Designation: C 1570 – 03

Standard Test Method for Wind Resistance of Concrete and Clay Roof Tiles (Air Permeability Method)[1]

This standard is issued under the fixed designation C 1570; 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 The air permeability of tile roofing systems is a critical factor in determining the wind resistance of tile roofing as applied to a roof. This Standard describes a procedure for measuring the air permeability of clay and concrete tile and slate roof systems when applied to a small section of roof deck in accordance with the manufacturer's instructions.

1.2 This test procedure measures the air permeability of a laid array of unsealed clay or concrete roof tiles or slates. The tiles or slates shall have a thickness between ⅛-in. (3-mm) and 2-in. (51-mm).

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 43 Terminology of Structural Clay Products[2]

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

C 140 Test Methods of Sampling and Testing Concrete Masonry Units[2]

C 1167 Specification for Clay Roof Tiles[2]

C 1492 Specification for Concrete Roof Tiles[2]

2.2 *SBCCI Standard:*

SBCCI SSDT 11, SBCCI Test Standard for Determining Wind Resistance of Concrete or Clay Roof Tiles[3]

NOTE 1—This standard is based on the International Code Council's ICC/SBCCI SSTD 11 and work derived from the tile industry's testing programs completed in the Redland Wind Tunnel in the UK.

2.3 *ASCE Standard:*

ASCE 7, Minimum Design Loads for Buildings and Other Structures[4]

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method refer to Terminology C 43, and Specifications C 1167 and C 1492.

4. Principle of the Test Method

4.1 Air pressure is applied to the underside of an air permeable assembly of a specified type of roofing elements. The difference in air pressure across the assembly and the volume air flow rate are measured and used to determine the air permeability of the assembly.

5. Significance and Use

5.1 The air permeability of roofing systems constructed from discrete elements, as is the case for clay and concrete tile and slate roof systems, is a critical factor in determining the wind resistance of the roof system. The ability of the roof system to relieve wind-induced uplift pressures as a result of the overall air permeability of the roof assembly relates to the resistance of the roof system to damage induced by wind.

5.2 Natural wind conditions differ with respect to intensity, duration, and turbulence; these conditions are beyond the means of this test method to simulate.

6. Apparatus

6.1 A plenum chamber is a rectangular box with a depth of not less than 1.64 ft (500 mm) or one-third of the least lateral dimension, whichever is the greater. The plenum chamber shall be made airtight except for an open upper face to receive a mounting board or cover panel, a tapping for a pressure difference gage (relative to atmospheric pressure) and a connection to an air delivery pipe. The tapping shall be positioned to avoid direct alignment with the air delivery pipe. The shape and area of the mounting surface shall be capable of accepting

[1] This test method is under the jurisdiction of ASTM Committee C15 on Manufactured Masonry Units and is the direct responsibility of Subcommittee C15.06 on Roofing Tile .

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

[3]

[4] Available from The American Society of Civil Engineers (ASCE), 1801 Alexander Bell Dr., Reston, VA 20191.

the number of test samples specified in 8.1 as a minimum. A schematic of the air permeability apparatus is shown in Fig. 1.

6.2 An airtight removable cover panel shall be secured airtight to the plenum chamber.

6.3 An open face mounting board to receive the roofing substrate and test samples.

6.4 A controllable air flow generator shall be capable of continuously delivering air at a rate such that the uplift overturning moment on the roofing elements induced by the pressure in the plenum chamber by the air flow is equal and opposite to the dead weight restoring moment.

6.5 An airflow meter capable of measuring air volume flow rates in the delivery pipe and having an accuracy of 0.1 ft^3/s (0.003 m^3/s) or better.

6.6 A pressure difference measuring device (such as a manometer) connected to the inside and outside of the plenum chamber, capable of measuring a pressure difference of not less than 0.15 psi (1000 Pa).

6.7 Airtight seals for pipe connections, mounting board and cover panels, and at joints and edges of the roofing assembly.

6.8 A weighing device capable of measuring the dead weight of the roofing elements to the nearest 0.1 lbm (0.05 kg).

7. Check on Air-tightness of the Apparatus

7.1 Close the top of the plenum chamber by attaching and sealing the edges of the mounting board or cover panel so that the plenum chamber is air-tight except where connected to the delivery pipe.

7.2 Supply air from the airflow generator to induce a pressure difference between the inside and outside of the plenum chamber at test pressure but not less than 10.5 lbf/ft^2 (500 Pa). The air tightness of the plenum chamber shall be considered satisfactory if this pressure difference is maintained with an air flow-rate not exceeding 0.15 ft^3/s (0.004 m^3/s).

