Secondary Risk Characteristics for Verisk Hail Models

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Revision History

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June 2022	Original release

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1 Introduction

This document explains the Secondary Risk Characteristics (SRCs) related to hail used in Verisk's severe thunderstorm models. SRCs are structural features of a building and its environment that have significant impact on the building's vulnerability to damage. The SRCs presented in this document are important contributing factors to the losses sustained by residential, commercial, and industrial properties due to hail. They were identified based on structural engineering expertise and observations of building damage following historical events.

Examples of SRCs for hail vulnerability include:

- Roof Covering
- Roof Year Built
- Roof Geometry
- Roof Pitch
- Roof Attached Structure
- Wall Siding

For a complete list of the SRCs, see Chapter 3. Options corresponding to each SRC are based on construction practices. The Verisk Severe Thunderstorm Model for the United States in Touchstone supports any combination of hail SRCs.

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2 Damage Estimation Overview

The base damage functions that characterize hail damage in Verisk models are developed for a “typical” building at a particular location that has certain primary risk characteristics, including:

- Construction Type
- Occupancy Class
- Height
- Age (represented by year built)
- Building Gross Area or Square Footage

The model takes the user-supplied SRCs and applies them as intensity-dependent modification functions to the base damage functions to reflect the difference between the performance of a building with known structural and environmental characteristics and that of a “typical” building. User input overrides the default SRCs assumed in the model based on location and year of construction.

The Damage Estimation component of the Verisk model applies the local intensity of the simulated event to a database of exposed properties to estimate the corresponding damage. This estimated damage is calculated using damage (i.e., vulnerability) functions, which relate the mean damage level of a building and its contents, as well as the damage variability, to the measure of intensity to which they are exposed. Losses are calculated by applying the appropriate damage function to the insured property’s replacement value.

Since different structure types experience different degrees of damage, the damage functions vary according to a building’s primary (construction and occupancy classes, height, age, and gross area) and secondary risk characteristics. When risk characteristics are not available, vulnerability calculations incorporate regional data obtained from comprehensive Verisk studies and other proprietary Verisk datasets. The data account for the regional variation in construction practices, building code requirements, and building code enforcement.

Damage functions provide estimates of the mean, or expected, damage ratio and the probability distributions around each mean corresponding to each hazard intensity level (i.e., the damage uncertainty). This damage uncertainty comes from many sources, including variability in the strength of building components and building features as well as uncertainty in the modeled intensity (e.g., hail size) at the location under consideration. Further, uncertainty in the human response (whether windows are covered, for example) can significantly affect the damage severity.

To define the uncertainty around a modeled given mean damage ratio (MDR), Verisk researchers create secondary uncertainty distributions using empirical claims data and modeled sub-peril (e.g., hail impact energy) intensities (Figure 1). These probability distributions allow for non-zero probabilities of zero percent and one hundred percent damage.

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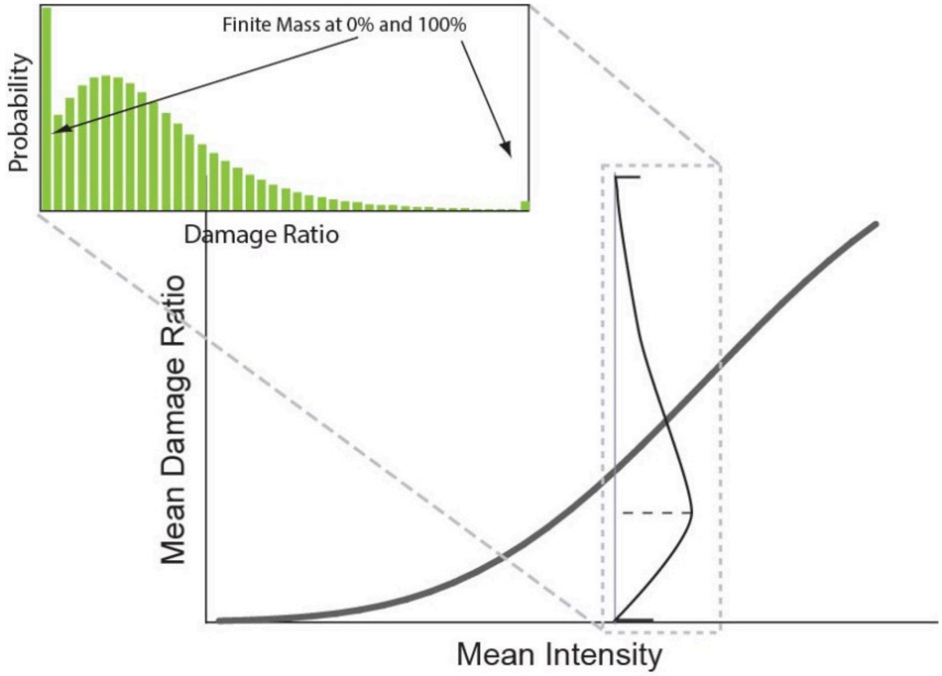

Figure 1. Representative damage function

Verisk engineers refine and extensively validate damage functions using post-disaster field survey data and through an exhaustive analysis of detailed loss data from actual events. Validation is performed by comparing simulated and actual losses for client companies by region, coverage, and line of business.

2.1 Hail Damage to Buildings

Hail damage to buildings can include cracks, tears, spatter marks, dents, and finishing and coating damage, depending on the type of property at risk as well as the physical characteristics of the hailstorm. In general, buildings may be classified as either engineered or non-engineered. Non-engineered buildings are usually more susceptible to hail damage than engineered buildings. Non-engineered buildings include most residential dwellings (e.g., a wood-frame single-family dwelling), which may not have received attention from a structural engineer during construction. Most residential building hail damage occurs to roofs and roof coverings (Dagnew & Edson, 2016).

Engineered buildings include structures that are built in accordance with building codes and under the supervision of a structural engineer (e.g., a high-rise reinforced concrete building). Damage is typically seen on the nonstructural components of engineered buildings, including mechanical equipment, roofing, cladding, and openings. Hail damage to structural components is rare. Examples of hail damage to non-structural components of engineered and non-engineered buildings are shown in Figure 2.

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Figure 2. Examples of hail damage to non-structural components
(Top left) Dented metal vent; (top right) dented air handler; (bottom left) dented gutter; and (bottom right) broken skylight (Source: RICOWI, 2012; cropped by Verisk)

Among single-family residential homes, wood and masonry are the predominant construction classes throughout the United States. Wood frame is the most common construction type overall, although masonry is also common in the Gulf States and along the East Coast. In general, masonry houses can withstand hailstorms better than wood-frame buildings. The exterior walls of wood-frame homes can be finished with stucco, wood siding, wood shingles, vinyl, or aluminum cladding. When masonry is used as the exterior wall material, the walls are normally constructed to full height. Then, wood floors and the roof are framed into masonry, resulting in continuous exterior walls and an overall strong structural frame. As such, masonry structures are more resistant to the impact of hailstones than wood-frame buildings. Figure 3 shows typical examples of hail damage to wall siding and windows.

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Figure 3. Examples of hail damage to wall siding and windows
(Top left) Hail damage to EIFS wall cladding; (top right) hail punctures in EIFS wall; (bottom left) hail impact marks to wood siding; and (bottom right) a windowpane broken by hailstones (Source: RICOWI, 2012; cropped by Verisk)

Apartment buildings tend to have a more diversified construction mix than single-family homes. In addition to wood and masonry, apartments may be comprised of reinforced concrete and steel. Unlike single-family or small multi-family houses, large apartment and condominium buildings frequently receive a degree of engineering attention like that given to commercial construction. Nevertheless, apartments and condominiums have exterior features, such as balconies, awnings, and sliding glass doors, that are less engineered at the design and construction stages and, thus, more vulnerable to damage, than the main building structure itself.

Typically, buildings built of certain materials have similar components regardless of occupancy type. For example, concrete structures typically have flat roofs with either a bitumen layer or built-up roofs, whose surfaces are generally resistant to hail but can be punctured or damaged by large hailstones. On the other hand, masonry and wood-frame buildings typically have sloped roofs with either asphalt shingles, metal, or clay tiles as the covering (Figure 4). Asphalt shingles are the least hail-resistant roofing material; hailstones of 1.0-inch diameter or greater generally result in roof covering damage. Hail resistance varies within the clay tile roof cover group. High-profile tiles (e.g., Spanish and terracotta tiles) can be quite brittle and may damage at lower hail intensities, while low-profile tiles are stronger and may begin to experience damage at higher intensities. Metal roofs can appear to only sustain cosmetic damage from dents and dings, but small cracks at the impact points can allow water to enter the building. Damage and scoring of the surface can also make a metal roof susceptible to rust.

