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DEPARTMENT OF TRANSPORTATION

OFFICE OF RESEARCH & INNOVATION

TECHNICAL SUMMARY

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PROJECT COST:
$175,000

The Skidmore-Wilhelm test apparatus determines the tension of a tightened assembled sample.

Evaluating Improved Specifications for Retightening Anchor Rods on Support Poles

Researchers checked the effectiveness of revised specifications used to tighten anchor rods on sign and signal support poles that were developed in Phase I of this project. Field data showed good performance, and lab testing supported the changes. The new specifications will be adopted agencywide.

What Was the Need?

MnDOT maintains poles supporting lights, traffic signals and more than 2,000 overhead signs in Minnesota's highway system. Federal standards require that these tall, anchored pole installations be inspected at least once every five years, but MnDOT learned that on newly installed poles, nuts on the anchor rods could loosen in as little as three weeks. On older structures, the nuts could loosen on anchor rods as soon as two years after retightening.

At any time, as many as 20% of the anchoring connectors on traffic signal, sign and luminaire structures across the state could be loose. The failure of light and sign pole anchors could result in heavy structures falling into active traffic. Further, anchor rod looseness could shorten the normal service life of a structure.

Like most other state transportation agencies, MnDOT follows American Association of State Highway and Transportation Officials' (AASHTO's) specifications for tightening anchor rods in these installations. After a previous project examined whether AASHTO's specifications were sufficient, MnDOT developed new, more comprehensive and effective tightening specifications.

In the second phase of the study, MnDOT wanted to check the efficacy of the new specifications developed in Phase I and revise them if needed. Researchers closely examined the results of MnDOT and contract crews using the new rod tightening specifications in the field, investigated performance differences between new and old specifications, and measured the effects.

What Was Our Goal?

The goal of Phase II was to effectively revise the anchor rod tightening procedures to increase the construction assurance and quality of anchor rod tightness for highway signs, traffic signals and luminaires. The overall goal was to assure the adequate initial installation during construction and decrease the time and cost of additional inspections and maintenance work for the agency.

What Did We Do?

In Phase I, researchers developed new procedures after conducting a literature review, site visits and laboratory testing, and then monitoring strain gauges and the device on one cantilevered sign structure and its anchor rods. They revised the existing specifications to include procedures for more rod types, grades and baseplate thicknesses, and changed torque, turn-of-nut verification and lubrication methods. Extensive tables were provided to verify tightness for each rod, plate and pole type. The revised specifications were released to MnDOT staff and others to be implemented in the field.

In Phase II, the research team examined and evaluated the effectiveness of the revised specifications over two years using several different approaches.

continued

"Results from this project have greatly improved the anchor rod tightening procedures with more efficient and effective methods that save time, reduce inspection frequency, significantly improve safety, reduce cost and ease maintenance workloads."

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

"Our research provided a better understanding of the mechanics of anchor rods and methods for ensuring correct tension, which reduces metal fatigue and structural failure. Increasing public safety is one meaningful result of this study."

—Brent Phares,
Associate Research Professor, Iowa State University Institute for Transportation

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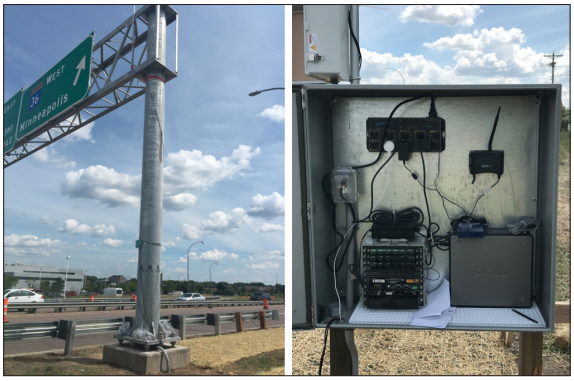

A large cantilevered highway sign on a tall post installation (far left) was instrumented to gather strain/wind-load data from the anchor rods in the base. A data logging box (left) contained and protected the data-collecting equipment.

Stakeholders and field inspectors were interviewed to gather feedback on the revised procedures, with assessments from maintenance and bridge staff who service overhead signs; overhead sign and lighting construction inspectors; and a hydraulic wrench manufacturer. In addition, the research team made site visits to six overhead sign support structures that had been installed according to the new procedures.

In the lab, researchers evaluated different tightening aspects of the protocols by investigating metal strain and fatigue. They tested the behavior of single anchor rods under stresses and the laboratory post structure as a whole using data gathered from an instrumented overhead sign structure in the field. Researchers conducted numerous Skidmore tests to determine rod pretension levels versus different grip lengths for different rod sizes attained through the revised specifications. Using finite element modeling, researchers closely examined where stresses manifested in anchor rods under load.

Finally, the research team developed an anchor rod tightening handbook along with field inspection forms that contractors and MnDOT inspectors can use to verify the execution of all steps. These materials can be used in the field, easily revised and added to other relevant construction aids available on MnDOT's website.

What Was the Result?

After reviewing all data, researchers concluded that anchor rod looseness was likely caused by installation procedures. Surveyed staff described the existing AASHTO guidelines as incomplete and lacking clarity. To increase clarity, researchers recommended separating specifications into two groups: overhead signs and lighting/traffic signals. The anchor bases on these structures differed, and separate specifications allowed for closer focus on specific aspects of each type.

Because installation procedures differ considerably from maintenance procedures, researchers suggested that MnDOT would benefit from a new set of maintenance procedures for these structures. Clear specifications for lubrication were also recommended, including lubricant type and placement, with instructive graphics.

Researchers found that pretightening procedures for all structures could be effectively covered in a simple seven-step process. The team noted that even though this process is shorter than the AASHTO guidelines, the steps would result in greater accuracy for the final connection across all structures, increase efficiency in the field and be communicated better among workers.

What's Next?

The anchor rod tightening procedures resulting from this study combine theory, extensive empirical testing and field implementation. The revised specifications provide an effective example of a solution to a nationwide challenge.

This Technical Summary pertains to Report 2021-23, "Re-Tightening the Large Anchor Bolts of Support Structures for Signs and Luminaires: Phase II," published October 2021. The full report can be accessed at mndot.gov/research/reports/2021/202123.pdf.