Designation: C 1167 – 96

Standard Specification for Clay Roof Tiles[1]

This standard is issued under the fixed designation C 1167; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers clay tiles intended for use as roof covering where durability and appearance are required to provide a weather-resistant surface of specified design.

1.2 Tiles are manufactured from clay, shale, or similar naturally occurring earthy substances and subjected to heat treatment at elevated temperatures (firing). The heat treatment must develop a fired bond between the particulate constitutents to provide the strength and durability requirements of this specification (see *firing* and *fired bond* in Terminology C 43).

1.3 Tiles are shaped during manufacture by molding, pressing, or extrusion and it is permitted to use the shaping method to describe the tiles.

1.4 Tiles are generally planar or undulating rectangular shapes available in a variety of cross-sectional profiles, shapes, sizes, surface textures, and colors.

1.5 Three grades of tile having various degrees of resistance to weathering are covered in this specification. Three types of tile are defined to cover the features that influence appearance.

1.6 The values stated in inch-pound units are to be regarded as the standard.

2. Referenced Documents

2.1 *ASTM Standards:*

C 43 Terminology of Structural Clay Products[2]

C 67 Test Methods of Sampling and Testing Brick and Structural Clay Tile[2]

C 297 Test Method for Tensile Strength of Flat Sandwich Constructions in Flatwise Plane[3]

C 554 Test Method for Crazing Resistance of Fired Glazed Ceramic Whitewares by a Thermal Shock Method[4]

3. Terminology

3.1 *Definitions*—For definitions of terms relating to structural clay products, and clay roof tiles, see Terminology C 43.

4. Classification

4.1 Clay roof tiles covered by this specification are classified by grade for durability and type for appearance as follows:

4.1.1 *Grades*:

4.1.1.1 *Grade 1*—Providing resistance to severe frost action.

4.1.1.2 *Grade 2*—Providing resistance to moderate frost action.

4.1.1.3 *Grade 3*—Providing negligible resistance to any frost action.

4.1.1.4 Grades relate to exposure to weather as defined in Table 1.

4.2 *Types*:

4.2.1 *Type I*—High-profile tiles—tiles having a rise-to-width ratio greater than 1:5.

4.2.2 *Type II*—Low-profiles tiles—tiles having a rise-to-width ratio equal to, or less than 1:5.

4.2.3 *Type III*—All other tiles, including flat.

5. Material and Finish

5.1 Colors and textures produced by application of inorganic coatings to the faces of the tiles are permissible provided that evidence satisfactory to the purchaser is furnished regarding the durability of the coatings. Tiles that are colored by flashing or textured by sanding, where the sand does not form a continuous coating, are not considered as surface-colored tiles for the purpose of this specification.

NOTE 1—When surface colored tiles (other than sanded or flashed) are specified, data satisfactory to the purchaser shall be submitted showing that after 50 cycles of freezing-thawing (5.2) there is no observable difference in the applied finish when viewed from a distance of 40 ft (12 m) under an illumination of not less than 50 fc (538 lm/m^2) by an observer with normal vision. It is permitted to present service records of the performance of the particular coated tiles in appropriate locations in place of the freezing and thawing test, with the consent of the purchaser.

5.2 The tiles shall be free of defects, deficiencies, or bloating, that would interfere with the proper laying of the tiles, the performance of the roof, or the requirements of this specification.

5.2.1 Tiles, when broken, may have a dark area that has a steely appearance and is sharply delineated from the surrounding normal color of tile. This area is known as black heart or black core. Black heart is generally the result of the reduction

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[2] *Annual Book of ASTM Standards*, Vol 04.05.

[3] *Annual Book of ASTM Standards*, Vol 15.03.

[4] *Annual Book of ASTM Standards*, Vol 15.02.

TABLE 1 Grade Classification for Clay Roof Tiles

Grade (All Types)	Weathering Index (see Annex A1)
1	500 and greater
2	50 to 500
3	less than 50

of iron minerals during the firing process. Its presence, regardless of the size in the tile that otherwise meets the physical performance of this specification, shall not be cause for rejection.

