Online Damage Report

The 17th November 2013 Illinois Tornado Outbreak

Washington, IL Nov 18, 2013
(Image Courtesy: Jessica Koscielniak via Twitter)

University of Florida's Wind Hazard Damage Assessment Team

PI: David O. Prevatt, Ph.D., PE, dprev@ufl.edu

Contributing Authors:
David Roueche
Austin Thompson
Naser Elsbihi
Jeandona Doreste
Alyssa Egnew

19 November 2013

E·S·S·I·E Engineering School of Sustainable Infrastructure & Environment

Gator Engineering University of Florida

Wind Hazard Damage Assessment Team
Engineering School of Sustainable Infrastructure and Environment
University of Florida
19 November 2013

Executive Summary

A significant outbreak of severe late-season thunderstorms spawned a series of tornadoes that rapidly moved through Central Illinois, Indiana, Kentucky, Missouri, Michigan, and Ohio on Sunday, November 17 2013. There have been at least 45 confirmed tornado sighting within this system; they caused significant damage in towns in Illinois, Indiana and Kentucky. Two tornadoes in Illinois have been rated EF-4 – a first for November tornado outbreak in that state. Six direct fatalities have been reported, occurring in New Minden, IL (2 fatalities), Washington, IL (1 fatality) and Massac County (3 fatalities in a mobile home park). The tornadoes ended just shy (5 miles to south-east) of Chicago's city limits. Had they continued further the extent of building damage and loss of life could have been far worse.

The damage was similar to expected patterns observed in previous tornado outbreaks. In the worst hit areas, trees were toppled, stripped of leaves and branches had their bark removed. Of the constructed buildings, light-framed wood residential structures suffered by far the worst, due to the greater numbers of houses in the path as compared to other structures, and because these houses in general were not constructed to resist high winds. There are reports of houses ripped off their foundations, and several slab-on-grade homes were swept clean. Many houses in this area did have basements, which may have been used by many to take shelter from the storm. There were few reports on or photos of the performance of tornado shelters.

Stronger buildings can be built quite economically today that would mitigate some structural damage and improve life safety protection in our homes. It is up to communities and their leaders to decide whether they wish to pursue such resilient and sustainable approaches to construction or whether to continue with the status quo. These solutions come at a price, yet to be determined and accepted. Engineers and scientists are working together to gain a better idea of the appropriate design loads, and to develop cost-effective technologies that can resist those loads. It is up to society, people at large to determine what costs are acceptable to reduce the risks and minimize economic losses from tornadoes.

About the Wind Hazard Damage Assessment Team

This report was prepared from online sources by University of Florida civil engineering students in Prof. David O. Prevatt's Research Group. The study is done in parallel to our experimental research seeking to understand and quantify the strength of tornadoes and their impact on vulnerable wood-framed residential structures. Compilation of this information is part of student learning objectives in forensic engineering and post-disaster damage investigation.

The students gathered the information from reliable online sources, such as the National Weather Service, Accuweather, the US Census Bureau and the national media. Photographs were also obtained from publicly available Twitter feeds.

Please visit our website, http://windhazard.davidoprevatt.com, for additional information, and to download previous damage reports, and filed survey results conducted by our group. Dr. Prevatt and his colleagues have published several papers on recent violent tornadoes, that stuck Tuscaloosa, AL, Joplin, MO, and Moore, OK. His group has also inspected damaged structures and compiled reports on tornadoes that occur in Florida. Information is also available on the research at www.davidoprevatt.com. Your questions and comments on any aspects of our work are most welcome. Please direct your enquiries to NSF Graduate Research Fellow and PhD Graduate Student, Mr. David B. Roueche, who can be reached at david.roueche@ufl.edu. Mr. Jeandona (JD) Doreste, is a civil engineering undergraduate student at UF and Webmaster of the Wind Hazard Damage Assessment Team site. JD is actively recruiting other UF students to join the team, and he can be reached at jdoreste1@ufl.edu.

The Wind Hazard Damage Assessment Team was created through support from the NSF Award #1150975. *Its mission is to train university students interested in building construction, engineering and architecture in the forensic engineering and techniques for post-hazard damage surveys and data collection. The team has surveyed damage after several Florida tornadoes and continuously monitors the prevalence of tornadoes worldwide. Ultimately the Damage Assessment Team hopes to inspire upcoming engineers and building professionals in hopes to change the paradigm of widespread catastrophic damage to houses in tornadoes and other extreme wind events.*

Forecasts and Predictions

The likelihood of this tornado outbreak was well anticipated based on the meteorological conditions – there was a significant tornado risk forecast for 17 November, by the Storm Prediction Center, with 30% probability of tornado genesis in mid Illinois and Indiana.

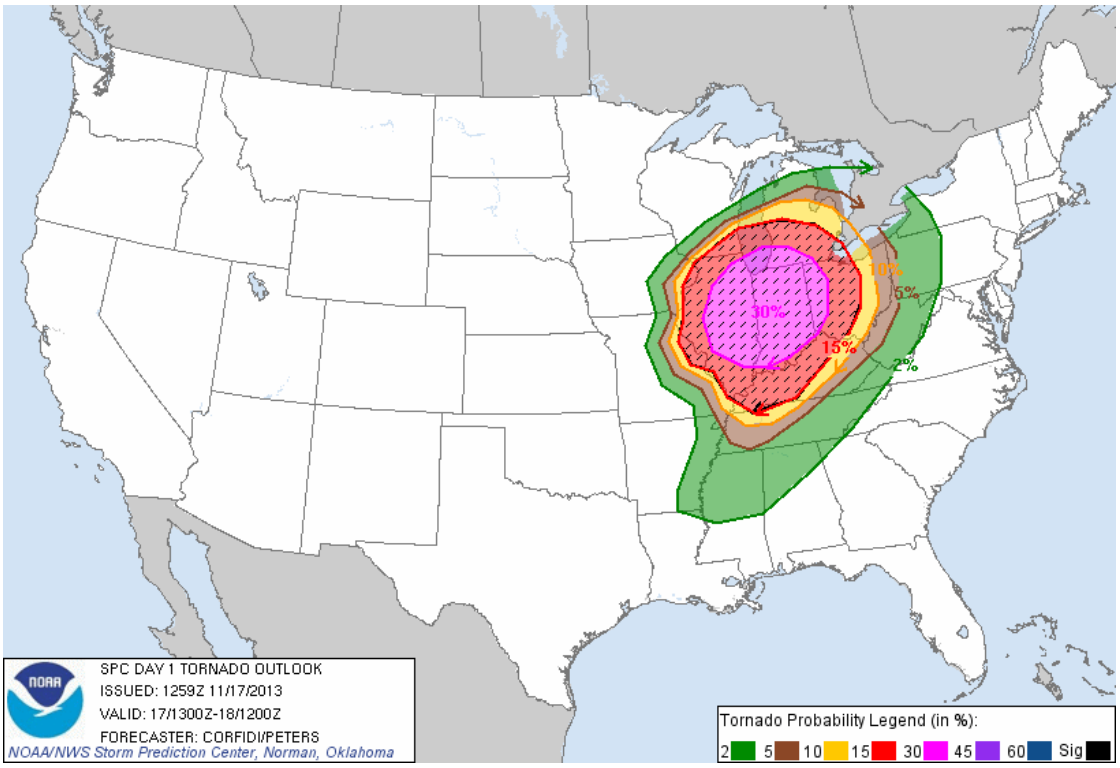

Figure 1: Tornado Probability for November 17, 2013 as Issued by NWS SPC at 1:03 PM UTC (Source: http://www.spc.noaa.gov/products/outlook/archive/2013/day1otlk_20131117_1300.html)

Tweets

Warnings about a likely outbreak were abundant on social media from a variety of sources.

Timing of Outbreak

The timeline of the tornado outbreak as it formed is given below. All times are Central Standard Time.
10:15 AM – Thunderstorm wind gust of 52 mph in Jacksonville, IL
10:25 AM – 0.88 in hail in Princeville, IL

10:45 AM – Thunderstorm wind gust of 70 mph in Peoria, IL
10:55 AM – Tornado touchdown in Pekin, IL
11:00 AM – Tornado touchdown in Peoria, IL
11:05 AM – Tornado touchdown in Washington, IL

