

# Slate Roof Evaluations and Design Considerations

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Slate has been used in the United States since the 1600s, with much of the early rock being imported from Wales. 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 northeast and through the central/mid United States—Oklahoma, Colorado, Utah, Nevada, and California.

The country's slate production peaked in 1902 with approximately 1.4 million squares (*i.e.* 9.3-m<sup>2</sup> [100-sf] units) reportedly produced. The National Slate Association (NSA) formed in 1922—it not only clarified the industry's descriptive terminology, but also standardized product sizes and manufacturing practices to reduce waste.

Slate production and use slowed dramatically in the 1930s (due to the Great Depression) and 1940s (due to World War II). Another cause of the decline was new alternate roofing shingle materials, such as asphalt and composite (typically asbestos/cement-based) products. These materials were introduced to lower production and labor costs associated with roofing operations. However, one of the ironic aspects of the alternative roofing products was many of them incorporated crushed slate on their surfaces to mimic the appearance and color of natural slate. In the 1950s, many of these alternate roofing products started to fail. This, along with asbestos-associated environmental health concerns and rising petroleum prices, resulted in a slate revival in the 1970s. Unfortunately, slate roofing was a lost art since the skilled slaters of the 1930s were unavailable to train new labor, resulting in many incorrectly installed slate roofs. The problems included improper:

- fastening of the shingles;
- overlapping of slate coursings;
- head laps to shed water; and
- slate and metal flashing transitions.

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, as this allows for some movement. When slate is fastened too tight, the underside of the slate may crack and even punch out the back of the shingle. This often went unnoticed during construction and eventually resulted in broken slate. Similarly, when the fastener is not properly recessed into the pre-punched fastener hole of the slate, it can protrude into the underside of the upper course, eventually fracturing or cracking as a result of applied loading (*e.g.* snow or roof traffic).

Improper overlapping and head laps of the shingles also posed a problem—these conditions allowed water infiltration into the nail holes or openings between the shingle coursing, potentially deteriorating the roof decking and enabling moisture infiltration to the interior.

### **Evaluation phase of in-place roof systems**

This author evaluates many slate roof projects on historically significant structures. For such projects, it is important to review available plans and the history of the building prior to initiating work. Determining whether the building is a local or nationally registered structure is critical to the design and construction efforts as this affects the overall recommendations if replacement is required. (It is possible to determine the building's historic value by asking the client, researching photos/plaques within the building, or visiting various websites listing local and nationally registered buildings.)

### **Interior leak survey**

Performing an interior leak survey is important in determining potential defects in the existing roof. It 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 roof deck's underside should be noted. This can indicate absence of dampproofing under the slate and the possibility 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 purlins used to support lightweight concrete or angle iron decking;
- staining on sheathing boards; and
- deteriorated roof rafters.

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

### **History of renovations**

An important phase of any slate roof evaluation is to research and confirm the building's history. This is accomplished by determining the existing building configurations, construction, and design intent. Aesthetics of historically significant structures are typically very important and require replacement with similar detailing and historic fabric. When possible, the original slate configuration (*i.e.* standard, textured, or graduated) should be documented to allow for proper replacement materials.

## Sampling

With slate roofs, varying colors and thicknesses are often observed. When the evaluation/design is progressing, it is therefore important to obtain a minimum of three full shingles (the designer and the owner should agree these best represent the building's original slate color). They should be divided amongst the designer, the owner, and product supplier so a future match can be specified and quarried for installation at the site.

Where faded or multi-color slates are present, all parties should agree on the intended color scheme when selecting the color sample from the existing roof. Other samples required from the roof include:

- 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.

## Defects typically encountered

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

- cracked slate (either vertically or horizontally);
- broken corners exceeding a 25 x 25-mm (1 x 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 reacting with water and forming gypsum within the cleavage planes)
- backed out or protruding fasteners; and
- sealant repairs over defective slate.

## Questions to ask

By ascertaining answers to a few select questions, a design/construction team can be better prepared for a repair/restoration project.

### 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 they were not part of the original installation contractor's roof bracket system, which is not considered a defect condition.

### **Does more than 20 percent of the slate roof need to be repaired?**

If so, preservation briefs and guidelines strongly recommend the entire roof system be replaced.<sup>4</sup> This is based on the fact a roofing contractor will likely cross the majority of the roof system to replace individual shingles. With workers walking across the roof, there is a strong possibility additional cracked shingles will occur without being observed or replaced.

