



# Testing Standards for Slate Roofing

By Matt Hicks

Over the last two decades, new standards have been developed to address quality issues for slate roofing. Testing procedures and techniques vary widely, and results show this. It was assumed by many that slates from the same region or company were identical in quality, but this is not correct. Different continents and countries set up their own standards, which makes it difficult to compare slate from different parts of the world. In the U.S., the American Society for Testing and Materials (ASTM) oversees the grading of roofing slate. Now more than ever, roofing slate from different quarries, regions, and countries needs to be compared with regard to durability and quality.

Originally, three tests were developed to grade slate under one standard, ASTM C 406. These tests, developed in the 1930s, were used to categorize U.S.-produced roofing slate. The test series consisted of ASTM C 217, Depth of Softening; ASTM C 121, Water Absorption; and ASTM C 120, Modulus of Rupture.

## **ASTM C 217, Depth of Softening**

This test is based on the fact that slate, which contains pyrite, calcite, and carbon, undergoes a chemical weathering that results in the conversion of the calcite particles to gypsum. The resulting swelling causes disintegration of the slate. The extent of this action on various slates in the test has been found to correlate with the durability of the materials in actual weathering.

## **ASTM C 121, Water Absorption**

The water absorption test attempts to quantify the percentage of water a slate absorbs after being immersed for 48 hours. The correlation has been made that the greater the absorption percentage, the more susceptible the slate is to freeze/thaw cycles, which would directly reduce the expected service life of the slate.

The above-mentioned tests attempt to calculate the detrimental effects of erosion on materials. Like the more predictable tests associated with ASTM, they have remained relatively unchanged since their inception. They are often regarded as the two most dependable methods of determining a slate's potential longevity. The third component of the ASTM C 406 series has proven to be somewhat less predictable.

## **ASTM C 120, Modulus of Rupture**

The modulus-of-rupture test attempts to simulate the effects of foot traffic and hail on natural roofing slate. The test tries to quantify the amount of load that can be placed upon a slate before it fails. The assumption is made that more impervious materials can withstand more force. Their increased durability would presumably result in increased longevity upon installation.

Unlike the absorption and depth-of-softening test, the modulus-of-rupture test focuses on the manufacturing practices used by quarries to produce roofing slate. The absorption and softening levels associated with a slate are intrinsic mineral properties that cannot be manipulated by a

WATER ABSORPTION	
Specimen No.	Absorption %
1	0.164
2	0.199
3	0.221
4	0.186
5	0.205
6	0.160
Average	0.189%
Amber Consulting Company Semi-Weathering Gray/Green South Poultney/Wells Quarry	

Table 1 – Water absorption test results on Vermont slate tested in 2007.

MODULUS OF RUPTURE			
Specimen #	Load (lb)	Thickness (in)	Stress (psi)
1	568	0.251	6,796
2	787	0.246	10,253
3	886	0.267	9,384
4	935	0.270	9,677
5	900	0.323	6,515
6	953	0.321	6,977
7	970	0.341	6,291
8	638	0.283	6,021
9	945	0.298	8,031
10	1,335	0.315	10,154
Average	892	0.291	
Amber Consulting Company Semi-Weathering Gray/Green; South Poultney/Wells Quarry			

Table 2 – Modulus-of-rupture test data on Vermont slate in 2007.

manufacturing technique. However, a quarry can modify the thickness of a slate, and the results of the modification can have great bearing on the reported durability of the slate.

ASTM arbitrarily introduced the standard level of 9,000 psi for 3/16-inch, commercial, standard-thickness slate. This number was determined after experiments indicated all slate of U.S. origin would meet or exceed this level. The standard was not to be applied to slates of greater thickness. There was no scientific basis that the 9,000-psi level would indeed lead to a serviceable life of 75+ years. The level was derived purely by an assumption, and the actual requirement is probably low. ASTM changed

this part of the standard, now C 120-05, in 2006. The level now used is load, calculated in pounds, with a minimum of 575 lb for S-1 slate, the highest grade.<sup>1</sup>

These standards were used to replicate the most common causes of failure. Consequently:

- The water absorption limit for S-1 slate is 0.25% (ASTM C 121-90).
- The water resistance (depth of softening) for S-1 slate is 0.002 in (ASTM C 217-94).
- The modulus of rupture for S-1 slate is 575 lb (ASTM C 120-05).

Tables 1 to 3 review the results of a Vermont slate tested in 2007.

WEATHER RESISTANCE	
Specimen #	Depth of Softening (in)
1	0.0011
2	0.0013
3	0.0020
Average	0.0015
Amber Consulting Company Semiweathering Gray/Green South Poultney/Wells Quarry	

Table 3 – Weather resistance test data on Vermont slate in 2007.

PROPERTY	ASTM TEST METHOD	RESULT	ASTM C 406 REQUIREMENT		
Modulus of rupture across the grain; min; (psi)	C 120	9,379	9,000		
Absorption: max (%)	C 121	0.23	S1	S2	S3
			0.25	0.36	0.45
Depth of softening: max (in)	C 217	0.002	S1	S2	S3
			0.002	0.008	0.014
Broken corners (exposed area): (in)	C 406	½	≤1½		
Curvature max: (in)	C 406	1/16	1/8		
Knots or knurls on nonexposed surface: (in)	C 406	None	≤1/16		
Ribbons: inspection (pass/fail)	C 406	Pass	None		
Face dimension variation from specified: inspection (pass/fail)	C 406	Pass	± 1/8		

Table 4 – Test results for material quality and static uplift.