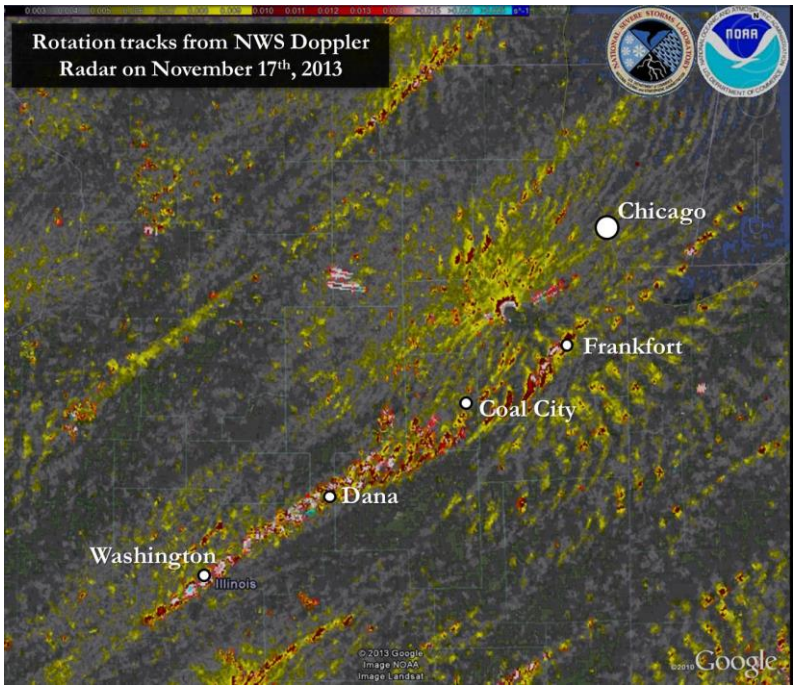

Figure 2: Rotation tracks from NWS Radar based out of Lincoln, IL (http://www.crh.noaa.gov/images/lot/13nov17/radar/rotation.jpg)

The National Weather Service survey teams have provided the preliminary breakdown of tornado intensities, the majority of which were EF-1 (17 tornadoes) and EF-2 (13 tornadoes), Figure 4.