Further, if the building is experiencing defects and most of the slate is from the same installation period, the roof system likely has reached its useful service life. Removing a large section of the slate could result in improper tie-ins to render the area watertight.

### **What could potentially affect the roof system installation that should be budgeted for?**

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 (typically budget-driven), the amount of future foot traffic and scaffolding required on the new roof system should be limited.

### **Testing requirements of slate replacements**

Slate comes in three types of grades:

- S1 (service life of more than 75 years);
- S2 (service life between 40 and 75 years); and
- S3 (service life of 20 to 40 years).

This grading is based on ASTM International C 406, *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 C 406 testing should be performed and submitted to the designer within a four-year period of quarrying to confirm the slate being processed meets the required grading for roofing projects.

The industry does not typically recognize the need for ASTM testing on slate shingles more than 30 years old, as variations in the material can be present. Additionally, if the slate is sampled from an existing covering, the shingles could have been taken from a repair area and would not be a true indication of the original shingle composition.

## Design considerations

During the evaluation and schematic design phases, potential construction issues should be presented to clients for their consideration, particularly modifications to historic details to make watertight connections. Installing new components can modify the aesthetics of the building's profile (*e.g.* 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 replacement slate system's desired service life. Metal flashing configurations and thickness is important to achieve the anticipated extended service life of slate replacement systems.

It is also very important to notify clients of potential lead times associated with obtaining slate. The material is not typically stockpiled and may require quarrying to generate sufficient quantities for a specific project. This lead-time is particularly critical when bidding a project for a specific construction duration (*e.g.* over the summer holidays for a K-12 school), as a delay in the project award could result in the slate not being delivered in time to complete the work.

It is important to ensure the existing building configuration is matched as closely as possible, but long-term detailing should be provided 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. It should not be assumed the structure is sufficient based solely on the fact the previous covering was slate.

Potential cost implications can be discussed with the client for slate configurations (*e.g.* standard versus random width) because a random-sized slate shingle will cost more in labor than the standard configuration. The sizing of gutters and downspouts are very important to comply with building codes for storm drainage. Snow guard types and placements are critical to address snow slide to other roof areas and site features, such as walkways, parking areas, and access locations.

## Cautioning the client

Since slate is a natural product, variations in the colors selected should be anticipated. Clients should also be made aware of the potential of 'shedding' or falling slate from the roof following the replacement. It is not uncommon for approximately two percent of the slate shingles to shed during this period. This phenomenon typically occurs on completion of the project and up to a two-year period. It is due to cracked slate that may not have been noticed prior to the contractor's demobilization and/or slate that has become loose over time because of vibrations (*e.g.* swinging doors, mechanical equipment, wind loads.). These slate shingles will need to be replaced.

The owner should consider keeping an 'attic stock' of the replacement materials so this shedding slate (and any other future repairs due to wind damage) can be replaced with products of the same 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.

## **[SIDEBAR ONE]**

### **Slate 101**

Created millions of years ago during mountain formations, slate was typically aqueous sediment (clay) or volcanic ash in its previous form, but then subjected to high pressure and tremendous heat. Consequently, 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. Slate is harvested in large sections from the earth. When excavating these large portions of the stone, it 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 6.4 mm (¼ in.) to approximately 51 mm (2 in.) 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 pre-punched by the manufacturer, allowing the nail heads to fit flush within the shingles surface. Slate is dense, durable, and virtually 'non-absorbent.' However, with varying grades and physical/chemical composition, some materials might 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/chemical compositions can vary the slate's texture, color, and weathering characteristics.

### **Further reading**

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

- John Meyer and Brian and Alan Sterns' *The Slate Book: How to Design, Specify, Install, and Repair a Slate Roof* (Vermont Slate and Copper Services, 1998);
- Joseph Jenkins' *The Slate Roof Bible: Understanding, Installing, and Restoring the World's Finest Roof* (Jenkins Publishing, 2003);
- National Park Service (NPS) *Preservation Brief 29; The Repair, Replacement and Maintenance of Historic Slate Roofs*, and
- the resources of the National Slate Association ([www.slateassociation.org](http://www.slateassociation.org)).