THIN GAUGED PORCELAIN TILE—NORTH AMERICAN RESEARCH, COLLABORATION, AND STANDARDIZATION

Bill Griese

Director of Standards Development, Tile Council of North America

Noah Chitty

Director of Technical Services, Crossville Inc.

1. ABSTRACT

Over the last decade, designs for ceramic tile and the technology behind how products are made have both advanced quickly. One result of this advancement has been the widespread availability of large-sized tiles with reduced thickness. More so than ever before, dimensional characteristics, especially as they relate to thickness, are central to how some products are marketed, installed and used.

In 2017, the North American tile industry marked the culmination of more than four years of cross-disciplinary collaboration and hundreds of hours of research with the release of new standards addressing product characterization, performance, and installation of gauged porcelain tiles and tile panels/slabs. The term "gauged" means products differentiated by their thickness; which for tiles means products that can carry different loads and be used in different ways.

This paper provides an in-depth overview of North America's new standards for gauged porcelain tile and tile panels/slabs, including a background on the emergence of gauged products, an explanation of differences from traditional tiles, a review of research toward the development of product and installation criteria, and a walk-through of the new standards and how they can be properly used.

2. INTRODUCTION

With the market emergence of "thinner" and "larger" tiles, the industry needed to characterize these products, based not just on their performance, but also on their intrinsic properties so that they could be properly classified, tested, standardized, and specified. Fulfilling this need was paramount to ensuring consumer expectations are properly met, and products are transparently characterized for what they are and how they will perform.

The North American tile industry released two new standards: ANSI A137.3, *American National Standard Specifications for Gauged Porcelain Tiles and Gauged Porcelain Tile Panels/Slabs*, and its companion, ANSI A108.19, *Interior Installation of Gauged Porcelain Tiles and Gauged Porcelain Tile Panels/Slabs by the Thin-Bed Method bonded with Modified Dry-Set Cement Mortar or Improved Modified Dry-Set Cement Mortar*. Catalyzed initially by the rapid growth of thinner, larger products, the intent of these efforts was to establish a framework within which specifications could be established for products which are intentionally "gauged" to a specific thickness. Currently two classes of gauged tile products are defined by the standards: those for wall applications from 3.5 to 4.9 mm and for floor and wall applications from 5.0 to 6.5 mm. Other products, which either fall outside of these ranges or for which the manufacturer has not specifically provided a gauged thickness designation, continue to be standardized under traditional tile specifications.

These standards, developed for the benefit of all tile consumers, are the result of a multi-year research and consensus process of the ANSI Accredited A108 Standards Committee, which maintains a broad and diverse group of participants reflecting stakeholder interests in all aspects of the tile industry.

3. "THINNER" AND "LARGER" MARKET AND MANUFACTURING

Beginning in the early 2000s, new technologies started to emerge which gave manufacturers the capability of producing porcelain tiles as thin as 2.5 mm [2]. With high density, modulus of rupture equal to or greater than traditional porcelain tile, and the introduction of reinforcement backings, recommended applications for such products ranged from floors and walls to interior and exterior. This was a significant industrial milestone as porcelain floor tiles were historically 8 to 12 mm thick and porcelain tiles less than 7.5 mm were held to lower breaking strength requirements [3] and thus not very common in flooring applications [1]. As an added benefit, these same technologies made possible the production of significantly larger panels and slabs, as large as 1200 x 3600 mm in size, which introduced a host of new opportunities in the realm of product decoration and architectural design. Over the next decade, the market began to grow for "thin tile."

Initially, manufacturers were touting a range of advantages for thin tile, including installation over existing floor and wall coverings, eliminating the need for ripping out existing finishing materials in renovation projects, saving time and money in labor costs. Additionally, the environmental benefits from lighter product weight and reduced material consumption were being promoted. From a design standpoint, thin tile was viewed in the market as sleek and contemporary [2]. Further, the sheer size options associated with such products and continued advancements in glazing and surface decoration made possible new and very realistic designs which could rival wood planks, stone slabs, and many other surfaces. In 2011 at the Cersaie show in Italy and

Cevisama in Spain, thin tile was observed as the hottest trend [2]. Shortly thereafter, these products made their way into the US Market as some manufacturers began adding thin tile options to their product offerings.

Today, products currently promoted as 'thin' are typically porcelain with the vast majority created through one of two ways. The first involves pressing of powders between two large plates, and the second achieves compaction through two large steel rollers. Both eliminate the traditional die mold, therefore relieving tension in the finished product and making possible increased size formats not previously possible with traditional dust pressing [7]. Advancements in these technologies are making possible all varieties of thickness, not just thin, but as thick as 3 cm. Limited only in facial size by the width of compaction equipment, final products are available in very large sizes [8]. Perhaps equally as important, now possible is increased efficiency in manufacturing as final pieces can be trimmed to virtually any size, eliminating the time required with traditional pressing to change die molds and the need to stock varieties of shapes and sizes.

