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Use of the Repairability Assessment Method for Evaluating Asphalt-Composition Shingle Roof Repairs

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Abstract

Each year, wind and hail cause billions of dollars in damage to asphalt shingle roofs of residential and commercial buildings. In some instances, the damage is clearly apparent to justify replacement of the entire roof surface. In other instances, the damage is more difficult to ascertain, leading to divergent opinions on whether the roof should be fully replaced or have more economical, localized repairs conducted. Historically, methods used to evaluate whether localized shingle repairs can be successfully and adequately performed have been done using a variety of approaches that rely on inconsistent and subjective analysis. This paper offers an alternative approach — the Repairability Assessment method. In this approach, the repairability of the roof is determined by evaluating whether repair actions will propagate damage. Evaluators using this method can calculate a damage rate and damage ratio that will provide them with a quantitative and repeatable means to guide their repairability assessment.

Keywords

Asphalt-composition shingles, roofing, repairability assessment, forensic engineering

Introduction

Every year since 2008, thunderstorms generating tornadoes, large hail, and damaging straight-line winds result in public and private insurance payments that top $10 billion annually[1]. These damaging wind and hail conditions can wreak havoc on the asphalt-composition shingle roofs of residential and light commercial buildings. The challenge for owners and the insurance industry is understanding to what extent these types of roofing surfaces have been compromised. In some instances, the damage is clearly apparent to justify replacement of the entire roof surface. In other instances, the damage is more difficult to ascertain, leading to divergent opinions on whether it is more feasible to do localized repairs or if (based on the asphalt-composition shingles' condition) the roof's surface needs to be removed and replaced in its entirety.

This decision on whether to repair or replace the asphalt-composition shingle roof surfaces commonly involves a licensed professional engineer, who will have the expertise to properly evaluate, assess, and recommend whether a repair is feasible. Depending on the roofing system, type and condition of the asphalt-composition shingles, material availability, and other local or environmental factors, the engineer can determine the effectiveness of repair actions versus a full replacement.

A repair to an asphalt-composition roof, if feasible, may provide a cost-effective means to bring the roof to full functionality while ensuring it remains durable and reliable through its original intended service life. However, the ease with which such repairs can be accomplished and still be in compliance with manufacturer specifications, building codes, or other applicable requirements is often misjudged. Thus, determining the repairability of the roof requires a thorough evaluation of the structure, the condition of the existing materials, the impact of the repair process, and the complexity of the reconstruction task.

Asphalt-composition shingle roofs, while durable and long lasting, can be challenging to repair, especially as they age. However, even newer and tighter adhering seal strips can also present challenges when repairing relatively new roof surfaces. The bottom line is that simply removing and replacing damaged shingles in the area appearing to need repair does not necessarily return the roof's functionality or service life. Asphalt-composition shingles are essentially separate pieces that are interwoven into a

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mat of material that overlays and protects the roof from the natural elements. Each shingle relies on and, in turn, supports the integrity of the surrounding shingles. Therefore, the roof must be evaluated as a system — not just as individual shingles.

Since asphalt composite shingles overlap and interweave into each other, the removal of a single shingle requires that several surrounding shingles also be disturbed and or disengaged in order to accomplish a repair. When the shingles are new, they are flexible and pliant. However, as they age, they lose elasticity and become more brittle and prone to cracking when stressed. In these situations, a more extensive repair is usually necessary to increase the integration area between the old and new material in order to assure a proper, secure connection and overlay. **Figure 1** provides a visual example that demonstrates the results of a failed asphalt-composition shingle repair. In this example, the new material was not properly integrated with the existing shingles. In addition, the older shingles had lost their pliability; therefore, the stress of the repair caused extensive cracking and breakage, resulting in a failure at the junction between the old and new shingles.

Depending on the integrity of the existing roofing system and materials, it may not be feasible or possible to execute a localized repair. As discussed above, asphalt-composition shingles will degrade with time. In addition, depending on the location of the shingles on the roof, it has been observed that certain areas of shingles will degrade at different rates. For example, south-facing areas of the roof experience higher ultraviolet exposure, while north-facing sections may experience a higher wind or ice load. Therefore, prior to executing repairs, it may be necessary to delineate the unique conditions of the shingles based on their location in the overall roof system.

Figure 1
Failure of shingles along the perimeter of a previous repair.
This represents a typical result of a nondurable and unreliable repair to a three-tab-style asphalt-composition shingle roof surface.

Common Construction and Types of Asphalt-Composition Shingles

Asphalt-composition shingles are generically constructed with a fiberglass mat that serves as the structural backing or support for the shingle. Older shingles may include mats made of organic fibers or other materials The next layer surrounding the core is an asphalt mix. The primary purpose of this layer is to prevent water incursion. It coats the fiberglass core and provides a layer of waterproofing protection on the upper and lower side of the fiberglass. This mix is typically made of a bituminous material similar to that used in asphalt road construction.

The topmost layer typically consists of ceramic covered granules that are overlaid on an adhesive mix and then pressed into the asphalt mix (**Figure 2**). The ceramic coating is designed to protect the granule's mineral core and prevent it from degrading. These granules not only provide vital protection to the asphalt mix against the sun's ultraviolet radiation, but they also reflect the sun's light away from the roof, thereby decreasing the temperature of the roof and the spaces below it (**Figure 3**).

Asphalt-composition shingles are primarily manufactured in two distinct styles: the "three-tab" style and the "laminate-style" (also often referred to as "architectural" or "dimensional"). Certain manufacturers may have additional styles boasting additional thickness or

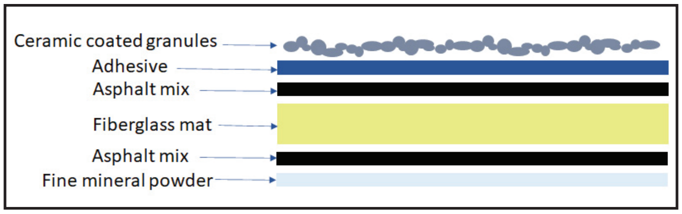


Figure 2
Generic construction of an asphalt-composite shingle.

Figure 3
Magnified view of shingle granules.

