Assessing Wind Damage To Asphalt Roof Shingles

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ABSTRACT

Distress to asphalt roof shingles due to high wind events, beyond obvious physical dislocation, might not be evident and is often overlooked, improperly evaluated and/or is a source of debate among insurance adjusters, roofing contractors, building inspectors, and design professionals.

This paper presents an overview of asphalt roof shingles including material composition, style, grade, and installation, and their impact on wind resistance. A practical non-destructive method for identifying, quantifying, and categorizing wind distress is presented. Distress not related to wind is briefly considered including installation deficiencies and manufacturing defects. Recommendations for repairing or replacing a damaged roof are also discussed, considering material properties and type and extent of distress.

Finally, this paper highlights the role of the builder and/or design professional regarding the proper specification and application of shingles based on the geographical region and climate in which they are installed. Regulation which correlates with existing guidelines needs to be specified and enforced.

BACKGROUND

The apparent recent increase of tornado and hurricane activity impacting U.S. territories, including densely populated areas, has augmented the need for accurate and thorough assessment of wind damage to residential structures. The roof covering is one of the primary building envelope components in residential construction to suffer damages related to high winds.

In the authors' experience, evaluation methods for wind damage to asphalt shingle roofs vary widely among insurance adjusters, roofing contractors, building inspectors, and design professionals. Often, evaluator opinions of wind damage to asphalt roof shingles on a given roof can range from minor or no damage to significant damage that requires a complete roof replacement. Therefore, standard methods for identifying and quantifying wind distress beyond a qualitative analysis are needed.

Asphalt shingle is the preferred roof covering in residential structures in most parts of the country including areas subjected to high winds. Based on the authors' experience, roofing and re-roofing projects in some of these regions incorporate inappropriate shingle grades and/or improper shingle installation methods. In the authors' opinion construction and design industries must self regulate to ensure that building code mandates are enforced in roof structures with asphalt shingles.

ASPHALT ROOF SHINGLES – GENERAL DISCUSSION

The shingle material properties, grade, style, installation method and quality, and wind rating influence its wind resistance and plays an important role in the assessment of wind related damage.

Materials. Asphalt shingles consist of a reinforcing mat (fiberglass or organic based) with top and bottom asphalt coatings, and a top surface layer of coarse mineral granules. The mineral granules protect the asphalt from ultraviolet rays and weathering, increase the external fire resistance, add weight, and provide a variety of aesthetic appearances to the shingles (NRCA 2006).

Asphalt shingles contain heat sensitive, self-sealing adhesive strips that secure the leading edge of the shingle to the shingle underneath, resulting in increased wind resistance (NRCA 2006). If installation occurs during the winter, self-sealing may not occur until the following spring. For winter installation, a process referred to as "hand sealing" or "hand tabbing" may be performed as discussed later in this paper.

Grade. Shingle weights and dimensions vary by manufacturer. Generally, higher grade shingles have greater asphalt content and are heavier, last longer, and have an improved aesthetic appearance. Higher grade shingles also have higher wind ratings.

Style. The two most common styles of asphalt shingles are strip shingles and laminated shingles. Strip shingles, commonly referred to as "3-tab" shingles, consist of one laminate layer with interior keys that divide the lower half section of the shingle into three tabs. Standard size shingles are generally 12" x 36" in length with a typical 5" exposure. Laminated shingles, commonly referred to as "dimensional" or "architectural" shingles, have additional laminate layers and do not contain interior keys. **Figures 1a** and **1b** provide a representative depiction of each shingle style.

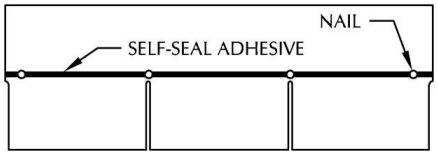


Figure 1a. 3-Tab Shingle

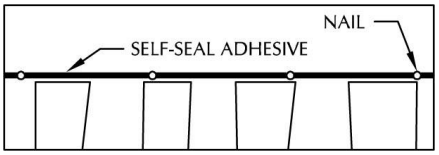


Figure 1b. Laminated Shingle

Installation. The National Roofing Contractors Association *Roofing and Waterproofing Manual* (NRCA) is considered the industry standard for the specification and installation of asphalt shingles. NRCA recommends a minimum roof slope of 2:12 (2" rise on a 12" horizontal projection) for shingle application. Most shingle roofs typically have slopes between 4:12 and 8:12. Applications on roofs with slopes between 2:12 and 4:12, and greater than 20:12 (i.e. mansard application), require special installation requirements including the use of special underlayment, flashing, and/or additional fasteners.

