Properties of Ceramic Tile

Ceramic tiles possess a wide range of properties, and certain tiles are better suited for some installations than others. Few tiles are suited for all types of installations; consequently, precise knowledge of the properties is essential for the consumer to achieve the desired and anticipated value of the tile. Because so many tile installations are built around or near water, and because porous materials can absorb moisture and harbor unwanted organisms, absorption is one of the most important properties, because, in wet-area applications, it can involve health and safety issues, and in exterior applications, it can initiate significant freeze/thaw damage. This is why ABSORPTION is #1 on my list, otherwise, the contents of the list is in no particular order except that the first seven properties have useful ANSI Reference Tables that are easy to access and understand.

Contractors should have a basic understanding of the first eight properties and their values, to avoid selling the wrong product. This group (not really of greater importance than the others) contains the key properties of most interest to consumers and end users: Does the tile absorb moisture? Will it show wear? Can the tile be stained? Damaged by frost or freezing conditions? Hurt by cleaning chemicals? Slippery? Slippery when wet? Will it be beautiful?

The remaining properties do not have quick reference tables, and are not currently on the consumer inquiry list, but the ASTM tests and values are nevertheless essential for manufacturers, designers, and sellers, and all the tile tests are included in the list. Where a table does not exist, I have included comments or values related to the standard. Altogether, there are 20 properties for which ASTM tests or ANSI test methods already exist, with other properties remaining to be proposed in the future: The following information was developed using the new ANSI A137.1 standards (ANSI A137.1- 2008)

1**. Water Absorption –** The ability of a tile's bisque to absorb water or moisture. ASTM test method C373 measures the rate of absorption as a percent of the volume of the body of the tile, with different designations for dust-pressed, extruded, and other body forms (see ANSI A137 Table 1)

	Impervious	Vitreous	Semi-Vitreous	Non-Vitreous
	≤0.5%	3-0.5%	3-7%	7-20%
Forming Method				
Pressed	P1	P2	P3	P4
Extruded	E1	E2	E3	E4
Other	O1	O2	O3	O4

2. **Visual Abrasion Resistance –** A measure of the resistance of tile surfaces to visible surface abrasion. The ASTM C1027 test applies to glazed floor, quarry, mosaic, or porcelain tiles only. Note: The PEI scale is not valid for ceramic tiles. (see ANSI A137 Table 12)

Class	
O	Not recommended for floors.
I	Light Residential
II	Residential
III	Heavy Residential/Light Commercial
IV	Commercial
V	Heavy Commercial

3. **Aesthetic Class –** This is a classification that has long been needed by the tile industry—especially tile showrooms—to help educate tile consumers regarding color, blending, and shade variations. On one hand (the most uniform), determination of class involves precise testing (ASTM C609); but at the other extreme, the designation "Substantial Variation" requires no testing, but rather a subjective call by the manufacturer. Consequently, manufacturers and showrooms now have a positive standard and a simple classification for both commodity and artisan tiles (see ANSI A137 Table 3).

Class

V0 - Very Uniform, Pieces of same shade value are very uniform.
V1 – Uniform, Difference among pieces of same production are minimal.
V2 – Slight Variation, Distinguishing differences in texture/pattern within similar colors.
V3 – Moderate Variations – Significant variations in color/texture.
V4 - Substantial variation, Random color/texture differences from tile to tile.

4. Chemical Resistance – The chemicals comprising this class include the most popular cleaning solutions and materials used for residential and light commercial tile installations. The classes – A to E – are determined by ASTM test C 650, and are based on resistance to staining, with samples unaffected by any of the chemicals rated A, while samples affected by 4 or more chemicals are given an E rating (see ANSI A137 Table 13).

Resistance Class	Maximum number of affected samples
A	0
B	1
C	2
D	3
E	4 or more

5. Stain Resistance – ASTM C1378 measures a tile's resistance to the most common household stains, with a rating similar to ASTM C650, above (see ANSI A137 Table 14).

Resistance Class	Maximum Number of Samples that Retain a Stain
A	0
B	1
C	2
D	3
E	4 or more

6. Deep Abrasion Resistance – ASTM C1243 measures the resistance to wear of an unglazed tile intended for floor covering. Values depend upon the type of tile tested (see ANSI A137 Table 11).

Class	Maximum Value
P1, E1, O1	175
P2	225
E2, O2	275
P3	345
E3, O3	393
E4, O4	2365
P4	No requirement.

