StEER STRUCTURAL EXTREME EVENTS RECONNAISSANCE	**EVENT BRIEFING**		
	Event:	10.20.2019 Dallas, TX EF-3 Tornado	
	Region:	Dallas, TX	
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Key Lessons

- ❏ Tornadoes can and do strike large urban areas like Dallas. In fact, this is the second violent tornado to impact the Dallas metro in the last four years, with an EF4 tornado occurring in 2015. As these large urban areas continue to grow, the probability of being impacted by a tornado continues to grow, known as the expanding bullseye effect (Strader and Ashley, 2015).
- ❏ The current design wind speed in Dallas per ASCE 7-10 is 115 mph for a typical building and 120 mph for a building with higher risk (ASCE Category III) (e.g., school). These design wind speeds specifically exclude tornado-induced risks, leaving most buildings vulnerable to critical failures even in an EF2 tornado (111-135 mph). An engineering study on the 2015 Garland/Rowlett tornado (Prevatt and Roueche, 2017) found that residential buildings were not constructed with a continuous, wind-resistant load path, instead using toe-nails in roof-to-wall connections, insulation boards rather than structural wall sheathing, and anchor bolts with no nuts and washers.
- ❏ The permanent closure of potentially three schools due to a low-end EF3 tornado has far-reaching societal impacts beyond the physical damage and replacement costs, due to the reorganization of displaced teachers and students. With the cost of the structural system typically only a small fraction of the total project cost, future schools should be designed with tornado resiliency in mind beyond simply providing life safety. The same is true for emergency response facilities, with reports of two fire stations destroyed along the path. Coulbourne et al. (2015) identified key weak links in the design of critical facilities, including schools, from the 2013 Moore, OK tornado and provided recommendations for more tornado-resilient construction.
- ❏ The lack of significant injuries and fatalities despite the tornado path over dense urban areas is potentially due to several key factors, including (1) effective warnings by the National Weather Service, with the issuance of a tornado warning nearly simultaneous with initial touchdown of the tornado; (2) the intensity of the tornado (63% of tornado fatalities

occur in EF4/5 tornadoes, only 22% in EF3 tornadoes); (3) the day and time of the tornado (Sunday night with a primetime Dallas Cowboys NFL game on TV) meaning more people were likely sheltered; and (4) the lack of mobile/manufactured homes or other structures with enhanced vulnerability in the damage path. The interaction of these factors and the prominence of their respective influences deserves further study.

Event Description

At approximately 8:58 PM local time on 20 October 2019, a tornado touched down near Dallas Love Field and traveled 25 km (15.5 miles) northeast through densely populated northern regions of Dallas, TX before lifting around 9:30 PM. The National Weather Service assigned a preliminary EF3 rating to the tornado, with an estimated peak wind speed of 225 km/hr (140 mph). The tornado was the worst of a small tornado outbreak, associated with the passage of a cold front, which included tornadoes in Texas, Louisiana, Oklahoma, Arkansas, Missouri and Tennessee. Most of the tornadoes were rated EF1 or lower, but some storm surveys by the National Weather Service forecast offices are still ongoing.

Hazard Description

The potential for tornadoes was forecasted well in advance, with the Storm Prediction Center issuing a Moderate outlook on Saturday, October 19th, including a small region extending from Dallas, TX to southern Missouri with 10% probability of a tornado within 25 miles of a point, as shown in Figure 1. A tornado warning for the Dallas tornado was issued at 8:58 PM, activating the Emergency Alert System for local residents. The tornado touched down northeast of Dallas Love Field and then moved northeast at approximately 40 km/hr (25 mph), crossing I35E. As the tornado continued its generally northeastern movement through densely suburban and urban regions, it caused significant structural damage to a large number of schools, businesses, fire stations, residences and other structures. Despite the damage, no fatalities occurred and no serious injuries were reported, an outcome likely influenced by the NWS warnings in place, the day and time (Sunday night), and the lack of manufactured homes and unregulated housing in the path (commonly associated with tornado fatalities in rural communities).