8. Test Specimen

8.1 Select, at random, sufficient roofing elements and half width elements, where appropriate, to assemble an array with a minimum of 4 unsealed elements. Roofing elements for covering the perimeter of the mounting board shall be provided and are to be air-sealed at their appropriate laps, front and side joints.

NOTE 2—A typical array illustrated for tiles or slates is shown in Fig. 2. This shows 5 unsealed tiles (5 unsealed headlaps and 5 unsealed sidelaps).

8.2 Provide sufficient roof element fastening systems, where appropriate.

8.3 Provide sufficient roof substrate materials, such as battens and their fasteners.

9. Determination of the Critical Uplift Pressure Difference, Δp_c, lbf/ft^2 (Pa)

9.1 Weigh each of the roofing elements in the air-dry condition.

9.2 Calculate the average weight (w_t), lbm (kg), of a roofing element.

9.3 Calculate the upward pressure difference, Δp_c, which is the critical pressure drop which will just fail to lift an array of unfixed samples from:

$$\Delta p_c = 0.9 \{w_t L_g / (b g_a L_u)\} \quad (1)$$

where:

L_g = distance, ft (m), from the center of gravity of the sample to its uppermost line of support or the top edge of the batten,

b = exposed width, ft (m), of the roof tile or slate,

g_a = batten gage, ft (m) which is also the exposed length of the tile, and

L_u = distance, ft (m), from the center of the exposed area of the sample to its uppermost line of support or the top edge of the batten.

10. Preparation of the Test Assembly

10.1 Construct the roof substrate without underlayment, underlayment for spaced sheathing, or sheathing boards. Battens shall be laid across the rafters to provide support for the elements. Battens shall be used without sheathing to provide support for the elements regardless of the roof construction, direct deck or batten construction. Where the element may be laid to different gages and the test is to be carried out on only one gage, set out to the maximum specified gage.

10.2 Lay and secure the roofing elements. For double lapped elements, lay elements with no gap between adjacent elements. For single lap elements, lay elements with maximum sidelap in order to produce the minimum exposed width. It is not necessary to secure the elements with clips unless these are essential to maintain appropriate headlap/sidelap gaps.