5.3 The exposed tile surface shall be free of chippage or other imperfections detracting from the appearance of the designated sample when viewed from a distance 40 ft (12 m) under an illumination of not less than 50 fc (538 lm/m^2) by an observer with normal vision.

5.4 Unless otherwise agreed upon between the purchaser and the seller, a delivery of tiles shall contain not less than 95 % whole tiles. In this specification, the term *whole tiles* shall be understood to mean tiles meeting the appearance requirements of this specification.

5.5 After tiles are placed in usage, the manufacturer or his agent shall not be held responsible for compliance of tiles with the requirements of this specification for dimensional tolerances, finish, texture, or color.

6. Performance Requirements

6.1 *Durability*—The tiles shall conform to the physical requirements for the grade specified as prescribed in Table 2. Unless otherwise specified by the purchaser, tiles of a higher grade (greater weathering index) shall be accepted instead of a lower grade. It is permitted to waive the saturation coefficient requirement when the average cold water absorption of a random sample of five tiles does not exceed 6 %, no more than one tile of the sample exceeds 6 % and its cold water absorption is less than 8 %. When Grade 3 tiles are used in regions where the weathering index is less than 50 (see Annex A1), unless otherwise specified, the requirements for water absorption and for saturation coefficient shall be waived.

NOTE 2—Frost is of profound importance in mechanical weathering where its effectiveness is dependent on the frequency of temperature fluctuation across the freezing point in the presence of water. The ability of a tile to resist failure in a wet and freezing environment is, therefore, of paramount importance. If a tile fails in such an environment, its use will result in an unacceptable deterioration of appearance or more likely, a total failure to function (that is, protect the underlying structure from rain), or both. Such a tile is completely unacceptable for use regardless of its other properties such as strength.

TABLE 2 Physical Requirements

Grade	Absorption Requirements			
	Cold Water Absorption Maximum Percent		Maximum Saturation Coefficient[A]	
	Average of Five Tiles	Individual Tile	Average of Five Tiles	Individual Tile
1	6	8	0.74	0.76
2	11	13	0.80	0.82
3	13	15	0.84	0.86

[A]The saturation coefficient is the ratio of absorption by 24-h submersion in water at a temperature of 75 ± 10°F (24 ± 6°C) to that after 5 h submersion in boiling water.

NOTE 3—The resistance of clay roof tiles to weathering cannot be predicted with complete assurance using any of the physical tests prescribed. However, practical experience has demonstrated satisfactory performance of clay roof tiles, some for hundreds of years, and this experience forms the basis of the prescriptive requirements of Table 2. There is generally excellent correlation between field performance and the requirements. However, it is possible that some tiles that meet this specification are not suitable for severe climates. Furthermore, it is also possible for other tiles that do not meet this specification to show acceptable serviceability in the most severe climates. The best indication of clay roof tile durability is the service record of experience with the specified product in the environment of its intended use.

6.1.1 Measure the water absorption, and calculate the saturation coefficient, in accordance with Test Methods C 67. The test specimen shall consist of five whole tiles.

6.1.2 The physical requirements in Table 2 shall be achieved as a result of the firing process and associated thermal reactions within the tile body (and glaze, if present) which include development of the fired bond, increase in density, increase in strength, and reduction in water absorption. Tiles shall not comply with this specification if other processes, for example, immersion in solutions of organic materials to effect impregnation or surface sealing, are used to change the physical properties which result from the firing process.

6.2 *Freezing and Thawing*—The requirements specified in 6.1 for water absorption (5-h boiling) and saturation coefficient shall not be required for all grades provided that a sample of five tiles, meeting all of the other requirements, experiences no breakage and not greater than 0.5 % loss in dry weight when subjected to 50 cycles of the freezing-and-thawing test of Test Methods C 67, modified in accordance with 6.2.1.

6.2.1 Modify Test Methods C 67, Section 8, as follows: The test specimens shall consist of five whole tiles. The freezing trays and containers shall be of sufficient size and depth to allow the tiles to be completely submerged in water when placed horizontally. The tiles shall be completely submerged in water when the trays are placed in the freezing chamber. It is permitted to test individual tile or to stack tile on top of each other in the tray, provided that spacers at least ¼ in. (6 mm) thick are used between adjacent tiles and that the total stack is completely submerged.

