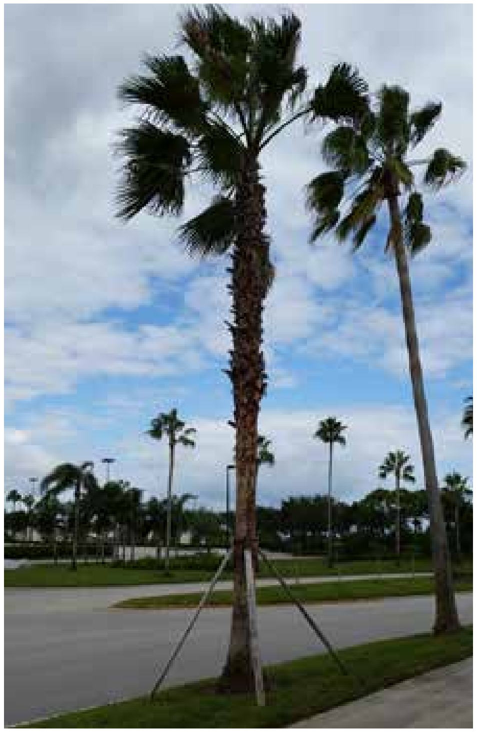
Investigating an atypical "other structure" collapse

Buildings are designed by structural engineers to safely support loads:

- Live loads from occupants
- Dead loads from their own self-weight
- Loads imposed by natural elements (wind, earthquake, snow, water & earth)

While building codes specify minimum design loads for the most "typical" instances, one Standard is referenced by all national building codes and provides the criteria and design guidance for building loads; the American Society of Civil Engineers' "Minimum Design Loads for Buildings and Other Structures", commonly referred to as ASCE 7. ASCE 7 defines its scope as providing minimum load requirements for the design of buildings and *other structures*. In this article we explore the engineering issues associated with *other structures*.



Buildings vs. "Other Structures"

ASCE 7 defines a building as "A structure, usually enclosed by walls and a roof, constructed to provide support or shelter for an intended occupancy." While that is intuitively obvious, the question then asked is…"What is an *other structure*"? Examples of other structures include signs, billboards, light-poles, fences, pools, water towers, culverts…even bridges. Loading (design forces) for those types of *other structures* is explicitly provided in building codes and/or in the ASCE standard.

"Other Structures" without Explicit Loading Requirements

There are yet other, *other structures* for which building codes and the ASCE standard do not explicitly address with respect to their design loading. When these types of structures are involved in litigation due to a structural defect or collapse, it can be difficult to ascertain the minimum design loading for them. When investigating those types of structures, structural engineers must often develop their own models based upon engineering judgment to calculate the requisite design loads.

Case Example:
Collapse of a Recently Planted Tree

Several years ago, I was retained in a case where a recently planted and temporarily braced palm tree had blown over and struck and injured a pedestrian. In this matter, I was tasked with analyzing the wood braces that had been used to temporarily brace this palm to determine if their design was reasonable for the anticipated loads. No code or standard dictates the forces for which tree braces are to be designed, but this configuration (tree being structurally braced by the wood members) falls neatly into the ASCE definition of *other structures*. The wood braces are intended to provide the required lateral support until such time that the tree takes root and is self-stable. Until that occurs, the wood braces need to brace the tree (i.e., take load) so that it doesn't fall…potentially damaging itself, surrounding property, or causing injury.

What are the Forces in the Braces?

The forces present in the braces are dependent upon the offset of the center of gravity of the weight of the tree and, to a greater extent, those generated by wind blowing on the tree. However; the modeling of the tree to calculate wind forces is highly complex and is NOT addressed in any code or Standard. Further, trees assume different shapes at differing heights and wind interacts differently based upon the shape of the object.

If the tree is a palm tree, the flexibility of the palm fronds (head of palm) affect how the wind interacts with them; the flexible fronds of a Queen Palm might be more appropriately modeled as a series of increasing smaller triangular flags while the head of a Medjool Palm, with its rigid fronds, might be more accurately modeled as a "rough" ball; the "roughness" of an object's surface also affects the how wind interacts with that object.

Engineering Solutions in Atypical Cases

In instances where design loads are not explicitly provided, engineers need to draw from their education, training and (especially) their experience to use their best judgment and apply a rational analysis approach to the "model" they create to allow them to properly analyze those structures. Experience of your expert is critical in matters like these. Be certain that your engineering expert has the depth of relevant experience in matters germane to your case.

Mark Duckett, P.E., S.I.
Structural Engineer
mduckett@robsonforensic.com

Mark has almost three decades of professional experience in structural engineering; in this time he has designed and inspected all types of structures including residential, commercial, marine, industrial, institutional, religious, retail, hi-rise, and warehouse. Mark's expertise extends to almost every type of building material, including concrete, steel, wood, masonry and many other types of materials. Mark has additional training that qualifies him in wind engineering; specifically, how wind acts upon structures and how structures react to the wind. Mark is a Professional Engineer (P.E.) licensed in multiple states. He is also a Special (Threshold) Inspector and in the State of Florida.