

Asphalt Roofing: Wind or Hail Damaged vs. Deterioration

by Rick Abbott, PE, SE

Hail Evaluation

There seems to be two camps of thinking with regards to what people perceive to be hail damage to asphalt shingles. Both camps agree that mat fracture, punctures, and bruising is damage caused by hail. Some strongly believe granule loss is hail damage while other strongly disagree. This article attempts to summarize each view and present a reasonable path to resolve the conflict.

Camp A - Granule Loss is Damage

Camp A will argue that:

1. Granule loss observed after a hail storm should be attributed to hail. They state that hail displaced the granules, and therefore, reduced the life of the shingle.
2. Any granule loss attributed to hail is damage.

They tend to ignore the following facts:

1. Loose granules can easily be removed or displaced from deteriorated shingles with little or no energy exchange.
2. Granules are released from shingles over the life of the shingle starting on day one.
3. Granule loss is normal and expected in the aging process of an asphalt shingle.

Camp B - Granule Loss is Not Damage

Camp B will argue that:

1. Any granule loss observed after a hail storm should not be attributed to hail. They suggest that the granules were loose prior to the event, and are a part of the normal weathering and aging process of the shingles. The removal of the granules should be viewed as a cleaning of the roof of loosely attached granules.
2. Any granule loss that is attributed to hail is not damage.

They tend to ignore, the following facts:

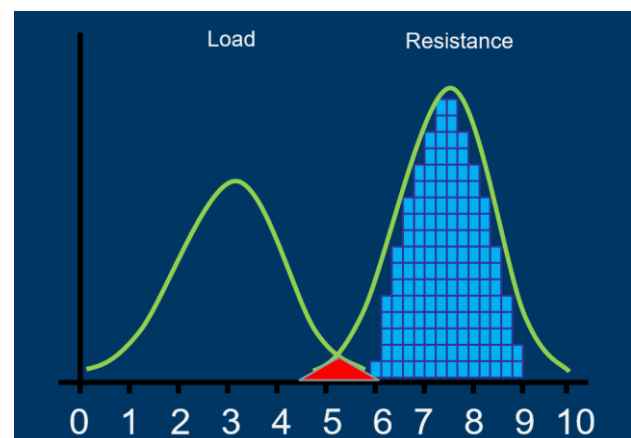
1. Impact blemish locations where larger hail removed granules from the roof surfaces that were still well attached.
2. The granules were attached to the shingle to protect the asphalt from UV rays, to give the roof color, and to provide a wearing surface.

So who is right? Is granule loss hail damage?

To fully understand the problem, more information is needed. In the arena of forensic engineering, more information is needed to draw an engineering opinion on a specific roof. In order to offer an opinion on technical data, a forensic engineer must follow the scientific method when forming an opinion. The following is a brief outline of what the scientific method includes:

1. Propose or define a non-biased question.
2. Information Gathering Stage – Make site observations of damaged and not damaged conditions. Make observations of the surrounding area. Gather storm data.
3. Construct a Hypothesis.
4. Test the individual hypothesis one by one. Analyze the data, draw conclusions, and accept or reject the hypothesis.
5. Communicate the results.

Design engineers are constantly looking at anticipated loads and the resistance of materials. Load Resistance Factored Design (LRFD) has long been the accepted method of designing new materials in the building industry. Using statistics, material testing, and other engineering sciences, engineers simply keep anticipated loads less than the ultimate loads that a certain system can take without failure. Agreed upon limits are set to minimize the probability of failure. The graph below shows the representation of this design process. The area in red is the area of failure where the load has exceeded the resistance. In most instances some probability of failure is acceptable else things would get too expensive to build.



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The problem with the above methodology in evaluating hail damage is that both sides of this problem are changing. The shingles (the resistance side) degrades and the hail (the load side) is usually an unknown. Since hail at a specific site is rarely saved or measured the hail that struck the roof is unknown.

The primary reason for the disparity in views of granule loss being considered as hail damage is due to the lack of clearly evaluating a roof's existing condition prior to the hail event. A roof's pre-existing condition must be taken into account when evaluating a specific roof for a specific hail event. All asphalt roofs age. It is normal and expected that the shingles will deteriorate overtime. A roof will transform from new to old, and will eventually exceed its useful service life. The deterioration is on a sliding scale of time as shown below.



In the absence of a hail event, granule loss is considered normal wear. Shingles are expected to resist weathering within limits. Granules release from a shingle over the life of the shingle at different rates during the course of a life of a shingle. In the early years, granules described as "hitchhiker granules" release soon after installation. Hitchhiker granules are not sufficiently embedded in the asphalt and easily fall off the roof. After the initial release of these "hitchhiker granules", the granules will release from the shingles at a slower rate. The granules release from the asphalt layer due to thermal cycling and a general breakdown of the shingle. Toward the end of the life of a shingle, the granule loss rate will increase again as the asphalt becomes more brittle. When shingles are left on a roof beyond their service life, the end condition of a roof often consists of portions of the roof having heavily deteriorated shingles with little or no granules. Leaks may even be present.

