The vulnerability of residential window glass to lightweight windborne debris

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Project motivation: Unprotected residential window glass was subjected to impact by lightweight debris in order to document its expected performance in hurricane conditions. Damage to windows is a common failure during hurricanes, and can lead to significant additional damage due to rain water ingress and increased wind loading on the roof and walls. Window failure is often caused by windborne debris. The Florida Building Code addresses this issue by requiring the use of window protection (e.g. shutters) for residences close to the coast (Windborne Debris Region). However, the installation of window protection prior to hurricane land fall is ultimately the responsibility of the homeowner. This study documents how vulnerable, unprotected windows can be in a typical suburban environment.

Project scope and results: Post-hurricane damage studies indicate that roof shingles and light vegetation are primary sources of windborne debris in residential areas. More than 600 samples of unprotected typical residential window glass were impacted with either roof shingles or wooden dowels (vegetation) of various sizes, flight speeds, and impact angles. These experiments determined the momentum required to damage the glass, which was then related to the wind speed needed to cause the debris speed and observed damage. It was determined that:

- A shingle traveling in winds from a minimal Category 1 hurricane has a 50% chance of breaking a residential window upon impact.
- A shingle traveling in winds from a minimal Category 2 hurricane has a greater than 70% chance of breaking a residential window upon impact.
- Vegetation traveling in winds from a minimal Category 1 hurricane has a greater than 80% chance of breaking a residential window upon impact.

Significant shingle loss in older neighborhoods has been observed to occur in low Category 2 winds. Therefore, winds strong enough to remove shingles from a roof will impart a momentum to that shingle, sufficient to break a typical residential double-strength window pane. Wooden dowels representing lightweight vegetation are even more likely to break windows.

Summary Outcome: This study provides strong evidence that windows are highly likely to break, if impacted by common windborne debris in low to moderate strength hurricanes. Therefore, window protection is a vitally important measure to mitigate a very common cause of residential damage.

The complete study has been documented in the following peer reviewed journal publication: