### *Parking Problems …*

Structural engineering has always been a very conservative profession. This is particularly evident in building codes and standards. These regulations are intended to protect the public from deficiencies in design and construction. Why then, do so many parking garages collapse? In 2015, at least six parking garages collapsed in the United States. More have collapsed in 2016. Some failures are due to deficient design or construction, or to inadequate maintenance, but most are due to excessive loading.

For decades, codes and standards have stipulated that parking garages be designed for a minimum live load of 50 psf. This is more than adequate for sedans, SUVs, and half-ton pickups. The average vehicle today weighs 4,009 pounds and can safely be parked in any garage. With the margin of safety inherent in codes and standards, failure becomes imminent only when an actual live load approaches 100 psf. Some parking garages post maximum vehicle weights at their entrances. More commonly, the entrances limit vehicle height (thus, vehicle size/weight) with clearance bars typically set at 7'. Here are four recent examples where parking garages collapsed due to excessive loading.

***Saturday, 01/24/15, Secaucus, NJ:*** A 3-level garage with 600 parking spaces serves the Harmon Plaza Office Tower, the Clarion Empire Meadowlands Hotel, and the Osprey Cove Apartments. Following a 4"snowfall, the top level of the garage was being plowed by a small Bobcat utility vehicle. The weight of the Bobcat was not a problem, nor was the weight of the accumulated snow. However, compacted snow weighs about 20 pcf, and 30 pcf or more if wet. The snow was being pushed into one big compacted pile. At 7:00 am, with the pile more than 4' high, the top level beneath the pile collapsed. The resulting opening swallowed the Bobcat, and one vehicle parked below was crushed. No one was injured except the Bobcat driver, who had a mild concussion. On weekdays, the garage would have been filled with vehicles and people.

***Friday, 05/01/15, Washington, DC:*** A 3-level garage serves the iconic Watergate mixed-use complex. Now 50 years old, the complex was undergoing a comprehensive restoration. A landscaping contractor piled dirt and debris on the top level of the parking garage. Dirt weighs about 75 pcf if dry, and up to 125 pcf if wet. Thus, only one foot of dirt could cause failure. At 10:00 am, the top level beneath the dirt collapsed. Everything on the two levels below was crushed in a "pancake" failure. Two people were injured, one critically, and about 35 vehicles were destroyed.

***Friday, 10/23/15, Dallas, TX:*** A 7-level garage with 800 parking spaces serves the upscale Renaissance on Turtle Creek Condominiums. The pool and amenities deck at the top of the garage were being renovated, and the contractor piled dirt and miscellaneous debris at the toe of a ramp near one corner of the top level. A video a few hours before the collapse shows that the pile was about 3' high. During a rainstorm, water flowed down the ramp and saturated the pile. At 5:00 pm, the top level beneath the pile collapsed. Everything on the six levels below was crushed in a "pancake" failure. Amazingly, no one was injured. Numerous vehicles were destroyed, and about 250 vehicles and their contents remained inaccessible to their owners for 58 days. The garage will remain closed until June or July 2016, when reconstruction should be complete.

***Friday, 04/22/16, Houston, TX:*** An underground garage with an at-grade top deck serves adjacent office buildings on Town & Country Boulevard in Houston. The garage had been flooded during a period of record rainfall. A tanker truck was summoned to the site to pump out the water. The entrance to the top deck was blocked by a clearance bar proclaiming "MAXIMUM WEIGHT 4,000 LBS", so the truck driver backed his tanker over the curb and onto the deck a few feet to the right of the entrance. The tanker has a capacity of 5,800 gallons. That amounts to 48,400 pounds of water, not including the weight of the truck. As the tanker filled with water, the deck eventually failed under the weight of the rear wheels. Fortunately, no one was injured.

None of these collapses are related to design, construction, or maintenance. Rather, they are the result of stupidity, which building codes and standards will never adequately address.