ANCHOR ROD TIGHTENING REQUIREMENTS

Tightening requirements of double-nut anchor rod connections, connections using bottom nuts (leveling nuts) and top nuts to clamp signal and light poles are presented in this chapter. Consult with the MnDOT Anchor Rod Tightening Handbook for additional information.

Refer to Chapter 17 Signal and Light Poles for tightening requirements of single nut anchor rod connections and structural bolting (bolts).

18.1 Anchor Rod Tightening

18.1.1 BASIC CONCEPTS OF ANCHOR ROD TIGHTENING

Double-Nut Connection

MnDOT requires two types of anchor rod connections, single nut connection and a double nut connection. The anchor rod connection type used depends on the pole structure, based on the pole design and in some cases how the pole was tested during breakaway testing evaluation.

Contractors must know which type of anchor rod connection to use that is required by the pole manufacturer. If it is unclear which anchor rod connection type is required for the pole, then consult with the pole manufacturer or refer to contract documents.

The anchor rod connection type covered in this chapter is the double-nut connection, which means the baseplate of the pole is clamped or sandwiched between two nuts, a top nut and a bottom nut (leveling nut) as shown in Figure 18-2 Double-Nut Connection. The MnDOT Anchor Rod Tightening Handbook applies to double-nut anchor rod connections only. For tightening information on single nut connections and structural bolts refer to Chapter 17 Signal and Light Poles.

Concerns with Anchor Rod Connections

MnDOT has a wide variety of Sign, Luminaire, and Traffic Signal Structures (SLTS), anywhere from 50 ft-lbs to 6,000 ft-lbs of torque is required to properly tighten the anchor rods. Previous tightening procedures resulted in anchor rods coming loose for a variety of structures and resulted in a decreased lifespan for the structures. In addition, having to re-tighten loose anchor rod connections on structures that were tightened at initial installation imposed a significant drain on MnDOT resources. Old procedures were also difficult to perform for lighting structures and ones with enclosed bases. Finally, the connections on SLTS structures can have a large error in the final clamp force if improper procedures are used.
**Torque Controlled Tightening Method**

It’s important to control the amount of torque on anchor rods to make sure they perform well over the long-term. Too little torque and the nuts shake loose on the anchor rods. Too much torque and the anchor rod can stretch too much and break. Anchor rod failures from increased loads was shown to be a danger to the traveling public in the 1990s. Properly tightened nuts can help increase the life of the structure and avoid dangerous failures.

To help understand why it is crucial to properly tighten anchor rods at initial installation, a basic understanding of anchor rod behavior is necessary. Turning/tightening the nut against the base plate stretches (pulls) the anchor rod like a stiff spring creating an opposite force that acts as a clamp. That clamp force is what holds the structure to the anchor rods and foundation. Like a stiff spring, stretch it very little (under-tighten) there’s not a much opposing force so over time the pole anchorages shake or vibrate loose. Stretch it too much (overtighten) the spring (anchor rod) loses its elasticity, the opposing force (clamp force) is then lost and the pole anchorages come loose.

Based on Iowa State University Institute of Transportation research, tightening anchor rods to a point, that is sufficient to prevent loosening but not beyond the limit that will cause yielding, known as “the sweet spot”, is the best way to prevent anchor rod connections from coming loose. Therefore, MnDOT requires using torque controlled tightening method to prevent anchor rod connections from coming loose. Using the specified torque values and calibrated torque wrenches is an accurate application to properly tighten anchor rods. Torque controlled tightening ensures that each anchor rod for the structure has been consistently tightened to the same torque value. Again, properly tightened anchor rods are the best way to prevent loosening of anchor rod connections over any other type of tightening method or method to prevent loosening.

**Other Methods to Prevent Loosening**

There are many different methods for preventing bolts from coming loose, and most, if not all, were investigated for SLTS structures. Many of these solutions work very well for other types of connections. However, for SLTS structures anchor rods it is more effective to properly torque the nuts to get the right clamp force in the connections. The following are some of the traditional nutlocking methods used for bolts. **DO NOT USE** these methods on signal and light pole anchor rods unless specified in MnDOT contract documents.