Despite the night-time occurrence of the tornado, several videos and photos of the tornado were taken, illuminated by lightning, as shown in Figure 2. The photos and video indicate a somewhat narrow core structure of the vortex, often referred to as a stovepipe tornado, although damaging winds would still extend well beyond this core region. The maximum width of the tornado damage path was estimated to be approximately 1.2 km (0.75 miles). The NWS Fort Worth survey team found most damage was consistent with EF1/2 damage, with the exception of a single family home that experienced complete removal of the roof structure and multiple walls collapsed. This home was assigned an EF3 rating, which resulted in the tornado also being assigned an EF3 rating with maximum wind speed of 225 km/hr (140 mph).

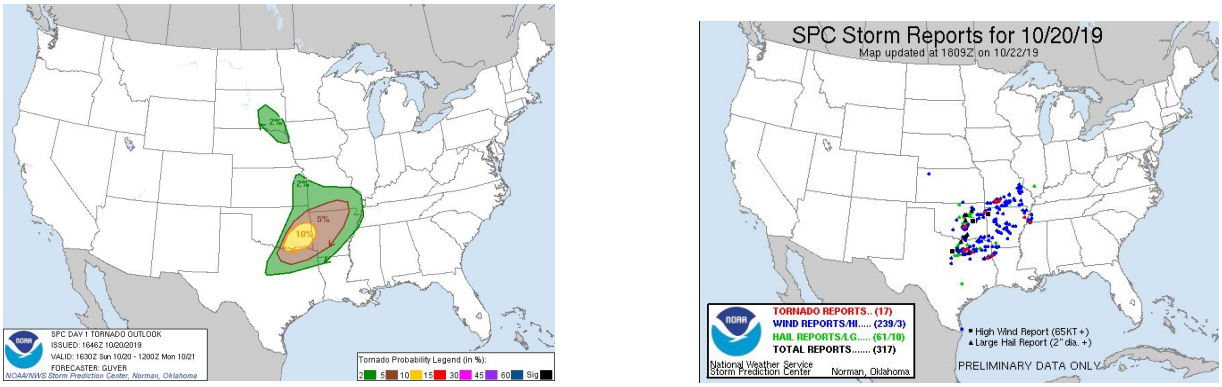

Figure 1. Day 1 tornado probabilities issued by the Storm Prediction Center on October 19, 2019 and preliminary storm reports.

Figure 2. View of the 10/20/2019 Dallas, TX tornado indicating a “stovepipe” tornado. Note that the feature in the top left corner is an object in the camera field of view, but not a second vortex. Photo credit: Twitter @AthenaRising.

Damage to Structures

The path of the tornado through the Dallas metropolitan area affected a large number of buildings. The preliminary tornado path given by the NWS Dallas/Fort Worth office indicates 11,313 buildings were nominally affected by the tornado. The vast majority (approximately 9,500) were houses, but there were also 373 apartment buildings, 36 church buildings, and 59 school buildings within the damage path based on data from OpenStreetMap. The City of Dallas reported 104 homes destroyed, 286 with major damage, and about 500 needing minor repairs[1]. Damage to power distribution systems resulted in an estimated 150,000 customers without power immediately after the storm.

[1] Source: J.D. Miles via Twitter - https://twitter.com/jdmiles11/status/1186829038473699328

Buildings

An overview of the damage path with locations of key impacted structures is provided later in Figure 14. Damage was widespread amongst a variety of building types. The worst damage primarily consisted of roof failure and limited wall collapse throughout the path.

The Dallas Independent School District Superintendent reported damage to Cary Middle School, Cigarroa Elementary School, Pershing Elementary School, Thomas Jefferson High School, and Walnut Hill Elementary School. In all, twenty schools were closed the following day due to either power outages or damage. The worst damage appears to have been experienced by Thomas Jefferson High School (Fig. 3), Cary Middle School (Fig. 4), and Walnut Hill Elementary School (Fig. 5).

Figure 3. Thomas Jefferson High School with primarily envelope and cladding damage to the main facility (Source: Fox 7 Austin).

Figure 4. Cary Middle School with severe damage to cladding and fenestration and some structural roof damage (Source: WFAA TV).

Figure 5. Walnut Hill Elementary School with structural roof damage (Source: Fox 4 News).

