Costs, aged infrastructure influence widespread incorporation of safe structures

by Michelle Leach

As if Nebraskans needed yet another reminder of the power of tornadoes, in late May the world watched an EF5 barrel down on the Oklahoma City-area of Moore, hitting three schools and claiming the lives of two dozen people, including 10 children.

As fellow residents of Tornado Alley, these tragic events bring to the surface what some AEC professionals grapple with in their day-to-day work lives; what can be built into offices and homes to at least mitigate damage associated with a side of Mother Nature so fierce that it can't possibly be outwitted?

"People always want to know, how can they engineer for earthquakes and not for tornadoes, but earthquakes happen from the bottom up, and if you've got a good foundation and the footings are strong, the rest of the building can absorb the shocks," said Jackie McCullough, executive director of the American Council of Engineering Companies of Nebraska, contrasting earthquake damage to twisters, which pack a punch from the "top down," effectively pulling at the roof. "Like a house of cards, once that top starts to fall down, the sides don't stay up."

Compounding the character of Mother Nature on this front is the general age of infrastructure stateside.

"Bridges and roadways … weren't constructed with the knowledge we have now," McCullough said. "If infrastructure was built with the information we have now, it might help mitigate some of the physical damage, and loss of life, but we haven't invested in infrastructure as a nation."

McCullough

Christensen

Hennessey

Zubrod

Sam Ucman, structural engineer with Key Professional Engineers (KPE) said buildings, old and new, should have maintenance programs and periodic assessments, otherwise over time leaks or wear on structural components can occur.

"It should take a tornado or extreme event to cause damage to a building structure," he said. "Extreme tornadoes reach another category of severity. The pressures from winds are a function of the square of velocity; therefore doubling or tripling the wind speed results in four times or nine times the wind pressure, respectively."

While structures can be designed to withstand even the most extreme twisters on the Fujita Scale, costs are prohibitive (however, with residential, he noted a few thousand dollars-worth of improvements can ready a home to withstand much more damage.)

"Generally, small safe areas of a building can be provided," Ucman said. "Safe areas are rooms or portions of a building that are designed to withstand these forces and the collapse of building above and around them (essentially a bunker within the building)."

In this vein, Adam Christensen, a senior project engineer with Olsson Associate's bridge/structural team, noted the actual statistical probability of sustaining a direct hit from such extreme forces is "fairly low."

He also indicated the cost-benefit to all-over hardening of one's facilities doesn't compute.

Olsson's team leader Shane Hennessey, citing FEMA's 361 document from 2008 (developed on the heels of the devastating Joplin tornado), said a hardened area or safe room designed to resist 250-mile per hour winds, increases costs "roughly 20 to 30 percent."

To put this increase in terms of building hardiness into perspective, Christensen noted that a structure as a whole is typically designed to withstand 90 MPH wind speeds, with some cushion to withstand higher winds.

"But that 250 represents a huge increase," he said.

Olsson leadership also emphasized that the FEMA document really dictates above-grade engineering — as "below-grade" basements already don't have to contend with the flying debris exposed to extreme winds.

It was also noted that safe rooms are very much basic, amenity-free bunkers, whereas existing all-over hardened structures include the likes of data centers housing sensitive information and, due to the costs and infrequency of such weather events a broad mandate governing the incorporation of the structures is unlikely.

Kirkham Michael's Rick Zubrod said the firm was involved with Twin Platte, Central Platte and Lower Loup Natural Resources Districts to develop multi-jurisdiction All Hazard Mitigation Plans, funded partly by FEMA and NEMA with matching funds from the NRDs and/or local governments.

The plan involved the likes of county, municipal and school district reps attending public meetings, completing surveys to identify hazards including tornados and assessing the vulnerability of life and property to those hazards.

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"Several jurisdictions identified the need for safe rooms to protect from deaths and injuries in schools, mobile home parks and fair grounds," he said.

Olsson leadership noted that, following the Moore tornado, there may be an update to the FEMA 361 documentation.

Forensic engineers like KPE's sister company, KPE Investigative Engineers, offer direction in the aftermath of tornados and other storm damage, having been contacted, according to President Kevin Power, by insurance companies' catastrophic teams to sift through damage, assess its causes and determine what to repair and what to replace.

Power reported nine common causes of roof, foundation and HVAC failures, as follows: value-engineering conducted to reduce cost; lack of professional engineering by a consulting engineer in rural areas not requiring permits or public inspections; incorrect construction of thermal breaks in material assemblies; poor or incorrect automatic HVAC control algorithms/strategies; improper gutter maintenance; lack of sloped landscape away from buildings' footings; expansive backfill soils prompting foundations to move; incorrect sizing of HVAC ducts, piping, equipment; and either plugged or a lack of attic ventilation flutes.

"Problems with larger, commercial or industrial facilities are generally attributed to the first four causes," he said of the preceding list. "Causes one and two don't generally apply to residential facilities."

An increase in foundation movement associated with poor maintenance of gutters, expansive soils used for backfill and a lack of sloping landscape away from footings was noted last year, attributed, he said, to drought and a wet spring.

"When foundations become wet or poor backfill is used these problems manifest themselves during periods of rapid change (dry to wet and vice-versa)," Power said.