IBHS RESEARCH

Cedar Rapids, Iowa and the 2020 Midwest Derecho

The Performance of Asphalt Shingle Roofs in Extreme Severe Convective Storm Winds

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Acknowledgements

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Executive Summary

The derecho windstorm of August 10–11, 2020 was the most prolific single severe convective storm event of 2020. It caused between $7 and $10 billion in total insured losses. Impacts were felt across multiple states from Nebraska to Indiana[1]. The cluster of thunderstorms and associated extreme outflow winds traveled more than 750 miles over 12 hours. Some of the most widespread and severe property damage occurred in Cedar Rapids, Iowa from the magnitude and duration of the straight-line winds.

The performance of asphalt shingle roofs in high winds is a dominant driver of loss in any windstorm. However, most of the research into the wind performance of asphalt shingles has centered on their performance in hurricanes. The 2020 derecho event offered an opportunity to explore asphalt shingle performance and how it evolves with roof age from a damaging straight-line severe convective storm wind event.

High-resolution aerial imagery courtesy of the Geospatial Insurance Consortium (GIC) Gray Sky program was used to assess asphalt shingle roof cover performance across 680 single-family homes in four different areas of Cedar Rapids. The four areas experienced a range of peak estimated winds from 80 mph to 120 mph. Estimated roof age was assigned using data from multiple sources including building permit data, historical aerial imagery, and real estate databases. In addition, claims information from two IBHS Member companies was applied to help understand loss characteristics, identify which building components beyond the roof were driving loss, identify the presence of water intrusion due to damaged roof cover, and to compare with other severe convective storm hazards such as hail.

derecho
A large fast-moving complex of thunderstorms with powerful straight-line winds that cause widespread destruction.

Specifically, any family of particularly damaging downburst clusters produced by a mesoscale convective system. Such systems have sustained bow echoes with book-end vortices and/or rear-inflow jets and can generate considerable damage from straight-line winds.

Damage must be incurred either continuously or intermittently over a swath of at least 650 km (~400 mi) and a width of approximately 100 km (~60 mi) or more.

The term *derecho* derives from a Spanish word that can be interpreted as "straight ahead" or "direct" and was chosen to discriminate between wind damage caused by tornadoes, which have rotating flow, from straight-line winds.

[1] Loss estimates sources: SwissRe, AON

The key results from this study are:

- Almost 1 in 5 asphalt shingle roofs in Cedar Rapids suffered damage during the 2020 derecho.
- Asphalt shingle performance declined with roof age. A statistically significant increase in asphalt shingle roof cover damage was found for asphalt shingle roofs from seven to eight years old and from nine to ten years old. The probability of visible damage for an asphalt shingle roof older than ten years was approximately 25% compared to 5% for a 3- to 6-year-old roof. This outcome was nearly identical to that observed in the Kovar et al. (2022) [2] post-Hurricane Laura (2020) study.
- Total asphalt shingle roof cover loss greater than 25% was less widespread than observed in the Kovar et al. (2022) study. Factors influencing the differences in results include less severe wind exposures, shorter duration of high winds, and the possible influence of different climate zones on asphalt shingle performance.
- For the surveyed area with the most severe wind exposure (maximum gusts estimated near 120 mph and open upstream terrain exposure), the probability of detectable damage was close to 50%. This neighborhood had a mean roof age of approximately 9 years.
- Water intrusion, while not common, was a loss amplifier. When water intrusion was noted, roof cover damage always exceeded 25%. When water intrusion was present, total losses were four to seven times higher than the mean claim for homes without water intrusion damage.
- Loss of underlayment leading to an exposed roof deck was not common (found on only 11 homes), which could have reduced the potential for water intrusion.
- When damage to shingles was visible in aerial imagery, the probability of a claim was 100%. However, the probability of detecting all claims through aerial imagery was 73% due to damage to garage doors, siding, and other components that are more difficult to assess using aerial imagery.
- The average claim value was approximately $13,900 with a mean ratio of loss to Coverage A limit of 7.5%. The average loss ratio was approximately 2.5% greater than that observed on asphalt shingle roofs from a Dallas-Fort Worth hail event studied by IBHS[3].
- Damage to siding was the second highest building component loss driver behind asphalt shingle damage.

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[2] Kovar, R., F. Lombardo, T.M. Brown-Giammanco, M. Morrison, and I.M. Giammanco, 2022: The effect of roof age on asphalt shingle performance: Hurricane Rita to Hurricane Laura, *Insurance Institute for Business & Home Safety*, 20 pp.

[3] Brown, T.M., W.H. Pogorzelski, I.M. Giammanco, 2015: Evaluating hail damage using property insurance claims data. *Wea. Clim. Soc.*, 7, 197-210. https://doi.org/10.1175/WCAS-D-15-0011.1

Introduction

Almost 75% of single-family homes in the United States have an asphalt shingle roof covering, and the poor wind performance of asphalt shingles is one of the largest drivers of windstorm losses in North America. Unfortunately, standardized testing and the associated product approval ratings for asphalt shingles have shown little relevance to real-world performance. Past studies of asphalt shingle performance have been mostly confined to post-event assessments from landfalling tropical cyclones using both ground and aerial image-based surveys (McDonald and Smith, 1990; Smith, 1995; FEMA, 2005; RICOWI, 2006; Liu et al., 2010; Kovar et al., 2022). Exploring this body of work, the performance of asphalt shingles is still a major problem and has shown no evidence of improvement over the past three decades.

Early studies from post-storm ground surveys showed the performance problems of asphalt shingles but quickly attributed the lack of performance to issues with poor installation and inadequate fastening of the shingles to the underlying roof deck. However, two foundational studies that focused on exploring how shingle sealants perform changed the view of shingle vulnerabilities. Dixon et al. (2012) and Dixon et al. (2014) were able to tie the primary wind vulnerability of asphalt shingle to whether or not the shingles were fully sealed to the underneath tab. Building upon this work, Kovar et al. (2022) clearly showed that the age of an asphalt shingle roof was the best predictor of performance with secondary dependences on building attributes (i.e., roof shape, orientation relative to peak winds, and number of stories). Coupling this emerging research with the experimental testing of Dixon et al. (2012) and Dixon et al. (2014), the performance of the shingle sealant compounds became the primary suspect in understanding why asphalt shingles were continuing to show poor windstorm performance, despite many carrying the highest wind ratings from standardized tests.

The Dixon et al. (2014) study found that typical asphalt shingles in a southern United States climate remain well sealed for their first four to five years, but then the sealant performance began to decline, and tabs became unsealed. The result was validated by the post-Hurricane Laura forensic study, Kovar et al. (2022), which found a decline in shingle wind performance by 5 years of age and an acceleration in degradation by 7 years. Once asphalt shingles reached at least 10 years of age, in the regions affected by Hurricane Laura (2020), there was a near 100% probability a roof had damage detectable from aerial imagery. Unfortunately, over the past three decades, both research and changes to standardized testing methods had focused on the installation methods and the characteristics and patterns of fasteners (i.e., nails). During this time, eighteen modifications to the ASTM consensus test standards for the wind performance of asphalt shingles—ASTM D7158 and ASTM 3168—were made that were focused on diagnosing fastener strength, while only one modification to ASTM D6381 addressed sealant performance.