Each stage of the roof has a different level of strength (resistance) to wind and hail. Obviously, a roof

immediately after install has greater value than one near or at the end of the life of the shingle. For this reason, the condition of the roof cannot be ignored when evaluating a roof for wind or hail damage.

So what is damage? Different people have come up with their interpretation of what hail damage is. Is that fair? Who is allowed to decide what it damage? The general public has an understanding of what damage is. The criteria for hail damage should remain the same and not be some mysterious definition created by individuals. Webster defines damage as:

dam-age /'damij/ noun
1. physical harm caused to something in such a way as to impair (lessen, weaken, reduce, diminish) its value, usefulness, or normal function.

Therefore, according to the general public's understanding of what damage is, a roof shingle is damaged by hail or wind when its value, usefulness, or normal function has been lessened, weakened, reduced, or diminished.

When determining if a roof has been damaged by hail, the following must be considered and understood:

1. Both function and form need to be evaluated. Pre-existing conditions must be considered when evaluating systems that deteriorate over time.
2. A roof has a gradient from new to dead.
3. A storm event has a gradient from mild to severe.
4. There is a load side & resistance side to the problem of evaluating existing roofs for site specific wind and hail damage.






Newly installed shingles

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Focusing on the resistance side of this problem, it is clear that a roof must be evaluated for function and form. Below are simplified descriptions (the form) of three stages of a deteriorated roofs and their ability to shed water (function):

Early Stage (Slight Deterioration)	Middle Stage (Moderate Deterioration)	Advanced Stage (Severe Deterioration)
Description (form): Shingle tab edges are curled. The surfaces of the shingle tabs are not flat, but have slight bump or ridges.	Description (form): Granules have come off, leaving the mat exposed in localized areas. Granules easily flake off the shingle.	Description (form): The mat is disintegrated. The shingle tabs are missing or holes are present. The roof should not be walked on.
Function: Shingles are able to shed water.	Function: Shingles are able to shed water.	Function: Not functioning. Leaks are likely.
		

Hail has a certain amount of kinetic energy based on its mass and velocity. Numerous studies have been conducted to mimic hail impact on various roof test specimens. The mass and velocity of the hail are both related to the diameter of the hail, which is related to the kinetic energy.

$$\text{Kinetic Energy} = \frac{1}{2} \times \text{mass} \times \text{velocity}^2$$

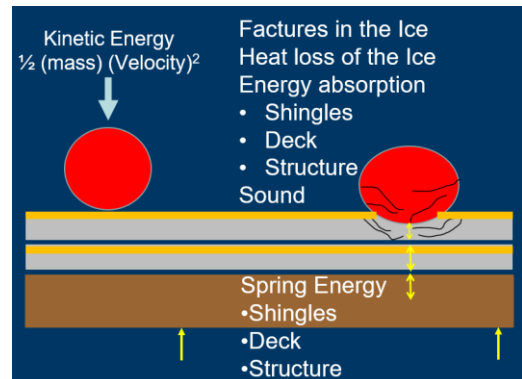
The increase in hail size has a disproportionate increase in energy due to the fact that kinetic energy is proportional to the diameter³ x velocity². The following table illustrates the drastic increase in energy for hail increase in diameter by ¼ inch.

¾" hail	= 4	times Energy of ½" Hail
1" hail	= 13	times "
1 ¼" hail	= 30	times "
1 ½" hail	= 60	times "
1 ¾" hail	= 120	times "
2" hail	= 200	times "

The following are examples of everyday items that have the same amount of energy as hail.

- ½" Hail = 1/2 lb roll of quarters @ 6 in
- ¾" Hail = 1/2 lb roll of quarters @ 1 ft
- 1" Hail = 1 lb can of soup @ 1 ft
- 1 ¼" Hail = 1 lb can of soup @ 4 ft
- 1 ½" Hail = 1 lb can of soup @ 8 ft
- 1 ¾" Hail = 3 lb toaster @ 5 ft
- 2" Hail = 5 lb bottle of pop @ 5 ft

When the hail comes to rest after the impact to the roof, the kinetic energy changes into other types of energy. Below is a representation of the energy conversion:



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It takes a certain amount of energy to displace granules from a new shingle. Threshold hail diameter that causes visible damage to newer shingles has been studied at length. It has been determined and published that threshold hail diameter for asphalt shingles is on the order of 1 to 1 1/4 inch. But in reality, a specific roof has a different resistance to hail due to material differences, exposure, service history, installation, and numerous other factors. The specific hail at the site will also have a different density, size, shape, direction and numerous other factors.

As the size of hail increases, the energy rapidly increases. More energy needs to be dissipated or changed from kinetic energy to other forms of energy. Energy from larger hail impact can be absorbed by the shingles as evident by granule displacement or fractures, punctures, or bruising.

The ability of the shingle to transfer compressive forces is related to its ductility, the adhesion of the granule, and its support condition. Over time, the ductility decreases and granules lose their adhesion. The shingles ability to resist compressive forces degrades with time; therefore, the threshold hail that causes noticeable change decreases as well.