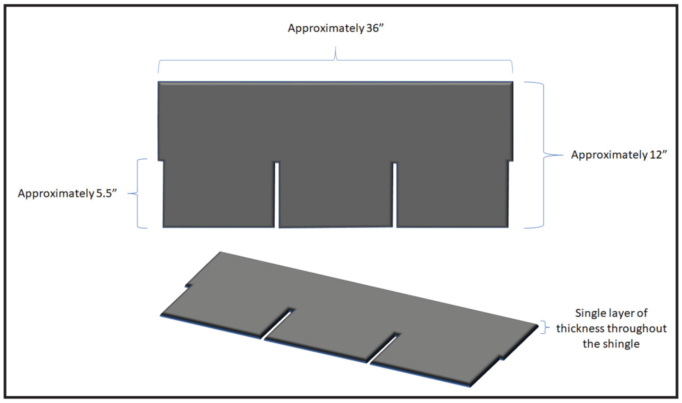


Figure 4
Typical three-tab style asphalt-composition shingle construction and dimensions.

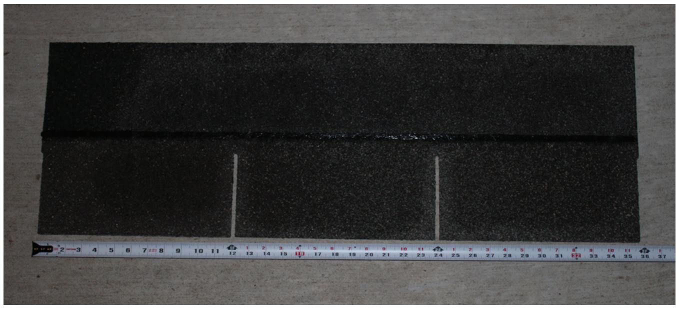


Figure 5
Photograph of a typical three-tab style asphalt-composition shingle.

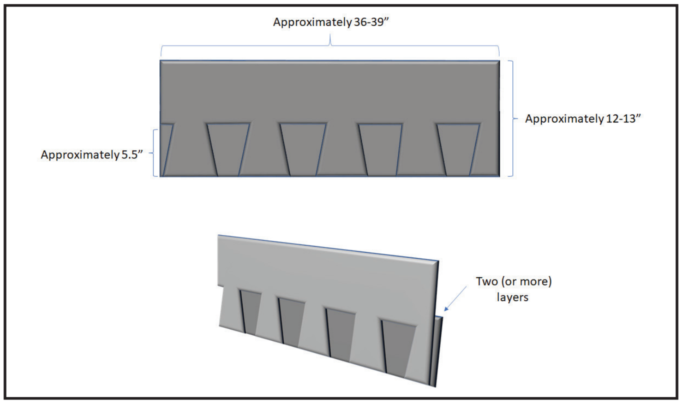


Figure 6
Typical laminate style asphalt-composition shingle construction and dimensions.

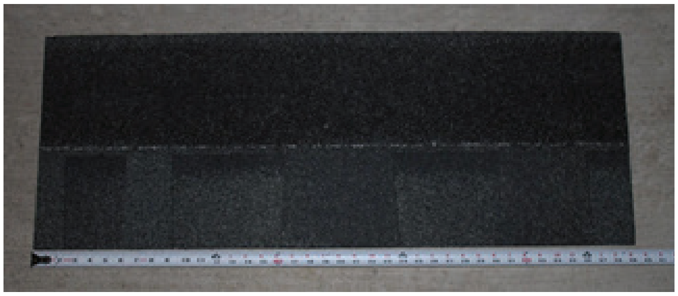


Figure 7
Photograph of a typical laminate-style asphalt-composition shingle

layers; however, the focus of this paper is on these two types, which are used predominantly throughout the industry.

Three-tab-style shingles are constructed of a single layer of the matrix of materials depicted in **Figure 2**. This type of shingle is approximately 36 in. long by 12 in. wide (although sizes may vary slightly by manufacturer). The top half of the shingle is solid, and the bottom half has three cutouts or "tabs" — hence the reason they are referred to as three-tab shingles (**Figures 4** and **5**).

Laminate shingles, on the other hand, are typically constructed of two or more layers of material. The top layer has a solid, uncut section on its top half with cutout tabs on the bottom portion. These tabs will vary in shape and width based on the aesthetic desire of the manufacturer. The bottom layer will be a solid piece with no cutouts. The top layer's tabs are then adhered to the bottom layer with an asphalt sealant to prevent movement and flexing during wind events (**Figures 6** and **7**). In some cases, manufacturers will have additional internal layers. These are usually for aesthetic purposes. For example, they will have a middle layer that also has cut out tabs of varying shapes and sizes that provide additional visual enhancements to the roof surface.

A very generic laydown for these types of shingles consists of an underlayment of plywood and roofing felt or other synthetic materials, with the asphalt-composite shingles being the topmost layer (**Figure 8**). It is important to note, however, that this underlayment will vary by region and manufacturer specifications. This paper will not address the specifications of the underlayment, as each layer in the roof structure has specific requirements based on the type of shingles being installed, geographic

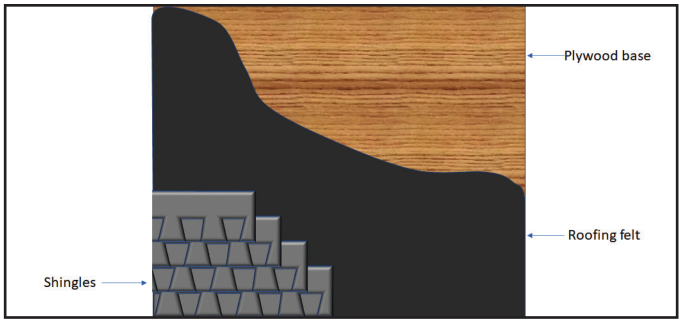


Figure 8
Example of a shingle and underlayment configuration.

location of the structure, material's location and purpose within the roof system, and other local or environmental considerations.

Shingles are typically attached to a roof substructure by galvanized steel nails, with 1¼ in. being one of the more common sizes. Again, the size and type of nail may vary by manufacturer and other considerations. However, the nailing process is an important factor in the performance and life expectancy of the shingles. Some of the more common issues associated with the nailing of shingles are:

- *Over-driven nails* — A nail is over-driven when it is hit too hard and is driven too far into or even through the shingle. The obvious issue in this situation is that it leaves a gap around the nail where water can now migrate through.

- *Using the correct number of nails per shingle* — Depending on the manufacturer and the climate the roof will be in, there is a specified number of nails that should be used. This can range from about four to six nails per shingle, with more nails being required in areas that experience higher wind loads.

