RICOWI, Inc.

Roofing Industry Committee on Weather Issues, Inc.

Hurricane Ian

September 28, 2022

Roofing Industry Committee on Weather Issues, Inc.
Storm Investigation Program
September 30, 2023

Contents

Preface

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Abstract

The Roofing Industry Committee on Weather Issues, Inc. (RICOWI, Inc.) investigates and reports on the field performance of low-slope and steep-slope roofing systems after major hurricanes (sustained winds of 95 mph or greater) make landfall in populated areas of the continental United States.

RICOWI, Inc. deployed four teams to investigate conditions of roofs in the areas impacted by Hurricane Ian in the mid Gulf Coast landfall regions of Florida and surrounding areas. This report covers the investigations of October 26-29, 2022.

Information on the damage encountered, including photos and specific information, is included in this unbiased report.

Hurricane Ian Executive Summary

Hurricane Ian came ashore on September 28, 2022, with windspeeds of 130 mph at 10 meters (33 ft) above ground level (AGL). RICOWI deployed a scout team on October 19 to 21, 2022. This was followed by three four-person teams during the following week of October 24. This slow-moving, long duration storm (forward speed 8 mph) with 130 mph winds as far inland as 30 miles, caused more occurrences of roof damage than expected; however, the magnitude of most damage was relatively minor.

All types of newer roofs (post-2006 construction) performed better than older roofs. Most dramatic was the improvement in tile roofs, where serious damage occurred during Hurricane Charley (2004). Damage to newer tile roofs consisted primarily of hip and ridge tile loss, with most roofs remaining water resistant.

Hurricane Ian History

Hurricane Ian emerged in the Atlantic as a tropical wave and moved west toward the Caribbean. It was initially slow to develop due to interactions with Hurricane Fiona, which was a major Category 4 hurricane at the time in the Atlantic Ocean. TD9 became Tropical Storm Ian on September 23 and strengthened into a Category 1 hurricane on September 26.

Ian struck western Cuba with winds of around 125 mph. After crossing Cuba, Ian rapidly intensified, developing into a high-end Category 4 storm within 24 hours. It had maximum winds of 155 mph as it approached southwestern Florida.

Ian landed at nearly the same place and followed the same path as Hurricane Charley had in 2004. At its maximum size, the eye was roughly 34 miles wide. However, Ian moved much slower, with an approximate forward speed of eight mph, its hurricane-force wind field extended over a much larger area than Charley's. These two factors combined to generate greater damage from wind, storm surge, and rain.

Hurricane-force winds in Ian extended out over 75 miles from Ian's eye, and tropical storm wind speeds up to 175 miles from the eye. The slow forward speed and enormous size resulted in hurricane-force wind speeds over sizable inland areas. Hurricane force winds were sustained over eight hours, with tropical wind speeds for up to 20 hours in areas inland from the Florida coast to Punta Gorda, Port Charlotte and beyond.

Ian made landfall on September 28 at Cayo Costa and then near Fort Myers, where the triple threat of high winds, high storm surge and wave action, and heavy rain resulted in catastrophic damage and loss of life. Ian slowed down at landfall, prolonging the onslaught of high surge and winds, and ultimately worsening the storm's impacts.

Compared to the six previous hurricanes investigated by RICOWI, Ian differed in two ways: the wind speeds did not slow significantly when Ian made landfall, and the highest winds were on the left side of the eye. Although hurricane Katrina was a Category 5 storm when in the Gulf of Mexico, the winds quickly slowed to 120 mph when it reached the coast and were less than 100 mph when it was over 30 miles inland.

Field Investigation

Although Hurricane Ian met the RICOWI basic criteria for a post hurricane investigation with sustained winds greater than 95 mph striking a populated area, early reports indicated significant limitations on investigations including lack of access to shoreline and barrier islands. Photos from NOAA flyovers available a few days after the storm appeared to show very limited roof damage and negligible debris fields. This information and the lack of available lodging delayed implementation of the investigation. However, based on the widespread wind profile of the storm a RICOWI scout team's investigation concluded that further evaluation of storm damage was warranted. Three teams were assembled on October 25 to continue the investigation.

Mini-Investigation

As only three teams were deployed for just a few days, this was not a full-scale investigation; it was an attempt to survey the types of roofs that were damaged and to some extent, the geographical extent of significant roof damage.

Initial findings

RICOWI's review of NOAA flyover photos located several roofs that sustained damage. The teams investigated these roofs and noted that significant roof damage did exist but was not pervasive. However, there was extensive minor damage that may or may not have resulted in leaks. This damage may not have been obvious from the aerial photos and may not have created extensive debris fields. Past hurricane experience found the greatest damage on the right side of the eye, resulting in the teams' initial focus being near the Cape Coral and Fort Myers area, whereas with Ian, the highest winds were on the left side of the eye, in the Port Charlotte and Placida area.

At the time of the investigation, many of the buildings of interest were occupied. Roofs were tarped over or had temporary or permanent repairs. Managers and owners were often reluctant to allow inspection of roofs that were not repaired. This limited the teams' ability to get definable data on causes of damage.

Valuable data were obtained, however, RICOWI teams were diligent in using the time available and took every opportunity to investigate accessible roofs.

Building Code Effects

A key goal of RICOWI post hurricane investigations is to provide data that can improve the sustainability of roof systems wherever installed. This has resulted in improved products, system design, installation methods, and building code requirements.

Even though it is challenging to sort out the effects of each of these investigations, the data in this report show the improved performance of roofs installed since 2004. Anecdotal evidence of the likely effects on building codes is illustrated in Figures 1-7 on the following pages. Changes that were likely driven by the building code are as follows:

Figure 1. The view is from Google Earth on 9/29/2022 and shows significant roof and structure damage. This area of modular homes was developed between the years 1994 and 1998. This subdivision was just north of Rt 776 and in the highest wind area with projected 130 mph winds.

Figure 2: This is the area immediately east of that shown in Figure 1. It shows some debris but little or no roof damage. This section was developed from 2004 to 2016 with units around the cul-de-sacs built last.

Figure 3: This photo shows the subdivision immediately east of that shown in Figure 2. There was more damage here to units that were built between 1998 and 2004. Other sections were completed after 2004.

Figure 4: This photo is from NOAA flyovers of the same areas shown in Figure 1.

Figure 5: This photo is from NOAA flyovers of the same areas shown in Figure 2.

Figure 6: This neighborhood on Pine Island was mostly built between 1985 and 1995. It had significant damage from 120 mph winds and storm surge.

Figure 7: A Google photo from December 2004 of the same areas as shown in Figure 6. Note the blue tarp-covered roofs and the devastated forest, all caused by Hurricane Charley's 140 mph winds. It is likely that much damage had already been remediated, as the storm was three months before this photo was taken.

Key to understanding the differences in damage from Hurricane Charley and Hurricane Ian is that all the illustrated structures in 2022 were over 25 years old and although many had to be repaired after Hurricane Charley, they were vulnerable to the long-duration winds of Ian.

There were many examples of damage to roofs from Hurricane Charley in 2004, but we saw limited damage in 2022. From aerial views after the storm, little damage can be seen, even in areas that were in the eyewall of Ian. Ian was clearly stronger on the north side of the eye. Unfortunately, the differences were not well captured by wind instruments that were present during the storm.

Roof Inspections by Roof Type – Low Slope

The types of low slope roofs that were investigated after Hurricane Ian can be grouped into:
- Single ply (Mechanically Attached and Adhered)
- BUR
- Modified
- SPUF
- Metal.

The case studies for each of the types are discussed in the sections below.

Adhered Single Ply

Out of the buildings investigated three were adhered single ply (Case studies 1 to 3) with white membranes, two of which were TPOs, and one was PVC.

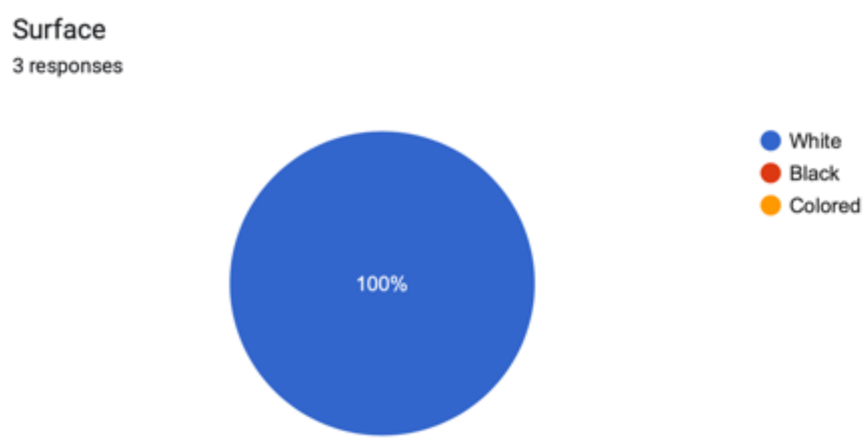


Figure 8: Chart shows that all three adhered single ply roofs inspected were white.

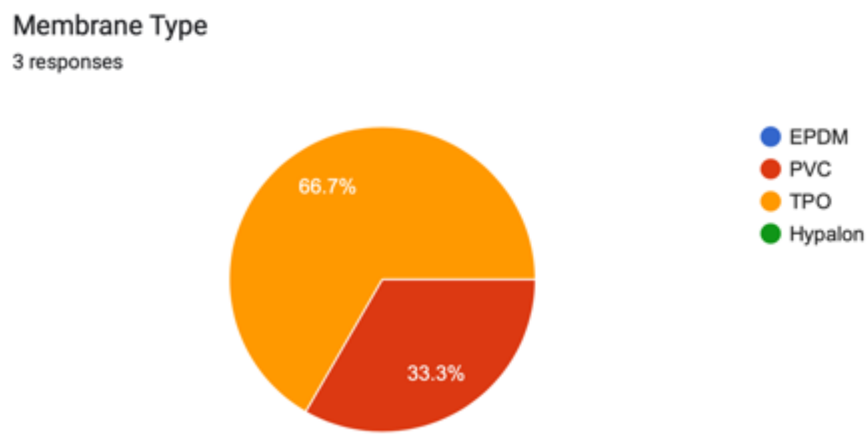


Figure 9: Chart depicts two of the adhered single ply roofs inspected were TPO and one was PVC.

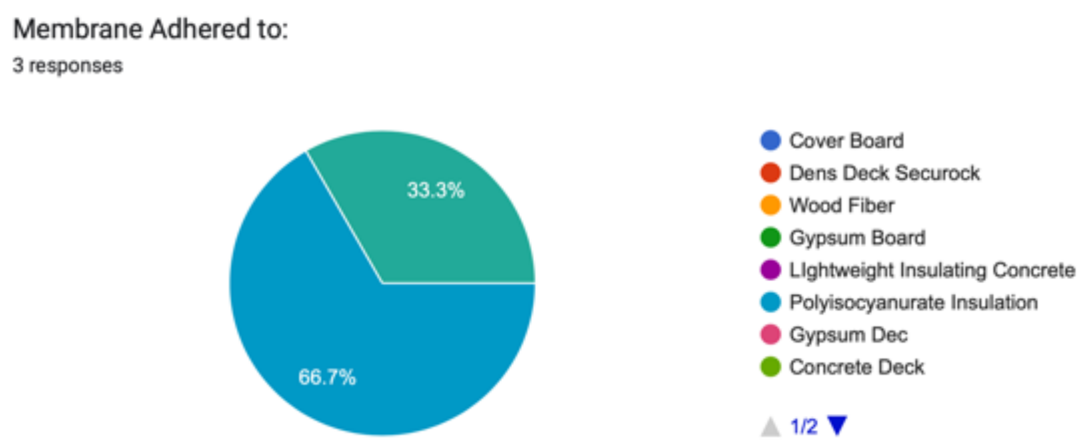


Figure 10: Chart depicts two of the membranes that were adhered to polyisocyanurate insulation, and one was adhered to gypsum board.

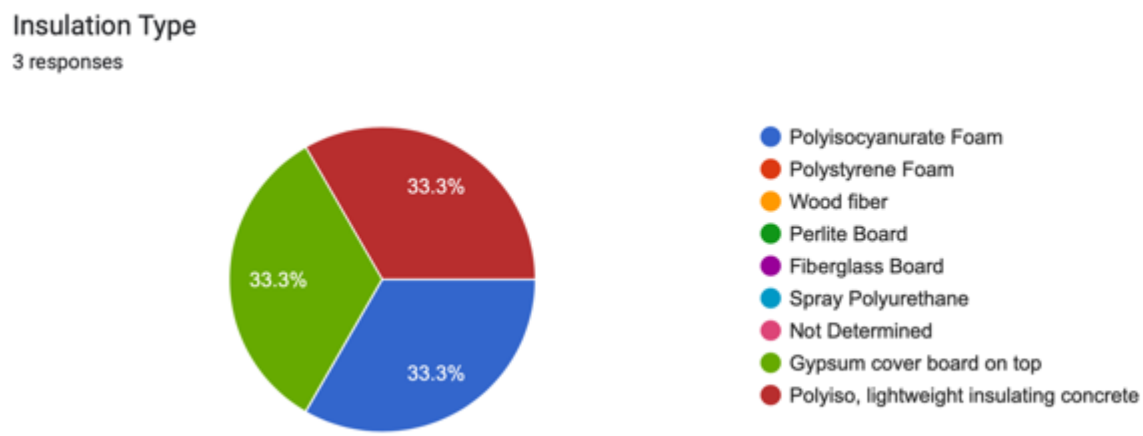


Figure 11: Of the three roofs inspected, three different types of insulation board were installed;

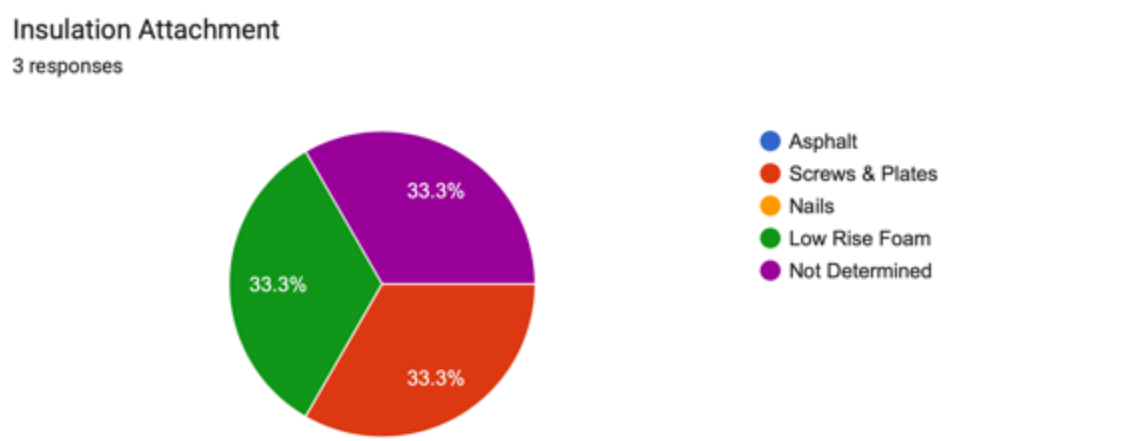


Figure 12: Chart depicts that the insulation in each of the three roofs were attached with three different methods: not determined, screws & plates.

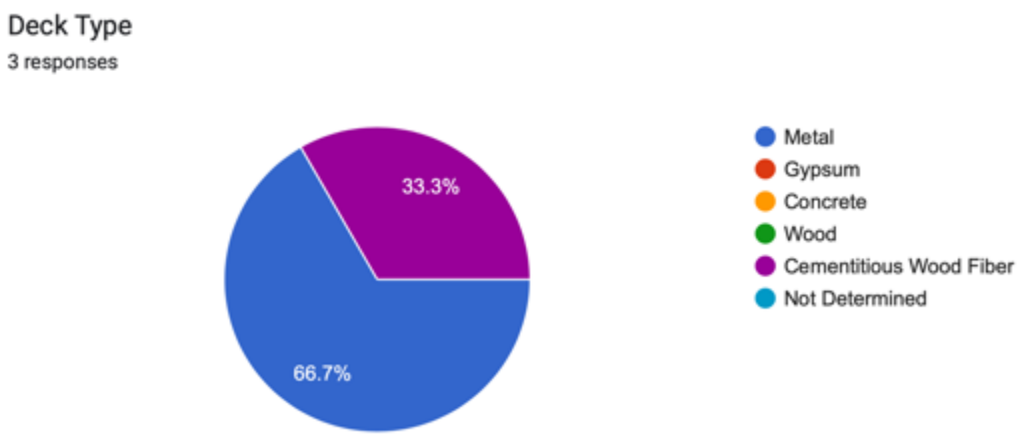
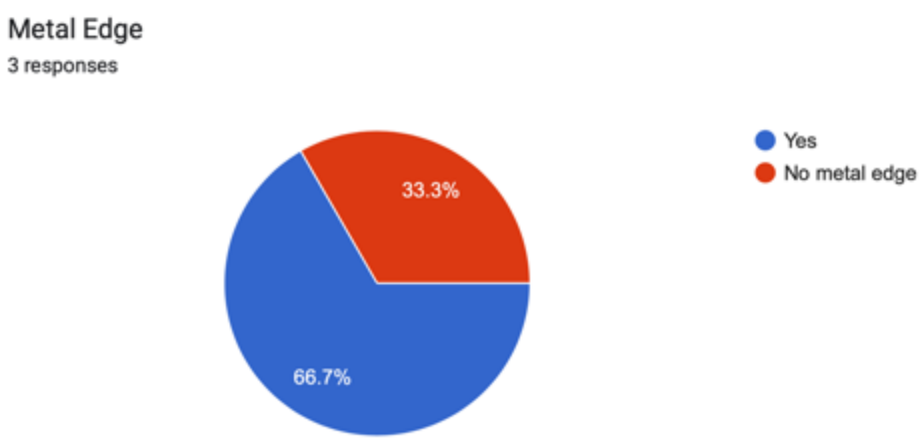


Figure 13: Chart depicts two of the adhered single ply membranes inspected were installed over metal decks and the third was installed over a cementitious wood fiber roof deck.



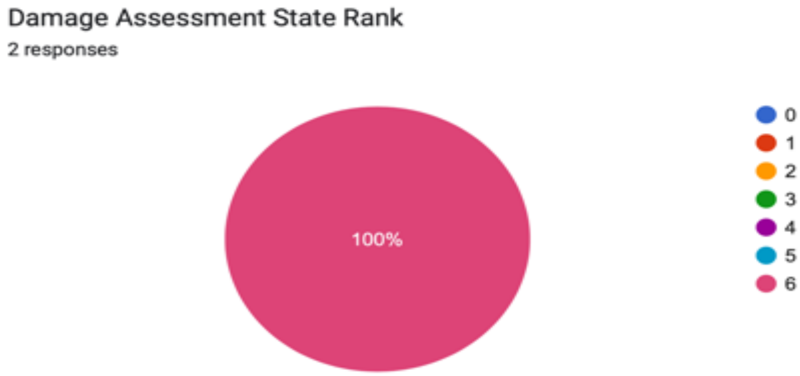


Figure 14: Damage Assessment State; Rank. This table ranks the damage observed, with 0 indicating no damage and 6 indicating total removal of the roof cover. Systems ranked over 3 are considered to have significant leakage and potential interior damage with entire roof replacement expected. Systems ranked less than 3 other than 0 are likely to need significant repairs but may be repairable.

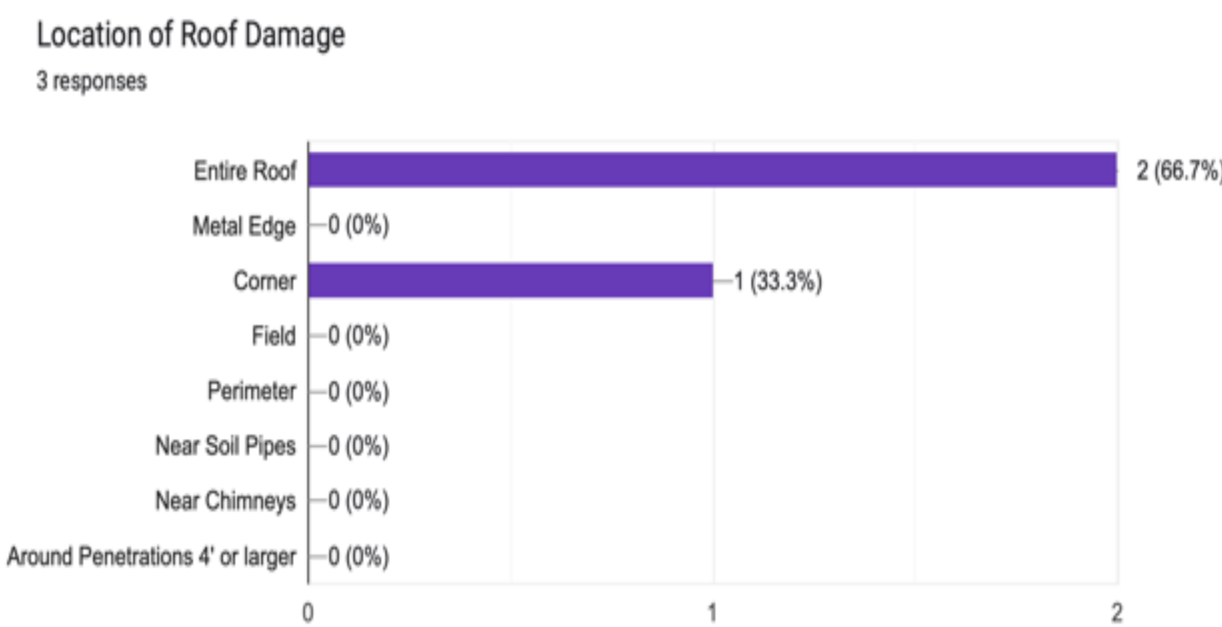


Figure 15: Describes where damage was observed on the roofs. Not shown were anomalies hidden beneath the roof membrane e.g., entrapped moisture, crushed insulation, deck damage.