Figure 6 shows before and after images of Dallas Fire Station #41. The tornado damage to the roof and front doors of the fire station likely rendered the building and equipment unusable for recovery after the event. Figure 7 and 8 show before and after images of two church buildings with substantial to total structural damage. Figure 9 shows before and after images of a roof failure at Preston Royal shopping center. Figure 10 shows damage to the Home Depot near US HWY-75.

Figure 6. Google street view image of Dallas Fire Station #41 before the tornado (left) and photo taken after the tornado (right) (Lat: 32.8945N; Long: 96.8065W) (Sources: MSN 2019, DALLAS FIRE-RESCUE/HANDOUT/EPA-EFE/Shutterstock)

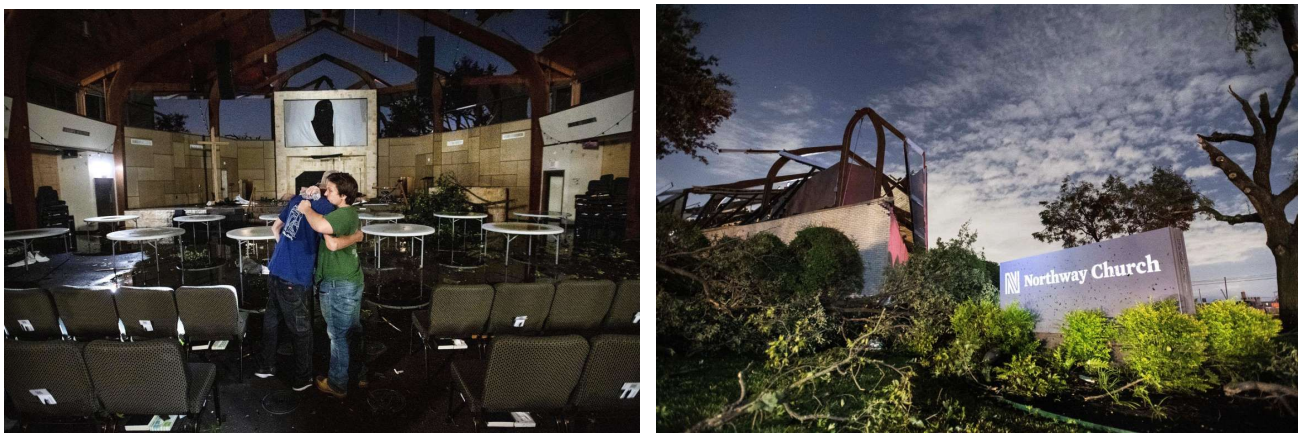

Figure 7. Tornado damage to Northway Church building (Lat: 32.8845N, Long: 96.8496W) (Sources: MSN 2019, Jeffrey McWhorter/AP Photo)

Figure 8. Google street view image of Primera Iglesia Dallas church before tornado (left) and photo

taken after the tornado (right) (Lat: 32.8811N; Long: 96.8536W) (Source: MSN 2019, Jeffrey McWhorter/AP Photo)

Figure 9. Google Street View before tornado and roof failure after tornado at Preston Royal Shopping Center (Lat: 32.8935N; Long: 96.8023W) (Sources: MSN 2019, Ronald Martinez/Getty Images)