- *Incorrect nail placement* — Not only do manufacturers specify the number of nails that should be used, but they also have specific locations designated on their shingles for placing these nails. Usually, there is some type of marking on the shingle that highlights this location. **Figure 9** is an example of a laminate shingle where the manufacturer used white lines to indicate the boundaries in which the nails should be placed. Typically, this marked nail strip location is also where all the layers of the shingle merge. Therefore, nails that are errantly placed above the top line or below the bottom line may result in lower shingle performance, as they are subject to tearing or the nails being over-driven.

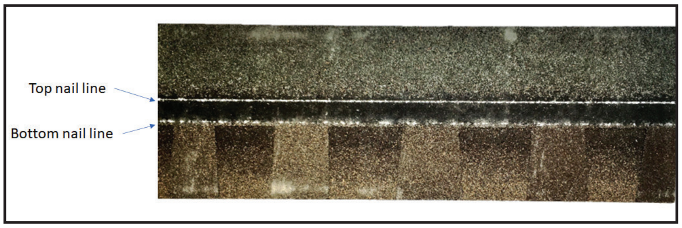


Figure 9
Nail location for a typical laminate asphalt-composite shingle.

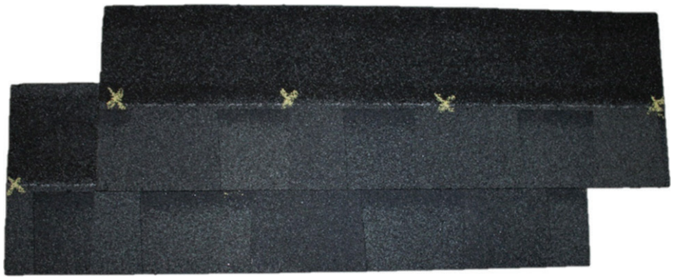


Figure 10
Typical shingle overlap, indicating the nail placement.

Due to how shingles are overlaid on top of each other during installation, individual shingles will also have a second set of nails that is above the nail strip of the underlying shingle. An example highlighting this is demonstrated in **Figure 10**. Here the "x"s on the top shingle mark nail locations within the shingle's nailing strip. These nails will also penetrate the top portion of the underlying shingle, thereby enhancing the overall strength of the shingle matrix.

Review of Historical Methods Used to Determine Repairability

In order to decide if a repair is even possible, the first challenge of a repair/replace decision is to establish the condition of the remaining or existing shingles. Asphalt-composition shingles typically have their greatest flexibility when they are new and ready to be applied to a roof surface. Over time, the asphalt within the shingles age and degrade, resulting in the individual shingles becoming less flexible. In addition, the seal strips located along the lower edges of the shingles also tend to weaken over time (**Figure 11**). As mentioned at the beginning of this paper, the natural aging of the shingles increases the potential for additional damage during repair or maintenance activities. The challenge then becomes determining whether the roof must be completely replaced or if it is possible to repair only the damaged areas.

The roofing industry has relied on a number of different methods to determine asphalt-composition shingle

Figure 11
Typical seal strip location on the back side of a laminate asphalt-composite shingle.

condition. However, these historical investigative methods are subjective and lack a consistent method for guiding repair versus replacement determinations. This inconsistency leads to improper roof repairs, failed repairs, repairs that potentially further compromise the roofing system, or the need for future repairs resulting from the damage created by the original repair itself.

One of the more common methods employed examines the pliability or brittleness of the existing shingles. Known colloquially as the "brittle test," this involves the evaluator observing and documenting the ability of the existing shingle to bend with or without further damage (e.g., cracking or breaking). Another method evaluates the cost benefits of repair versus replacement. (e.g., the "DURA" formula). Finally, other methods may use mathematical calculations, models, or even internal company-based policies or methods. Some of these techniques are described in further detail below. Upon review, it is easy to see the challenges these methods present when using them to make reliable and repeatable repair determinations.

Brittle Test Method

The "brittle test" was originally developed as a method for determining whether three-tab shingles had enough flexibility to allow for replacement and repair without cracking or breaking. There is no known or industry-accepted standard for how the "brittle test" should be conducted. As such, it is subject to variation, depending on the personnel conducting the assessment.

In general, the brittle test begins with the unsealing of the seal strip along the lower edge of a shingle tab. The shingle tab is then lifted to an angle between 45 degrees or 90 degrees, relative to the roof deck. In some cases, this lifting of the tab is repeated several cycles. Failure is commonly identified by the displacement of granules where the tab creases, cracks, or breaks.

Aside from the lack of a standardized industry protocol for executing this test method, other complaints include its expanded use on laminate-style asphalt-composition shingles for which it was not intended and its evaluation of only the shingle bending and not the entire repair process.

Economic Feasibility Method

The economic feasibility of repairing shingles versus replacing roof slopes has historically been determined using mathematical equations and/or models. In these types of assessments, the cost of repairs is factored in as part of the repairability consideration. One of the most common variants of this method is the "repair cost formula" presented in the "Protocol for Assessment of Hail Damaged Roofing" paper by Tim Marshall and Richard Herzog[2]. Commonly referred to as the "DURA" equation, this method attempts to estimate the potential cost of a repair by multiplying a unit price variable to an area of existing shingle damage and then applying a weighting factor. The equation is:

$RC = D \times U \times R \times A$ where:

RC = The cost to repair the entire slope (in dollars)

D = The number of damaged shingles or shakes per roofing square

U = The unit cost to repair a shingle or shake (in dollars)

R = The repair difficulty factor

A = The actual area of the slope (in roofing squares)

Note: A "roofing square" is equal to 100 square feet.

The weighting factor (R) is an attempt to quantify how difficult a roofing repair would be to implement. Marshall and Herzog provide the following guidance in selecting a value for "R":

> "The repair difficulty factor is based on the age and condition of the roofing and is assigned values ranging from 1 to 2. Roof coverings in good, fair, or poor condition can be assigned repair difficulty factors 1, 1.5, and 2, respectively, which effectively adjusts the unit cost of repair. The repair difficulty factor considers that roof coverings become brittle with age and are broken more easily during the repair process; therefore, difficulty factors of 1.5 or 2 account for the additional breakage that may occur or extra care needed in the repair process. The repair difficulty factor is a subjective determination based on the inspector's experience in assessing and/or repairing roofs."

