Hail and Composition Shingles

Presented by

HAAG ENGINEERING CO.

Presenter:

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COMPANY PROFILE

Haag Engineering Co. is one of the oldest firms in this country specializing in the analysis of failure and damage. Mechanical, civil, structural, chemical, electrical, aerospace, architectural, and meteorological specialties are represented on the Haag engineering staff. Services include determining cause and/or scope of damage, computing costs of repair, reconstruction monitoring, rework/restoration analysis, laboratory and field testing, and legal testimony. Offices are located in Dallas and Houston.

Haag Engineering Co. serves a broad spectrum of clients ranging from large and small companies and corporations throughout the world to major insurance and adjusting companies, law firms and attorneys, and individuals.

Haag Engineering research data and studies have resulted in the publication and dissemination of information vital to persons involved in damage assessment, including a 20-year study of hail damage to cedar shingles. Other studies have been conducted on hail damage to various types of manufactured roofing materials.

PRESENTER PROFILE

Scott J. Morrison, P.E.

M.S. Civil Engineering
B.S. Civil Engineering
B.A. Architecture

Scott J. Morrison graduated from Iowa State University with a B.A. in Architecture and a B.S. in Civil Engineering. He also received a M.S. in Civil Engineering (Structures) from the University of Oklahoma. Currently, he is a member of the American Society of Civil Engineering, American Institute of Steel Construction, American Concrete Institute, Wind Engineering Research Council, and Chi Epsilon, the national civil engineering scholastic honorary.

Mr. Morrison has inspected and assessed hail- and wind-caused damage to hundreds of roofs. He participated in writing Wood Roofs: Damage and Repair, Second and Third Editions. His speaking experience includes numerous lectures on steel structures, steel connection design, steel and concrete fastening design, residential and commercial roof damage assessment, and damage to structures.

HAIL AND COMPOSITION SHINGLES

I. HAIL

A. Frequent and large hail area in the United States occurs east of the Rocky Mountains and west of the Mississippi River.