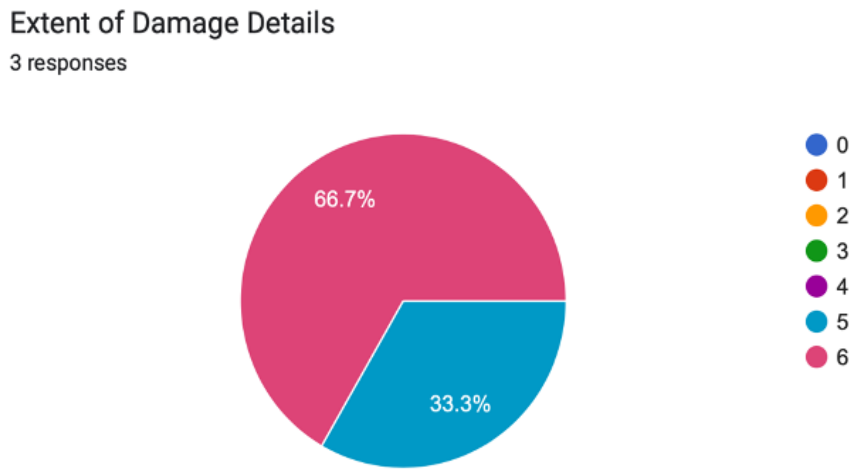


Figure 16: Chart shows inspectors' estimates of how much of each building was damaged. A ranking of 6 indicates a total or partial building collapse. A ranking of 5 indicates more than 75% of the roof cover is missing. A ranking of 1 indicates there is less than 10% of the roof damaged.

CASE STUDY 1 – Stone Warehouse

Inspection# Inspection Number (team #, Day, Inspection-example 1,2,4 for team 1 on day 2 and the 4th inspection that day)	**3,2,4**
Surface	White
Membrane Type	TPO, 45-mil
Membrane Adhered to:	Polyisocyanurate Insulation board
Insulation Type	Polyisocyanurate
Insulation Thickness (inches)	1
Insulation Attachment	Not Determined appears to be partially adhered to deck
Deck Type	Cementitious Wood Fiber (CWF)
Metal Edge	Yes
Metal Edge Thickness (gauge)	
Metal Edge - metal type	Steel
Fastener Spacing inches on center "typical"	
Damage Assessment Rank	6
Location of Roof Damage	Entire Roof
Extent of Damage	6
Damage Initiation	Not determined but large overhead doors failed - see photos.
Describe Damage	Blue sky closest to doors that failed. 45 mil TPO mostly gone. Most insulation seemed to still be attached although damaged, except for blue sky area noted. Some Cementitious Wood Fiber (CWF) is missing, as well.
Roof Height (feet)	24
Parapet Height (feet)	
Roof Width (feet)	150
Roof Length (feet)	210
Roof Area (square feet)	31,500

Case Study 1 Photo documentation

Photo 1: Stone Warehouse - One photo tells a lot. Overhead door failure caused a pressurized building, leading to blow off of cementitious wood fiber deck & membrane.	Photo 2: Stone Warehouse - Extensive loss of CWF roof deck.

Photo 3: This was insulation/cover board retrofit over a CWF deck.

Photo 4: Membrane was adhered to insulation board.

CASE STUDY 2: Cultural Center of Port Charlotte County 120 mph Wind speed

Inspection #	**2,2,3**
Surface	White
Roof Installation Date	2018
Membrane Type	PVC
Membrane Adhered to:	Polyisocyanurate Insulation board
Insulation Type	Polyisocyanurate, lightweight insulating concrete (LWIC)
Insulation Thickness (inches)	1.5
Insulation Attachment	Low Rise Foam
Deck Type	Metal
Metal Edge	No metal edges
Metal Edge Thickness (gauge)	N/A
Metal Edge – type metal	
Fastener Spacing inches on center "typical"	6
Location of Roof Damage	Entire Roof
Extent of Damage Details	6
Damage Initiation	Damage initiated from the SE direction where the drip edge and cleat were damaged and became detached, followed by peel off of the membrane Damage impact. The perimeter peel stop was attached with 2.5" auger fasteners which did not have sufficient embedment into deck.
Describe Damage	The drip edge was damaged, the membrane was peeled off the insulation along with the insulation facer also and the insulation board.
Roof Height (feet)	15
Parapet Height (feet)	N/A
Roof Width (feet)	59
Roof Length (feet)	98
Roof Area (square feet)	5,782

Data is documented in photos on the following page.

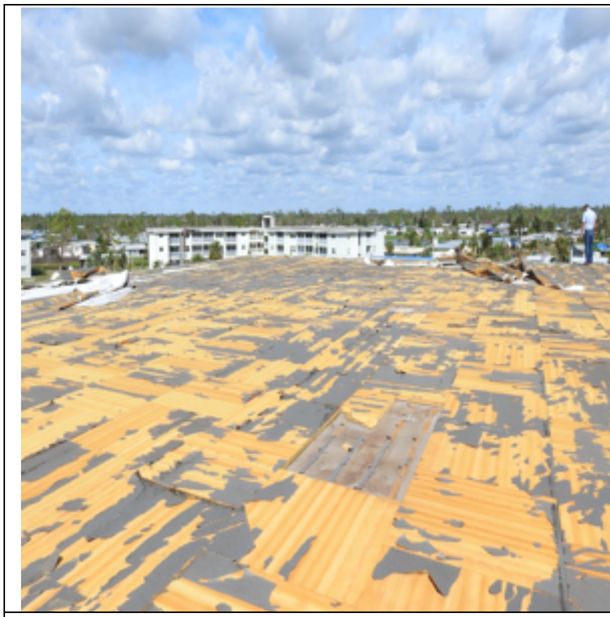


Photo 5: Major loss of membrane

Photo 6: A large piece of membrane was left hanging over the roof edge.

Photo 7: Loss of edge securement was a key factor in membrane blow off.

Photo 8: Close fastener placement along the perimeter appeared to be intended as a peel stop but attachment to lightweight concrete (LWC) deck was inadequate.

Photo 13: Improper insulation used. Insulation was marked to be used only with BUR and Mod Bit membranes

CASE STUDY 3: Lower roof at same location.

Photo 9: Fastener was not adequately embedded in LWC

Photo 10. LWC damaged and metal edge missing.

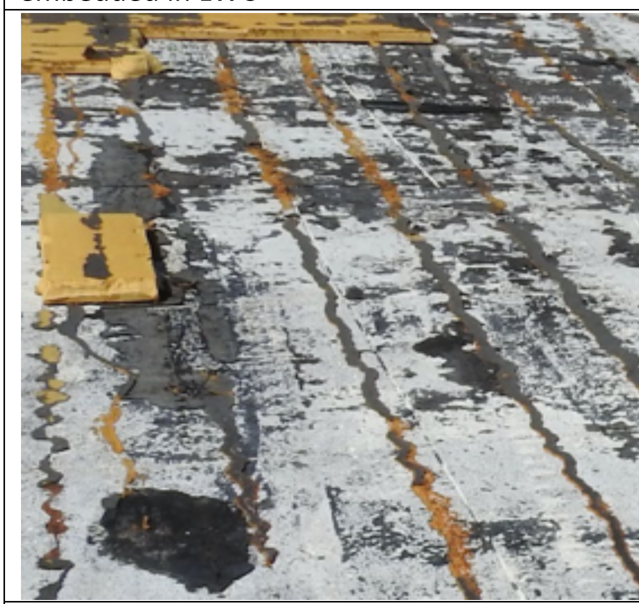


Photo 11: Limited low-rise foam resulted in inadequate wind uplift resistance.

Photo 12: Sky lights became detached along with insulation and AHU’s

Mechanically Attached Single Ply

Out of the buildings investigated, seven were mechanically attached single ply (Case studies 4 to 10) with white membranes, 57% of which were PVC and 43% were TPO.

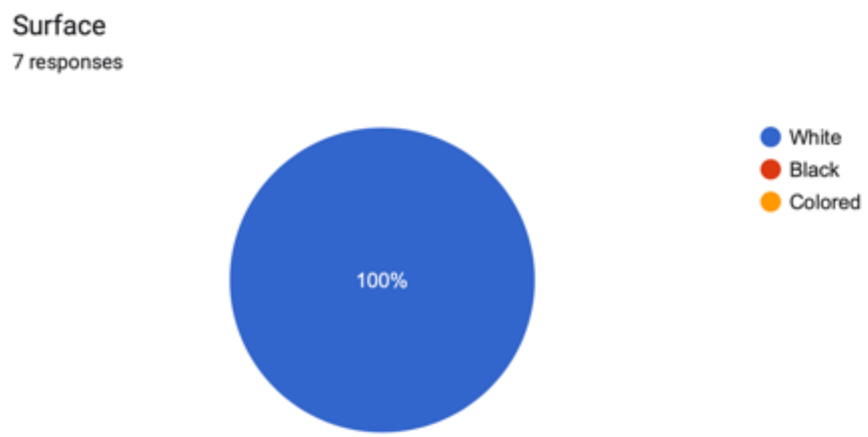


Figure 19: Chart illustrates that all mechanically attached single-ply membranes were white.

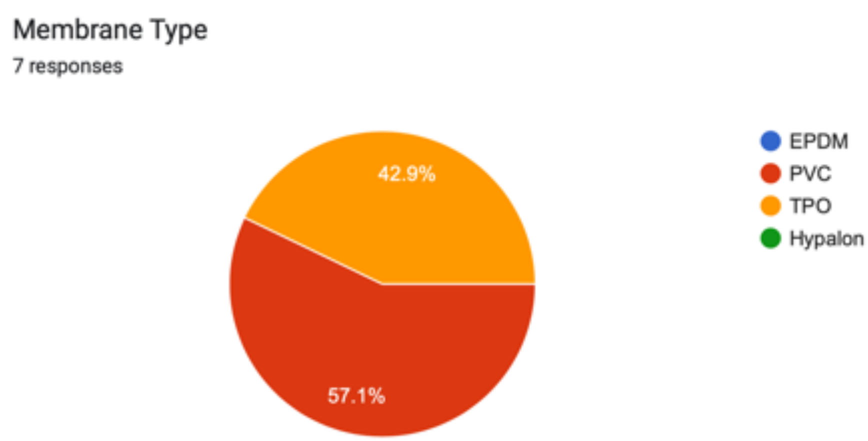


Figure 20: Chart depicts 57.1% of mechanically attached single-ply membranes were PVC. The rest were TPO.

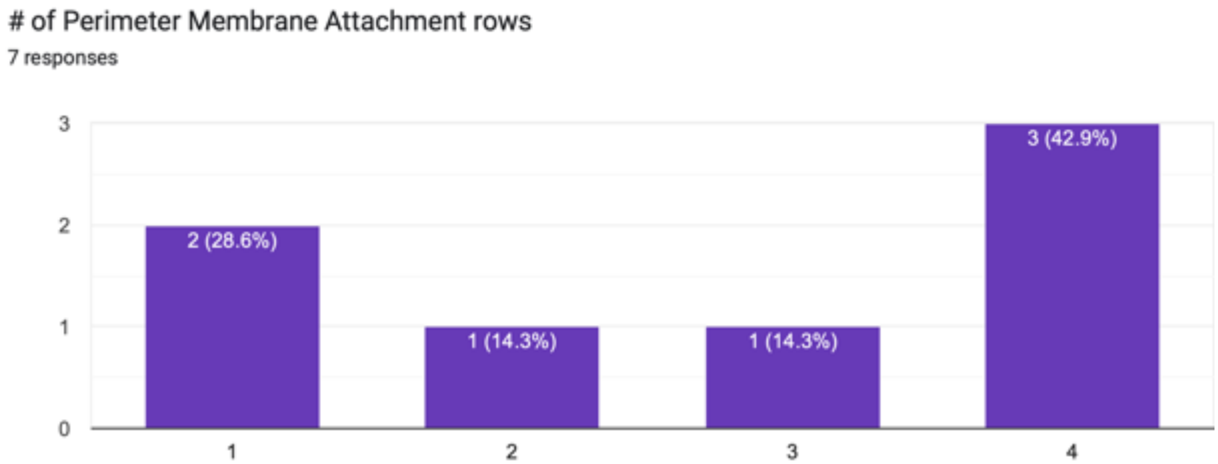
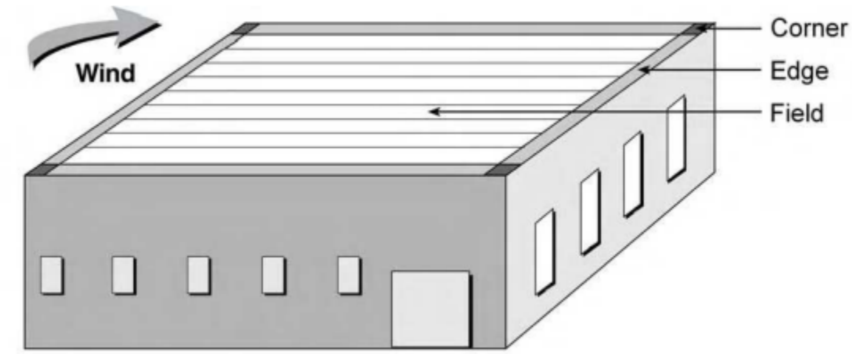
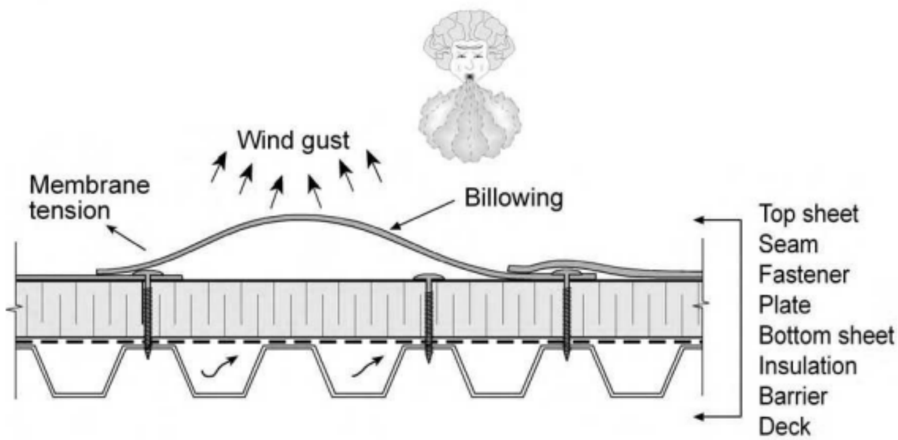


Figure 21: Chart depicts the number of perimeter securement rows of the mechanically attached single ply membranes. As shown, there were 2 systems where there was only 1 perimeter row, 1 system where there were 2 rows, 1 system with 3 rows, and 3 where there were 4 rows of perimeter securement rows.

Baskaran, B. A...]
https://nrc-publications.canada.ca/eng/view/accepted/?id=5af87230-e224-4b67-b67a-0f3c9bf848b9

All figures courtesy Institute for Research in Construction





Wind effects on mechanically attached roofing systems.

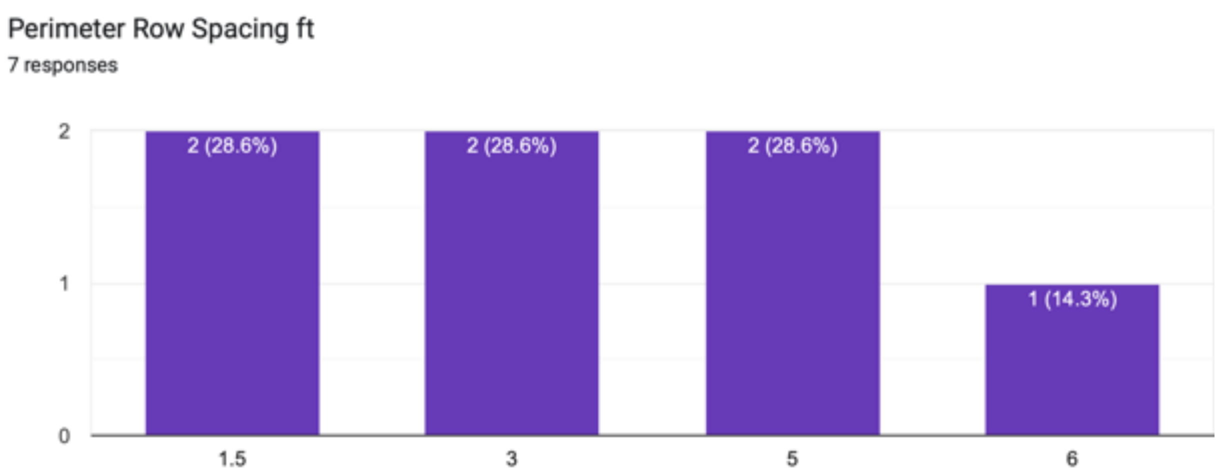


Figure 22: Chart depicts the spacing in feet between the perimeter securement rows.

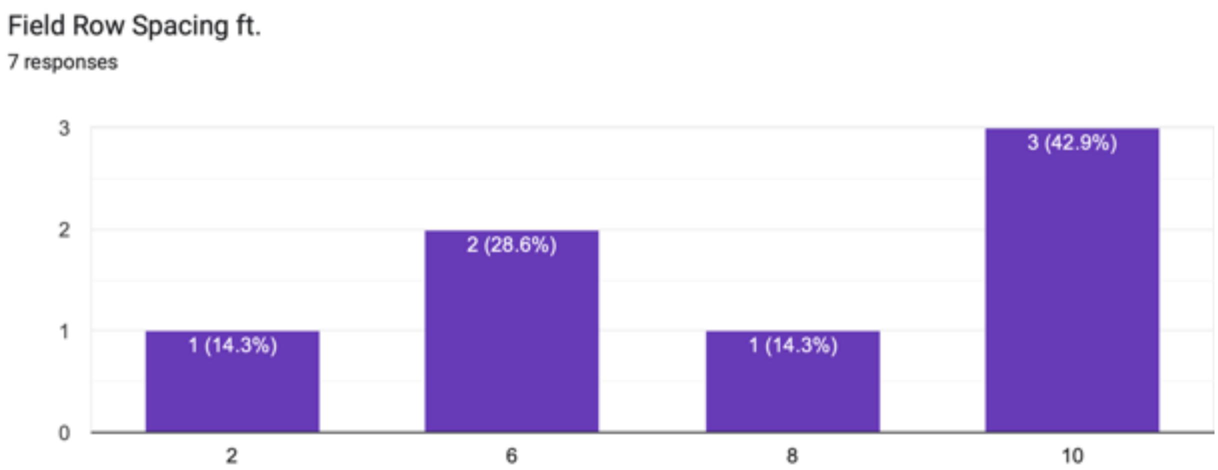


Figure 23: Chart depicts the spacing in feet between the interior securement rows.

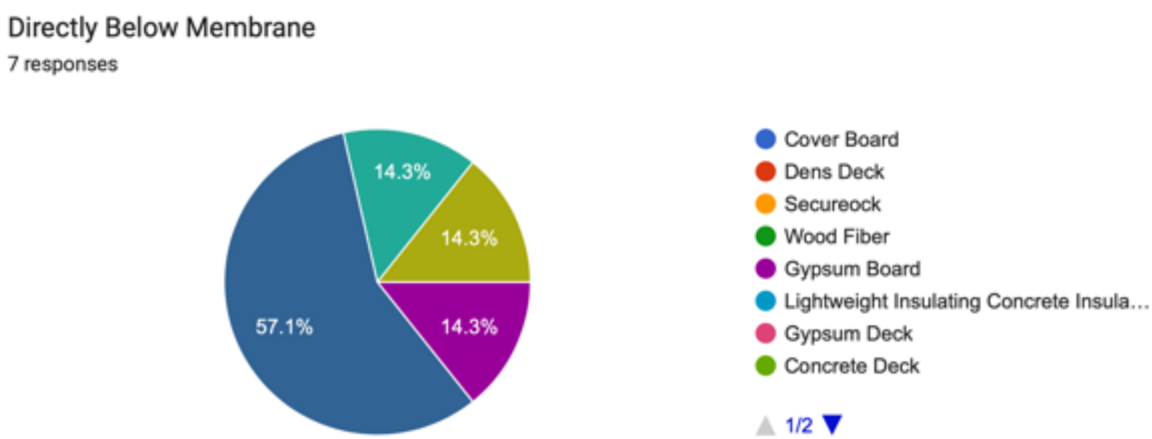


Figure 24: Chart shows that 57.1% of the membranes were attached directly over a cover board, with the remaining being installed over lightweight insulating concrete (LWIC), concrete, or gypsum at 14.3% each.

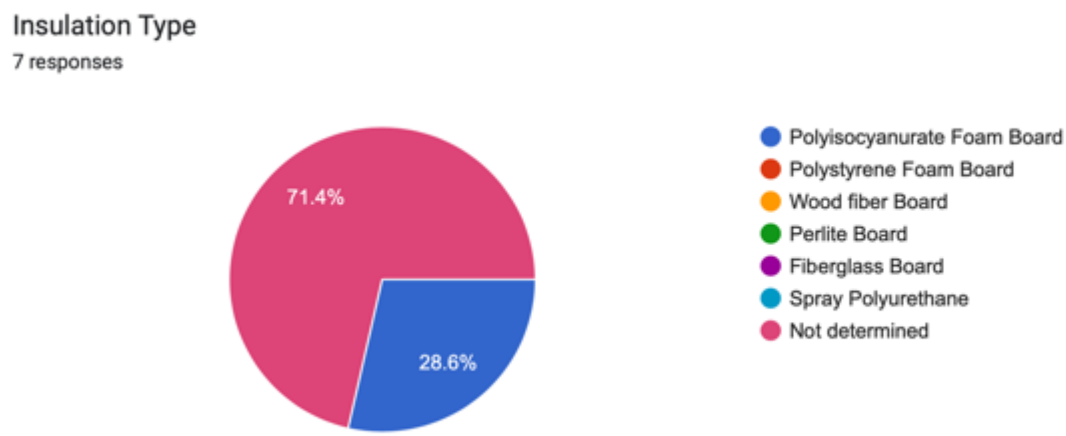


Figure 25: Chart shows that investigators were unable to determine the insulation type on 71.4% of the roofs. The remaining roofs had polyisocyanurate board.

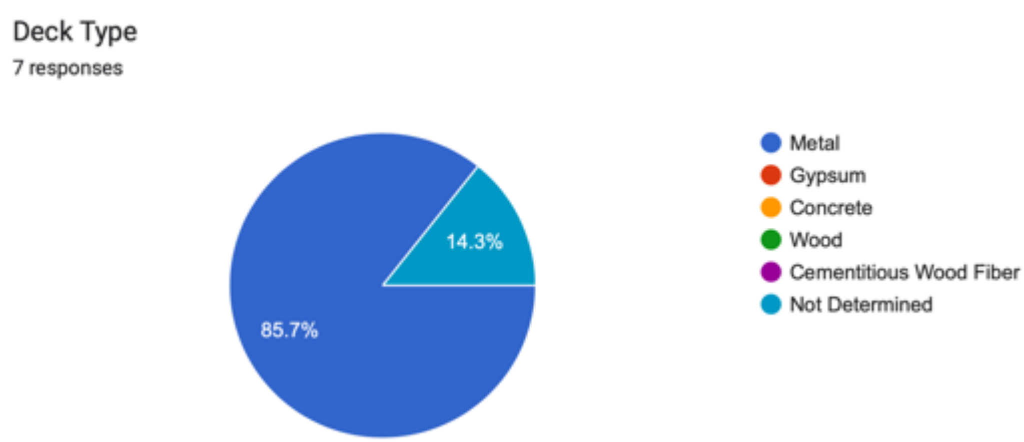


Figure 26: Chart shows that 85.7% of the roofs had a metal roof deck, with the remaining not determined.

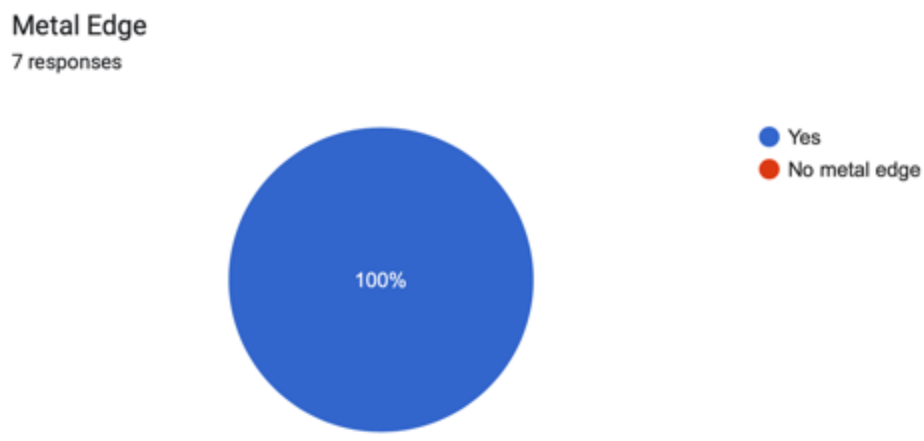


Figure 27: Chart indicates that all roofs had perimeter metal edge.

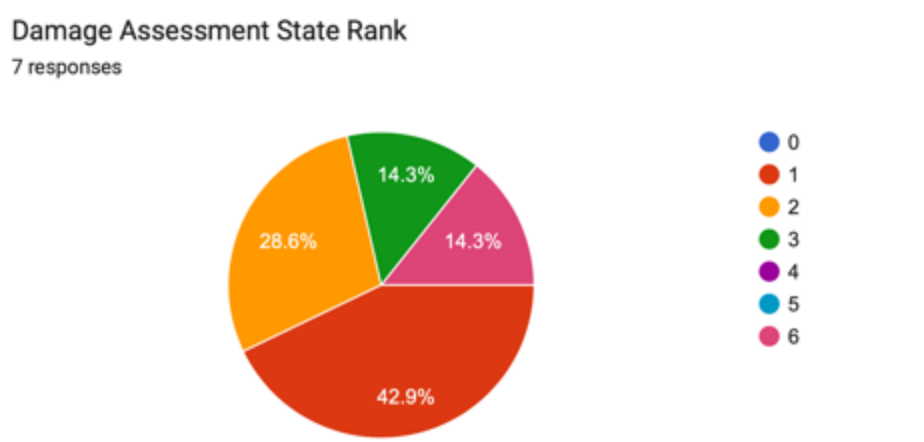


Figure 28: Chart depicts damage assessments indicating that 42.9% had less than 10% damage, 28.6% had more than 10% and less than 25% damage, 14.3% had more than 25% damage, but less than 50%, and the remaining 14.3% were more than 50% damaged.

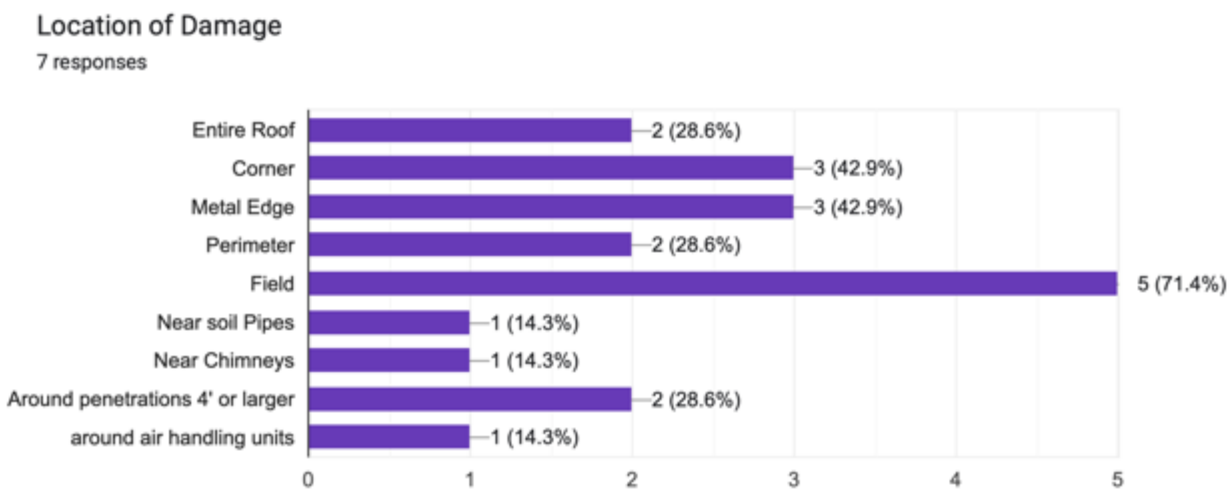


Figure 29: Chart reveals where wind-related damage was observed on the roof.

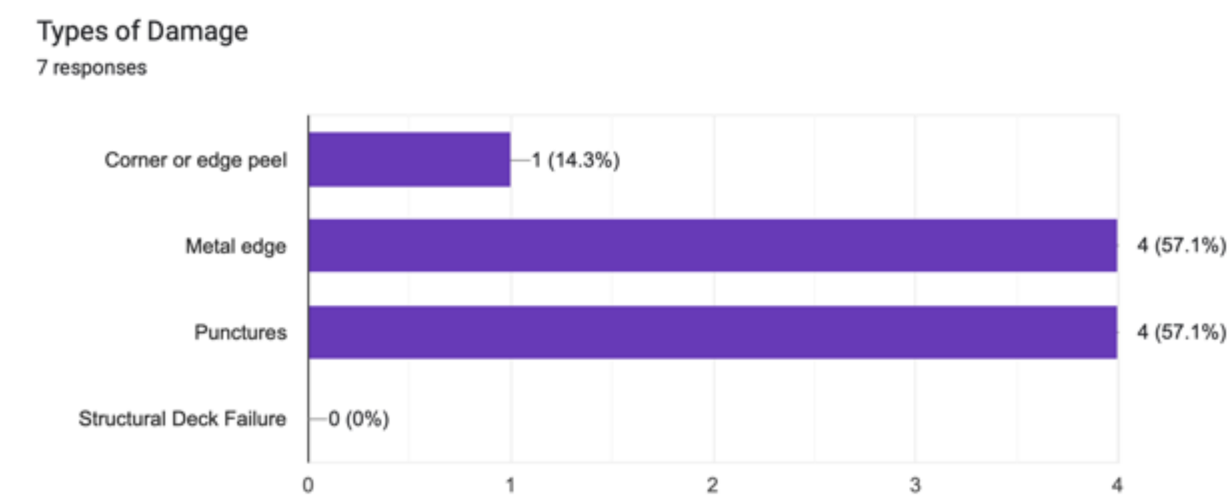


Figure 30: Chart shows the different types of wind-related damage observed.

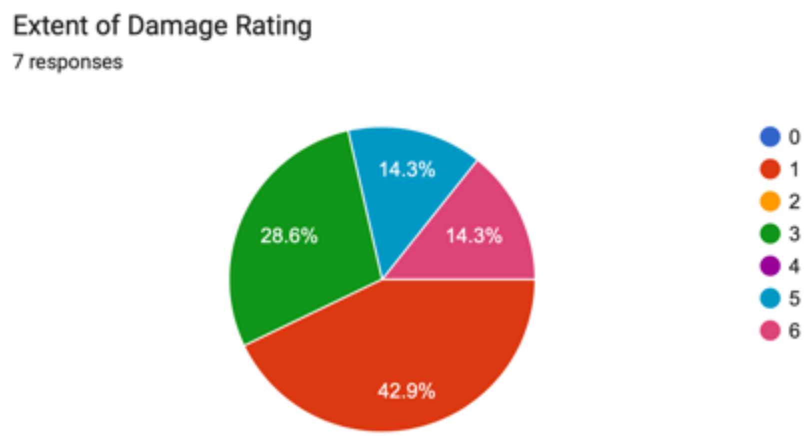


Figure 31: Chart estimates how much of each roof exhibited damage.

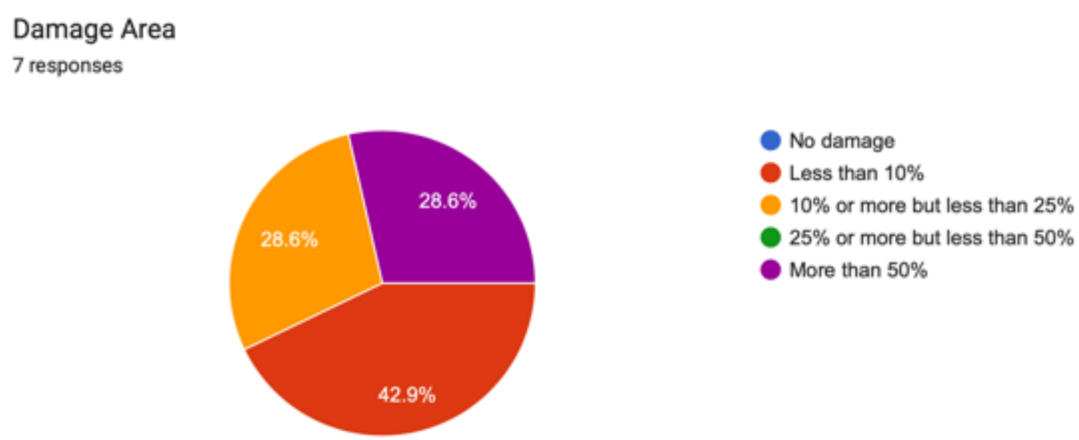


Figure 32: Chart depicts the damage area of each roof deck with 42.9% having less than 10% damage, 28.6% having between 10-25% damage, and 28.6% having more than 50% damage.

CASE STUDY 4: Fidelitone Building
Photos 13-16 show a building observed by the scout team before repairs were made. It was built in 2021, the year before Hurricane Ian.
Fidelitone, 16321 Domestic Ave Ft Myers FL 33912 26º30’26.67” N 81º49’01.44 W with 100 mph winds.

	
Photo 13: Near total blow off of a mechanically attached single ply system. It originated at a roof corner where ground-floor window damage caused a breach in the metal deck and pressurized the roof.	Photo 14: There were large areas where the induction welds to fasteners were completely missed or poorly done, making them more vulnerable to blow off.

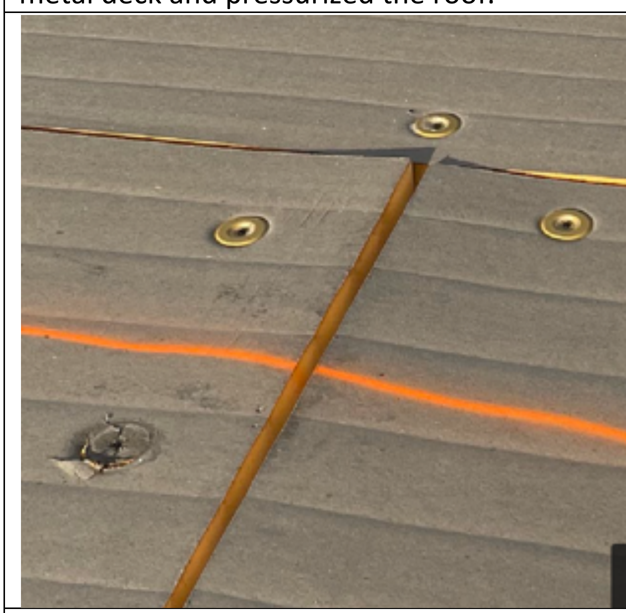
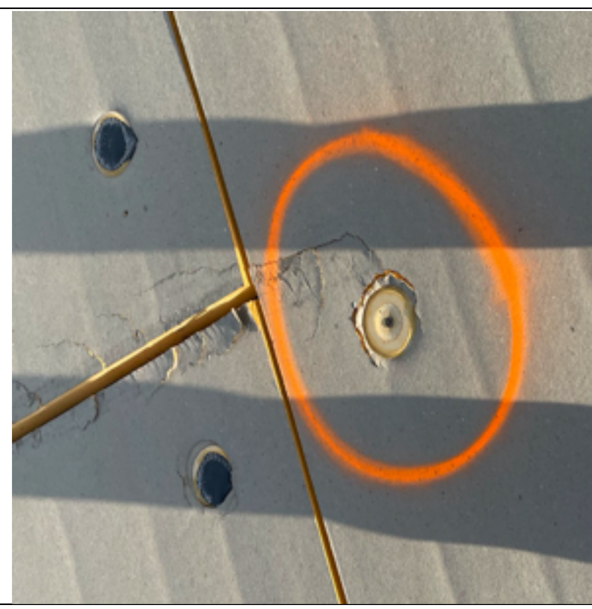

	

Photo 15: A fastener with a good weld and fasteners with incomplete welds.	Photo 16: Incomplete weld to fastener, adversely affecting wind uplift resistance.

CASE STUDY 5: 90 mph windspeed.

Inspection #	**3,3,2**
Surface Color	White
Membrane Type	PVC
# of Perimeter Membrane Attachment rows	4
Perimeter Row Spacing ft	3
Perimeter Fasteners on-center spacing (inches)	6
Field Row Spacing ft.	6
Field fasteners on-center spacing (inches)	12
Fastener Type	Not determined
Plate Diameter (inches)	3
Directly Below Membrane	Not Determined
Insulation Type	Not determined
Insulation Thickness (inches)	Not determined
Insulation Attachment	Screws & Plates
Deck Type	Metal
Metal Edge	Yes
Metal Edge metal thickness (inches or gauge)	26
Metal Edge metal type	Steel
Metal edge fastener spacing? inches on center "typical'	12
Damage Assessment (State Rank)	1
Location of Damage	Field
Types of Damage	Punctures
Extent of Damage Rating	1
Damage initiation	Plates dislodged from air handling units and tumbled across the roof. Found plates
Describe damage details, include all reference to "other"	Only damage was punctures
Roof Height (feet)	24
Parapet Height (feet)	4 to 10 ft
Roof Width (feet)	400
Roof Length (feet)	340
Roof Area (square feet)	136,000
Damage Area	Less than 10%

Data is documented in photos on the following page.

Photo 17: Overview of a 14-year-old roof.

Photo 18: Punctures from air handler parts that became windblown projectiles.


Photo 19: A secure air handler still attached.


Photo 20: Coping that is undamaged.

CASE STUDY 6

Inspection #	**3,3,1**
Surface	White
Membrane Type	PVC
# of Perimeter Membrane Attachment rows	4
Perimeter Row Spacing (feet)	3
Perimeter Fasteners on Centers Spacing (inches)	6
Field Row Spacing (feet)	6
Field fasteners on Centers Spacing (inches)	12
Fastener Type	Not determined
Plate Diameter (inches)	3
Directly Below Membrane	Not determined
Insulation Type	Not determined
Insulation Thickness (inches)	
Insulation Attachment	Not determined
Deck Type	Metal
Metal Edge	Yes
Metal Edge metal thickness (inches or gauge)	26
Metal Edge metal type	Steel
Metal edge fastener spacing? inches on center "typical'	Not determined
Damage Assessment State Rank	1
Location of Damage	Field
Types of Damage	Punctures
Extent of Damage Rating	1
Damage initiation	Metal plates dislodged from air handling units and tumbled across roof, creating cuts and punctures
Describe damage details, include all reference to "other"	Only damage was a limited number of punctures
Roof Height (feet)	24
Parapet Height (feet)	4 to 6 feet
Roof Width (feet)	500
Roof Length (feet)	360
Roof Area (square feet)	180,000
Damage Area	Less than 10%

Data is documented in photos on the following page.

	
Photo 21: Overview of the CASE STUDY 6 roof.	Source of much of the roof damage i.e., when inspection panel detached it became a windblown projectile with sharp corners.
	
Photo 23: Detached metal panels that were dislodged and created many cuts in the membrane on this roof.	Photo 24: Pipe was moved by wind, tearing the membrane.

CASE STUDY 7: Three Identical Buildings (reported windspeed of 130 mph)

Inspection #	**3,1,1**
Surface	White
Membrane Type	TPO
# of Perimeter Membrane Attachment rows	1
Perimeter Row Spacing ft	1.5
Perimeter Fasteners on-center Spacing (inches)	1.5
Field Row Spacing ft.	2
Field fasteners on-center Spacing (inches)	2
Fastener Type	#12
Plate Diameter (inches)	3
Directly Below Membrane	Not Determined
Insulation Type	Not determined
Insulation Thickness (inches)	
Insulation Attachment	Not determined
Deck Type	Metal
Metal Edge	Yes
Metal Edge metal thickness (inches or gauge)	
Metal Edge metal type	Steel
Metal edge fastener spacing? inches on center "typical'	12
Damage Assessment State Rank	3
Location of Damage	Entire Roof, corner, metal edge, perimeter, Field, Near soil Pipes, Near Chimneys, Around penetrations 4' or larger
Types of Damage	Corner or edge peel, Metal edge
Extent of Damage Rating	5
Damage initiation	Not known
Describe damage details, include all reference to "other"	Three identical buildings with new TPO roofs fastened by bonding to the tops of fasteners. One total roof loss, one mostly gone and one with minor damage
Roof Height (feet)	60 ft.
Parapet Height (feet)	12
Roof Width (feet)	60
Roof Length (feet)	300
Roof Area (square feet)	18,000
Damage Area	More than 50%

Data is documented in photos.

Photo 25: Temporary roof over entire building.

Photo 26: Emergency (temporary) repairs to adjacent building.

Photo 27: A tight fastener pattern is visible securing this membrane.

Photo 28: All three buildings had significant coping and edge metal detachment.

CASE STUDY 8: Dollar Tree 3314 Del Prado Blvd. Cape Coral FL (110 mph wind speed)

Inspection #	**2,1,3**
Surface	White
Membrane Type	TPO
# of Perimeter Membrane Attachment rows	2
Perimeter Row Spacing ft	5
Perimeter Fasteners on Centers Spacing (inches)	6
Field Row Spacing ft.	10
Field fasteners on Centers Spacing (inches)	6
Fastener Type	Not determined
Plate Diameter	Not determined
Directly Below Membrane	Not Determined
Insulation Type	Not determined
Insulation Thickness	Not determined
Insulation Attachment	Not determined
Deck Type	Metal
Metal Edge	Yes
Metal Edge metal thickness (inches or gauge)	22 gauge
Metal Edge metal type	Steel
Metal edge fastener spacing? inches on center "typical'	60 (five feet)
Damage Assessment State Rank	2
Location of Damage	Metal Edge
Types of Damage	Metal edge
Extent of Damage Rating	3
Damage initiation	Metal coping detached due to insufficient fasteners. Impact damage where coping hit the roof
Describe damage details, include all reference to "other"	Impact damage where coping hit the roof. Also, loss of coping left roof open to water intrusion between TPO and deck.
Roof Height (feet)	18 ft.
Parapet Height (feet)	
Roof Width (feet)	100
Roof Length (feet)	160
Roof Area (square feet)	16,000
Damage Area	10% or more but less than 25%

Data is documented in photos on the following page.

Photo 29: Overview with repaired sections shown as newer/cleaner membrane.

Photo 30: Metal coping partial detachment.

Photo 31: Extensive metal coping detachment left openings for water intrusion between membrane and deck.

Photo 32: Lack of edge metal fasteners caused coping to have inadequate wind resistance and contributed to detachment.

CASE STUDY 9: Pace Center for Girls (26º36’24.18” N 81º51’36.51” W, a 100-mph wind zone)

Inspection #	**2,3,1;**
Surface	White
Membrane Type	PVC
# of Perimeter Membrane Attachment rows	3
Perimeter Row Spacing (feet)	1.5
Perimeter Fasteners on Centers Spacing (inches)	6
Field Row Spacing (feet)	10
Field fasteners on Centers Spacing (inches)	12
Fastener Type	Not determined
Plate Diameter (inches)	2.75
Directly Below Membrane	Gypsum Board
Insulation Type	Polyisocyanurate Foam Board
Insulation Thickness (inches)	Not determined
Insulation Attachment	Screws & Plates
Deck Type	Metal
Metal Edge	Yes
Metal Edge metal thickness (inches or gauge)	24
Metal Edge metal type	Steel
Metal edge fastener spacing? inches on center "typical'	12
Damage Assessment Rank	1
Location of Damage	Field
Types of Damage	Punctures
Extent of Damage Rating	1
Damage initiation	Punctures from debris impact and membrane seam delamination
Describe damage details, include all reference to "other"	Several Punctures
Roof Height (feet)	24
Parapet Height (feet)	4
Roof Width (feet)	400
Roof Length (feet)	450
Roof Area (square feet)	180,000
Damage Area	Less than 10%

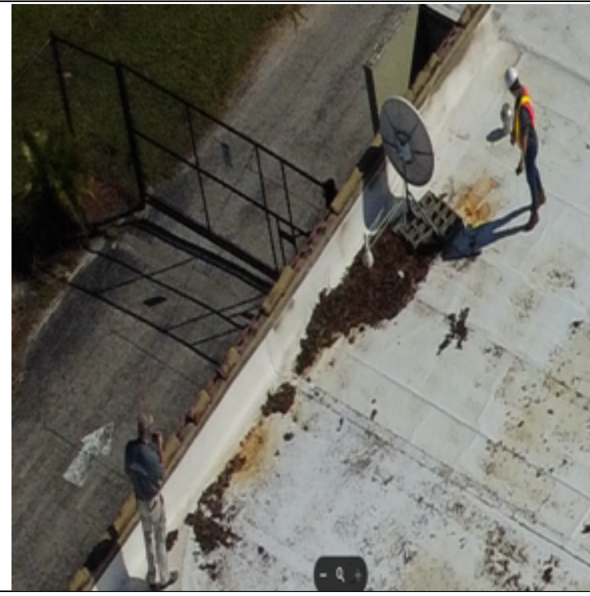
Data is documented in photos on the following page.

Photo 33: An overview shows that the field of the roof appears largely undamaged.

Photo 34: Intact edges indicate that much of the roof was relatively undamaged.

Photo 35: Damaged edge and tile, apparently from windblown projectile impact.

Photo 36: Damaged tile, from windblown projectile impact or wind-induced vibration.

	
Photo 37: A drone view of the Pace Center roof shows the field largely undamaged.	Photo 38: Aerial view of RICOWI inspectors checking tile damage.