By including this variable in the calculation, it provides evaluators with a means to adjust the cost based on the potential ease or difficulty a repair might entail. However, the variable is somewhat subjective and open to interpretation by the evaluator. A lack of specific parameters to determine what values should be used for R has led to disagreements about the validity of the formula in evaluating a roof repair. In addition, there is a lack of consensus in the industry as to whether the maximum value of 2 for R can provide a sufficient enough weighting factor to capture extremely challenging or deteriorated conditions. Finally, the value for "D" is calculated based on a roofing section selected by the evaluator. While Marshall and Herzog provide guidance on how these areas should be selected, it is still up to the evaluator on what part of the roof they choose to use for this part of the calculation. So, while the DURA formula attempts to inject a quantitative means to measure a roofing condition, it still is affected by subjectivity and individual interpretations.

Shingle Age Method

Another common approach for determining the repairability of asphalt-composition shingles is based on the "age" of the shingles (i.e., the length of time since their original installation). The assumption is that an older shingle will be more difficult to repair due to its deterioration and fragility.

As with the brittle test, this method also lacks standardized protocols. In this situation, however, there is no consistent means to identify at what age a shingle can or should no longer be repaired. Additionally, this method makes the erroneous assumption that younger shingles are less susceptible to damage. While this may be true for the shingle material itself, the problem is that the sealant on the backside of the shingle (**Figure 11**) that secures the top shingle to the one beneath it is quite robust on newer shingles. Therefore, when shingles are "unsealed" or pried apart during a repair, this bonded strength can override the latent strength of the shingle material, resulting in tears and chipping. This can exacerbate damage to the roof's shingles as repair actions propagate new damage on adjacent shingles during the process.

Repairability Assessment Method

To address the concerns and limitations presented with other assessment methods, it is necessary to develop a protocol that reduces the subjectivity inherent in those methods. While subjectivity will always be a factor when humans are required to exercise any sort of evaluation, there are ways to minimize its overall impact on the final results. The repairability assessment method was developed to help reduce this subjectivity by expanding the scope of the assessment to include the evaluation of repair actions.

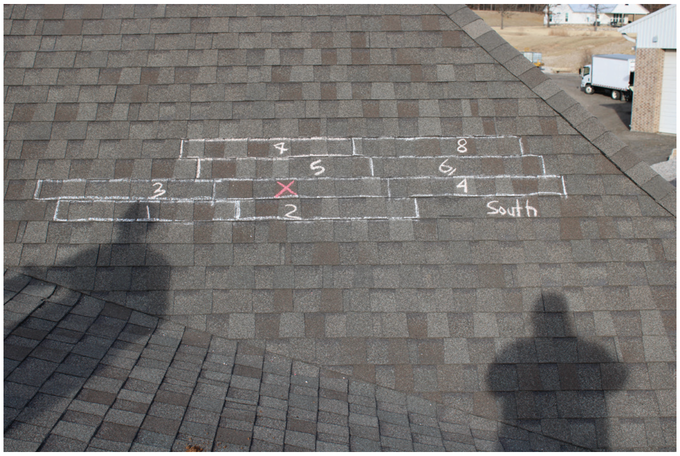


Figure 12
Outline of the primary damage assessment area.

As discussed previously, the removal and replacement of an asphalt-composition shingle has the potential to directly damage the surrounding shingles. For example, in **Figure 12**, the shingle marked with an "X" represents a single damaged shingle. In order to remove and replace this shingle, approximately eight other shingles surrounding this one would be impacted.

- The sealant on the bottom of the damaged shingle, "X," is adhering to the top surfaces of shingles 1 and 2. Therefore, there is potential to damage shingles 1 and 2 as the sealant is pried open in order to loosen the bottom edge of the damaged shingle.
- Conversely, the same thing exists for shingles 5 and 6, except in this case the sealant strip on the bottom edges of these shingles is bound to the top surface of shingle "X." Again, there is potential to damage these shingles when prying the sealant loose.
- Because of the nailing pattern previously discussed (**Figure 10**), the underlying shingles, 1 and 2, would be subjected to additional damage during the nail removal process. In these cases, the nail often strips through the shingle material, leaving tears and unsealed holes.
- The nails placed in the nail strip area of shingles of 5 and 6 also go through shingle "X" and therefore also require removal. Again, there is potential for damaging these shingles when removing these nails.
- In order to access the nailing strips of shingles 5 and 6, the bottom sealed edges of shingles 7 and 8 must also be pried loose.

- Finally, shingles 3 and 4 are also susceptible to damage, resulting from the unsealing of the seal strips for shingles 5 and 6 above.

This example highlights the potential cascading repair effects and why it is important to take into consideration the possible damage that might be imparted upon these adjacent shingles during the repair. The repairability assessment method offers a means by which these outlying shingles are integrated into the evaluation. By taking into consideration the amount and type of damage caused to these surrounding shingles, the evaluator is able to get a measurable sense of the impact the repair process may have on the overall roof's surface. One note of caution, however. The repairability assessment is intended to supplement a damage assessment of these surfaces and is not to be used in place of a conventional damage evaluation. Only by conducting a damage assessment will the evaluator be able to confirm existence of actual wind, hail, or other damage to the roof surface to know if a repair assessment is necessary.

It is important to note that because of construction inconsistencies during the initial installation of the original shingles, there may, in fact, be damage that extends beyond the eight shingles used in this example. Therefore, while not specifically part of the repairability assessment process, the condition of the shingles around the assessment area or areas of recent repairs should also be visually evaluated and documented.

Repairability Assessment Procedures

The following sections provide details on conducting a repairability assessment. While the emphasis of the discussions primarily focuses on the technical aspects of conducting the assessment, practical considerations are offered as well to provide additional context when appropriate.

Initiating the Assessment

There are eight shingles that constitute the primary damage assessment area and form the basis of the repairability assessment (**Figure 12**). These shingles are specifically selected to capture the potential impact of repair actions. As outlined in the previous section, each of these eight shingles must be disturbed in order to remove a damaged shingle.

Since the repairability assessment is designed to simulate the conditions that would occur during the repair process, the location of the test area should be established on a section of the roof that is most representative of where the repairs are to be performed. In addition, as this assessment involves the removal and replacement of individual shingles, it should be obvious that this may potentially undermine the existing integrity of the roof in that area. Therefore, the evaluator should first obtain the approval of the building owner prior to conducting the assessment and have the ability and materials available to complete a larger repair — or, if necessary, have the means to temporarily tarp the roof.