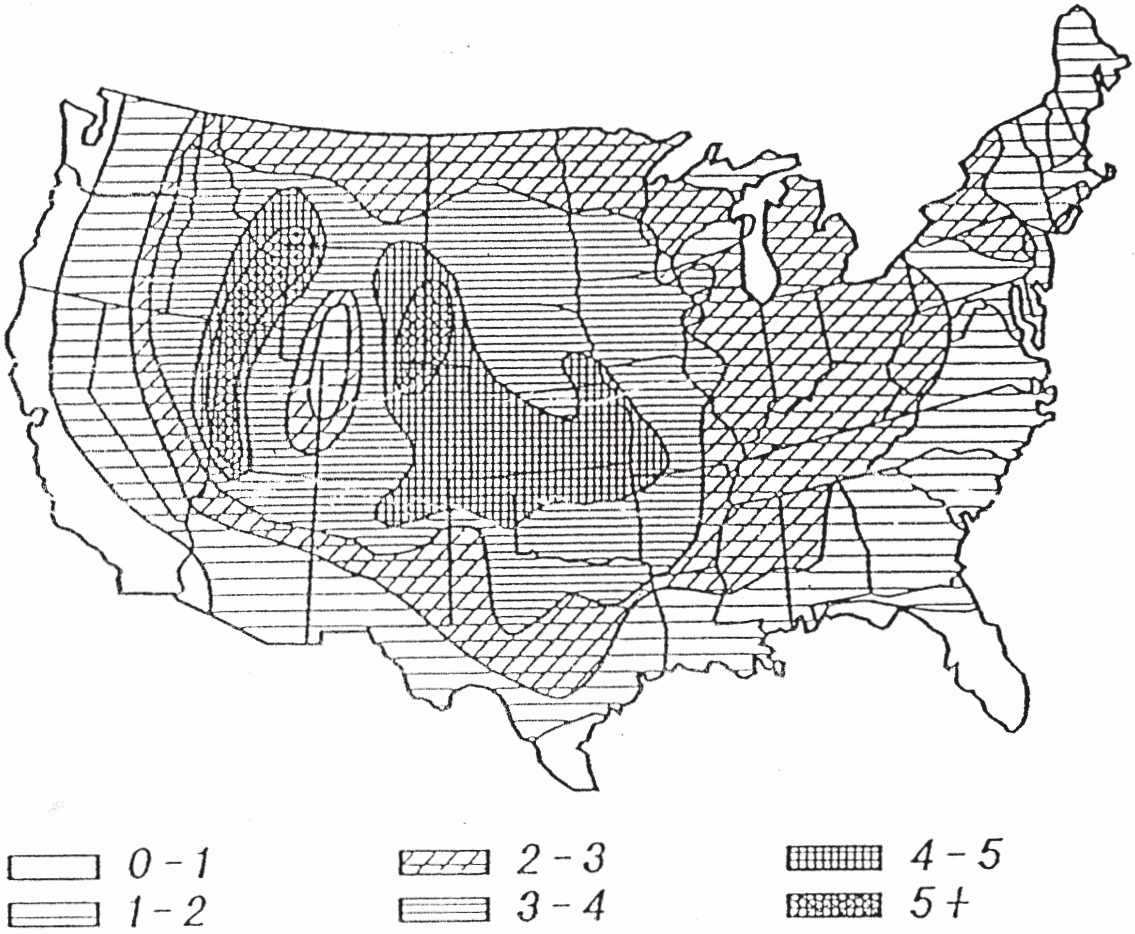

Figure I.1 - Average Hail Days in United States
(Source: Weatherwise)

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I. HAIL (CONT'D.)

B. *Hailstone evolution*

1. *Updraft*

A frozen water droplet, piece of dust, insect, etc., is caught in an updraft and carried upward.

2. *Cycling*

A layer of ice is added each time the hailstone is carried upward and downward through the thunderstorm cloud. This cycling continues until the stone is too heavy to be supported by updraft winds, and it falls to earth.