As the market grows, it is important that products are characterized, applications are well-understood, and standards for quality and installation are widely adopted. Standards are especially important in growing the market as they enable specification, which would otherwise be conducted using proprietary methods restricting options otherwise available through competition [8].

4. GENESIS OF "GAUGED" AND DIFFERENCES FROM TRADITIONAL TILES

North American industry stakeholders formally convened, beginning in 2011, to initiate a plan to research and characterize thin tile toward the development of a consensus standard [2]. One of the earliest topics on which the North American industry debated was terminology. Until the time of these discussions, the term "thin" had been casually adopted for the purposes of common dialogue and product differentiation. However, given that the same technologies used to make thin products could also make thick products, this approach was less than ideal [7]. These technologies also introduced intrinsically unique properties which served as the basis for new applications, special installation considerations, and marketability.

It was then that the group came to the realization that the industry had reached a milestone. For the first time, end users were prioritizing tile thickness as a key characteristic, not just for dimensional reasons, but also because the technology used to make tiles to a specific thickness introduced other new and intrinsically unique product characteristics. Hence, the term "gauged" was born. For the purposes of a technical specification, the group identified this approach as analogous to other construction products, such as electrical wire and sheet metal, which carry different load capabilities and usage parameters across a variety of gauges. The group agreed to further differentiate gauged products based on their size, with gauged tiles being less than a square meter and gauged tile panels/slabs being greater than or equal to one square meter.

With regards to discussions of developing standards and potential differences from traditional tiles, initial conversations were around thin gauged tiles and tile panels/slabs. The first key concern was breaking strength, as the North American requirement for traditional tiles was 250 lbf [5]. At the time of the initial conversations, very few, if any thin gauged products met the requirement. Therefore, it was assumed that installed strength was essential to achieve performance levels comparable to those of traditional tiles. With traditional tiles, exceedingly high breaking strength could often make-up for flaws in mortar coverage or quality, but with thin gauged tiles, the group considered it was important to examine how lower breaking strength may be offset by installation rigidity and increased mortar coverage.

5. RESEARCH TOWARD DEVELOPING PRODUCT TEST METHODS, REQUIREMENTS, AND CATEGORIZATION

Upon identifying key differences from traditional tiles and the most relevant properties to test and characterize, North American manufacturers developed a research program as the basis for the development of ANSI A137.3 *American National Standard Specifications for Gauged Porcelain Tiles and Gauged Porcelain Tile Panels/Slabs*. The project was divided into two phases.

In the first phase, a simple spectrum of destructive mechanical tests was applied to thicknesses common to the US market, including products ranging from 3.5 mm to 4 mm with reinforcement backing and 5 mm to 6 mm with and without reinforcement backing. All tests applied to the gauged research samples were also performed on traditional porcelain tiles for a point of reference.

Tests for modulus of rupture, breaking strength, yield strength, and modulus of elasticity were conducted in order to evaluate various strength characteristics of tiles and tile panels/slabs, using ISO 10545-4. Impact resistance was also evaluated on specimens in bonded and un-bonded conditions. The height from which a 1.2 lb. ball needed to fall in order to cause failure was recorded. Crush resistance, though typically unorthodox in evaluating tile, was also evaluated due to reports that edge "crumbling" was a common failure mode for thin gauged products. Compression between two steel plates was applied to small 1 cm x 1 cm specimens removed from various portions of products at a rate of 3000 PSI/minute. Point loading was also conducted to further evaluate "crumbling" by loading assemblies with a ½ inch steel ball bearing at a rate of 0.05 inches/minute. This test was applied to bonded assemblies in their center and near an original manufactured edge, adjacent to a grouted joint.

