JS HELD

PERSPECTIVES

Forensic Laboratory Analysis and Roof Evaluations

Our perspectives feature the viewpoints of our subject matter experts on current topics and emerging trends.

INTRODUCTION

The roofing industry in the United States is prominent, with an estimated market size[1] of over $25 billion annually, which covers various segments such as residential, commercial, and industrial roofing. Owing to its core function to protect structures from the exterior environment, roofing can be prone to damage by weather (e.g., storms) and other exterior environmental factors. For example, hailstorms in the United States result in an average of about $1 billion in damages to crops and property annually.[2] In Canada, in 2020 alone, hailstorms caused $1.3 billion in insured damage to homes, cars, and commercial properties.[3]

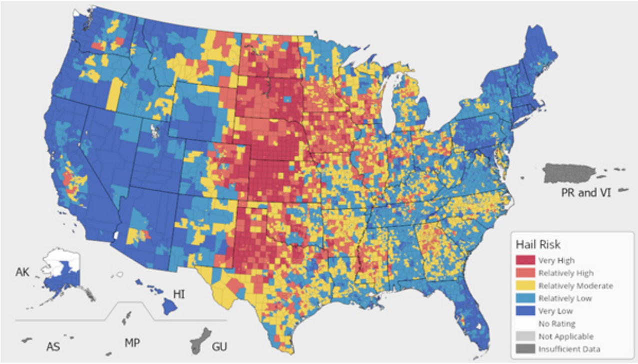

Figure 1 *- Hail Risk*
(source: https://hazards.fema.gov/nri/hail).

Forensic analysis is crucial for accurately assessing reported damage to roof coverings. Investigation begins with an onsite inspection by competent engineers or other experts with specialized knowledge in roofing and involves detailed examination of roofing materials and other exterior components.

Forensic analysis includes identification of various types of damage such as deformation in polymeric membranes or metallic assemblies, cracking in coated surfaces, and fractures and other physical distress within different roofing materials and assemblies, which are fundamental for an accurate assessment of the cause, extent, and repairability of damage conditions.

When it comes to distinguishing between damage caused by natural phenomena like hail and damage inflicted by human activity, forensic analysis presents a crucial role in determining whether the damage aligns with the characteristics of hail impact.

In such cases where insurance claims or legal disputes arise, competent evaluations provide objective evidence to support conclusive positions, founded upon reliable methodologies and scientific rationale.

In some instances, in situ and visual assessment of roofing conditions does not provide sufficiently comprehensive information that is needed to accurately determine the causes or extents of damage. In these cases, competent evaluators acknowledge that destructive assessment is warranted, which often includes offsite laboratory evaluations of representative materials removed from the site. In this article, we will discuss how a forensic roofing laboratory can support roofing damage evaluations needed by engineers, contractors, insurance companies, facility owners, owners' associations, and other interested parties.

BENEFITS OF A FORENSIC ROOFING LABORATORY

Forensic laboratory analysis is essential for matters such as determining the technical causes of failures, mitigating liabilities, resolving insurance claims, and implementing preventive measures to ensure expected performance relating to roofing materials.

A professional and accredited forensic roofing laboratory, dedicated to conducting specific testing relating to roofing performance and damage, can support:

- **Damage Assessment**
  Evaluating damage characteristics in samples collected from the field, as well as conducting controlled experiments and analysis to characterize hail damage to various roofing materials such as shingles, membranes, tiles, metal panels, and others.

[1] Expertmarketresearch.com; sphericalinsights.com; freedoniagroup.com
[2] National Oceanic and Atmospheric Administration (NOAA) (https://www.noaa.gov/jetstream/ll-hailsize)
[3] Insurance Bureau of Canada (IBC) (https://www.ibc.ca/stay-protected/severe-weather-safety/hail)

- **Research and Continuing Education**
  Serving as a hub for research that contributes to the roofing industry body of knowledge as well as training and education for professionals engaging in forensic roofing analysis.

To deliver these services effectively, experts utilize a range of tests and tools that offer insight into the structural integrity of materials, allowing for a proper characterization of the specific types of damage they may have incurred.

Figure 2 *- Photo documentation:*
Detailed documentation and appropriate chain of custody to support claims and litigations.