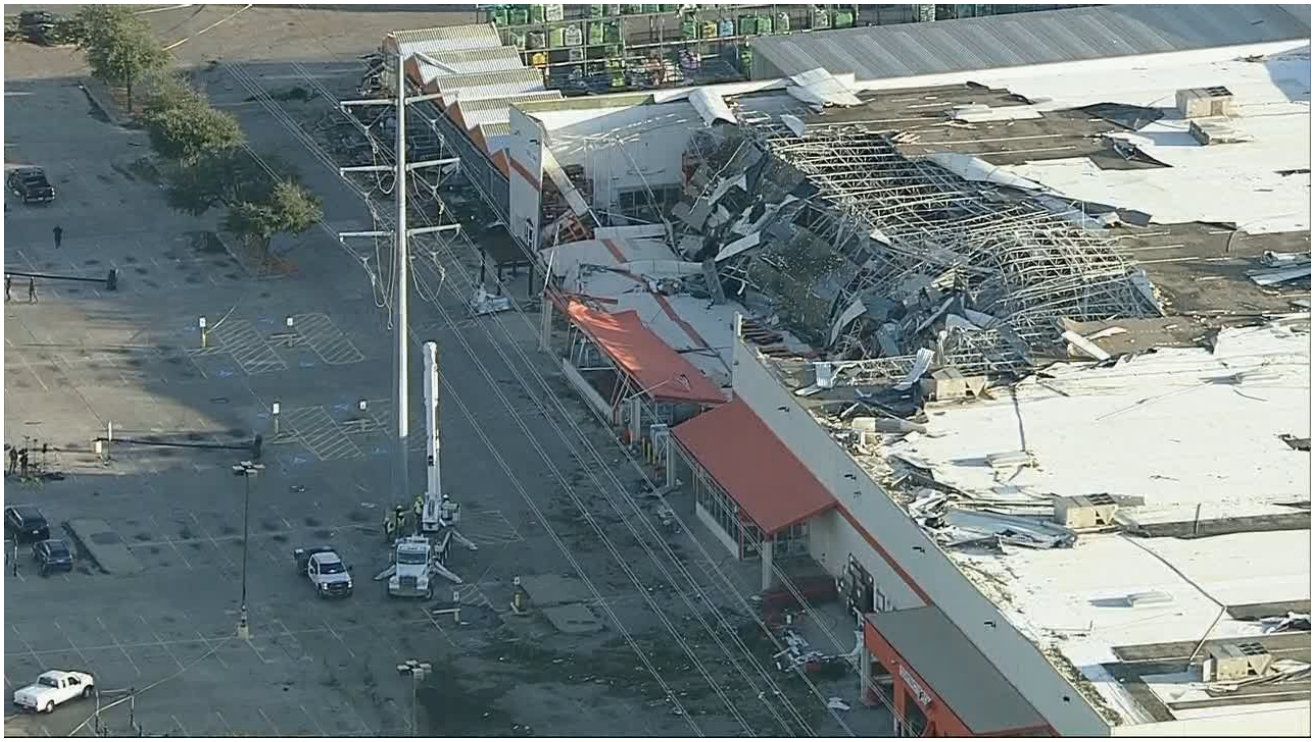

Figure 10. Aerial view of damage to the Home Depot (Lat: 32.906987; Long: -96.764696) (Sources: Fox 4 News).

Damage to residential buildings was widespread, including both single-family homes and apartments, at both middle- and high-income levels. Figure 11 illustrates the intermittent nature of the damage, with the roof severely damaged in one home and little visible damage to adjacent homes. Figure 12 illustrates damage to a home in the more affluent Preston Hollows neighborhood in Dallas. Figure 13 shows roof and upper story wall damage to an apartment building in the Walnut Hill area. A field investigation of the 2015 EF4 tornado in nearby Garland and Rowlett found that residential structures were generally poorly constructed for wind resistance, with toe-nail roof-to-wall connections, presence of non-structural wall sheathing, and improper anchor bolt installation at the roof-to-wall connections (Prevatt and Roueche, 2017). Both high-income and middle-income-level homes were found to perform equally poorly.

Figure 11. Isolated roof damage to a single-family home with limited impacts to adjacent homes (Source: Twitter via @Jberm236).

Figure 12. Damage to a single-family home in the Preston Hollows neighborhood (Source: CBS 11).

Figure 13. Damage to apartments located in Walnut Hill (Source: NWS Fort Worth).