NOTE 4—A large capacity freezer is generally necessary to accomplish freezing in the manner specified in Test Methods C 67 for trays containing more than one tile. It is permitted to use custom trays to enclose the tile(s) and minimize the volume of water required to completely submerge the tile(s).

6.2.2 A lot of tiles shall be given the Grade 1 rating without repeating a freezing and thawing test provided that a previous lot made by the supplier from similar materials, by the same process, at the same production plant, and within the previous 12 months, had passed the test, and provided also that a sample of five tiles selected from the lot has an average and individual minimum transverse strength not less than the previously graded sample and has average and individual maximum water absorption and saturation coefficient not greater than those of the previously graded sample.

NOTE 5—Unless specifically requested by the purchaser, the 50-cycle

freezing and thawing test is specified only as an alternative when tiles do not conform to either Table 2 requirements for maximum water absorption and saturation coefficient, or to the restrictive absorption requirements in 6.1.

6.3 *Strength*—The transverse breaking strength of tiles shall be determined as described for the Flexure Test in Test Methods C 67 except as modified in 6.3.1 to 6.3.7.

6.3.1 Five tiles shall be tested wet after a 24-h submersion in water at a temperature of 75 ± 10°F (24 ± 6°C) or five tiles shall be tested dry after heating in a ventilated oven for 24 h at a temperature of 230 to 239°F (110 to 115°C).

6.3.1.1 Tile shall be considered to comply with this specification when they pass the requirement of either the wet or the dry transverse strength test. The choice of method, wet or dry, shall be mutually agreed upon between specifier and supplier.

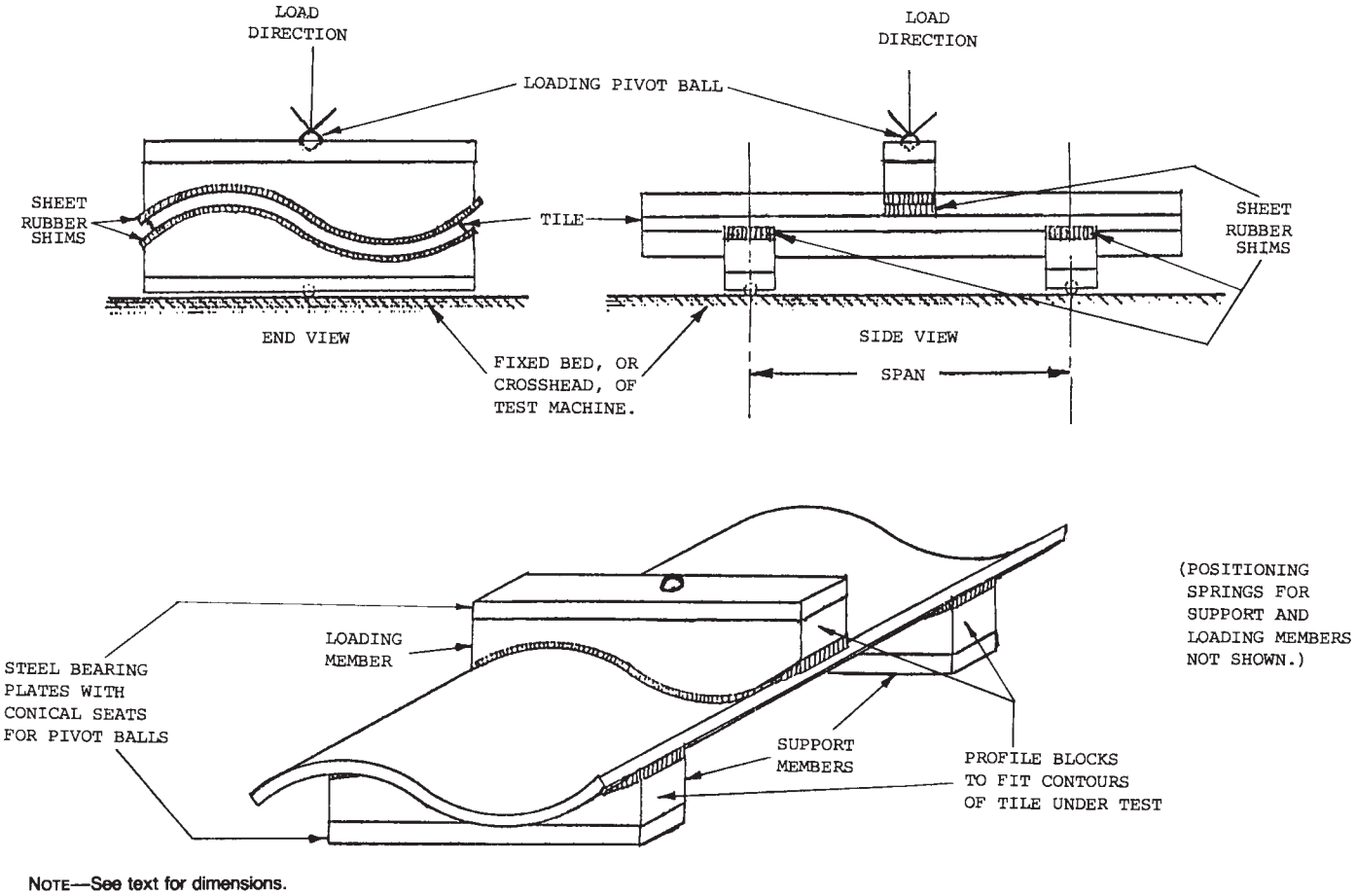
6.3.2 The span chosen for the test shall be 12 in. (30.5 cm) ± 5 % or ⅔ of the length of the tile, whichever is greater. The span is measured between the centers of the lower support members (6.3.3 and Fig. 1).

6.3.2.1 It is permitted to use a shorter span than required by 6.3.2 when the length of the tile to be tested is not sufficient to allow a 12 in. (30.5 cm) span to be used. In that case, a shorter span, not less than two-thirds of the length of the tile, shall be used and the required minimum values in Table 3 shall be increased proportionately to the reduction in span, that is, multiplied by:

$$\frac{12}{\text{span used (in.)}} \quad (1)$$

6.3.3 The tile shall be tested in a three-point bending mode in a horizontal plane with the bottom surface of the tile resting on two lower support members and with the load being applied to the upper (exposed) surface of the tile by a third member moving in a direction perpendicular to the plane of the tile and at mid-span (that is, equidistant from each of the lower support members).

6.3.4 The two support members and the loading member shall be of metal or hardwood with 1 in. (25 mm) ± 5 % wide faces. The faces shall be shaped (see Note 6) to closely conform to the profile of the surface of the tile upon which they bear during the test (it is permitted to use different profiles for each member depending on the profile and cross-sectional shape of the tile). The total height of the members shall not be more than 1 in. (25 mm) greater than the rise of the tile profile and, if hardwood, they should be backed up with steel bearing plates at least ½ in. (13 mm) thick. A rubber shim strip 3⁄16 in. (4.8 mm) ± 10 % thick of hardness no greater than Shore



NOTE 1—See text for dimensions.

FIG. 1 Schematic of Assembly for Flexure Strength Testing

TABLE 3 Transverse Breaking Strength Requirements

Type (All Grades)	Wet Transverse Strength, min, lbf (N)		Dry Transverse Strength, min, lbf (N)	
	Average of Five Tiles	Individual Tile	Average of Five Tiles	Individual Tile
Type I—High Profile	300 (1334)	260 (1157)	400 (1779)	350 (1556)
Type II—Low Profile	225 (1001)	200 (890)	300 (1334)	250 (1112)
Type III—Other Tiles	225 (1001)	200 (890)	300 (1334)	250 (1112)

Durometer 30 (A scale), and 1 in. (25 mm) ± 5 % wide, shall be placed between the faces of the support and loading members and the surface of the tile. A schematic of the assembly for testing a typical " S" tile is shown in Fig. 1.

NOTE 6—The intent of the defined loading system is (*1*) to apply the bending force with a loading member that pushes against as much of the profiled surface of the tile as is practical, (*2*) to support the tile on members that support as much of the profiled surface of the tile as is practical, and (*3*) to ensure that the contact area of both the loading and support members be equally distributed on either side of the length centerline on the tile to avoid non-symmetrical loading.

