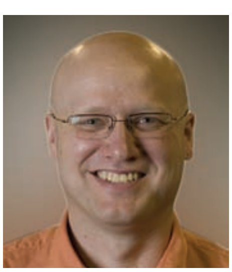
Tornadoes:

The Hidden Damage



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Detailed tornado research has used debris patterns and downburst damage surveys to help determine wind speeds during severe storms

Knowledge of tornado and downburst wind damage is critical to engineering evaluations of structural performance and, in particular, for the development of appropriate design guidelines for critical infrastructure systems. For example, the design of electrical power distribution systems for wind loads is governed by tornadoes in southern Ontario, so knowledge of wind speeds, tornado size distributions, track lengths, etc. is required. Tornado sizes and track lengths come from damage surveys. Wind speeds are associated with damage surveys and indicators. These indicators are based on the well-known Fujita Scale.

In the United States, the Fujita Scale was recently revised and is now called the Enhanced Fujita Scale, which includes a wider range of structural damage indicators. The enhanced scale also has a new range of (reduced) wind speeds at the higher end of the scale. It is important to realize all of the information we use regarding tornado wind speeds comes from damage surveys and the Fujita Scale. Thus, there could be a powerful tornado in a particular area, but if it does not hit anything, there is no statistical record of it. In addition, the maximum damage rating depends on the (expected) strength of the structure, so if a powerful tornado hits a weak structure, the maximum rating possible is limited.

None of this is intended as a criticism of the Fujita Scale. Rather, it indicates the truly limited knowledge we have about these severe winds. To aid our understanding, wide-ranging wind damage research is being conducted at the University of Western Ontario — under the sponsorship of the Institute for Catastrophic Loss Reduction (ICLR) and the Natural Sciences and Engineering Research Council of Canada (NSERC), in partnership with Environment Canada — to develop greater numbers of damage indicators, based on scientific testing, to obtain more realistic wind speed estimates for severe windstorms. We are focussing on two aspects that have not previously been explored, namely wind throw of trees and flight of wind-borne debris. In this article, we focus only on the latter.

Well-defined roof failures and debris flight distances allow the possibility of assessing wind speeds.

Wind-borne debris arises when a building element fails and subsequently flies through the air. The main problem with debris is that it often hits downwind structures, causing additional damage. This can be particularly severe if a window or door is destroyed, because subsequent internal pressurization could lead to roof failure. It is estimated wind-borne debris caused about 40% of the damage when Hurricane Andrew hit South Florida in August 1992. However, well-defined failures and flight distances, as observed post-storm, allow the possibility of assessing wind speeds.

We have conducted research of debris flight for particular failure mechanisms by using carefully designed models in wind tunnel experiments. In particular, detailed data have been obtained for common debris types such as roof shingles and tiles and roof sheathing — and even a full woodtruss, gable roof. One limitation of the research is that it has been done only for hurricane-type wind conditions. But a new downburst simulator at the University of Western Ontario will be used to determine the effects of thunderstorm winds. Tornado wind fields are still beyond our current capacity, although details of tornado vortices have been obtained at UWO, as well as by full-scale, portable Doppler radar in the United States, and through model scale vortex chambers at other universities.

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PROBABILITY

Once we have debris flight data from carefully controlled wind tunnel experiments, we have data relating flight distances with wind speeds. One could use this database then to infer wind speeds from full-scale damage observations, assuming conditions were similar between full-scale and wind tunnel. The database might also be used to develop computer models that can predict the flight speeds based on the physics of flight, calibrated against the wind tunnel experiments. This would allow estimation of wind speeds for a much larger range of observations. Data from damage surveys plays a key role in the development of these models.

As this research progresses, we hope to provide new damage indicators for severe wind storms based on such numerical models, and enhancing the usefulness of the Fujita Scale for engineering design of critical infrastructure.