A look at freeze-thaw resistance: A major North American testing advancement

Through a collaboration of TCNA and its members, a massive revision to ASTM C1026 is being considered, including improved testing conditions, an automated procedure, 300 freeze-thaw cycles and a drastic reduction in the amount of time required to perform the test

by Eric Astrachan, Executive Director, and Ryan Marino, Ceramic Engineer, Tile Council of North America

Some areas of North America have as many as 100 freeze-thaw days per year and sometimes multiple freezing events per day. In such cases, resistance to freeze-thaw conditions is an important factor to consider when selecting tiles for exterior installation.

While the current testing method requires 150 cycles of freeze-thaw cycling, some argue that is not enough for areas with many freeze-thaw days and potentially multiple cycles per day. Recent Tile Council of North America (TCNA) research and the work of TCNA members support this with failures observed in some semi-vitreous mono-cottura floor tiles only after more than 150 cycles of freezing. While the vast majority of floor tiles in the market will perform well in freeze-thaw conditions, we are always striving to better predict field performance through inexpensive laboratory testing.

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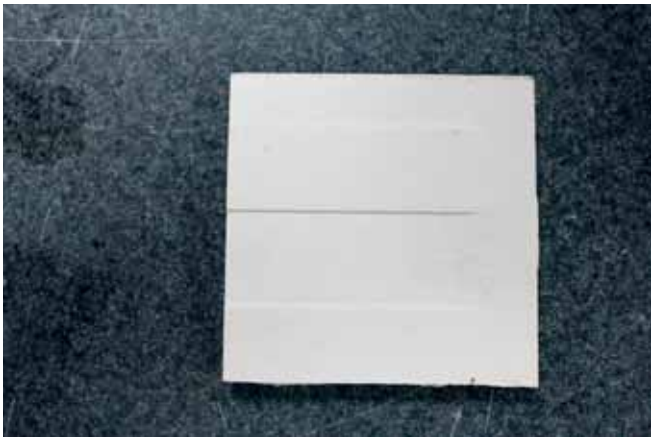

A talc wall tile before freeze-thaw resistance testing using the new methodology.

The same talc wall tile after 175 freeze-thaw cycles using the new methodology. The tile split completely in half.

The current version of ASTM C1026, Standard Test Method for Measuring the Resistance of Ceramic Tile to Freeze-Thaw Cycling, requires manual cycling and 150 laboratory days to complete. While more exhaustive than the ISO method that requires 100 cycles to complete, it requires too much time, especially if more cycles are to be considered.

Through a collaboration of TCNA and its members, with special thanks to Quarry Tile and Ironrock, which assisted in the development of a low-cost easily replicable apparatus, a massive revision to ASTM C1026 is being considered. This revision includes improved testing conditions, an automated procedure, 300 freeze-thaw cycles and a drastic reduction in the amount of time required to perform the test.

To better understand how tile samples are evaluated, ASTM C1026 can be broken into three sections: sample preparation, freeze-thaw cycling and inspection.

Currently, ASTM C1026 specifies the selection of 10 samples at random. These tiles are closely inspected to ensure that no cracks or damage are evident prior to testing, following which the tiles are saturated with water. Since freeze-thaw failures can be due to the expansion and contraction of water in the inner structure of the tile, complete saturation is critical. To ensure such, the tiles are subjected to a five-hour boil and a 24-hour soak.

After the saturation process, the tiles are placed into a freezer and exposed to cold air until the internal temperature reaches 0 degrees Fahrenheit, which occurs in approximately eight hours. The samples are then removed from the freezer and thawed in a room-temperature water bath. This completes one freeze-thaw cycle. The tiles remain in the water bath until the next freezing cycle can start, usually the next working day.

Every five cycles, the sample tiles are visually inspected for damage. Samples with evidence of cracking, chipping or spalling are removed from the sample set, and testing continues on the remaining tiles. After 150 cycles, all remaining tiles are inspected a final time, and observations are reported.

While the current ASTM C1026 test described above provides a useful and eminently simple evaluation of freeze-thaw resistance, which anyone with empty space in their freezer can run, there are three important limiting factors:

1. The products are frozen in air
2. Only 150 freeze-thaw cycles are evaluated
3. The test typically takes 30 weeks (which potentially could be shortened to 11 weeks in a facility operating 24/7)

Let's discuss each limiting factor. Freezing saturated tiles in air is a reasonable approach when simulating freeze-thaw cycling for exterior wall applications. To simulate floor applications though, especially where adequate slope and drainage are not provided, or where snow and ice are not fully removed, freezing in water would be a better and more rigorous simulation of real-world conditions.

Regarding the limit of 150 cycles, experience has shown that some freeze-thaw failures can only be predicted by testing well over 150 cycles. Regarding the amount of time the current test takes, shortening the start-to-finish time without reducing the number of cycles can only be beneficial.

To address these limits, TCNA and its members set out to develop a new test where the tiles could be frozen in water, 300 cycles could be run, and the total testing time reduced.

In this test, as in the previous test, the tiles are fully saturated in the same fashion as previously described prior to testing. Inside the freezer though, the tiles are partially submerged in water throughout the test, as opposed to freezing in air.

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A temperature controller connected to a thermocouple monitors the temperature of the samples continuously. Once the samples are fully frozen, a relay engages a water pump to thaw the samples while keeping them fully saturated. Once fully thawed the temperature controller disengages the water pump, completing one freeze-thaw cycle. This automated process continues 24 hours a day, seven days a week, with as many as six cycles per day. Depending on the number of samples and the cooling capacity of the freezer, 300 cycles can be run in eight to 10 weeks.

To validate this new protocol, a wide variety of products were evaluated by TCNA's Product Performance Testing Laboratory. Covering the entire spectrum of freeze-thaw resistance, some products had a history of successful freeze-thaw applications, and others were sold solely for interior applications. The test method provided a clear distinction between tiles that were freeze-thaw resistant and those that were not. Talc wall tiles and glazed mono-cottura tiles for interior environments did not pass — with some tiles failing between 150 and 300 cycles, further validating the increase in cycles over the current method. The tiles tested with a history of successful exterior installations all passed. These results were then further validated by testing in other facilities.

This new methodology will soon be balloted through the rigorous ASTM approval process. Once approved, distributors, retailers, contractors, architects and specifiers will have a consensus standard test method to reference with confidence when choosing products for freeze-thaw environments. Keep an eye on the TCNA Web site (www.tcnatile.com) for updates on the progress of this method. **TILE**

ABOUT THE AUTHORS

Eric Astrachan, Executive Director of the TCNA, Inc., has 36 years experience in international business with the past 18 years in the ceramic tile industry in manufacturing, installation, research and association management. Presently, he is chairman of the TCNA *Handbook* Committee, Co-Secretary of the ANSI (American National Standards Institute) Accredited Standards Committee A108 and Head of Delegation representing ANSI's vote in ISO TC-189 (International Organization for Standardization, Technical Committee on ceramic tiles). Additionally, Astrachan is a member of the Board of Directors for the Ceramic Tile Education Foundation and the Board of Governors of the international trade show Coverings. He is a regular speaker in the industry and a recognized expert on tile installation and testing associated with slip/fall litigation.

Ryan Marino is a ceramic engineer at the Tile Council of North America working in standards development. He is involved in the research, development and revision of ASTM, ANSI and ISO standards. Marino earned his Bachelor of Science degree in Ceramic and Materials Engineering from Clemson University.