The repairability assessment method should be performed in the months when normal roofing construction activities are usually conducted, such as late spring, summer, and early fall. Performing a repairability assessment "off season" risks providing an inaccurate perspective of the shingle's ability to withstand repair actions. For example, shingles tested during the cold weather may prove to be more fragile than if the same assessment was conducted during warmer months when the repair might actually be performed. However, there are situations that may occur that drive such an assessment to be performed off season. In these cases, the assessment should be conducted under conditions that mirror the potential repair activity.

Roles and Responsibilities of Repairability Assessment Personnel

The repairability assessment typically requires the minimum participation of two personnel. It includes a licensed and insured roofing contractor (per state requirements as applicable) to remove and replace the individual shingles in a careful and workmanlike manner and an independent and knowledgeable evaluator, such as a qualified forensic engineer (licensed in the state in which the building is located). The roofing contractor selected to assist with the repairability assessment should be independent and not under contract for the repair or replacement of the shingle roof surfaces if possible.

Repairability Assessment Weather Conditions

As previously mentioned, removal and replacement of asphalt-composition shingles are ideally undertaken in environmental conditions that allow the shingle to flex without damage during the assessment and subsequent repair. Therefore, air temperatures should be between 40ºF and 90ºF. While the lower temperatures are not ideal when performing a repairability assessment, the 40-degree lower threshold is based on the minimum temperatures commonly present in manufacturer installation instructions. During periods of cooler weather, it is recommended that the shingles to be used for the assessment are on roof slopes that have been exposed directly to sunlight for at least two hours.

The 90ºF upper limit is also based on manufacturer recommendations regarding the maximum temperature for installing asphalt-composition shingles. This higher threshold is due to the potential for marring of the shingles. As shingles soften with the increase in temperature, they become more susceptible to scratches, dents, or the sliding or moving of granules on the shingles' surface. This type of damage can happen when the roof is walked upon or tools/other equipment are placed on the softened shingles. Evaluators should take care during these higher temperatures to avoid further damaging the roof beyond what is necessary as part of the repairability assessment.

For safety of the evaluators — and to minimize unnecessary damage to the roof and shingles — the following additional weather considerations should be followed:

1. Conduct assessments during weather without an immediate forecast of precipitation. This is done in order to avoid slippery conditions and the potential to expose the roofing underlayment to rain during the assessment.

2. Ensure that the roof surfaces are dry at the time of the assessment. Again, this is to protect the evaluator and any other personnel from slippery conditions and potential falls.

3. Wind gusts should be less than 25 miles per hour. This is a typical safety measure taken by industry roofers and personnel working on exposed, elevated surfaces.

Repairability Assessment Shingle Selection Criteria

When conducting a repairability assessment, it is important to select an appropriately representative area for laying out the primary damage assessment area. This area should be centered away from edges and protuberances as much as possible, located in an area of the roof that is safe to access, and minimize the impact on the outlying shingles (e.g., walking, ladder marks, unnecessary tool marks, etc.). The subject shingle for the repairability assessment, marked as an "X" in **Figure 11**, should meet the following criteria:

1. It should be of full length and uncut.

2. Be at least two rows above any eaves.

3. Be at least a full shingle length from any rakes or hips.

4. Be at least a full shingle length away from valleys.

5. It must not contain any vents, structural irregularities, or other roof appurtenances within the primary damage assessment area.

6. It should be in an area that is representative of the overall roof (i.e., not sheltered by trees, other roof surfaces, or building elements that would alter the natural weathering of the roof surfaces).

When possible, the repairability assessment should be performed on shingles where wind and/or hail damage has already been identified. In cases where it is not possible to utilize storm damaged shingles, the testing should be performed on the slopes where damage has been identified. If the roof surfaces include shingles of different types, styles, manufacturers, or dates of manufacture or installation, it will be necessary to perform a repairability assessment for each type of damaged shingle.

Protocol for Conducting the Repairability Assessment

Once the location of the primary damage assessment area has been identified, the following steps outline the process to be undertaken when conducting the repairability assessment. **Figure 13** provides an expanded shingle layout of the primary damage assessment area. In this graphic, the shingles are drawn unlayered to aid in identifying the specific shingles used in this process.

1. The first step is to mark the subject assessment shingle. This is the individual shingle to be removed and replaced as part of the repairability assessment. **Figure 12** has denoted this shingle with an "X" and pink outline. In some cases, more than one shingle can be used, depending on the area required to perform the assessment. However, for clarity, the steps and process provided below will use the layout described above.

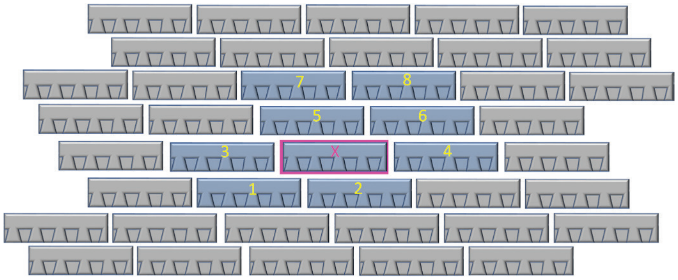


Figure 13
Expanded, unlayered perspective of the shingles to be used in the primary damage assessment area.

2. Mark and number the other eight perimeter shingles used in the primary damage assessment area following the location and numbering sequence provided in **Figure 13**. For clarity, the markings for shingle X should be distinctive from the other eight perimeter shingles. For example, in **Figure 13**, shingle X is marked using pink while the perimeter shingles are numbered in yellow. The specific choice of colors is not important. The only imperative is that the colors and markings must be distinguishable from one another in photographs and video. Once the markings and outlines are complete, digital images of the entire primary damage assessment area should be taken.

3. Any preexisting damage to the asphalt-composition shingles in the primary damage assessment area should be marked and documented with digital images. While the method for marking or highlighting damage can vary from one evaluator to another, it is important to provide a legend or reference that explains the markings used for that particular investigation. Additionally, since the existing damage should be easily distinguishable from the damage caused during the assessment, it is wise to select distinguishing colors for each type of damage (e.g., pre-assessment versus post-assessment damage).

4. Use a flat pry bar, crowbar, “five-in-one” painter tool (or similar) to gently pry open the seal strips securing shingle X in order to access its nails or fasteners. Document any damage (e.g., splits. cracks, tears, etc.) to the eight-perimeter shingles resulting from this action. Also document the condition of the seal strips as well as the condition of the shingles and fasteners where the shingles have pulled past the original nail head or shaft.