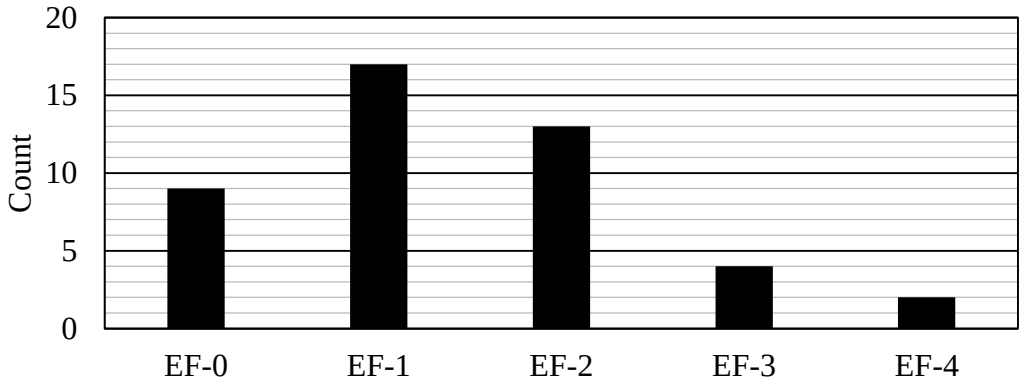

Figure 3: Preliminary breakdown in tornado intensities

Confirmed Tornado Strikes

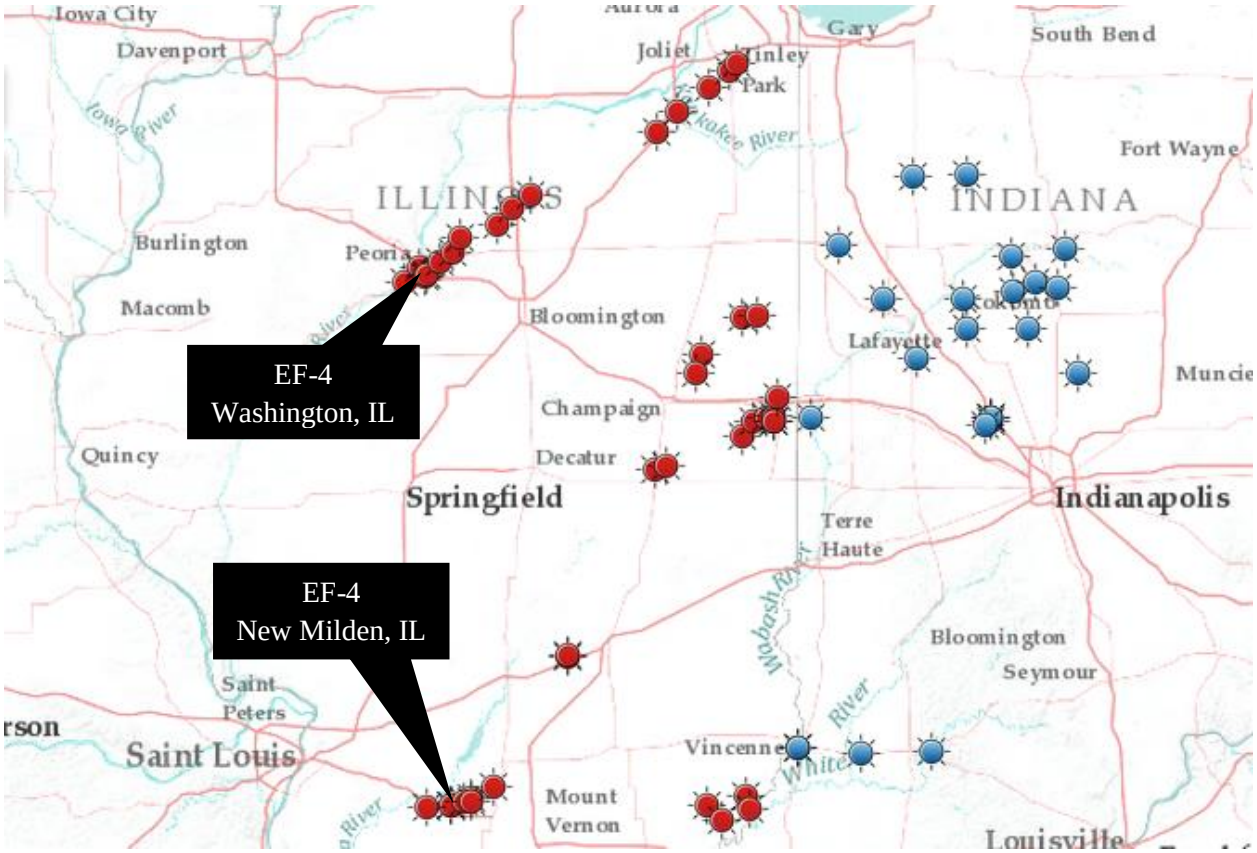

Figure 4: Tornado locations in Illinois (red markers) and in Indiana (blue markers). Locations of the two EF-4 rated tornadoes shown in callouts. (http://arc-nhq-gis.maps.arcgis.com)

Climatology of Outbreak

While late-season tornadoes do occur, it is rare to see such widespread outbreaks in the Midwest during November. Historically, a secondary severe weather season often occurs during October and November, but the location of such weather usually is located within the southern states. The increase in severe thunderstorms during October and November is related to the strengthening of storm systems during these months that are able to pull lingering warm and humid air northward from the Gulf of Mexico (Accuweather).

Table 1: Confirmed Tornado Data

State	City	Population	EF Rating	Est. Peak Wind (mph)	Path Length (miles)	Path Width (miles)	Injuries	Fatalities	Buildings Damaged	Buildings Destroyed
IL	Peoria	115687	EF-1	100	-	-	1	-	-	-
IL	Washington	15410	EF-4	180	-	0.5	75	1	250-500	-
IL	Metamora	3682	EF-1	100	-	-	-	-	-	-
IL	Metamora		EF-3	140	8.5	0.6	9	-	-	-
IL	Dana	158	EF-2	-	-	-	-	-	6	2
IL	New Minden	212	EF-4	90	6	-	dozens	2	-	-
IN	Rensselaer	5,912	EF-1	-	-	-	-	-	-	-
IL	Coal City	5557	EF-2	122	12.9	200 yards	-	-	-	-
IN	Kokomo	56,866	EF-2	-	10	-	dozens	-	-	-
IN	Lebanon	15,715	EF-2	115	3.5	75 yards	4	-	221	-
IN	Vincennes	18239	EF-2	-	19.4	100 yards	-	-	-	-
IN	Shoals	751	EF-1	90	-	-	-	-	-	-
IN	Lafayette	67925	EF-2	-	-	-	-	-	-	-
IN	Tipton	5,106	EF-1	100	1.9	150 yards	-	-	-	1
KY	Maysville	9,011	EF-2	-	2.75	130 yards	-	-	-	-
IL	Pekin	34084	EF-2	-	2.5	100 yards	-	-	-	-
IL	Hoyleton	527	EF-1	-	4.9	100 yards	-	-	-	-
IL	Gifford	975	EF-3	-	-	0.25	-	-	-	-
KY-IL	Paducah	25048	EF-3	-	11.3	500 yards	-	3	-	-
KY	Corydon	722	EF-3	-	-	-	-	-	-	-
KY	Huntsville	-	EF-1	-	-	200 yards	-	-	-	-
MI	Cassopolis	1763	EF-1	-	0.5	50 yards	-	-	-	-
OH	Cloverdale	166	EF-2	-	2	150 yards	-	-	-	-
IL	Manhattan	7136	EF-2	125	5.5	-	-	-	5	2