NRCA recommends using nails for the application of asphalt shingles to wood based decking. Shingles can also be fastened with staples. Although staples are not prohibited by manufacturers or building codes, based on the authors' experience, the use of staples is often prone to installation deficiencies. Asphalt shingles should have the minimum number of fasteners required by the manufacturer and applicable building codes. Some manufacturers increase the wind rating of shingles with increased number of fasteners. The current International Residential Code (ICC 2006) requires that asphalt shingles be secured with at least four fasteners per strip shingle; however, additional fasteners and/or special methods of fastening are required under certain circumstances.

Manufacturer's Wind Rating. It is important to install only shingles that have a wind capacity equal to or higher than the design wind speeds for the roof structure. Standard grade 3-tab shingles have a typical manufacturer wind rating of 60 mph. Higher-grade 3-tab shingles have manufacturer wind ratings up to 80 mph. Standard grade laminated shingles have manufacturer wind ratings between 70 and 80 mph. High grade laminated shingles have manufacturer wind ratings of up to 110 mph. As described in the next section, the manufacturer's wind ratings do not correlate to basic design wind speeds as described in the International Residential Code (IRC), but are rather based on a standardized American Society for Testing and Materials (ASTM) test procedure.

STANDARIZED ASPHALT SHINGLE WIND TESTING

Available standardized tests for shingle wind resistance focus on design and/or rating requirements, not on field performance or condition assessment. The International Building Code (IBC) requires that asphalt shingles be tested in accordance with ASTM D3161 *Standard Test Method for Wind-Resistance of Asphalt Shingles (Fan-Induced Method)* (ASTM 2003). This test classifies shingles into three classes. Class A shingles pass the test at a velocity of 60 mph, Class D shingles pass the test at a

velocity of 90 mph, and Class F shingles pass the test at a velocity of 110 mph.

According to the ASTM D3161 test procedure, the test results do not correlate directly to wind speeds experienced in service and intrinsically do not correlate to the 3-second basic design wind speeds (the testing lasts for 2 hours or until such lesser time as a failure occurs).

SHINGLE WIND RATING - BUILDING CODE REQUIREMENTS

Presently, the IBC and IRC provide wind resistance code requirements for roofing assemblies and roof coverings. In the authors' experience, some of the code requirements for asphalt shingles are not well defined and can lead to the specification of underperforming shingles in certain areas of the country.

For roofing assemblies the codes reference *ASCE 7 Minimum Design Loads for Buildings and Other Structures* (ASCE 2005). In practice, the degree of wind shingle distress correlates closely with higher wind pressures as calculated by ASCE 7, namely higher distress at the ridges and corners of roofs.

In regards to wind resistance of asphalt shingles, the IRC states that shingles meeting ASTM D3161 are acceptable for use in wind zones less than 110 mph (3-second). However, no shingle classification as per ASTM D3161 (i.e. Class A, Class D, Class F) is specified. The code does require Class F shingles for areas where the basic wind speed is 110 mph or higher and where special fastening is required.

In the author's experience, Class A shingles, including most 3-tab shingles, under-perform in wind zones with basic wind speeds over 90 mph (3-second). Yet, 3-tab shingles are readily seen in residential construction in most of the east coast where basic wind speeds are in excess of 110 mph (3-second) and where yearly tropical storms and hurricanes result in the dislocation of such shingles. In the authors' opinion, there is either a lack of compliance or lack of proper regulations and enforcement from local authorities to require a shingle with an appropriate wind rating.

Based on the authors' experience of underperforming Class A shingles in wind zones above 90 mph (3-second) and due to the lack of shingle class specification in the IRC for wind zones below 110 mph (3-second), the authors propose the following guideline which is in agreement with regulations by the Florida Building Code Residential (FBCR):

> *ASTM D3161 Class D shingles (90 mph) should be used on wind zone regions of 100 mph (3-second) or less. ASTM D3161 Class F shingles (110 mph) should be used on wind zone regions of 110 mph (3-second) or more.*

TYPICAL WIND DAMAGE TO ROOF SHINGLES

Typical damage to shingles related to high winds includes partially or fully un-adhered shingle tabs, bent/failed shingle tabs, and missing shingles. During high wind events, such as during a tornado or hurricane, damage can also occur due to wind-blown debris such as punctured and scuffed shingles.

Partially or fully un-adhered shingles. A partially or fully un-adhered shingle or shingle tab can usually be easily lifted by hand (**Figure 2a**). An un-adhered shingle or shingle tab may or may not show signs of surface distress depending on whether it has been subjected to repeated high wind speed cycles. An un-adhered shingle or shingle tab is usually related to wind uplift but can also be affected by manufacturing and/or installation defects, natural weathering, and/or improper storage prior to installation. Depending on the degree and extent of un-adherence, partially or fully un-adhered shingles or shingle tabs can be either repaired or replaced.

