Concrete and Clay Roof Tile Fastening in Designated High Wind Areas

By Reese Moody

History of Wind Design

Beginning in the late 1980s with Hurricane Hugo and continuing through the early 1990s (Hurricane Andrew), considerable emphasis was placed on keeping buildings intact when subjected to high wind forces. This focus included the concrete and clay roof tile industry. It was incumbent on the industry to develop fastening systems that would resist the velocity pressures associated with high winds.

The Roof Tile Institute (RTI), formerly the NTRMA (National Tile Roofing Manufacturers Association), and its member companies have spent a tremendous amount of time, money, and resources to study the effects of wind on tile.

Redland Technologies was commissioned in 1988 to evaluate the performance of U.S.-made roof tiles in high wind conditions. Subsequent testing was done in the UK at its Wind Research Center. The resulting Redland Report was the first study of any U.S. roofing material and formed the basis for code compliance reports and approvals to follow.

The Basics

Central to a realistic approach to effective fastening systems for concrete and clay roof tiles is the air permeable principle developed and proven during these studies.

Individual rigid units conforming to a specific size range that

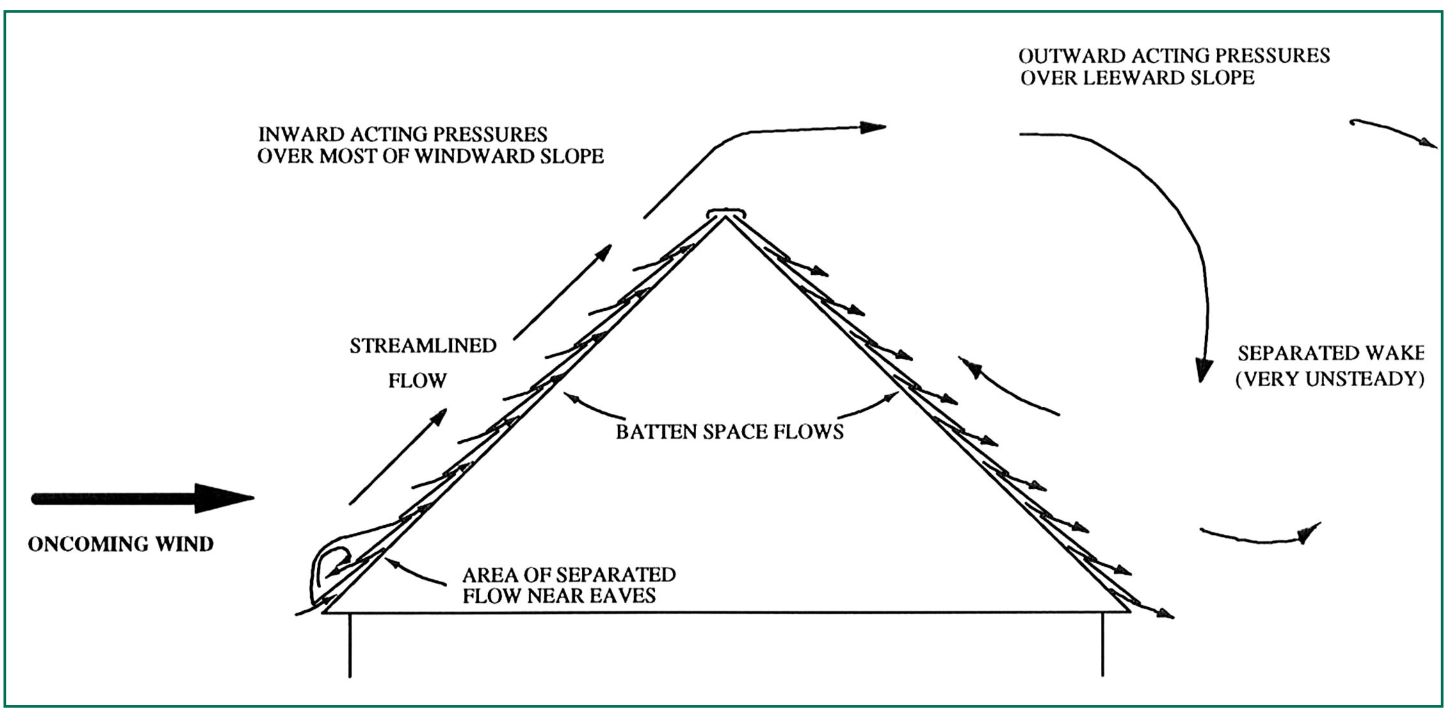


Illustration 1 – Batten Space Flows

comprise a roof tile assembly allow partial air pressure equalization of the top surface and the underside of the tile as a result of the gaps between the tiles. This reduces uplift forces by approxi-mately 70% and allows cost-effective fastening systems to be used even in extreme cases. (This air flow pattern offers the added benefit of reduced heat transfer to the attic, resulting in a positive effect on energy costs.)