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Figure 4. Examples of hail damage to roof covering
(Top left) Damaged asphalt shingle; (top right) broken cedar shake; (middle left) fractured tile; (middle right) dented metal roof; (lower left) damaged tile roof; and (lower right) fractured concrete tile (Source: RICOWI, 2012; cropped by Verisk)

For conventional buildings (e.g., residential housing or commercial buildings), most of the damage from hail is to roof tiles or shingles, wall claddings, and windows. Buildings built with bitumen layer and gravel roofs are resilient to hail damage, but large hailstones can puncture or damage the surface (Figure 5). Disruption of a gravel surface by large hailstones may leave it more vulnerable to later impacts and shorten its lifespan. While the building envelope is vulnerable to hail damage, damage to structural components (e.g., roof deck/sheathing, beams, or columns) is rare, even in severe hailstorms.

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Figure 5. Examples of hail damage to roof covering
(Left) Single-ply roof and (right) modified bitumen roof (Source: RICOWI, 2012; cropped by Verisk)

In the United States, the phrase "commercial buildings" is an umbrella term that includes many categories of structures, such as hotels, offices, and restaurants, to mention a few. As with residential buildings, construction materials used for commercial buildings vary regionally. Around the Gulf of Mexico, concrete, masonry, and light metal are often used, while steel and wood are more common along the East Coast. Low-rise commercial structures are generally similar to single-family homes, involving wood and masonry construction. Post-disaster surveys indicate that low-rise commercial wood-frame and masonry buildings have vulnerabilities like those of their residential counterparts because they are generally non-engineered. Large commercial buildings, while engineered, often have a large amount of external glass due to glass windows or cladding, which is quite vulnerable to hail damage.

Small industrial plants are assumed to consist of multiple sets of buildings with different construction types. Most of the equipment is located within the buildings of small industrial plants. Mid-rise and high-rise commercial and small industrial buildings are similar to large apartment buildings or condominiums and are generally made of reinforced masonry, concrete, or steel. These buildings typically follow stricter standards and are built under the supervision of an engineer (i.e., engineered structures), which makes them less vulnerable to hail damage than residential and low-rise commercial structures. Even though taller buildings tend to have flat roofs with various structures installed on them, overall damage ratios tend to be lower because the roofs and equipment comprise a smaller portion of the building replacement value than they would for low-rise structures.

2.2 Assessing Hail Damage at the Component Level

The severity of hail damage depends upon the impact energy of the hail, which depends mainly upon hailstone size and hailstorm duration. For that reason and the fact that hail reports are typically given in terms of hailstone size, it is useful to discuss hail damage in terms of hailstone size. In general, building roofs start to experience visible damage when

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hailstones approach quarter size (1.0 in.) in diameter, and significant property damage, mainly to the roof, usually occurs when hailstones are of golf-ball size (1.75 in.) or larger.

Size alone does not determine damage potential. Rather, damage from a hailstorm is determined by several factors, including the shape and density of the hailstones; the rate at which the hailstones fall; the concentration of the hailstones in the storm; and the storm's duration, path length, path width, wind speed, and wind direction. Larger hailstones generally create more damage than smaller stones because they can fall at higher speeds (up to 100 mph). In addition, compound damage can result when high winds drive hail to high velocities. These high winds can increase the kinetic energy of hailstones and blow them at angles significantly off the vertical, thus increasing the likelihood of damage to windows, skylights, cladding and rooftop equipment, wall siding, screens, doors, exterior insulating finishing systems (EIFS), downspouts, and vents. For these reasons, the hail energy calculation includes both a horizontal component, which is a function of wind speed, and a vertical component, which is a function of the hailstone's terminal velocity.

Verisk engineers developed a novel component-level hail vulnerability framework to account for the impact of primary and secondary risk characteristics to the hail vulnerability of a structure. This framework builds building-level damage estimations through the development and aggregation of a series of component-level vulnerability functions. The individual component-level damage functions were developed and aggregated to the system level by accounting for three primary factors: hail resistance, hail impact load modification, and component cost ratios (Figure 6). Hail resistance refers to the building component's strength as well as factors that improve or reduce material resistance to hail damage. Some hail resistance factors include roof age, material type, and impact rating. The hail impact load modification factor includes building features that modify the loads acting on a building, including roof geometry and pitch. Component cost ratios refer to the cost incurred to replace individual components and is a function of the building's height, square footage, geometry, and material cost. The component cost information was ultimately used to aggregate the component-level damage functions to obtain the building damage functions.

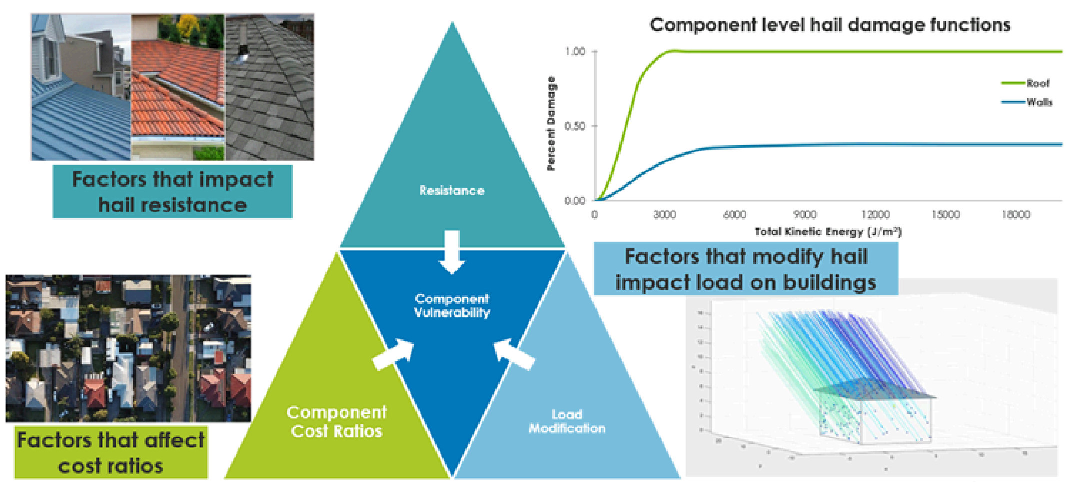

Figure 6. Component-level hail vulnerability framework
Source: Verisk

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In addition, different construction and occupancy types behave differently with respect to hail impact energy. As a result, Verisk developed different hail damage functions to account for these different primary and secondary characteristics. In addition to claims data, several key studies were used in building these functions. These key studies include:

- U.S. Insurance Institute for Business and Home Safety's (IBHS) study on the impact of hail on property damage (Brown and Pogorzelski, 2014; IBHS, 2004).
- Roofing Industry Committee on Weather Issues, Inc. (RICOWI) hail damage survey following the 2011 Dallas/Fort Worth, Texas hailstorm (RICOWI, 2012).
- Literature on hail damage to roofing, including the Underwriters Laboratory (UL) roof classes on impact resistance, FM Global standards, and Haag Engineering experiment (Crenshaw and Koontz, 2001; Marshall et al., 2002).
- Literature on hail damage to siding, including the Haag Engineering experiment (Herzog et al., 2012).
- Roofing Industry Committee on Weather Issues, Inc. (RICOWI) hail damage survey following the 2016 North Texas hailstorm (RICOWI, 2016).
- IBHS's first-ever indoor hailstorm experiment, conducted on February 20, 2013. This test, observed by Verisk engineers, has been used to better quantify the exacerbating effects of hail on the building envelope when hailstones are accompanied by strong wind. In addition, this realistic test demonstrated how key construction features, such as roof covers (non-impact versus impact resistance asphalt shingles), wall sidings (fiber-cement versus vinyl), and windows (vinyl versus aluminum), perform under a hailstorm with varying hailstone sizes.

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3 Secondary Risk Characteristics for Hail Damage

The first step in the development of vulnerability functions that account for hail SRCs is the identification of building and environmental characteristics that impact the performance of a building in a hailstorm. These features are selected based on fundamental engineering research and post-event damage surveys.

The SRCs for hail damage are listed in Table 1.

Table 1. Secondary Risk Characteristics (SRCs) for hail damage

Hail Damage Secondary Risk Characteristics (SRCs)	
Roof Covering	Wall Siding
Roof Deck	Wall Attached Structure
Roof Year Built	Glass Type
Roof Hail Impact Resistance	Glass Percentage
Roof Pitch	Window Protection
Roof Geometry	Certified Structures (IBHS)
Roof Attached Structure	

The following sections describe each SRC and explain the options available in Touchstone for its value. In addition, the *Touchstone Exposure Validation Reference*, available at www.unicede.com, provides:

- Validation rules for each location field in the Touchstone input file
- List of Verisk models to which each SRC applies

3.1 Roof Covering

The material used for a structure's roof covering has a significant impact on the roof's ability to resist hail damage. If the roof covering is damaged, then the building's interior and its contents become more vulnerable to significant water and wind damage.

Table 2 presents the valid options for Touchstone user-input values for roof covering materials supported in the Verisk Severe Thunderstorm Model for the United States.