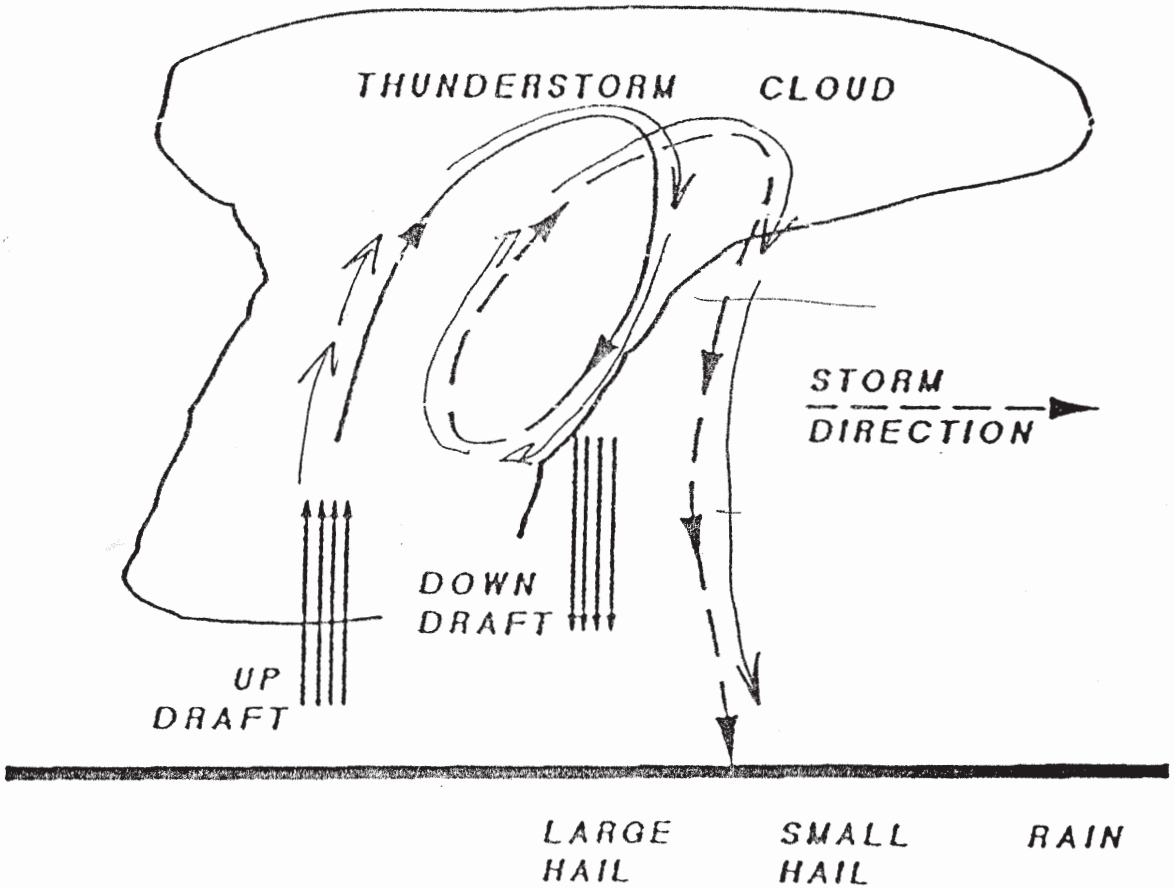

Figure I.2 - Cross Section of a Thunderstorm

II. HAIL-CAUSED DAMAGE

A. *Random aspects of hail*

1. Size
2. Shape
3. Hardness
4. Distribution

B. *Hail-caused damage parallels random aspects of hail*

C. *Directionality of hail*

1. Windward slopes receive ***more*** damage than the leeward slopes
2. Steep-sloped roofs sustain less damage than shallow-sloped roofs