7. **Freeze/Thaw Resistance** – ASTM C1026 measures a tile's resistance to damage induced by cycles of freezing and thawing, and rates 10 samples according to damage done at 5, 10, and 15 testing cycles:

Number of Observed Defects	Number of Cycles
	5
	10
	15

8. **Coefficient of Friction –** ASTM C1028 is a test to determine the coefficient of friction for manufactured tiles or for installed tiles under both wet and dry conditions. A minimum ASTM C1028 test value may be required as part of an engineer's or architect's project specification for floor tile. A value of .5 is considered acceptable for most applications.

9. **Bond Strength –** A measure of the ability of a tile to be bonded with Portland cement paste, with test values (ASTM C482) expressed in inch/pounds. The minimum value for this test is 50 psi. An especially important value for glass tiles, especially those with a smooth or coated back.

10. **Breaking Strength –** A measure of the breaking strength of tile with test values (ASTM C648) expressed in pounds-force. Minimum value for glazed or unglazed mosaic, quarry, or paver tile is 250-pounds. Minimum value for glazed wall tile is 90-pounds. Samples of non-ceramic tiles, made of stone, glass, metal, concrete, or other materials can be submitted for ASTM C648 testing and evaluation.

11. **Crazing Resistance –** A one cycle pass-or-fail test (ASTM C424) to determine resistance to crazing. The test uses staining dyes and steam to induce and identify thermal shock damage. Any tile claiming craze or crackle resistance should be able to pass the ASTM C424. There is no test value: The sample either passes or fails.

12. **Thermal Shock Resistance –** ASTM C484 measures a glazed ceramic tile's resistance to thermal shock created by rapid or severe temperature changes, as might be found near a fireplace or stove surround, for example. The test uses staining dyes and approximate 300°F temperatures to induce and identify cracks or other damage. There is no test value: The sample either passes or fails.

13. **Moisture Expansion –** A negative property, rarely found in ceramic tile, where prolonged moisture absorption causes a tile to permanently grow in volume. ASTM C370 is the test used to reveal this property. It is included here only to highlight that the moisture expansion phenomenon exists.

14. **Facial Dimensions -** A measure of the uniformity of size of a particular tile, determined by ASTM test C499 with values found, under "Nominal Size", "Caliber Range", and "Thickness", in ANSI A137, Tables 6 through 10.

15. **Warpage –** The curving of a flat tile surface, as measured by ASTM C485, with values found, under "Warpage Edge", "Warpage Diagonal", in ANSI A137, Tables 6 through 10.

16. **Wedging –** A change in edge dimension, from one tile to another, in a given lot, as measured by ASTM C502, with values found, under "Wedging", in ANSI A137, Tables 6 through 10.

17. **Thermal Expansion –** Linear thermal expansion is determined by ASTM test C372.

18. **Thickness –** The uniformity of thickness for a given lot of tile is determined by ASTM C499, with values found, under "Thickness" in ANSI A137 Tables 6 through 10.

19. **Evaluation for Facial and Structural Defects*** - ANSI A137, 9.1 and 9.2

20. **Evaluation of Shade Value* –** ANSI A137, 9.4, test method for evaluating ceramic tile, Class V1 to V4.

21. **Mounting*** - ANSI A137, 9.5, an alternative test method for evaluating mosaic sheets.

*These properties are determined by standardized visual test methods using specific test apparatus and samples, and apply mostly to tiles classified as V0 (see ANSI A137 Table 3).

Suggested format for a tile classification label:

Property	Pass/Conforms	Value
Aesthetic Class		V0 to V4
Water Absorption		P1 to P4
		E1 to E4
Visual Abrasion Resistance		0, I, II, III, IV, V
Chemical Resistance		A to E
Freeze/Thaw Resistance		Defects per cycle
Coefficient of Friction		No less than .5 wet
Stain Resistance		A to E
Deep Abrasion Resistance	Conforms	
Crazing Resistance	Passes	
Thermal Shock Resistance	Passes	
Facial Dimensions	Passes	
Warpage	Passes	
Wedging	Passes	
Thickness	Passes	

(These are properties of use to the more technically-minded.

Bond Strength		≥50 psi
Breaking Strength, glazed wall tiles		≥90 pounds
Breaking Strength, floor tiles		≥250 pounds
Facial and Structural Defects	Passes	
Evaluation of Shade Value		V1 to V4
Thermal Expansion	Passes	
Moisture Expansion	Conforms	
Mounting	Conforms	