Over their lifespan, asphalt shingles are exposed to day-to-day weather conditions and severe storms. It is hypothesized that this exposure, or natural weathering, weakens the sealant bond between shingle tabs, leading to its failure. Over time, the sealant can no longer adhere the two layers of material together leading to an increase in its vulnerability to high winds. Data collected by the IBHS roof material aging facilities has shown that shingle temperatures can vary over the course of a day by over 100°F and even passing clouds or precipitation can result in 50°F temperature swings within the span of a few minutes, shown in Figure 1. The exposure to these natural cycles and its effect on the material properties of the sealant and the shingle may be the cause of shingles unsealing. Due to these factors, it is postulated that a region's climate zone could play a role in the sealant failures and therefore the vulnerability of asphalt shingles to high winds. Other visible effects of weathering commonly seen on asphalt shingles are deformities such as blistering and cupping at shingle edges.

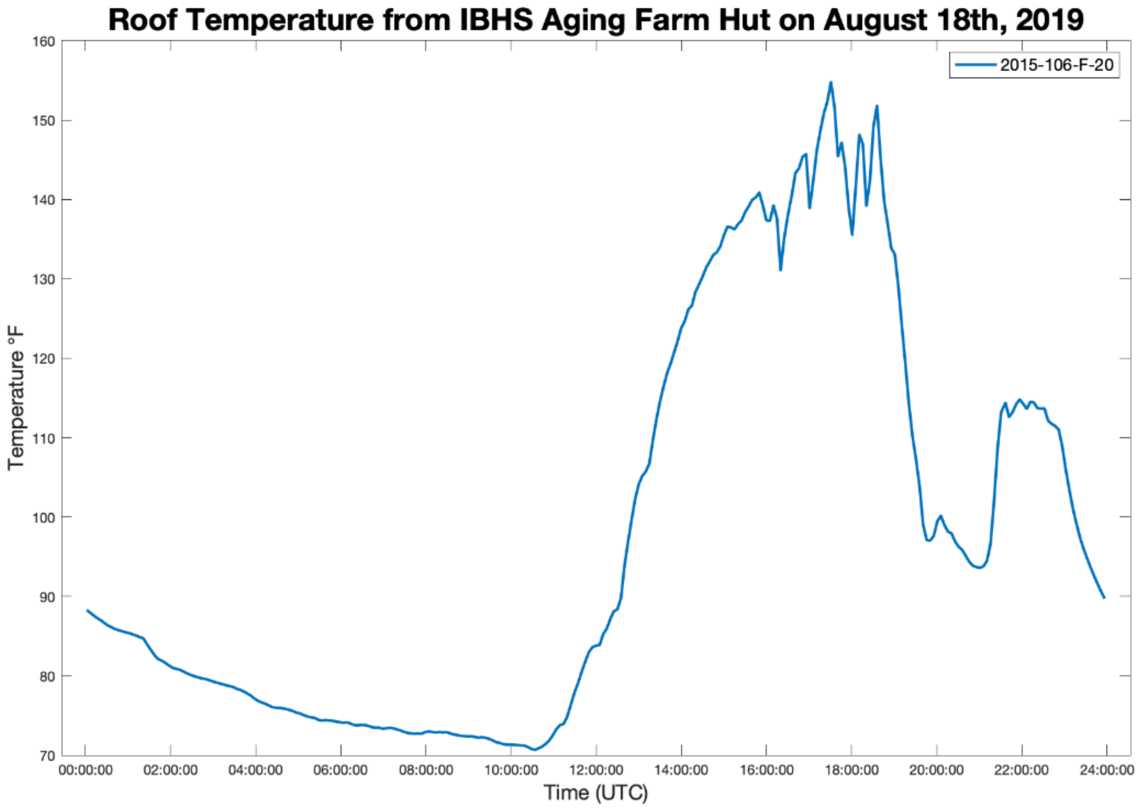

Figure 1: Example aging farm time history temperatures from August 18, 2019 showing the temperature swings experienced by an asphalt shingle roof.

Past observational studies of the wind performance of asphalt shingles have focused on hurricanes in traditional low-latitude climates. To date, there has not been an observational study on asphalt shingle performance in a severe convective storm event such as a derecho. The methodology used by Kovar et al. (2022) was directly applied to explore asphalt shingle performance and how it changes with roof age following the 2020 Midwest Derecho.

August 10–11, 2020 Midwest Derecho

The cluster of thunderstorms, which would later be classified as a derecho, developed during the morning hours of August 10 in extreme southeast South Dakota and northeast Nebraska. An enhanced risk for severe weather was in place prior to the morning of August 10 and was upgraded to a moderate risk of severe weather by 11 a.m. CDT (1600 UTC) by NOAA's Storm Prediction Center (SPC). As thunderstorms developed, a Particularly Dangerous Situation (PDS) Severe Thunderstorm Watch was issued, owing to the extreme environment that had developed and was highly supportive of a long propagating line of storms with potentially destructive winds. The cluster of storms quickly matured and produced its first severe wind reports as it moved into Iowa between 8 a.m. and 9 a.m. CDT (1300 and 1400 UTC). A composite of the derecho and its wind reports are shown in Figure 2.