**Lock Washers**

Lock washers of almost all types prevent mostly sliding or rotational loosening of the nuts. For SLTS structures most clamp loss comes from relaxation. The major forces come from temperature changes and a push-pull force from the pole. There is some sliding force, but not near as much as the other forces. Lock washers can damage the protective galvanizing on many structures,
leading to unwanted rust and corrosion. Finally, the installation of some lock washers requires correct placement, which if done incorrectly can impact the connection negatively.

Threadlocker
Thread locking substances of many types were also investigated. The major issue with thread locker was servicing structures with it. In many cases, light poles need to be replaced if struck by a vehicle and have specially designed bases to do so. Thread locker would make the nuts more difficult to remove in service. In addition, thread locking substances have different tightening properties than the MnDOT specified anti-seize lubricant compound. Finally, like the lock washers, connections generally don’t loosen by nut turning, so the thread locking substances likely would not significantly minimize loosening.

Mechanical
Mechanical methods of nut locking such as welding in place, cotter pins, safety wires, and more were explored. Many of the methods involved damage to the structure that wasn’t desired or overly complex installations. Finally, like the other two methods, all the mechanical methods are to prevent loosening from sliding and not push-pull forces.

DTI Washers
Direct Tensile Indicating (DTI) washers are not permitted for use with signal and light poles anchor rod connections. DTIs were investigated and found to be insufficient for properly tightening the anchor rods on all structures. Direct Tension Indicators are special washers with protrusions on one face which compresses when a bolt is tightened. One type of DTI requires the use of a feeler gauge to verify proper tightening. This type of DTI requires training on proper procedures and use for both the contractor and the inspector, which can place a significant drain on Construction resources. In addition, the clearances and design limitations of the high base and transformer base for signal and lighting structures limits the accessibility of the feeler gauge type DTIs. Another type of DTI (Squirter DTI) when compressed to the specified pre-tension, will release a colored polymer. Although the squirter type DTIs make it easier for both the contractors installing and the inspectors having to do inspections, this type of DTI washer is produced for structural steel bolts, not for anchor rods.

Jam Nuts
As a final note on methods to prevent loosening of anchor rods, MnDOT no longer requires the use of jam nuts for anchor rod connections. Jam nuts were typically used on anchor rod connections for barrier light poles to prevent the top nuts from coming loose.
**TCT Advantage and Disadvantage**

The advantage to torque controlled tightening (TCT) is it provides a consistent and precise torque for each anchor rod. This will allow the anchor rods to carry an even load at the end of the tightening process. This is not possible with other tightening methods.

However, torque controlled tightening is more than just applying torque values using torque wrenches. The disadvantage to torque controlled tightening is; if any one of these specific tasks listed are not employed with torque controlled tightening and corners are cut, then anchor rods risk being improperly tightened. Don’t cut corners. Successful torque controlled tightening depends on implementing the following tasks.

- Placing a wrench on the leveling nuts
- Using the right wrenches for tightening anchor rods on the job
- Using calibrated torque wrenches
- Applying lubricant and to the right areas (friction points) of the connection
- Tightening anchor rods in a cross-tightening pattern
- Tightening in three rounds of 20%, 60% and 100% of the required torque value
- Allowing the anchor rods to relax for 10 minutes after tightening
- Re-tightening to 100% torque after allowing the anchor rods to relax

**Placing A Wrench on The Leveling Nuts**

For double nut connections and torque controlled tightening, placing a wrench on the leveling nuts after turning down the top nuts by hand is a must. The reason is the pole installer cannot ensure that all the leveling nuts are in full contact with the bottom washers and baseplate without ever having to put a wrench on the leveling nuts. The leveling nuts must bear tightly against the bottom washer and base plate.

*Why?* Even though a carpenter’s level is placed on the leveling nuts before setting the pole, the bottom of the pole base plate may not sit perfectly flat on every leveling nut in the group. One reason for this is leveling the bottom (leveling) nuts is not precise. The other is pole base plates are not perfectly flat. Deformation may occur with the base plate that would prevent it from sitting perfectly flat on all the leveling nuts in the group. If any of the leveling nuts are loose or there is space between the leveling nuts and base plate.
plate, then when final tightening of the top nuts is executed, the baseplate won’t be properly clamped. Instead, the baseplate will deflect, or the pole will be “pulled” downward creating additional stresses on the adjacent anchor rods and uneven forces that could potentially damage the pole base. The purpose of placing a wrench on the leveling nuts, after hand tightening the top nuts, is to remove any space between the leveling nuts and base plate by bringing the leveling nuts up tight against the bottom of the base plate. It is not done to tighten the anchor rods; hence the reason for specified lengths in Table 2545-1 of the Anchor Rod Tightening Handbook. Restricting wrench length, thereby controlling leverage (force) used to turn the leveling nuts.