5. Again, using a flat pry bar (or similar tool), remove the nails, securing both the middle of shingle X as well as the nails in the middle of shingles 5 and 6 that are also penetrating through the top of shingle X (i.e., the mid nails on the far right of shingle 6 will not need to be removed since they do not penetrate through shingle X). Once both rows of nails securing shingle X have been removed, shingle X can then be removed.

6. Visually assess the condition of all the shingles within the primary damage assessment area for damage. Any shingle that sustained damage as part of the removal actions of shingle X must be appropriately marked. The shingle on which the damage occurred will then have the number stricken through for tracking purposes. It is important to note that preexisting damage to the shingles that was annotated and marked as part of Step 3 above is excluded; only the additional damage sustained during the repairability assessment determines if the shingle’s number is crossed out.

7. While shingle X is removed, visually assess the exposed underlayment (e.g., roofing felt, moisture barrier, etc.) for indications of damage resulting from the removal process. Document and record any findings.

8. A new asphalt-composition shingle (compliant with the manufacturer’s instructions) should then be inserted and secured. The new shingle X will first require a series of nails in the manufacturer specified nail strip. Next, shingles 5 and 6 will need to be secured with nails in their nail strip area as well. The nails from this action should also penetrate through the top portion of the new shingle X. In addition, it will likely be necessary to supplement the now weakened seal strips on all the disturbed shingles with additional adhesives. Follow the guidance and instructions of the shingle manufacturer when applying these adhesives. Finally, ensure all surfaces are properly and adequately re-secured.

9. Any additional damage that occurs during the installation of the new asphalt-composition shingle and the placement of the fasteners should be documented. Again, as noted in step 6 above, if a shingle sustains damage during this process, cross out the shingle number for tracking purposes. If it was already crossed out, then no additional action is required.

10. Of the eight perimeter shingles, count the number of shingles where the number was stricken through or crossed out. This is the total number of shingles that were damaged as a result of the removal and replacement process.

Damage to shingles is reported on a “per shingle” basis, regardless of the types of damage present or the number of times that specific type of damage occurs. The

Figure 14
View of a narrow tear along the bottom edge of an asphalt-composition shingle.

Figure 15
View of a tear along the bottom edge of an asphalt-composition shingle.

Figure 16
Shingle pulled past the nail head during the repairability assessment.

subject assessment shingle (i.e., shingle "X") is already considered to be damaged. Therefore, any additional damage to this shingle from the assessment process is excluded from the assessment count. An evaluator may find damage to the subject assessment shingle resulting from the repairability assessment noteworthy. In these cases, the damage may be documented and reported; however, this damage will not alter the resulting damage calculations.

As part of the damage assessment process, the evaluator may deem it necessary to remove a shingle for identification purposes. The subject assessment shingle removed as part of the repairability assessment may be retained or otherwise documented to assist with separate identification processes.

Reporting Repairability Assessment Findings

Damage to the asphalt-composition shingles within the primary damage assessment area resulting from the repairability assessment process is reported as follows:

1. The damage rate provides a single-digit, whole number that represents the number of shingles damaged in the assessment. This value will be from 0 to 8.

2. The damage ratio is the damage rate divided by the total number of shingles used in the primary damage assessment area (not including the subject assessment shingle). For example, the damage ratio would be presented as "1 to 8" for a situation — where one shingle was damaged during repairability assessment and eight shingles were located within the primary damage assessment area.

Common Types of Damage to Asphalt-Composition Shingles

The potential for damage to the shingles within the primary damage assessment area is usually associated with the necessary breaking of the seal strips and the removal/replacement of fasteners. Damage will commonly present as tears, gouges, holes, or chipping. In some cases, the sealant will strip away the underlying shingle's granules and asphalt binder, leaving the fiberglass mat exposed.

The following list outlines a variety of types of damage often seen as part of a repairability assessment. It is not an exhaustive list, and other types of damage may be seen.

1. Tearing or cracking of the asphalt-composition shingles (**Figures 14** and **15**).

2. Pulling of a shingle past the nail head or fastener resulting in a hole or tear. (**Figure 16**).

3. Hinging or fracturing of the granule surface. In some cases, the fracture may extend into or through the asphalt binder or fiberglass mat.

4. The displacement or stripping of granules and binder, resulting in exposed fiberglass mat of either the overlying or underlying shingle (**Figures 17** and **18**).

5. The chipping of a shingle as pieces of it remain bonded to the surface of an underlying or overlying shingle (**Figure 19**).

6. Impact damage to the lower edges or sides of shingles resulting from the placement of the new nails. Since the shingle no longer has the flexibility to be lifted out of the way in order to have the new nails inserted, the hammer cannot get the clearance it needs to set the nails. The supporting roofing contractor should take extra care in these situations to limit the potential for this type of damage while replacing the test subject's assessment shingle.

7. Laminate-style shingles may also experience delamination between the top cut sheet and the lower continual sheet. This separation of sheets on a multi-sheet shingle should also be noted on a repairability assessment as either preexisting damage or damage resulting from the assessment process.

Repairability Assessment Findings and Damage Propagation

A roof surface is considered to be repairable when individual damaged shingles can be removed and replaced without causing additional damage to the surrounding shingles. However, when adjacent shingles are weakened or unable to maintain their integrity during the repair action, it is likely that any subsequent repairs to fix these newly damaged shingles will result in a continued propagation of damage. **Figure 20** shows an 8-ft by 8-ft demonstration area that underscores this repair issue.

Figure 17
Transfer and accumulation of asphalt from the overlying shingle.

Figure 19
Shingles torn, and sections remained bonded to the underlying shingle.

Figure 18
Displaced sections of granules at the lower seal strip. In this case, the granules and binder asphalts were transferred to the overlying shingle.

