Structural Bolt Tightening Methods Checklist

The Research Council on Structural Connections (RCSC) currently recognizes four approved ways to control the tightness of structural bolts in a production environment. They are:

1. Turn-of-nut method;
2. Calibrated wrench method;
3. Direct tension indicator method; and
4. Twist-off bolt method.

Below is a checklist of information on all four of these methods.

Note that some specifications described in the following content may not be the same as the specifications followed by your agency. Always check with your State agency's standards and specifications when using these guidelines.

Sections

Turn-of-nut Method

- ❑ **Accurate and common bolting method**
- ❑ **Works on the theory that since bolts act as springs, by knowing the number of threads per inch on a bolt and the angle of turn of a nut, we can determine how far that bolt is being stretched**
  - — Because we know how much force it takes to stretch steel for that distance, we know how much pre-tension we are creating in the joint with that bolt

- Since longer bolts stretch more, we also take bolt length into account

- **Always snug-tighten the joint eliminating gaps before applying the additional turn to the nuts**
- **Remember to close all gaps in the joint and keep the bolt from turning as the nut turns**
- **The nut or head rotation specified in the table should be applied to all fastener assemblies in the joint, progressing systematically from the most rigid part of the joint, usually from the center outward**
- **Advantages:**
  - Does not require calibrated tools
  - Does not depend on friction or lubrication
  - Simple, intuitive, and repeatable
- **Disadvantages:**
  - All gaps must be closed before tightening starts; only steel plies can be inside the joint because softer materials can compress under the pressure
  - The bolt head, or the back nut if you are tightening the bolt, must not turn—if it does, all of your angle of turn measurement is lost
  - Usually this means that there must be two people involved, one to turn the nut and another to hold the bolt
  - Success depends on the assembler paying attention and meeting his marks
  - In critical applications, the engineer may require a pre-installation verification test in a Skidmore to make sure that the appropriate loads are being generated

Calibrated Wrench Method

- **Involves using a known torque applied to the bolt to obtain a required pre-tension**
- **When this method is employed to measure tightness, published torque-tension tables or formulas must not be used**

- Instead, verify the torque-to-load relationship by means of a load cell with a pre-installation verification test

- **The purpose of a pre-installation verification test is to determine the actual amount of torque required to achieve a desired pre-tension bolt load for a given lot of bolts**
- **This is necessary because many things can change how easy it is to turn the nut or bolt, and those changing conditions can make a huge difference in the achieved pre-tension**
- **The pre-tightening verification of torque must be repeated and a new value established:**
  - Daily
  - When the lot of any component of the fastener assembly is changed
  - When the lot of any component of the fastener assembly is re-lubricated
  - When significant differences are noted in the surface condition of the bolt threads, nuts, or washers
  - When the tool or any major component of the tightening tool is changed
- **Calibrated torque can only be performed by precision tools that measure their output in a repeatable way. Such tools may include:**
  - Manual torque wrenches
  - Hydraulic torque tools
  - Pneumatic multipliers
  - Electric programmable wrenches
  - A battery powered digital unit that can accurately deliver torque or can perform self-limiting torque and angle tightening
- **Calibrated tightening cannot be performed using air impact wrenches**
- **Advantages:**
  - Self-limiting because the tool stalls at the appropriate torque
  - Faster and less operator dependent than other methods
  - Equal torque gives equal load

- Simple, intuitive, and repeatable

- **Disadvantages:**
  - Depends on knowing the friction and anything that changes the friction condition will change the torque-tension relationship
  - Requires recalibration at least daily and when anything significant changes
  - Can require a second person or at least a special backup fixture to hold the bolt head or the opposite nut
  - Recalibration takes time

Direct Tension Indicator Method

- **Direct tension indicators (DTIs) are washers with raised protrusions on one side that crush at a fixed pre-load to indicate when proper pre-tension is achieved**
- **DTIs provide a quick method of verifying proper tensioning**
- **Typically the DTIs will be marked with:**
  - The grade of bolt the DTI must be paired with (such as 325 or 490)
  - The manufacturer's mark
  - A production lot number for identification
- **For each bolt diameter and grade, the DTI may have a different number of raised protrusions**
- **In order to test whether there has been sufficient bolt tension to compress the washer, a feeler gauge should be inserted into the gaps between the DTI bumps**
- **AASHTO guidelines state that when the DTI washer is properly compressed, a 0.005 in. feeler gauge must not be able to be inserted in at least half the gaps between the bumps**
- **Some proprietary DTIs have a silicone-like material that squirts out when the bump on the washer is compressed, giving a visual indication that the bolt has been properly tightened**
- **Audit checks with a feeler gauge are recommended just to be sure**

- ❑ **After tensioning, the number of refusals of the 0.005 in. between gaps should be at a minimum**
- ❑ **DTI should be placed under the fixed element**
- ❑ **Do not place the DTI against the joint because most joint materials are not hardened and this could give inconsistent and wrong results**
- ❑ **The bumps of the DTI should never face the joint**
- ❑ **All bolts shall be pre-tensioned, progressing systematically in a manner that will reduce the potential for relaxation**
- ❑ **The installer should verify that the DTI protrusions have been compressed to a gap that is less than the job inspection gap**
- ❑ **Advantages:**
  - — I**ndependent of tor**que and friction concerns
  - — Measures **load directly and consistently**
  - — **Squirt washers giv**e visible indication of tension
- ❑ **Disadvantages:**
  - — "Crosstalk", or interaction between the bolts, can give false tension readings when one bolt loosens another that was previously tightened
  - — Requires operator measurement and interpretation of results
  - — Does not reveal overtightening
  - — Sensitive to the squareness of the joint and washer

Twist-off Bolt Method

- ❑ **Twist–off bolts are becoming more common**
- ❑ **Referred to as torque-control, or TC, bolts**
- ❑ **Enable an inspector to rapidly determine the installation status of bolts**
- ❑ **This method is a torque control method with the same conditions as the torque wrench; however, the torque control is within the fastener**

- **Twist-off bolts are designed to break of the spline when achieving the proper pre-tension**
- **It is important to snug-tighten prior to completing the tensioning operation**
- **It is important to keep the TC bolts clean and lubricated as they were when tested**
- **Advantages:**
  - Self-limiting without requiring operator to stop the tool or measure any gaps
  - There's no torsion applied to the bolt head so no backup is needed
- **Disadvantages:**
  - "Crosstalk" can give false tension readings when one bolt loosens a previously tightened one
  - Measures torque, not load directly
  - Sensitive to friction and lubrication factors and can give false load readings