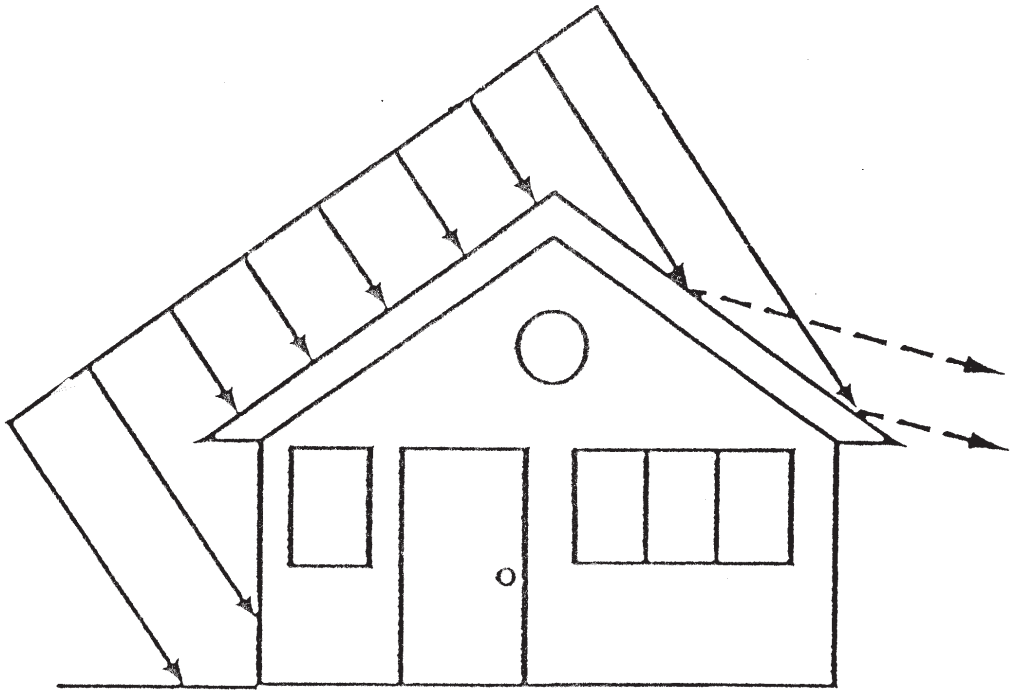

Figure II.1 - Directionality of Hail

II. HAIL-CAUSED DAMAGE (CONT'D.)

Size (in.)	Weight (lbs.)	Freefall Velocity (mph)	Freefall Energy (ft.-lbs.)
1/2	0.002	34.7	0.09
3/4	0.007	42.3	0.44
1	0.017	49.8	1.43
1-1/4	0.034	55.9	3.53
1-1/2	0.058	61.4	7.35
1-3/4	0.093	66.2	13.56
2	0.138	71.6	23.71
2-1/4	0.197	75.7	37.73
2-1/2	0.270	79.8	57.48
2-3/4	0.360	84.6	85.95
3	0.467	88.6	122.66
3-1/4	0.594	93.4	173.21
3-1/2	0.742	97.5	235.67
3-3/4	0.913	101.6	314.71
4	1.108	105.7	413.31

Table II.1 - Characteristics of Free Falling Hailstones

II. HAIL-CAUSED DAMAGE (CONT'D.)

D. *Functional damage to roofing*

1. Diminishment of water-shedding capability

2. Reduction in the expected long-term service life

II. HAIL-CAUSED DAMAGE (CONT'D.)

HAIL SIZE	TYPICAL DAMAGE
≤ 1/2"	Few, if any, roofs damaged. Leaves stripped from bushes and trees; crops destroyed. Oxidation coatings on paint, wood, and metal spattered. Thin polyvinylchloride coatings on roofs cracked or broken. Thin aluminum vents, fins on air conditioning units, lead sleeves on soil stacks, window screens, and aluminum awnings dented.
3/4"	*THRESHOLD SIZE FOR DAMAGE TO ROLL ROOFING AND DETERIORATED COMPOSITION SHINGLES, ESPECIALLY WHERE UNSUPPORTED.* Painted wood surfaces and deteriorated gray-black slates (especially at corners) chipped; most aluminum vents, flashings, valleys, and siding dented.
1"	*THRESHOLD SIZE FOR DAMAGE TO MOST LIGHTWEIGHT COMPOSITION SHINGLES.* Thin and/or deteriorated wood shingles and shakes occasionally punctured or cracked. Deteriorated unballasted built-up roofs bruised, and brittle flood coats cracked. Single pane windows and thin skylight shells cracked or broken.
1-1/4"	*THRESHOLD SIZE FOR DAMAGE TO MOST HEAVY COMPOSITION SHINGLES, WOOD SHINGLES,* AND OLDER MEDIUM SHAKES. Blisters and other unsupported areas on built-up roofs punctured. Automobile body metal dented, and (rarely) windshields cracked. Galvanized metal vents dented. Thicker skylights cracked or broken.
1-1/2"	*THRESHOLD SIZE FOR DAMAGE TO CLAY TILE, SLATE, AND NEW MEDIUM SHAKES.* Serious denting of automobile body metal.
1-3/4"	*THRESHOLD SIZE FOR DAMAGE TO NEW HEAVY SHAKES.* Metal vents caved in. Bare spots on built-up roofs bruised or punctured.
2"	*THRESHOLD SIZE FOR DAMAGE TO NEW JUMBO SHAKES, MOST CONCRETE TILE, AND UNBALLASTED BUILT-UP ROOFING ON FLEXIBLE UNDERLAYMENT.* (Note: Testing stopped at 2" stones. Gravel-ballasted, three-ply with base membranes were not damaged by 2" diameter stones, regardless of the underlying insulation system.)

These guidelines are for hard ice hailstones that strike the impacted material perpendicular to its surface. These general guidelines apply in most circumstances, but there are exceptions. In order to quantify hail damage accurately, test areas (one square each) should be drawn on the roofs, and the number of hail-damaged units, counted in each test area.