An installed pole with leveling nuts that cannot be accessed with a wrench is a telltale for construction inspectors that the pole has not been installed according to contract documents. Don’t cut corners. If a wrench cannot access the level nuts, then adjust the leveling nuts standoff distance accordingly.

**Wrenches Used for Torque Controlled Tightening**

Manual “click type” torque wrenches do work inside the stainless steel light pole bases for both Design E and Design H and other high base designs such as galvanized steel barrier poles. The installer can generate enough force using the click type torque wrench to meet the required torque values for Grade 55 anchor rods with diameters of 1 ½ inches and less. For Grade 105 anchors with diameter 1 ¾ inches and greater used traffic signal mast arm poles and high mast light towers, it is unlikely that the installer can generate enough force using a manual torque wrench to meet the specified torque values, let alone consistently. Therefore, hydraulic torque wrenches are required to tighten the 2 inch diameter Grade 105 anchor rods for PA traffic signal poles and high mast light towers. The required hydraulic torque wrenches must be a low profile design, to fit in tight spaces such as inside transformer bases and high bases.

Because specified torque values are required for anchor rod tightening, the torque wrenches used must be accurate. One of the problems encountered with any tool or instrument that is calibrated to a specific standard is that it may go out of calibration due to frequent use or misuse. Documentation showing when the torque wrench was calibrated is required to be submitted to the Engineer before using on the project in accordance with 2565.3 “Calibration Requirements for Measurement Tools and Test Equipment.” In addition, torque wrenches are required to be calibrated annually.
**Applying Anti-Seize Lubricant**

Apply lubricant at the time directed and not before then. The reason is to ensure only those specified parts of the anchor rod connection shown in the green area are lubricated and nowhere else. Lubricant should only be applied to upper portion of threads on the anchor rods, the threads of the top nuts, the face of the top nuts, and the top face of the top washers. Do not apply lubricant anywhere else on the anchor rod connection. Placing lubricant to the entire anchor rod connection point could cause the base to slide in the final clamped connection causing the connection to come loose. Therefore, lubricant should only be used where final torque tightening is done.

Use the MnDOT approved lubricant listed on MnDOT’s APL for Lighting. The current approved lubricant is called ECK and is listed under Lighting products as “Electrolytic Corrosion Inhibitor Lubricant”. Eck is a lubricant that is also a corrosive inhibitor to be employed when dissimilar metals are used together. MnDOT is finding a faster rate of dissimilar metals corrosion with stainless steel light poles and galvanized steel anchor rods. To slow down this corrosion caused from dissimilar metals, MnDOT is exploring other alternatives to help mitigate the dissimilar metals corrosion issue. Eck lubricant can be used with all anchor rod connections and poles. Refer to the special provisions for the project to see if Eck is required. The other approved anti-seize lubricant listed on MnDOT’s APL for Bridge products is Bostick Never-Seez, also called “Bridge Grease”.

Torque can be adversely affected by an opposing force that results from resistant surfaces in an anchor rod joint when two surfaces in contact move. For example, the face of the top nut that turns into the face of the washer or the threads of the top nuts turned on the threads of the rods. This opposing force is called friction and the resistant surfaces are known as friction points. Applying lubricant to the friction points in the anchor rod joint significantly reduces the friction. In this case applying lubricant to the face of the nut that turns into the face of the top washer, and the threads of the top nuts and upper portion of the anchor rods.

Torque value readings from a torque wrench are not reliable if lubricant is not applied to those friction points. Just because an anchor rod connection was tightened to a specific torque value, doesn’t mean it is tight if friction was not removed or at least reduced. Since torque values and torque wrenches are now specified in the new anchor rod tightening requirements, lubricant plays a crucial role with accuracy of torque controlled tightening. Don’t cut corners. Use a MnDOT approved anti-seize lubricant when directed and only on the specified areas of anchor.
Anchor Rod Tightening

rod connections as shown in the *MnDOT Anchor Rod Tightening Handbook*.