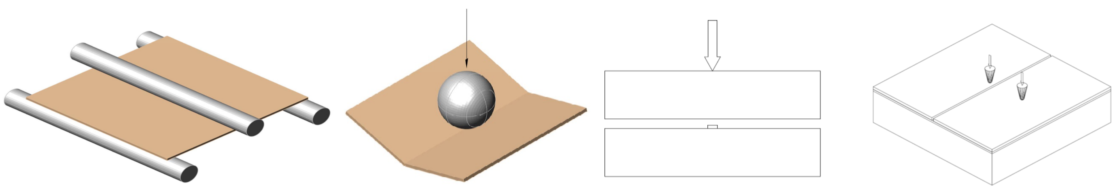

Figure 1. *Preliminary tests included 3-point breakage, impact breakage, crushing and point loading*

There were several key observations from the first phase of testing. As hypothesized, strength was directly dependent upon thickness. Breakage of the specimens occurred at approximately 50% of the load required to break traditional porcelain for gauged specimens ranging from 5 mm to 6 mm, and at approximately 25% for those ranging from 3.5 mm to 4 mm. Similarly, point load resistance was largely dependent on thickness, with gauged products from 5 mm to 6 mm exhibiting failure at approximately 60% of the load exhibited by traditional porcelain, and those from 3.5 mm to 4 mm exhibiting failure at 50% of the load. With regards to reinforced backings, little improvement to breaking strength was observed. Although reinforced backings significantly increased overall flexibility and breakage load at ultimate failure, it provided only a 5% increase in initial breakage load and had negligible effect on flexibility and MOR at initial breakage. Taking into account initial breakage, MOR remained reasonably consistent among all products, regardless of thickness or reinforcing. The same was true for crushing, indicating that the material nature of porcelain remained fairly consistent between thin gauged products and traditional tile.

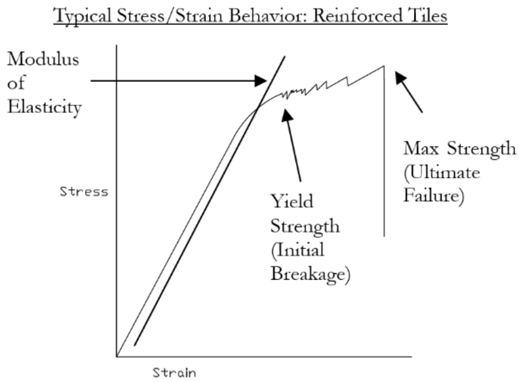

Figure 2. *For reinforced products, only values associated with initial breakage were considered*

With regards to impact resistance of reinforced products, substantial increases were observed in an un-bonded scenario. Un-bonded specimens with reinforced backings were able to resist breakage from falling ball heights nearly twice as high as those for traditional porcelain tile. However, in a bonded condition, reinforced backings did not demonstrate meaningful improvement as impact resistance was directly dependent on thickness. Regardless of reinforcing, breakage was exhibited from a falling ball height 60% of that of traditional porcelain tile for gauged specimens ranging from 5 mm to 6 mm and 45% of that of traditional porcelain tile for gauged specimens ranging from 3.5 mm to 4 mm.

An additional takeaway was that variations were observed across different portions of samples, with the tendency for slightly lower strength in general closer to the edge. Moving forward, it was concluded as fair to assume overall strength of thin gauged porcelain products to be lower than traditional porcelain tile, due not necessarily to the nature of the material itself, but to inherent thinness. Reinforced backing added little to the overall strength in an installed condition, but significantly improved impact resistance in an un-bonded condition and perhaps improved overall strength while handling.

For the second phase of research, the following evaluations were conducted on a variety of thin gauged samples, with and without reinforcing and ranging from 3.5 mm to 6 mm.

Floor testing was conducted, per ASTM C627. A range of mortar and grout combinations was evaluated, with the same range applied to each different type of tile evaluated for comparative purposes. In all cases, the tests were conducted twice to verify a repeatable result. Additional test assemblies were intentionally constructed with engineered 'lippage' in order to evaluate a worst-case scenario. Each test assembly consisted of 3 mm grout joints and four 20" x 20" specimens. Each specimen was removed from a 1 m x 1 m factory-cut sample. The samples were cut such that original factory-cut edges were exposed to the test, and the remaining pieces from each 1 m x 1 m sample were reserved for additional strength and impact resistance tests. For each test assembly, the test cycle at which damage was first observed was recorded. Achieving 3 cycles without failure is considered "Residential," 6 cycles "Light" commercial, 10 cycles "Moderate" commercial, 12 cycles "Heavy" commercial, and 14 cycles "Extra Heavy" commercial.[4]

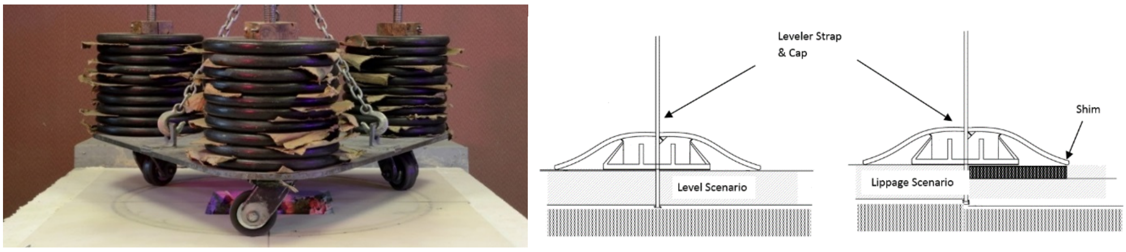

Figure 3. *Floor testing, ASTM C627, included samples installed flat as well as with engineered lippage*

