By Katelyn Simpson

Warpage, Lippage, and Related Challenges

For almost 20 years, the ceramic tile industry has been guided by the ANSI A137.1 specifications of ceramic tile characteristics and properties. When the specifications were last revised in 1988, large format tiles were 8" x 8" and 12" x 12". Now 12" x 24", 18" x 18", 24" x 24", and larger ceramic tiles are manufactured. Though increasingly popular, these tiles can cause headaches when it comes to their installation if the floor is not flat or if there is any warpage in the tiles.

What are the current ANSI A137.1 guidelines for warpage?

ANSI A137.1 states for "Glazed Paver (Floor) Tile," "When measured as described in ASTM C485, the warpage of each tile in the sample shall not exceed 1% along any edge or .75% on either diagonal." Percent warpage is calculated by dividing the measured amount the tile deviates from flatness by the length of the edge or diagonal. For example, according to the standard, a 24" x 24" tile is allowed just under 1/4" edge warpage. For diagonal warpage, the maximum allowed for the same size tile is just over 1/4".

When the specifications were revised in 1988, the allowable percent warpage was based on the much smaller sizes prevalent then. Therefore, the specifications did not take into account how large 1% or 0.75% could be for today's larger tiles.

What are the current ANSI lippage guidelines?

ANSI A108.02 is the specification for "General Requirements: Materials, Environmental, and Workmanship" for ceramic tile. Section 4.3.7 gives a specification for allowable lippage, which is the difference in elevation of the edges of two adjacent tiles. The allowable lippage is the specified dimension of lippage from the table on page 29 in section 4.3.7 plus the actual warpage of the tile, if the tile meets ANSI A137.1. The table states that for paver tile with 1/8" to 1/4" grout joints, the allowable lippage beyond the actual warpage measured is 1/32". With grout joints 1/4" or greater, the allowable lippage beyond the actual warpage measured is 1/16". If a 24" x 24" tile is manufactured with the maximum allowed warpage according to ANSI A137.1 and is installed with 1/4" grout joints or greater, then lippage can be up to 5/16" (0.31") and still meet ANSI specifications. That much lippage can clearly present a trip hazard and is not commercially acceptable.

How can trip hazards be avoided?

Lippage has always been a concern in the industry but now that tiles have gotten larger, lippage has become an increasing problem.

Dimensional analysis equipment used to measure facial dimensions, warpage, and wedging of tile. Picture courtesy of Tile Council of North America's Product Performance Testing Laboratory.

The lippage calculated in the example above is the maximum allowed for that size according to ANSI A108.02, however, quality conscious manufacturers produce tiles which are well below the maximum warpage allowed in the ANSI A137.1 specification. Most of the time, tile is manufactured with nearly zero percent warpage. Still, to avoid problems, it is useful to look at test results for dimensions and warpage carefully to avoid tiles that will be difficult or impossible to install. Occasionally, tiles are imported with a high percent of warpage and should not be considered commercially viable for floor applications. In these rare cases, the tiles should only be considered for installations where there is not foot traffic.

It is also important that the project designer is aware of what setting patterns to avoid. If the results from ASTM C485 testing show any warpage, then installing a brick pattern (especially with a large format rectangular tile) should not be done. If the designer/customer chooses to install using this pattern, then the tile must be completely flat, or it cannot be installed without lippage.

Fortunately, warpage is rarely a problem with most tiles. Overwhelmingly, the majority of lippage is caused by an uneven substrate or improper application of setting material while attempting to compensate for irregularities in the subfloor. Generally, it is well worth the time and money to flatten the floor first. Self-leveling cements are excellent for this purpose, although a skilled installer can also level a floor with thinset and careful use of his trowel (although, depending on the extent of the problem, it may take more than one pass). Not only does a flat substrate help avoid lippage, it usually makes it easier and faster to install the tile.

Are the challenges introduced by larger tile being addressed?

It is encouraging that the ANSI Accredited Standards Committee responsible for revising A137.1, is aware of the unsuitability of the current percent warpage specifications in the standard. The committee is already drafting revisions to the standard to address these issues. **TILE**

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About the Author

Katelyn Simpson works for the Tile Council of North America's Product Performance Testing Laboratory as a Laboratory Engineer. She is responsible for testing tile, stone and other installation materials to ASTM, ANSI and ISO standards. She is also involved in the development and revision of ASTM and ANSI standards. Mrs. Simpson earned her B.S. degree in Ceramic and Materials Engineering from Clemson University.