SIGN STRUCTURE BOLT TESTING AND INSPECTION!
WHAT HAVE WE FOUND AND WHAT ARE WE DOING...

Maryland State Highway Administration
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The Golden Anniversary of the Mid-Atlantic Quality Assurance Workshop
February 8, 2017
NEWS FLASH

904 OVER HEAD STRUCTURES IN INVENTORY
14,829 ANCHOR BOLTS TESTED
7 STRUCTURES REMOVED DUE TO CRACK LIKE INDICATIONS

1127 CANTILEVER STRUCTURES IN INVENTORY
8,216 ANCHOR BOLTS TESTED
1 STRUCTURE REMOVED DUE TO CRACK LIKE INDICATIONS
8 STRUCTURES HAVE SPLICE BOLTS (MECHANICAL)
2 WELDED NOT FULL PENETRATION WELDS

5 YEAR CYCLE COMPLETED IN 2016 WILL RESTART IN FY 18

FIRST CYCLE TOOK 5 YEARS BUT 2ND CYCLE MAY RESULT AS MUCH AS A 50% TIME SAVINGS DUE TO NOT HAVING TO SPEND AS MUCH TIME PREPPING THE BOLT TOPS. (GRINDING SMOOTH)
NEWS FLASH

AT THE PRESENT TIME SIGNAL POLES ARE BEING INSPECTED. THIS INCLUDES ANCHOR BOLTS AND ARM CONNECTION BOLTS.

1688 POLES
1292 ARMS
6792 ANCHOR BOLTS
5162 CONNECTION BOLTS

INSPECTIONS OF SIGNAL POLES HAVE RESULTED IN LOCATING DAMAGE THAT MAY HAVE NEVER BEEN REPORTED.
WHAT ELSE DID WE FIND

~10% of all bolts are loose.

SHA AND WAGNALLS

Loose anchor bolt. The ability of one or more washers to be moved under the nuts with little or no effort.
WHAT DID WE FIND
Project Inspector “Well they were tight when we looked at them yesterday. Must have relaxed over night or they vibrated loose.”
HOW DID THIS HAPPEN?

#1 Priority Fix the Loose Bolts & Install ALL NEW Structures Properly.
WHAT ARE THE REQUIREMENTS / RECOMMENDATIONS

FHWA Guidelines recommend tightening the anchor bolts and nuts using the “turn on the nut method” after being brought to a SNUG TIGHT condition.

<table>
<thead>
<tr>
<th>Bolt Dim</th>
<th>ASTM Bolt F1554</th>
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</thead>
<tbody>
<tr>
<td>Gr36</td>
<td>Gr55</td>
</tr>
<tr>
<td>Less Than 1 1/2&quot;</td>
<td>1/6 turn</td>
</tr>
<tr>
<td>1 1/2&quot; and Larger</td>
<td>1/12 turn</td>
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</table>

This table should only be used with double nut moment joints.
2.4.9 Pretensioned Anchor Bolts

As noted in Section 2.4.2, pretensioned anchor bolts are not widely used by state transportation agencies. The literature review did not uncover any references on the design or performance of pretensioned anchor bolts for support structure foundations. The ultimate strength of the anchor bolt in tension is not affected by pretensioning.

However, for designs where fatigue is an important consideration, pretensioning may offer a benefit by reducing the vibration of the structure and reducing the stress range in the anchor bolt. For these designs, use of lower-yield point ductile steel combined with pretensioning may provide better fatigue performance. However, this better fatigue performance needs to be verified through experimental research.
SNUG TIGHT OR FULLY TIGHTENED ???

Of course, whenever practical, anchor rods should be installed in the fully tightened condition (i.e., tightened to one-third of a turn beyond snug for most anchor rod sizes). Although no benefit is recommended when designing fully tightened anchor rods for infinite life, it should be noted that the fully tightened condition precludes the possibility of anchor rod nuts becoming loose under service-load conditions.

As a result, the fully tightened condition is inherently better with respect to the fatigue performance of anchor rods. Large-diameter rods will require the use of a hydraulic wrench with external lubrication of the threaded and bearing surfaces in order to achieve a fully tightened condition.