To further characterize bonded impact performance, thin gauged specimens were bonded to a concrete substrate and subjected to a single drop of a 1.2 lb. steel ball from constant heights. The diameter of the circular impact area was measured. To characterize edge impact, the same steel ball was rolled into the side of bonded specimens from a standardized distance and angle. The edge length of the impact area was measured. To facilitate direct comparison, bonding mortar and gauged tile specimens were consistent with all samples subjected to floor testing. Portions of the same samples were also subjected to additional MOR and breaking strength evaluation.

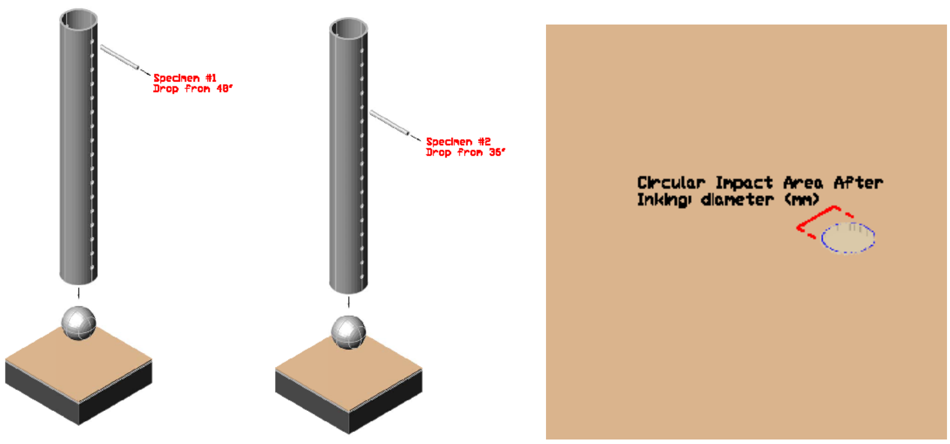

Figure 4. *Falling ball impact test on bonded assembly*

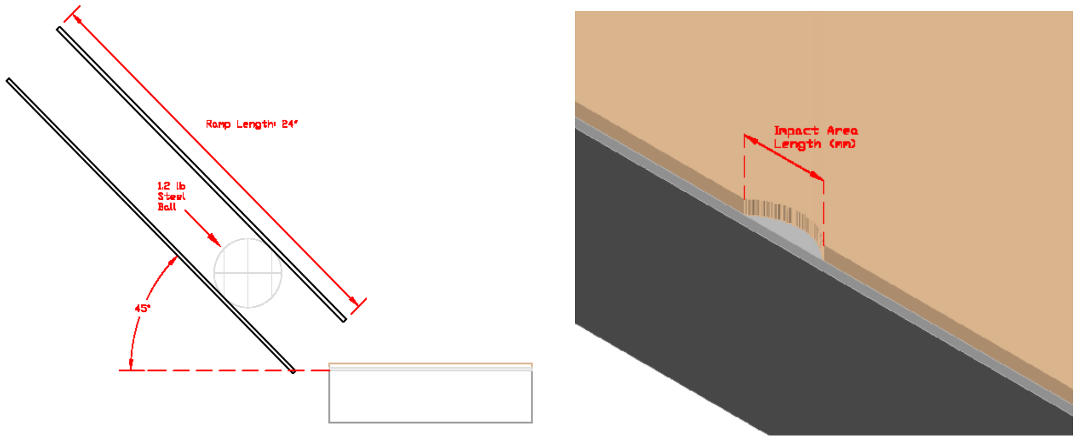

Figure 5. *Rolling ball impact test on edge of bonded assembly*

A total of 51 floor systems were assembled and subjected to floor testing. Of the gauged products 5.0 mm and thicker, 68% were rated "Moderate" commercial or higher, with 57% achieving "Extra Heavy" commercial, the highest possible rating. None received a rating lower than "Light" commercial. Of the gauged products less than 5.0 mm in thickness, 92% achieved "Light" commercial or worse, with only 8% receiving higher. A clear takeaway was that there was a definitive distinction between floor test performance above and below 5.0 mm in gauged thickness.