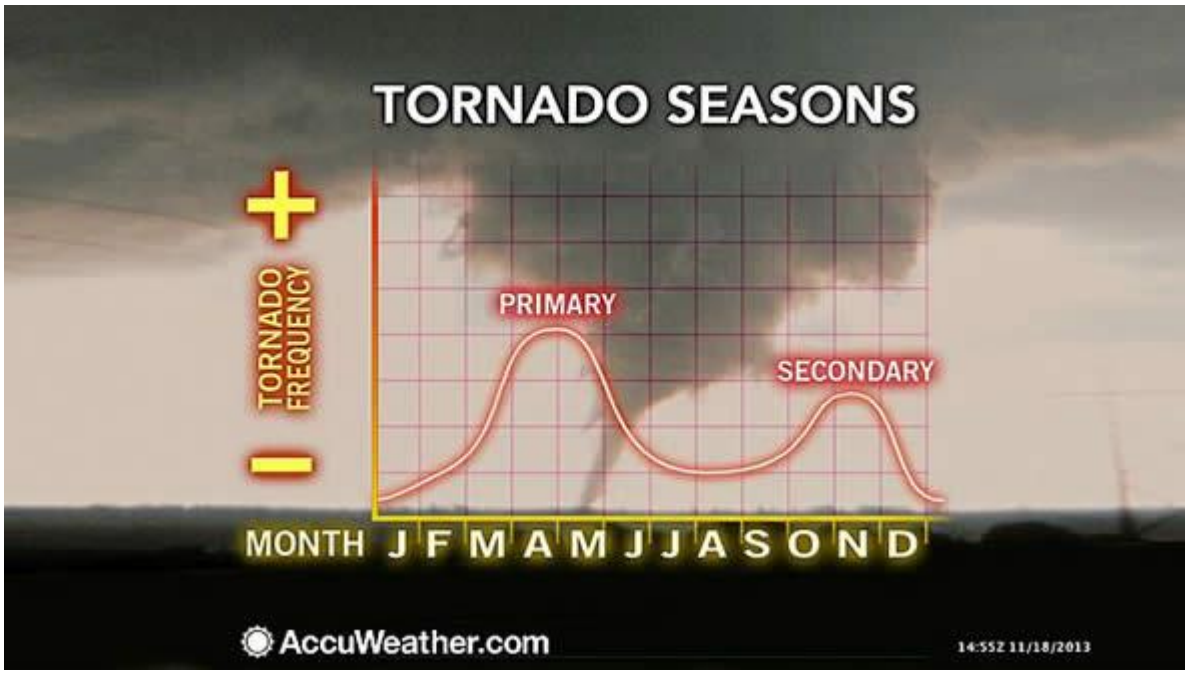

Figure 5: Graphic explaining the weather conditions that caused such a strong outbreak. (Image courtesy of Accuweather)

Demographics on Construction in Tornado-Impacted Towns

The heaviest damage occurred in the Illinois' counties of Washington, Tazewell and Vermillion. Over 90% of the homes in these counties were built before 2000, and the distribution of building age is shown in Figure 6. With more than 50% of the homes built after 1970, the communities are relatively new, i.e. houses are less than 40 years old. The 2000 International Residential Building Code has been adopted in six of the seven affected counties.