CASE STUDY 10: 4102 SE 19th Place, Cape Coral, Florida 33904 (110 mph wind)

Inspection #	**2,1,1**
Surface	White
Membrane Type	PVC
# of Perimeter Membrane Attachment rows	1
Perimeter Row Spacing (feet)	5
Perimeter Fasteners on Centers Spacing (inches)	12
Field Row Spacing (feet)	10
Field fasteners on Centers Spacing (inches)	12
Fastener Type	Not determined
Plate Diameter (inches)	3.5
Directly Below Membrane	EPS insulation
Insulation Type	Not determined
Insulation Thickness (inches	Not determined
Insulation Attachment	Not determined
Deck Type	Not Determined
Metal Edge	Yes
Metal Edge metal thickness (inches or gauge)	22 gauge
Metal Edge metal type	Steel
Metal edge fastener spacing? inches on center "typical'	Not determined
Damage Assessment Rank	2
Location of Damage	Entire Roof, Corner, Perimeter, Field, Around penetrations 4' or larger, around air handling units
Types of Damage	Metal edge, Punctures
Extent of Damage Rating	6
Damage initiation	The air handling unit and the edge metal were where the damage began. The air handing unit was not attached to the unit or the structure. The edge metal was not secured to the structure.
Describe damage details, include all reference to "other"	The air handling unit due to not being secured to the unit or the structure cause punctures to the surrounding area when it tipped over as well as the membrane to peel. The edge metal was not secured.
Roof Height (feet)	20
Parapet Height (feet)	Less than 1
Roof Width (feet)	43
Roof Length (feet)	175

Roof Area (square feet)	7,525
Damage Area	More than 50%

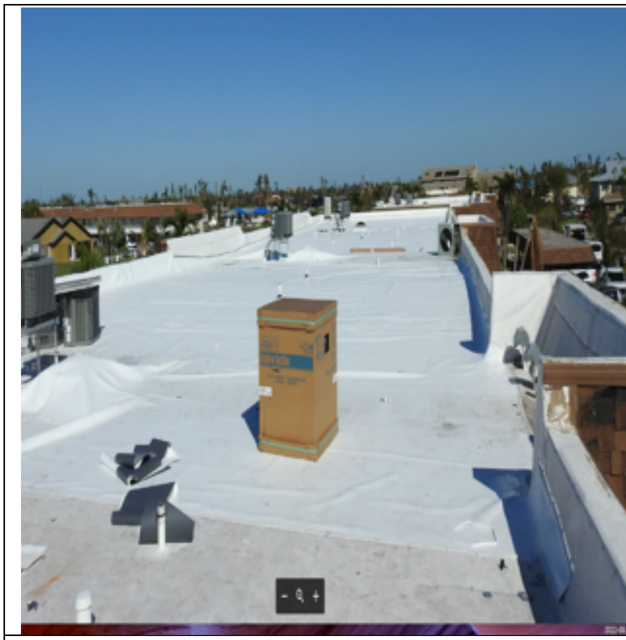


Photo 39: Overview shows ongoing temporary repairs.

Photo 40: A typical membrane tear or cut from the traumatic impact of either a windblown projectile or wind-propelled object tumbling over the roof surface.

Photo 41: Typical air handler damage from storm winds blowing units from stands and/or curbs.

Photo 42: Some parapet damage.

Photo 43: Edge damage like this may allow water intrusion through openings between roof membrane and deck.

Photo 44: Typical air handler stanchion damage, which often causes punctures, gouges, cuts, or tears in the membrane

Multi-ply Bituminous Systems: Built-up Roofing (BUR) and Modified Bitumen

A total of seven roofs were investigated where 42.9% of the membranes were BUR with 57.1% being covered with modified bitumen membranes. The summary data can be seen below.

Total of seven roofs. Summary data

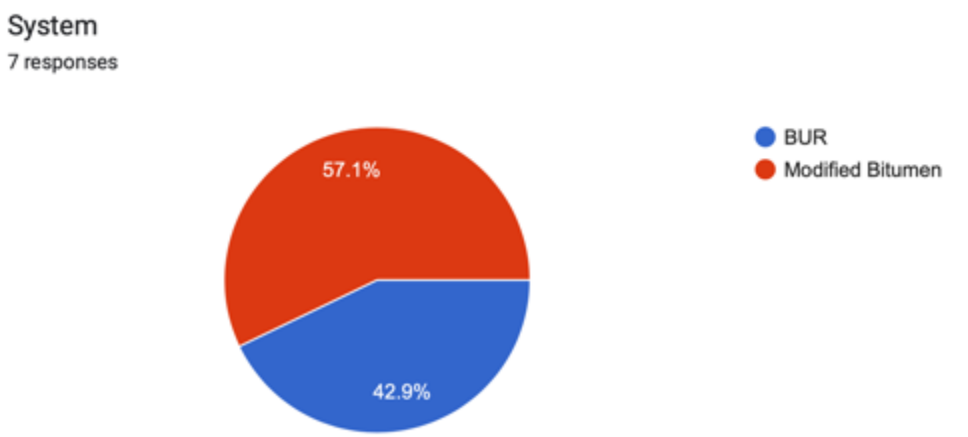


Figure 39: Chart shows that 42.9% of the membranes were BUR with 57.1% being covered with modified bitumen membranes.

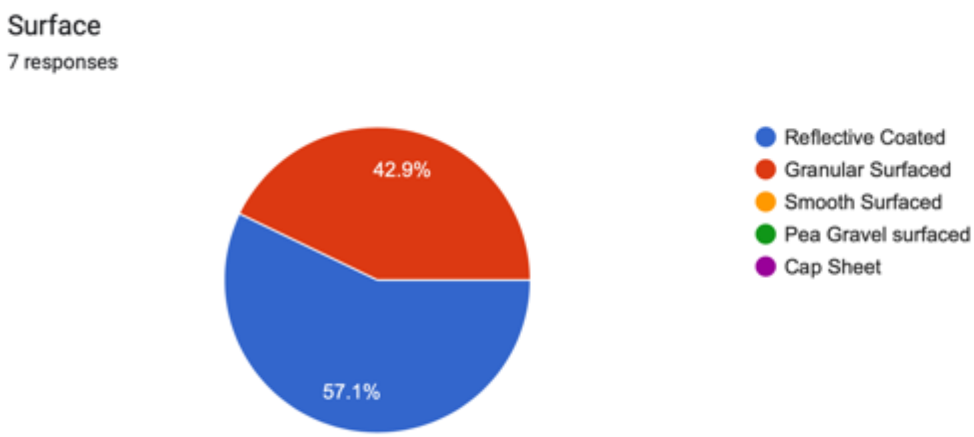


Figure 40: Chart shows that 57.1% of roof surfaces had reflective coating and 42.9% were granular surfaced.

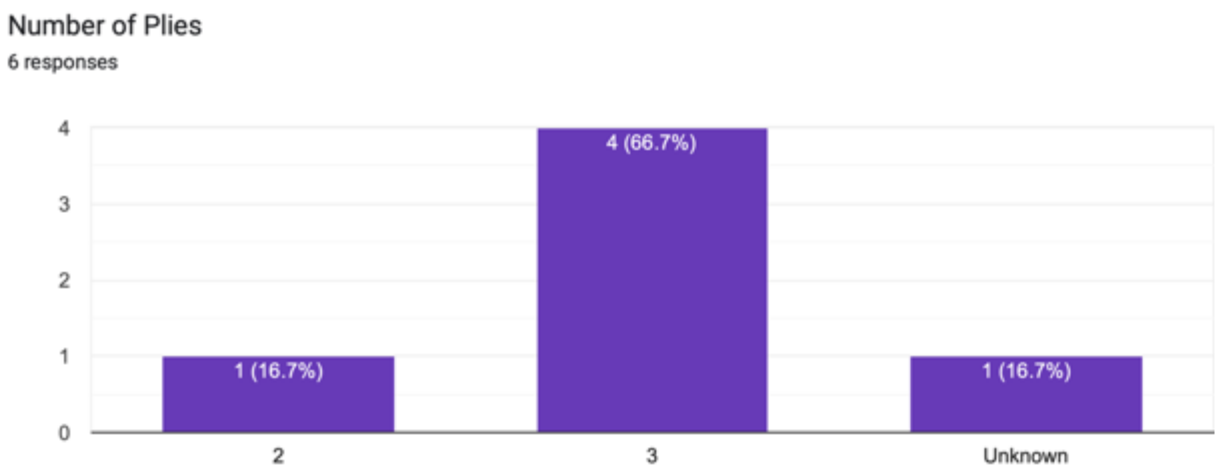


Figure 41: Chart shows the number of plies observed in each multi-ply bituminous membrane.

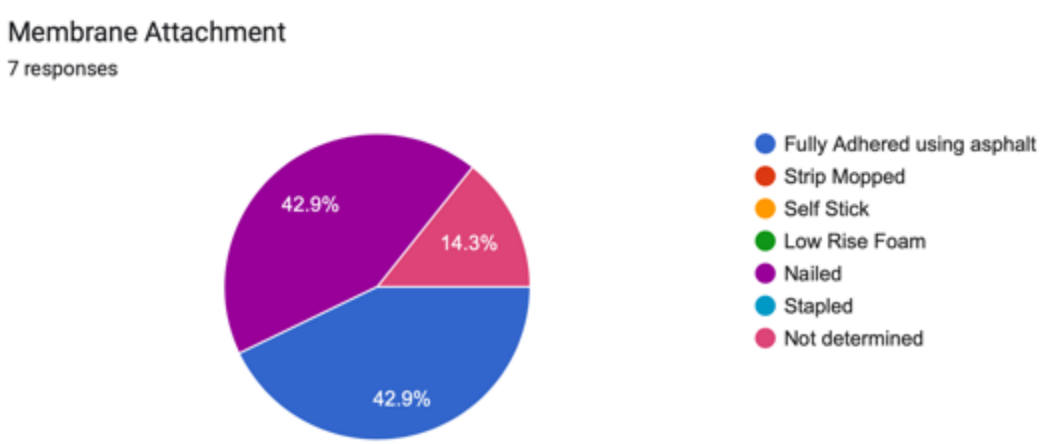


Figure 42: Chart depicts that 42.9% of the inspected membranes were attached with staples, 42.9% attached with nails, and 14.3% were not determined.

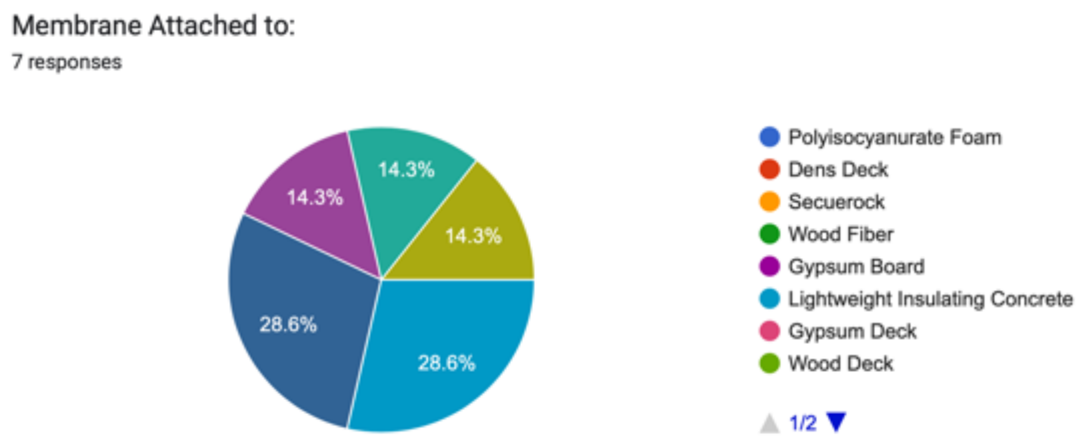


Figure 43: Chart depicts percentages of membranes attached to each of the listed deck types.

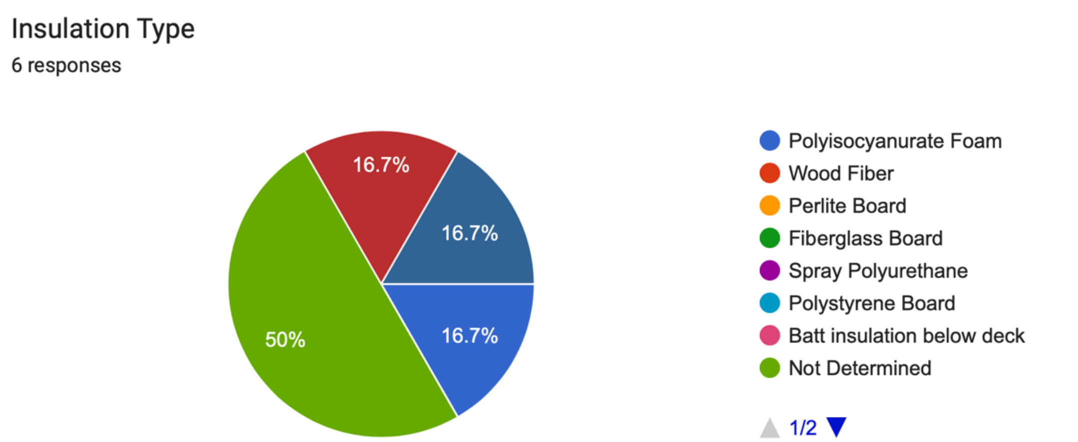


Figure 44: Chart shows the percentage of each listed type of insulation installed beneath bituminous multi-ply membranes.

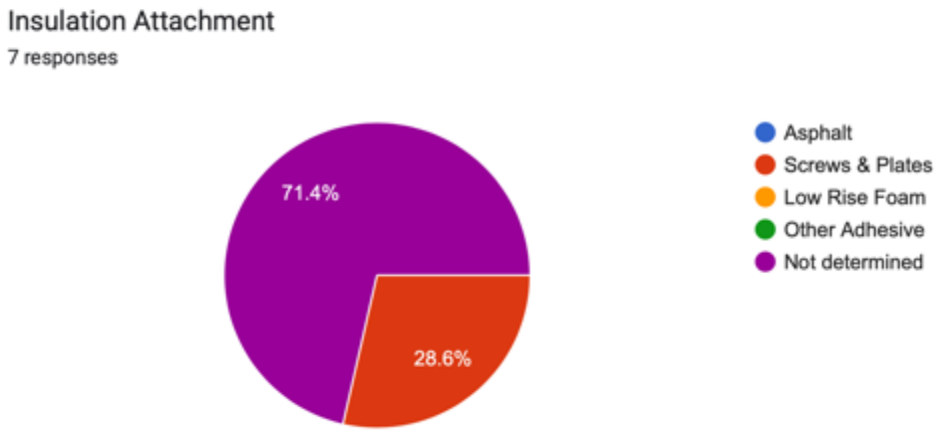


Figure 45: Chart depicts that 28.6% of the roof decks inspected had insulation attached using screws and plates. The insulation attachment for the remaining 71.4% roofs was not determined.

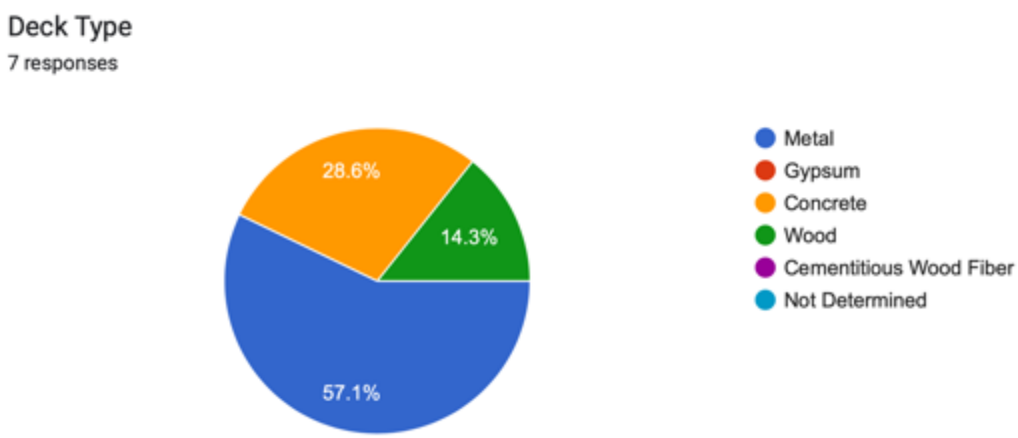


Figure 46: Chart indicates that 57.1% of inspected roofs had a metal roof deck, 28.6% had concrete decks, and 14.3% had wood.

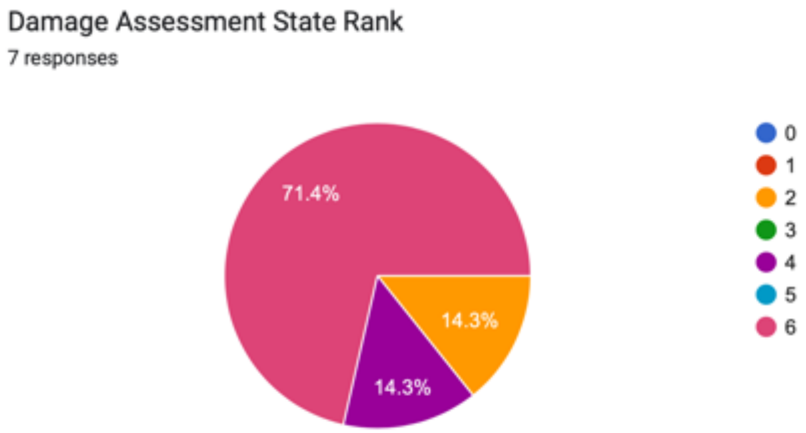


Figure 47: Chart indicates that of seven inspected bituminous roofs, 71.4% were assigned a damage level of “6,” meaning extreme damage; 14.3% were assigned “4,” meaning moderate-to-high; and another 14.3% were assigned “2,” meaning low-to-moderate damage.

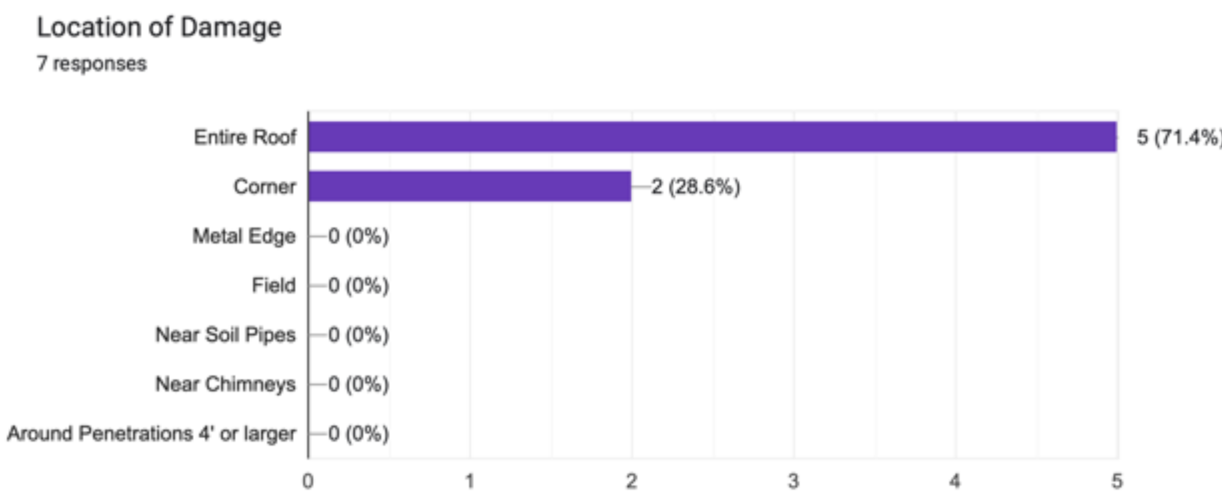


Figure 48: Chart shows that, of the seven bituminous roofs inspected, five exhibited damage to the entire roof, and two exhibited damage only in roof corners, where wind uplift forces are commonly the greatest.

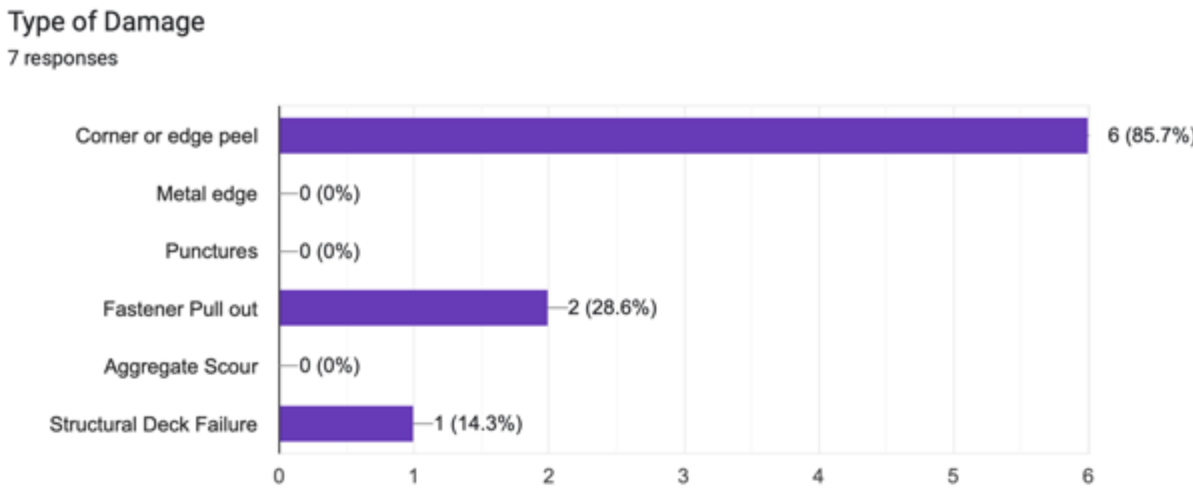


Figure 49: Chart shows the nature of damage to the seven inspected multi-ply bituminous membranes. All but one exhibited peel back of the membrane at the high-uplift roof areas – corners and perimeter edges, as would be expected. Two also exhibited fastener pull-out, and one exhibited failure of the structural deck.