Table 2. Valid options for roof covering materials in Touchstone

Value	Description	Details	Pictures
0	Unknown/ default	No designation/ unknown	

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Value	Description	Details	Pictures
1	Asphalt shingles	These shingles are among the most widely used roof coverings, especially for residential use, in the U.S. due to their relatively inexpensive up-front cost and fairly simple installation procedure. These shingles are made up of either an organic (cellulose, wood fiber, etc.) or a fiberglass base. One or both sides of the base are usually coated with asphalt or modified asphalt. An adhesive seal is then used to affix the shingles to the roof decking.	 **Figure 7. Example of asphalt shingles** Source: UIUC Arboretum 20070923 img 1927 by Dori, CC BY-SA 3.0
2	Wooden shingles	Wooden shingles and shakes are thin, tapered pieces of wood used to cover roofs. Shingles have a smooth and uniform look, while shakes have a split surface on the side facing the weather and are thicker than shingles. The wood cells are aligned with the surface of the shake, which creates a lateral surface with minimally-cut wood cells and, thus, decreases water penetration into this surface. Shingles and shakes can be installed on roofs over spaced sheathing or solid deck sheathing using nails (normally 2 ring-shank nails per shingle). Shingles must be a three-ply application; shakes may be a two- or three-ply application.	 **Figure 8. Example of wooden shingles** Source: Wood shingles by Malcolm Jacobson, CC BY-SA 2.0

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Value	Description	Details	Pictures
3	Clay/ concrete tiles	Tiles made of clay or concrete are among the most durable roofing materials, are naturally fire resistant, and offer a relatively high level of insulation. Their interlocking mode of installation coupled with their weight makes tiles stronger and less likely to blow away from the roof in comparison to shingles. The old-fashioned method of installation is to stack and overlap the pieces on top of each other in a waterfall format and use concrete mortar to hold them in place, but modern versions also include metal fasteners and horizontal battens. These battens and fasteners are designed to take the place of mortar and are mounted with special screws that have rubber seals to keep water from penetrating the hole. Mortar/foam is still widely used in the attachment of clay/concrete tiles.	 **Figure 9. Example of clay tiles** Source: Verisk
4	Light metal panels	Metal panels are long sheets of corrugated metal used as roof covers. They are watertight, durable, economical, and relatively easy to install. Metal panels are normally installed over plywood, wood roof decking, or intermittent supports, such as wood or metal purlins. They are installed using screws in the direction opposite the prevailing wind direction. Sealants are also used for roofs having pitches less than 3/12.	 **Figure 10. Example of light metal panels** Source: Verisk

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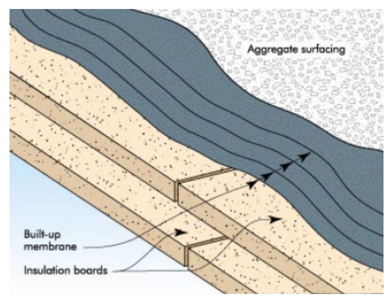
Value	Description	Details	Pictures
5	Slate	Slate roof tiles are relatively flat, easy to stack, heavy, and durable. Slate roof tiles are installed over a substrate normally made up of wooden boards, gypsum, or nailable concrete.	 **Figure 11. Example of slate roof tiles** Source: Roof slates by Øyvind Holmstad, CC0 1.0
6	Built-up roof with gravel	The built-up roof, sometimes called a tar-and-gravel roof, is the oldest and most common flat roofing system. These roofs are more common in commercial and industrial buildings than in residential structures. A built-up roof is made of successive layers of asphalt and roofing felts. After a base layer of roofing felt is installed, a coat of hot asphalt is applied. While the asphalt is still hot, a layer of felt is embedded, followed by another layer of hot asphalt. This layering process is repeated until the roof is built up to the desired number of layers or plies. A residential home can have three to five plies, four being typical. A flood coat of asphalt is spread on top of the final ply of felt. Gravel is then raked onto this coat while the asphalt is still hot. In addition to protecting the roof surface from the sun's ultra-violet radiation, gravel helps spread water across the roof and around the gravel, increasing the surface area for faster evaporation and more efficient drainage.	 **Figure 12. Example of a built-up roof with gravel** Source: FEMA, 1999; cropped by Verisk

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Value	Description	Details	Pictures
7	Single-ply membrane	Single-ply membranes are factory-manufactured sheet membranes that are categorized as either thermoplastic or thermoset. The membranes may contain reinforcement layers made of polyester fabrics or scrims, glass fiber, or a felt or fleece backing. The thickness of a finished sheet is referred to as its mil thickness, where 1 mil equals 0.001 inch. Common mil thicknesses for sheet membranes range from 30 mils to 60 mils. Single-ply membranes can be installed fully adhered, mechanically attached, or held down with ballast. Most single-ply roof systems are not surfaced.	 **Figure 13. Example of a single-ply membrane roof** Source: EPDM rubber roof - Halifax by Crownbuild; cropped by Verisk, CC BY-SA 3.0
8	Standing seam metal roofs	Standing seam metal roofs consist of continuous panels that run from the ridge of the roof down to the eaves. The seams between the panels are connected by fasteners that are raised or standing above the level of the metal roofing, as opposed to flush-mounted. An advantage of standing seam metal roofs is that the potential entry point for moisture is raised above the level of the roofing panels. Because the metal panels run unhindered from the top to the bottom of the roof, there are no horizontal seams, and the roof has a much smaller total number of seams. The roof panels are fastened onto the roof decking using seam fasteners.	 **Figure 14. Example of a standing seam metal roof** Source: Verisk

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Value	Description	Details	Pictures
9	Built-up roof without gravel	A built-up roof without gravel is identical to a built-up roof with gravel (see Value 6 above) except that gravel is not raked onto the top surface. The absence of gravel offers less protection to the roof surface from the sun's ultra-violet radiation.	 **Figure 15. Example of a built-up roof without gravel** Source: FEMA, 2006
10	Single-ply membrane ballasted	While stone ballasted single-ply membrane roofs superficially appear to be similar to built-up roofs, there are major differences. Both systems are topped with rocks, but built-up roofs have a thin layer of pea gravel or crushed stone, no larger than ¼-inch in diameter, partially embedded into the asphalt topcoat to protect it from the sun's ultra-violet rays. In a ballasted roof, the stones are much larger, at least 1-inch in diameter, and are applied much more heavily than in a built-up roof. The weight of the stone ballast holds the roof components in place. Ballasted roofs are loose-laid. As a result, the contractor can assemble all the components, including the thermal barrier and insulation, without fastening them to each other or to the roof deck. Membrane seams are sealed, and the waterproofing layer is secured both to the parapet and to roof penetrations, but they do not adhere to the roof deck nor to the layers beneath it. These roofs are more common in commercial and industrial buildings than in residential structures.	 **Figure 16. Example of a single-ply membrane ballasted roof** Source: FEMA, 2006; cropped by Verisk

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Value	Description	Details	Pictures
11	Hurricane wind-rated roof coverings	These roof coverings are used in hurricane-prone areas. Roof coverings that pass the American Society for Testing and Materials (ASTM) roof covering testing standards are considered to be hurricane wind-rated roof coverings. Any type of roof cover can be hurricane wind-rated if it is tested according to ASTM standards to withstand design wind speeds (110 mph and higher) in the regions where it is going to be installed, as mandated by the building codes. Therefore, Value 11 is not a special type of cover like asphalt, shingles, or tiles. Instead, it is a standard for existing roof covers in the market to meet certain criteria mandated by building codes.	 **Figure 17. Example of a standing seam roof that withstood Hurricane Andrew (1992) in Florida with estimated peak gusts of 170 mph** Source: FEMA, 2009  **Figure 18. Example of a typical roof in Bermuda** Source: Bermuda Roof, Bermuda by Acroterion, CC BY-SA 3.0

See Also
Hail Damage to Buildings

3.2 Roof Deck

A structure's roof deck material affects how well the roof deck holds up against hail damage. Roof decks transfer roof loads to the underlying joists and purlins. A damaged roof deck results in a breached building envelope, which causes significant building, contents damage, and business interruption/loss of use if water intrusion occurs.

Table 3 presents the valid options for Touchstone user-input values for roof deck materials supported in the Verisk Severe Thunderstorm Model for the United States.

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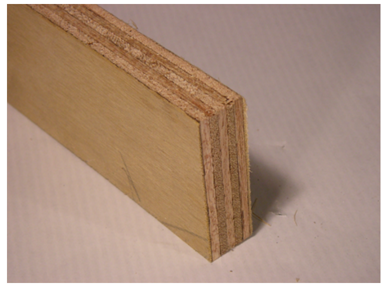
Table 3. Valid options for roof deck materials in Touchstone

Value	Description	Details	Pictures
0	Unknown/ default	No designation/ unknown	
1	Plywood	Plywood panels used for roof deck materials are standard 4-ft x 8-ft panels that come in various thicknesses, wood species, and qualities. They are generally used in frame construction for residences. Plywood roof decking is attached to trusses or joists by screws or nails.	 **Figure 19. Example of a plywood panel** Source: Plywood by Rotor DB, CC BY-SA 3.0

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Value	Description	Details	Pictures
2	Wood planks	Wood planks are a less common roof deck type. Some varieties, such as tongue and groove, interlock along the edge for added strength and water resistance. Each plank in the system requires fastening to the supporting truss, which increases the total number of fasteners and, therefore, increases the resistance to uplift forces generated during wind events.	 **Figure 20. Example of a wood plank ceiling** Source: Interior building details of Building D, Room D-101 partition wall with multi-pane wood sash, timber wood truss ceiling; northerly view - San Quentin State Prison, Building 22, Point San Quentin, San Quentin, Marin County, CA by Robert A. Hicks: cropped by Verisk, HABS CA-2804-A-127  **Figure 21. Example of tongue and groove wood planks** Source: Dusheme.jpg by Petko Yotov, CC BY-SA 3.0

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Value	Description	Details	Pictures
3	Particle board/ OSB	Particle board is made of compressed wood chips and shavings, which are mixed with synthetic resins and formed into a usable wood panel. Oriented Strand Board (OSB) is a similar wood product that is more common as an exterior wood construction material. OSB is generally cheaper and denser than standard plywood. Historically, OSB was susceptible to swelling and nail withdrawal when exposed to water. However, current treatment/ manufacturing processes have reduced this risk, making them comparable to plywood in terms of strength but at a lower cost.	 **Figure 22. Example of particle board** Source: Particle board close up-big-plane face PNr°0099.jpg by D-Kuru, CC BY-SA 3.0  **Figure 23. Example of Oriented Strand Board (OSB)** Source: Oriented strand board at Courtabœuf 2011.jpg by Lionel Allorge, CC BY-SA 3.0

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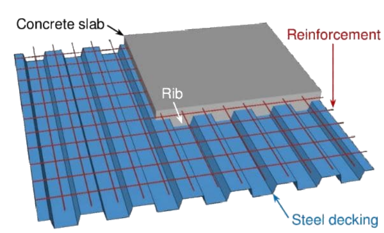
Value	Description	Details	Pictures
4	Metal deck with insulation board	This roof deck material is common in commercial construction, such as warehouses or retail establishments with flat roofs. Steel purlins or joists support a metal/steel deck. Insulation (foamed plastic or rigid) is added for climate control and fire resistance. The insulation is connected to the deck by means of adhesive epoxy or by mechanical attachment at the manufacturer-specified spacing. An optional barrier board is mechanically attached to the deck and covered by a metal roof cover.	 **Figure 24. Example of hurricane damage sustained by rigid insulation installed over a steel deck** Source: FEMA, 2007  **Figure 25. Close-up example of damage to insulation installed over a steel deck** Source: FEMA, 1999
5	Metal deck with concrete	Often referred to as a composite deck, metal decks with concrete are common in commercial steel frame construction. Metal purlins, trusses, or I-beams are connected to a metal deck by either welding or mechanical fasteners. Reinforced concrete is poured in place on the metal deck at a specified thickness. Lateral loads are transferred by shear studs, which are welded to the metal deck and underlying supports.	 **Figure 26. Example of light-weight concrete poured over a metal roof deck** Source: https://theconstructor.org/building/lightweight-concrete-floor-systems/27324/

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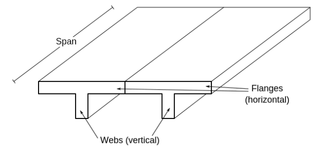
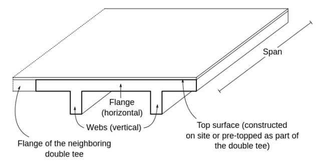
Value	Description	Details	Pictures
6	Pre-cast concrete slabs	Pre-cast roof panels are poured offsite and shipped to the jobsite during construction. These slabs are common in concrete commercial structures or in steel structures.	 **Figure 27. Diagram of a Single T pre-cast concrete slab** Source: Diagram of two T-beams.svg by Z22; edited by Verisk, CC BY-SA 4.0  **Figure 28. Diagram of a Double T pre-cast concrete slab** Source: Diagram of double tee.svg by Z22; edited by Verisk, CC BY-SA 4.0  **Figure 29. Example of precast concrete walls and roof** Source: Precastbuilding.jpg by A. Engel; cropped by Verisk, CC BY-SA 3.0  **Figure 30. Example of a precast hollow core plank being placed** Source: pannbetonFertigdecke Montage.jpg by M. Schmahl; cropped by Verisk, CC BY-SA 3.0

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Value	Description	Details	Pictures
7	Reinforced concrete slabs	Reinforced concrete slabs are similar to precast slabs but are poured at the jobsite. Reinforcements include steel rebar, wire mesh, or, in some cases, carbon/ steel fibers, which aid in resisting tension.	 **Figure 31. Example of rebar-reinforced concrete slabs under construction** Source: Suspended-slab-formwork.jpg by Bill Bradley/ billbeee, CC BY-SA 3.0
8	Light metal	A light metal deck does not include insulation or a composite concrete deck. A light metal deck can be attached to a steel framing system or to a timber frame system. These decks are typically used in agricultural buildings (e.g., poultry farm sheds) and in low-occupancy buildings (e.g., warehouses).	 **Figure 32. Example of light metal panels** Source: Verisk

3.3 Roof Year Built

This feature indicates the year in which the roof of the building was built or had a major renovation. Roofing elements lose their strength over time and become brittle and vulnerable to hail damage due to aging and regular wear and tear.

Table 4 presents the valid options for Touchstone user-input values for roof year built supported in the Verisk Severe Thunderstorm Model for the United States.

Table 4. Valid options for roof year built in Touchstone

Value	Description	Details	Notes
0	Unknown/ default		
<Y>	Year roof built	Year the current roof was installed.	Numeric value between 1,000 and the current year, inclusive.

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3.4 Roof Hail Impact Resistance

Hail impact-resistant roofs are made with roofing material that can withstand damage caused by hailstorms. These roofing materials are classified into one of four classes (A, B, C, or D) by Underwriters Laboratories (UL) based on their ability to remain undamaged after being struck by various-sized hailstones (i.e., the UL 2218 Impact Rating).

Table 5 presents the valid options for Touchstone user-input classes of roof hail impact resistance, as classified by UL, supported in the Verisk Severe Thunderstorm Model for the United States.

Table 5. Valid options for roof hail impact resistance in Touchstone

Value	Description	Details
0	Unknown/ non-impact resistant	Not impact-resistant/ unknown
1	Class A	Least impact-resistant. Roof material can withstand up to 1.25-inch diameter ice ball impact twice in the same spot.
2	Class B	Roof material can withstand up to 1.5-inch diameter ice ball impact twice in the same spot.
3	Class C	Roof material can withstand up to 1.75-inch diameter ice ball impact twice in the same spot.
4	Class D	Most impact-resistant. Roof material can withstand up to 2-inch diameter ice ball impact twice in the same spot.

3.5 Roof Pitch

A building's roof pitch is defined by its slope angle, which is a ratio of the roof's rise to the roof's run (Figure 33). Examples of various roof pitches are shown in Figure 34.

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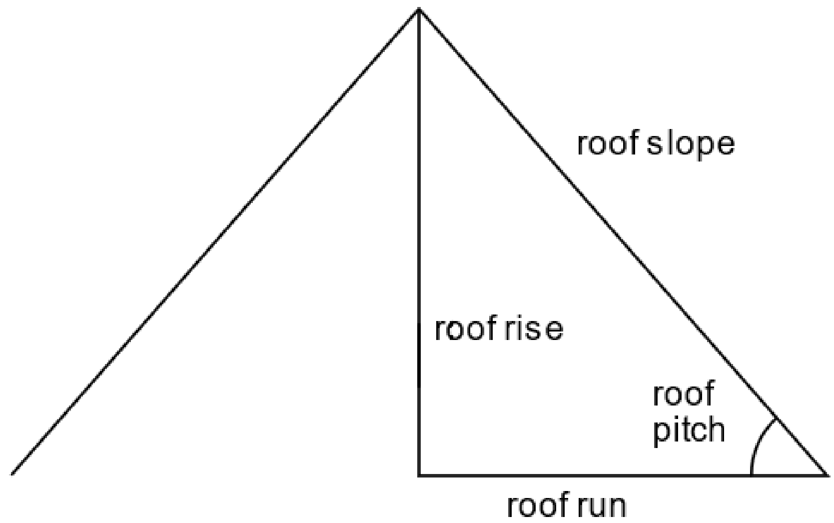

Figure 33. Schematic definition of a roof pitch
Source: Roof pitch.svg by Sarang; modified by Verisk, Public domain

Figure 34. Various roof pitches
Source: Example of Roof Pitches.jpg by Sean Reeves; modified by Verisk, CC BY-SA 3.0

Roof pitch is important when considering hail damage, as the resultant impact force on the roof covering is lower if the pitch deflects the hail. Depending on the horizontal component of the hail trajectory and the roof slope, the angle of hail impact can affect the loss experienced. In addition, as roof pitch increases, the area of the roof also increases (Figure 35), which correspondingly increases the roof's replacement cost.

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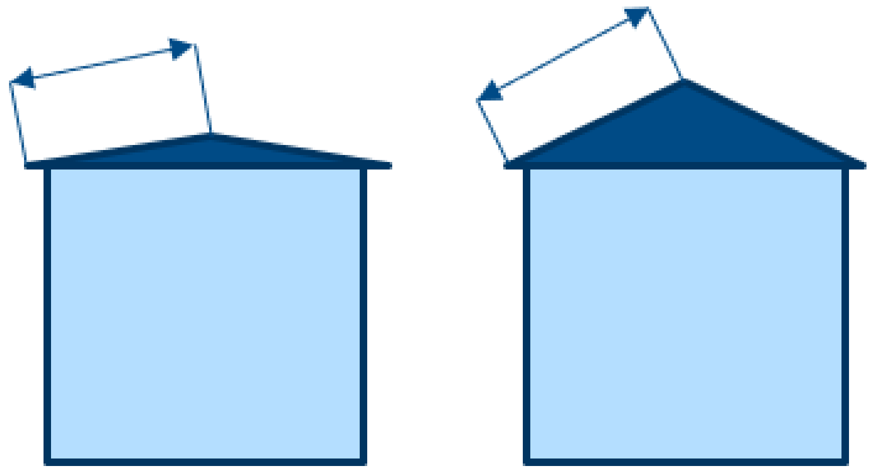

Figure 35. Impact of roof pitch on roof area
Source: Verisk

Regionally, areas in the United States that experience high snow loads tend to have steeper roofs to encourage snow to slide off and to prevent ice dam build-up, whereas areas that receive little or no snow have higher proportions of medium-pitched roofs.

Table 6 presents the valid options for Touchstone user-input values for roof pitch supported in the Verisk Severe Thunderstorm Model for the United States.

Table 6. Valid options for roof pitch in Touchstone

Value	Description	Details	Pictures
0	Unknown/ default	No designation/ unknown	
1	Low (<10°)	A low roof pitch has a slope of less than 10 degrees. It is essentially a flat roof.	 **Figure 36. Example of a flat/ low roof pitch** Source: Wright System3 Milw Apr09.jpg, Burnham Street District, Milwaukee; the original uploader was Freekee at English Wikipedia. Transferred from en.wikipedia to Commons by James Steakley using CommonsHelper, CC BY-SA 3.0

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Value	Description	Details	Pictures
2	Medium (10° to 30°)	Most residential buildings have a medium roof pitch, with a slope between 10 and 30 degrees, also represented as 3 in./12 in. (3-in. rise for every foot run) to 6 in./12 in. slopes.	 **Figure 37. Example of a medium roof pitch** Source: Apple Garage.jpg by Mathieu Thouvenin, CC BY-SA 2.0
3	High (>30°)	A high roof pitch has a slope of more than 30 degrees.	 **Figure 38. Example of a high roof pitch** Source: Oak Park Il Thomas Gale House2.jpg by IvoShandor, CC BY-SA 3.0

3.6 Roof Geometry

The shape of a roof has a significant effect on its vulnerability to hail damage because, similar to roof pitch, it affects the impact force on the roof covering and the resulting loss experienced.

Table 7 presents the valid options for Touchstone user-input values for roof geometry supported in the Verisk Severe Thunderstorm Model for the United States.

Table 7. Valid options for roof geometry in Touchstone

Value	Description	Details	Pictures
0	Unknown/ default	No designation/ unknown	

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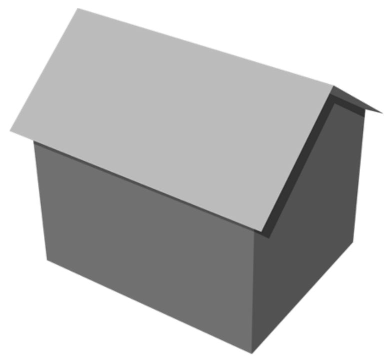
Value	Description	Details	Pictures
1	Flat	Flat or low-sloped roof	 **Figure 39. Example of a flat roof** Source: Flat roof.jpg by Wikiwikiyarou, CC BY-SA 3.0
2	Gable end without bracing	A gable roof is a two-sided sloped roof in which the sides meet at the center of the building. Each gable end (triangular portion of the wall that intersects with the roof pitch) is not laterally-braced in the framing system.	 **Figure 40. Example of a gable roof (in this case, the gable ends would NOT be braced)** Source: Gable roof.svg by Wikiwikiyarou; derivative work by Malyszkz, CC BY-SA 3.0

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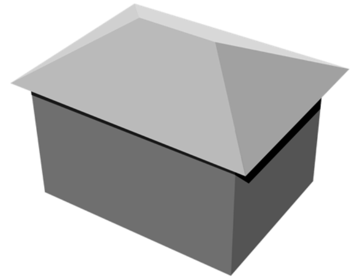
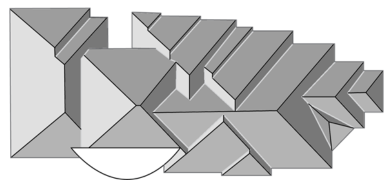
Value	Description	Details	Pictures
3	Hip	A hip roof is sloped in all directions from the eave to the ridge of each wall. The frame structure is laterally-braced in all directions.	 **Figure 41. Example of a hip roof** Source: Hip roof.svg by Wikiwikiyarou; derivative work by Malyszkz, CC BY-SA 3.0
4	Complex	A complex roof may include multiple hips, valleys, gable ends, or changes in direction. The complexity of a roof generally indicates professional attention and design. Typically, the framing system is laterally-braced and supported on multiple sides.	 **Figure 42. Example of a complex roof** Source: Verisk
5	Stepped	A stepped roof has multiple flat or low-sloped roof levels.	 **Figure 43. Example of a stepped roof** Source: Wright System3 Milw Apr09.jpg, Burnham Street District, Milwaukee; the original uploader was Freekee at English Wikipedia. Transferred from en.wikipedia to Commons by James Steakley using CommonsHelper, CC BY-SA 3.0

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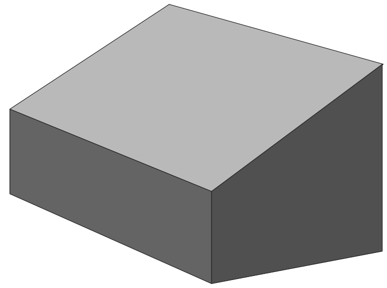
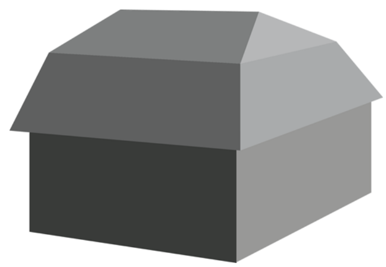
Value	Description	Details	Pictures
6	Shed	A shed has a mono-slope roof.	 **Figure 44. Example of a shed/ mono-slope roof** Source: Pultowa trecha.svg, Grafik from de_Wikipedia-Benotzer Shannon; derivative work by Malyszkz; colors edited and image rotated by Verisk, CC BY-SA 3.0
7	Mansard	A mansard roof is similar to a hip roof, but its slope is discontinuous from ridge to eave, becoming steeper halfway down. Mansard roofs often indicate livable attic space.	 **Figure 45. Example of a mansard roof** Source: Verisk

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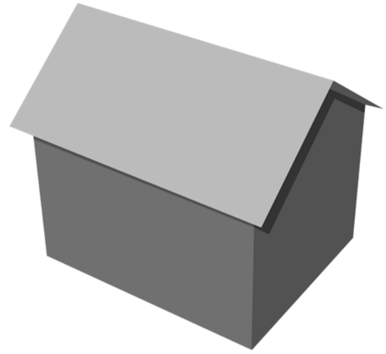
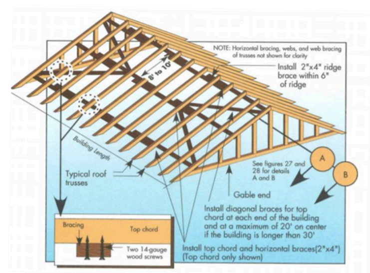
Value	Description	Details	Pictures
8	Gable end with bracing	A gable roof with bracing is a two-sided sloped roof in which the sides meet at the center of the building and are braced. Bracing is achieved by adding lateral support to the gable end truss or framing other than the roof sheathing. Bracing prevents toppling if the roof sheathing along the edge becomes compromised. The lateral support could be wooden bracing or mechanical bracing; it is usually cross bracing, illustrated in Figure 47. Continuous horizontal support and lateral blocking can be used to brace the end trusses together. This bracing greatly improves resistance to gable end failure, which has been consistently observed in post-damage surveys.	 **Figure 46. Example of a gable roof (in this case, the gable ends would be braced)** Source: Gable roof.svg by Wikiwikiyarou; derivative work by Malyszkz, CC BY-SA 3.0  **Figure 47. Detailed schematic of a gable roof with end bracings** Source: FEMA, 1992