Bent/Failed shingles. Bent/failed shingle or shingle tabs show flexural distress in a pattern usually parallel to the edge of the exposed shingle or shingle tab (**Figure 2b**). In many cases, the shingle or shingle tab is partially or completely detached from the underlying shingle. The uplift pressures and/or lateral wind loads lift the shingle tab during a windstorm and bend the shingle tab back and forth as wind speeds increase and decrease, thus weakening the tab at the location of the bend. A crease in the shingle is evidence of flexural distress and shingle replacement is required.

Missing shingles. Fully dislocated shingles with exposed underlayment and/or roof decking (**Figure 2c**) are typically associated with high wind distress, but are also associated with improper installation such as improper number and/or application of fasteners. Typically, areas of higher wind pressure concentrations such as at ridges and corners are the first to show this type of distress. Missing shingles must be replaced.

Punctured, scuffed shingles. Wind-borne debris can impact a shingle. Depending on the severity of the impact, a scuff mark or puncture may result. A scuff mark may remove only granules from the shingle surface, reducing UV protection. This type of distress typically is localized and requires individual shingle replacement.



Figure 2a. Fully Un-adhered Shingle



Figure 2b. Bent/Failed Shingle Tab



Figure 2c. Missing Shingles

REPAIR PROCEDURE FOR UN-ADHERED ASPHALT SHINGLES

When wind lifts a shingle and breaks the seal, it is not likely that the shingle will re-seal itself (GAF). Whether a shingle will re-seal or not depends on many factors, such as the age of the shingle, time and amount of high temperature exposure, previous high wind exposure, and contamination of the sealant by dirt and debris. In addition, re-sealing of the shingles will more than likely result in a weaker bond that the bond provided by the original seal. Depending on the extent of un-adhered shingles and other considerations, hand sealing of shingles can be performed.

Hand sealing of shingles may be performed as a repair on partially and fully un-adhered shingles. Hand sealing should not be considered as effective as the original seal and the shingle does not regain its full original wind resistance. Hand sealing is performed by placing daubs of adhesive under the shingle to be sealed using a caulking gun or small trowel. Most shingle manufacturers allow hand sealing under certain circumstances.

PRACTICAL WIND DAMAGE ASSESSMENT PROCEDURE

As part of the wind assessment of roof shingles, the evaluator must evaluate the wind speeds that the structure experienced. Site-specific weather information including wind speeds and wind directions can be obtained from several sources including the National Oceanic and Atmospheric Administration (NOAA). Knowledge of the magnitude and duration of wind speeds can provide the evaluator an idea of expected distress based on the wind rating of the shingles. Sustained wind speeds (1-minute) in excess of shingle manufacturer ratings typically result in some form of shingle distress. Lower speeds can also result in shingle distress due to aged and/or deficient and/or improperly installed asphalt shingles.

In assessing shingle damage, the roof must be walked thoroughly and a roof plan should be drawn. When evaluating a roof for wind damage, distress which is not related to wind should be noted and manufacturing and installation deficiencies must also be considered.

Sampled Areas. To obtain a representative sampling of the roof distress, 10' x 10' sample roof areas are used. A 10' x 10' area equates to what is normally referred to as "one square" (100 SF) of roofing. It is recommended that one sample area be taken on each roof plane for every 1000 SF of roofing area at representative roof areas. For a typical shingle roof, one square of roofing consists of approximately 80 shingles and 240 shingle tabs (3-tab shingles).

Analysis. Shingles within the sample areas should be evaluated for the four types of distress mentioned previously: un-adhered shingles (partial and full), bent shingles,

missing shingles, and punctured/scuffed shingles. The testing consists of both visual observations and hand lifting of the bottom edge of each shingle throughout the sample areas. The distressed shingles are then marked and quantified.

The types of distress are separated by Groups (I and II) for categorizing purposes. Bent, missing, and punctured/scuffed shingles are grouped together in Group I. Shingles within Group I require replacement. Partially un-adhered shingles or shingle tabs and fully un-adhered shingles or shingle tabs are grouped separately in Groups IIA and IIB respectively. Shingles or shingle tabs within Group II may require repair or replacement. A summary of Groups distress is shown on **Table 1**.