NCHRP Report 469 Fatigue-Resistant Design of Cantilevered Signal, Sign and Light Supports.
5.17.5.2 – Anchor bolt Pre-tensioning

All anchor bolts shall be adequately tightened to prevent loosening of nuts and to reduce the susceptibility of fatigue damage. **Anchor bolts in double-nut connection shall be pre-tensioned**…

C 5.17.5.2

...Lubrication of the threaded and bearing surfaces is typically performed prior to Tightening. In double-nut connections, lower nuts/washers should be in full contact with the base plate prior to snug tightening the top nuts. After top nuts are snug-tight, the lower nuts should be retightened to assure the full contact has been maintained.
SO HOW MUCH IS REQUIRED

Anchor Bolt Tightening for Highmast Light Towers and Cantilever Sign Structures
Collins Engineering, Inc. July 30, 2010  (TRB 2011)

<table>
<thead>
<tr>
<th>Bolt Size</th>
<th>TPI</th>
<th>Area (\text{inch}^2)</th>
<th>Thread Area (\text{inch}^2)</th>
<th>GR 36 (F_u) PSI</th>
<th>GR 55 (F_u) PSI</th>
<th>GR 105 (F_u) PSI</th>
<th>Snug PSI</th>
<th>50% PSI</th>
<th>60% PSI</th>
<th>Snug Torque Value Ft/Lbs*</th>
<th>Torque Value Ft/Lbs*</th>
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<tr>
<td>1 1/2</td>
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<td>132000</td>
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<td>6600</td>
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<td>990</td>
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*Anchor Rod Tightening for Highmast Light Towers and Cantilever Sign Structures
Collins Engineering, Inc. July 30, 2010  (TRB 2011)
SO HOW MUCH IS REQUIRED?

The torque requirements are based on new and well lubricated anchor rod threads and nuts. The NCHRO 469 report recommends that new installations have rod tightness rechecked after two days using a verification torque of 110%...

Apparently, the reason for this check is possible connection loosening due to deformation or creep of the galvanizing within the threads.¹

¹Anchor Rod Tightening for Highmast Light Towers and Cantilever Sign Structures Collins Engineering, Inc. July 30, 2010 (TRB 2011)
SO HOW MUCH IS REQUIRED?

SHA/OMT performed limited load cell tests in 2016 using 2 ¼” HDG Studs that showed the torque values were not achievable with hand tools or slugging wrenches.

The tests also showed a small relaxing or compression of the zinc after being tensioned. ~2% and resulted in less than 30 mins.

One sample was left for over 48 hours and showed no creep after the first 30mins.

Our Feeling, if it is not tight now it never was tight.
MARYLAND’S APPROACH

New Special Provision has been written to require the use of Hydraulic Wrenches for all NEW installations on Traffic Structures.

Calibration will be required on all units no less than Once a Year

OMT in process of ordering new Load Cell Units up to 3” bolt diameter.

Bolt diameters are being restricted in design to standard limited sizes 2” 2½” 3”

OOTS and or OMT personnel will be on site during tightening evaluations.

TRAINING TRAINING and more TRAINING !
MARYLAND’S APPROACH

- Loose Bolts being re-tightened under OOTS Contract.
- Use of Slugging Wrench
- 10 Structures are being selected to use the hydraulic wrench system.
- Value will be based on grade 36 bolts and the thread area. Due to we don’t have a 100% guarantee of what bolts was used.
- 100% UT before, after and 90 days after re-tightening.
MARYLAND’S APPROACH

Top nuts will be removed, cleaned, and relubricated before being re-tightened.

Lower (Leveling) nuts will be brought into full contact before re-tightening of top nuts.

Tension will be based on Gr 36* bolts and 50% of $F_u$.

*Based on not knowing what bolts are in the foundations.
MARYLAND’S APPROACH

Hydraulic Equipment
MARYLAND’S APPROACH

- Equipment for “Small Bolts”
- 36Volt Can install 1” plus A325 bolts to proper tension
- Repeatability
- End of Day Reports
CONCLUSION

Loose anchor bolts can reduce the life span of cantilever and single structures.

Ongoing training for personnel tightening and inspecting the operation is a high priority.

Oversight inspection of anchor bolt tightening is required.

NEXT STEPS

TRB 2017 Traffic Signal Sub-Committee agreed to submit a new problem statement to look at the true pre load requirements.

Maryland SHA, VA Research Counsel and VDOT have agreed to performing laboratory testing of real time samples during 2017 that will include vibration testing.
QUESTIONS