



# SLATE ROOF EVALUATIONS AND DESIGN CONSIDERATIONS

By  
Christopher  
Musorofiti, RRC

*Figure 2 - Fastener cracks on slate, not noticeable during construction.*

## HISTORY OF SLATE IN THE UNITED STATES

Slate has been used in the United States since the 1600s, with much of the early slate being imported from Wales in the British Isles. In 1734, the first recognized slate quarry was opened on the Pennsylvania/Maryland border. From this point onward, numerous quarries could be found in the northeastern states and through the central/mid U.S. (Oklahoma, Colorado, Utah, Nevada). Slate production in the U.S. peaked in 1902 with approximately 1.4 million squares of slate reportedly produced that year. The National Slate Association was formed in 1922<sup>1</sup> to increase product marketing, standardize slate sizes and manufacturing practices, eliminate product waste, and clarify the industry's descriptive terminology.

Slate production and use slowed dramati-

cally in the 1930s (due to the Depression) and the 1940s (due to World War II). Another cause of the decline was the introduction of alternative roofing shingles, such as asphalt and composite (typically, asbestos- or cement-based) shingles. These products were introduced to lower production and labor costs associated with roofing operations. However, one of the ironic aspects of the alternative roofing products was that many of them incorporated crushed slate applied to their surfaces to mimic the appearance and color of natural slate.

In the 1950s, many of these alternate roofing products started to fail. Failure of these products, environmental health concerns associated with the asbestos added to some roofing products, and rising costs associated with petroleum-based products resulted in a slate revival that began in the 1970s. Unfortunately, slate roofing was

a lost art, since the skilled slaters of the 1930s were not available to train new labor, resulting in many incorrectly installed slate roofs. The problems included improper fastening of the shingles, incorrect overlapping of slate coursings, and poor slate and metal flashing transitioning.

Typically, the tradesmen of this period were accustomed to driving nails into the alternative materials to "fasten" the products to the roof deck. However, slate shingles are intended to be "hung" by the shank of the roofing nail, which allows for some movement (*Figure 1*). When slate is fastened too tightly, the underside of the slate may crack and even punch out the back of the slate shingle. This is often not noticed during construction and eventually results in broken slate (*Figure 2*). Similarly, when the fastener is not properly recessed into the prepunched fastener hole of the

slate, it can protrude into the underside of the upper course of slate and will fracture/crack as a result of applied loading (snow or trafficking of the roof).

Improper overlapping and head laps of the shingles (Figure 3) also posed a problem, as these conditions can allow water infiltration into the nail holes or openings between the shingle coursing, potentially deteriorating the roof decking and allowing moisture infiltration to the interior.

### What Is Slate?

Slate is a natural material that is excavated from the ground. It is dense, durable, and considered “virtually nonabsorbent.” However, with the varying grades of slate and physical/chemical composition, some slates do have the ability to absorb moisture within the structure, which can result in deterioration of the roof deck components over time. As with most natural products, the differences in physical and chemical compositions can vary the slate’s texture, color, and weathering characteristics.

### Where Does Slate Come From?

Slate is a natural product created millions of years ago during mountain formations. Slate in its previous form was typically aqueous sediment (clay) or volcanic ash that was subject to high pressure and tremendous heat. As a result of these combined effects, the sediments were compressed, allowing the molecular structure to form a cleavage plane that is 90 degrees with respect to the sediment plane. This allows the slate to be “split” into thin planes such as shingles.

### How Is Slate Made?

Slate is harvested in large sections from the earth. After the excavation of these large portions of slate, each section is split into smaller pieces along cleavage planes to achieve nominal dimensions. The splitting is repeated until the required nominal thickness of the slate shingle is obtained. This nominal thickness can range from a typical shingle thickness of ¼ inch to approximately 2

inches or greater. Once the desired thickness is obtained, the units are trimmed to meet the sizes required for specific projects. For slate shingle uses, nail holes are typically prepunched by the slate manufacturer, allowing for the nail heads to fit flush within the shingles’ surfaces.