MICROSCOPIC ANALYSIS EXPERTS

Microscopy is a fundamental technique used to examine the surface of materials at varying degrees of magnification to observe the characteristics of an area of interest for potential signs of damage, such as fractures, cracks, and indentations. Microscopy also provides supplemental information concerning sample weathering, signs of exposed reinforcement, accumulation of debris in fractures, presence of broken granules, etc. Microscopic analysis can help to identify specific features or patterns that may indicate whether particular damage was caused by hail or other factors, assisting in determining the causes of roof damage in forensic investigations.

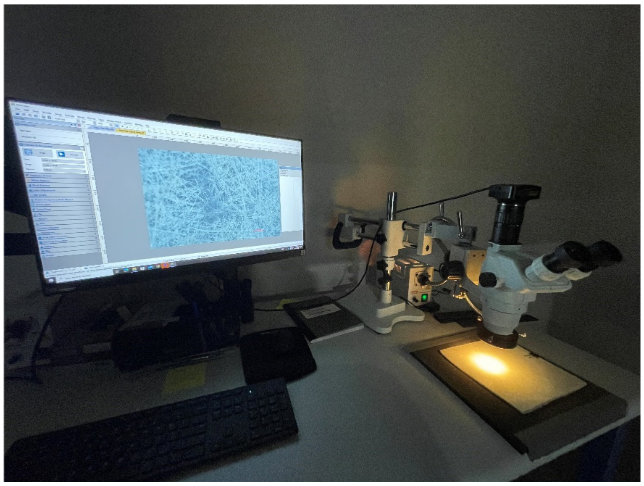

Figure 3 *- Stereomicroscope in use, displaying hail impact characteristic damage in roofing's shingle fiberglass reinforcement sheet.*

BACKLIGHT IMAGING ANALYSIS EXPERTS

Backlight imaging analysis employs high intensity transmitted light to identify disturbances in the materials such as tears, punctures, or fractures that otherwise may not be visible by naked eye.

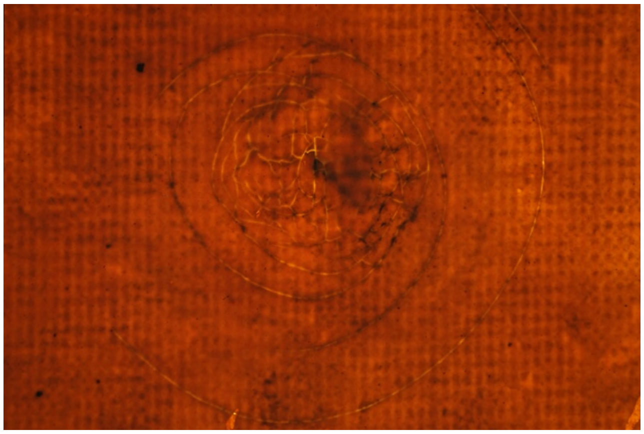

Figure 4 *- Example of a characteristic hail impact pattern in membrane roofing, observed through high intensity backlighting and registered by long exposure photograph.*

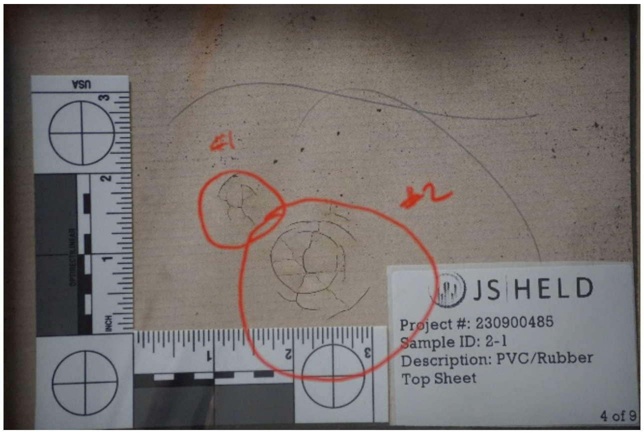

Figure 5 *- Another example of a characteristic hail impact pattern in membrane roofing, with Areas of Interest identified and no backlighting illumination.*

Figure 6 *- Light passing thorough fully developed fractures in membrane roofing, observed with use of high intensity backlighting, and registered by long-exposure photography.*

THE ROLE OF THE WATER COLUMN TEST IN ROOFING INTEGRITY

The water column test evaluates the potential of water migration through a roofing material specimen over a continuous seven-day period.