The basis for wind uplift requirements, as well as quantifying resistance values for various fastening systems, was developed during this study and further refined through the code approval and compliance process. The requirements then were determined using code-developed pressures modified by the aerodynamic multiplier (partial equalization of pressure through tile gaps, as mentioned). Static uplift testing protocols (establishing resistance values) were then developed for various fastening alternatives to determine their limitations when compared to the code requirements.

When writing specifications, it is necessary to use the specific guidelines that pertain to the area in question to develop wind uplift requirements. In many cases, a combination of standards will apply.

- Standard Building Code (as outlined in the SBCCI Manufacturer Evaluation Reports)
- International Conference of Building Officials (ICBO)
- ASCE 7-88, 93, 95, 98
- South Florida Building Code (SFBC)
- Local code bodies, such as the Texas Department of Insurance (TDI) and other special high wind requirement areas
- Redland Technologies Report

There are five data items needed to calculate required fixing for a moment-based system (mechanically fastened or mortar/adhesive systems are moment-based and are allowed to use the aerodynamic multiplier, which is profile-specific or the lift coefficient, which is a constant):

- Wind zone (reference current wind map)
- Exposure – as defined in ASCE 7-95 or ASCE 7-98
- Building category – as defined in ASCE 7-95 or ASCE 7-98
- Mean roof height
- Roof slope (<7:12 or >7:12)

At this point, the contractor, designer, or engineer can calculate the required uplift using the following formula from the 1999 SBC, Section 1606.3.3 (modified versions of the following example formula exist; consult local requirements):

- Ma = qh x CL x b x L x La x (1.0 – GCp)
- Ma = aerodynamic uplift moment (value required for code compliance)
- qh = wind velocity pressure (using Table 1606.2A)
- CL = lift coefficient (0.20)

