASTM E 1155-87, Marble Institute of America MIA Installation of Modular Stone Floor Tile: Thinset Method)

- Understand the various means, methods, and interpretation of levelness and flatness standards (especially the F-Number System)

- Develop proactive bidding, documentation and execution strategies to reduce floor profile disputes, and improve communications and coordination between the design professional, general contractor, and other construction trades

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