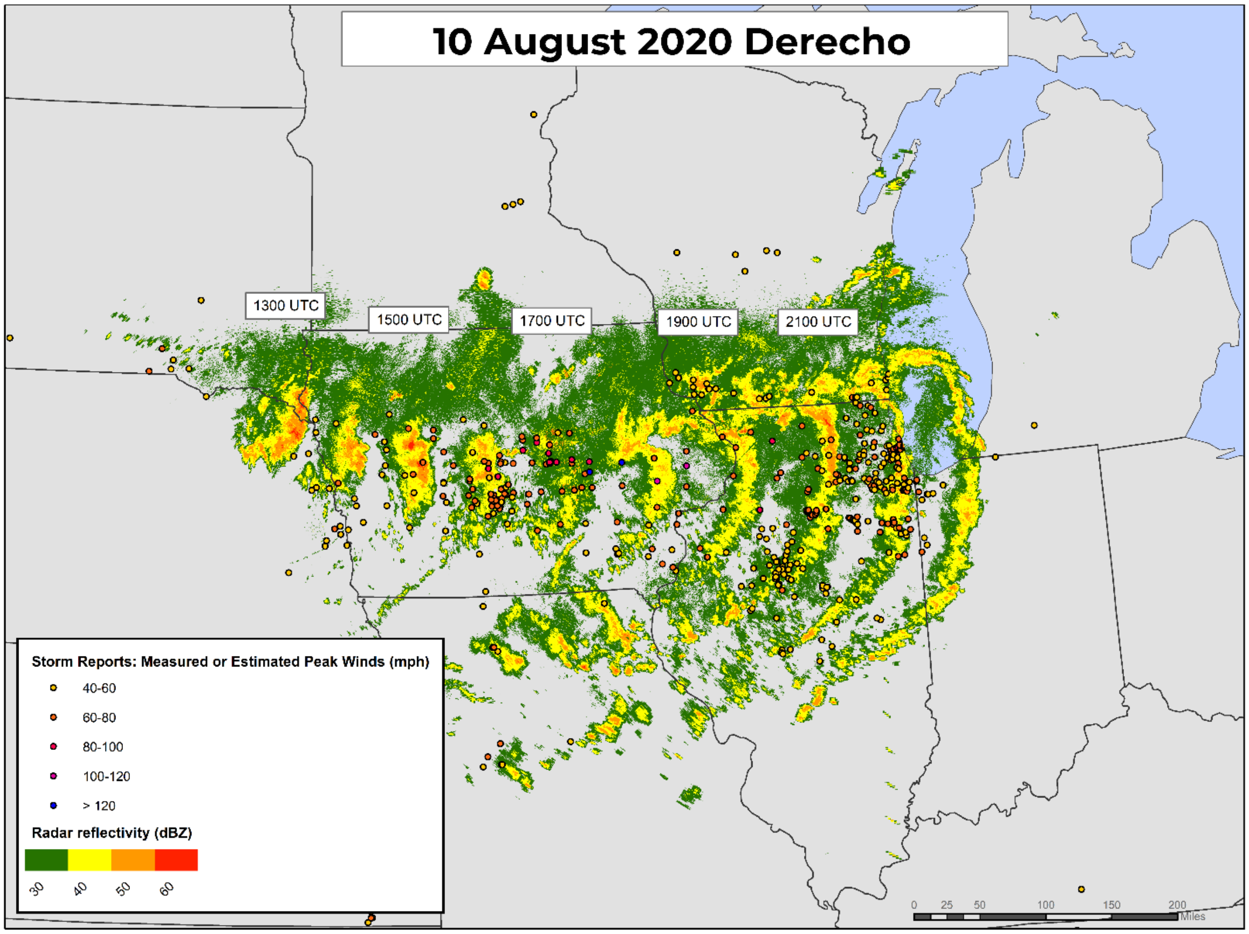

Figure 2: Radar composite, at selected times, and storm reports from the August 10–11, 2020 derecho event.

The line of storms intensified as it progressed across Iowa, producing a large number of severe wind reports. By approximately 11 a.m. CDT (1600 UTC), the Marshalltown Airport Automated Surface Observing Station (ASOS) recorded a gust of 99 mph. The line of storms continued to intensify as it reached Cedar Rapids, Iowa by approximately 1 p.m. CDT (1800 UTC), and it is estimated that the system reached its peak intensity (as estimated by damage and peak wind speeds produced).

As the leading edge of the line of storms reached Atkins, Iowa, just west of Cedar Rapids, a personal weather station recorded a wind gust of 126 mph. This observation would be the maximum observed wind speed for the entire event. After passing Cedar Rapids, the line of storms expanded in geographic coverage with a well-defined "bookend" vortex structure and extending line of storms to its south (Figure 2). By 7 p.m. CDT (0000 UTC), the line of storms had reached the Chicago metropolitan area and began to move into Indiana. While the severity of wind gusts had subsided by this time, the geographic coverage had increased substantially.

Over the course of August 10, the line of storms produced over 400 severe wind reports and two confirmed tornadoes. The event easily met derecho criteria. Substantial agricultural crop and infrastructure damage, especially to grain bin facilities, was reported along the entire path of the derecho (Figure 3). The most intense building damage occurred in Cedar Rapids as the derecho passed over this area at its peak intensity. The most severe damage observed was to an apartment complex in Cedar Rapids, as its roof system failed leading to an inward collapse of the exterior second floor walls.

The National Weather Service (NWS), using the EF scale to assess the damage, estimated peak gust wind speeds approaching 140 mph; however, Doppler radar-based estimates produced for this study suggest slightly lower peak gust winds. It was likely that the derecho produced localized areas of wind gusts that exceeded the design level for even the most-current building design standards at the time of the event (ASCE 7-16). NOAA estimated the total losses were about $11 billion making this derecho event the costliest US severe convective storm event on record.

Figure 3: Severe damage to agricultural grain bins near Cedar Rapids, Iowa. Photograph courtesy of the National Weather Service Forecast Office - Des Moines, Iowa, and the NOAA Damage Assessment Toolkit.

Data and Methodology

The severity of building damage in Cedar Rapids from the derecho prompted the Geospatial Insurance Consortium (GIC) to collect post-event aerial imagery across the city through their Gray Sky post-natural disaster imagery program. Aerial images (nadir, 15 cm resolution) were collected five days after the derecho affected Cedar Rapids. This imagery enabled the analyses presented in this study. Additional datasets such as building permit information, historical Digital Globe satellite imagery, and real estate databases were used to determine the building and roof ages. Estimated maximum wind gusts for areas surveyed were estimated using the KDVN NWS WSR-88D Doppler radar data.

Aerial Imagery Damage Assessment

The GIC Gray Sky aerial imagery dataset was used to select the areas of focus for this study. Four areas with predominantly asphalt shingle roof covers were surveyed. These areas had a variety of building ages and represented typical single-family home construction. The locations of the four areas surveyed are shown in Figure 4Figure 3. The analysis presented here represents a survey of 680 homes using the methodology of Kovar et al. (2022) to compile the following information:

- What was the roof shape? (e.g., hip, gable, or complex)
- Was structural damage visible?
- Was roof cover damage visible?
- What was the percentage of roof cover damage (>0%–100%)
- Was the roof deck exposed?
- Was there tree damage that affected the roof?
- Was there evidence of water intrusion damage? (i.e., interior home debris at the street)

This information was compiled for each home manually using the aerial imagery dataset imported into the Google Earth platform. An example of the GIC Gray Sky imagery is shown in Figure 5. For each surveyed home, its latitude and longitude were captured at the centroid of the roof. For homes in which temporary repairs had already been put in place (e.g., blue tarps, use of membrane to cover damaged shingles), the percentage of roof cover damage was estimated as the coverage of the material used to cover the damaged shingles. While this likely overestimated of the true damage state, it was important to maintain a consistent and objective method.

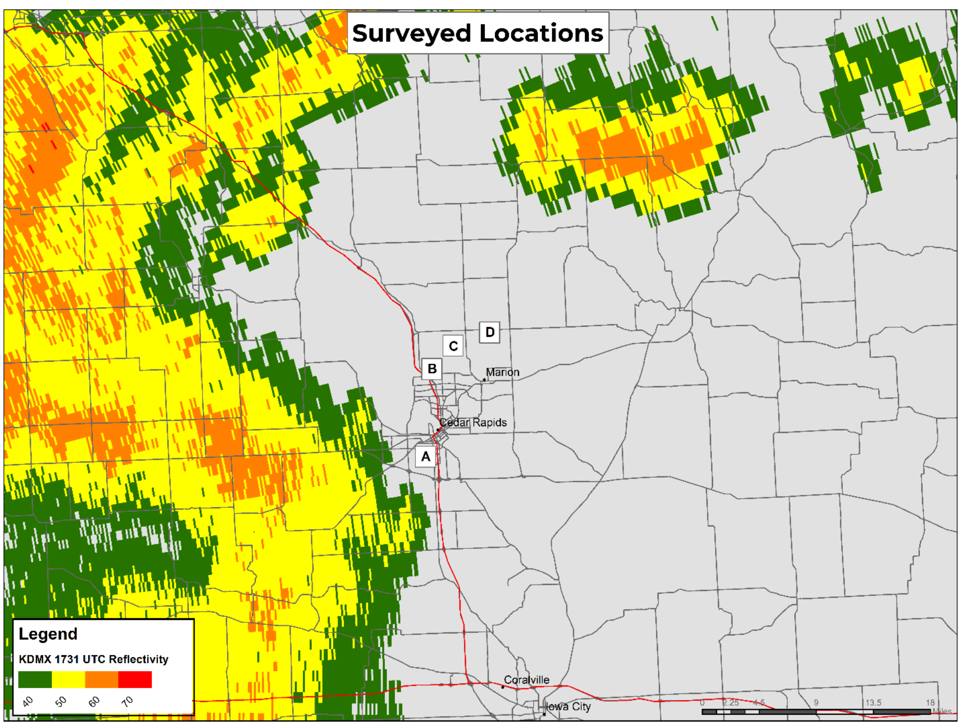

Figure 4: Map of the four surveyed locations (A, B, C, and D) and the 1731 UTC KDMX radar reflectivity as the derecho approached Cedar Rapids, Iowa.