Table 1. Shingle Group Distress Categories

Group I	Group II	
	A	B
Bent, Missing, Punctured	Partially un-adhered	Fully un-adhered

Note the quantification for Group I type of shingle distress is based on the entire surface of one shingle. If the shingle is a 3-tab shingle, the distress is only counted once for each shingle even if two or three tabs show the same type of distress. This accounts for the fact that if any one of the three tabs is damaged, the entire shingle must be replaced. **Equation 1** below can be used to determine the percentage of damaged shingles on a square of shingles with Group I distress, where N_s represents the number of damaged shingles observed in the 10' x 10' sample area.

$$(N_s / 80) * 100 \qquad \textbf{(Eq. 1)}$$

Quantification for Group II distress varies depending on the type of shingle. For laminated shingles a partial un-adhered shingle is considered to be one where one third or less of the shingle is un-adhered. A shingle that has more than 1/3 of its surface un-adhered is considered a fully un-adhered shingle. For 3-tab shingles, individual tabs are quantified. For these, a partial un-adhered shingle tab is one where tab corners are able to be lifted. A fully un-adhered shingle tab is one where the complete shingle tab can be lifted by hand.

Equations 1 or **2** can be used to determine the percentage of damaged shingles with Group II distress. Equation 1 should be used for laminated shingles and Equation 2 should be used for 3-tab shingles. In Equation 2, N_t represents the number of damaged shingle tabs observed in the 10' x 10' sample area.

$$(N_t / 240) * 100 \qquad \textbf{(Eq. 2)}$$

Table 2 below shows a sample form used to document laminate shingle distress within three sample areas.

Table 2. Example Shingle Distress Documentation for Laminated Shingles

Area	Group I Distress		Group II Distress			
			A - Partially Un-adhered		B - Fully Un-adhered	
	N_s (Qty.)	%	N_s (Qty.)	%	N_s (Qty.)	%
A	7	9	10	13	7	9
B	3	4	5	6	5	6
C	8	10	18	23	9	11

Damage Assessment and Recommendations. Based on the type and percent of distress at the roof sample areas, one can estimate the percentage of overall roof damage. Depending on the type and percentage of overall distress, the roof shingle distress can be categorized as minimal, moderate, or severe. Based on the authors' experience, percentage threshold recommendations are provided below and are summarized on **Figure 3**. Note that the overall condition of the subject roof (and often each individual plane) should be considered including the type, degree and extent of distress, overall condition of the shingles, quality of installation, and the age of the roof. In some cases individual planes may require separate analysis depending on factors such as different age slopes (additions or previous repairs) or differing degrees of damage due to the direction of a traveling storm. The final decision when considering repair versus replacement may be based on other factors than engineering judgment such as availability of like kind and quality shingles and local code requirements.

Minimal Damage. A roof with minimal wind damage will have very low, if any, Group I type of distress (typically less than 2%) and low Group II type of distress (typically up to 7%). For this level of distress, we recommend replacement of individually bent, punctured, or missing shingles and hand sealing of partially un-adhered shingles in accordance with shingle manufacturer recommendations.

Moderate Damage. A moderately damaged roof will have moderate Group I distress, typically below 15% and low to moderate Group IIB distress ranging from 8% to 15%. In addition, the total percentage of Group II distress (IIA + IIB) should not exceed 25%. Recommendations for moderate damage are more difficult to specify. For example, consideration must be given to the age of the shingles. Newer shingles that are lying mostly flat can be hand sealed. However, if the shingles are older, then full replacement should be considered.

Severe Damage. A severely damaged roof will have moderate to high each Group I and IIB distress (above 15%). However if the total of Group II distress (IIA + IIB) is more than 25%, it should be categorized as severe. This accounts for the fact that it is unlikely to be economical to repair (hand seal) shingles in excess of 25% of the roof area. A roof with severe shingle damage requires replacement of the entire roof.

Figure 3 below provides a summary for determining the type of roof distress. Engineering judgment should be used, especially when numbers fall near the boundary values of each category.

MINIMAL	MODERATE	SEVERE
Group I < 2% Group II (A+B) ≤ 7%	Group I < 15% 8% ≤ Group IIB ≤ 15% and Group II (A+B) ≤ 25%	Group I > 15% Group IIB > 15% and Group II (A+B) > 25%

Figure 3. Summary of Categorized Roof Distress

CONCLUSION

The wind resistance of asphalt shingles depends on many variables including the shingle material properties, grade, style, quality of installation, age of shingles, and the direction of weather exposure.

The building code wind requirements for residential asphalt shingles are not well defined and can lead to the specification of underperforming shingles in certain areas of the country. The authors recommend that ASTM D3161 Class D shingles should be used on wind zone regions of 100 mph (3-second) or less and ASTM D3161 Class F shingles should be used on wind zone regions of 110 mph (3-second) or more.

A practical non-destructive procedure for identifying and quantifying shingle wind distress includes on-site visual and physical evaluations of sample roof areas representative of overall roof distress. Roof distress including bent, missing, punctured, scuffed, and partially and fully un-adhered shingles is categorized as minimal, moderate, and severe. Depending on the type and extent of the roof distress, different repair procedures are recommended. The final decision when considering repairing versus replacement may be based on other factors than engineering judgment such as availability of like kind and quality shingles and local code requirements.

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