**Tightening Using A Cross Tightening Pattern**

Cross tightening, not to be confused with cross-threading, is done to prevent uneven forces, and wedging of the base plate. Whenever directed to tighten, whether it be hand tighten, turning the leveling nuts, the 20%, 60% and 100% final torque tightening passes, or the re-torque tightening, automatically think cross tightening. The cross tightening pattern used is determined by the number of anchor rods and numbered in the order that they should be tightened. The *MnDOT Anchor Rod Tightening Handbook* provides cross tightening patterns of many foundation anchor rod clusters commonly used for MnDOT structures.

**Tighten in Three Passes (20%, 60%, 100%)**

When directed to do final tightening of the top nuts make sure to implement the required three passes of 20%, 60% and 100% of the torque value, respectively. The Anchor Rod Tightening Handbook has broken down the torque values to use for each pass according to structure type on the Anchor Rod Pretensioning Table. Include the cross tightening into each pass.

Why is it important to tighten the top nuts in three passes? Because anchor rods cannot be tightened simultaneously, tightening needs to be done in passes to spread the load evenly. By loading an anchor rod immediately to 100% torque, it will have a negative effect on structures base plate and adjacent anchor rods. This is called point load. Point load can cause structural failure and additional stresses on the adjacent anchor rods. To avoid this, and to ensure consistent tightening for each anchor rod, tightening in passes provides a uniform load which is spread evenly throughout and ensures that the anchor rods will carry an even load at the end of the tightening process. Again, cross tightening in conjunction with the implementation of the three passes is critical to spreading the load evenly to each anchor rod connection within the pole.

**Relax Anchor Rods, Then Re-Tighten**

Anchor rod connection surfaces are a little rough. During tightening the higher rough parts are crushed and the galvanized coating can slip. Research found that by letting the anchor rods relax for just 10 minutes, it was enough time allowed for the initial crushing and any slippage due to catch up with the tightening force. Past retightening requirements were typically after 48 hours.

Retightening to the 100% torque has been shown to decrease the overall amount of relaxation clamp over the lifespan of the anchor rod connection. If the connections aren’t retightened,
they can lose around half of the applied clamping force over their life. Again, any time directed to tighten, make sure to cross tighten.

**How Are Torque Values Determined**

Factors that determine how much torque value to assign to MnDOT pole structures are;

- Anchor rod diameter
- Anchor rod grade
- Grip length

The smaller the anchor rod diameter the easier it is to tighten or stretch. Same with anchor rod grade. Grade 36 is a very soft material and easy to stretch. Grade 55 is not as easy to stretch as Grade 36 but is typically what is preferred to use as it provides a good clamp force. Grade 105 is very difficult to stretch like a very stiff spring. That’s why the torque requirements are much higher than Grade 36 or Grade 55 with similar diameters.

Grip length is the material between the top nuts and bottom nuts. The turn of nut method for tightening, that was once the required tightening method for MnDOT anchor rod connections, is for structural bolts with thick grip lengths of 3 inches or more. Grip lengths for signal and light poles are minimal. Typically, less than 2 inches thick. For stainless steel light pole for example, grip lengths are less than 1 inch thick.

### 18.2 Anchor Rod Tightening Requirements

**18.2.1 7 STEP TORQUE CONTROLLED TIGHTENING PROCEDURE**

Special provisions for the project will require the 7 step torque controlled tightening procedure found in the “New Installation Procedures” section of the *MnDOT Anchor Rod Tightening Handbook*.

**18.2.2 ANCHOR ROD TIGHTENING FORM**

After completing the 7 step torque controlled tightening procedure in the *MnDOT Anchor Rod Tightening Handbook*, an anchor rod tightening form is required to be filled out for each traffic signal mast arm pole and high mast light tower. For light poles, the form will be required to be filled out at a rate of one form per every 15 light poles with a minimum of one completed form per project. Submit completed forms to the Engineer. A copy of the Anchor Rod Tightening Form will be included in the special provision for the project.
18.3 Chapter 18 Resources

- MnDOT Anchor Rod Tightening Handbook (pdf)
- MnDOT Anchor Rod Tightening Form – For Traffic Signal and Light Poles (pdf)