The tragic collapse of the I-35 West Bridge in Minneapolis in 2007 has heightened the concern for the safety and condition of our nation’s aging infrastructure.

Since the I-35W collapse, bridge inspections have borne intense scrutiny, while other structures along the nation’s highway system continue to be overlooked. High-mast light towers, overhead sign structures and traffic-signal supports, known as ancillary structures, represent a significant danger to roadways because of the lack of proper inspection and maintenance. As the largest member, high-mast light towers exemplify the safety concerns of these structures.

Huge number of giants

High-mast light towers are the silent, overlooked, vertical giants nestled along our highways. They light the interchanges, toll plazas and roadways of the nation’s interstates and urban freeways, standing as high as 150 ft and within yards of highways and interchange ramps that handle thousands of speeding vehicles every day.

Their purpose becomes obvious as soon as the sun sets. Ample lighting at high-traffic areas has long been an accepted highway safety issue for night driving. Studies have shown a direct correlation between accidents and the level and uniformity of lighting, especially with aging drivers.

High-mast towers are huge steel structures constructed of welded, tapered, tubular sections. Installers assemble towers in the field by sliding these tubular sections together like a giant fishing rod, forming “slip joints” at each juncture. The towers have a welded base plate that is bolted to threaded rods embedded in concrete foundations buried deep in the ground. Capping the towers is a ring that holds multiple light fixtures, aka luminaires. Depending on height, an individual tower can weigh between 2,000 and 2,800 lb.

According to the most comprehensive nationwide survey, it is estimated that there are approximately 65,000 towers dotting the nation’s major highways. Over 80% of state respondents admit having towers over 35 years old—approaching generally accepted life expectancy. Many of these
towers were installed with the initial construction of the interstate system in the mid-1960s. By the late 1970s, high-mast towers had grown in popularity and became a standard highway design element.

The Transportation Research Board (TRB) has sponsored research projects to study causes of tower failures, and results have led to important updates of the American Association of State Highway & Transportation Officials (AASHTO) specifications. Additional research is required to correlate life expectancy and inspection results.

**Structural damage**

High-mast towers withstand years of abuse from the environment. Wind continues to fatigue all parts of the structure, from the anchor bolts and base-plate weld to the vertical welds running the full height of the tower. Moisture from condensation along with rain and snow provide perfect conditions for corrosion, especially within slip joints and in the vicinity of welded connections that may continue to harbor residual stresses created during manufacturing.

The Federal Highway Administration (FHWA) classifies high-mast towers as structures, assigning the responsibility for the integrity of these assets to the structural experts within state departments of transportation (DOTs) and other state highway authorities. On the other hand, maintenance and corrective actions are often the duties of highway maintenance or operations sections of transportation agencies. Consequently, high-mast towers fall into a “gray area” of responsibility. The result is that these giant structures somehow slip between the cracks. Coordination of activities and budget considerations often become confused, further frustrating efforts for scheduled inspection.

Many state DOTs have yet to implement a formal inspection program for ancillary structures, including high-mast towers. Since there is no national inspection and reporting standard, there exists no accurate inventory of high-mast light towers in the U.S. State DOTs and highway authorities do perform routine electrical maintenance as required—replacing lamps when they burn out. However, the structural and mechanical maintenance necessary to keep the towers safe and operational is sporadic at best in most operations.

**Up for inspection**

Understanding the condition of towers is central to managing their extended usefulness and minimizing life-cycle costs. Few states with planned inspection cycles for their high-mast towers formally record and track the towers’ condition. Those that do use this data to help plan preventive maintenance efforts, allowing for corrective action in the presence of serious corrosion and cracks.

While bridges must be inspected every two years, there exists no FHWA mandate to inspect these ancillary structures. The FHWA strongly encourages states to implement formal inspection programs and has published a manual with recommended guidelines, “Guidelines for the Installation, Inspection, Maintenance, and Repair of Structural Supports for Highway Signs, Luminaries, and Traffic Signals.” These guidelines recommend a four-year inspection cycle and describe various inspection and maintenance procedures similar to those currently used in bridge inspection. Just as bridge inspection and corrective actions increase safety and extend usage, so too would consistent inspections and maintenance preserve and ensure longer life of high-mast towers.

**Light years behind**

As part of the recommended inspection procedure, FHWA refers to the key areas of examination as CoRE elements, or Commonly Recognized Elements, the same terminology used for bridges. These are areas where deficiencies are likely to occur. The nine points of inspection on high-mast light towers can be divided between the base and the above-grade portions of the tower.

The CoRE elements reachable from ground level include anchor bolts, foundation, base plate, base weld and hand hole. Common areas of high-mast tower failures at the base include anchor bolts cracking, base-plate weld failures and foundation deterioration. Wind pressure at the top of the tower causes an increased moment, or force, at the base that, over time, will deteriorate these CoRE elements. In this situation, the experiment about how many times a paper clip can be bent before it breaks has some relevance.

The current FHWA-recommended inspection of the base area includes a variety of standard nondestructive techniques using readily available instruments and well-documented procedures. Ultrasonic, dye-penetrant and magnetic-particle tests are com-
mon methods that are well accepted as sufficient methods for determining the structural integrity at the base. In addition to inspections, proper structural maintenance procedures, such as tightening the bolts on the anchor rods, are recommended. Many studies have shown that loose anchor bolt nuts can drastically reduce the life of a tower.

The most neglected area of potential damage to the tower’s integrity involves the joints where the sections of the tower slip together. The first slip joint is normally 30 to 35 ft above the ground, and towers often have multiple sections and slip joints. Moisture accumulates at these slip joints, producing corrosion known as “pack rust.” The pack rust places additional pressure on the slip joints, distorting or flaring the joints, a condition that can lead to cracks at the seam weld. As with the deteriorated base components, wind adds further stress and accelerates cracking. Casual observation and scanning of the above-grade tower surface does not guarantee discovery of all irregularities.

The FHWA guidelines recommend that the surface of the tower be visually inspected at “arm’s length.” If an arm’s-length inspection is not practical due to cost or accessibility, the guidelines suggest using binoculars or a spotting scope of at least 10-power magnification. While this type of cursory inspection is better than no inspection at all, the visual distance of the scan makes most structural cracks invisible. The guideline further acknowledges that camera inspection systems may become routinely used as they become available, especially for inspecting tower slip joints.

### Digital surrounding

Advances in technology are creating new, cost-effective methods for obtaining a detailed arm’s-length inspection. MastCheck Inc., a technology company in Columbus, Ohio, has developed an inspection system that remotely ascends the tower and creates a 360° digital inspection of the tower’s surface. These images are archived for historical reference, allowing examination by multiple engineers to provide a consensus opinion on potential structural issues.

The system has inspected more than 500 towers in seven states over the past year. The company reports that significant above-grade deficiencies, such as slip-joint deformation and cracks, were discovered on more than 7% of those towers. Extrapolating that statistic indicates that more than 4,500 high-mast towers can be exhibiting structural problems. These results indicate the safety issues ex-
isting with high-mast light towers are more significant than most tower owners realize. This study also demonstrates the need for more states to adopt detailed inspection and maintenance procedures for high-mast towers.

“By their very nature, high-mast towers are located in high-traffic locations,” stated Peter DallePezze, president and CEO of MastCheck Inc. “Taking measures to ensure these massive structures do not fall into traffic needs to be a higher priority.”

Dan Walsh, of Athavale, Lystad and Associates, used the inspection system for a series of tower inspections in 2008. The firm was tasked with providing an arm’s-length visual inspection of 132 towers on the East Coast. “The system allowed us to provide our customer with a detailed inspection in a safe, cost-effective manner. Without the system, we would have needed to rent a 125-ft boom truck and close a lane of the freeway for the inspections. It would have taken us twice as long and cost a lot more,” reported Walsh.

A Midwest state DOT also used the inspection system to validate a prior inspection performed by a consulting engineer. Using a 30-power spotting scope on a tripod, the engineering firm found what appeared to be a crack on the upper portion of a high-mast tower. The camera system not only refuted the presence of the reported crack, but also detected the presence of a small slip-joint crack that had been overlooked. The originally reported crack was actually revealed to be a skid mark left by the roller wheel of the luminaire ring.

As new inspection technology is introduced to the market, inspections will become more prevalent and cost-efficient. However, the first step in making ancillary structures safer is further understanding the problem. To that end, AASHTO T-12 technical committee (Structural Supports for Signs, Luminaries, and Traffic Signals) is working to create a national database of high-mast tower failures. Safety for the motoring public is core to the charter of our national transportation system. Our country’s infrastructure is aging. We cannot build our way out of the problem, and ignoring the issue or mass replacement of the assets is not the prudent or even a viable path. For high-mast towers, preservation through inspection and active maintenance programs remains the only logical and fiscally responsible solution.

Ward leads Com Synch Ltd., a consulting firm in Lewis Center, Ohio.