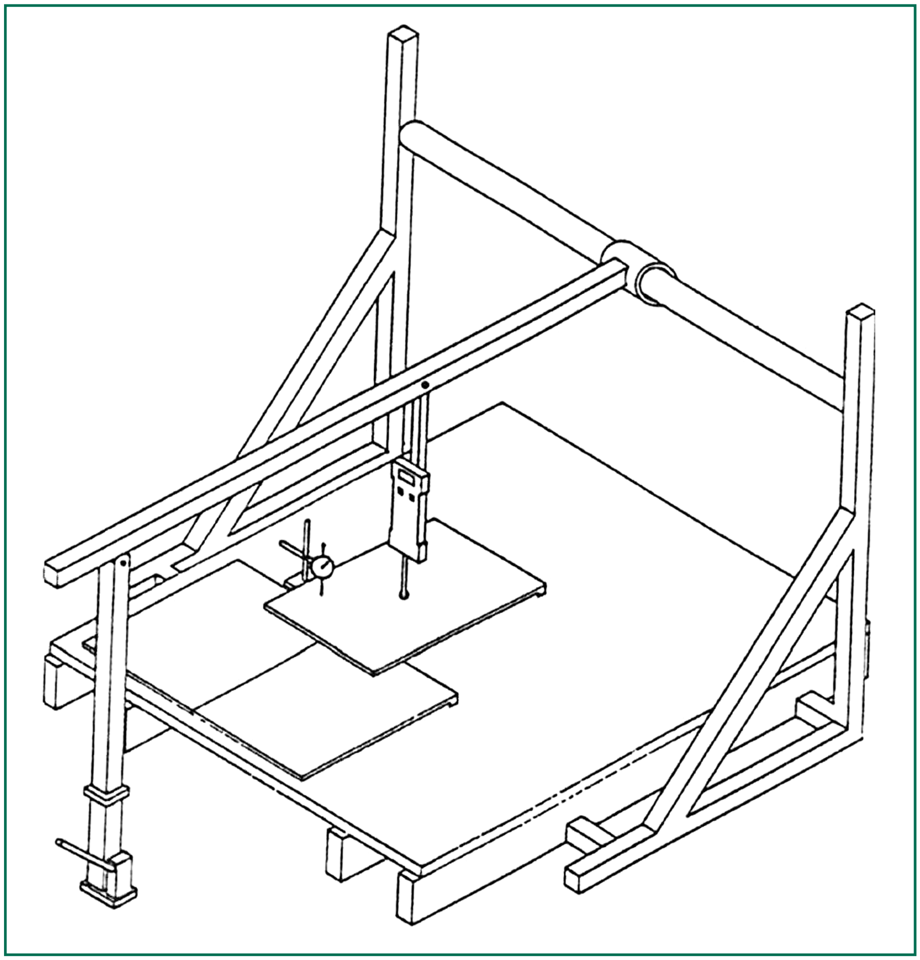


Illustration 2 – Static Load Test Rig.

- b = roof tile width
- L = roof tile length
- L_a = moment arm (from the axis of rotation to the point of uplift)
- GC_p = roof coefficient (Table 1606.2E)

Note: Determine a single value for the entire roof using most stringent roof zones (corner and perimeter) or separate lower requirement of field zone when further analysis is desirable.

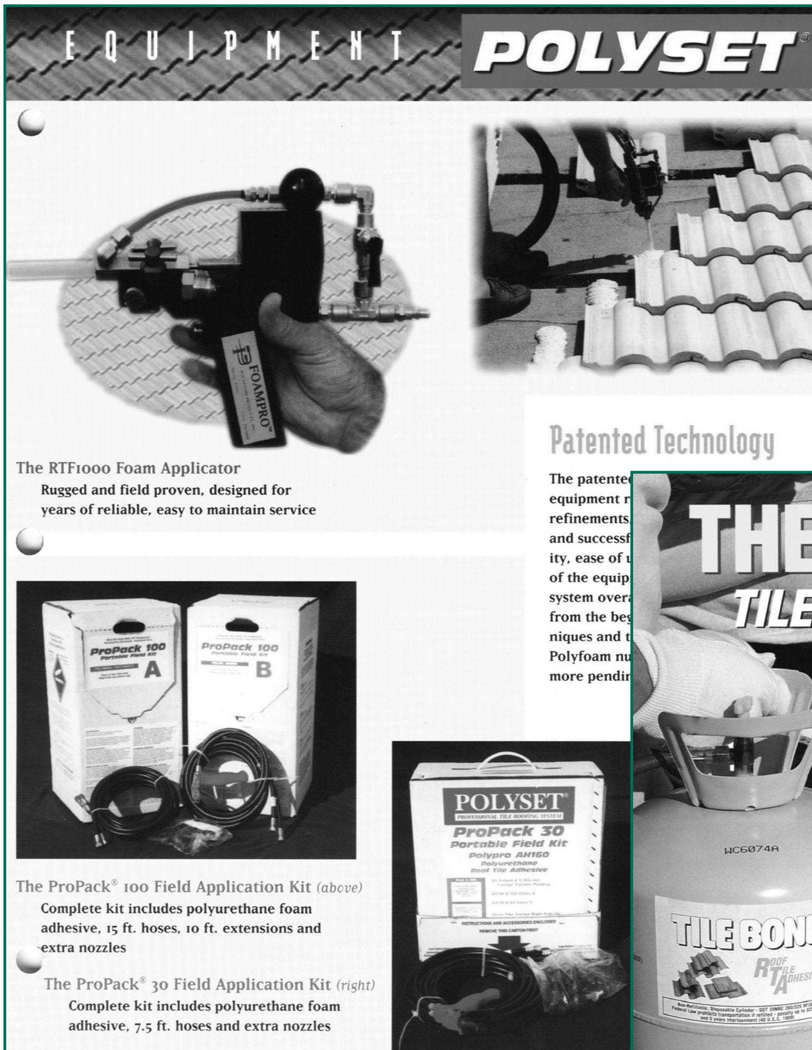


Illustration 3 – Polyset two-part system

– OR –

- Consult published fastening charts (maximum mean roof height varies).

The resulting values then become the standard that the proposed fastening system must meet, expressed in ft-lbs.

Developing Fastening System Resistance Values

Static uplift testing to evaluate selected fastening systems was carried out by RTI members and certified for code compliant use in the field.