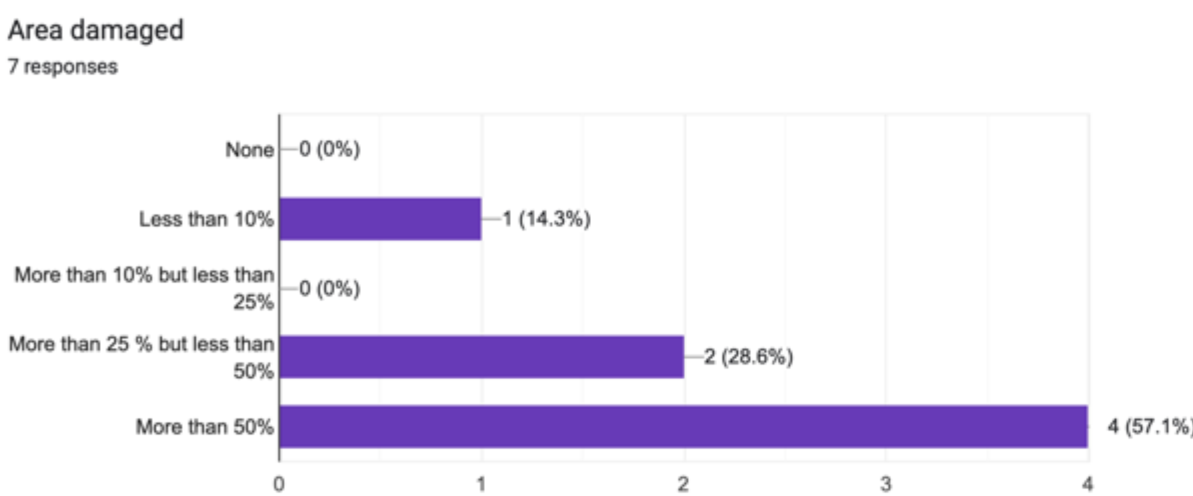


Figure 50: Chart is a different way of determining the extent of damage, which is also addressed in “Damage Assessment State Rank,”

Case Study 11
Inspection 2.2.2 - Modified Bitumen (120 mph windspeed)

Inspection #	**2,2,2**
System	Modified Bitumen
Surface	Reflective Coated
Number of Plies	2
Membrane Attachment	Fully adhered using asphalt
Membrane Attached to:	Not determined
Insulation Type	Not Determined
Insulation Thickness	Not determined
Insulation Attachment	Not Determined
Deck Type	Wood
Metal Edge Thickness	Not determined
Type of Metal Edge	
Metal Edge Fasteners distance between centers (typical)	Not determined
Solar Equipment	None
Damage Assessment State Rank	2
Location of Damage	Entire roof section with sporadic impact damage
Type of Damage	Corner or edge peel
Extent of Damage Detail Ranking	6
Damage Initiation	The roof section in direct contact with the wind direction had to be replaced. Impact damage from windblown projectile and/or wind-propelled objects tumbling across the roof.
Describe the damage in detail. discuss all references to "other"	There were three roof sections. Roof section 1 in direct contact with the wind direction had to be completely replaced. In roof section 2 and 3 there was sporadic impact damage.
Parapet height	N/A
Roof Width	69
Roof Length	104
Total Roof Area, Square feet	7176
Area damaged	More than 25 % but less than 50%

A synopsis of data from the building documented in photos on the following page.

	
Photo 40: Modified Bitumen roof with only minor damage. Small parapet intact.	Photo 41: Air handling unit displaced
	
Photo 42: Cut from debris	Photo 43: Roof section with temporary recover

	
Photo 44: Google Earth 9-29-22 See damaged section.	Photo 45: Displaced AHU

Case Study 12- Hotel 1538 Cape Coral Pkwy E Cape Coral, FL 33904, USA

Inspection #	**2,1,4**
System	Modified bitumen
Surface	reflective coated
Number of Plies	2
Membrane Attachment	fully adhered using asphalt
Membrane Attached to:	lightweight insulating concrete
Insulation Type	perlite board
Insulation Thickness	Not determined
Insulation Attachment	screws and plates
Deck Type	steel
Metal Edge Thickness	Not determined
Type of Metal Edge	Not determined
Metal Edge Fasteners distance between centers (typical)	Not determined
Solar Equipment	none
Damage Assessment State Rank	1
Location of Damage	corner
Type of Damage	membrane peel, fastener pull out
Extent of Damage Detail Ranking	2
Damage Initiation	membrane peel, fastener pull out, roof wall junction air intrusion from the bottom. Deterioration along the drain and the internal pressure built up at the junction initiated the damage. Impact damage.
Describe the damage in detail. discuss all references to "other"	membrane peel, fastener pull out, roof wall junction air intrusion from the bottom. Deterioration along the drain and the internal pressure built up at the junction initiated the damage.
Parapet height	16"
Roof Width	60
Roof Length	110
Total Roof Area, Square feet	6600
Area damaged	less than 10%

Photos from the above inspection.

Photo 45a: Membrane peeling exposing the lightweight insulating concrete and fasteners and plates

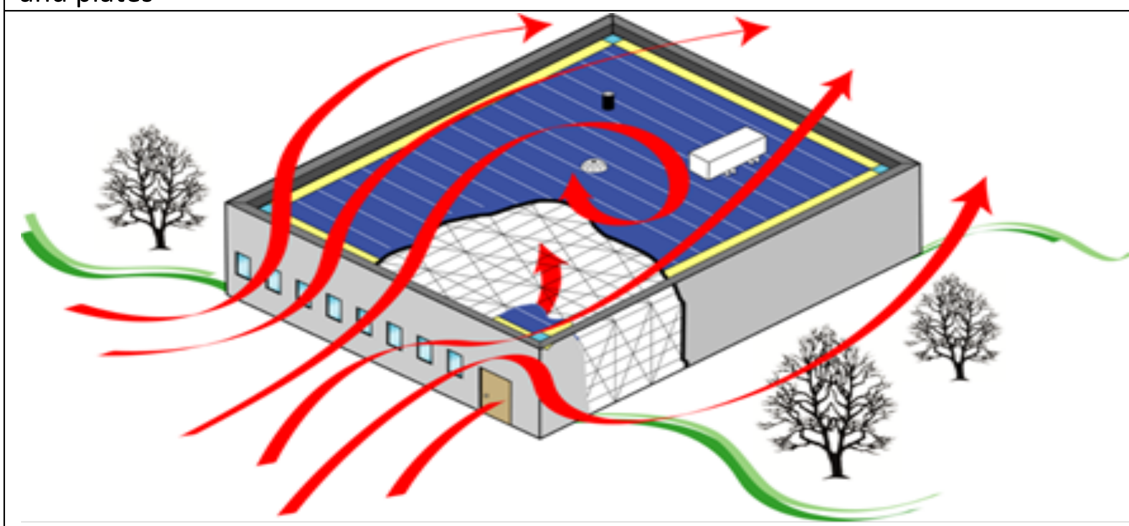


Photo 45b: Failure at the roof wall junction causing air intrusion from the bottom of the roof

Photo 45c: The rest of the roof was not damaged

Case Study 13: Inspection 2-1-2

Tire Kingdom 4503 Del Prado Blvd S. Cape Coral, FL 33904 110 mph wind zone

Inspection #	**2,1,2**
System	BUR
Surface	Granular Surfaced
Number of Plies	3
Membrane Attachment	Fully adhered using asphalt
Membrane Attached to:	Fiberglass Board
Insulation Type	Fiberglass Board
Insulation Thickness	1"
Insulation Attachment	Screws & Plates
Deck Type	Metal
Metal Edge Thickness	Not determined
Type of Metal Edge	Steel
Metal Edge Fasteners distance between centers (typical)	12"
Solar Equipment	None
Damage Assessment State Rank	6
Location of Damage	Entire Roof
Type of Damage	Corner or edge peel, Metal edge, Fastener Pull out
Extent of Damage Detail Ranking	6
Damage Initiation	Membrane peeled from the back where the gutter was attached and there was no presence of a parapet. Deck was severely corroded at the back of the building where damage initiated.
Describe the damage in detail. discuss all references to "other"	Membrane peeled from the back where the gutter was attached and there was no presence of a parapet
Parapet height	13"
Roof Width	44
Roof Length	105
Total Roof Area, Square feet	4620

Area damaged	More than 50%

Photos following document the data above.


Photo 46: Adhered Mod Bit damage


Photo 47: Some parapet damage


Photo 48: Rusted deck main source of blow off


Photo 49: Intact fasteners, although much rust

Case Study 14: Port Charlotte Town Center 120 mph windspeed

Inspection #	**2,2,4**
Surface	White
Membrane Type	TPO
# of Perimeter Membrane Attachment rows	4
Perimeter Row Spacing ft	6
Perimeter Fasteners on Centers Spacing (inches)	Not determined
Field Row Spacing ft.	8
Field fasteners on Centers Spacing (inches)	6
Fastener Type	Not determined
Plate Diameter	2 1/4"
Directly Below Membrane	High density polyisocyanurate
Insulation Type	Polyisocyanurate Foam Board
Insulation Thickness	0.5
Insulation Attachment	Not determined
Deck Type	Metal
Metal Edge	Yes
Metal Edge metal thickness (inches or gauge)	22
Metal Edge metal type	Steel
Metal edge fastener spacing? inches on center "typical'	14
Damage Assessment State Rank	6
Location of Damage	Corner, Metal Edge
Types of Damage	Metal edge
Extent of Damage Rating	3
Damage initiation	Structural failure. Metal edge failure, skylight damage due to gravel debris impact
Describe damage details, include all reference to "other"	Structural failure of the beam caused the roof section to collapse. Metal edge failure, skylight damage due to gravel debris impact.
Roof Height	24
Parapet Height	6ft
Roof Width	259
Roof Length	394
Roof Area	102046
Damage Area	10% or more but less than 25%

Photos following document the data above.

Photo 50: Damaged Skylights

Photo 51: Google earth view

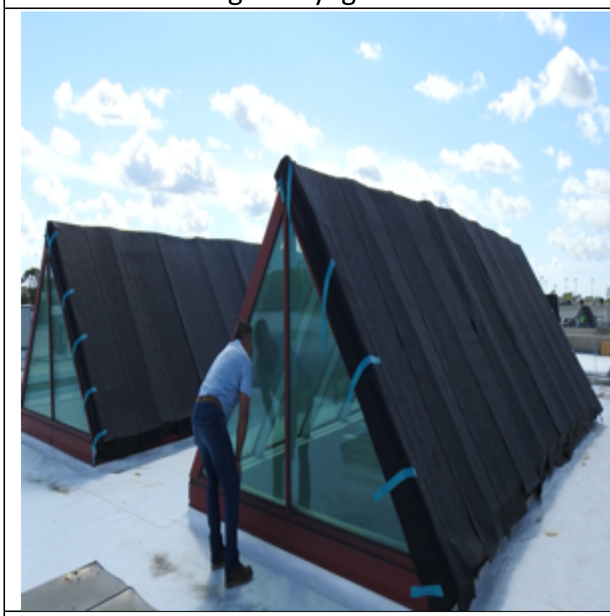


Photo 52: Skylights

Photo 53: Loose lightening arrester wire

	
Photo 54: Structural damage	Photo 55: Initial fastening over BUR roof.
	
Photo: 55a the rest of the roof had 5ft parapets and was not damaged	

Case Study 15: Inspection 2-2-5
2230 Hariet St, Port Charlotte, Fl 33952 Wind Speed ARA 120 mph

Inspection #	**2,2,5**
System	BUR
Surface	Pea Gravel
Number of Plies	3
Membrane Attachment	Fully Adhered using asphalt
Membrane Attached to:	Not determined
Insulation Type	Not determined
Insulation Thickness	Not determined
Insulation Attachment	Not determined
Deck Type	Metal
Metal Edge Thickness	Not determined
Type of Metal Edge	Steel
Metal Edge Fasteners distance between centers (typical)	Not determined
Solar Equipment	None
Damage Assessment State Rank	4
Location of Damage	Corner
Type of Damage	Corner or edge peel, structural deck failure, structural failure, air handling unit, corner and edge peel
Extent of Damage Detail Ranking	4
Damage Initiation	Two out of three roof sections were in direct contact with the wind (open exposure, waterfront) these had part of the roof replaced. One had a structural failure which could have been initiated by the failure of the soffit located underneath due to pressure built-up. The failure on the other roof section could not be determined. There were also air handling units that had been tipped over.
Describe the damage in detail. discuss all references to "other"	Air handling units tipped over, two out of three roof sections were replaced
Parapet height	No parapets
Roof Width (feet)	85
Roof Length (feet)	105
Total Roof Area, Square feet	8925
Area damaged	More than 25 % but less than 50%

Photos following document the data above.

	
Photo 56: Temporary patch in corner	Photo 57: Another roof section with a temporary roof. Note no parapet or gravel stop. Also, soffit damage.
	
Photo 58: Damaged air handling unit	Photo 59: Missing down spout, and debris damaged window

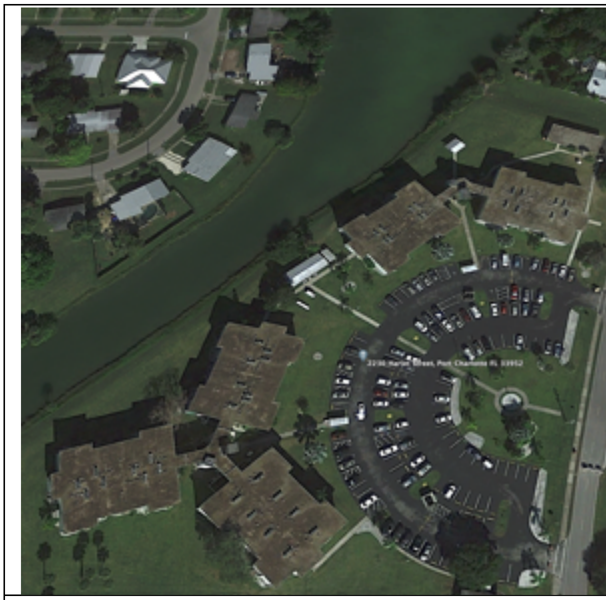


Photo 59: Google earth view (2021) water facing units had most damage	Photo 60: Structural damage

Case Study 16: Kane's Furniture

Inspection #	**3,2,2**
System	Modified Bitumen
Surface	Granular Surface
Number of Plies	3
Membrane Attachment	Mechanically Attached
Membrane Attached to:	Lightweight Insulating Concrete
Insulation Type	No Insulation
Insulation Thickness	NA
Insulation Attachment	NA
Deck Type	Form Board
Metal Edge Thickness	Not determined
Type of Metal Edge	Steal
Metal Edge Fasteners distance between centers (typical)	Not determined
Solar Equipment	None
Damage Assessment State Rank	6
Location of Damage	Entire Roof
Type of Damage	Almost total roof covering dislodged
Extent of Damage Detail Ranking	6
Damage Initiation	Not determined. However overhead doors were blown in likely causing overpressure. The front of the store suffered major structural damage where the larger doors were located - see before and after google earth photos.
Describe the damage in detail. discuss all references to "other"	Coping metal dislodged in several areas as well as missing gutter.
Parapet height	0 expect store front
Roof Width (feet)	175
Roof Length (feet)	350
Total Roof Area, Square feet	61250
Area damaged	More than 50%

Photos following document the data above.

Photo 61: Temporary(?) Roof installation. Plywood being placed between membrane and lightweight concrete, both to separate and provide a safe (?) walking surface.

Photo 62: Primary source of roof damage, door failure pressurizing the roof.

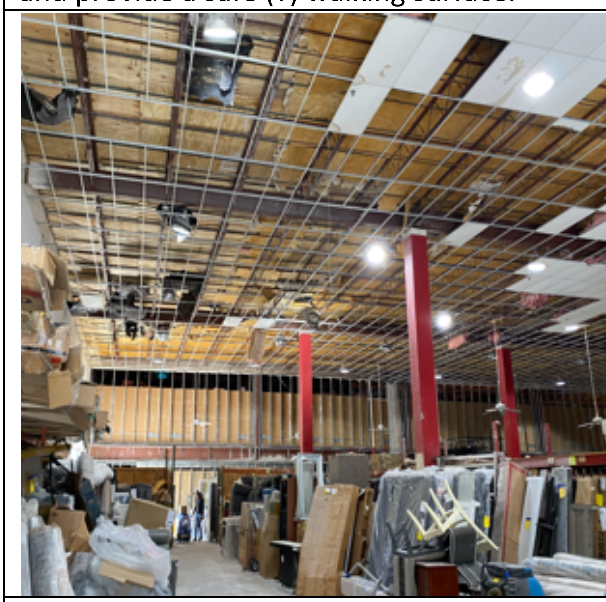


Photo 62: Significant interior and product damage

Photo 63: Membrane debris

Photo 64: Temporary fastening to deck

Photo 65: Missing gutters

SPUF

Case Study 17: 1 Inspection

Condominiums (Hampshire House 21320 Brinson Ave, Port Charlotte, Fl 33952)   120 mph windspeed.

Inspection # Inspection # --team #, Day, (Inspection-example 1,2,4 for team 1 on day 2 and the 4th inspection that day)	**2,2,1**
Surface	white coated and granules
Coating Type	Acrylic and Granules
Re-cover	Yes
Spray Polyurethane installed over	Existing Metal
Insulation Type	Spray Polyurethane
Insulation Thickness (inches)	Not determined
Metal edge installed	No
Metal Edge Thickness (inches or gauge)	N/A
Edge Metal Type	
Metal edge fasteners ---inches on center "typical"	N/A
Spray Foam Damage Assessment	3
Location of Roof Damage	Entire roof, edges where gravel was displaced
Type of Damage	Stone scour, Widespread blistering which may have been exacerbated by wind
Extent of damage	2
Damage initiation	damage initiated near the edges where there is scour
Describe Damage	Gravel scour, widespread blistering

Photos following document the data above.

Photo 66: Foam is intact, significant scour

Photo 67: Typical Blister

Photo 68: No parapet or gravel stop. Wind scour at all perimeters. Notice widespread blisters are also scoured.

Photo 69: Upwind low parapet typical wind scour of small aggregate.

Photo 70: Intact air handlers

Photo 71: Foam thickness

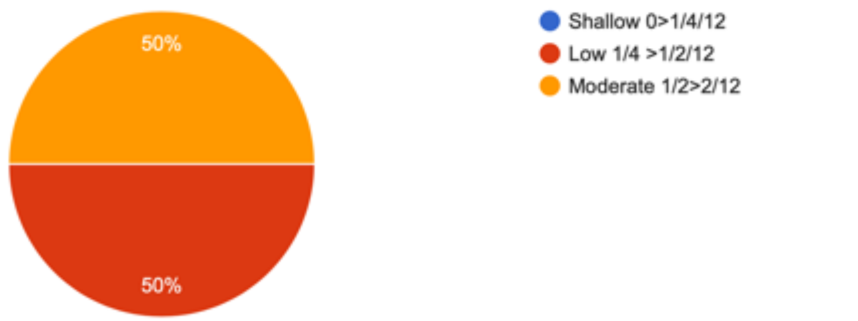
Metal Roofs

2 Low slope metal roofs

Metal Panel Low Slope

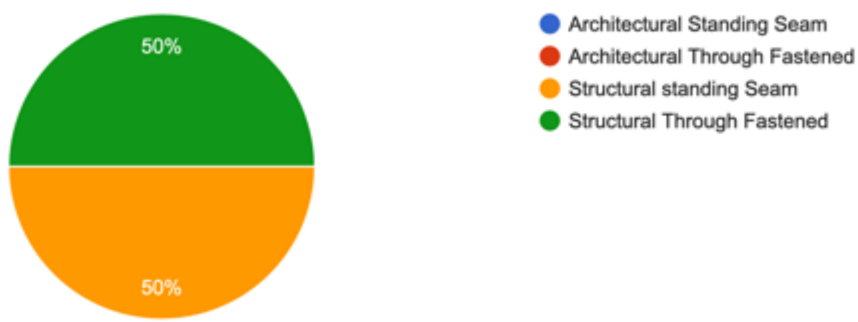
Slope

2 responses



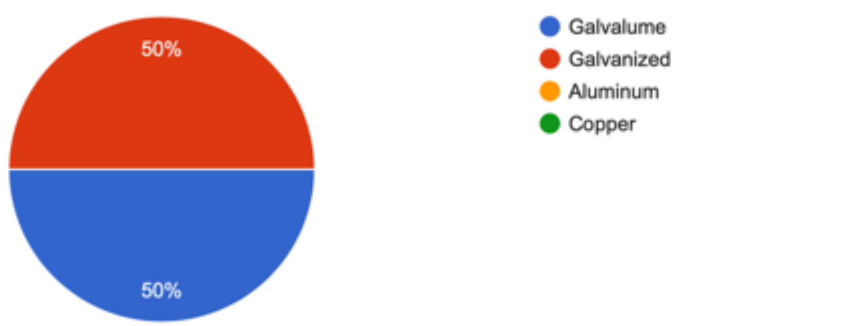
System Type

2 responses



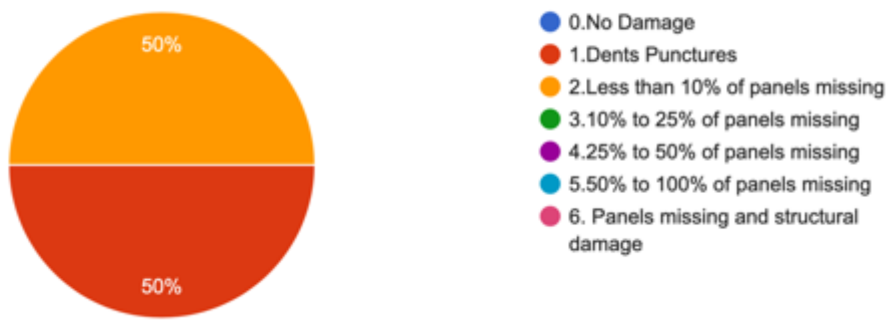
Unfinished Metal

2 responses



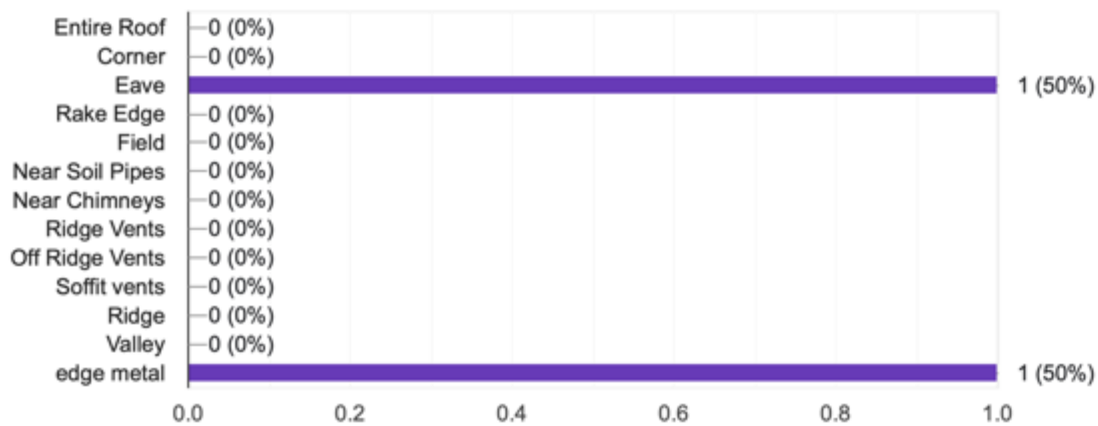
Damage Assessment State Rank

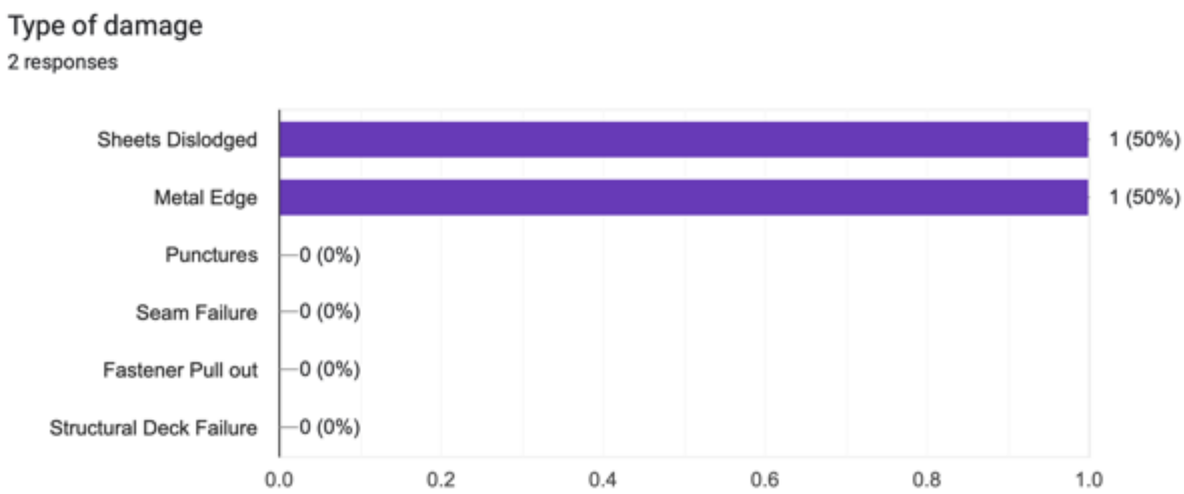
2 responses



Location of Roof Damage

2 responses





Case Study 18

Inspection #	**2,1,5**
Slope	Moderate 1/2>2/12
System Type	Structural standing seam
Unfinished Metal	Galvalume
Painted	Untreated Steel
Installation	
Fastener Spacing	
Corner or perimeter enhancement	None
Valleys	
Underlayment	
Underlayment Type	
Deck	
Damage Assessment State Rank	1.Dents Punctures
Location of Roof Damage	Edge metal
Type of damage	Metal Edge
Damage Initiation	70% of the front was damaged, along with 10% of the right, 80% of the back and 70% of the left. The damage was due to insufficient wood nailer.
Describe Damage	Edge metal was damaged due there being insufficient wood nailer as only a 1/2inch plywood sheet was used that was 2 ft wide. There were also some impact punctures on the metal panels where the coping struck the roof.