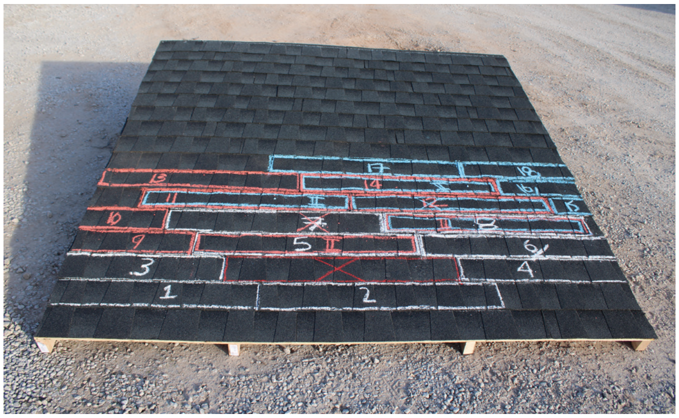


Figure 20
Initial area of influence located within a demonstration roof section.

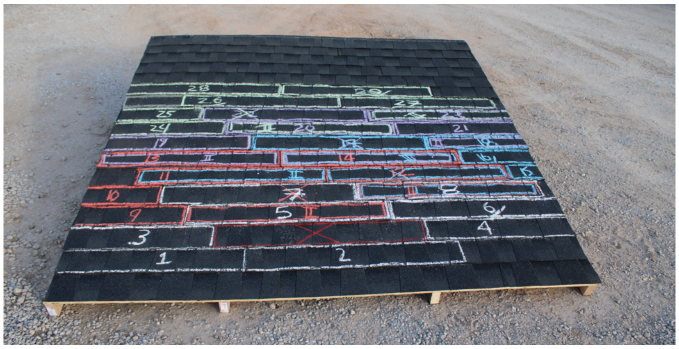


Figure 21
Fifth iteration highlighted with green chalk.

In this example, the shingle marked with a red "X" demonstrates a shingle undergoing a repair by replacement, and the shingles outlined in white represent the area of influence for this repair. In this case, assume that shingle 7 was damaged during the repair process. The damage rate would be "1," and the damage ratio would be "1 to 8." While a 1 to 8 damage ratio sounds nominal, it has the potential to cascade. Since shingle 7 was damaged during the repair process of shingle X, it must now also be replaced. Thus, the repair process must now be repeated and moves into its second iteration.

This iterative repair process will continue to potentially damage additional shingles with each follow-on repair. Continuing with the 1 to 8 damage ratio, **Figure 21** shows an enlarging area of influence after five iterations of repair. The colors indicating the specific iterations are as follows:

1) Iteration 1 – White
2) Iteration 2 – Orange
3) Iteration 3 – Blue
4) Iteration 4 – Purple
5) Iteration 5 – Green

At the completion of the fifth repair iteration, 29 shingles have been disturbed, and five additional shingles have been damaged. Additionally, several times throughout these series of repairs, certain shingles were disturbed two or more times, resulting in a higher potential of damage to those shingles.

Additional Factors Limiting the Repairability of Asphalt-Composition Shingles

Aside from the ability to adequately conduct a repair, there are other considerations that need to be taken into account when deciding if a roof can be repaired. While these factors may or may not affect the performance of the repair, they are, nonetheless, important aspects that can ultimately impact an evaluator's repairability decision.

- *Material obsolescence* — Manufacturers must continue to make changes to their shingle inventory. These types of changes include altering shingles' sizes and shapes. Older roofs, therefore, may have shingles that are no longer being manufactured and thus can no longer be replaced in kind.

- *Visual incompatibility* — In these cases, the roofing color or style can no longer be matched. For example, a faded roof with new shingle patches will likely have a color mismatch and be aesthetically undesirable.

- *Manufacturing defects* — Over the years, there have been a number of recalls on asphalt-composition shingles. Typical problems include, but are not limited to, premature cracking, curling, loss of granule, failed seal strips, and thermal splitting. The reason for the failures can stem from a number of causes; substandard source material, improper construction, or logistics and storage issues.

- *Installation errors* — Typically, these types of errors include not following manufacturer's installation recommendations, not applying proper underlayment materials or techniques, not using the correct type or number of fasteners, not placing fasteners in the correct area of the shingle, etc.

- *History of previous repairs* — Previous repairs can be an indication of an underlying problem, or because of improper actions or materials be a source of water incursion.

- *Deterioration related to age or materials* (e.g., deterioration of the asphalt binder) — Weather, sunlight, shade, and trees can accelerate the deterioration of the shingles and shorten their lifespan.

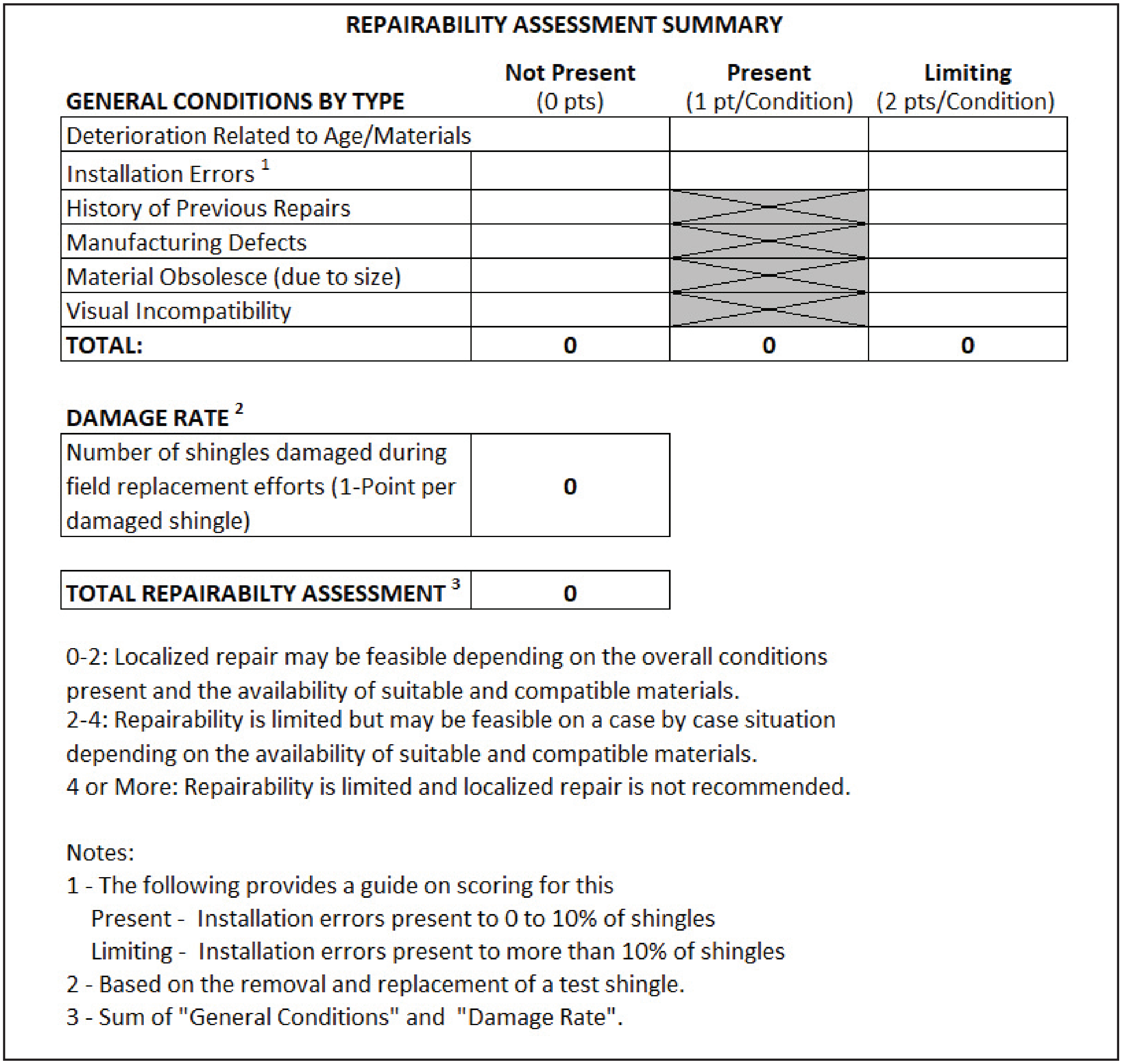
- *The presence of roof vents, turbines, solar panels, or other devices* — These types of appurtenances have the potential to undermine the shingle system by permitting water incursion through poorly formed flanges or seals.