The Static Load Test rig shown on page 19 was designed to perform static uplift testing for moment-based systems.

- Each tile is tested individually.
- Moment arm = point of uplift to the axis of rotation (head of tile).
- Mortar or adhesive set must allow 2/3 of tile area to be free of mortar/adhesive contact.
- Appropriate failure criterion was established for a variety of fastening systems.

The resulting fastening systems with certified resistance values are:

- Ring shank nails (10d, 18 to 20 rings per inch); no hurricane clips required
- Screw(s) (2-1/2 inch, #8, coarse thread); no hurricane clips required
- Nail/clip (10d smooth shank with appropriate clip)
- Mortar (certain tested formulations as approved for the individual mortar manufacturer)
- Adhesive set systems (as approved for the individual adhesive manufacturer)

If the published resistance value for any given fastening system is equal to or greater than the code uplift requirement (derived either through calculations or ref-

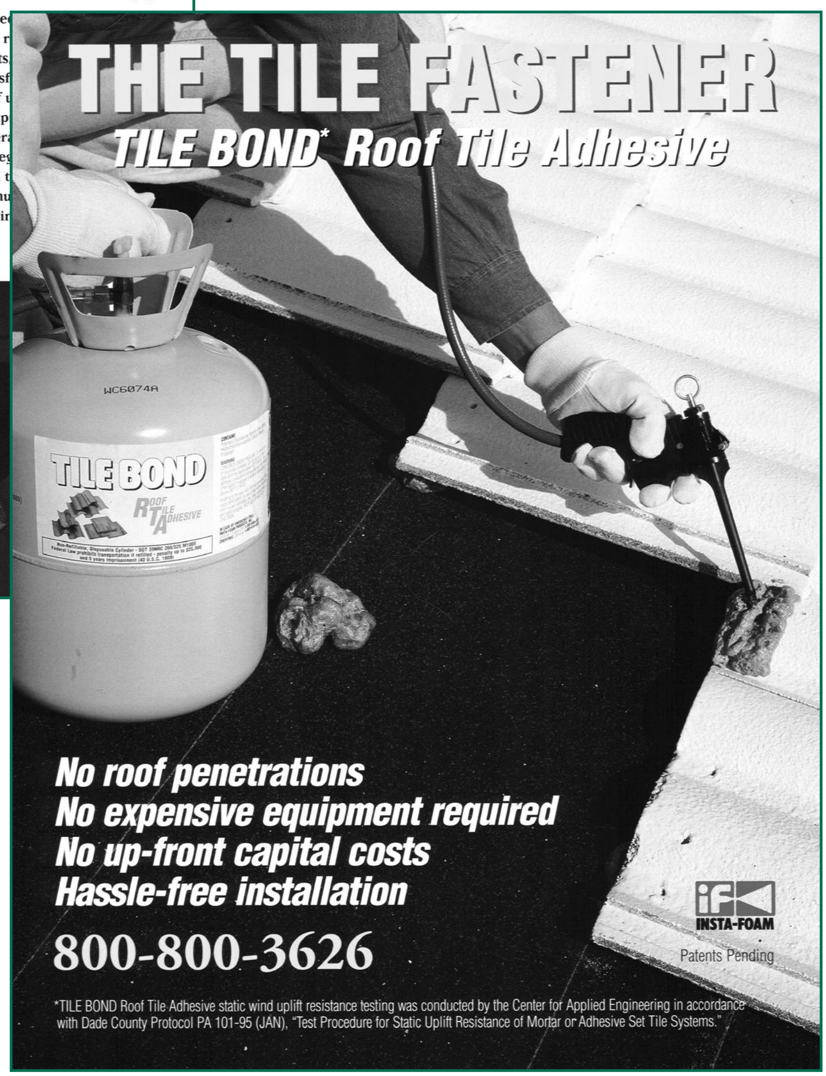


Illustration 4 – Tile Bond one-part system

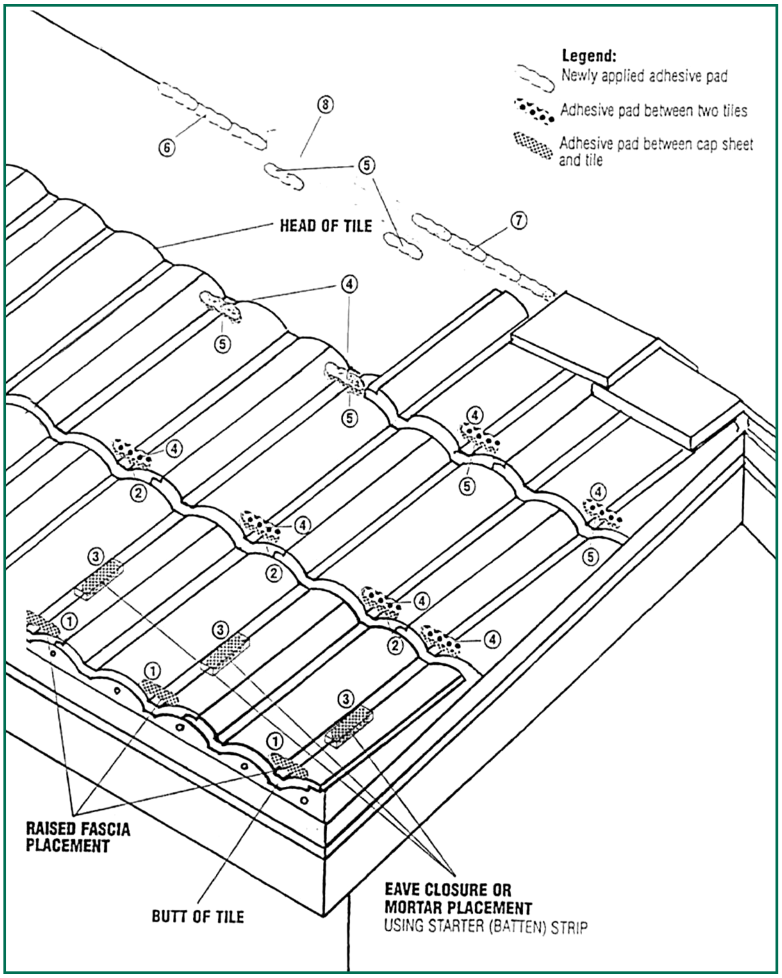


Illustration 5 – One-Part System Including Eave Course

erenced in industry prepared charts), then that system is in compliance.

This system, born of engineering data and laboratory analysis (in essence, a foreign language), was difficult to implement when it was formalized in the mid-1990s. Through the years, however, some parts of the country, especially Florida, have come to accept these code-based realities and work them into the roof tile installation process. It is gradually becoming apparent that wind issues are now of concern in areas other than hurricane-prone regions, such as the Midwest and other designated special wind zones. Therefore, it is important that relevant parties become familiar with at least the basic concept of designing wind resistant roof tile installations, namely establishing what the code requires and assigning a fastening system that meets that standard.

Sheathing – Plywood vs. OSB

All formal testing for high wind compliance was done on 15/32 inch and 19/32 inch plywood. While OSB (oriented strand board) is common throughout the U.S., including high wind areas, it is not a tested substrate for any roofing materials, including concrete or clay roof tile, in areas of anticipated wind speeds of greater than 80 mph. Having said that, the American Plywood Association (APA) has stated that OSB is equal to or greater than plywood when comparing physical properties values. In many cases local code jurisdictions will allow the use of OSB, based on the APA position.

Polyurethane Adhesive Systems (Foam)

There is considerable interest in foam as a cost-effective roof tile fastening system for high wind regions. Structural support for lightweight tiles and seismic benefits should also be mentioned. There are two types of polyurethane adhesives currently on the market with code compliance and approval reports, and they are quite different in composition and application. The two-part adhesive system will expand within minutes of application to achieve the desired contact area with the underside of the tile. The one-part adhesive requires compression (forcing the tiles together) to achieve proper contact with the tile units.

The basic, two-part adhesive system is applied to the underlayment with a large, medium, or small paddy (dollop) placement—depending on code requirements. (There is also a two-paddy system common to both formulations.) The two-part adhesive has an eight-year history with a Miami-Dade Notice of Acceptance (NOA) approval, an SBCCI compliance report, and a recently published ICBO report. The product has been used in Hawaii for two years. The system features various paddy placements for specific wind load requirements. There is also an aggressive roofer-training program to ensure proper application.[1]

The one-part adhesive features only a two-paddy system, which engages both the head and nose of the tile. The one-part adhesive has a shorter history of use as a roof tile fastening system. One key element of one-part foam with the two-paddy placement is securing the eave course. (In a tile-to-tile system, the eave course requires special attention.) Two options are currently offered: two paddies with a wood filler (minimizes volume of material required, which also assists in the curing of the adhesive) or two screws on the eave course only.[2] (See *Illustration 5*.) Testing for both formulations has produced excellent resistance values.