Table II.2 - Hail Size Versus Typical Damage

III. INSPECTION FOR HAIL-CAUSED DAMAGE

A. *Diagram and measure*

B. *Overview*

C. *Examine details*

1. Appurtenances

2. Hail-sensitive roofing areas

D. *Select up to four test areas*

1. Outline one-square areas on direction-facing slopes

2. Visually observe punctures and tears; hand manipulate for bruises

3. Compare costs to repair versus to replace roofing on a slope-by-slope basis

4. Assess ridge and valley shingles separately

IV. CONTROLLED IMPACT TESTING AT HAAG

A. *Beginning in 1963*

B. *Testing protocol*

1. Target specific shingle area
2. Verify ice sphere weight
3. Measure ice sphere velocity
4. Calculate impact energy
5. Document impact site
6. De-asphalt shingle in vapor degreaser
7. Inspect mats for damage (fracture, tear, or strain over area greater than 1/4-inch diameter)
8. A detailed protocol is appended as Attachment A.

C. *Composition shingle studies*

1. Haag studies
2. Proprietary threshold studies
3. Proprietary development studies

IV. CONTROLLED IMPACT TESTING AT HAAG CONT'D.

D. *General findings*

1. Thresholds for most composition shingles have ranged from 1 to 1-1/2 inches

2. Shingles produced by the same manufacturer and of similar warranty but with organic versus fiberglass mats have demonstrated approximately the same hail threshold resistance.

3. With composition shingles produced by the same manufacturer, products have not exhibited increased hailstone damage threshold sizes with increased warranty durations.

4. Of all composition shingles tested, a modified bitumen product has demonstrated the greatest impact resistance as a function of weight.

E. *Testing of weathered materials*

F. *Statistical models*

V. TESTING STANDARDS

A. *Factory Mutual Research Approval Standard, Class I Roof Covers*, Class Number 4470, April 1986

B. *ASTM E 822-81: Standard Practice for Determining Resistance of Solar Collector Covers to Hail by Impact with Propelled Ice Balls*

C. *Underwriters Laboratory* (under development)

VI. THE INSTITUTE FOR PROPERTY LOSS REDUCTION (THE INSTITUTE)

A. *Roofing Materials Committee*

B. "*The committee will seek ways to encourage the development and use of more damage-resistant roofing materials for both residential and commercial buildings.*"

ATTACHMENT A

ATTACHMENT A
Controlled Impact Testing of Composition Shingles

Test panels would be constructed to simulate typical roofing applications and set in a heated oven (140°F) and kept there until the shingles had "cooked down" and tab adhesives, bonded, approximately 48 hours. Mylar sheets would be cut to panel dimensions, fitted over the roofing, and marked with roofing outlines. Roofing on each panel would be impacted with molded ice spheres propelled at no less than free-fall speeds. Projectile speeds and projectile weights would be measured, and impact energies, calculated. Impact energies would fall within the range between minus zero and plus ten percent of target impact energies, or the data would be discarded. The projectiles would be launched perpendicular to the panels. Areas of roofing materials would be targeted according to support conditions (unsupported, marginally supported, and fully supported) or geometry (field, edge, corner, upper trough, lower trough, etc.). Immediately after a simulated hailstone would strike a roofing material surface, the impact area would be marked. Marks later would be transferred to the mylar sheet overlays to form a permanent record. Roofing materials carefully would be scrutinized for impact-caused damage. Composition shingle tabs would be cut from the panels, de-asphalted in a vapor-degreasing unit, and examined for damage. Damage results also would be recorded on the mylar sheets. Damage to the roofing material would be defined as diminishment of the water-shedding capability or the reduction of expected long-term service life of the tested materials. More specifically, for composition shingles, impact-caused damage would be the rupture of the shingle's structural element, its mat (base), or strain (permanent deformation) of the base over an area greater than 1/4 inch in diameter. The various stages of the testing procedure also would be documented photographically.