With regards to floor test performance in direct comparison to breaking strength, higher floor ratings generally started becoming possible with the usage of products of breaking strength around 175 lbf. However, in a few cases, some of the highest strength products yielded lower floor ratings, likely due to the mortar used or other details of the installation system, resulting in a less than meaningful overall correlation. With regards to impact diameter, a slight correlation was observed. Products used in systems with lower floor ratings generally had a larger impact area when tested using the same materials as the floor system. The same was true for edge impact. These comparisons led to two very important conclusions: 1) Installed performance of gauged products is largely dependent on the installation system, not just breaking strength, and 2) Though not always guaranteed, breaking strength of 175 lbf was identified as an important threshold in identifying products that gave systems a chance of achieving higher floor test ratings. Of all the samples tested, only twice did an assembly achieve the highest floor rating when using a product of lower breaking strength.

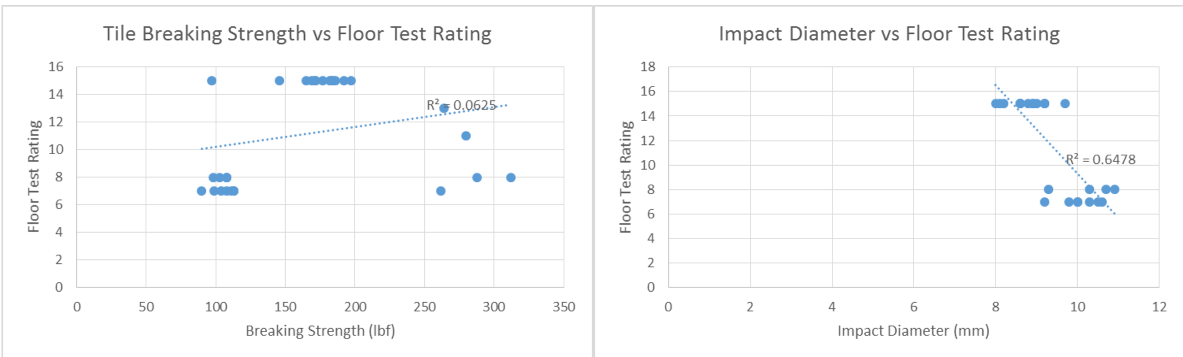

Figure 6. *Relationship between breaking strength, impact resistance, and floor testing*

This became the basis for developing two separate ranges of gauged nominal thickness and minimum physical properties associated with those ranges. In general, the takeaway was that for products of gauged thickness 5.0 mm and greater, minimum breaking strength could be expected to be 175 lbf, and using such products increased the probability of floor test ratings better than "Light" commercial with appropriate installation materials and procedures. Products of gauged thickness 4.9 mm and less could have breaking strength as low as 85 lbf, and at best "Light" commercial ratings could be expected in the majority of cases. Therefore, ANSI A137.3 divides gauged porcelain tiles into two separate gauges of nominal thickness, 5.0 mm to 6.5 mm ("Table 4" products) and 3.5 mm to 4.9 mm ("Table 5" products), with "Table 4" products having provisions for floor, wall and countertop usage, and "Table 5" products having provisions for wall and countertop usage only [6]. This encompasses most of the thin gauged products currently seen the United States marketplace.

The ANSI A137.3 minimum breaking strength for gauged porcelain products is 175 lbf for "Table 4" products and 85 lbf for "Table 5" products. The minimum MOR is 6000 PSI, regardless of gauge [6] and fairly typical of all types of porcelain tile products, as confirmed by research. With regards to installed floor system performance, the minimum requirement is that a floor test assembly, constructed with a solid concrete base and mortar and grout as specified by the manufacturer, pass six cycles of floor testing per ASTM C627. This requirement is only applicable to "Table 4" products intended for usage on floors [6]. Regarding impact resistance, though helpful toward confirmation that installed performance is vastly dependent upon setting materials and procedures, North American stakeholders agreed that it was not a suitable characteristic in lieu of floor test performance and thus not necessary for inclusion in the standard.

There are several other provisions of ANSI A137.3 which should be noted as unique to gauged porcelain products. Gauged products with reinforced backings are termed "back-layered," and the standard contains requirements which specifically address their characteristics and performance. Such products shall have a minimum cement mortar bond strength of 100 PSI following a full week of water submersion. Also, additional saturation introduced by back-layering is standardized. Back-layered products are required to have a maximum water absorption of 0.5% with the back layering removed, and are further required to have a maximum back-layer saturation of 0.5%. Back-layer saturation is calculated using the following formula:

Back-layer saturation = Water Absorption with Back-Layer (%) – Water Absorption with Back-Layer Removed (%)

With regards to dimensional characteristics, as can be expected, tolerances for thickness consistency are far more stringent in ANSI A137.3 for gauged tile products than they are in ANSI A137.1 for traditional tile products. For all gauged products, the actual thickness of a product can vary +/- 0.5 mm, on average, from the manufacturer-declared nominal thickness, but the maximum allowable thickness range within a measured sample is 0.5 mm. As gauged porcelain tile panels/slabs are defined as those with facial dimensions greater than or equal to one square meter, sampling procedures are established such that specimens can be removed, at random, from no fewer than three panels/slabs. Also with regards to dimensional characteristics, warpage is not a standardized property as gauged products typically employ the use of lippage control systems when being installed.

With standardized properties differentiated between "Table 4" and "Table 5," and with an established divide between "tile" and "tile panel/slab," ANSI A137.3 provides the product characterization necessary for gauged porcelain tiles and tile panels/slabs to be appropriately specified and installed.

6. DEVELOPING REQUISITE SETTING PROCEDURES FOR SUCCESSFUL INSTALLATION

An ad-hoc group of architects, installers, tile manufacturers and setting material manufacturers was formed to conduct research toward the development of ANSI A108.19, the standard for installing gauged porcelain tile and tile panels/slabs specified by ANSI A137.3. It began by reviewing available industry information on installing thin tile, including information from ASSOPOSA (The Italian Association of Contractors and Ceramic Tile Fixers) and ISO TC-189 WG6 [10][11]. It then explored provisions of existing standards which could be used. Due to the unique properties of gauged porcelain products and importance of achieving full mortar coverage, especially for flooring applications, it was agreed a much more comprehensive approach would be required to address all aspects of installation, from mortar application, to embedding procedures, to tool requirements. Where existing standard language was applicable it was utilized, but where requirements were unique, new language would need to be developed. Particularly for tile panels/slabs, a host of experiments were conducted to learn the effective techniques for achieving full mortar coverage so that appropriate strategies and standards could be developed.

With regards to mortar application, it was investigated whether or not it was necessary for mortar to be applied to a tile panel/slab, as well as the substrate prior to setting. It was concluded that, especially on floors, if two layers were not used for tile panels/slabs, the resulting embedded mortar layer thickness would be either less than or critically close to the agreed upon substrate tolerance of a maximum deviation of 1/8 inch in 10 horizontal feet (3mm in 3m) from the required plane when measured from the high points in the surface. Additionally, double mortar application on tile panels/slabs slightly increased mortar coverage and made possible the full encapsulation of lippage control systems. Therefore, it was agreed a requirement to apply mortar to the gauged tile panel/slab and substrate would be included in the installation standard, with a resulting requirement for a minimum bond coat thickness of 3/16 inch (4.8mm) [9].

Also with regards to mortar application, several experiments were conducted to determine what types of trowels should be used to achieve full coverage on tile panels/slabs. It was concluded that traditional square or U-shaped notched trowels were insufficient and that trowels such as Euro-trowel, Flow-Ridge trowel, and Superior notch trowel were needed which could facilitate ridge collapse. The group agreed to standardize the use of such trowels, described more generically in ANSI A108.19 as trowels which facilitate ridge collapse without the need to press and slide the tile [9].

The focus then shifted to embedding procedures for tile panels/slabs on floors. Several experiments were conducted to evaluate resulting mortar coverage following various embedding methodologies, including tapping with a grout float, applying vibration, striking with a weighted beat-in paddle, and physically walking on the surface of tile panels/slabs. For floors, it was found that the method producing the greatest supporting mortar coverage was physically walking on the surface. The following was found effective: 1) walk down the centerline of the tile; 2) take small shuffling steps left and right from center to push air toward the edges. This is the standardized procedure in ANSI A108.19 for embedding tile panels/slabs on floors [9].

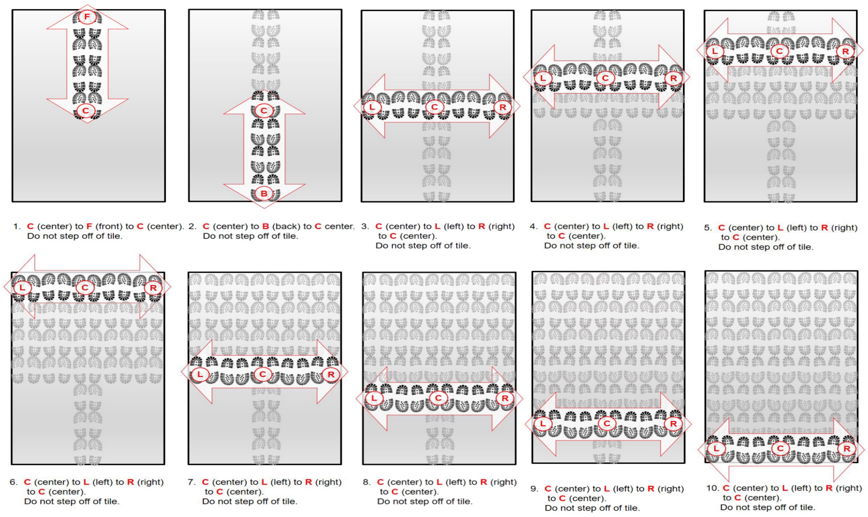

Figure 7. *ANSI A118.19 Embedding Procedure for Gauged Porcelain Tile Panels/Slabs on Floors*

For embedding tile panels/slabs on walls, a vibration tool and a weighted beat-in paddle were found to produce better coverage than grout float tapping and thus were specified in ANSI A108.19 [9]. For walls and floors, it was observed that a vibrational tool used at the perimeter, exploiting the properties of the mortar, was beneficial in achieving full coverage on the edge. Mortar support on the edge is especially critical for overall durability in flooring applications, and also facilitates full encapsulation of lippage control systems. For these reasons, edge coverage achieved through vibration is a provision of ANSI A108.19 [9].

With the above mortar application and embedding techniques established as requisite in achieving the highest level of mortar coverage, measurements were taken and calculations made from actual test installations in order to provide a quantification of actual coverage. These calculations, along with outside data provided by an ad-hoc group of installers and manufacturers, were the basis for establishing minimum coverage requirements and maximum void size in ANSI A108.19. The ANSI A108.19 minimum required coverage was established as 80% for walls and 85% for floors. Additionally, maximum void size was established as 2 square inches (1290 square mm) [9].

It was considered that coverage calculation under such a large area of tile could present challenges. For one, it would be time-consuming. But more importantly, considering only the overall coverage under a single tile panel/slab could have resulted in scenarios where the minimum requirement was met even though there were areas of noticeably poor coverage. To address this, the standardized evaluation involves measurement and calculation of coverage within square foot (0.1 square meters) partitions. ANSI A108.19 states, "In any single square foot under the embedded tile, coverage . . . is calculated by measuring the voids and the marked off square foot and dividing by 144 square inches (929 square cm) where the dry set mortar is not in full contact from the back of the tile to the substrate" [9].

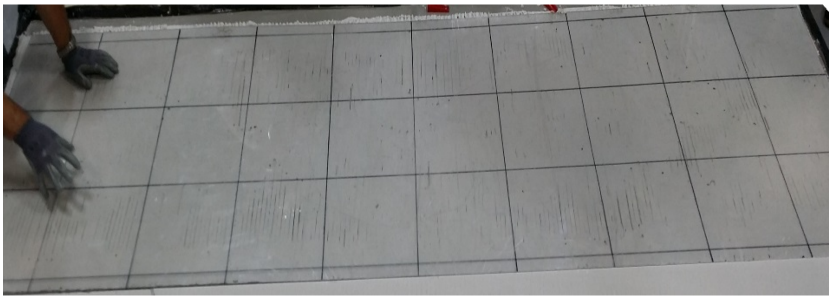

Figure 8. *Visual Examination of Mortar Voids under Clear Plexiglas with Marked Square Foot Partitions*

Standardized suitable substrates for the installation of gauged porcelain tiles and tile panels/slabs are mostly consistent with those of traditional tile, with the exception of direct bonding to plywood floors. ANSI A108.19 has special provisions regarding installation over wood framed construction, particularly requiring the use of a mortar bed or specified backer board and referencing floor rigidity requirements established by building codes and other widespread industry specifications. Regarding the installation of gauged porcelain tiles and tile panels/slabs over existing surfaces, ANSI A108.19 addresses the suitability of the existing surface, its flatness, and the proper preparation. Applicable to all substrates, ANSI A108.19 details required flatness as maximum deviation of 1/8 inch over 10 feet (3mm in 3m) from the required plane when measured from the high points in the surface. Additional guidance is provided within the standard on the details of a proper specification to facilitate comparative labor quotes and proper bidding of surface preparation [9].

Regarding mortar, experiments showed that not all generic mortars used with traditional tile suffice. Especially with regards to tile panels/slabs, specific mortar properties were found to be critical, including extended open time, flow to achieve coverage, and curing parameters appropriate to the application. Additionally, it was found that saturation of porous substrates, over-spreading the substrate more than the footprint of the tile, and troweling from the center of the tile out on larger pieces should be employed. ANSI A108.19 specifies these provisions, as well as a requirement for suitable mortar identification through consultation with the tile and setting material manufacturer [9].

Regarding jobsite conditions and material handling, special provisions are included in ANSI A108.19 which address the overall experience related to the installation of gauged porcelain tiles and tile panels/slabs as different from that of traditional tile. ANSI A108.19 requires adequate jobsite space for storage and utilization, particularly for tile panels/slabs, as well as the allocation of adequate time often necessary for mortar curing. Logistics related to transporting tile panels/slabs onsite are also specified, including awareness of elevator heights and access to clear pathways. Taking measures to protect finished tilework from concentrated loads such as scissor lifts, pallet jacks, automobiles and forklifts is also specified. Additionally, requirements for material handling are established as they are necessary in preventing damage to thin-gauged products, especially larger sized tile panels/slabs. For example, the use of fork extensions on lifts is specified to facilitate the movement of the large crates and A-frames used to package tile panels/slabs. The use of suction cupped frames is specified for moving tile panels/slabs or gauged products weakened by cut-outs or holes.

ANSI A108.19 also specifies the use of properly qualified installers. Due to the unique material characteristics and unconventional installation techniques required of gauged porcelain tile and tile panels/slabs, the standard specifies the use of installers who are equipped with proper tools and have acquired sufficient product knowledge and installation experience through the completion of an installer qualification program: ACT (Advanced Certification for Tile Installers) [12], gauged porcelain tile or tile/panel manufacturer established program, or setting material manufacturer established program specifically on gauged porcelain products [9].

There are several other key provisions contained within ANSI A108.19, including grouting, workmanship, movement accommodation, and maintenance, completing a very comprehensive specification for how to install products defined by ANSI A137.3.

7. CONCLUSION

ANSI A137.3 and ANSI A108.19 are the result of years of exhaustive research and industry collaboration. To develop ANSI A137.3 *American National Standard Specifications for Gauged Porcelain Tile and Gauged Porcelain Tile Panels/Slabs*, stakeholders collaborated in conducting a variety of mechanical tests on products and installed floor systems. This led to the establishment of standardized categories and minimum thresholds for strength and performance so that products could be appropriately characterized for further specification. To develop ANSI A108.19 *Interior Installation of Gauged Porcelain Tiles and Gauged Porcelain Tile Panels/Slabs by the Thin-Bed Method bonded with Modified Dry-Set Cement Mortar or Improved Modified Dry-Set Cement Mortar*, a group of installers, architects, and manufacturers conducted countless experiments to discover application and embedding techniques which make possible maximum mortar coverage, particularly for tile panels/slabs. Through these experiments, standard setting procedures for gauged porcelain tiles and tile panels/slabs were developed which facilitate optimal workmanship and system integrity. Although focused predominately on criteria for "thinner" products, these standards employ a framework within which technical requirements can evolve as new "gauges" of tiles and tile panels/slabs emerge in the years ahead. Together, ANSI A137.3 and ANSI A108.19 will contribute to proper product usage, specification and installation in an exciting and rapidly growing market segment.

8. REFERENCES

[1] "Thin Tiles: Concerns and Expectations," TILE, May/June 2010.

[2] "The Skinny on Thin Tiles," TileLetter, November, 2011.

[3] ISO 13006: 2012—Ceramic Tiles—Definitions Classification Characteristics and Marking, International Organization for Standardization, Geneva, Switzerland.

[4] Tile Council of North America. Handbook for Ceramic, Glass, and Stone Tile Installation, 2017.

[5] ANSI A137.1-2012, American National Standard Specifications for Ceramic Tile.

[6] ANSI A137.3-2017, American National Standard Specifications for Gauged Porcelain Tile and Gauged Porcelain Tile Panels/Slabs.

[7] "Technical Feature—Gauged Porcelain Tile Panels," TileLetter, October, 2016.

[8] Marvin, Dan. "Light and Large, Considerations for Commercial Thin Tile Installations," Construction Specifier, May 28, 2015.

[9] ANSI A108.19-2017, Interior Installation of Gauged Porcelain Tiles and Gauged Porcelain Tile Panels/Slabs by the Thin-Bed Method bonded with Modified Dry-Set Cement Mortar or Improved Modified Dry-Set Cement Mortar

[10] ISO/TR 17870-2: 2015—Ceramic Tiles—Guidelines for Installation—Part 2: Installation of thin ceramic wall and floor tiles and panels

[11] ASSOPOSA. Guidelines for Installation of Thin Ceramic Wall and Floor Tiles and Panels, 2015.

[12] "Thin Porcelain Tile (TPT) Study Guide," Advanced Certifications for Tile Installers.