The following photos document the data above.

Photo 72: Top of rotted parapet, inadequately fastened coping

Photo 73: Damage to metal deck from coping hit.

Photo: Fastener pulled out of the coping

Photo: The right of the roof was mostly undamaged

	
Photo: Damaged edge metal and ½ inch plywood sheet	Photo: Missing coping increasing risk of water infiltration

Case Study 19
Ray Electric Outboards

Ray Electric Outboards, Northeast 24th Lane, Cape Coral, FL 110 mph windspeed.

Photo 74: Metal roofed building with minimal roofing loss, with gutter damage

Photo 75: Decorative protective entrance cover completely missing

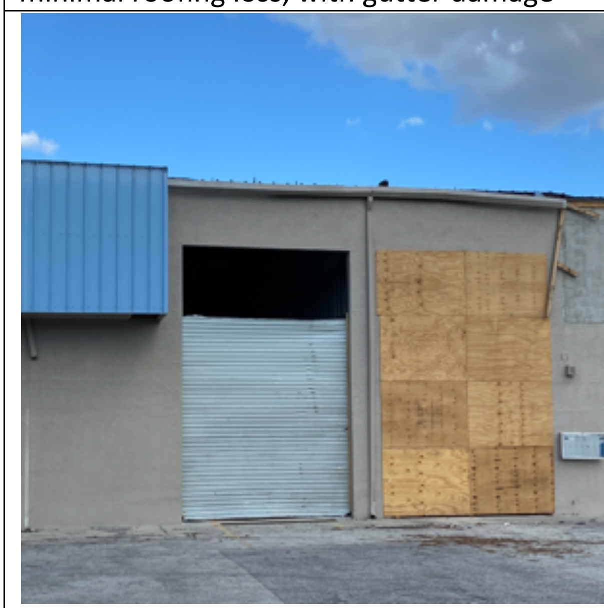


Photo 76: Intact entrance cover, door damage

Photo 77: Another damaged door

Case Study 20: Several roofs with similar damage.
Fort Myers area 100 mph winds

Photo 78: Overhang damage

Photo 79: Temporary repairs of metal panel roof

Photo 79: Adjacent building

Photo 80: Same result

Case Study 21: Partial building collapse.
This is included as it is an unusual result. The building is at Punta Gorda airport and likely had wind gusts of 130 mph. It also had little obstruction between the building and the open airfield. The building built in the 1980's appears to not have been damaged by Hurricane Charley in 2004. Other significant structural damage was not noted in the RICOWI field investigations.

Photo 81: This wall faces Northeast, where the greatest wind speed gust in Hurricane Ian is likely.

Photo 82: Wall is breached

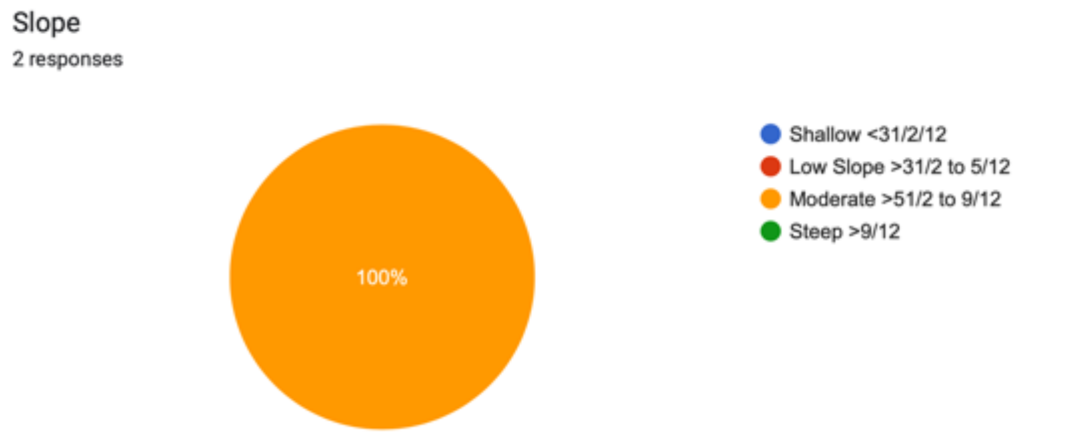
Photo 83: Standing seam clips attached to purlins, but released from seams

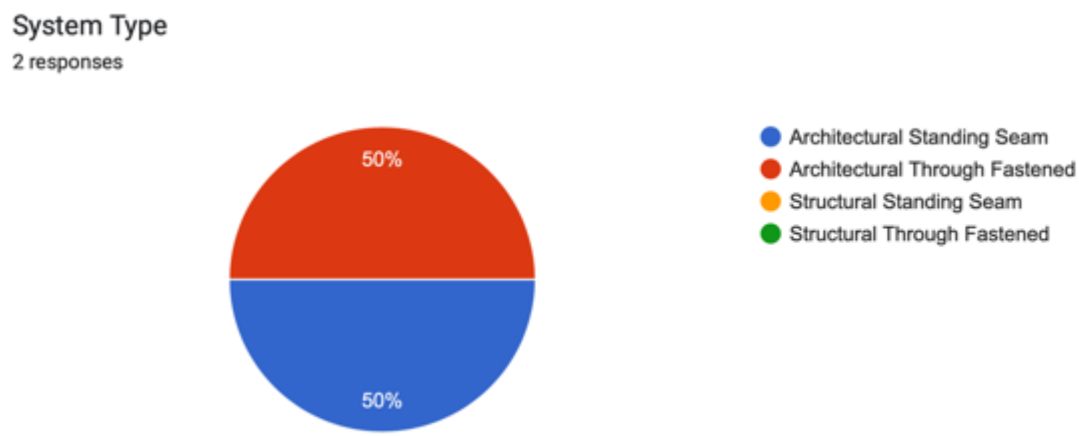
Photo 84: Doors resisted the winds.

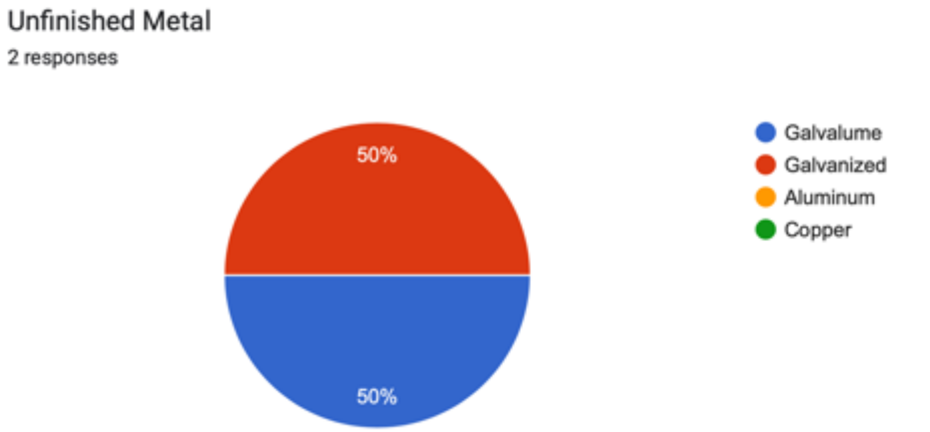
Steep Slope

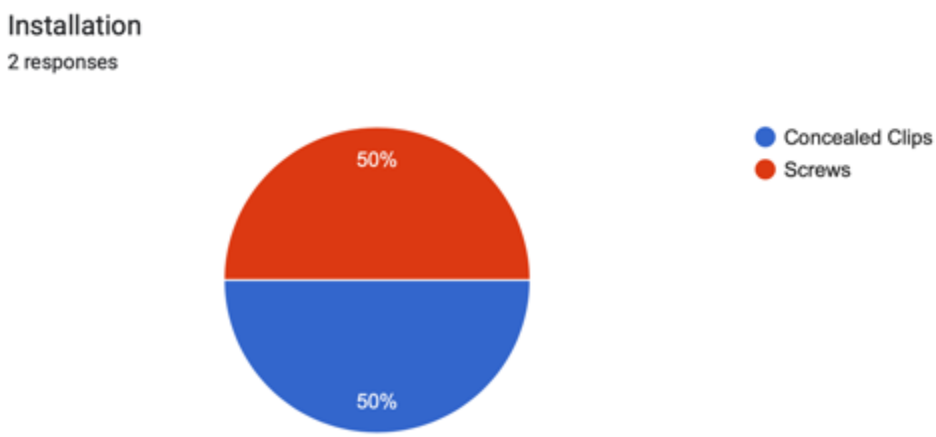
Metal Panel

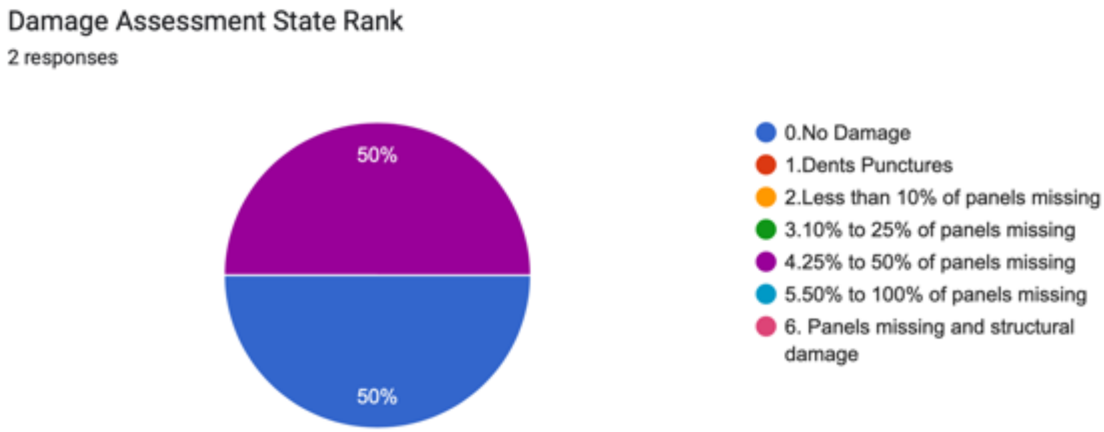
2 Steep slope metal roofs

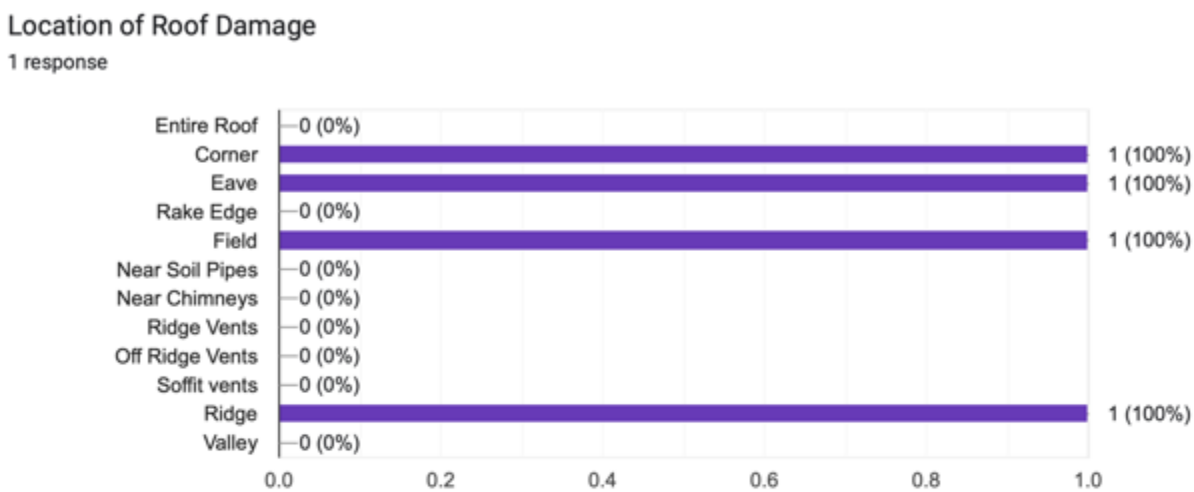





Unfinished Metal
2 responses
50%
50%
Galvalume
Galvanized
Aluminum
Copper


Installation
2 responses
50%
50%
Concealed Clips
Screws


Damage Assessment State Rank
2 responses
50%
50%
0.No Damage
1.Dents Punctures
2.Less than 10% of panels missing
3.10% to 25% of panels missing
4.25% to 50% of panels missing
5.50% to 100% of panels missing
6. Panels missing and structural damage


Location of Roof Damage
1 response
Entire Roof
Corner
Eave
Rake Edge
Field
Near Soil Pipes
Near Chimneys
Ridge Vents
Off Ridge Vents
Soffit vents
Ridge
Valley
0 (0%)
1 (100%)
1 (100%)
0 (0%)
1 (100%)
0 (0%)
0 (0%)
0 (0%)
0 (0%)
0 (0%)
1 (100%)
0 (0%)
0.0
0.2
0.4
0.6
0.8
1.0

Case Study 22. Port Charlotte Area 130 mph gust windspeed

	
Photo 85: Through fastened metal Roof Survivor of 130 mph winds. Open terrain.	Photo 86: Good detail and installation

Case Study 23: Cape Coral 110 mph windspeed

	
Photo 87: About half this metal roof may have been damaged	Photo 88: Tarps cover most of the roof
	
Photo 89: The debris pile shows lack of fasteners	Photo 90: This tiny fastener did not hold the metal

Street Survey Photos

	
Photo 91: Total survival of 120mph winds	Photo 92: Successful older installation, 120 mph wind
	
Photo 93: Damaged roof in 130 mph windspeed. Inadequate edge fastening	Photo 94: Overhangs are vulnerable, more bracing was needed, 110 mph winds.

Case Study 24: Inspection 1-2-4
Project Woodwind Development, Gasparilla area, 26 43 48 N/82 15 45 W
General observations: Most roofs were metal and performed well. One roof in the area was a nail strip with seams 16" O.C and fastening 10" O.C., minor roof failure due to fastener pull out and pull over. Hip flashing failure due to rivets being spaced at 30" **O.C.** to cleat.

Photo 95: Panels missing on rake edge

Photo 96: Another view

Photo 97: This roof had seams 16 O.C. and fastening 10” O.C.

Photo 97: Hip flashing failure due to rivets being spaced at 30” O.C. to cleat.

Case Study 25: Inspection 2-5
3025 Gulf Blvd. Port Boca Grande, FL 26 44 21 N/82 15 47 W
Project information: Metal 5V crimp on ½” plywood experienced complete deck failure due to re-roof with staples and smooth nails for fastening of plywood.

Photo 98: Debris pile

Street Survey: The following roofs survived 120 mph winds

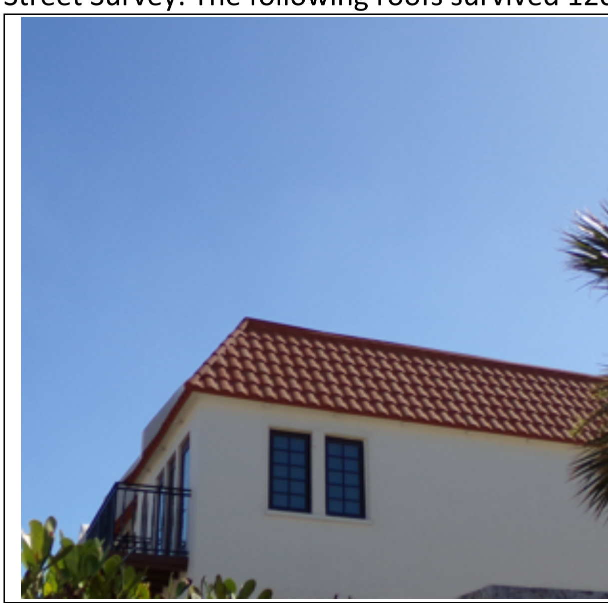


Photo 99: Metal panel simulated tile	Photo 100: Metal panel tile exhibiting good installation
	
Photo 101: Metal panel tile exhibiting good installation	Photo 102: Metal panel

Tile Roofs

Typical Tile issues

	
Photo 103: This roof endured 130-mph winds. Many tiles that were nailed to battens became detached	Photo 104: Section not recovered, showing battens and underlayment

Photo 105: A few mortar-installed tiles were missing along this hip

Photo 106: This was a frequent scene with a few hip tiles not contacted with SPF

Photo 107: Lack of full foam contact at the hip and allowed ridge tiles to become detached, becoming windblown projectiles, and further damaging the roof.

Photo 108: This is an extreme case of tile and underlayment detachment. Tiles were nailed.

	
Photo 109: Some hip tiles were dislodged and/or detached.	Photo 110: Random impact damage from windblown projectiles; underlayment intact.

	
Photo 111: Older system subjected to 110 mph winds, resulting in dislodged and detached tile	Photo 112: Area of damage, along roof edge

Photo 113: SW 39th Ave Cape Coral A tile roof subjected to 110 mph exhibited some hip damage.

Photo 114: Another tile roof subjected to 110 mph winds, causing dislodged/detached hip tiles.

Photo 115: SW 39th Ave Winds of 110 mph. No damage observed

Photo 116: Winds of 120 mph or greater with no damage observed.

Case Study 26:

Wind Speed ARA	120
Inspection Number	1. 1.3 -- Chiquita Blvd.
Eave Height ft.	20
Ridge Height	32
Slope	Steep >9/12
Tile Type	Barrel
Tile Material	Concrete
Attachment	Foam
Underlayment Type	
Deck	
Ventilation, check all that apply	
Solar Equipment on Roof	NO
Damage Assessment	Less than 25% of tiles damaged
Location of Damage-Check all that apply	Ridge
What Failed First - How do you know	Tile detached at ridges
Describe Damage	Tile missing from many ridges, attached with only one nail and a foam paddy that was not large enough to attach to ridge board


Photo 117: Typical missing tile on hip


Photo 118: Tile missing from high hip

	
Photo 119: Tile missing from low hip	Photo 120: One nail and small paddy were not adequate to hold this hip tile.

Street Survey: Placida, FL. Area ARA 130 mph winds in Ian

How observed	**Drove**
Number of units on street section observed	25
Street Surveyed	Spanish Pointe
Cross Street	Ponce DeLeon
Street Number Range X to Y	Port Charlotte
Wind Speed ARA 130 mph	
Buildings	Homes
	Tile
Number of Tile Roofs in Street section observed	25
Percent of Tile Roofs in this street section severely damaged	1 to 10%
Percent of Tile Roofs in this street section that had damages but were NOT severely damaged	1 to 10%
Tile Roofs in this street section damage start location	Ridges & hips
Comments	Hip/ridge tiles on some homes were damaged. 3-year-old sub-division. Overall good performance. The damage seemed to be caused by poor foam application. North winds appeared to cause damage.


Photo 121: One example of tile loss. Cause not determined.

Photo 122: Small area of hip tile missing


Photos 123 & 124: These roofs appeared undamaged despite 130 mph winds and are in very flat terrain with few obstacles I.e., likely Class C wind exposure.


Photos 125 & 126: These roofs appeared undamaged despite Class C wind exposure and 130 mph winds so neatly cleaned up.

Asphalt Shingles

Street Survey: Asphalt Shingle Roofs in 130 mph wind zone near Mayflower and Carnation. Cape Coral Fl.

