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DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES & LIBRARY

TECHNICAL SUMMARY

Technical Liaison:
Jihshya Lin
Jihshya.Lin@state.mn.us

Project Coordinator:
Deb Fick, MnDOT
Deb.Fick@state.mn.us

Principal Investigator:
An Chen, Iowa State University

PROJECT COST:
$145,238

Proper lubrication is one of several critical steps in properly tightening anchor bolts and nuts.

Improved Specifications for Tightening Anchor Bolts on Signs, Luminaires and Traffic Signals

Researchers examined specifications and procedures for tightening anchor bolts on support structures in Minnesota. New specifications and instructions will help crews tighten bolts properly and ensure lasting safety of signs and lights in Minnesota's highway system.

What Was the Need?

In recent years, MnDOT inspection crews have reported loose anchor bolts on many support structures for overhead signs, high-mast light towers, tall traffic signals, and other signs and luminaires. On newly installed structures, many nuts on anchor bolts may loosen in as little as three weeks; on older structures, they may loosen less than two years after retightening.

Federal standards mandate inspections at least once every five years, a requirement that already stretched MnDOT's resources for managing light poles, traffic signals and 2,000-plus overhead signs. With an estimated 20 percent of loose anchor bolts in MnDOT's highway system at any given time, crews would have to inspect structures every year to ensure public safety.

This issue is not unique to Minnesota. In a national survey, some states estimate as many as 60 percent of their anchor bolts may be loose. Minnesota, like other states, tightens anchor bolts according to American Association of State Highway and Transportation Officials (AASHTO) standards. But the standards and procedures for tightening and retightening bolts are insufficient. To develop appropriate specifications, MnDOT needed to know why bolts loosen. The agency also needed improved standards and procedures to ensure that anchor bolts are tightened effectively.

What Was Our Goal?

The goals of this project were to determine why anchor bolts and nuts on sign and luminaire support structures loosen after installation or retightening, and to develop new standards and procedures that ensure proper and lasting tightening of these bolts.

What Did We Do?

Researchers conducted a literature search on anchor bolt loosening. Then they surveyed MnDOT district maintenance staff on bolt lubrication and tightening practices, and visited sites in Minnesota and Iowa to observe installation and retightening practices.

In the laboratory, investigators studied the relationship of torque, rotation and tension of various bolt diameters and material grades. They found that bolt stiffness, grip length (the distance between the nuts at each end of an anchor bolt in a two-nut bolt system), snug-tight standards, lubrication and verification after 48 hours played a role in effective tightening practices.

To determine the impact of environmental and structural strain on bolt tightness, researchers monitored sign structures in the field and in the lab. They attached strain gages to the bolts and post of an overhead sign near Minneapolis-St. Paul and installed a wind monitor, camera and data logging unit nearby to collect strain and environmental data for four months. In the lab, they instrumented a post and baseplate mounted in concrete to compare current and proposed tightening specifications and practices.

continued

"We have revised our specs to follow the recommended procedures for anchor bolt tightening. The new tables of verification torque values will be fine for both two-nut and one-nut anchor bolt systems."

—Jihshya Lin,
Bridge Evaluation and Fabrication Methods Engineer, MnDOT Bridge Office

"AASHTO's snug-tight requirement was vague and not well-defined. It can easily damage small-diameter bolts and might not be enough for large-diameter bolts. The new specs specify snug-tight based on different bolt types."

—An Chen,
Assistant Professor, Iowa State University Department of Civil, Construction and Environmental Engineering

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Research Services & Library
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
651-366-3780
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Researchers attached strain gages to the bolts and the mast of a new overhead sign. Installers followed new procedures and specifications to tighten the bolts so that investigators could evaluate the effectiveness of the new standards.

Investigators developed specifications for each bolt size and grade, anchor baseplate dimension and pole size used by MnDOT based on lab and field results. They also created finite element models to analyze future anchor bolt configurations.

What Did We Learn?

Over- and undertightening contribute to premature loosening of nuts on anchor bolts. While contractors may lack the experience and training to properly use turn-of-nut guidance, AASHTO recommendations poorly serve the bolt sizes and grades used by MnDOT.

AASHTO's snug-tight guidance neglects certain characteristics of nuts and bolts, and its turn-of-nut direction is provided for only two bolt sizes and two bolt grades. In some cases, these standards may cause the heads of small bolts to break off and may lead to undertightening of large bolts. MnDOT can measure torque in the field but cannot determine tension, making AASHTO's equation for verifying torque and tension impractical.

Researchers revised the specifications to require bolt lubrication, establish torque levels for snug-tight and specify turn-of-nut rotation after snug-tight for a range of MnDOT materials:

- Eight bolt sizes, ranging from ¾-inch diameter to 2.5-inch diameter.
- Five bolt grades.
- Nine baseplate thicknesses.
- 12 single- and double-mast pole types.

The new specifications provide torque levels in tables to verify the tightness for each bolt, plate and pole type, eliminating the need to run equations. To assist crews that are installing or retightening anchor bolts, researchers developed guidelines that include a compliance form with a checklist to direct crews through each step of the tightening process and ensure proper tension.

What's Next?

The new specifications and procedures should improve public safety and reduce the traffic control, manpower and equipment expenditures required to respond to prematurely loosened nuts. An implementation project will demonstrate the method in the field. Continued monitoring of bolts installed and retightened under these specifications over time would help evaluate the new procedures.

This Technical Summary pertains to Report 2018-27, "Re-Tightening the Large Anchor Bolts of Support Structures for Signs and Luminaires," published August 2018. The full report can be accessed at mndot.gov/research/reports/2018/201827.pdf.