Performed in accordance with ASTM D7281, the test evaluates the water-tightness integrity of the roofing membrane, which can be used for confirming potential leak sources such as punctures, perforations, and defective seams.

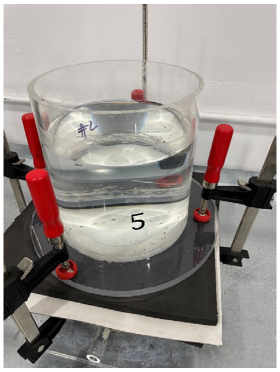

Figure 7 *- Apparatus for testing the integrity of roofing membranes, as per ASTM D7281.*

THE SIGNIFICANCE OF DESATURATION IN ROOFING ANALYSIS

Desaturation is the process used primarily to remove bitumen and aggregates from asphalt impregnated materials such as composite shingles and built-up roofing assemblies. This process allows for analysis of the integral reinforcement materials that are otherwise concealed and unable to be viewed, facilitating the identification and analysis of damages and defects.

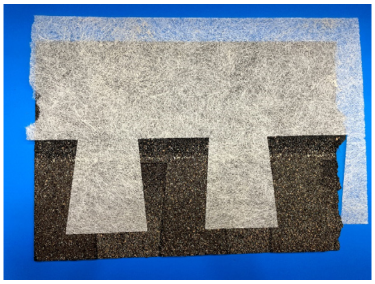

Figure 8 *- Roofing shingle and its reinforcement sheet. Note that both samples are from the same roofing shingle cut in half, showing the efficiency of the desaturation process.*

Microscopic analysis can be (and is frequently) employed after the desaturation process to characterize signs of damage in the reinforcement sheets of roofing samples, such as the single-ply shingle shown in Figure 9, below.

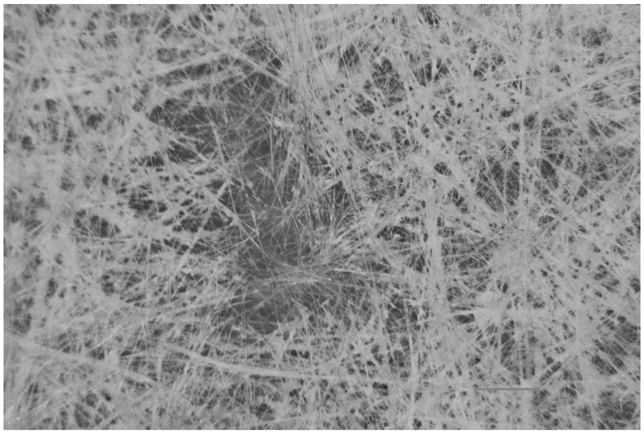

Figure 9 *- Hail impact on fiberglass reinforcement sheet.*

HAIL IMPACT SIMULATION AND THE RESILIENCE OF MATERIALS

The Ice Ball Cannon (or IBC for short), is capable of simulating hail impacts of varying sized hail on different roofing materials and fixtures, allowing for the study and analysis of roofing failure modes. Researchers can investigate the influence of factors such as angle of impact, velocity, and size of hailstones and systematically establish correlations between hail impact characteristics and the resulting damage patterns.

Figure 10 *- Naturally occurring hail: variety of shapes and sizes.*

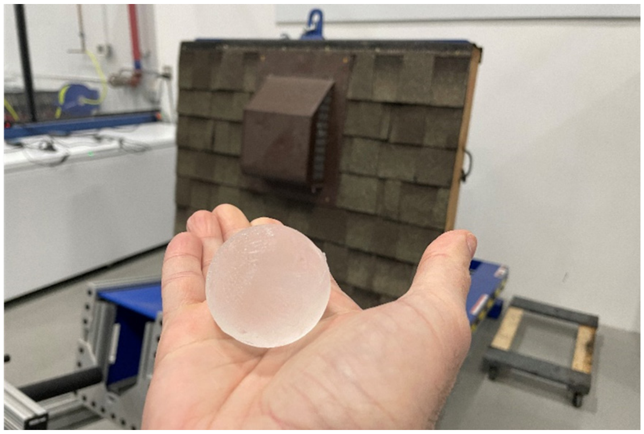

Figure 11 *- A hail stone manufactured in the Roofing Lab, ready to be propelled by the Ice Ball Cannon. Made under controlled conditions to generate reliable, repeatable, and consistent results.*

Performed in accordance with ANSI/FM 4478, the IBC also assists in evaluating performance and resilience of materials and structures against hail damage. Able to launch lab-controlled spherical hailstones at controlled speeds and angles, the equipment provides the necessary information to calculate the force of impact of the hailstones, allowing the Roofing Laboratory to replicate natural events, perform comparative analysis, and identify defects caused by product non-conformities or natural weathering.