Photo 127: Ridge and hip damage

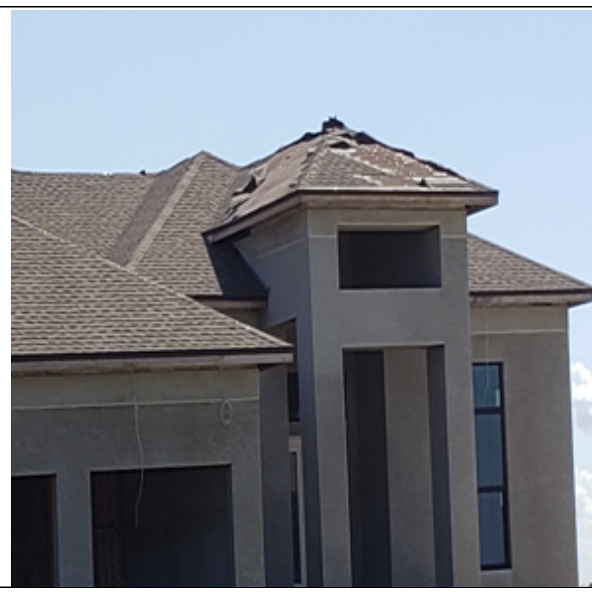


Photo128: Some damage on high roof

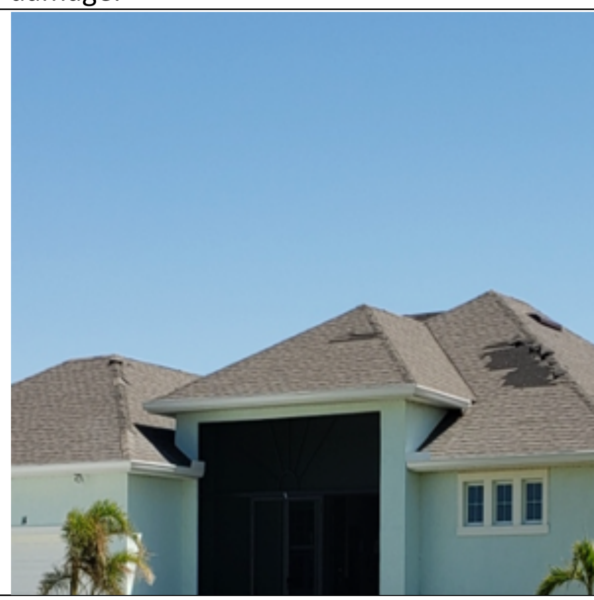
	
Photo 129: Two areas of damage in the field of this roof	Photo 130: Small amount of hip and ridge damage.
	
Photo 131: Hip and ridge damage	Photo 132: Some field of roof damage

Photo 133: Solar array undamaged

Photo 134: Older asphalt shingles

Photo 135: Unusual damage location on hip and eave

Photo 136: Hip and ridge damage that appears to have spread

Photo 137: Shingle detachment on a roof constructed in 2022, exposed to 110 mph windspeed.

Photo 138: Note that the shingles were still bonded together, exhibiting low loss of sealant strip adhesion Inadequate nailing may have contributed to detachment.

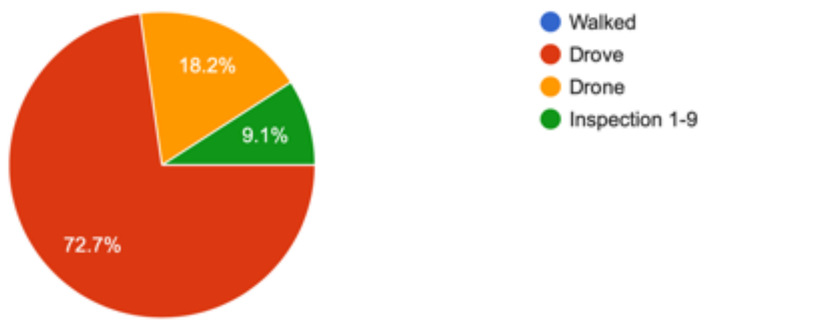
Photo 139: Debris pile

Photo 140: Hip shingles were inadequately adhered.

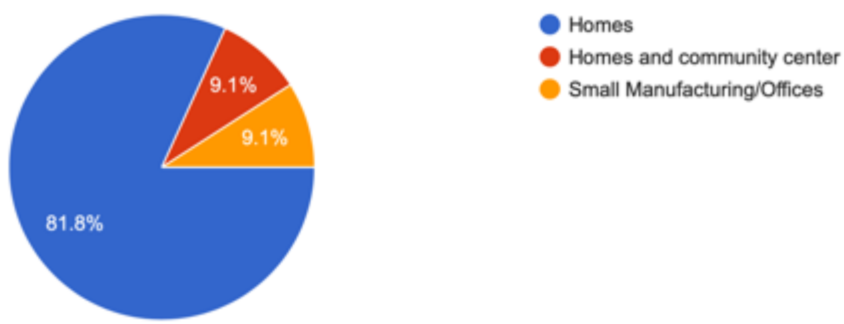
Ian Street Surveys

Portions of at least 12 streets or sections of streets were surveyed. Summaries by roof type follow.

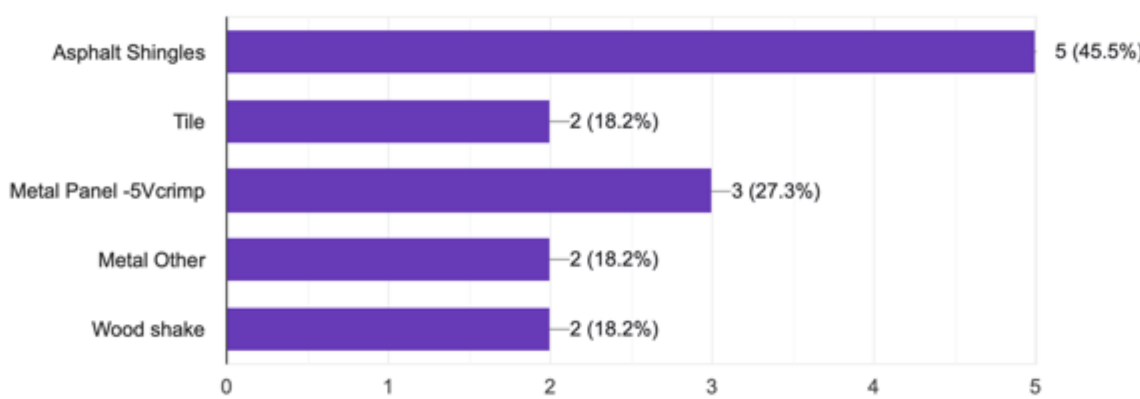
How observed
11 responses



Buildings
11 responses

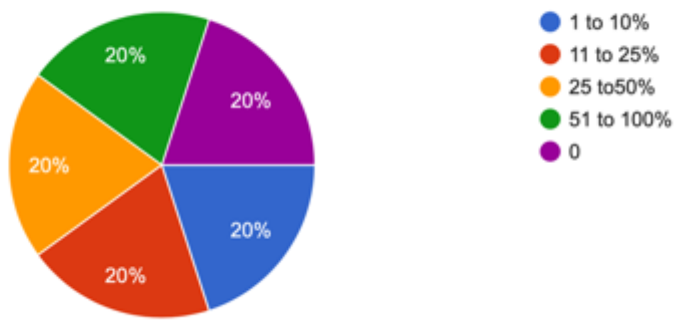


11 responses



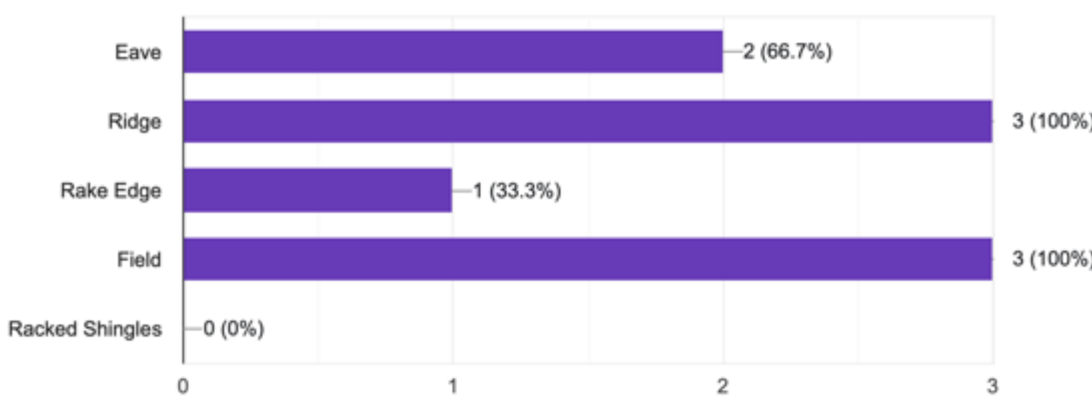
Percent of severely damaged asphalt shingle roofs on this street section

5 responses



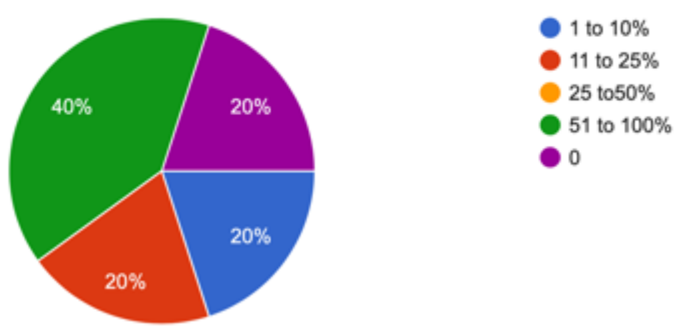
Start of damage

3 responses



Percent of asphalt shingle roofs on this street section not severely damaged but with some damage

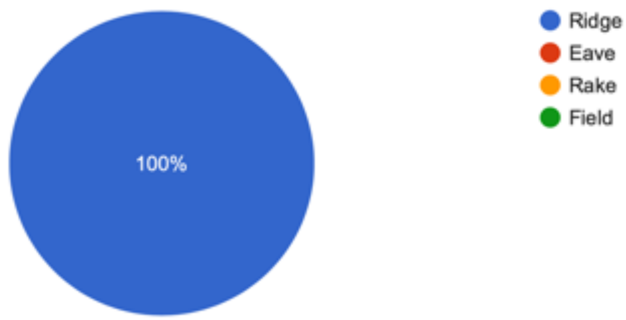
5 responses



Tile roofs reported, many more observed

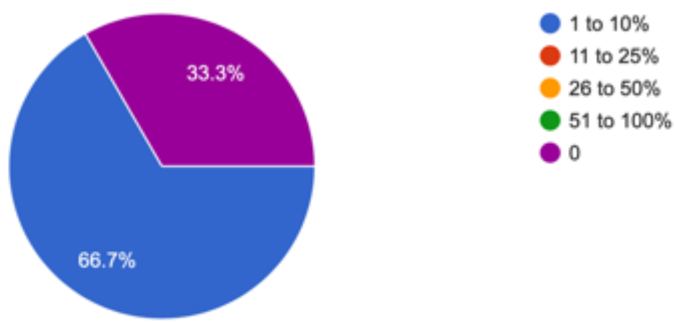
Tile Roofs in this street section damage start location

3 responses



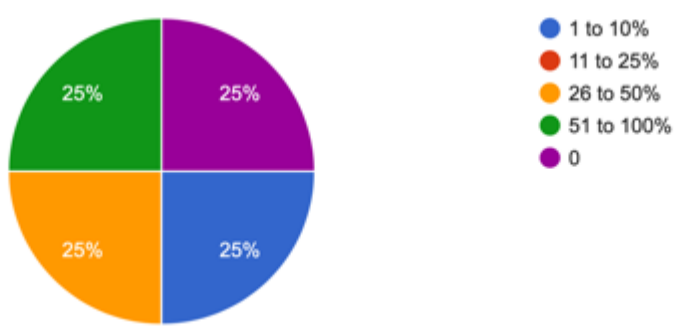
Percent of Tile Roofs in this street section severely damaged

3 responses



Percent of Tile Roofs in this street section NOT severely damaged

4 responses



Street survey with photos. The street survey data is from the database.

Street Survey

How observed:	Inspection 1-9 - Walked
Number of units on street section observed	Approximately 12
Street Surveyed	Calusa Palms Drive, Port Charlotte FL.
Cross Street	Same
Wind Speed (mph)	110
Building Type	Homes
Roof Type	Asphalt Shingles
Number of asphalt shingle roofs on street section observed	12
Percent of severely damaged asphalt shingle roofs on this street section	25 to 50
Percent of asphalt shingle roofs on this street section not severely damaged but with some damage	1 to 10

Newly replaced shingles (within six months) performed well. A twenty-year-old building appeared to suffer most of the damage. Evidence of "high nailing" found in debris pile. Easterly winds created the most damage.

Photo 141: New construction and asphalt shingles

Photo 142: New construction and asphalt shingle roof

Photo 143: Many asphalt roofs in this area were intact. This neighborhood was built in 2005 and it appears to have been reroofed about seven years prior to the hurricane.

Photo 144: This area had a windspeed of 110 mph.

Photo 145: The opposite side of the street had many tarped roofs. Residents reported that houses on this side of the street had not been reroofed. They are likely original roofs installed around 2005.

Photo 146: These asphalt shingles were detached from roofs on the west side of the street.

	
Photo 147: The roof had ridge damage and some field damage	Photo 148: The debris

How observed	**Walked**
Number of units on street section observed	11
Street Surveyed	Memory Lane FL
Cross Street	Shaddelene Lane East
Wind Speed (mph)	110
Building Type	Homes
Roof Type	Asphalt Shingles
Number of asphalt shingle roofs on street section observed	7
Percent of severely damaged asphalt shingle roofs on this street section	80
Percent of asphalt shingle roofs on this street section not severely damaged but with some damage	1 to 10

Spanish Point

How observed	**Drove**
Number of units on street section observed	25
Street Surveyed	Spanish Pointe, Port Charlotte
Cross Street	Ponce DeLeon
Street Number Range X to Y	
Wind Speed, mph May be added later or best guess)	130
Building Type	Homes
	Tile
Number of Tile Roofs in Street section observed	25
Percent of Tile Roofs in this street section severely damaged	1 to 10%
Percent of Tile Roofs in this street section NOT severely damaged	1 to 10%
Tile Roofs in this street section damage initiation location	Ridge/Hip
Comments	Hip/ridge tiles on some homes were damaged. 3-year-old sub-division. Overall good performance. The damage seemed to be caused by poor foam application. North winds appeared to cause damage.

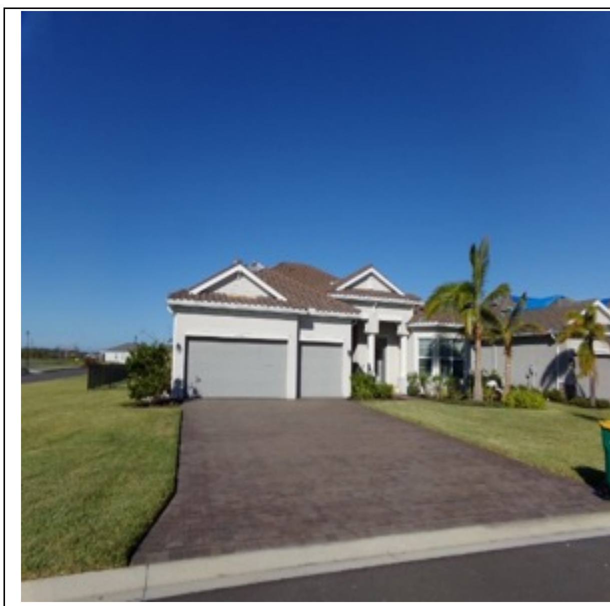


Photo 149: Typical hip and ridge tile dislodgement/detachment	Photo 150: Foam did not reach cap tile

	
Photo 151: This detached cap tile caused field damage i.e., windblown projectile impact.	Photo 152: A typical home in area; open terrain could be considered C roughness.

How observed	**Drove**
Number of units on street section observed	10
Street Surveyed	Boca Grande Causeway Placida FL
Cross Street	
Street Number Range X to Y	
Wind Speed, mph (May be added later or best guess)	130
Building Type	Homes
	Asphalt Shingles
Number of asphalt shingle roofs on street section observed	5
Percent of severely damaged asphalt shingle roofs on this street section	51 to 100%
Start of damage	
Percent of asphalt shingle roofs on this street section not severely damaged but with some damage	0
Comments	2-story multi-family units suffered deck failure from north winds. The buildings were older than 10 years.

Photo 153: Difficult to diagnose damage initiation, but ridges and rake areas appeared likely to be a primary source of damage initiation.

How observed	**Drove**
Number of units on street section observed	5
Street Surveyed	5th Street, Boca Grande, FL
Cross Street	26 45 9 N - 82 15 48 W
Street Number Range X to Y	
Wind Speed, mph (May be added later or best guess)	130
Building Type	Homes and community center
	Wood shake
Damage Initiation	
	Small number of asphalt roofs in area. Asphalt overall performed very poorly.
Percent of Tile Roofs in this street section Not severely damaged	26 to 50
Tile Roofs in this street section damage initiation location	Ridge
Comments	Tile roofs in the area suffered moderate damage. Hip/ridge failure and some field.
Number of 5v Crimp or similar roofs in this street section	Some
Percent of severely damaged 5 v roofs in this street section	11 to 25
Percent 5 v roofs NOT Severely Damaged in this street section	51 to 100

Percent of other metal panel roofs Severely Damaged in this street section	1 to 10
Percent of other metal panel roofs NOT Severely Damaged in this street section	51 to 100
Describe roof type and damage observed.	Some metal roof failure occurred due to deck failure (see photos). Some minor damage on nail strip (clipless concealed fastener). Nail strip panels observed appeared to be of decent fastening methods.

Photo 154: Wood shake roof, being repaired

Photo 155: Appears to be siding and roof damage

Photo 156: Detached deck and metal roof

Photo 157: Source of debris

	
Photo 158: Edge metal damage resulting in loss of panels	Photo 159: Inadequate fastening

How observed	**Drove**
Number of units on street section observed	Multiple
Street Surveyed	308 Gulf Blvd.
Cross Street	26 44 21 N - 82 15 47 W
Street Number Range X to Y	
Wind Speed (May be added later or best guess)	130
Buildings	Homes
	Metal Panel -5Vcrimp
Number of 5v Crimp or similar roofs in this street section	Multiple
Percent of severely damaged 5 v roofs in this street section	11 to 25
Percent 5 v roofs NOT Severely Damaged in this street section	51 to 100
Describe roof type and damage observed.	Deck failure occurred. Older re-roof as evidenced by plywood that was stapled versus nailed to trusses.

Underlayment

The second line of defense required by code on all roofs has kept many buildings dry. The improvements in underlayment installation made a difference in Ian. This storm clearly demonstrated the importance of proper underlayment installation.

	
Photo 156: Although the shingles were missing, the underlayment in most cases kept the building dry.	Photo 157: Fully intact underlayment
	
Photo 158: Asphalt impregnated felt underlayment appeared intact.	Photo 159: Some damaged underlayment was observed on this older asphalt shingle roof.

Gutters

Gutter requirements have recently been added to the International Building Code. Hurricane Ian inspections saw many examples of gutter damage that spread to the interior of the roof, resulting in water intrusion. These systems can now be designed and tested to resist wind loads.

Door Gutter and coping damage following 100 mph windspeed in Fort Myers.

Photo 160: Missing door and gutter

Photo 161: Missing coping

Photo 162: More missing doors and gutters

Photo 163: Missing overhead (roll-up) door

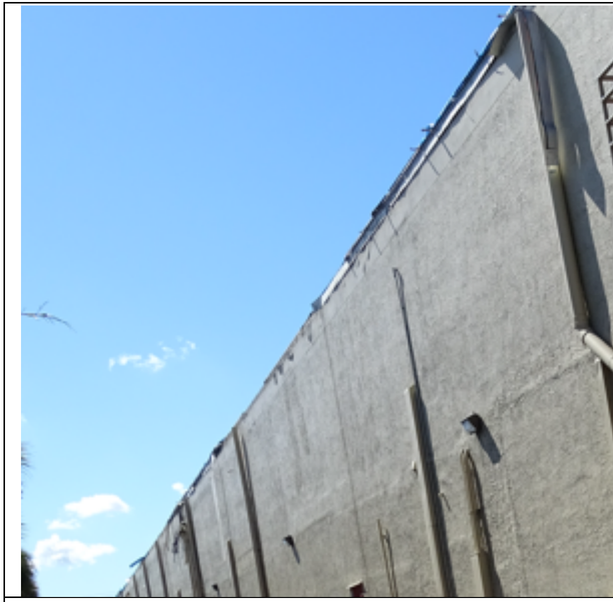


Photo 164: Missing gutters and downspouts

Photo 165: Approximately 18” O.C. Fastening

Photo 166: Gutters missing on windward (front) side of two adjacent buildings

Photo 167: Detached edge metal and gutter

Drone Usage

A drone proved useful in locating areas where there was significant roof damage. It was also used to photograph general details showing areas of specific damage, such as membrane loss or dislodged/detached edge metal. Drones are especially useful for scout teams to find areas where detailed investigations should be undertaken.

Drone flights in a residential area. This area of Cape Coral was built between 1998 and the present. Primarily, asphalt shingle roofs were installed. As the photo below shows there were many blue or black tarps covering damaged roof areas. Observed damage was primarily to hips and ridges, sometimes spreading inward from rake edges.

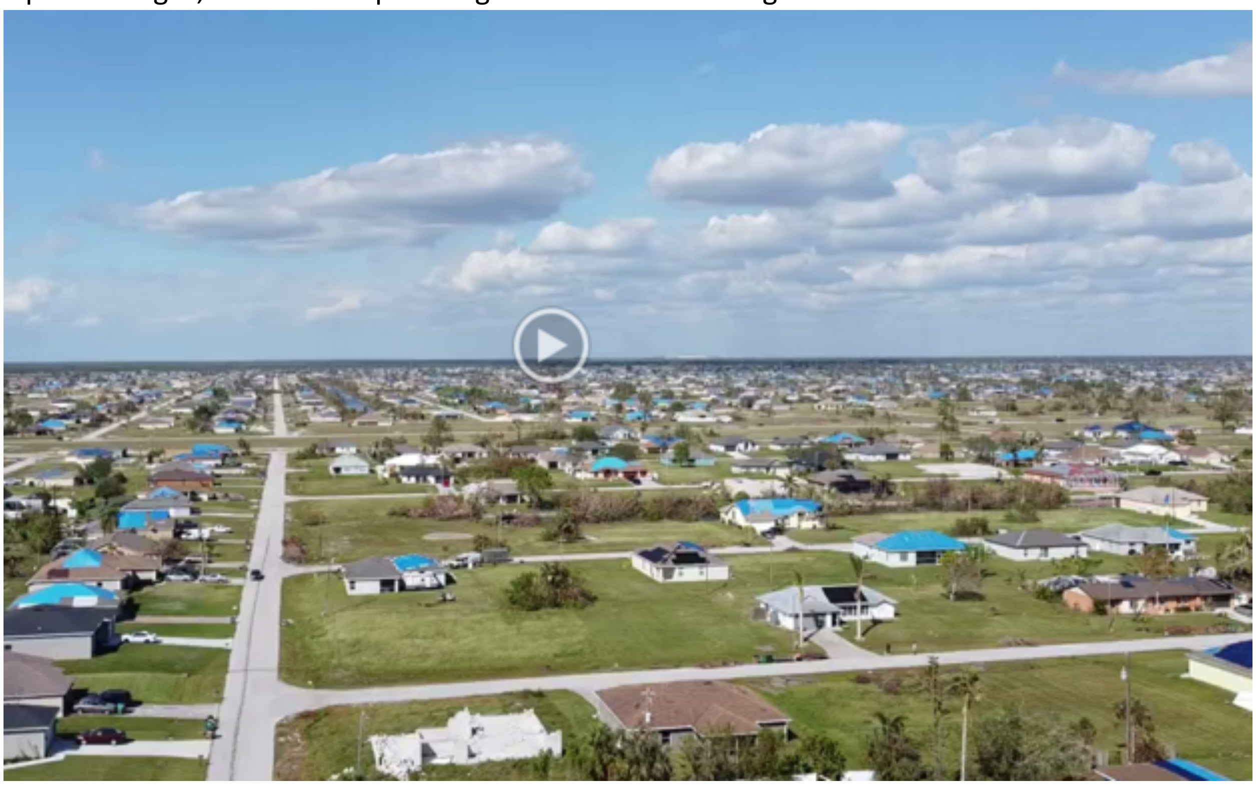


Photo 168


Photo 169


Photo 170

Photo 171

Aerial overviews from Drone

Photo 172


Photo 173

Acknowledgements

RICOWI wishes to thank the following organizations, corporations, and individuals for supporting this research investigation program through their generous contribution of time, knowledge, and funding to this seventh hurricane investigation.