So what should be the criteria to determine if hail has caused damage? Hopefully, all could agree with the following statements based on the general public's understanding of the definition of damage as defined by Webster:

1. Hail impact that resulted in reduced water shedding capability of the roof.
2. Hail impact that has resulted in a visual undesirable appearance.
3. Hail impact that resulted in a reduction in the remaining service life of the roof.

Based on the above criteria, it could be argued that if hail caused the removal of enough granules to expose the asphalt to UV light, its life of the shingles may have been diminished.

Based on the above criteria, it could be argued that if hail has removed enough granules to shorten the life of the wearing surface, the life of the shingles may have been diminished.

Based on the above criteria, it could be argued that if hail caused the removal of enough granules to cause visual blemishes that can be readily seen, the appearance may have been damaged. Therefore, the resale value may have been diminished. This would be considered damage due to the undesirable appearance and the reduction in re-sale value of the house as seen in the eyes of the future buyers.

It is not the intent of this paper to discuss all the aspects of a proper hail inspection, but a proper hail inspection should include the following:

1. A review of the weather data to estimate the size of hail.
2. Interviews with eye witnesses.
3. An inspection of other items that would have been struck by hail such as gutters, windows, downspouts, air conditioning equipment, siding, garage doors, exterior lighting etc....
4. A study of the roof for its ability to resist hail; and an evaluate of its condition, and age. A study to identify all defects or other sources of damage that are present.
5. A study of the blemishes and an evaluation to determine if they are consistent with hail to rule out other forms of damage and deterioration.

The characteristics of blemishes that are genuinely caused by hail impact to a roof include the following:




1. Blemishes are random in size and location.
2. Blemishes are usually directional; more pronounced on certain slopes.
3. Blemishes are generally round
4. Hail typically leaves markings on various materials (spatter marks)
5. Hail may leave smooth indentations on some metals

Based on the fact that shingles deteriorate over time, it is reasonable to recognize that the shingles ability to resist hail and not caused noticeable effect diminishes overtime as well. To ignore this fact would lead to the unethical conclusion and recommendation that owners should leave their roofs on as long as possible and wait for that mild storm to occur so that they can claim storm damage when, in fact, the roof has long exceeded its service life.

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Based on the above discussion, the table below summarizes, reasonable criteria for evaluating existing roofs for their integrity to resist hail, and for determining if hail has damaged a deteriorated roof.

	Early Stage (Slight Deterioration)	Middle Stage (Moderate Deterioration)	Advanced Stage (Severe Deterioration)
Integrity to resist hail impacts	Some, but the top layer is delaminating making it easier to flake. The shingles are more brittle.	Little to no resistance to impact. Granules easily flake off with the slightest effort.	None
Criteria used for "Hail Damage"	Treat similar to a new roof.	Depression of the mat, along with mat fracture. Granule loss is not a considered loss since it easily releases from the roof.	None. Hail cannot damage a shingle that has no integrity. If the roof is leaking and looks terrible prior to a storm no further damage and occur.
			

Wind Evaluation

Wind damage to deteriorated shingles requires the same amount of careful inspection of existing conditions. A proper wind inspection would include:

1. Researching the weather data. Determine if the wind speeds were "severe"?
2. Inspecting for collateral damages?
3. Inspecting the roof's existing conditions. Determining if the roof was inherently susceptible to wind damage? Were the shingles properly sealed? Were the shingles properly nailed? Were the nails overdriven, under driven or of proper size? Were the nails in the right location.
4. Inspecting the roof for classic and accepted forms of wind damage such as creased, flipped, or missing shingle tabs? Inspecting for larger areas of unattached shingles?




Especially in the case of wind, a roof must be evaluated for its ability to resist moderate or small amounts of wind. The fact remains that if a roof is left to deteriorate on a roof indefinitely, the slightest wind will remove the fragments that are barely attached.

Again, based on the fact that shingles deteriorate over time, it is reasonable to recognize that the shingles ability to resist strong amounts of wind and not caused noticeable effect diminishes. To ignore this fact would lead to the unethical conclusion and recommendation that owners should leave their roofs on as long as possible and wait for that mild storm to pass so that they can claim storm damage when in fact the roof has long exceeded its service life.

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Based on the above discussion, the table below summarizes the condition of a deteriorated roof and its ability to resist wind loads. It also gives reasonable criteria for determining if wind has damaged a deteriorated roof.

	Early Stage (Slight Deterioration)	Middle Stage (Moderate Deterioration)	Advanced Stage (Severe Deterioration)
Integrity to resist wind load	Some, but definitely weakened due to curled edges and deteriorated sealant strips.	Little or no resistance to wind. Shingles are unsealed, and easily lifted.	None
Criteria used for "Wind Damage"	Treat similar to a new roof. Creased, flipped, missing, or whole sections missing or lifted.	Whole sections missing and roof is cleaned. No loose granules remain after a wind storm.	Dead. If it is still on the roof and looks like this, wind did not damage it. Deterioration is the cause. The roof has exceeded its useful service life.
			

A number of installation errors have been identified as causing roof shingles to be prone to wind damage include the following:

