Roof Inspection Survey

John J. Basso, CR

September 1992

RESTORERS STATEMENT

This report is a roof inspection and survey. The report is based on physical evidence observed at the site on September 29, 1992.

Test samples and laboratory analysis were deemed not necessary. The materials involved, such as three tab asphalt shingles and prepared roll roofing by its own nature will normally reveal hail damage by careful visual inspection.

The purpose of this report is to determine the scope of damage to the structure as a result of hail damage. A estimate of the observed damage will be provided. The estimate will consider the cost to return the property to pre-loss condition or better.

Some roof areas had little hail damage if any, with the exception of a slight loss of mica granule from the shingle surface. The loss of granule will affect the life expectancy of the shingle. An estimate of the percentage of granule loss is submitted to arrive at the monetary value.

The accuracy of this report is contingent on several factors being properly identified. These factors have varying impact on the ability to arrive at a final hypothesis. Some information has been submitted from outside sources and has been accepted as accurate. The economics of not accepting this data as accurate and thereby pursuing other avenues for confirmation, does not at this time seem justifiable. Some of these factors are as follows.

1) Age of the roof
2) Manufacturer's design life
3) Elapsed time since exposed to hail
4) Ability to reuse existing flashings
5) Identify normal weathering
6) Foot traffic from original installer
7) Manufacturer's defective product

The affects of hail damage to a roof vary dramatically, due to many conditions. A copy of a recent report on the effects of hail damage is enclosed at the end of this report. This report may help explain more of the phenomenon associated with hail related roof damage.

A percent of granule loss is given where evident. This amount is a rough, rule of thumb. My intent is to give a gauge of damage. It is by no means an exact science.

To convert a percentage of granule loss to a monetary value, I suggest the following formula. { (Roof replacement value) - (roof repairs) } x (% of granule loss) = value.

Mr. Wick assisted me in this survey with his photography and sketches. The owner assisted by furnishing the historical data on the property.

A glossary is furnished at the back of this report in an effort to help with the interpretation of technical terms.

INTRODUCTION

On September 21, 1992 I was contacted by:
Mr. Frank Caper
Quick Claim Adjusters
103 Happy Times Ln.
Orlando, FL. 32804

OBJECTIVE

To conduct a survey of the following property, especially the roof to determine if the structures received any damage resulting from a hail storm occurring on March 3, 1992.

1114 - 1126	Plant St.	Winter Garden, FL.
1132 - 1138	Plant St.	Winter Garden, FL.
1148	Plant St.	Winter Garden, FL.
1150	Plant St.	Winter Garden, FL.

AUTHORIZED BY

John P. Jones Insurance Company
One If By Land Ave.
Boston, Ma 12121
(Claim # A920047)

DEFINITION OF ASSIGNMENT

The assignment authorized me to conduct an on site visual inspection of the property. Document the findings with photographs, notes, samples and laboratory test. Interview the owner for historical information and documentation of preexisting conditions if necessary.

THIS REPORT WAS PREPARED BY

JOHN J. BASSO, CPRC, PRESIDENT
FIRST GENERAL SERVICES OF CENTRAL FLORIDA

BACKGROUND

On March 3, 1992 the Central Florida area was hit by a severe hail storm. The magnitude of the insurance loss was estimated to be approximately ten million dollars. This information was given on the local news and confirmed in Claims Magazine several months later. I was personally involved in several hail claims and repairs in the Central Florida area as a result of this storm. Mr. Caper informed me he has conducted a roof inspection of his own. He asked John P Jones Insurance to authorize a roof inspection by an expert on roofing . Due to the size of the property involved and the diversity in damage to the property, he suggested it was in all parties' interest to get a second opinion

THE INVESTIGATION

The procedures used for this investigation are as follows:

The owner was interviewed for the purpose of obtaining the necessary history relevant to this claim. The interview took place at the owner's office. This was convenient as the buildings in question are rental properties. The owner currently rents and manages the properties from this office. The documents with the appropriate history required for this investigation where available as the owner was the original builder and restorer of the properties in question. I had the opportunity to review the original plans and specifications for the construction of the buildings.

During the course of my investigation the tenants of the rental properties were interviewed. Verification of existing leaks and damage prior to the hail storm was documented when possible.

INSPECTION

The inspection was conducted on September 29, 1992 by Mr. John J. Basso. Assisting with the inspection was Mr. Jon Wick. The weather was overcast, wind out of the southeast at 10 MPH. The temperature was in the mid to upper 60 % range.

All of the structures, with the exception of the auto garage, are constructed of masonry block walls with wood trusses and wood decking. The roof has a medium slope with three tab 20 year asphalt shingles. The auto garage has a low slope roof with modified bituminous roll roofing. The front of the building has a steep mansard roof with three tab 20 year asphalt shingles.

The building interiors are typical drywall walls and ceiling. Concrete floor slab on grade, with vinyl or carpet flooring. Some areas have suspended acoustical ceiling tile.

Most buildings are rectangular or square in shape. One is T shaped and the other is H shaped. The building sizes vary from as little as 1300 sf. to as large as 12000 sf..

The construction materials used are of good quality and the workmanship is in accordance with industry standards.

The condition of the property prior to the storm appears to have been good. It is obvious the owner has been successful in conducting a quality routine maintenance program.

The areas under consideration are all exterior surfaces of the buildings that where potentially exposed to hail damage. The areas of most concern are the roof surface with associated flashings and trim. Guttering and down spouts along with siding and paint are subject to damage also, windows, shutters and exterior fixtures are vulnerable to hail damage.

Generally, most hail damage occurred on the western exposure of the structures. The heaviest damage to the shingle roofs were on those areas facing west.

ROOF INSPECTION SURVEY
1150 Plant St.
Winter Garden,Florida

This roof consists of approximately 57 sqs. of roof area. The roof is constructed with 20 yr. type 3 tab asphalt shingle, installed over a wood roof deck, on a medium slope.

There are signs of puncture and total deterioration in approximately a half dozen areas of the roof on the west exposure of this roof. The east side of the roof has very minor granule loss, approximately 10%-20%.

My recommendation is to replace the roof on the entire west side, which is approximately 50% of the roof area.

I estimate the replacement value of the entire roof to be approximately $

Please refer to photo numbers 1,2,3,4,5,& 6.

ROOF INSPECTION SURVEY
1148 Plant St.
Winter Garden,Florida

This property has three buildings, which we have indicated on our roof plan as building A, the main Funeral Home, and buildings B & C , the auxiliary buildings, which are located in the rear of the property.

All three buildings are constructed similarly with 3 tab asphalt shingles installed over a wood deck on a medium slope.

Building A has no sign of hail damage, other then minor granule loss, which I estimate at approximately 5%-15%.

Building B has on the west side a few broken shingles due to defective plywood decking, and inadequate support for the shingles which has allowed hail to damage this area. The east side has minor granule loss, approximately 10%-20%.

Building C has hail damage on the west side only, with minor granule loss of approximately 10%-20% on the east side.

My recommendation on buildings B & C is to replace the west half of the roof, approximately 12 1/2 squares each. I estimate the total roof area and replacement value as follows:

* Building A 58 squares at $
* Building B 13 squares at $
* Building C 13 squares at $

Please refer to photos for Bldg. A, numbers 7,8,9,10,11,& 12
for Bldgs. B & C, numbers 13,14,15,& 16

ROOF INSPECTION SURVEY
1137 Plant St.
Winter Garden.Florida

My inspection of this building revealed two types of roofing. A three tab 20 yr. type asphalt shingle was installed over the sloped areas, and the mansard roof, located at the front of the building. A smooth surface built up roof system, composed of modified bituminous rolled roofing. (i.e:, torched down Brie) was installed on the flat, or low sloped areas.

The smooth surface rolled roofing has no hail damage. The shingled areas on the main portion of the building have normal wear, with 0%-10% granule loss, due to hail.

The shingle mansard has heavy wear, due to age, yet has no hail damage.

The total roof area is approximately 62 squares. I estimate the replacement value to be $10,200.00.

The breakdown of this figure is as follows:

* Sloped roof shingles 22 sq. at $:
* Mansard roof shingles 8 sq. at $
* Low sloped built-up roof 32 sq. at $

Please refer to photo numbers 17,18,19,20,& 21

ROOF INSPECTION SURVEY
1132 thru 1138 Plant St.
Winter Garden ,Florida

My inspection revealed the roof consists of three tab asphalt, 20 yr. type shingles over a wood deck, on a medium slope.

The shingles apparently were installed at three separate phases of construction. The center section appears to be the original roof. The gables appear to have been added to the central section several years later, with a different color shingle. The extreme east and west wing has yet a third color shingle, and appears to be the most recently applied.

The extreme west wing of the roof has approximately a dozen areas, where hail has damaged the shingle by causing deterioration, approximately one and half millimeters in diameter.

The remainder of the roof seems to show normal wear, with the exception of approximately 10%-20% granule loss, that is hail related.

My recommendation is to replace the shingled roof area at the extreme west end of the building, 18 1/2ft. by 82ft.

The total roof area is approximately 120 squares. I estimate the replacement value to be approximately $

Please refer to photo numbers 22,23,24,25,26,& 27

ROOF INSPECTION SURVEY
1114 thru 1126 Plant St.
Winter Garden, Florida

This roof is a 3 tab asphalt 20 yr. type shingle, installed over a wood deck on a medium slope.

My inspection revealed some deterioration of approximately 10-20%. There are no signs of hail impact, such as bruises or punctures.

The total roof area is approximately 87sqs. I estimate the replacement value to be approximately $

The aluminum awning at the rear of the building, has minor hail damage.

Please refer to photo numbers 28,29,30,31,& 32

SCOPE OF REPAIRS

Generally the work required will be partial reroofing of some roof areas. Gutter and down spout replacement. Aluminum roof and awning replacement, and painting.

The shingle areas that had minor granule loss were not considered for replacement, as this condition does not constitute imminent failure of the product. The shingle areas that had bruises or dents in the surface area from the hail are candidates for replacement, as the shingle will deteriorate rapidly and fail in the near future. The aluminum products that were damaged by the hail, such as denting will require replacement. It is not economically feasible to repair dents in aluminum products. The dents are not going to affect the performance of the product. Replacement is based solely on a cosmetic value. The areas that have painted surfaces pitted by hail, will require repainting. The paint is required to protect the surface from the elements and some surfaces are painted solely for cosmetics. The recommended repairs will bring the structures back to pre-loss condition or better. The only exception is the shingle areas that had granule loss. The worst case scenario for this condition will be a loss of performance life of the product. An effort was initiated to determine the amount of granule lost. A value can be established for the lost granules. This value can be used to compensate the owner for the loss of performance expected from the product. The ability to estimate the loss of granules is difficult. The granules are lost annually in a natural weathering and wear process. As this procedure has a possible potential for error, I was very conservative in my findings.

SPECIFICATIONS AND PRICES

Existing damaged asphalt shingles shall be removed, and the wood roof deck swept clean, to enable inspection.

The owner shall be made aware of any defective wood decking, and an estimate prepared for the proper repair of the deck.

Dry in felt shall be #15 plain shingle paper.

Shingles shall be UL Class "A" ASTM D 3018-82 Type 1 fungus resistant, 3 tab fiberglass.

Roofing nails shall be 7/8 galvanized, (staples are not permitted).

Shingle drip shall be installed under dry in felt at the eaves and over the felt at the rake.

All soil stack boots shall be replaced with new 2 1/2 lb. lead boots.

All existing fan and vent housings shall be reused.

Aluminum gutter and downspout shall be seamless .025", prefinished white.

Caulking and sealant shall be 20 yr.urethane, by Sonaborn or Equal.

Aluminum awning and roof panels shall be 032", prefinished white. Installation shall be in accordance with Smacna Manual 1991.

Paint shall be Sherwin Williams exterior latex A100, or Equal. Installation and preparation shall be accordance with manufacturers' literature.

PRICE BASIS

The following factors have affected the pricing for this project. The hail storm was of such large magnitude, that the local sources are overwhelmed. Outside contractors have moved into the area to assist with the repairs. This normally would help to deter escalating prices. At this point in time Hurricane Andrew has had far reaching consequences on this local economy. It has created enormous material and labor shortages. The pricing in this estimate takes the shortages into consideration and reflects a fair a reasonable value. The short term indicators are that pricing is stable and should descend in the near future. All pricing allow for appropriate insurance and mark up for sub contractors.

CONCLUSION

Generally the damage to the property was considerably light. There is no emergency work required. If the repairs do not start immediately there is no concern of further damage occurring to the property.

RECAPITULATION

PROPERTY		REPAIRS	GRANULE LOSS
1150 Plant St.			
1148 Plant St.	Bldg. A		
	Bldg. B		
	Bldg. C		
1137 Plant St.			
1132 Plant St.			
1114 Plant St.			
TOTAL			

What are the effects of hail on residential roofing products?

This article examines the sometimes-devastating effects that hail can have on asphalt shingles, wood shingles and shakes, and concrete tile shingles

by **Jim D. Koontz**

Editor's note: *The following article was adapted from a paper that was presented at the Third International Symposium on Roofing Technology, which was held in April 1991, in Montreal, Canada.*

Roofing products are subject to a number of severe weather exposures. These exposures include ultraviolet radiation, heat, wind, rain, pollutants and hail.

Hail damage to roofing products results in millions of dollars of losses on an annual basis. The result of this damage is an obvious boon for roofing contractors and, over the years, has certainly been very costly for the insurance industry. The ultimate cost, however, is borne by consumers.

Hail damage can affect virtually all types of roofing systems, including both commercial and residential. For the purposes of this paper, however, the primary area to be examined will be the hail resistance of common residential roofing products: asphalt shingles, wood shingles and shakes, and concrete tile shingles.

Whenever a city in North America is subjected to a severe hail storm, and the dollar losses exceed $5 million, the area is listed as a catastrophic loss area by the American Insurance Association. This is a methodology in which the insurance industry can then keep statistics on the amount of loss for each particular geographical location. These numbers are later used in actuarial tables to develop insurance rates for any given location.

In the United States, the geographical frequency of hail has been studied by groups such as the National Board of Catastrophe (from 1949 to 1964) and the United States Weather Bureau (from 1950 to 1960). The data from both groups indicate that a large number of severe hailstorms tends to occur in the central section of the United States. This covers an area from South Texas to Minnesota and from Colorado to Illinois. It should be pointed out, however, that no area in North America is totally excluded from the possibility of a hail storm occurrence.

The hail phenomena

Research on the phenomena of hail has been performed throughout the world, with the bulk being performed in Europe, South Africa, Australia and North America. Hail varies by size, shape, density and terminal velocity. Three of these factors—size, density and terminal velocity—affect the overall impact energy of hail.

1. *Size:* The size of hail has been reported from as small as sleet (¼ inch or 6.35 mm) to sizes reportedly larger than softballs, with diameters exceeding 5 inches (127 mm). The frequency of hail and the number of impacts for any given area also varies. The overriding factor, however, of whether a hailstorm can inflict damage to a roofing system is the ultimate impact energy, or kinetic energy, imparted by the hailstone to the roofing system, and the impact resistance of the roofing system.

2. *Shape:* The shape of hail can be spherical or somewhat elliptical. For purposes of this particular study, spherical hailstones were used.

3. *Density:* Studies have shown that hailstones vary in density. In cold-weather storms, relatively soft hail with small diameters is generated. In the warmer, spring-type weather, however, large hail (several inches in diameter) is generated with a relatively high density.

Hail is initially formed as an embryonic droplet that goes through a series of updraft cycles. Each cycle of rising and falling adds a layer of ice to the hailstone. The stronger the updraft force, the higher the hail is carried to colder and colder regions of the atmosphere. At these colder regions, the density of hail will increase, and approach that of ice (about 0.9 grams per cubic centimeter). Measurements of soft hail will show densities ranging from 0.5 to 0.7 grams per cubic centimeter.

It is normally assumed that hail has a density that approximates that of ice. However, a number of researchers have pointed out that hail is somewhat layered, and often consists of rings of ice. For purposes of this study, an overall density of 0.9 grams per cubic centimeter was used.

4. *Terminal velocity:* The terminal velocity of hailstones was originally determined by J.A.P. Lauri. These terminal velocities (see Figure 1) have been used throughout the industry in other research, particularly that performed by the National Institute of Standards and Technology (formerly the National Bureau of Standards).

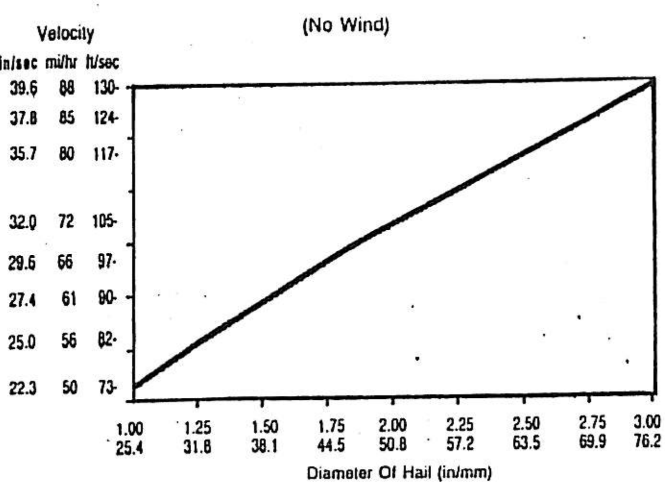


Figure 1: Terminal velocities of hail.

Terminal velocity assumes that a hailstone free-falls straight down, or in a vertical direction. However, it has generally been observed in severe hailstorms that hail does not fall vertically, but impacts surfaces at an angle. Obviously, the terminal velocity of the hailstone is determined by its free-fall velocity and its component horizontal wind velocity.

An example would be a 2-inch (51-mm) hailstone that would have a free-falling terminal velocity of 105 feet per second (32 meters per second) or 72 mph. If this stone was associated with a 59-feet per second (54 meters per second) or 40-mph horizontal wind, the resultant terminal velocity would increase to 120 feet per second (36 meters per second) or 82 mph.

The overall increase in kinetic energy would be from 23.29 pound force (31.58 joules) to 30.24 pound

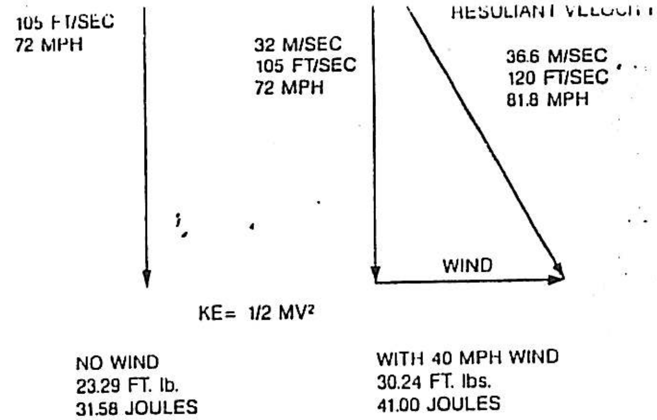


Figure 2: Effect of 40-mph wind on 2-inch-diameter hail.

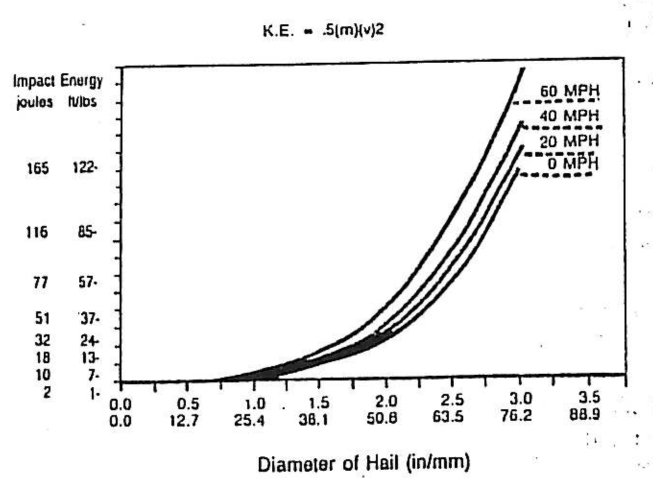
force (41.0 joules), or an increase of 30 percent in impact energy. By varying the horizontal wind factor, the ultimate impact energy can be varied dramatically (see Figure 2).

In reviewing this initial data, it is also interesting to note the overall difference in impact energy between hailstones with diameters of 1 inch (25.4 mm) and 2 inches (51 mm). Increasing the diameter of the hail from 1 inch to 2 inches increases the ultimate impact energy from less than 1 foot per pound (1.4 joules) to approximately 22 foot per pound (29.83 joules—see Figure 3).

The approximate impact energy obviously increases on an exponential scale, which is determined by the mass and the increase in terminal velocity. These two factors, mass and velocity (which are both increasing exponentially), cause a dramatic increase in the impact energy with small, incremental fluctuations of hail diameters.

Testing equipment that was used

To test various residential roofing products for resistance to hail damage, a hail gun was constructed.



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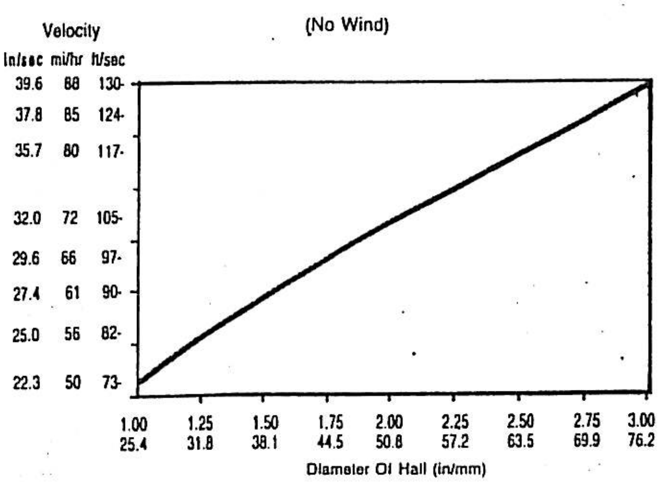

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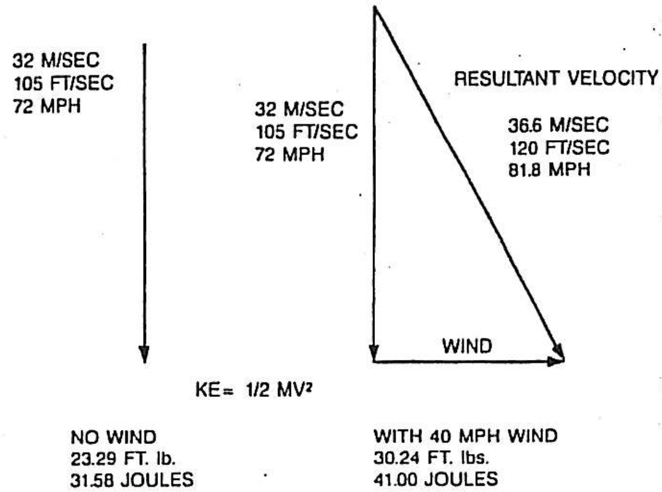

Figure 2: *Effect of 40-mph wind on 2-inch-diameter hail.*

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Testing equipment that was used

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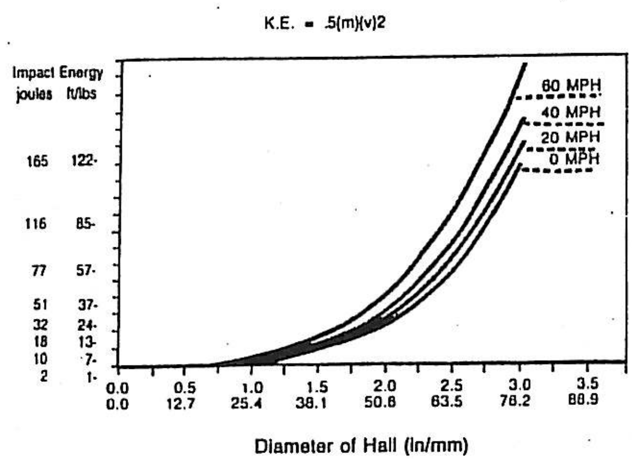


Figure 3: *Impact energy of hail.*

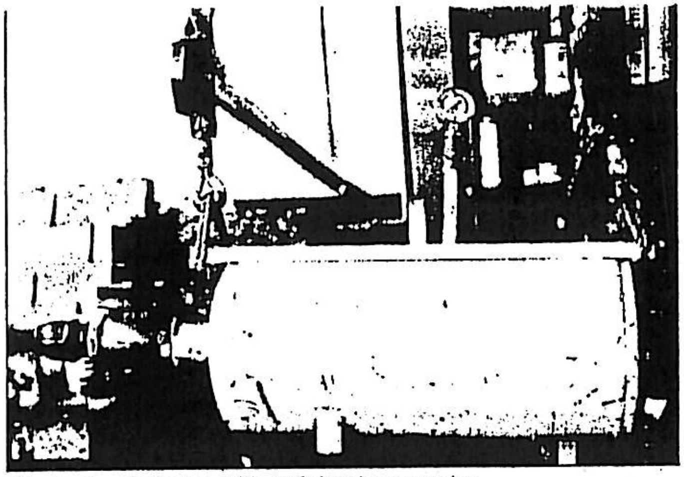


Photo 1: Hail gun with quick-release valve.

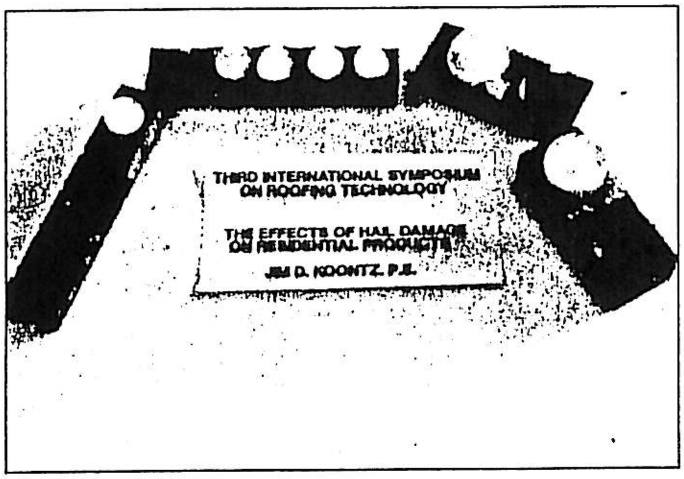


Photo 2: Hail molds.

This gun consisted of a pressurized air tank fitted with a quick-release, electronically actuated valve (see Photo 1). The barrels of the hail gun were interchangeable to accommodate the size of the hail, which was formed in molds (see Photo 2).

By pressurizing the tank and by opening the electronically actuated, quick-release valve, the sudden surge of air pressure propels the hailstone towards the target. To accurately measure the terminal velocity of the hailstone, a ballistic timer was used. Once this equipment was assembled, the hail gun was calibrated between air pressures and terminal free-fall velocities for different sizes of hailstones.

Hailstone targets that were used

Nineteen roofing assemblies were tested for resistance to hail damage (see Photo 3). The substrate of 18 of the samples was ½-inch (12.7-mm) CDX plywood. One sample was tested with ½-inch (12.7-mm) OSB decking.

Prior studies have shown that variations in the substrate can affect the puncture resistance of roofing assemblies. All targets were constructed on 2-foot x 2-foot x ½-inch (.61-mm x .61-mm x 12.7-mm) sheets. And all were constructed with one layer of ASTM D226-Type-I organic underlayment beneath the shingles.

Eleven of the targets were asphalt shingles with

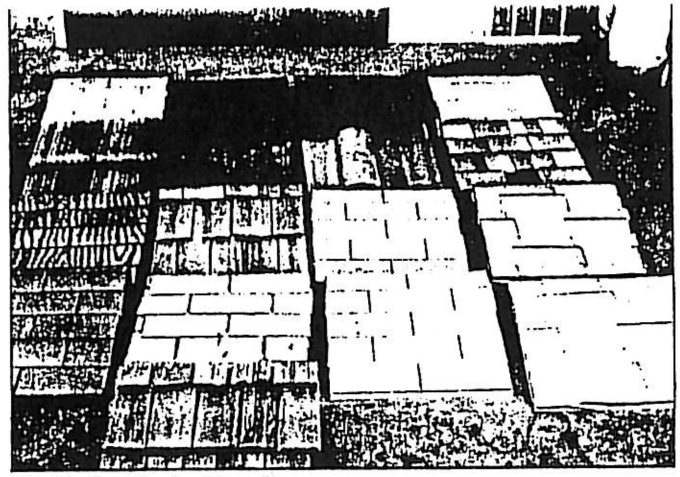


Photo 3: The hail targets.

either fiberglass or organic mats, in a three-tab, T-lock, grain pattern and layered, and simulated wood configuration. Three wood shingle targets had medium shake shingles, cedar shingles and 20-year-old, heavy red cedar shake shingles. Three concrete tiles were used in three configurations: "S," barrel and shake.

Two of the previously impacted asphalt shingle targets (constructed of 15-year-old, three-tab organic and T-lock organic) were then overlaid with new shingles (three-tab fiberglass and T-lock fiberglass, respectively). These roofing assemblies were included in the study because, in many cases, hail-damaged residential roofs are simply overlaid with a second layer of shingles. The older shingles, by default, serve as an underlayment on many residential roofing projects.

Most building codes, however, do not allow a third layer due to potential structural limitations. It has also been experienced that the fastener length for a third layer of shingles becomes too long and results in some movement of the roofing materials due to a slight flexing, or rotation, of the fastener itself.

Testing procedures

Each sample was impacted by hail 15 times. This included five different sizes of hail—¾ inch (19 mm), 1¼ inch (32 mm), 1¾ inch (44 mm), 2 inch (51 mm) and 2½ inch (64 mm)—impacting at three different angles of impact (15, 45 and 90 degrees—see Figure 4). A variation in the angle of impact from 15, 45 to 90 degrees produces a resultant force ranging from 25.88 percent, 70.7 percent and 100 percent, respectively.

Simulated hailstones were frozen in molds at approximately 10 F (12 C). The hailstones were quickly removed, placed in the gun barrel and fired within 30 seconds of loading. Following the impact of each specimen, results were recorded. Tests were performed at a room temperature of about 80 F (27 C).

All hail was fired at its terminal free-fall velocity (Figure 1). Concrete tile targets were then impacted in a secondary test with hail at speeds higher than normal terminal velocity to simulate the effects of high horizontal winds.

A fiberglass three-tab assembly over a plywood deck was subjected to three surface temperatures—60 F

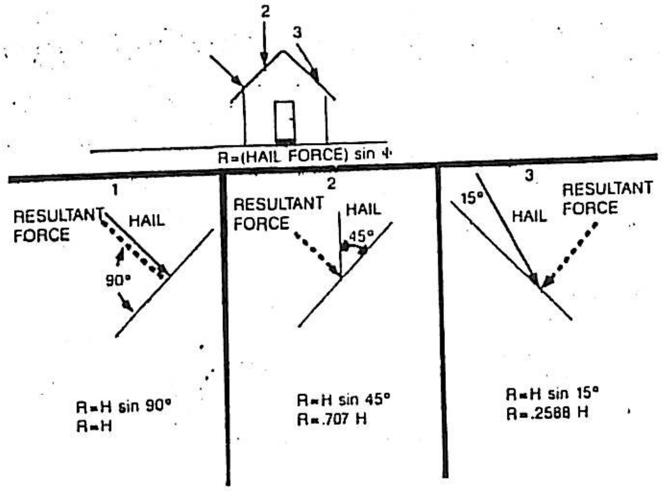


Figure 4: Angle of impact of hail.

(15.6 C), 80 F (27 C) and 120 F (49 C)—for hail damage evaluation with a 2-inch (51-mm) hailstone. The effects of higher and lower surface temperatures were then evaluated.

Damage assessment

Evaluating marginal damage to roofing products has not been clearly understood by either the roofing or insurance industries. Catastrophic failure damage is very clear and easy to observe. This would be a complete fracture/puncture through the installed residential roofing product.

Other types of damage, however, are not so obvious. Indentations may not fracture, but may result in some aesthetic loss, or in some potential loss of performance in years to come. As each of the targets was impacted with hail, the visible damage was recorded in a table (see Figure 5 for a representative number of testing samples). Various ratings for damage were used: ND (No Damage); I (Indentation); IG (Indentation with Granule Loss); ED (Edge Damage); IF (Indentation with Fracture); and P (Puncture).

In some cases, an indentation can occur, and the fracture in either the reinforcement mat (fiberglass or organic) or in some cases, even a fracture in the wood shingle is not readily observable. In the case of an organic or fiberglass mat shingle, desaturation of the shingle may be required to observe the damage. In the case of a wood shingle, close examination may be required to observe the split or fracture.

Asphalt shingle performance

Fourteen assemblies of asphalt shingles were targeted. Damage varied from no damage to puncture. All of the new, single-layer, fiberglass three-tab shingle assemblies had a resistance to fracture in the ¾-inch (19-mm) to 1¾-inch (64-mm) category, with an angle of impact ranging from 15 to 90 degrees. Fiberglass asphaltic shingles installed over OSB decking had the same degree of fracture resistance as similar shingles installed over plywood decking.

Indentations in the bulk of these areas were superficial, with just minor granule loss. It was observed in some shingles, such as Target No. 1, that indentations would occur (hail size of 2 inches or 51 mm, 90-degree angle). At this point, the shingles were desaturated with hot solvent, and fractures were observed in the shingle mat. These fractures were not readily detected by visual observation.

There did not appear to be a visible difference in hail resistance between organic and fiberglass three-tab products. The three-tab, assembly-type shingles, however, did have a higher hailstone resistance than T-lock shingles (see Photo 4). This increase in hail resistance appears to be a result of the smoother, flatter installation of the three-tab shingles.

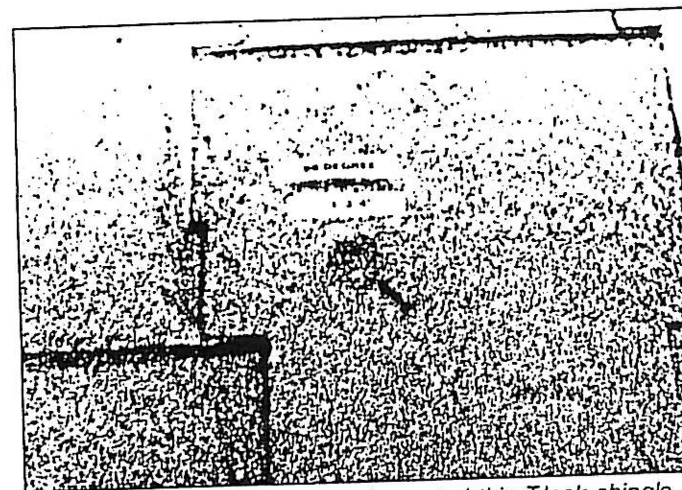


Photo 4: A 1¾-inch hailstone impacted this T-lock shingle at a 90-degree angle.

The heavier-weight, laminated shingles (Target No. 7) offered a slightly higher hail resistance to that of other fiberglass shingles in that a fracture did not occur until 2-inch hail (51-mm) at a 90-degree angle impacted the target. It should be pointed out, however, that the damage was not readily visible, and could not be observed until the shingle was desaturated.

The older, organic three-tab and T-lock shingles exhibited a very low threshold of hail resistance (see Photo 5). As shingles age, asphalt within the shingle obviously hardens and becomes somewhat more brittle. This creates a situation in which tow residences could be next door to one another, and one residence could sustain damage to a slightly older roof, while the other residence could have virtually no damage with a new roofing system.

When a roof system is overlayed, there is an increased void space between the new and old shingles. This is particularly evident in the case of new T-locks installed over old T-locks. In this situation, as demonstrated by Target No. 13, a fracture occurred with hail as small as 1¼ inches (32 mm) fired at a 90-degree angle.

All asphalt shingles had a fairly low threshold of

Velocity:						
Feet/Second	65	82	97	105	117	
Meters/Second	20	25	30	32	36	
Miles/Hour	44	56	66	72	80	
Kinetic Energy: Angle of Impact						
Ft. Lbs./Joules: 90°	.43/.59	4/5.4	14/19	22/30	53/72	
Ft. Lbs./Joules: 45°	.31/.42	2.8/3.8	9.9/13.4	15.6/21.2	37.4/50.9	
Ft. Lbs./Joules: 15°	.11/.15	1.0/1.4	3.6/4.9	5.7/7.8	13.7/18.6	
Hailstone Size	3/4 inch (19 mm)	1¼ inch (32 mm)	1¾ inch (44 mm)	2 inch (51 mm)	2½ inch (64 mm)	Target Description
Target Number: Angle of Impact						
Number 1:						Fiberglass, White, 3-Tab, ASTM D3018-1, Class A, 210 Lbs./Sq., Plywood Deck
90°	ND	ND	I	IF/NV	IF	
45°	ND	ND	I	IG	IF	
15°	ND	ND	ND	EED	IFP	
Number 7:						Fiberglass, Brown, Laminated, Class A, 300 Lbs./Sq., Plywood
90°	ND	I	I	IF/NV	IF	
45°	ND	ND	IG	IG	IF	
15°	ND	ND	ND	I/ED	I/ED	
Number 13:						Fiberglass, White, T-Lock, ASTM D3018-1, Class A, 210 Lbs./Sq., Plywood Deck ***Overlay Old T-Locks***
90°	ND	IF	IF	P/F	P/F	
45°	ND	IG	IG	P/F	P/F	
15°	ND	ND	EP	IG	IGED	
Number 14:						Fiberglass, White, 3-Tab, ASTM D3018-1, 210 Lbs./Sq., Plywood Deck **Temperature Variation**
60°F/90°	ND	IF	IF	P	P	
80°F/90°	ND	ND	I	IF/NV	IF	
120°F/90°	ND	I	I	I	IF	
Number 15:						Wood, Saw Cut, Both Sides 18 inches long 6-inch exposure ⅜ inches thick
90°	I	IF	I	IF	IF	
45°	I	I	I	IF	IF	
15°	I	I	I	I	I	
Number 16:						Wood, Saw Cut, One Side 24 inches long 10-inch exposure ½ inches thick
90°	I	IF	IF	IF	IF	
45°	I	I	I	IF	IF	
15°	I	I	I	I	I	

Figure 5: Nineteen roofing assemblies were tested for resistance to hail damage—the results of six of these are shown above. The ratings for damage that were used are: ND (no damage); I (indentation); IG (indentation with granule loss); IED (indentation with edge damage); IF (indentation with fracture); P (puncture); and NV (fracture not visible without solvent desaturation).

damage when the impact occurred at the butt edge (or shingle cutout) in a three-tab assembly. This ypically produces a somewhat semi-circular break at the leading butt edge. Although this may not effect the performance of the shingle, it may cause some slight problems from an aesthetic standpoint.

Variations in temperature

Temperature of the roof assembly surface is a definite factor in hail damage (see Target No. 14). Lower surface temperatures, such as 60 F (15.6 C), are much more prone to fracture than higher surface temperatures. This produces a lower threshold for damage.

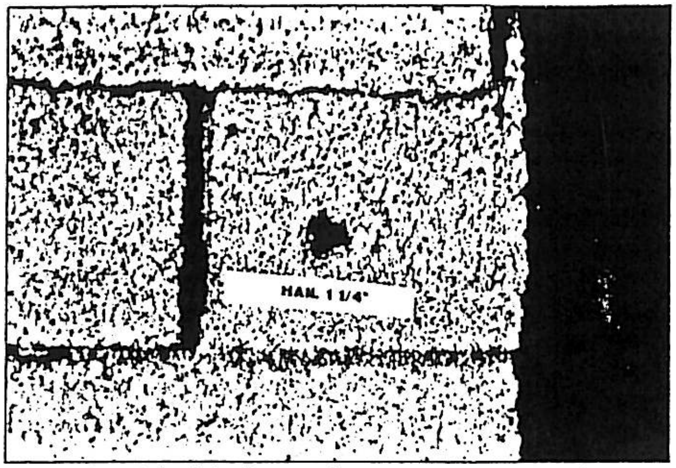


Photo 5: 1¼-inch hailstones impacted on an older, three-tab shingle.

The asphalt into which the granules are imbedded appears to shatter more readily at colder temperatures. When the surface temperature of the shingle is somewhat higher, such as 120 F (49 C), the surface is somewhat softer and, though easily indented, does not readily fracture.

Wood shingle performance

Three different groups of wood shingles were used; new No. 1 red cedar shingles, new No. 1 red cedar handsplit mediums and 20-year-old No. 1 red handsplit heavies.

The three wood shingles that were tested exhibited various degrees of indentation, which occurred at very low thresholds of kinetic energy. When the wood shingles were impacted with hailstones from ¾ inches (19 mm) in diameter to 1¾ inches (44 mm) in diameter, fairly uniform indentions occurred.

The indentations, depending upon the angle of impact, were either circular or somewhat elliptical. Damage in this particular area, for the most part, was superficial, and would not effect the overall performance of the roofing system.

When the wood shingles (Targets No. 15 and 16) were impacted with hailstones 1¾ inches (44 mm) or larger, the shape of the indentation was not uniform (see Photo 6). This was due to two factors: One, the

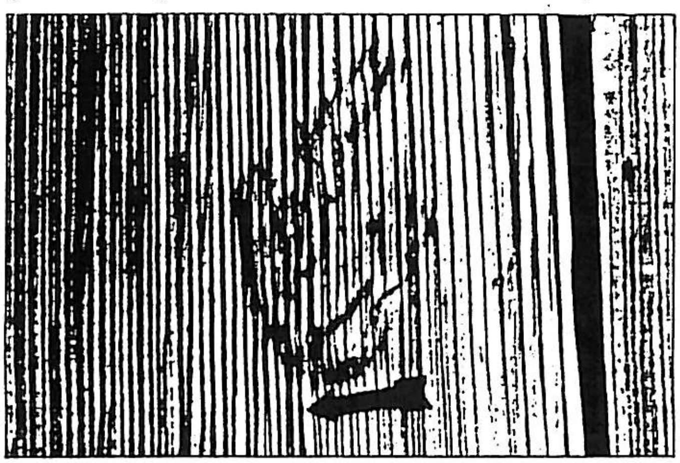
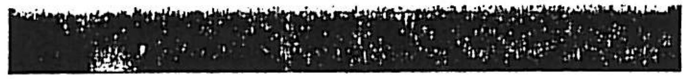


Photo 6: Irregular indentation of hailstone impacted on a wood shingle.



hail tends to crush and rotate somewhat as it impacts the shingle; two, because the surface of the wood shingle is irregular, the indentation becomes erratic.

The threshold for damage within the wood shingle was not clear-cut. This can obviously be due to the different thicknesses of the wood, points of impact, and non-uniform surfaces and sub-surfaces. An example is the ½-inch (13-mm) No. 1 red cedar handsplit medium shingle, where, at a 90-degree angle of impact, splits developed in the shingles with hailstones of 1¼ inches (32 mm) and 1¾ inches (44 mm). Indentations occurred, however, with 2-inch (51-mm) hail followed by fractures with 2½-inch (64-mm) hail.

The thicker wood shingles did not necessarily result in higher hailstone resistance. The thinner red cedar shingles (⅜ inch or 9.5 mm) with smoother surfaces and a greater uniformity in the substrate produced hailstone resistance equal to the thicker shingles. Some indentation of the wood shingles did occur at the leading butt edge and at the joint of the shingles. The bulk of this damage is somewhat superficial, and began at a fairly low threshold of kinetic energy (see Photo 7).

Concrete tile shingle performance

The three concrete tile targets all exhibited fairly high degrees of hail resistance. Fracture/breakage did not occur with the 2½-inch (64-mm) hail at a 90-degree angle of impact. Fracture/breakage did occur, however, when the velocity was increased to 131 feet per second (40 meters per second) or 89 mph, resulting in kinetic energy of 71.49 feet per second (96.9 joules—see Photo 8).

The flatter concrete tile shingle was the most hail-resistant concrete tile product tested. Multiple impacts with 2½-inch (64-mm) hail was required before fracture/breakage occurred.

In conclusion

Damage to residential roofing products is an obvious result of the size of hail, angle of impact, age of

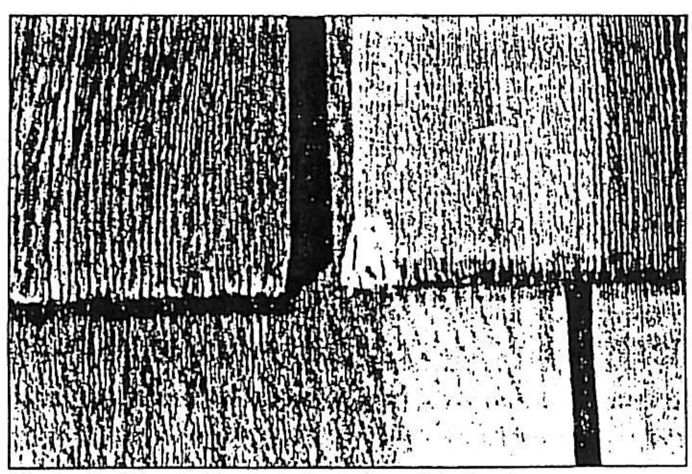


Photo 7: Wood shingle indentation at butt edge.

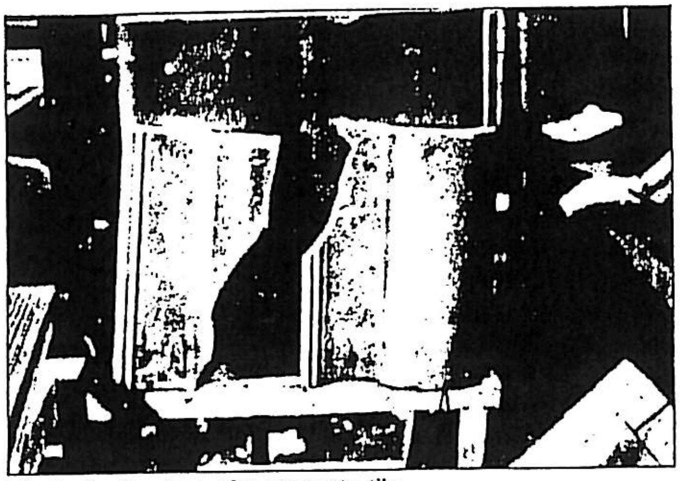


Photo 8: Fracture of a concrete tile.

materials, type of roofing system, temperature and substrate condition.

If the angle of impact is great enough, a situation could occur in which one side of a sloped residential roof is severely damaged due to an impact with a high normal resultant force, while the opposite side may have minimal to no damage because a glancing-type of impact may have occurred.

Fiberglass and organic three-tab materials, in single-layer applications over either plywood or OSB decking, appear to offer a high degree of hail resistance in asphaltic shingle construction.

It is obvious that in some questionable circumstances, desaturation of asphalt shingles is required to determine whether or not the reinforcing mat has suffered damage.

Threshold damage of wood shingle roofs are a result of the point of impact on the shingle assembly. Fracture of the wood shingles appears to be somewhat dependent upon whether the shingles are sawn on one or both sides.

When the shingles lay relatively flat, as in a double-sawn shingle, resistance to hail damage appears to improve.

Concrete tile systems appear to offer a very high degree of hail resistance. The lower-profile shingle—either flat or lower configurations—result in increased hail resistance. |PR|

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