For tile with complex profiles and cross-sections but with flat bearing surfaces which are at least 50 % of the width of the tile and which are also equally distributed on either side of the length centerline it is permitted to use flat support and loading members to perform this test provided that they otherwise comply with the requirements of 6.3.4, 6.3.5 and 6.3.6. When sufficient flat bearing surface does not exist, wood blocks of appropriate thickness and profile and 1 in. (25 mm) wide, shall be used to provide a surface that will permit load application using a flat loading member which otherwise meets the requirements of 6.3.4, 6.3.5 and 6.3.6, and causes the load to be applied to at least 50 % of the width of the tile and equally distributed on either side of the length centerline of the tile.

Each wood block used to provide sufficient flat surface to allow loading and supporting with flat bearing members shall have a length of at least 25 % of the width of the tile. Such blocks shall be spaced no farther apart than 25 % of the width of the tile to avoid concentrated loading. Loading and support members shall be parallel to each other and be placed in the same alignment across the width of the tile, when viewed from the end of the tile, to avoid torsional loading.

6.3.5 The length of the support and loading members shall be greater than the width of the tile.

6.3.6 Both of the support members and the loading member shall be free to rotate in the longitudinal and transverse directions of the test specimen and be adjusted so that they will exert no force in these directions. It is permitted to be accomplished by spherically seated steel balls with appropriate supporting springs.

6.3.7 The tile shall be loaded uniformly and continuously, without shock, at a rate not to exceed 1000 lbf (4550 N)/min until fracture.

6.3.8 Record the load in pounds (kilograms) at fracture of each of the five tiles and report the average of the five tests and the minimum individual result.

6.3.9 For tiles with width greater than 14 in. (35.6 cm) the minimum values in Table 3 are to be increased proportionately to the increase in width, that is, multiplied by:

$$\frac{\text{width (in.)}}{14} \qquad (2)$$

6.4 *Efflorescence*—The rating for efflorescence shall be "not effloresced" when tiles of any grade are tested in accordance with Test Methods C 67 (modified in accordance with 6.4.1).

6.4.1 Modify 10.4.1 of Test Methods C 67 as follows: Set one specimen of each of the five pairs, with appropriate support formed from corrosion-resistant material to maintain the tile in an approximately vertical position, on its nose end, partially immersed in distilled water to a depth of approximately 1 in. (25.4 mm) for 7 days in the drying room.

6.5 *Reactive Particulates*—Reactive particulates are not permitted in the composition of the tile if they result in a visible imperfection when viewed from a distance of 10 ft (3 m) under an illumination of not less than 50 fc (538.2 lm/m^2) by an observer with normal vision.

6.6 *Permeability*—The permeability of tiles shall be determined as follows:

6.6.1 *Apparatus*—Provide a walled frame and stand, as shown in Fig. 2, designed to closely surround the perimeter of the tile and provide for horizontal support of the tile with the exposed surface uppermost, and for sealing around the perimeter. Any support flange or sealant material shall not protrude more than ½ in. (12 mm) onto the surface of either side of the tile. The height of the stand shall be sufficient to allow observation of the underside of the tile. The height of the perimeter frame wall shall be at least 3 in. (75 mm) greater than the height of the tile profile to be tested.

6.6.2 *Procedure*—Seal the entire perimeter of the tile in the frame with a suitable compound such as putty, mastic, or silicone sealant that will provide a watertight seal. Nail holes shall be similarly sealed. Sealant shall not protrude more than ½ in. (12 mm) onto the surface of either side of the tile. Place the frame and stand assembly on a non-absorbant surface and adjust the stand so that the tile is horizontal. Add water at 75 ± 10°F (24 ± 6°C) to a depth of 2 ± ¼ in. (51 ± 6 mm) measured from the highest point of the upper surface of the tile. Maintain the depth of water for the 24 h duration of the test and periodically observe the underside of the tile and the surface beneath the stand for signs of water droplets. Protect the assembly from drafts to avoid evaporation from the underside of the tile.

6.6.3 *Acceptance Criteria*—Three tiles, selected at random from the lot, shall be tested. The tile shall have passed the permeability test when, after 24 h, no water droplets have fallen from the underside of the tile. When water droplets have fallen, the tile has failed the permeability test.

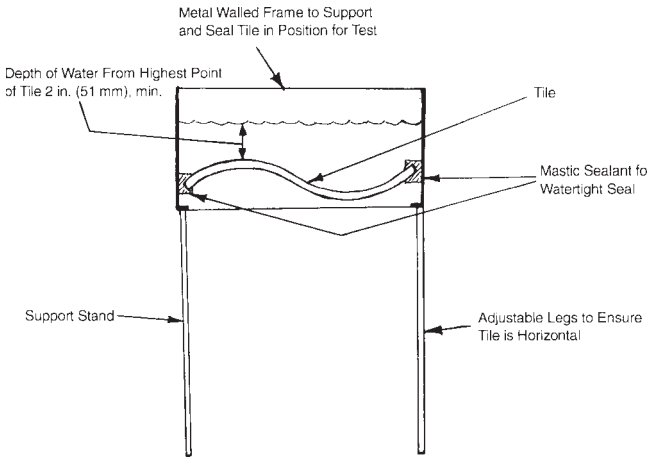


FIG. 2 Permeability Test Arrangement

7. Texture and Color

7.1 The color and texture of tiles shall be specified by the purchaser and mutually agreed upon between purchaser and supplier with reference to a sample of the grade and type specified representing the range of possible shades and textures.

7.2 *Glazed Tile*—It is permitted to coat the exposed surface of the tiles with a ceramic glaze of a color and gloss mutually agreed between purchaser and supplier with reference to a sample of the grade and type specified representing the range of possible shades of color and degrees of gloss.

7.2.1 *Glaze Adherence*—The adherence of the ceramic glaze shall be evaluated by the thermal shock method in accordance with Sections 2, 3, and 4 of Test Method C 554 with the exception that four heating and quenching cycles shall be conducted with an oven temperature of 450°F (232°C). After the four heating and quenching cycles, the glaze adherence shall be evaluated by flatwise tension tests conducted on five specimens in accordance with Test Method C 297. The adherence strength shall not be less than 100 lbf/in^2(689 kPa).

8. Tolerances on Dimensions and Weight

8.1 *Dimensions*—The total variation in dimensions of tiles, when measured in accordance with Test Methods C 67, shall not be more than ±5 % from the nominal dimension specified by the supplier.

8.2 *Weight*—The total variation in weight of tiles, when measured in accordance with Test Methods C 67, shall not be greater than ±10 % from the nominal weight specified by the supplier.

9. Inspection

9.1 Inspection of the material covered by this specification shall be agreed upon between the purchaser and the supplier as part of the purchase contract.

9.2 The tiles, as delivered to the site, shall, by visual inspection, conform to the requirements specified by the purchaser or to the sample or samples approved as the standard of comparison and to the samples passing the tests for physical requirements. Minor indentations, chips or surface cracks incidental to the usual method of manufacture, and not extending through the body of the tile, shall not be deemed grounds for rejection.

10. Rejection and Rehearing

10.1 When material that fails to conform to the requirements of this specification is rejected, such rejection shall be promptly reported in writing to the supplier. In case of rejection, and, when not specifically excluded in the purchase contract, the supplier shall have the right to inspect the rejected lot and resubmit the lot after removal of the material not conforming to the specified requirements, provided this is done within 20 days after receipt of notice of the specific cause for rejection.

10.2 When the shipment fails to conform to the requirements for the grade and type specified, the manufacturer is permitted to sort it, and new specimens shall be selected by the purchaser from the retained lot and tested at the expense of the supplier. When the second set of specimens fails to meet the requirements, the entire lot shall be rejected.

11. Certification

11.1 When specified in the purchase order or contract, the purchaser shall be furnished certification that a sample representative of each lot has been tested or inspected as required by this specification and the requirements have been met. When specified in the purchase order or contract, a report of the test results shall be furnished.