## EVALUATION PHASE OF IN-PLACE ROOF SYSTEMS

### Available Plans and History

Many of the slate roof projects we encounter and are asked to evaluate are on historically significant structures. It is important to review available plans and the history of the building prior to initiating work. Determining if the building is a local

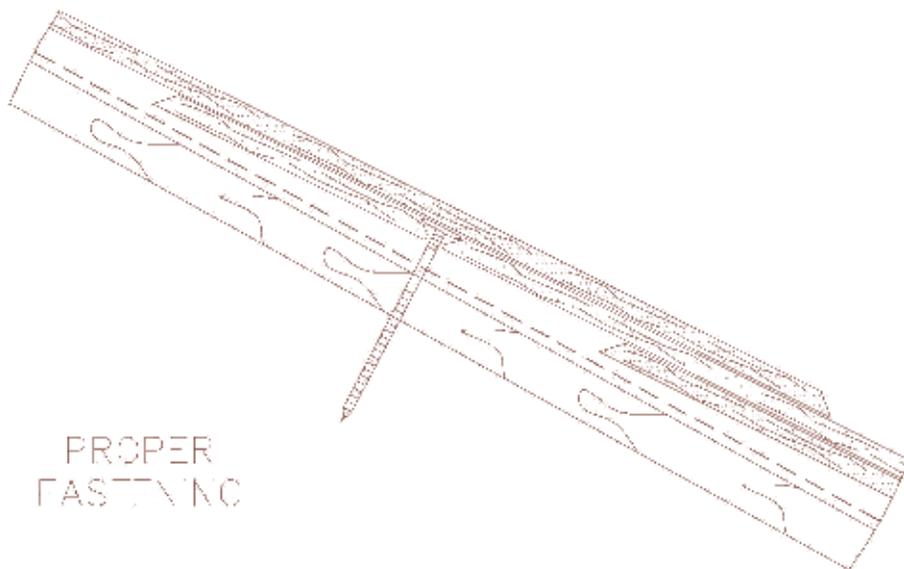


Figure 1 – Fastener sits flush with the top surface of the shingle, within the punched hole.



Figure 3 – Improper head laps.



Figure 4 – Staining under roof deck and on floor.

or nationally registered structure is critical to the design and construction efforts, as this will affect the overall recommendations if replacement is required. It is possible to determine the building's historical value by asking the client, researching photos/plaques within the building, or visiting the various websites that list local and nationally registered buildings.

### Interior Leak Survey

Performing an interior leak survey is important in determining potential defects in the existing roof system. A leak survey can pinpoint detailing issues that could pose a problem during the design and construction phases and can expose areas where repeated moisture intrusion may have resulted in deteriorated structural components. In addition to locating active leaks, staining on the underside of the roof deck should be noted (*Figure 4*). Staining can indicate the absence of dampproofing under the slate and the possibility that the shingles have absorbed moisture that has wicked into the deck components. Evidence of moisture intrusion typically includes:

- Staining under the roof deck or on the floor
- Efflorescent staining on the underside of a concrete deck
- Rust staining of structural steel pur-

lins used to support lightweight concrete or angle-iron decking

- Staining on sheathing boards
- Deteriorated roof rafters

Proper determination of these potential costly repairs can prevent surprises and embarrassment during the construction phase.

### History of Slate Roof Renovations

An important phase of any slate roof evaluation is to research and confirm the history of the building. This is accomplished by determining the existing building configurations, construction, and design intent. Aesthetics of historically significant buildings are typically very important and will require replacement with similar detailing and historical fabric. When possible, document the original slate configuration (standard, textured, or graduated) to allow for the proper replacement materials.

### Sampling

In the evaluation of slate buildings, varying colors and slate thicknesses are often observed. When the evaluation/design is progressing, it is important to obtain a minimum of three full slate shingles (the designer and the owner should agree these shingles best represent the original slate

color of the building). These samples should be divided amongst the designer, the owner, and the product supplier so that a future match of the same color and texture can be specified and quarried for installation at the site. Where fading or multicolor slates are present, all parties should agree what the intended color scheme should be when selecting the color sample from the existing roof.

Other samples required from the roof include the fasteners, sheet metal types and thicknesses (both sheet metal and slate configurations to match the original configurations), and any hazardous materials that may be encountered. Hazardous materials can typically be found in the underlayments, slater's cement, sealants, painted finishes, etc. The need for laboratory testing of slate is discussed under "Testing Requirements of Slate Replacements."

### Defects Typically Encountered

As with any roof evaluation, it is important to document the type and quantity of defects, which will assist in determining the potential problems and required renovations. Typical defects that indicate past, present, or future moisture intrusion into a building include:

- Cracked slate, either vertically or horizontally (*Figure 5*)
- Broken corners that exceed a 1-in by 1-in-square dimension
- Sheet metal repair materials under the slate shingles
- Insufficient slate overlaps
- Holes, results of iron deposits, or incorrectly installed shingle units
- Delamination of slate (typically a result of mineral impurities that react with water and form gypsum within the cleavage planes)
- Backed out or protruding fasteners
- Sealant repairs over defective slate

### QUESTIONS TO ASK

**"Were previous repairs performed on the original roof?"**

This is often the case when some of the slate is colored, textured, or sized differently than the original slate shingles; sealant or slater's cement has been applied; and bib

or hook metal has been installed to secure slate. However, an evaluator should use care when documenting sheet metal under slate shingles to confirm that they were not part of the original installation contractor's roof bracket system, which is not considered a defect condition.

**If repairs were performed, "Does over 20% of the slate roof need to be repaired?"**

If so, preservation briefs<sup>2</sup> and guidelines strongly recommend that the entire roof system be replaced. This recommendation is based on the fact that a roofing contractor will likely traffic the majority of the roof system to replace individual shingles. When the roof is trafficked, there is a strong possibility that additional cracked shingles will occur and not be observed or replaced. Also, if the building is experiencing defects and most of the slate is from the same installation period, it is likely that the roof system may have reached its useful service life. Removing a large section of the slate could result in improper tie-ins to render the area watertight.



Figure 5 – Cracked slate.

**WE TAKE THE FIRST STEP  
SO YOU DON'T TAKE YOUR LAST**



**NON PENETRATING FREE STANDING GUARDRAIL**

**SINGLE POST UPRIGHT ADVANTAGES:**

- Avoids non-compliant vertical openings greater than 4"
- Railings acts as a continuous system instead of independent sections
- Versatile - Screw set railing for permanent use or drop-lock pins for temporary use
- Ensure full compliance - Meets and exceeds OSHA standards for guardrails 29 CFR 1926.502(b)

Not all guardrail systems are created equal...find out what makes our guardrail systems fully compliant!

**WWW.LEADINGEDGESAFETY.NET**



**PRS**  
PREMIER RAIL SYSTEMS



Figure 6 – Snow guard installation.

**If replacement is being considered, “What potential problems could affect the roof system installation budget?”**

Gutters, masonry walls and chimneys, dormer windows, finial caps and spires, and wood trim components should all be considered when trying to determine what could affect the finished product of the roof system. Whenever possible (if the budget allows), attempt to limit the amount of future foot traffic and scaffolding that may be required on the new roof system.

**SLATE DESIGN**

Prior to embarking on the design for repairs or replacement to slate roofing and associated work, the following technical resources should be reviewed:

- Joseph Jenkins, *The Slate Roof Bible: Understanding, Installing, and Restoring the World’s Finest Roof*, Jenkins Publishing, 2003
- National Roofing Contractors Association
- National Slate Association, *Slate Roofs Design and Installation Manual*, 2010
- Preservation briefs, National Park Service, U.S. Department of the Interior.
- Brian Sterns, Alan Sterns, and

John Meyer, *The Slate Book: How to Design, Specify, Install and Repair a Slate Roof*, Vermont Slate and Copper Services, 1998

- Vermont Structural Slate, *Slate Roofs*

**Testing requirements of slate replacements**

Slate comes in three types of grades:

- S1 – Service life of over 75 years
- S2 – Service life of 40 to 75 years
- S3 – Service life of 20 to 40 years

This grading is based on ASTM Standard C406, *Standard Specification for Roofing Slate*, which classifies the service life based on the modulus of rupture, the absorption rate, and the depth of softening for the slate components. Only S1-graded slate is recommended for roofing applications. ASTM C406 testing should be performed and submitted to the designer within a four-year period of quarrying to confirm that the slate being processed meets the required grading for roofing projects.

It is typically not recognized in the industry that ASTM testing is required on slate shingles that are over 30 years old, as variations in the material can be present. Also, if the slate is sampled from an existing slate covering, the shingles could have been

taken from a repair area and would not be a true indication of the original roof slate shingle composition.

**PRIOR TO THE DESIGN**

During the evaluation and schematic design phases, potential construction issues (particularly modifications to historical details to make watertight connections) should be presented to clients for their consideration. Installing new components can modify the aesthetics of the building’s profile (i.e., roof-to-wall or eave locations). Structural issues, such as deteriorated decking or framing, should be communicated to the client, since replacement may be necessary to reach the desired service life of the replacement slate system. In order to achieve the anticipated extended service life of slate replacement systems, metal flashing configurations and thickness are important.

Also, it is very important to notify clients of potential lead times associated with obtaining slate. Slate is not typically stockpiled, and may require quarrying to generate sufficient slate for a specific project. This lead time is particularly critical when bidding a project for a specific construction duration (such as summer recess in a school building), as a delay in the project award could result in the slate not being delivered in time to complete the work.

**DESIGN CONSIDERATIONS**

Make sure to match the existing building configuration as much as possible, but provide long-term detailing to reduce the potential of moisture intrusion. During the design, reviewing the structural capacity of the structure for slate loading to confirm the building can handle the load requirements is important. The designer should not assume that the structure is sufficient based solely on the fact that the previous covering was slate. Discuss potential cost implications with the client for slate configurations (i.e., standard width vs. random width), because a random-size slate shingle will cost more in labor than the standard-width configuration. The sizing of gutters and downspouts is very important in order to comply with



Figure 7 – The final product.

building codes for storm drainage. Snow guard types and placements (Figure 6) are critical to address snow slide to other roof areas and site features such as walkways, parking areas, and access locations.

#### CAUTION THE CLIENT

Since slate is a natural product, variations in the colors that are selected should be anticipated. The final colors may not completely match the sample that was selected. Clients should be made aware of the potential of “shedding” or falling slate from the roof following the replacement. This phenomenon typically occurs upon completion of the project and up to a two-year period. It is not uncommon for approximately 2% of the slate shingles to shed during this period. This phenomenon can be caused by cracked slate that may not have been noticed prior to the contractor’s demobilization and slate that has become loose over time as a result of vibrations (swinging

doors, mechanical equipment, wind loads, etc.). These slate shingles will need to be replaced. The owner should consider keeping an “attic stock” of the replacement slate so that this shedding slate and any other future repairs as a result of wind damage can be replaced with the same slate color and texture. A good warranty/guarantee should include the contractor’s assistance over this two-year period to repair all shedding slate at no cost. 

#### FOOTNOTES

1. The National Slate Association became inactive shortly after its formation in 1922, but was revitalized in January 2002 by producers, contractors, architects, building owners, and other interested parties.
2. “The Repair, Replacement, and Maintenance of Historic Slate Roofs,” Preservation Brief 29 by the National Park Service, U.S. Dept. of the Interior.

*Editor’s Note: This article was originally published in the Proceedings of the 2007 RCI Symposium on Building Envelope Technology.*



Christopher Musorofiti, RRC

*Christopher Musorofiti, RRC, is an associate for the Building Envelope Technology Group at Gale Associates, Inc. He has 22 years of experience investigating existing facilities (roofs, walls, windows, waterproofing), designing exterior envelope systems to meet current building codes and industry standards, preparing contract documents, and performing construction period services. Musorofiti graduated from Worcester Polytechnic Institute with a B.S. in civil engineering.*