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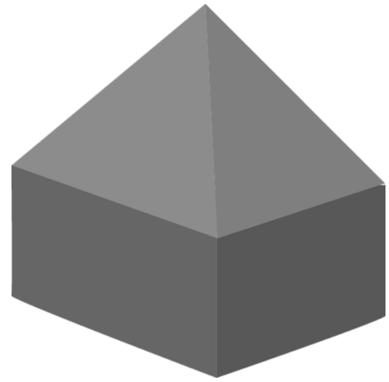
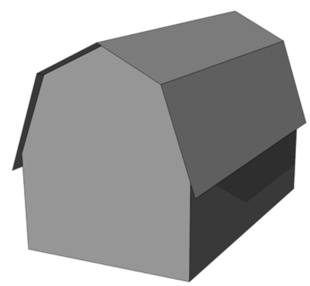
Value	Description	Details	Pictures
9	Pyramid	A pyramid roof is a higher-sloped roof that is similar to a hip roof but does not have a ridge. All slopes converge to a single apex.	 **Figure 48. Example of a pyramid roof** Source: Zeltdach.svg, by Shannon; derivative work by Malyszkz; colors edited and image rotated by Verisk, CC BY-SA 3.0
10	Gambrel	A gambrel roof is similar to a gable roof, but its slope is discontinuous from ridge to eave.	 **Figure 49. Example of a gambrel roof** Source: Drawing in perspective of gambrel-roofed building.svg by Fred the Oyster, CC BY-SA 4.0

3.7 Roof Attached Structure

Structures that are attached to a building's roof, such as mechanical equipment, may be more vulnerable to hail damage than the main building. Some roof attached structures may help protect the roof from damage.

Table 8 presents the valid options for Touchstone user-input values for roof attached structures supported in the Verisk Severe Thunderstorm Model for the United States.

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Table 8. Valid options for roof attached structures in Touchstone

Value	Description	Details	Pictures
0	Unknown/ default	No designation/ unknown	
1	Chimneys	A chimney is a primarily vertical flue that provides a path for smoke to be carried away through the roof or wall of a building. There is typically flashing around the connection between the chimney and the roof to prevent water intrusion.	 **Figure 50. Example of a chimney** Source: Chimney red.jpg by Jon Sullivan, Public domain
2	A/C units	A rooftop air conditioning unit is typical for commercial properties, and they are slowly becoming more popular for residential properties. These units are typically constructed around a framing system. Waterproof lids and additional sealing around joints limit water intrusion.	 **Figure 51. Example of a rooftop air conditioning unit** Source: Rooftop Packaged Units.JPG by P199, Public domain
3	Skylights	A skylight is a window installed in a roof or ceiling to allow daylight to enter the structure.	 **Figure 52. Example of a skylight** Source: Steel-and-glass-skylight-with-architectural-detail.jpg by Bill-in-SF, CC BY-SA 4.0

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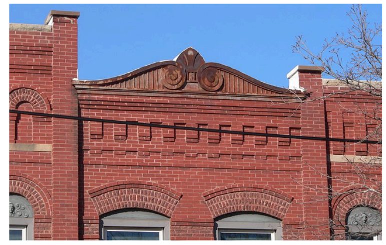
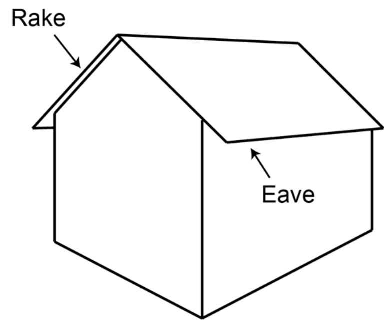
Value	Description	Details	Pictures
4	Parapet walls	A parapet wall is the part of a wall that is entirely above the roof line. They are located, for example, at the edge of a roof, terrace, balcony, or walkway. Parapet walls create a desired façade, hide rooftop equipment, and divert air flow over and away from the roof edge, among other functions.	 **Figure 53. Example of a parapet wall** Source: [Helmer-Winnett-White Flats parapet detail.JPG] by Ammodramus, [CC0 1.0]
5	Overhang/ Rake (8 - 36 in.)	An overhang, also called an eave, is the edge of the roof that extends beyond the face of a wall. Its purpose is to provide protection from the elements. If the overhang is on a gable end, it is called a rake. This option should be used for a structure with an overhang or rake that projects 8 - 36 inches from the edge of the vertical wall.	 **Figure 54. Example of a roof overhang and rake** Source: Verisk

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Value	Description	Details	Pictures
6	Dormers	A dormer is a structure that projects vertically beyond the plane of a pitched roof. Often, dormers contain vertical windows. Typically, they are used to increase the usable space in an attic or loft by adding headroom, light, or both, to the space.	 **Figure 55. Example of dormers** Source: Rangers' Club-5.jpg, by Almonroth; cropped by Verisk, CC BY-SA 3.0  **Figure 56. Example of a dormer** Source: Butte SS Peter-Paul school E dormer.JPG, by Ammodramus, CC0 1.0  **Figure 57. Example of dormers** Source: Cumberland dormers MD1.jpg, by Acroterion, CC BY-SA 3.0  **Figure 58. Example of eyebrow dormers** Source: Eyebrow dormers in Óbuda-Újlak.jpg, by Fekist, CC BY-SA 3.0

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Value	Description	Details	Pictures
7	Other	This option indicates roof attached structures not specifically listed in the other Roof Attached Structures options. Some examples include roof vents and ventilation fans.	 **Figure 59. Example of a roof vent** Source: FEMA, 2005  **Figure 60. Example of a roof vent** Source: Verisk
8	No attached structures	The roof does not have any attached structures.	 **Figure 61. Example of a building with no roof-attached structures** Source: OLD DEVONSHIRE CHURCH, DEVONSHIRE PARISH, BERMUDA.jpg by JERRYE AND ROY KLOTZ MD; cropped by Verisk, CC BY-SA 3.0

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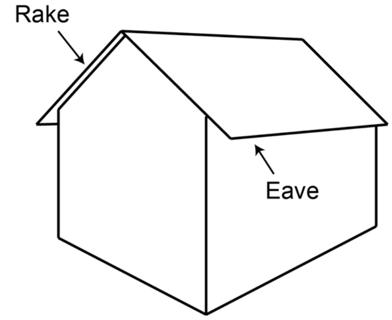
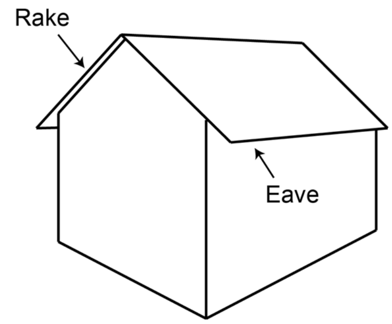
Value	Description	Details	Pictures
9	Overhang/ Rake (< 8 in.)	An overhang, also called an eave, is the edge of the roof that extends beyond the face of a wall. Its purpose is to provide protection from the elements. If the overhang is on a gable end, it is called a rake. This option should be used for a structure with an overhang or rake that projects less than 8 inches from the edge of the vertical wall.	 **Figure 62. Example of a roof overhang and rake** Source: Verisk
10	Overhang/ Rake (> 36 in.)	An overhang, also called an eave, is the edge of the roof that extends beyond the face of a wall. Its purpose is to provide protection from the elements. If the overhang is on a gable end, it is called a rake. This option should be used for a structure with an overhang or rake that projects more than 36 inches from the edge of the vertical wall.	 **Figure 63. Example of a roof overhang and rake** Source: Verisk

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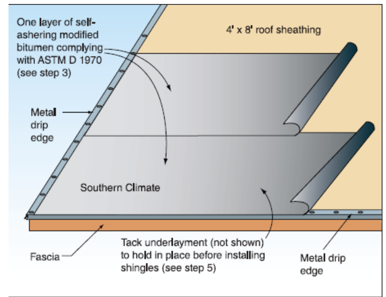
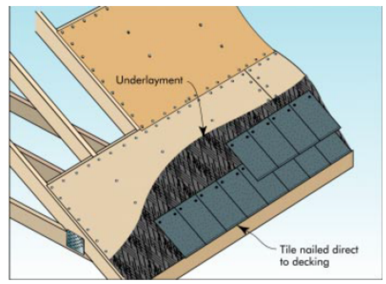
Value	Description	Details	Pictures
11	Waterproof membrane/ fabric	Waterproof membranes are waterproof plastic, rubber, or coated fabric membranes that are designed to be water resistant. They are used to prevent leaks and shed water from the roof of a structure. Waterproof membranes could be located underneath a protective topcoat or membrane and, therefore, hidden from view. Verbal confirmation from the building contractor, inspector, or owner might be needed to confirm their presence.	 **Figure 64. Schematic example of a waterproof roof membrane** Source: FEMA, 2010  **Figure 65. Schematic example of the layers of a waterproof roof membrane** Source: FEMA, 1999; cropped by Verisk

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Value	Description	Details	Pictures
12	Secondary water resistance	A secondary water-resistant barrier is typically a self-adhering modified bitumen underlayment that is applied directly to sheathing or a foam adhesive barrier. It must be covered with an approved underlayment system. The secondary water resistance is applied as a secondary means to protect the structure from water intrusion through the roof. These barriers are typically difficult to confirm because they are overlaid by roof covering, such as asphalt shingles or tiles.	 **Figure 66. Example of the installation of a water-resistant barrier** Source: FEMA, 2005; cropped by Verisk
13	No secondary water resistance	This option indicates that the secondary water-resistant barrier described by Value 12 is not present on the structure under consideration.	

3.8 Wall Siding

A building's wall siding protects the external walls from weathering, and different siding materials have varying degrees of resistance to hail damage. Wall siding and openings (e.g., windows) are quite susceptible to hail damage, particularly in the presence of strong winds or combined with a roof structure without a significant overhang. A breach in a wall siding can expose the wall to wind and rain, resulting in water intrusion and internal pressure buildup.

Table 9 presents the valid options for Touchstone user-input values for wall siding materials supported in the Verisk Severe Thunderstorm Model for the United States.

Table 9. Valid options for wall siding materials in Touchstone

Value	Description	Details	Pictures
0	Unknown/ default	No designation/unknown or no wall siding. Use this option if the exterior walls are painted or stained.	

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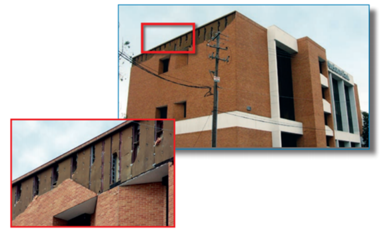
Value	Description	Details	Pictures
1	Veneer brick/ masonry	Brick or masonry veneer is predominantly a decorative feature and does not bear any structural load except its own weight. Generally, the veneer is attached to the main wall structure using wall ties, but reinforcement is not common.	 **Figure 67. Failure of brick veneer due to tie corrosion with no reinforcement - Hurricane Ivan, Florida, 2004** Source: FEMA, 2007
2	Wood shingles	Wood shingle siding is a versatile option that is used on a wide variety of building structures. Wood shingles are common in the Northeast United States.	 **Figure 68. Example of wood shingle siding** Source: Lech - Schindelfassade 01.jpg by Basotxerri; cropped by Verisk, CC BY-SA 4.0
3	Clapboards	Clapboards are long, thin, and flat pieces of wood or alternative material (e.g., fiber cement) that are used to cover the outer walls of buildings. The board edges overlap horizontally in series. Each board is nailed or fastened to the wall structure, which increases the strength when compared to larger, lighter weight aluminum or vinyl siding panels.	 **Figure 69. Example of clapboard siding** Source: Texture of Wooden Boards.jpg by Sadiq, CC BY-SA 3.0

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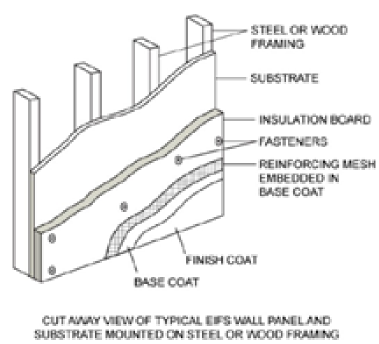
Value	Description	Details	Pictures
4	Aluminum/ vinyl siding	Aluminum/vinyl siding is relatively cheap and by far the most common siding type used in residential construction. It is a lightweight panel that interlocks to adjacent panels.	 **Figure 70. Example of vinyl siding** Source: [Middletown, CT - Main St 20.jpg] by Joe Mabel; cropped by Verisk, [CC BY-SA 3.0]
5	Stone panels	Stone panels are a decorative siding option that is similar to a veneer. They are applied to the main wall structure with plaster.	 **Figure 71. Example of stone panel siding** Source: [History of Stone Veneer.jpg] by c avery, [CC BY-SA 2.0]
6	Exterior Insulation Finishing System (EIFS)	Exterior Insulation Finishing System (EIFS) is a general class of non-load bearing building cladding systems that provides exterior walls with an insulated, water-resistant, finished surface in an integrated composite material system. EIFS can be attached by mechanical fasteners or by adhesive. EIFS is common in commercial applications, such as mid- or high-rise hotels and offices.	 **Figure 72. Schematic example of an EIFS wall panel** Source: FEMA, 2011

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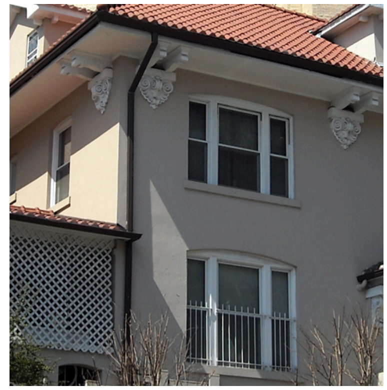
Value	Description	Details	Pictures
7	Stucco	Stucco is a very common exterior wall finish. It is a cement plaster that is usually applied on a metal mesh with a vapor barrier and attached to the main wall system. Wood-framed and masonry homes use stucco quite extensively.	 **Figure 73. Example of stucco siding** Source: 2112 19th Street, N.W..JPG by AgnosticPreachersKid; cropped by Verisk, CC BY-SA 3.0

3.9 Wall Attached Structure

A building may have objects physically attached to its exterior walls that are not an integral part of the main building structure. These attached structures are often more vulnerable to hail damage than the main building itself. The role of this SRC is to capture the impact of their presence on the damageability of the main building to which they are attached.

Table 10 presents the valid options for Touchstone user-input values for wall attached structures supported in the Verisk Severe Thunderstorm Model for the United States.

Table 10. Valid options for wall attached structures in Touchstone

Value	Description	Details	Pictures
0	Unknown/ default	No designation/unknown	

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Value	Description	Details	Pictures
1	Carports/ canopies/ porches	Carports, canopies, and porches have large surfaces that are exposed to hailstorms and can be damaged by hailstones.	 **Figure 74. Example of a carport** Source: Carport In Front Of Garages.jpg by Andreas -horn- Hornig; cropped by Verisk, CC BY-SA 3.0  **Figure 75. Example of a front porch** Source: John Smith House, Kingston, NY.jpg by Daniel Case; cropped by Verisk, CC BY-SA 3.0
2	Single-door garages	A garage that is part of the main wall structure is susceptible to hail damage. A single-door garage offers a smaller surface area than a double-door garage. Thus, hail damage to a single-door garage is generally less than hail damage to a double-door garage.	 **Figure 76. Example of a single-door garage** Source: Typical Colonial Hills Home.JPG by Georgeccampbell at en.wikipedia; cropped by Verisk, Public domain

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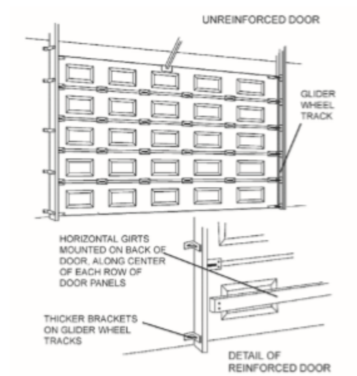
Value	Description	Details	Pictures
3	Double-door garages	Double-door garages are vulnerable to hail damage. Due to their greater surface area, double-door garages generally experience more hail damage than single-door garages.	 **Figure 77. Example of a double-door garage** Source: Apple Garage.jpg by Mathieu Thouvenin; cropped by Verisk, CC BY-SA 2.0
4	Reinforced single-door garages	Reinforced garage doors are susceptible to hail damage. A reinforced single-door garage offers a smaller surface area than a reinforced double-door garage. Thus, hail damage to a reinforced single-door garage is generally less than hail damage to a reinforced double-door garage.	 **Figure 78. Example of a reinforced garage door** Source: FEMA and the Texas Emergency Management Agency, 2008
5	Reinforced double-door garages	Double-door garages that are reinforced are vulnerable to hail damage. Due to their greater surface area, reinforced double-door garages generally experience more hail damage than reinforced single-door garages.	 **Figure 79. Example of a reinforced double-door garage** Source: Garage door opener.jpg by Oleg Alexandrov 21:31, 9 February 2008 (UTC), Public domain

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Value	Description	Details	Pictures
6	Screened porches/ glass patio doors	Screened porches are susceptible to tears or full failure during hailstorms. Glass patio doors are susceptible to cracks or breakage during hailstorms. In the event of a full failure of a screened porch or a glass patio door, the attached main building can also be damaged.	 **Figure 80. Example of a screened porch** Source: Cabin 4 First Landing enclosed porch (7815940856).jpg by Viginia State Parks staff, CC BY-SA 2.0
7	Balcony	Balconies are usually found on multi-story buildings and usually have an access point, such as a sliding door, to the main unit. The balcony and access point are both susceptible to hail damage.	 **Figure 81. Example of a balcony** Source: Modern Balcony.jpg by Squid22, CC BY-SA 4.0
8	No attached wall structures	A building with no wall attached structures has lower vulnerability to hail damage because there are no additional building components that could be susceptible to hail damage during a storm.	