Modulus-of-rupture tests are conducted on a Tinius Olsen testing machine. The weather-resistance tests are conducted using the hand scraping method. Thickness measurements were taken at different locations along the scrape tract. The average depth of softening was recorded.

This provides the information that the manufacturer, specifier, architect, contractor, and purchaser need to understand the material quality issue. The slate tested, which meets S-1 standards, will provide serviceability of 75+ years. Current testing results should be available from all manufacturers on their specific products for distinct quarry locations. If not, the quality of the material should be in question, as S-1 slate should be the only material used for a quality, long-lasting roof.

A new level of testing evolved as a result of the hurricanes that struck Florida in the 1990s, particularly Hurricane Andrew in South Florida. In the aftermath of that storm, building materials were found to be substandard. Miami-Dade County established an entirely new series of standards for all building materials to be used in the county, which differs somewhat from the ASTM standards.

The Miami-Dade testing incorporates three distinct tests, one of which uses the three ASTM standards. Miami-Dade requires a physical properties test, which includes the modulus-of-rupture, water absorption, and depth-of-softening tests. Unlike the updated ASTM C 406, Miami-Dade uses the previous 9,000-psi standard for its modulus-of-rupture test. Adjacent are the results of a test on Vermont slate in October 2007 with the results of the physical properties test and statement of compliance.

The second test, TAS 102-95, is a static uplift resistance test for mechanically attached systems. This test measures the breaking point of the material in ft-lbs. *Tables 5A and 5B* are the results of testing on the same material as in *Table 4*.

The third Miami-Dade test is a wind-driven rain resistance test in which a specified amount of simulated rainfall is applied to a roof deck with a specific pitch at varied wind velocities to test the roofing product. Water is applied up to 8.8 in/hr at wind speeds up to 110 mph to test the material and deck for water infiltration. *Table 6* shows results of the 2007 test.

Using all this information, anyone involved in a slate roofing project can understand why S-1 slate is a necessity.

Manufacturers should be able to provide recent testing results of their materials. This is becoming more important as imported slate continues to be shipped to the U.S. Imported material should have to conform to these same ASTM standards and certification should be required that the material tested is from the same quarry as the mate-

rial shipped. If current testing results and quarry certification cannot be obtained, one should question the origin and quality of the material.

The National Slate Association is working on recommending and certifying testing labs. At this time, each manufacturer or quarry uses its own criteria on how often to


TAS 102-95, STATIC UPLIFT RESISTANCE TEST RESULTS	
Number of test tiles measured	12
Average angle: $\alpha$ (degrees)	2.0
Average weight: W (lbF)	6.2
Average ultimate load: F' (lbF)	93
Percent deviation from the mean	4.0
Minimum characteristic resistance load: F' (lbF)	43.3
Attachment resistance exp. as a Moment: (Mf)	54.5
Aerodynamic multiplier: $\lambda$	0.438

RESTORING MOMENTS DUE TO GRAVITY MG, FT-LB						
Slope: (in)	≤ 2:12	≤ 3:12	≤ 4:12	≤ 5:12	≤ 6:12	≥ 7:12
Direct to deck	5.16	5.13	5.05	4.94	4.77	4.55

*Tables 5A and 5B – Test results of TAS 102-95, static uplift test, for slate mechanically fastened with two 1-7/8-in ring shank copper nails to 30/90 roofing underlayment.*

TAS 100-95, WIND-DRIVEN RAIN RESISTANCE TEST RESULTS		
<b>Slope: 2/12</b>	<b>Air Temperature: 86°F</b>	<b>Deck Conditioning: None required</b>
Air Velocity Condition	Simulated Rainfall Condition	Duration
35 mph No slate movement	8.8 in/hr No water infiltration under deck	15 min
0 mph No slate movement	Off No water infiltration under deck	10 min
70 mph No slate movement	8.8 in/hr No water infiltration under deck	15 min
0 mph No slate movement	Off No water infiltration under deck	10 min
90 mph No slate movement	8.8 in/hr No water infiltration under deck	15 min
0 mph No slate movement	Off No water infiltration under deck	10 min
110 mph No slate movement	8.8 in/hr No water infiltration under deck	5 min
0 mph No slate movement	Off No water infiltration under deck	10 min

*Table 6 – Hurricane test results on Vermont slate.*

test its slate, as there is no uniform standard. While it would be helpful to have the most recent testing results, it is time consuming and expensive to test more than once every year or two. The National Slate Association should be addressing this issue in the near future to create a standard for all manufacturers. 

#### References

- 1 Hill, Jonathan, "Standards for Testing Roofing Slate," December 2003, National Slate Association, [www.slate-association.org/standards.html](http://www.slate-association.org/standards.html)

#### Matthew Hicks

Matthew Hicks has been with Evergreen Slate Co., which his grandfather started in 1916, for over 25 years. He currently coordinates all material testing, including Miami-Dade approvals, for Evergreen. He is a member of the board of directors of the National Slate Association, serving on its Standards Committee. He is also a board member of the Slate Valley Museum.



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