10.3 Seal against air leakage between peripheral elements to mounting board and to each other on all sides.

10.4 Adjust the level of the plenum chamber such that the mounting board surface is at 100 to the horizontal (± ½°).

10.5 Determine the effective area A, ft^2 (m^2), of the roofing element assembly under test from the formula:

$$A = NBg_a \quad (2)$$

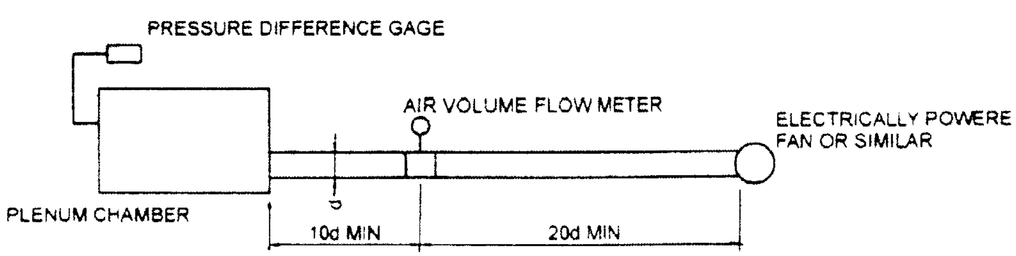

FIG. 1 Air Permeability Test Apparatus

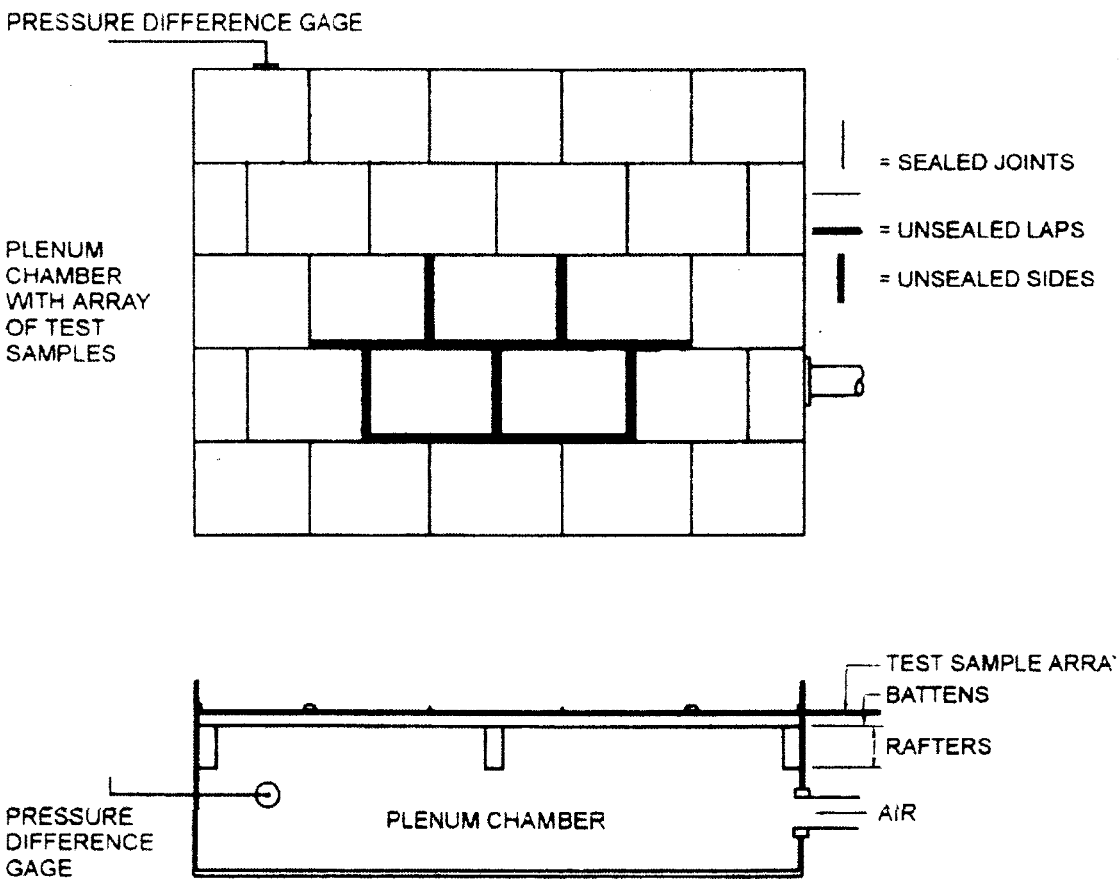

FIG. 2 Plenum Chamber Arrangement for Air Permeability Test

where:
N = number of unsealed roofing elements under test,
b = exposed width of the roof tile or slate, ft (m), and
g_a = batten gage, ft (m), which is also the exposed length of the tile.

11. Procedure

11.1 Check the air-tightness of the apparatus in accordance with Section 7.

11.2 Supply air from the airflow generator into the plenum chamber, gradually increasing the rate of supply until the pressure reaches a value equal to Δp_c. See Eq 1 in 9.3.

11.3 When the pressure equals Δp_c, record the volume flow rate Q_c, ft^3/s (m^3/s), in the delivery pipe and the pressure difference in the plenum chamber Δp_c, lbf/ft^2 (Pa). Gradually reduce the pressure difference to zero.

11.4 Repeat the test procedure three times and calculate the average value of the air permeability (C_d) from the three tests using the formula:

$$C_d = \frac{Q_c}{A} \frac{1}{\sqrt{\frac{2\,\Delta p_c\, g}{\rho}}} \qquad (3)$$

where:
ρ = density of air, lbm/ft^3 (kg/m^3),
g = acceleration due to gravity, ft/s^2 (m/s^2), and
A = effective area of the roofing assembly, from Eq 2 in 10.5, ft^2 (m^2).

12. Criterion for Uplift Coefficient

12.1 For an uplift coefficient, C_L of 0.20 the average value of the air permeability (C_d), shall be greater or equal to 3×10^3.

13. Report

13.1 The test report shall include:

13.1.1 The type, name, and dimensions of product,

13.1.2 Details of laps and any mechanical fastening system, where appropriate,

13.1.3 Details of the test apparatus,

13.1.4 A plan of the roofing assembly tested, indicating sealed and unsealed elements,

13.1.5 Calculated values of over-turning moment (uplift force) and critical upward pressure difference (Eq 1) to two significant figures,

13.1.6 Air volume flow rate at each of the pressure difference readings,

13.1.7 Date when the test was performed, and

13.1.8 Location where the test was performed.

14. Precision and Bias

14.1 *Precision*—It is not possible to specify the precision of the procedure for measuring air permeability because the apparatus is unique and has been used for an insufficient number of tests to allow calculation of precision.

14.2 *Bias*—No information can be presented on the bias of the procedure in Test Method C 1570 for measuring air permeability because no material having an accepted reference value is available.

15. Keywords

15.1 air permeability method; clay roof tile; concrete roof tile; critical upward pressure difference; uplift resistance; wind resistance