Mitigating Microburst-Related Damage in High Risk Areas

by Yves Khawam, Ph.D.

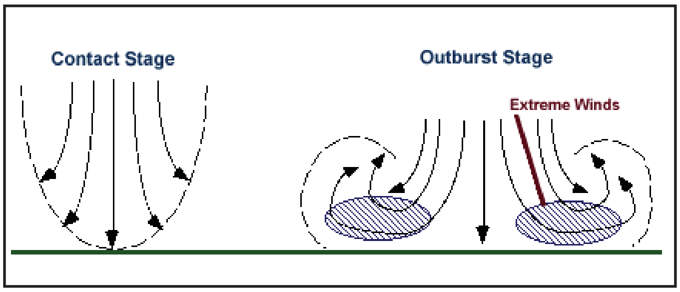

Figure 1. Microburst early stages.

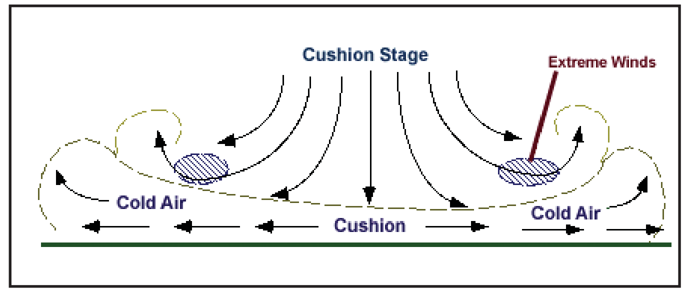

Figure 2. Microburst cushion stage.

Microbursts are strong downdrafts within thunderstorm clouds which can generate damaging winds at or near ground level. They are created as rain evaporates within a cloud, causing a temperature drop that results in a vertical downburst acceleration of cold air. As this air approaches the ground, it outbursts away from the point of impact within a radius of up to 1.25 miles (Figure 1). The accumulation of falling cold air quickly creates its own cushion on the ground, forcing winds to curl away from grade and further accelerate (Figure 2).

From a structural perspective, this accumulated air cushion helps to protect the lateral stability of buildings because the air contained within the cushion moves at slower speeds. The same buildings' roof system, however, may be subject to severe overhead winds, resulting in uplift forces that exceed tie down capacity.

A History of Safety

Pima County is located within the Sonoran Desert of Southern Arizona: an area affected by an annual summer season during which shifting winds bring frequent thunderstorm activity. As reported by the National Oceanic and Atmospheric Administration (NOAA), the best predictor of microburst activity is thunderstorm activity, making Pima County a high-risk microburst area.

Pima County and its largest incorporated jurisdiction, the City of Tucson, has had a policy in place dating back to locally adopted amendments to the 1982 *Uniform Building Code* requiring all conventionally framed structures to have their roofs tied down using premanufactured metal clips so as to resist uplift loads resulting from microburst activity. While the basic design wind speed for the area is 90 miles per hour (3-second gust), its susceptibility to microburst activity—which can produce gusts exceeding 140 miles per hour—has led past and present officials to apply more stringent tie down requirements in keeping with the intent of the codes to ensure public safety and help mitigate against property damage. These requirements were recently codified in a "Standard Operating Procedure" better aligned with the *International Codes*® to offer designers and builders both prescriptive and design alternatives.

There are over 300,000 residents in unincorporated Pima County and another 550,000-plus in its incorporated towns and cities. Given these numbers it is noteworthy that only nine permits have been issued in Pima County over the past five years to repair structures damaged from probable microburst activity, and none applied to homes built since the adoption of the more stringent clipping requirements.

Design to Resist Uplift Loads

In line with the accepted model that outbursts dissipate over a cushion of air, it seems reasonable to assume that when winds shift from vertical to horizontal, they transfer their strongest forces not directly at, but slightly above grade. This assumption correlates with empirical observations that structures affected by microbursts have lost roofs due to uplift forces but only rarely have had their lateral stability compromised. Therefore, little or no adjustments are required to the lateral bracing requirements of the codes to protect against microbursts. Uplift requirements, however, can be improved by offering design and prescriptive alternatives, as reflected by the following example derived from the current Pima County requirements.

Example

1.0 Design-based wind uplift criteria. Wind uplift requirements shall be determined by *International Building Code* Section 2308.10.1 or *International Residential Code* Section R802.11 for the continuous load path transmitting the uplift forces from the rafter or truss ties to the foundation using a design wind value of 140 mph or current table maximum wind speed. *[Note that the applicable tables do not currently include wind speeds of 140 mph—the intent is to offer designers a nonprescriptive alternative.]*

2.0 Prescriptive-based wind uplift criteria. A designer may opt to comply with this section in lieu of complying with Section 1.0. Note that the requirements of this section are in addition to those required for the structural connection of wood members.

2.1 Conventionally framed wood or cold-formed steel structures. All bearing wall vertical connections shall be connected with either approved structural sheathing or approved metal clips to provide a continuous load path from the rafter, joist or truss through the ledger or top plate to the bottom wall plate or sill. When metal clips are used, they shall be minimum Simpson H2.5 (A34 at ledger) or of equivalent load capacity, of configuration to match connection, and spaced at intervals not to exceed 24 inches. At openings, lower cripple studs do not require clipping but king/trimmer studs require double clips at bottom and upper cripples and require both full clipping to header as well as header to king stud. All platform framing requires either strapping listed for that purpose or continuous sheathing over rim joists from stud to stud vertically at each floor level. All nonbearing exterior walls shall be clipped as above except that the spacing may be extended not to exceed every other stud.

2.2 Masonry or concrete structures. If lateral design requires larger anchors or more conservative spacing, these may be used in lieu of those specified in this section.

2.2.1 Roof bearing on wall top plate. Top plates shall be secured to masonry or concrete walls with minimum 0.5-inch diameter embedded anchor bolts spaced at intervals not to exceed 48 inches. Each joist or truss shall be clipped to a plate at bearing with minimum Simpson H2.5 or those of equivalent load capacity and of configuration to match connection. Gable end joists or trusses shall also be clipped at intervals not to exceed 48 inches.

2.2.2 Roof bearing on wall ledger. Joists or trusses parallel or perpendicular to a wall ledger shall be secured to masonry or concrete walls with minimum Simpson PAI23 purlin anchors or approved equal with equivalent load capacity listed for the application and embedded into the wall in accordance with the manufacturer's listing at intervals not to exceed 48 inches.

Microburst over a desert community.

2.3 Structural steel structures. Structural steel buildings shall have roof members attached by welds, bolts or other approved connections at intervals not to exceed 48 inches. Ledgers shall be connected to roof trusses with straps listed for that purpose at intervals not to exceed 48 inches on all diaphragm sides. If lateral design requires larger anchors or more conservative spacing, these may be used in lieu of those specified in this section.

Conclusion

If we estimate that the construction of an average, conventionally framed home using the proposed prescriptive method would require approximately 200 clips, the additional material and labor costs is under $200. Most would agree that this is a small price to pay to mitigate against damage to roofs in areas susceptible to microbursts. ◆

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