3.10 Glass Type

Different types of glass have different levels of resistance to damage caused by hailstorms. This field describes the type of glass used in the building.

Table 11 presents the valid options for Touchstone user-input values for glass type supported in the Verisk Severe Thunderstorm Model for the United States.

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Table 11. Valid options for glass type in Touchstone

Value	Description	Details
0	Unknown/ default	No designation/unknown
1	Annealed	Annealed glass is the standard glass type for most windows in residential applications. It is susceptible to water ingress if breached.
2	Tempered	Tempered glass is made by heating and then force-cooling glass. This process makes it 4 – 5 times stronger than annealed glass. Tempered glass is susceptible to shattering under extreme loads or irregular stresses.
3	Heat strengthened	Heat-strengthened glass is made by heating and then slowly cooling glass. This process makes it 2 – 3 times stronger than annealed glass. When broken, heat-strengthened glass breaks into larger pieces than tempered glass.
4	Laminated	Laminated glass is a multi-layered product with a laminate interlayer. Although the window may crack under high loads, the glass remains in place, which is critical for reducing debris or water ingress after a breach caused by hailstorms.
5	Insulating glass units	Insulated units come in a wide variety of thicknesses, strengths, and layers. Generally, an insulated unit is a double-glass pane separated by an air space, which helps regulate temperature in the building. These units are more common in colder climate regions because they are predominantly an energy-saving measure as opposed to a hail-resistance measure.

3.11 Glass Percentage

This entry represents the percentage of a building's wall area that is covered with glass. In general, walls with greater percentages of glass are more vulnerable to hail damage. The exception being when glass elements perform better than siding elements with respect to hail resistance. In this case, the building envelope is more resilient to hail damage because glass area and siding area are inversely related.

Table 12 presents the valid options for Touchstone user-input values for glass percentage supported in the Verisk Severe Thunderstorm Model for the United States.

Table 12. Valid options for glass percentage in Touchstone

Value	Description	Details	Pictures
0	Unknown/ default	No designation/unknown	

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Value	Description	Details	Pictures
1	Less than 5%	Less than 5% of the wall is made of glass.	 **Figure 82. Example of a building's wall that is comprised of less than 5% glass (red box)** Source: Nuernberg Schauspielhaus.jpg by Andreas Praefcke; edited by Verisk, CC BY-SA 3.0
2	Between 5% and 20%	Between 5% and 20% of the wall is made of glass.	 **Figure 83. Example of a building's wall that is comprised of 5-20% glass** Source: Residential building with decor windows. Wood Gate. Monument ID 1478 - Budaörs, Szabadság Rd 102.JPG by Globetrotter19, CC BY-SA 3.0

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Value	Description	Details	Pictures
3	Between 20% and 60%	Between 20% and 60% of the wall is made of glass.	 **Figure 84. Example of a building's wall that is comprised of 20-60% glass** Source: Verisk
4	Greater than 60%	More than 60% of the wall is made of glass.	 **Figure 85. Example of a building's wall that is comprised of more than 60% glass** Source: Z glass wall Copenhagen.jpg by Øyvind Holmstad, CC BY-SA 4.0

3.12 Window Protection

This feature indicates a structure's type of window protection, if any. Generally, window protection is installed prior to hurricanes; it is not common that these systems are put in place during severe thunderstorms due to little or no advanced warning. However, if window protection is installed, it can reduce the potential hail damage to a building during a severe thunderstorm event.

Table 13 presents the valid options for Touchstone user-input values for types of window protection supported in the Verisk Severe Thunderstorm Model for the United States.

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Table 13. Valid options for types of window protection in Touchstone

Value	Description	Details	Pictures
0	Unknown/ default	No designation/unknown	
1	No protection	Unprotected windows are susceptible to hail impacts, including dents, cracks, and breaks. Breached windows could lead to water and/or moisture intrusion, further damaging a building and/or its contents.	 **Figure 86. Example of an unprotected glass house** Source: Case Study House No. 22.JPG by Ovs at English Wikipedia, Public domain
2	Non-engineered shutters	Non-engineered shutters have not been certified to comply with the missile impact tests described below for Value 3: Engineered shutters. Non-engineered shutters include plywood or any barrier that does not have a certified stamp indicating that the shutter complies with the tests described below.	 **Figure 87. Example of non-engineered vinyl shutters** Source: An example of a 1930s Colonial Revival in Forest Hills.jpg by Eastward Gypsy, CC BY-SA 4.0

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Value	Description	Details	Pictures
3	Engineered shutters	Engineered shutters have been certified to meet the following criteria of the International Building Code (IBC) Section 1609.1.2 (2010) or the equivalent testing protocols, such as those in the Florida Building Code (FBC): “Glazed opening protection for wind-borne debris shall meet the requirements of the SSTD 12, ASTM E 1886 and ASTM E 1996, or TAS 201, 202 and 203 or AAMA 506 referenced therein.”	 **Figure 88. Example of an aluminum steel-engineered hurricane shutter** Source: Panel.jpg, Public domain

3.13 Certified Structures (IBHS)

The Certified Structures (IBHS) secondary feature may be used to indicate that the structure has received one of the IBHS FORTIFIED certifications of Roof, Silver, Gold, or FORTIFIED for Safer Home or Business for the High Wind or Hurricane FORTIFIED Standards. To receive a certification at a particular level, the structure must meet minimum requirements specified at that level of mitigation. This secondary feature should only be used for structures whose certification can be verified.

Verisk engineers worked with IBHS to understand the FORTIFIED requirements and assess the appropriate secondary risk characteristic options that should be invoked when a particular IBHS FORTIFIED level is applied. Thus, when a user invokes the Certified Structures secondary risk characteristic, all SRCs associated with that level of certification are automatically enabled in the software.

The IBHS FORTIFIED designations considered within this secondary risk characteristic specifically address construction measures related to mitigating damage from **wind and wind-driven rain**. However, certain wind-related FORTIFIED mitigation measures involve SRCs that can have an impact on the hail resistance of the risk. Therefore, invoking this SRC will automatically reflect the same features in the hail framework and ensure consistency between structures considered across all perils.

Note that it is also possible to obtain a FORTIFIED Hail designation in addition to the wind-related designation. If a risk has an additional hail designation, it is suggested that the user enable both the wind-related designation level through this SRC and the “Roof Hail Impact Resistance” SRC using the “Class D” roof covering rating.

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Table 14 presents the valid options for Touchstone user-input values for types of Certified Structures (IBHS) supported in the Verisk Severe Thunderstorm Model for the United States. More information on FORTIFIED requirements are available here:

- FORTIFIED Home: https://fortifiedhome.org/
- FORTIFIED Commercial: https://fortifiedcommercial.org/

Table 14. Valid options for types of Certified Structures (IBHS) in Touchstone

Value	Description	Details
0	Unknown/ default	Unknown
1	FORTIFIED (IBHS) Bronze Option 1	Structure certified to old “Bronze” or new “Roof” designation
2	FORTIFIED (IBHS) Bronze Option 2	Structure certified to old “Bronze” or new “Roof” designation
3	FORTIFIED (IBHS) Silver Option 1	Structure certified to “Silver” designation
4	FORTIFIED (IBHS) Silver Option 2	Structure certified to “Silver” designation
5	FORTIFIED (IBHS) Gold Option 1	Structure certified to “Gold” designation
6	FORTIFIED (IBHS) Gold Option 2	Structure certified to “Gold” designation
7	FORTIFIED for Safer Living or Business	Structure certified to “FORTIFIED for Safer Living” or “FORTIFIED for Safer Business” designation

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Verisk Analytics (Verisk) provides risk modeling solutions that make individuals, businesses, and society more resilient to extreme events. In 1987, a Verisk subsidiary founded the catastrophe modeling industry and today models the risk from natural catastrophes, terrorism, pandemics, casualty catastrophes, and cyber incidents. Insurance, reinsurance, financial, corporate, and government clients rely on Verisk's advanced science, software, and consulting services for catastrophe risk management, insurance-linked securities, longevity modeling, site-specific engineering analyses, and agricultural risk management. Verisk (Nasdaq:VRSK) is headquartered in Jersey City, New Jersey with many offices throughout the United States and around the world. For information on our office locations, visit https://www.verisk.com/about/locations/.

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