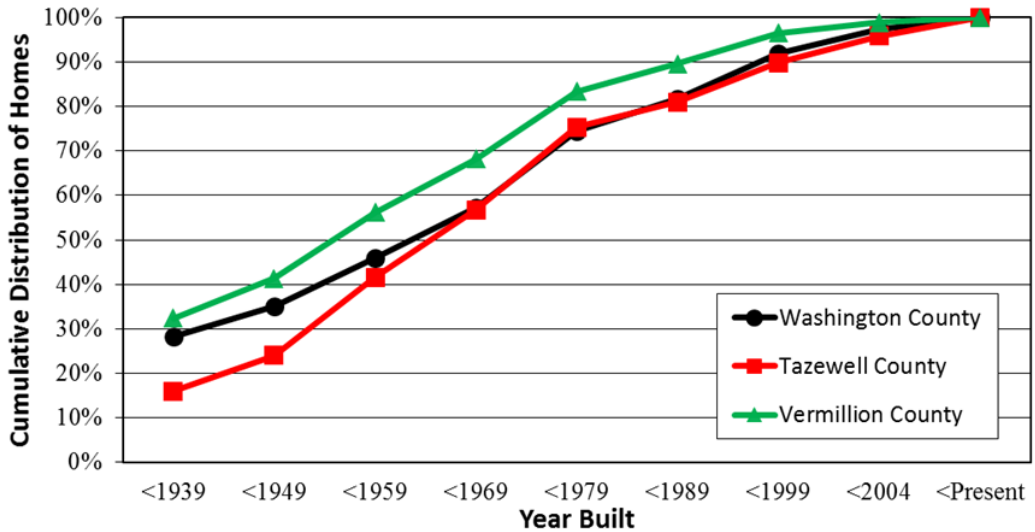

Figure 6: Distribution of Home Age in Impacted Counties (SOURCE: http://quickfacts.census.gov/qfd/index.html)

SELECTED DAMAGE REPORTS

Washington, IL Tornado

This tornado initially developed over the East Peoria County, IL at 10:59am CST and then moved northward towards Tazewell County and the city of Washington, reaching EF-4 intensity. The length of this tornado path was 46.2 miles, taking it through three counties. It caused one fatality, 122 injuries and damaged as many as 500 buildings in the city of Washington. The preliminary EF-4 rating was assigned due to the complete destruction of numerous homes in the tornado path. An aerial view of the damage path is shown in Figure 7, and an example of the EF-4 damage is provided in Figure 8.

Figure 7: Aerial view of damage to Washington, IL

Figure 8: Slab swept clean after tornado in Washington, IL

Gifford Tornado

The Gifford tornado touched down at 12:45pm CST in Champaign County and tracked northeast for 24 miles, reaching a maximum EF-3 intensity in the town of Gifford, IL and causing 6 injuries before lifting in Vermillion County, IL. Figure 9 shows most exterior walls collapsed of a single-family home, indicating EF-3 tornado intensity. Approximately 20 homes in all were destroyed.

Figure 9: EF-3 damage to single family home in Gifford, IL
(http://www.crh.noaa.gov/images/ilx/swop/2013pics/wycislo111713b.jpg)

Washington County, IL Tornado

The Washington County tornado began at 12:04 pm CST as an EF-0 near I-64. It continued moving northwest, causing EF-4 damage and two fatalities at a farmhouse just outside the town of New Minden, IL. The complete tornado path is estimated as shown in Figure 10.

Figure 10: EF-4 Tornado Path through Washington County, Illinois
(http://www.crh.noaa.gov/lsx/?n=survey1)

Figure 11 shows the EF-4 damage indicator for the Washington County tornado. The address of the home is 17642 Pheasant Rd, Nashville, IL 62263, but no details are available as to the year built or construction materials other than what can be seen from the photo, in which only the concrete foundation remains. Homes in the nearby town of New Minden however were mostly built in the 1930's to 1960's range.

Figure 11: The damage indicator for the EF-4 rating of the tornado through Washington County, Illinois (http://www.crh.noaa.gov/lsx/?n=survey1)

Summary of Observed Damage

To date, online reports attribute eight fatalities, numerous injuries and the destruction or damage to 600 single-family homes to this tornado outbreak. Early reports indicate that Washington, IL (pop. 15,000) was the hardest hit. The tornado tracked through residential communities lifting debris and in some cases carrying it nearly a hundred miles away. The National Weather Service assigned a preliminary EF-4 rating to the most powerful tornado, which hit the town Sunday afternoon resulting in one fatality and 120 injuries. One other tornado was assigned an EF-4 rating due to the complete destruction of a farmhouse outside New Milden, IL that also caused two fatalities.