- Code or manufacturer installation requirements may have changed, or there may be defects found in the roof decking, ventilation, etc. (e.g., existing roof decking may not be acceptable for the installation of new shingles). This most commonly occurs for plank decking.

While beyond the scope of this paper, these considerations and others may be relevant in the broader determination of the repairability of asphalt-composition shingles. The licensed professional engineer responsible for making the recommendations will need to consider such additional factors in concert with the results of the repairability assessment.

Determining a Repairability Assessment Score

The decision to repair or replace asphalt-compositions shingles using the repairability assessment method is based on the conditions of the roof as observed during the damage assessment survey, and the damage rate resulting from the repairability assessment. **Figure 22** provides a guide for calculating the total repairability assessment score. In the



REPAIRABILITY ASSESSMENT SUMMARY

GENERAL CONDITIONS BY TYPE	**Not Present** (0 pts)	**Present** (1 pt/Condition)	**Limiting** (2 pts/Condition)
Deterioration Related to Age/Materials			
Installation Errors [1]			
History of Previous Repairs		☒	
Manufacturing Defects		☒	
Material Obsolesce (due to size)		☒	
Visual Incompatibility		☒	
TOTAL:	**0**	**0**	**0**

DAMAGE RATE [2]

Number of shingles damaged during field replacement efforts (1-Point per damaged shingle)	**0**

TOTAL REPAIRABILTY ASSESSMENT [3]	**0**

0-2: Localized repair may be feasible depending on the overall conditions present and the availability of suitable and compatible materials.
2-4: Repairability is limited but may be feasible on a case by case situation depending on the availability of suitable and compatible materials.
4 or More: Repairability is limited and localized repair is not recommended.

Notes:
1 - The following provides a guide on scoring for this
Present - Installation errors present to 0 to 10% of shingles
Limiting - Installation errors present to more than 10% of shingles
2 - Based on the removal and replacement of a test shingle.
3 - Sum of "General Conditions" and "Damage Rate".

Figure 22
Repairability assessment calculation guide.

top portion of the guide, the evaluator will enter the roof's condition data. This data comes from the evaluator's visual inspection of the roofing surface and shingles. For this part of the calculation the evaluator will identify the appropriate category for each condition. It is divided into three damage categories: not present, present, and limiting. If a condition is not present, a "0" (zero) will be entered into the field. Only the deterioration and installation conditions offer the option for the evaluator to assess the condition as being "present." Finally, for conditions being assessed as a damage category of "limited," the evaluator will place a "2" in the corresponding field. These values are then totaled and added to the repairability assessment's damage rate.

Total repairability assessment values between 0 and 2 indicate that local repairs may be feasible, keeping in mind the potential for repair damage propagation. Total values falling between 2 and 4 may be possible on a case by case basis, depending on the availability of suitable and compatible materials. Total values of 4 and higher indicate that the ability to repair the roof is limited, and a localized repair is not recommended.

Conclusion

Historically, methods used to evaluate whether localized shingle repairs can be successfully and adequately performed have been done using a variety of approaches that rely on inconsistent and subjective analysis. This paper offers an alternative approach: the repairability assessment method.

It provides an improved process for analyzing whether an asphalt-composition shingle roof can be effectively repaired by taking into consideration the possible impacts the repair actions will have on the surrounding shingles. Evaluators using this method are able to track and report any damage as a total repairability assessment score that is based on the condition of the roof and shingle and repairability damage rate. Together, these values provide a quantitative and repeatable means to measure the potential for shingle damage to be propagated as a result of the repair process. While no processes that depend on human intervention or observations are infallible, when compared to other historical methods used to determine whether an asphalt-composition shingle roof is repairable or not, the repairability assessment method offers the most comprehensive physical assessment method to date.

Definitions

Area of influence — shingles requiring repair and their immediate, adjacent shingles.

Damage rate — the number of shingles damaged during a repairability assessment in the primary damage assessment area. The value will be 0 to 8.

Damage ratio — the damage rate divided by 8 (the total number of shingles evaluated for damage in the primary damage assessment area). It is reported as "(damage rate) to 8."

Evaluator — Licensed professional engineer conducting the repairability assessment.

Primary damage assessment area — The nine shingles used in a repairability assessment.

Subject assessment shingle — The shingle that will be replaced as part of the repairability assessment and is the center most shingle in the primary damage assessment area.

References

1. Aon, "Weather, Climate & Catastrophe Insight: 2019 Annual Report", p 27, 2020.

2. T. P. Marshall and R. F. Herzog, "Protocol for Assessment of Hail-Damaged Roofing," Proceedings of the North America Conference on Roofing Technology, p 40-46, 1999.