We gratefully acknowledge the following supporters:

- Air Barrier Association of America (ABAA)
- Asphalt Roofing Manufacturers Association (ARMA)
- Chemical Fabrics and Film Association (CFFA)
- Cedar Shake and Shingle Bureau (CSSB)
- Copper Development Association, Inc. (CDA)
- Insurance Institute for Business & Home Safety (IBHS)
- International Institute of Building Enclosure Consultants (IIBEC)
- International Staple, Nail and Tool Association (ISANTA)
- Metal Building Manufacturers Association (MBMA)
- Metal Construction Association (MCA)
- National Research Council Canada (NRCC)
- National Roof Deck Contractors Association (NRDCA)
- Spray Polyurethane Foam Alliance (SPFA)
- Single Ply Roofing Industry (SPRI)
- Tile Roofing Industry Alliance (TRI)

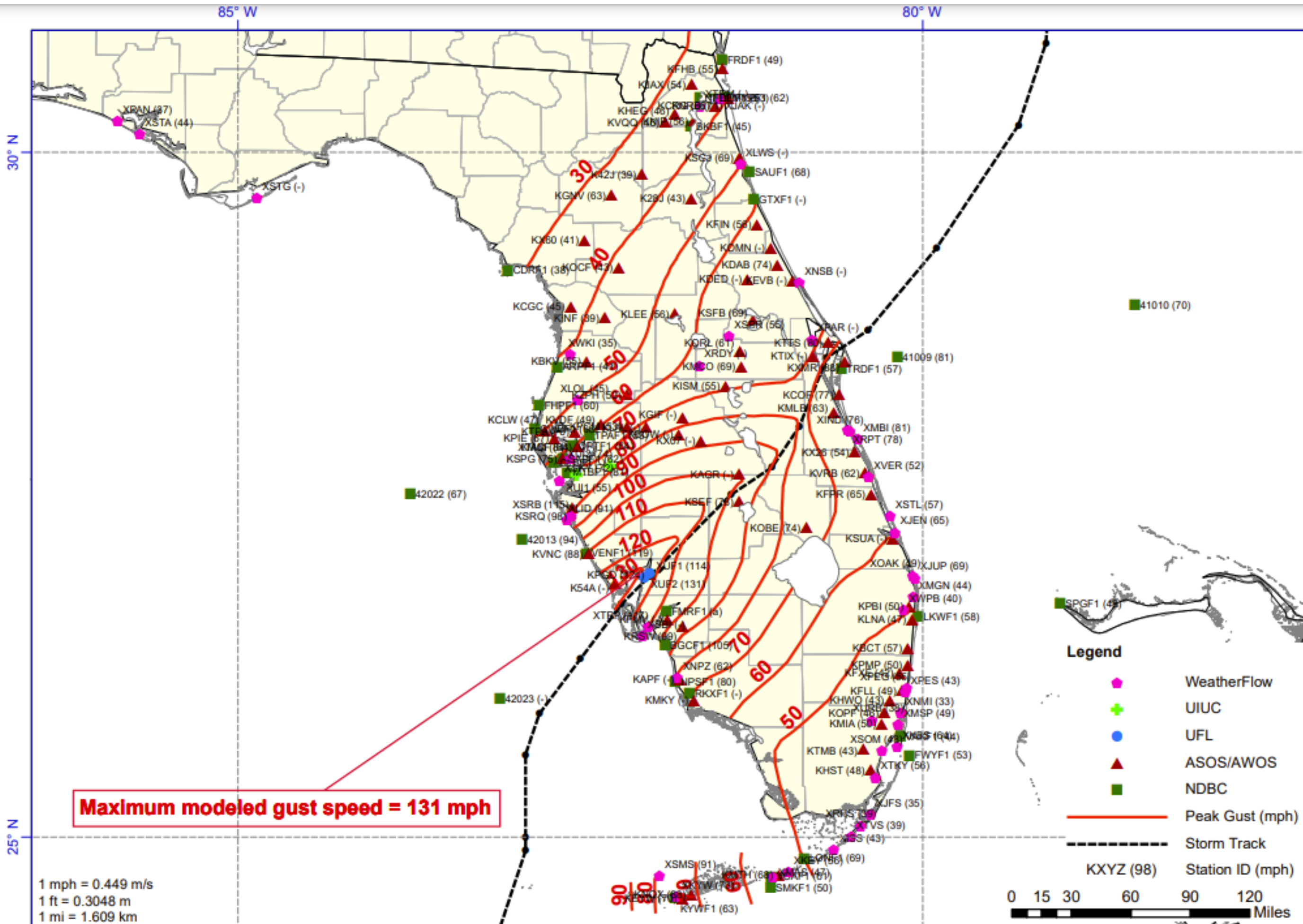
Thank you to the Storm Investigation Program (SIP) Committee Members, and especially the Storm Investigation Team **(Appendix B)** for this event. Many of the team members gave up their vacation days, and all funded their travel and expenses. Thank you to SIP Program Coordinator David Roodvoets and RICOWI, Inc. Executive Director Jordan Loudon for your strong leadership and dedication to this program.

RICOWI has used Applied Research Associates, Inc. (ARA) wind maps for post-hurricane deployment and for our comprehensive post-hurricane roof damage investigation reports. The ARA wind speed maps have been valuable in deployment of investigation teams and in relating damage to wind forces. RICOWI thanks those at ARA for allowing the use of their maps in the storm investigation reports.

RICOWI appreciates the State of Florida and the communities that welcomed the researchers and assisted with directions and suggestions.

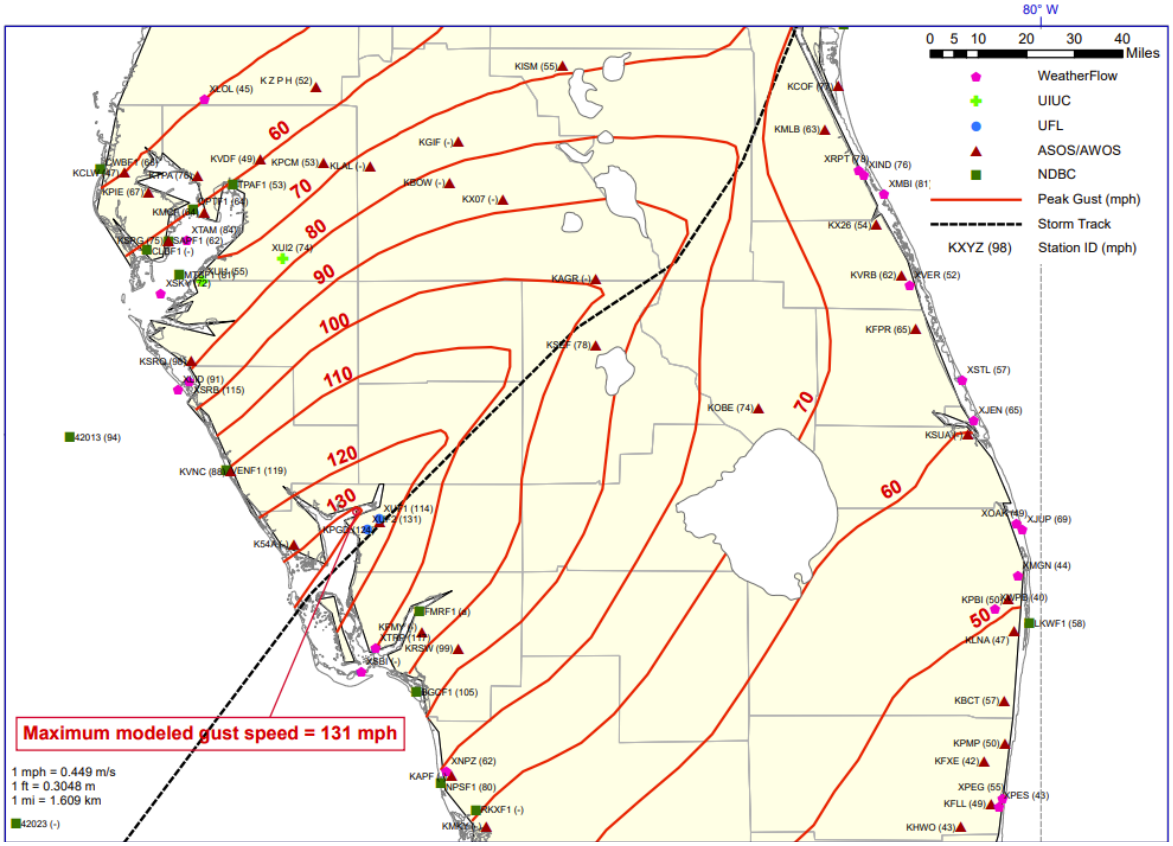
Appendices

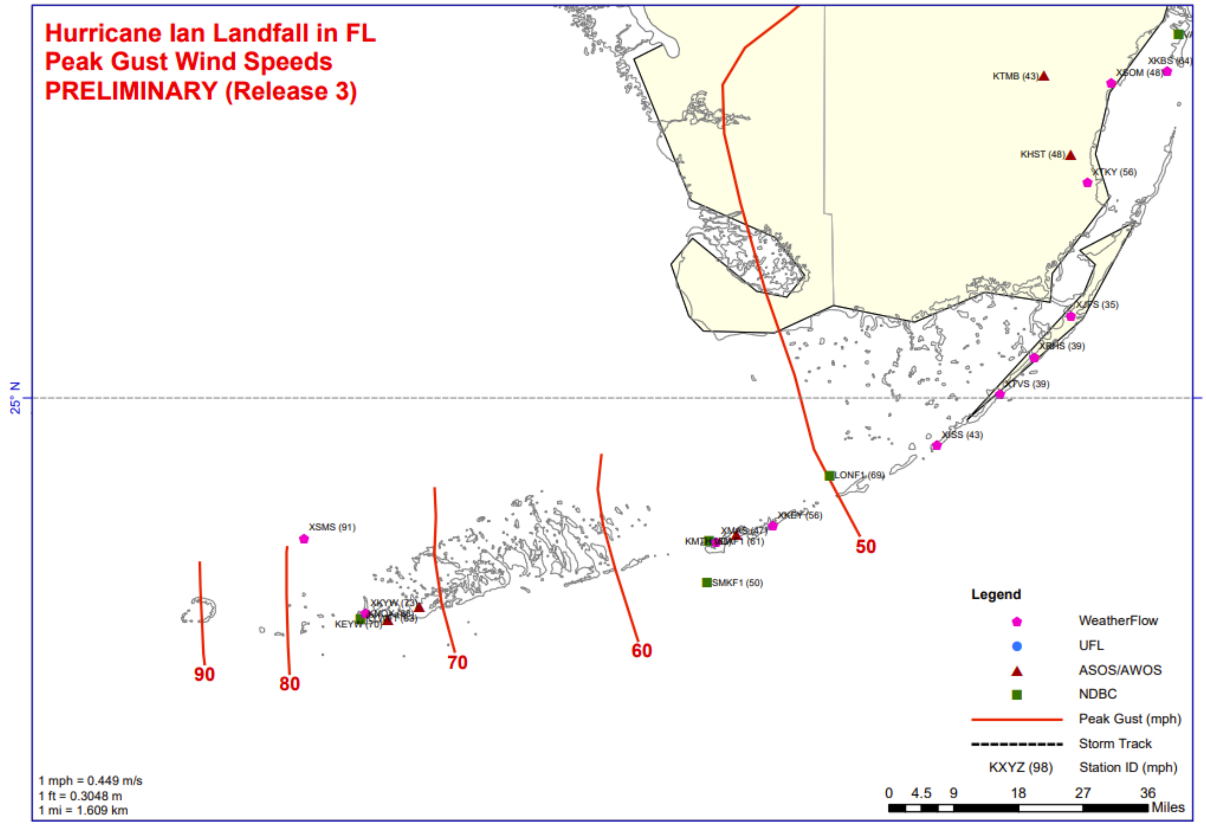
Appendix A: Wind Maps



Hurricane Ian (2022): Preliminary Peak Wind Gust (mph)

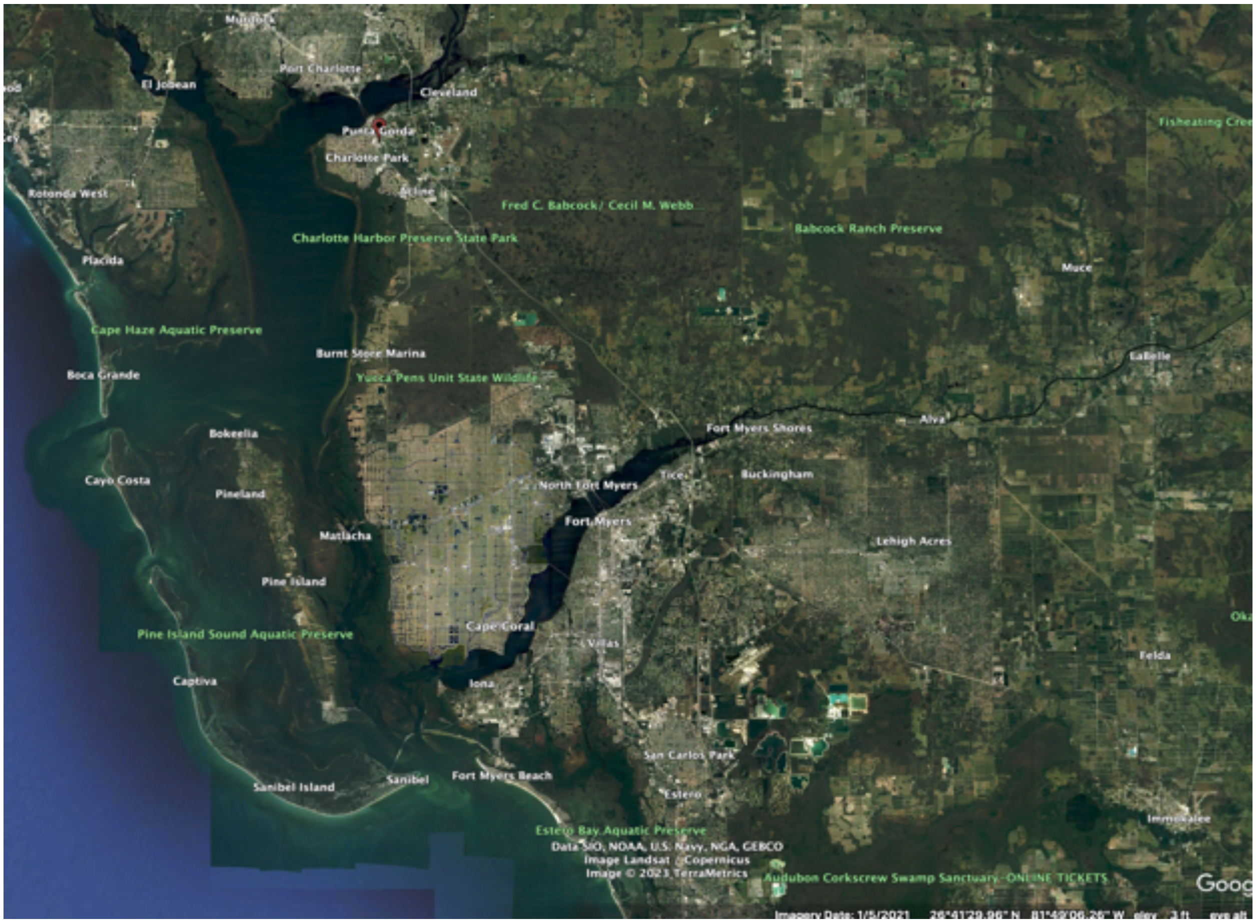
Estimated 3-second gust wind speeds (mph) at 33 ft above ground over flat open terrain from ARA model fit to surface level observations using storm track and central pressure data from NHC through Forecast Advisory Number 35 and observations through 1200 UTC on 10/1/2022. The values of peak gust winds in mph are shown after station names; Values have been adjusted for anemometer height and terrain; "-" means station failed before the arrival of the peak wind; "a" indicates a potentially anomalous value. The maps have been produced for the **National Institute of Standards and Technology** under Contract 1333ND22PNB730388. Maps are subject to change.
Created on: 10/13/2022


80° W
0 5 10 20 30 40
Miles
WeatherFlow
UIUC
UFL
ASOS/AWOS
NDBC
Peak Gust (mph)
Storm Track
KXYZ (98) Station ID (mph)
Maximum modeled gust speed = 131 mph
1 mph = 0.449 m/s
1 ft = 0.3048 m
1 mi = 1.609 km
60
70
80
90
100
110
120
130
50


Hurricane Ian Landfall in FL
Peak Gust Wind Speeds
PRELIMINARY (Release 3)
25° N
KTMB (43)
XSOM (48)
KHST (48)
XTKY (56)
XJPS (35)
XBHS (39)
XTVS (39)
XISS (43)
LONF1 (69)
XKEY (56)
XSMS (91)
SMKF1 (50)
KEYW (70)
90
80
70
60
50
Legend
WeatherFlow
UFL
ASOS/AWOS
NDBC
Peak Gust (mph)
Storm Track
KXYZ (98)
Station ID (mph)
1 mph = 0.449 m/s
1 ft = 0.3048 m
1 mi = 1.609 km
0 4.5 9 18 27 36
Miles

Area where winds were 130 mph or greater.

Area where winds were 90 mph or greater.



Appendix B: Investigation Teams

Team make up for Hurricane Ian

The teams were made up of volunteers that took the time to investigate in order to learn. There was a scout team of three people and three investigative teams of four people. Each team had an independent Roof Consultant. In addition to the independent consultant, one team had two metal roof industry members and a roofing contractor association representative.
One team had two members of a national research lab and a roofing manufacturer representative. One team had an additional independent roofing consultant, a member representing a metal roofing association, a manufacturer of roofing components, and an independent roofing contractor.

Scout Team
David Balistreri
Jason Hoerter
Phil Mayfield

Team 1
Robin Anderson
James Bush
Jose Escobar
Mike Silvers

Team 2
Bas Baskaran
Jason Bondurant
Flonja Shyti
Andy Six

Team 3
Rolando Figueroa
Tim Garboske
Allan Kidd
David Roodvoets
Lee Shoemaker

Appendix C: RICOWI Storm Investigation Program

In 1989, Oak Ridge National Laboratory held two workshops devoted to identifying and discussing roof wind uplift issues and alternatives. Discussions of important technical issues included causes of roof wind damage, dynamic testing of roof systems, the importance of sample size for tests, the role of wind tunnels, air retarders, and the need for acceptable procedures for ballasted systems. There was also concern for the general lack of communication within the roofing industry as to what the problems were, what was being done to alleviate them, and how effectively technology transfer was accomplished within the roofing industry and the building community. At the conclusion of the workshops, a consensus recommendation was to form a committee to address these matters. The Roofing Industry Committee on Wind Issues (RICOWI) was established, and its Charter approved October 11, 1990. This event was the synthesis of RICOWI's Wind Investigation Program (WIP).

Subsequent to RICOWI's formation, other concerns were raised. The insurance industry conveyed its concern regarding excessive property loss from both Wind and Hailstorms. In 1996 RICOWI, Inc was established as a 501(c)6 non-profit organization. RICOWI adopted hailstorms as a second focus in its mission and its Hail Investigation Program (HIP) was created. The "Roofing Industry Committee on *Wind* Issues" then changed its name to become the "Roofing Industry Committee on *Weather* Issues" reflecting its expanded scope.

RICOWI believes there is an essential link between product research, performance, and the model building codes. The model code groups are moving more toward "objective based codes" versus "prescriptive codes." Performance requirements are generally perceived to be requirements stated in a way that allows flexibility in the choice of solutions to satisfy the requirements and are based upon explicitly stated objectives. In addition, there is a general feeling that the right type of data, following a windstorm event, has not been gathered. There is no question that all roofing products and systems of all roofing manufacturers are going to have to meet more rigorous specifications and will be subject to tougher scrutiny of building departments such as seen in Dade and Broward counties (FL). Industry involvement in follow-up of severe weather events is imperative.

In 2021, RICOWI decided to merge its two separate programs, HIP and WIP into a singular "Storm Investigation Program" (SIP). The SIP mission is to investigate the field performance of roof assemblies after catastrophic storm events, factually describe roof assembly performance and modes of damage, and formally report findings for substantiated events. SIP puts credible people in the field that have the required product knowledge and program training to ensure that sound, scientific and unbiased reporting occurs.

RICOWI has now conducted seven of the most comprehensive roofing investigations of hurricane-stricken areas immediately following Hurricanes Charley (2004), Ivan (2004), Katrina (2005), Ike (2008), Irma (2017), Michael (2018), and Ian (2022) as well as three hailstorm events including Oklahoma City (2005), Dallas (2012) and North Texas (2017). The reports are publicly available at www.ricowi.com/reports.

Through RICOWI's efforts, codes are improved, buildings are safer; property losses will be reduced, and industry is provided clear insight as to needed direction. The reports generated by investigation teams are also utilized to help educate various segments of the building industry, and provide a valuable resource to federal, state and local disaster response and preparedness programs.

RICOWI's Board of Directors regularly reviews investigation processes for future events. Interested members of RICOWI, Inc. are encouraged to volunteer by signing up as a Team Member online at www.ricowi.com. For additional information, contact RICOWI's Executive Director, Jordan Loudon by phone: 808-421-8392 or by email: jlemke@ricowi.com.