Damage Survey Following the August 27th, 2012 Tornado in Vero Beach, FL

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Background

Tropical Storm Isaac brushed Florida's west coast and it spawned an **EF-1 tornado** on August 27, 2012 in Vero Beach, FL. This relatively weak it was strong enough to cause significant damage to approximately 104 homes within its path[1]. Local reports confirm that the rain band from Tropical Storm Isaac dumped 6.48 inches of rain in this area of Indian River County [2]. According to multiple reports, the Vero Beach tornado touched down at approximately 11:03AM ET and remained on the ground for nearly 1.6 miles before dissipating after about 2 minutes [3]Figure 1 shows the approximate tornado path based upon the damage observations.



Figure 1: Estimated Path of Tornado based on observations



Legend

Photo Locations

Figure 2: Photo Locations for Vero Beach Tornado Survey

The tornado in Vero Beach, FL mainly targeted two local mobile homes parks, where the typical buildings consist of double-wide manufactured homes built between 1989 and 1992 (Survey Region 3 in Figure 1) and Early 1980s (Survey Regions 1 and 2 in Figure 1). Both these communities had homes build after the enactment of the HUD (Housing and Urban Development) Code in 1974[4] but before the Manufactured Home Construction and Safety Standards on Wind Standards Rule became effective in July 1994 which was implemented to increase the safety of manufactured homes [5]A close up of these regions are shown in Figure 2.

These mobile homes typically sit on a steel undercarriage supported by unreinforced concrete block piers. with metal straps underneath the structure spaced every 10-12 ft to hold the mobile homes. Flat and gable roofs with asphalt shingles or metal sheathing are most common for this type of building.

EF Ratings and the degree of damage (DOD) for each indicator were assigned using the recommendations of the EF Scale [6]. Three damage indicators (DI) in total are initially chosen for the assessment of DOD. For each DI, a series of DODs are determined based on the described damage in the recommendation of EF scale. Following the assessment of DOD is to estimate the corresponding expected wind speed for each DOD taking the construction quality of damaged houses into consideration. Next, the maximum wind velocity estimated is used to assign the EF rating for the tornado.

Manufactured Home – Double Wide (MHDW)

The recommendations of the EF Scale provided the 12 DODs and corresponding descriptions for this indicator. The wind speed is plotted along with each DOD in the recommendation as well (Figure 3). There were approximately six degrees of damage observed in the present survey, represented as follows:



Figure 3: Wind Speed vs. Degree of Damage for double wide manufactured home



Figure 4: Threshold of Visible Damage (DOD 1)

For the first DOD, minor damage such as loss of a few metal panels and accessories usually occurs, but there is no evidence of any further damage. Figure 4a shows that very few parts, namely metal edge flashing or gutter, were damaged. From Figure 4b, it can be seen that a few protruded metal panels were torn down. However, neither of two examples had any evidence of any further damage. From Figure 3, it can be obtained that the probable wind speed leading to the first DOD is located in a range from 51 to 76 mph with an expected value of 61 mph.



Figure 5: Loss of shingles or other roof covering material (<20%) (DOD2)

A few houses were observed in the survey that a significant loss of roof covering materials occurred but their total area of loss was no more than 20%. Most of the damages were caused by the failure of links between the metal panels over extra rooms and main structures (Figure 5). After the mobile homes were fabricated, people often built some subsidiary structures used for the storage. This roof covering material (e.g., shingle or metal deck) over the extra room was attached to the main structure by toe-nails, even without a beam supported. Due to the deficiency of lacking of effective support and connections with the main structure, the roof materials over the extra room were very vulnerable to wind. Thus, it is very easy to see that the roofs over them were damaged or even blown off when the tornado touched down. The described damage above can be defined as the second DOD, corresponding to a wind speed range of 62 ~88 mph in the recommendation of EF scale rating.



Figure 6: Damaged carports (DOD 3)

(a)

(b)



Figure 7: Damaged Porch (DOD3)

It was very common to see that the porches or carports were severely damaged in the surveyed regions. Figure 6 shows us some damaged carports and Figure 7 provides some pictures of collapse or damage of porches. Similar to the roof covering over the storage room, the roof metal decks of porches or carports were usually attached to the manufactured home. In addition, it was noted that the columns used were fixed to the ground with only very few nails or bolts and minimal lateral bracing or blockings. Even if the porches or carports were sufficiently connected, the sum of the positive pressure over the roof and negative pressure underneath might lift the covering up. Thus, the porches and carports are very vulnerable to the extreme wind event. The wind speed range to cause the described damage mentioned above is from 67 to 96 mph.