Figure 12 *- Ice ball cannon, equipped with sophisticated timer and sensors for effective measurements of ice ball speeds.*

Although commonly utilized in relation to roofing materials, the IBC is also capable of simulating hail impact to other materials such as automobile windshields and bodies, photovoltaic panels, satellite antennas, vinyl sidings, and other materials of interest.

Figure 13 *- A multitude of events and structures for hail impact study and analysis.*

THE ROLE OF HEAT FLOW MEASUREMENT IN BUILDING EFFICIENCY

Heat flow measurement is an experimental technique used to investigate the transfer of heat through different materials, which provides valuable insight for designing energy efficient and thermally optimized building systems. The technique is also used for assessing material performance, optimizing energy consumption, and selecting appropriate building materials for improved thermal efficiency. Heat flow measurement is useful for determining the thermal conductivity of insulation materials for code compliance investigations or to confirm any suspected damage.

The Heat Flow Meter (HFM; pictured next column) is a calibrated instrument which performs tests according to ASTM C518, measuring the thermal conductivity (λ) of insulation materials such as polyisocyanurate (polyiso), cellulose, fiberglass, mineral (rock or slag) wool, etc.

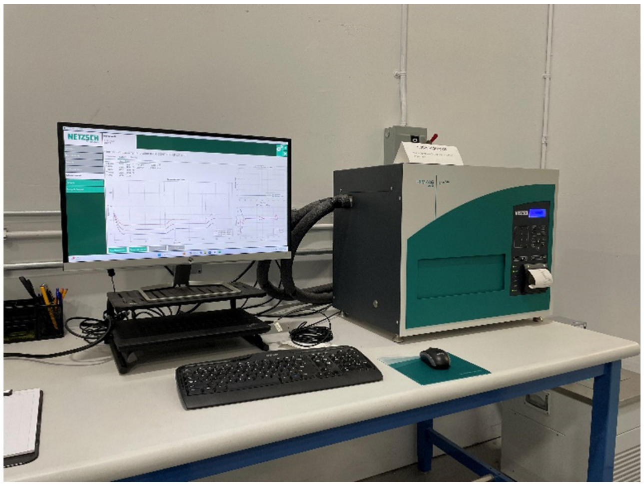

Figure 14 *- Heat flow meter in operation at the Roofing Laboratory.*

CONCLUSION & HOW EXPERTS CAN HELP

The laboratory techniques presented here frequently extend and improve the investigative capabilities of forensic engineers in the field. These techniques can and should be utilized as a crucial part of forensic analysis of roofing damage, to confirm the cause and extension of damage in substrates as diverse as roofing shingles, modified-bitumen, membrane roofing materials, sheet metal, clay, and accessories found in residential and commercial roofs.

ACKNOWLEDGMENTS

We would like to thank our colleague Marcos Flores Jr. for providing insight and expertise that greatly assisted this research.

Marcos Flores Jr. is the Roofing Lab Director in J.S. Held's Forensic Architecture & Engineering practice. A seasoned research and development scientist with over two decades of experience, Mr. Flores possesses extensive knowledge and expertise in failure mode and analysis of composite materials. His background in pulp and paper, coatings, and ceramic/abrasive materials has given him hands-on experience with a range of analytical

techniques, making him an expert in forensic analysis across various substrates.

As the Roofing Lab Director, Mr. Flores provides technical support to the roofing industry and consults with company experts and engineers. In this role, he is responsible for overseeing all laboratory operations, managing personnel, ensuring quality control and safety compliance, and delivering accurate and reliable test results. With a strong background in materials science and extensive knowledge of laboratory techniques and equipment, Mr. Flores is committed to providing exceptional service to clients and advancing the field of roofing through innovative research and development.

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