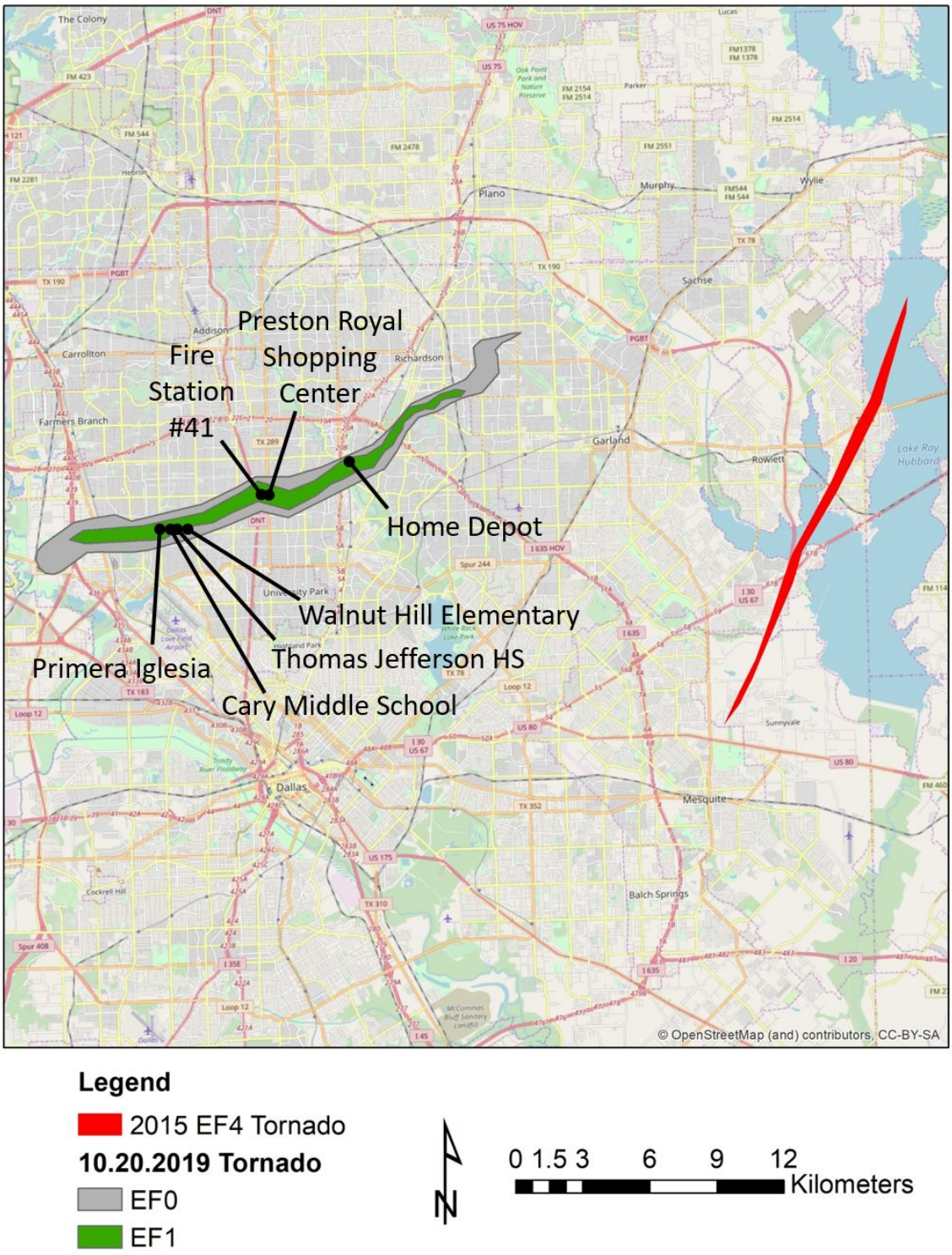

Figure 14. Overview of the damage path and key structures referenced elsewhere in this report. The damage path of the 2015 EF4 tornado is also shown, in red. Tornado path is radar-estimated and provided by the National Weather Service.

Other Infrastructure

A number of wooden power poles were snapped, causing power outages for over 150,000 customers. Several photos, such as Figure 10, showed main distribution lines still intact for at least portions of the tornado path. While the tornado crossed over several roadways and overpasses, no structural damage has been reported.

StEER Response Strategy

At present, StEER will not form a Virtual Assessment Structural Team (VAST) or formal Field Assessment Structural Team (FAST) in response to this event. However, StEER is coordinating with local engineers (Tim Marshall from Haag Engineering and Doug Allen and Keith Cullum from Simpson StrongTie) who are conducting limited assessments. StEER Members Allen and Cullum's data are currently available in the StEER Fulcrum Community Dashboard: https://web.fulcrumapp.com/communities/nsf-rapid.

StEER's formal response to this tornado is constituted by this Event Briefing, which shares with the community StEER's impressions of the event and implications for natural hazard research and practice. Information provided herein was gathered from various websites and the limited field observations from StEER Members form Simpson Strong Tie; therefore, this briefing does not include insights from detailed field investigations. StEER will update the community with findings from the local engineering assessments as warranted.

References

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