NOTE 7—Unless otherwise specified in the purchase contract, the cost of tests is typically borne as follows: When the results of the test show that the tiles do not conform to the requirements of this specification, the cost is typically borne by the seller. When the results of the tests show that the tiles do conform to the requirements of this specification, the cost is typically borne by the purchaser.

11.2 For the purposes of determining compliance to this specification, a lot is defined as 250 000 tiles or the total job site shipment quantity if fewer than 250 000 tiles.

12. Keywords

12.1 clay; durability; roof; roofing; tile

ANNEX

(Mandatory Information)

A1. EXPLANATORY INFORMATION

A1.1 The effect of weathering on tiles is related to the weathering index, which for any locality is the product of the average annual number of freezing cycle days and the average annual winter rainfall in inches (millimetres), defined as follows.[5]

A1.2 A freezing cycle day is any day during which the air temperature passes either above or below 32°F (0°C). The average number of freezing cycle days in a year may be taken to equal the difference between the mean number of days during which the minimum temperature was 32°F or below, and the mean number of days during which the maximum temperature was 32°F or below.

A1.3 Winter rainfall is the sum, in inches (millimetres), of the mean monthly corrected precipitation (rainfall) occurring

[5] Data needed to determine the weathering for any locality may be found or estimated from tables of Local Climatological Data published by the National Oceanic and Atmospheric Administration.

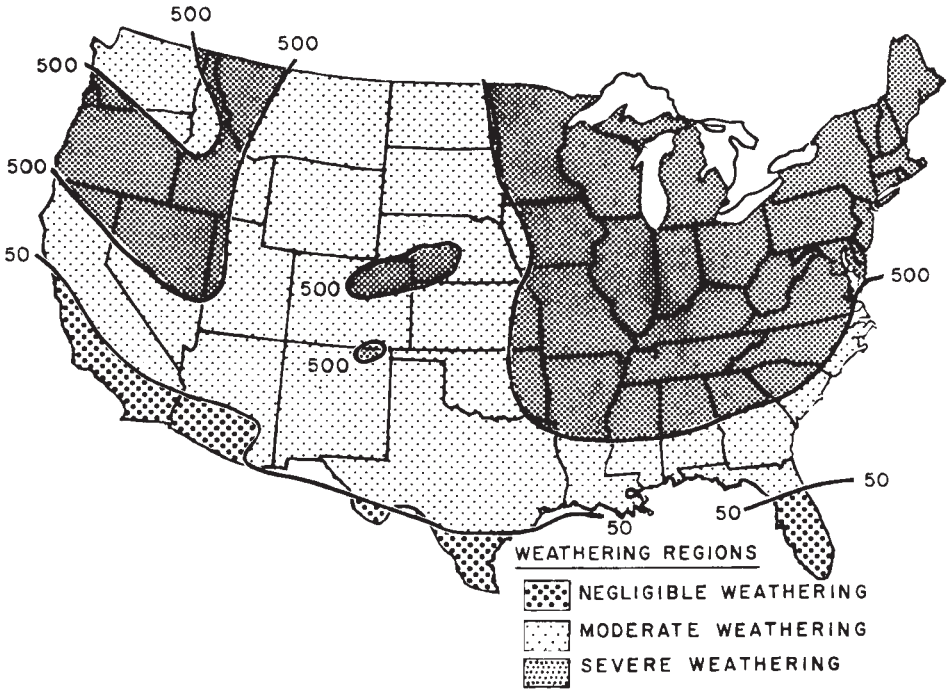


FIG. A1.1 Weathering Indexes in the United States

during the period between and including the normal date of the first killing frost in the fall and the normal date of the last killing frost in the spring. The winter rainfall for any period is equal to the total precipitation less one tenth of the total fall of snow, sleet, and hail. Rainfall for a portion of a month is prorated.

A1.4 Fig. A1.1 indicates general areas of the United States in which clay roof tiles are subject to severe, moderate, and negligible weathering. The severe weathering region has a weathering index greater than 500. The moderate weathering region has a weathering index of 50 to 500. The negligible weathering region has a weathering index of less than 50. The index for geographic locations near the 50 and 500-in. cycle lines should be determined by analysis of weather bureau local climatological summaries, with due regard to the effect of microclimatic conditions, especially altitude.