Figure 8: Broken windows (DOD 4)

Several homes were observed with broken windows (Figure 8). These instances occurred mostly in walls facing the direction of the tornado's translation, which matches the fourth DOD specified in the recommendation of EF rating with a wind speed range of 68~95 mph.



Figure 9: Uplift of roof deck and loss of significant roof covering material (>20%) (DOD5)

DOD 5 was observed in many homes where the significant loss of roof covering material occurred and the damaged area were more than 20%. From Figure 9a, it can be clearly seen that most of the roof metal deck were gone due to the strong suction on roof. Figure 9b shows another shot of damage of metal roof deck and pushover of porch. Although the main structure essentially remained intact or undamaged, the tornado resulted in the significant loss of roof covering materials (shingle or metal deck). The wind speed range for this DOD is from 75 to108 mph, having an average of 88mph.



(a) Front elevation(b) Side elevationFigure 10: House shifted 7 ft off foundation slid off CMU block piers (DOD 7)



(a) Detail View



(b) Location of corroded strap near knee wall

Figure 11: Completely corroded strap anchor used to attach metal foundation strap to ground anchor of House in Figure 10

For the seventh DOD defined in the recommendation, only one house was observed where the unit slid off the CMU block piers. As shown as in Figure 10, the whole mobile home shifted 6 ft. from the original position. It is worth mentioning that three metal straps with a spacing of 12 ft. were deployed each side to prevent the house from sliding off, but were severely corroded (Figure 11). Despite the wall and most of metal deck for this home still kept well and the anchors was corroded, the wind speed producing this damage is within a range of 78 ~109 mph.

Trees damage: Hardwood (TH) and Softwood



(a) Oak

Figure 12: Hardwood tree damage



Figure 13: Softwood tree damage

Besides the structural damage indicators mentioned above, the recommendation also provided the indicator on the tree damage. Figure 12a) shows the damaged Oak with the broken large branches. The corresponding wind speed for this DOD is a range of 61~88 mph with an average of 74 mph, which can be obtained from the Figure 10b. In contrast to the damage of hardwood tree, the expected wind speed resulting in the damage of softwood tree as shown as in Figure 13a slightly goes up to 75 mph.

Next, the EF rating is assigned based upon the estimated wind speed. Figure 14 and Figure 15 show the assessment of DOD and EF rating for the houses in the surveyed region 1, 2 and 3. From the analysis above, it can be obtained that the maximum wind speed range generating the DODs mentioned above is 78~109 mph, which mostly comes within the range of EF1 tornado, namely 86~109 mph. Thus, we could conclude that the tornado occurring in Vero Beach, FL, can be defined as the EF1 scale.



Figure 14: DOD assessment and EF Ratings for Surveyed Region 1 &2



Figure 15: DOD assessment and EF Ratings for Surveyed Region 3

Case Studies

Address: 227 Sandpiper Lane	DOD Rating: 2
Structure Use: Mobile Home	Wind Speed Estimate:
Year Built: 1982	EF Rating: 0



Address: 204 Plover Drive	DOD Rating: 4
Structure Use: Mobile Home	Wind Speed Estimate:
Year Built: 1992	EF Rating: 1
	Damage to carport. Parts of carport roof lost.
	Entire porch enclosure lost. Enclosure was light metal framing which was held to foundation by bolts protruding form concrete 1-1/4" spaced at 20" apart.
	Some loss of vinyl siding.

Address: 214 Plover Drive	DOD Rating: 4
Structure Use: Mobile Home	Wind Speed Estimate:
Year Built: Early '90s (Resident not home)	EF Rating: 1
	Loss of Porch and losses of parts of the roof.
	Broken windows and destruction to overhangs.

Address: 183 Flamingo Drive	DOD Rating: 7
Structure Use: Mobile Home	Wind Speed Estimate:
Year Built: Early '90s (Resident not home)	EF Rating: 2
	This home had damage to parts of roof along with some loss in the vinyl siding.
	House was shifted 80 inches off its foundation. The door seen in this picture was in the center of the foundation shown in the bottom right hand corner.
	Lifting up of the overhang of the roof showing the wood rafters underneath.

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