In Washington, IL 250 to 500 houses were either damaged or destroyed. The majority of these houses were light-framed wood structural systems supported on concrete masonry stem walls; the roof structures consisted of metal-plate connected wood trusses. The houses in the affected neighborhoods were built in the early 1960s, and as such, it is likely that they contain structurally inadequate connections along their vertical and lateral load paths. Specifically, one would expect to see toe-nailed roof truss-to-wall connections and cut nail anchors through wood sill plates into the foundation in buildings of this vintage. Some damage to residential buildings is shown in Figures 12 through 15 below.

Figure 12: Exposed foundation and Driveway of a Home in Washington, IL

Figure 13: Home destroyed in Kokomo, IN (Personal Correspondence ?)

Figure 14: House swept off foundation and only basement remains of a home in Washington, IL (http://www.crh.noaa.gov/ilx/?n=17nov13-tor2)

The catastrophic damage to residential structures was reported in several places. Several houses were swept off their foundations, despite having anchor bolts with washers that fastened their wood sill plates to the concrete slabs. From this limited photographic information, it is not possible to know fastening details of the wood studs in the exterior walls. However, we suspect that the vertical wall studs were fastened using end nails (i.e. nails hammered from underside of the sill plates into the end grain of the studs), rather than using more wind-resistant metal strap connections. Although allowed in the International Residential Code, this end nailing technique for wall studs is a notoriously weak connection that provides virtually no resistance to uplift forces. End nailing at best should be considered as

temporary measure used during construction to position and hold the studs in place while the wall is being erected.

Several commercial structures were also heavily damaged, including an auto parts store shown in Figure 15. It appears this lightly reinforced (single bars at 3 – 4 ft o.c) concrete masonry building had discontinuous rebars that were not effective in resisting the wind loads, leaving the walls vulnerable to collapse once support from roof structure was removed.

Figure 15: Failed auto parts store showing discontinuous rebar in lightly reinforced CMU (Accuweather)

Figure 16: Office building destroyed in Kokomo, IN

Conclusions

We are fortunate that the loss of life and damage to structures, buildings and homes were somewhat limited in this tornado outbreak. Despite the tragedy the many communities are experiencing today and the arduous tasks of rebuilding their lives, this could have been far worse. Wurman et al. (2007) suggested that a tornado path through the greater Chicago area "could cause widespread damage and loss of life on a scale that has not been observed historically with tornadoes." Tornado damage is the reality for many areas of the United States, but the extent of that damage is a function of the structural capacity of the communities within the path that are built over time within these tornado-prone regions.

Our knowledge on predicting natural hazards has grown substantially within the past 70 years, as has our ability to design wind-resistant structures to mitigate their effects. However, our ability to use this knowledge is hampered by socio-political realities and by decisions to focus more on post-disaster response than on preparation and structural mitigation for our communities in advance of the hazard. It is necessary for residents of these hard-hit areas in Illinois, Indiana and Kentucky to know that they do have an option to avoid the repeat of this "tornado strike→ substantial damage → rebuild the same" scenario. That option is to embrace on-going tornado-resilient construction research AND to implement the recommended techniques in the current rebuilding effort. The choices these communities make today will affect the resilience of their homes and communities for the next 40 to 50 years.

Acknowledgements

The authors gratefully acknowledge the National Science Foundation for the financial support of this study under research grant 1150975. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

About the PI

David O. Prevatt is an Associate Professor of Civil & Coastal Engineering, in the School of Sustainable Infrastructure & Environment, University of Florida, Gainesville, FL. He is a registered professional engineer registered in Massachusetts and in Trinidad and Tobago.

Peer-Reviewed Publications

Prevatt, D. O., Coulbourne, B., Graettinger, A., Pei, S., Gupta, R., and Grau, D. (2013). "Tornado of May 22, 2011 – Structural Damage Survey and Case for Tornado-Resilient Building Codes", 47 p. ASCE/Structural Engineering Institute, Reston, VA.

Prevatt, D. O., Roueche, D. B., et al. (2011c). "Building damage observations and EF classifications from the Tuscaloosa, AL and Joplin, MO tornadoes." *Proc., 2012 Structures Congress*, ASCE, Reston, VA, in press. Prevatt, D. O., van de Lindt, J. W., Graettinger, A., et al. (2011a). *Damage study and future direction for structural design following the Tuscaloosa tornado of 2011*. University of Florida, Gainesville.

Prevatt, David. O., van de Lindt, J.W., Back, E., Graettinger, A.J., Pei, S., Coulbourne, W., Gupta, R., James, D., Agdas, D.; (2012) Making the Case for Improved Structural Design: The Tornado

Outbreaks of 2011, October 2012 ASCE's Leadership and Management in Engineering Journal

Prevatt, D.O., van de Lindt, J.W., Graettinger, A.,Coulbourne, B., Gupta, R., Pei, S., Hensen, S., Grau, D. (2011a) Damage Study and Future Direction for Structural Design Following the Tuscaloosa Tornado of 2011, University of Florida, Gainesville, FL (April 5, 2012).

Prevatt, D. O., van de Lindt, J. W., Gupta, R., and Coulbourne, B. (2011d). "Structural performance—Tuscaloosa tornado." *Structure Magazine*, July, 24–26.

Vo, T. D., Prevatt, D. O., Acomb, G. A., Schild, N. K., & Fischer, K. T. (2012, October). High speed wind uplift research on green roof assemblies. Conference paper presented at Cities alive: 10th annual green roof & wall conference, Chicago, IL. Retrieved from http://windhazard.davidoprevatt.com/wp-content/uploads/2012/12/SUBMISSION-5R-1-Vo-et-al.-High-speed-wind-uplift-research-on-green-roof-assemblies.pdf

Wurman, J., Alexander, C., Robinson, P. & Richardson, Y. (2007, January). Low-level winds in tornadoes and potential catastrophic tornado impacts in urban areas, *Bull. Amer. Meteor. Soc.* American Meteorological Society, DOI:10.1175/BAMS-88-1-31.

Other Publications and Research Reports

Prevatt, D. O., Agdas, D., & Thompson, A. (2013). Tornado damage and impacts on nuclear facilities in the united states. Unpublished manuscript, Department of Civil and Coastal Engineering, University of Florida, Gainesville, Retrieved from http://windhazard.davidoprevatt.com/wp-content/uploads/2012/10/Prevatt-2013-US-Nuclear-Power-Plants-and-Tornadoes_dop.pdf

Prevatt, D. O., Doreste, J., & Egnew, A. (2013). Online summary damage from the 31 May 2013 tornado in El Reno, OK. Unpublished manuscript, Department of Civil and Coastal Engineering, University of Florida, Gainesville, Retrieved from http://windhazard.davidoprevatt.com/wp-content/uploads/2012/10/El-Reno-Tornado-31-May-2013-Summary-UNIV-FLORIDA.pdf

Prevatt, D. O., Kerr, A., Peng, X., Vo, T., & Doreste, J. (2012). Damage survey following the August 27th, 2012 tornado in Vero Beach, FL. Unpublished manuscript, Department of Civil and Coastal Engineering, University of Florida, Gainesville, Retrieved from http://windhazard.davidoprevatt.com/wp-content/uploads/2012/10/Damage-Survey-Vero-Beach-Tornado-Sept-7-2012-UNIV-FLORIDA.pdf

Prevatt, D. O., Roueche, D., Thompson, A., & Doreste, J. (2013). Online summary damage from the 20 May 2013 tornado in Moore, OK. Unpublished manuscript, Department of Civil and Coastal Engineering, University of Florida, Gainesville, Retrieved from http://windhazard.davidoprevatt.com/wp-content/uploads/2013/05/Moore-Tornado-20-May-2013-TORNADO-Summary-UNIV-FLORIDA.pdf

Prevatt, D. O., Roueche, D., Vo, T., Kerr, A., Thompson, A., Peng, X., & Egnew, A. (2013). Online/internet damage summary of the 15th May, 2013 North Texas tornado outbreak. Unpublished manuscript, Department of Civil and Coastal Engineering, University of Florida, Gainesville, Retrieved from http://windhazard.davidoprevatt.com/wp-content/uploads/2013/05/Summary-of-North-Texas-Tornado-Outbreak-on-May-15th_Final.pdf

Prevatt, D. O., Roueche, D., Kerr, A., & Peng, X. (2012). Summary of june 24, 2012 Lake Placid tornado. Unpublished manuscript, Department of Civil and Coastal Engineering, University of Florida, Gainesville, Retrieved from http://windhazard.davidoprevatt.com/wp-content/uploads/2012/10/June-24-Lake-Placid-Tornado-Damage-Survey.pdf

Engineering, Vol. 139, No. 2, February 1, 2013. ©ASCE, ISSN 0733-9445/2013/2-251–263.