In all cases, follow manufacturer application guidelines.

Hawaii

This market has traditionally used a batten system, clipping alternate courses. The method was based on relatively low wind speed requirements. Recently, however, Hawaii was designated a 105-mph wind zone. The upgraded wind speed requirement will affect the use of these traditional methods in the future. Many of the guidelines mentioned in this article will come into play as Hawaii adapts to the new wind speed guidelines. It takes time to implement this system of required uplift and proven resistance values. Hawaii, as a result of these upgraded standards, is an excellent example of what prompts this discussion in the first place. There are cultural as well as economic consequences to the industry when applying these quantifiable fastening requirements and methods for all roofing materials, including clay and concrete roof tile.

New Wind Load Criteria

Some parts of the country will adopt new guidelines based on ASCE 7-98 within the next year. Despite the higher wind speeds up to 150 mph (three-second gusts vs. current lower sustained wind speed criteria), the overall fastening requirements will not change significantly in most cases. Comparisons are available through roof tile manufacturers and their distributors or the Roof Tile Institute (RTI) at 541-689-0366 or the Florida Roofing, Sheet Metal and Air Conditioning Contractors Association (FRSA) at 407-671-3772. ■

Summary

It is hoped that this general discussion will help provide a basic outline for understanding code requirements and solutions for wind-resistant roof tile installations. Future events will determine the need to either strengthen or reduce present code directives. There is comfort in the fact, however, that considerable safety factors are built into the calculations as they exist now.

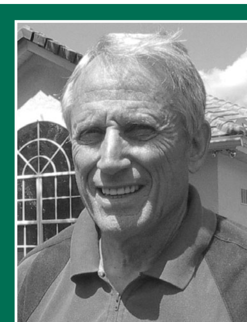
Finally, proper application of these standards, whether agreed with or not, is vital to protect the integrity of the system and maintain legally defensible roof tile installations.

References

1. For more information, call Polyfoam Products at 888-774-1099.
2. For more information, call Youmans Associates at 321-453-2709.

About the Author

Reese Moody served as Technical Services Manager, Eastern Region for Monier Inc. and later MonierLifetile. As an active member of the Roof Tile Institute and the FRSA, Reese provides both company and industry training seminars related to general clay and concrete roof tile installation procedures, as well as specific wind related presentations to groups such as RICOWI and RCI. He can be reached at 561-222-8322.



REESE MOODY

Top Roofing Contractors

The following roofing construction firms were listed recently in ENR magazine as having the largest revenue volume for 2000. Reported revenues of the top 20 firms ranged from $253 million plus to $16 million plus.

1. GeneralRoofing, Ft. Lauderdale, FL, $253.4
2. Centimark Corp., Pittsburgh, PA, $216.6
3. Tecta America Corp., Skokie, IL, $174.8
4. The Hartford Roofing Group, Glastonburg, CT, $68
5. Birdair Inc., Amherst, NY, $60
6. W.R. Kelso Co. Inc., Indianapolis, IN, $45.2
7. Latite Roofing & Sheet Metal Co. Inc., Pompano Beach, FL, $45.1
8. Baker Roofing Co., Raleigh, NC, $44.2
9. A.C. Dellovade Inc., Canonsburg, PA, $41.2
10. The Holland Roofing Group, Florence, KY, $36.0
11. Best Roofing & Waterproofing Inc., Torrance, CA, $30.1
12. Schreiber Corp., Detroit, MI, $28.8
13. Earl F. Douglas Roofing Co., Commerce City, CO, $27.6
14. Orndorff & Spaid Inc., Beltsville, MD, $22.1
15. All-South Subcontractors Inc., Beltsville, MD, $22.1
16. Evans Service Co. Inc., Elmira, NY, $20.1
17. Hamlin Roofing Co., Inc., Garner, NC, $18.5
18. The Young Group Ltd., St. Louis, MO, $17.9
19. L.E. Schwartz & Son Inc., Macon, GA, $16.6
20. Chamberlin Waterproofing & Roofing Systems, Houston, TX, $16.6.

—*ENR*