The age of each home surveyed was gathered through real estate databases, while roof age was estimated through a variety of ways. The primary source of roof age information was data mining of building permit information and real estate database information. For homes less than five years old, it was assumed that the asphalt shingle roof was original to the home unless satellite-based imagery clearly showed a color and/or pattern change. There were five hail events from 2010 to 2020 that produced damaging hail across Cedar Rapids affecting areas A and C. Using archives of satellite-based imagery, roof cover color and texture changes were used to identify which had roof cover replacements due to these hailstorms, using a Matlab-based machine vision algorithm. The process was sufficient to identify those roofs and assign their proper age at the time of the 2020 derecho. For roofs older than 16 years, the data needed to properly assign their true age became sparser. Permit information was inadequate, and aerial imagery archives with adequate resolution did not extend to dates earlier than 2005. Asphalt shingle roofs that were known to be older than 15 years but lack verification of their true age were all grouped together into a single category for analysis purposes. The distribution of all asphalt shingle roof ages is shown in Figure 6.

Figure 5: Example of post-derecho GIC Gray Sky imagery of two undamaged roofs in Cedar Rapids, Iowa. Note the blue tarp on a roof in the upper right corner and tree debris near the street five days following the event.

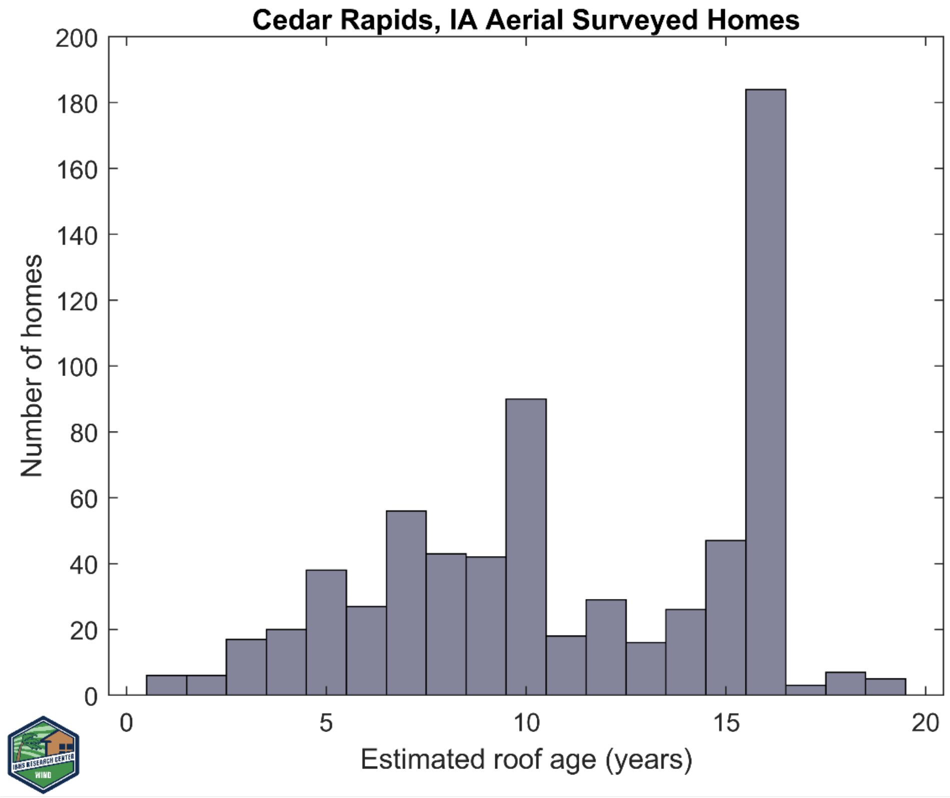

Figure 6: Histogram of estimated asphalt shingle roof age for single family homes included in this study.

Wind Speed Estimation

Capturing reliable wind speed information from severe convective storms such that it can be related to building material or component performance is difficult. The understanding of severe convective storm wind climates and associated risk has had to rely on local storm reports, typically from human observers. Recent work by Edwards et al. (2018) has shown that these wind speed estimates are often biased well above what true measurements would have yielded. Also, NWS ASOS stations are too far apart to capture the localized nature of thunderstorm outflow winds and often cease to function once their power supply is disrupted.

In the 2020 derecho event, the Cedar Rapids ASOS station was located approximately 5.25 miles southwest of survey location A. It measured a peak wind gust of 68 mph at approximately 12:30 p.m. CDT (1730 UTC) before the power failed, and it stopped recording data. In the absence of reliable surface observations, Doppler radar radial velocity data can provide some estimation of peak winds. The closest NWS Doppler radar was near Davenport, Iowa (KDVN), about 60 miles southeast of Cedar Rapids. At this distance, the radar beam height was between 4,200 and 4,700 feet above the four surveyed areas at the lowest tilt angle (0.5°). Wind speeds at these heights will typically be much higher than those at the surface; however, thunderstorm wind profiles are often very complex. At times, the peak wind speed in the vertical profile can occur near the surface, yet at other times the wind maximum can be well elevated (Gunter and Schroder 2015; Gunter et al. 2017; Canepa et al. 2020). Doppler velocities are also difficult to compare to conventional wind measurements made with an anemometer. Doppler velocities are not representative of a snapshot in time but measure the average motion of all the particles toward or away from the radar within the volume being sampled at each specific range and azimuth bin.

For the purposes of this study, an experimental technique to estimate maximum possible gusts over the four areas surveyed with aerial imagery was developed. The method builds upon a modified velocity azimuth display (VAD) technique developed by Giammanco et al. (2013) to generate a mean vertical wind profile of the lowest 2 km at the location of a radar. Vertical wind profiles were generated from the KDVN Doppler radar as the derecho passed the radar to determine the structure and where the wind speed maximum was within the profile. Then, the process developed by Ibrahim et al. (2022) was applied to provide a surface wind estimate to integrate within the profiles. This allowed for an adjustment factor to be found between various profile heights and the near surface wind speed to adjust raw Doppler velocities. A time-to-space conversion was used to create wind adjustment factors relative to the onset of the thunderstorm outflow winds and to allow for a more uniform application.

The method though assumes that the derecho wind profile shape and spatial evolution was a steady state from the time it passed Cedar Rapids until it passed the KDVN radar site about an hour later, 60 miles to the southeast. The derived KDVN wind profile over time is shown in Figure 7.

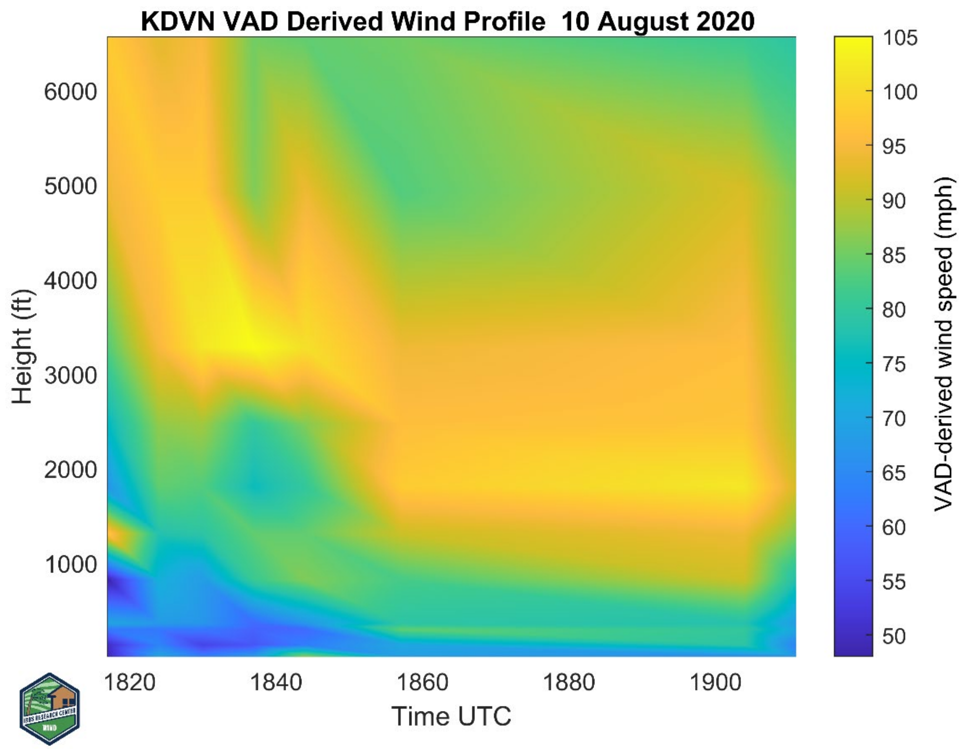

Figure 7: KDVN Doppler radar derived vertical wind profile as the derecho passed the radar site between 1820 and 1910 UTC on 10 August 2020.

To estimate the possible peak winds over the four surveyed areas, the Doppler velocity from the closest bin to the location (or directly over) was captured for each radar volume from 12:16 p.m. CDT to 3:09 p.m. CDT (1716 UTC to 2009 UTC) and the surface adjustment factor from the KDVN vertical profiles applied. The raw and adjusted time histories of Doppler velocities and estimated peak winds for the four surveyed locations are provided in Figure 8Figure 7Figure 7: KDVN Doppler radar derived vertical wind profile as the derecho passed the radar site between
1820 and 1910 UTC on 10 August 2020.. The maximum possible peak winds for the four areas included in this study are also shown in Table 1 along with the number of homes surveyed in each area and an estimate of the upstream terrain surface roughness category during the peak winds.

Table 1. Estimated maximum gust wind speeds for each surveyed area and the associated upstream terrain exposure classification.

Survey area	Sample size	Maximum possible gust wind speeds (mph)	Upstream terrain exposure at the time of peak winds
A	199	100	Suburban
B	148	85	Transitional—roughly open to suburban
C	176	115	Suburban
D	157	120	Open to roughly open

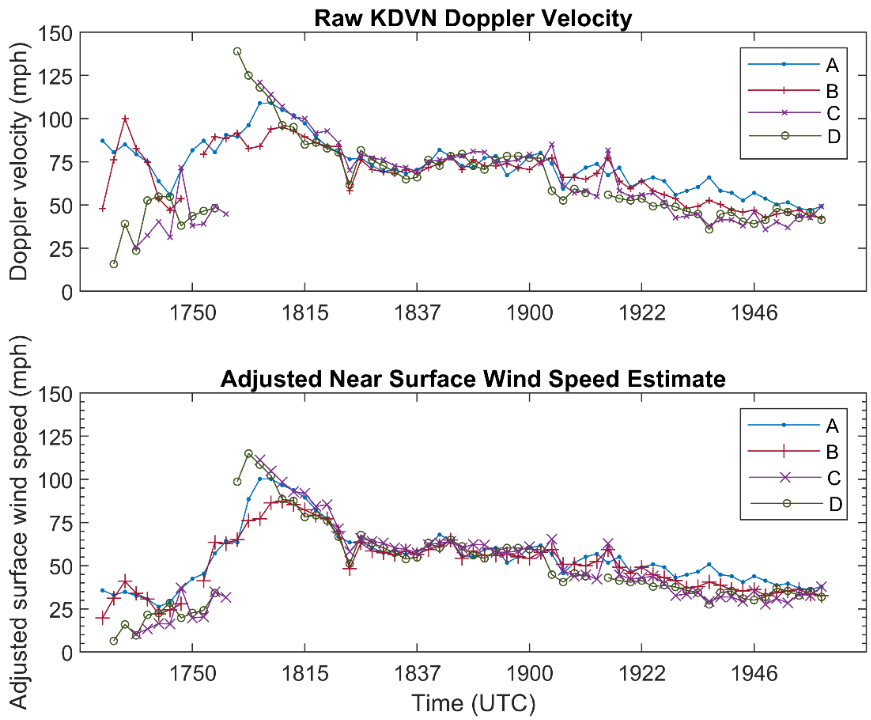

Figure 8: KDVN Doppler velocity time history for each surveyed area (top) and the adjusted estimated peak near surface wind speed time history (bottom).

Estimated wind speeds are rounded to the nearest 5 mph given the expected error within the experimental wind retrieval method. No attempt was made to adjust the retrieved wind estimates for terrain exposure. The predominant wind direction of the thunderstorm outflow winds from the derecho was west-northwest, allowing for a general assessment of upstream terrain exposure for the four areas. Area D was the only surveyed area with open or roughly open terrain, characterized by farmland and sports fields to the west. Given the more open exposure, it is more probable that this area experienced the estimated peak winds than the other surveyed locations in rougher terrain.

Analysis and Results

Much of Cedar Rapids experienced winds of 80 to 120 mph during the 2020 derecho event with wind gusts of 50 mph or higher lasting over an hour. Some locations may have experienced peak gust wind speeds that exceeded the existing building design standards. Cedar Rapids, at the time of the derecho, had adopted and was enforcing the 2018 International Residential Code. The specified design level wind speed (3-second gust) was 105 mph. Possibly due to a well-enforced building code, structural damage was not widespread across the city. The two most severe cases of structural damage were to a multifamily apartment building which lost its roof system causing a partial second-story wall collapse, and a light commercial structure which suffered a failure of the exterior walls due to interior pressurization.

Across the four areas included in this study, structural damage was observed on only two homes which were both built in the late 1960s. However, damage to components and cladding elements for both residential and commercial construction was widespread. From aerial imagery, approximately 1 out of every 5 homes in Cedar Rapids suffered some type of roof cover damage and across the four areas examined in this study, 25% of homes had detectable damage to their roofs.

Tree damage was also widespread across the city. The Iowa Department of Natural Resources estimated that 50% of the tree canopy in Cedar Rapids had damage (McGrath 2021). Tree damage to residential and commercial structures was also prevalent, including in the four areas used in this study to evaluate asphalt shingle roofs. Eleven of the 680 homes cataloged in this study had tree damage to their roofs. These 11 were excluded from the asphalt shingle performance analysis.

Asphalt Shingle Performance

Aerial imagery analysis of the performance of asphalt shingle roof covers was performed on 669 single-family homes in four areas of Cedar Rapids. Year-built for the homes ranged from 1907 to 2017, and roof surface areas were typically between 800 and 2,800 sq ft. Of the homes investigated, 25% had detectable asphalt shingle damage. Only 11 of those homes had asphalt shingle roofs less than 10 years old.

The severity of roof cover loss was less than that observed in post-hurricane studies. Asphalt shingle loss across greater than 25% of the roof was rare (5%) compared to the Kovar et al. (2022) post-Hurricane Laura study which found that nearly 40% of surveyed roofs had more than 25% roof cover loss. Loss of underlayment and exposed roof decking was uncommon and occurred only in 8 out of the 129 homes (4%) that had visible damage.

The most widespread damage to asphalt shingle roofs occurred in area D (Figure 9). Over half of the asphalt shingle roofs in this location experienced some damage. This location likely experienced the highest wind exposure. Of the four surveyed areas, Area C experienced the lowest frequency of damage to asphalt shingle roofs with only 5% of homes experiencing any roof cover damage. It also had the youngest shingle roofs, based on mean age.

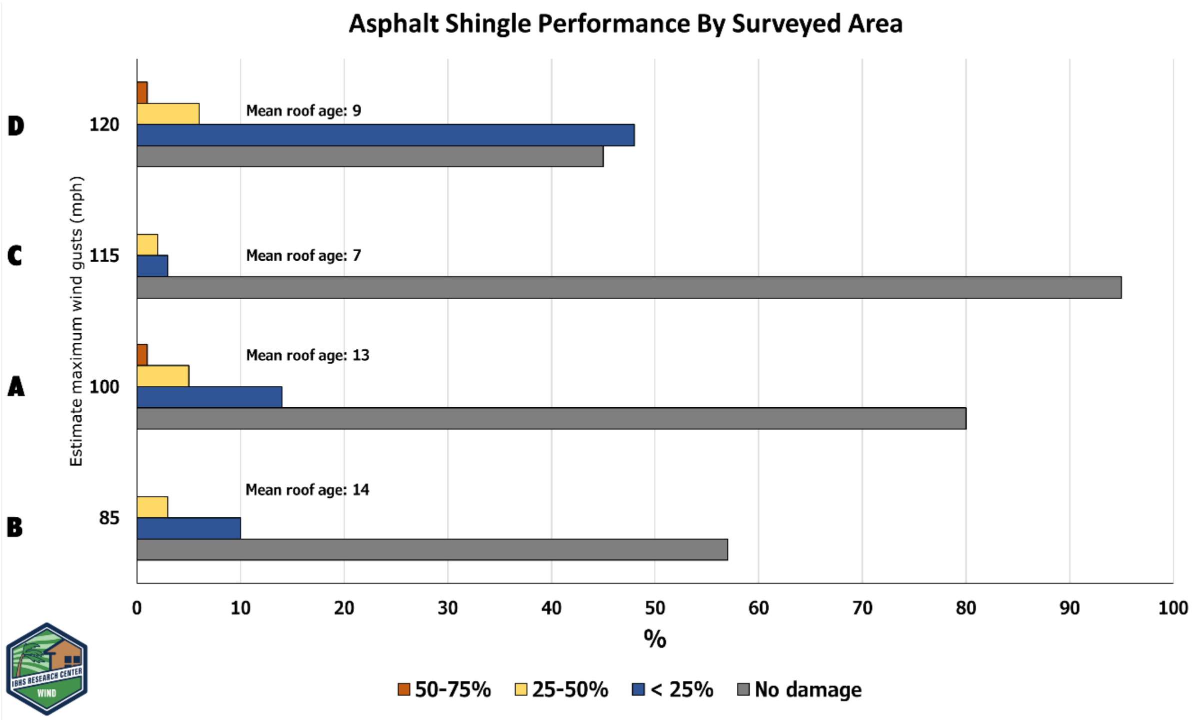

Figure 9: Bar chart of asphalt shingle performance shown as a function of estimated peak winds and location. The mean roof age for each area is noted. Gray bars represent homes with no visible damage, blue is 1%–25% roof cover damage, yellow is 25%–50% cover damage, and orange is 50%–75% roof cover damage.

The dataset of surveyed homes features a mixture of gable, hip, and complex roof shapes. While it has long been understood that hip roof configurations are less susceptible to structural damage, it is unclear whether this relationship exists with regards to asphalt shingle performance on these different roof configurations. Kovar et al. (2022) found that during Hurricane Laura, hip roof configurations had the poorest shingle performance. The result, however, was more a function of orientation of structures relative to the wind direction at the time of peak winds. It was also noted that the number of stories had little influence on shingle performance, unless the roof cover was less than five years old. Across the four areas surveyed in this study, gable roofs had slightly worse performance compared to hip roof shapes while complex roofs suffered the least damage (Figure 10). Between the hip and gable roof shapes, the performance showed a large variance, and no relationship was statistically significant.

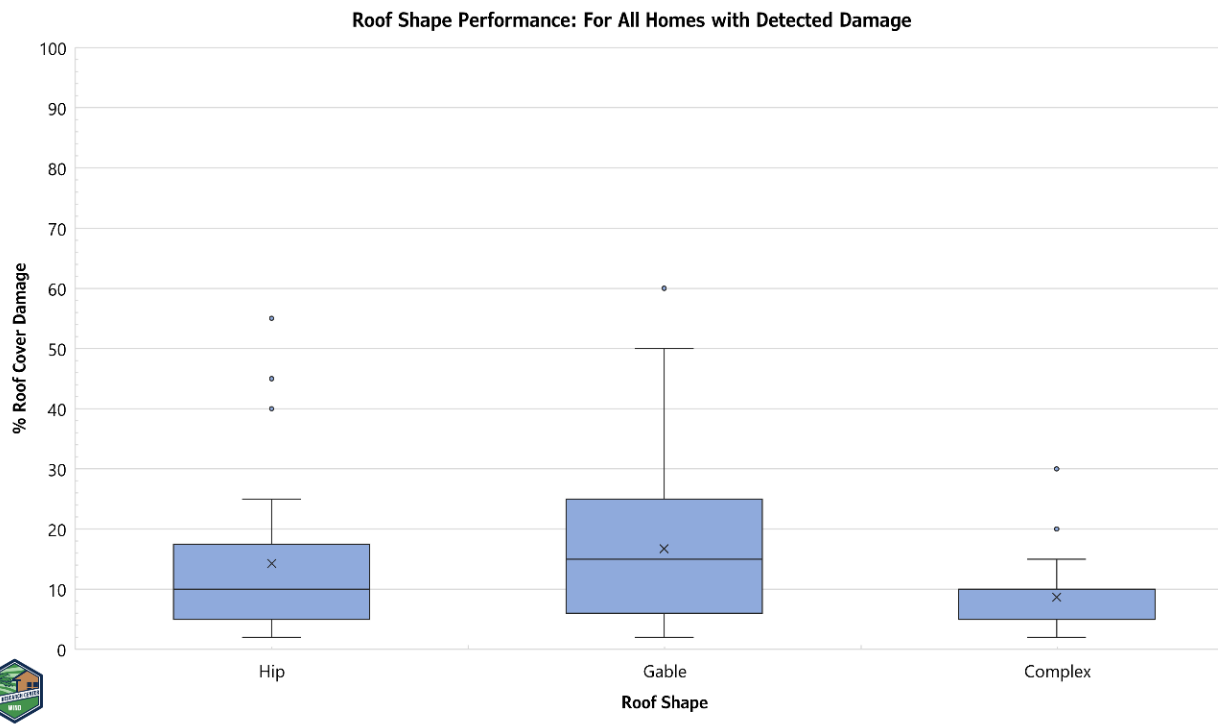

Figure 10: Box and whiskers plot of shingle performance by roof shape. Whiskers represent the 25th and 75th percentiles and outliers are also denoted.

Influence of Asphalt Shingle Age

The findings of Dixon et al. (2012) and Dixon et al. (2014) revealed what had been the hidden vulnerabilities of asphalt shingles and their sealants. Kovar et al. (2022) showed that age is the most effective predictor of shingle performance in hurricane winds as sealants begin to lose their ability to keep shingle tabs effectively sealed. Homes were grouped into 2-year bins by roof age to compare to the results of Kovar et al. (2022) from the post-Hurricane Laura analysis.

The severity of roof damage showed a strikingly similar relationship to that found by Kovar et al. (2022). As shown in Figure 11, the largest increase in shingle damage percentage occurred between the 7- to 8-year and the 9- to 10-year age groups (14% and 26%, respectively). The probability of greater roof cover loss (above 25%) also increased as well. The highest percentage of damage was observed in the 10- to 11-year group.

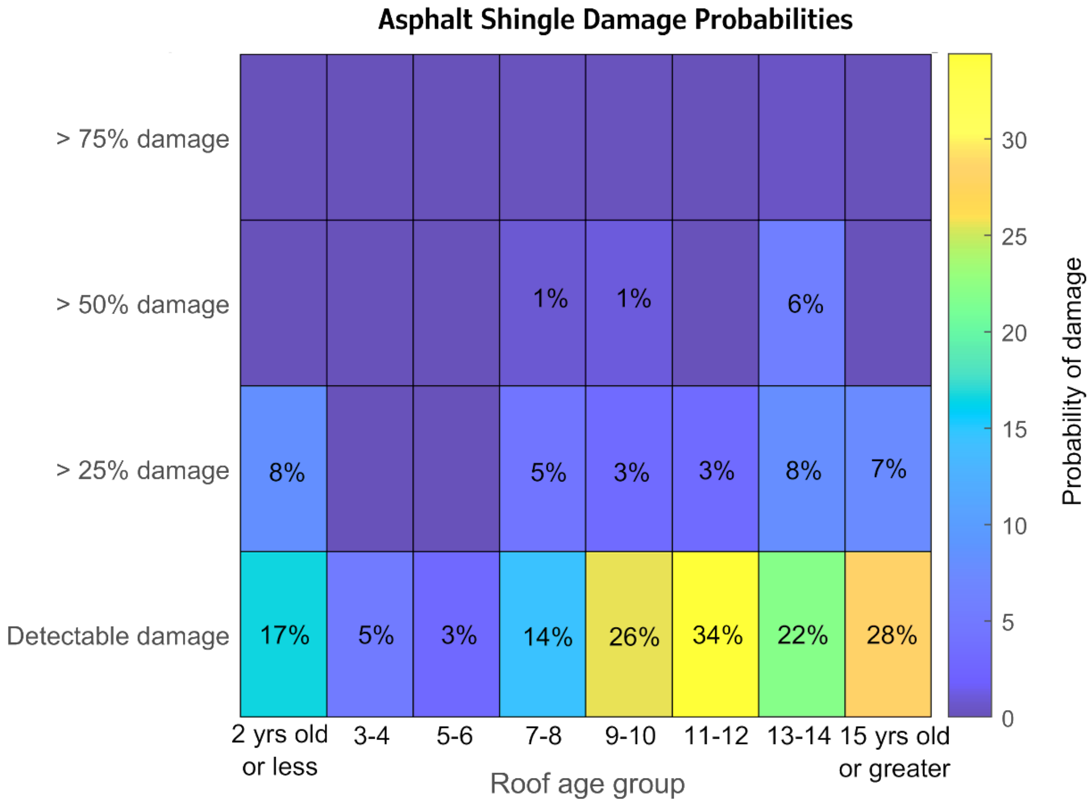

Figure 11: Probabilities of asphalt shingle damage grouped by age in years and damage severity. This chart includes wind speeds for all exposures.

This study noted some damage to roofs less than 2 years old. It would appear possible that these roofs may have had shingles that had not yet fully sealed—perhaps because of the time of year they were installed. For locations at higher latitudes such as Cedar Rapids, the amount of incoming solar radiation on the shingles during the late fall, winter, and early spring may not heat the material sufficiently to activate the sealant. Other factors could include dust or debris that accumulated on the sealant strip during installation or even during the packaging of the product that may have introduced non-uniformities in the sealant's ability to adhere to the underlying material. IBHS laboratory testing of aged asphalt shingles has shown that sealant strength can increase through the first five years of aging which is supported in this study.

Combining the results shown here and those of Kovar et al. (2022), it appears likely that shingle vulnerabilities grow as asphalt shingle roofs reach 8 to 10 years of age regardless of location. Age is a consistent factor in damage potential for an asphalt shingle roof. The severity of damage (i.e., percentage of roof cover lost), while also tied to age, may have more dependencies related to characteristics like the duration of severe winds.

Closed Claims Analysis

Two IBHS Members provided claims data from this event to compare to homes included in the aerial survey. Eighty-four homes within the claims data overlapped with those captured in this study (either with identified roof damage or not). For homes that overlapped with claims exposure data, if shingle damage was identified in the aerial imagery, there was a 100% probability of a claim. However, other damage modes including damage to garage doors, siding, and windows were also present and resulted in a claim even if the roof cover did not have detectable damage. The coupled data allowed for a sample with a variety of roof and building ages.

As expected, the most common source of damage was to roof covers (Figure 12) and roof replacement or repair was the dominant source of loss. However, damage to siding was present on nearly 30% of the claims. Approximately 1 in 4 claims also included garage door damage. Damage to peripheral cladding elements such as gutters and downspouts was observed in almost 30% of claims. This contributed to loss ratios that exceeded what Brown et al. (2015) found following a hailstorm event in the Dallas-Fort Worth metropolitan area by 2.5%. The average claim amount was $13,900 and the mean ratio of loss to the Coverage A (dwelling) limit was 7.5%. The mean loss per 100 sq ft (using the building footprint surface area) was $692 per 100 sq ft.

There was no relationship between the loss ratios and year built or roof age. The lack of age dependency is likely a result of damage to other elements beyond the roof. The event did not produce widespread structural damage in which building codes would play a substantial role.

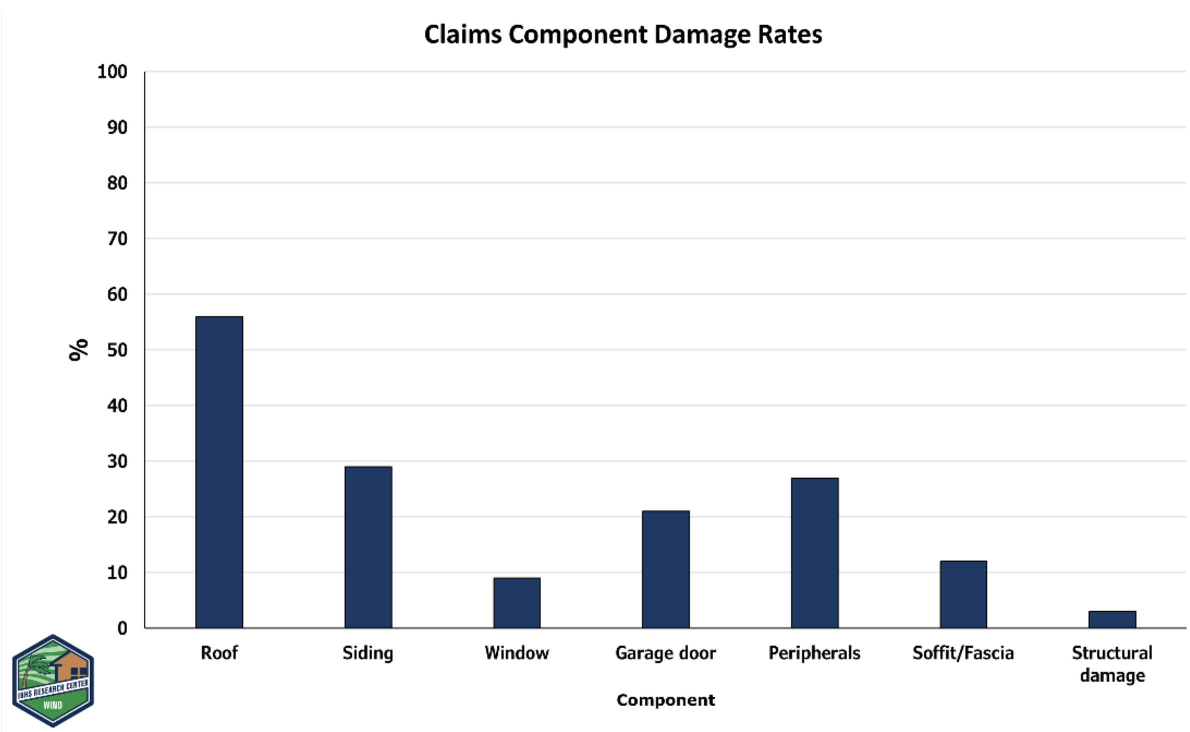

Figure 12: Component damage rates based on claims data. Note the peripherals category includes items such as gutters, downspouts, and shutters.

Eight homes were identified as having water intrusion damage from damaged roof covers (not related to downed trees). All eight homes had roof cover damage greater than 25%. Despite widespread roof cover damage, water intrusion damage appears to have been rare. However, when it is present, water intrusion was a substantial loss amplifier, as has been found following landfalling hurricanes. Total losses were found to increase by 4 to 7 times the mean claim amount for the event when water intrusion was present. When compared with the mean claim for roof cover replacement only (excluding the cost of siding, windows, and other peripherals), the loss amplification is nearly ten times higher.

This finding is in excellent agreement with post-hurricane studies and IBHS water intrusion experiments (Insurance Institute for Business & Home Safety 2005, Quarles et al. 2011, Milnes and Twisdale 2008). Given the small sample size of claims data in this study, it is unclear how common water intrusion damage is during severe convective storm wind events. Further research is needed to understand how much shingle loss is needed before water intrusion becomes an acute damage amplifier in both hurricanes and severe convective storms.

Summary

Aerial imagery collected after the 2020 Midwest Derecho event created an opportunity to explore asphalt shingle performance in a damaging severe convective storm wind event. The most severe damage to residential and commercial structures occurred in Cedar Rapids. The GIS Gray Sky aerial image database was used to assess asphalt shingle performance on 680 homes. Roof age was assessed through various data sources to compare with post-hurricane assessments of shingle performance.

The results found in this study revealed a striking similarity to those found by Kovar et al. (2022). The wind vulnerability of asphalt shingle roofs increases significantly once the roof reaches seven to ten years of age, regardless of climate zone. The damage severity from the 2020 derecho was less than the post-hurricane assessment of Kovar et al. (2022), as roof cover loss greater than 25% was not common in this study. Exceedance probability curves for the asphalt shingle damage states following the derecho as a function of age were developed and are shown in Figure 13.

Once a roof reached 10 years of age, the probability of detectable damage was nearly equivalent to having greater than 25% roof cover loss, or approximately 25%. Kovar et al. (2022) showed higher exceedance probabilities based on the Hurricane Laura shingle performance, for the same categories (63% probability for detectable damage, and 40% for greater than 25% roof cover loss). The higher damage states were found to be much less likely in this study than in the post-Hurricane Laura assessment.

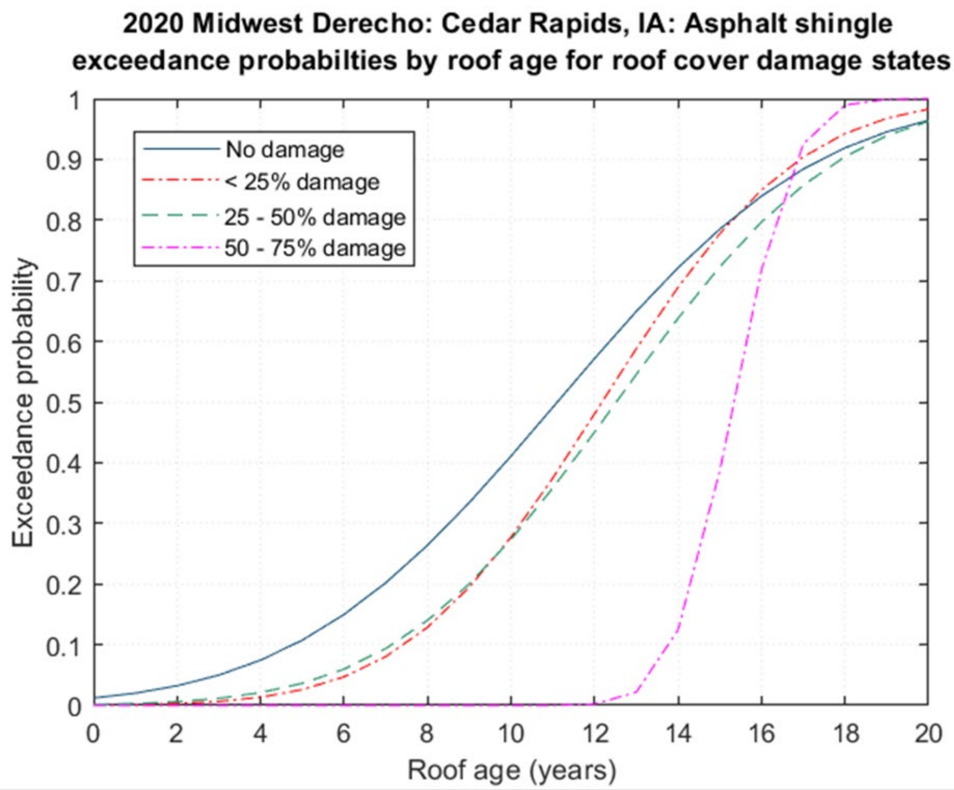

Figure 13: Exceedance probability curves for different shingle damage severities as a function of roof age.

The analysis of a small sample of claims that overlapped with roof cover performance assessments revealed that if shingle damage is visible from aerial imagery there was high confidence that a claim was filed. However, the aerial imagery used in this study was insufficient to detect individual shingle loss on hip and ridge cap shingles or to diagnose other sources of loss (oblique imagery was not used).

Loss ratios were higher than in hailstorms due to the greater contribution from other building elements such as siding, garage doors, soffits, and fascia. While rare, water intrusion was a loss amplifier, increasing claims amounts by 4 to 7 times.

This study confirms the findings on how wind performance of asphalt shingles declines with age. While shingle age is a reliable predictor of damage during a windstorm, the damage severity is tied to other factors beyond age and the peak magnitude of the winds.

The performance of siding materials was also identified as a major source of damage that accompanied the derecho event. While the performance of asphalt shingles—the most common roof cover in the United States—is a significant problem, the contribution of siding performance to windstorm damage must not be ignored.

Water intrusion is still a substantial loss amplifier, but the sample size of claims data in this study was not sufficient to properly determine how common water intrusion is from a severe convective storm wind event. Further research is needed in this area, which could provide meaningful guidance to the IBHS FORTIFIED standards and future evolution of the program to bend down the severe convective storm loss curve.

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