by Laurence Claus

Tension Control Bolts

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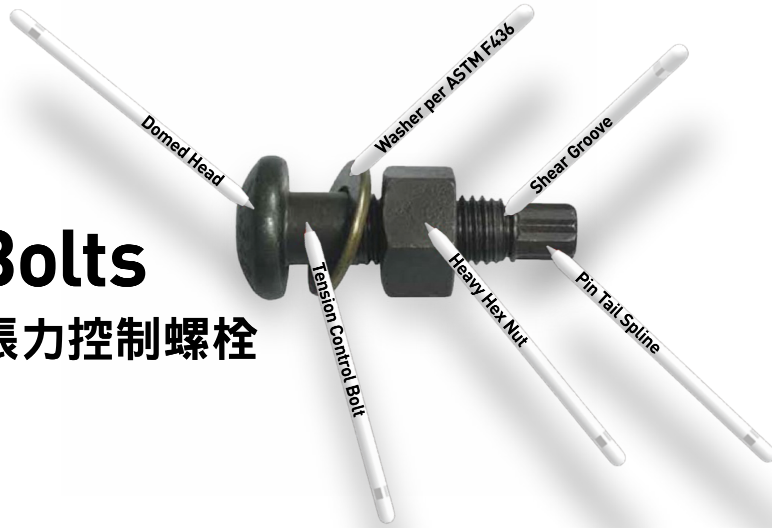

Figure 1: Anatomy of a Tension Control Bolt

Foreword

My friend, John Obrien, is the owner of Skidmore Wilhelm of Solon Ohio. Skidmore Wilhelm is an iconic name in the global fastener industry because they are the preeminent developers of the Skidmore testing device, a testing apparatus that you will find on nearly every major structural steel construction project. The Skidmore is a simple to use hydraulic load cell that steel erectors use at the beginning of each shift to validate the torque tension behavior of the structural bolting assemblies they will be using during that shift.

I often have John make a guest appearance in some of the classes that I conduct when I discuss the subject of torque tension. John has been all over the United States helping construction crews troubleshoot problems, so that he has some very interesting stories he likes to tell. One of my favorites is about a call he received from a construction foreman on a project in Barrow Alaska (now called Utqiagvik). Barrow is the northernmost city in the United States and is 320 miles north of the Arctic Circle. It is cold there, reaching temperatures above freezing on average only about a third of the year. John tells the story of getting a call because every lot of Tension Control Bolts the steel erectors tested was failing to meet the minimum Preload (Tension) requirements. They were convinced that the Skidmore wasn't working right. John instructed them to bring the samples inside and let them warm up to room temperature and see what would happen. This simple action changed the results entirely and the parts passed, allowing the construction crew to complete their project without further delay.

This simple story is just one of thousands of stories regarding **Tension Control Bolts. This ingenious product has become one of the most prevalent forms of structural bolting connections available. They have become a very popular choice among designers and construction crews for their ease of assembly,** but as the story above illustrates require some understanding of how they work when using them. They are, in fact, a sophisticated engineered product. Therefore, let's explore a little bit more about this product.

What are Tension Control Bolts?

Tension Control Bolts have a domed head, body, threads, and a splined tip known as the Pin Tail. (See Figure 1) Tension Control Bolts are part of the structural bolting family given by ASTM F3125. Like the other structural bolt variations, these come in two different types, regular and weathering steel and two different strength grades, 125,000 psi and 150,000 psi. The 125,000 psi version is considered Grade A325 and marked as A325TC or A325TC depending on whether it is Type 1 (regular steel) or Type 3 (weathering steel), respectively. The 150,000 psi version is considered Grade A490 and marked as A490TC or A490TC depending on whether it is Type 1 or Type 3, respectively.

Tension Control Bolts always come as an assembly. In fact, they are not to be used unless all the components have been matched for one another and what might be considered a simple rework, such as re-lubricating parts, is not allowed by any party except the original manufacturer. **A Tension Control Bolt assembly consists of the Tension Control Bolt, a Washer per ASTM F436, and a Heavy Hex Nut per ASTM A563.**

The installation will appear to the untrained eye to be relatively simple; the entire assembly is disassembled and immediately reassembled into the joint. The part is then snugged tight and a special driver is used to properly tension the joint. Although it appears pretty simple and mundane, there is a significant amount of engineering going on below the surface. **Once the joint has been snugged, a point where all joint components are in close contact but absent any significant preload, there are three primary frictions areas. These are where…**

- **The bolt head contacts the clamped material**
- **The washer contacts the clamped material**
- **The nut bearing face contacts the washer**

Again, once the joint has been snugged, there are no gaps between these contact points but no significant tension has yet been developed. To complete the joint, therefore, and develop the desired tension, a special electrical wrench is employed. This tool has two separate spindles, an outer spindle which turns the nut clockwise and an inner spindle which turns counterclockwise and grips the splined Pin Tail. Essentially, **since the nut to washer face contact area is the smallest of the three contacting areas and it is completely lubricated it will experience the lowest level of friction and turning will begin there.** While the nut is turning the bolt remains stationary, held in place by friction at the bolt head contact area and by the countering force exerted by the tool holding the Pin Tail. **Since the joint does not turn and it started out "snugged" the turning nut results in bolt stretch or Preload.** As the bolt tightens, the counteracting force on the pin continues to grow until the Pin Tail breaks off, completing the installation and locking the joint with the developed Preload.

All of these things do not happen by chance. Every Tension Control Bolt is manufactured to exacting standards, especially those related to the groove separating the threads and Pin Tail and the lubrication. Every lot of assembled parts is tested and certified to meet specific minimum tension values before leaving the manufacturing plant.

Advantages of Using Tension Control Bolts

There are a number of advantages of Tension Control Bolts over the more traditional structural hex bolt, washer, and nut assemblies. The advantages are primarily about assembly. **Tension Control Bolts can be installed by a single operator working from the tail end of the bolt.** Although there must be access to both sides so that the Tension Control Bolt can be fit into place, because the head is domed and has no place to hold it, clearance need only be sufficient to be able to fit the bolt into place. The process of placing and snugging the parts are at least equivalent to a hex bolt, if not a little easier, but final installation is clearly easier as the electronic driver only needs to be placed on the part and the trigger pulled. **Other advantages include consistent tension assuming uniformity in assembly conditions, easy visual inspection, and parts come preassembled, ready for installation.**

Disadvantages of Using Tension Control Bolts

Tension Control Bolts also have some serious disadvantages. The name suggests "Tension Control" when, in fact, the tension is derived relative to torque. These assemblies would probably be more aptly named "Torsion Control Bolts". Even a beginning fastener engineer knows, however, that the torque-tension relationship is very sensitive. In other words, small changes in friction can and do result in significant variation in the tension generated. As a result, careless practice could result in either an over or under tension scenario.

Likely **Tension Control Bolts are most vulnerable to poor storage practices and environmental conditions.** As the story in the introduction about parts in Barrow Alaska illustrates, temperature can have a dramatic impact. Consider that the parts were validated by the manufacturer in conditions close to average room temperature, but when exposed to the cold field conditions they failed to perform according to plan. We get the opposite problem on the other end of the extreme. When field conditions, such as direct sun exposure result in parts getting very warm, the efficiency of the lubricant goes up resulting in less friction and greater tension. If that tension level is too high, the parts will reach their Tensile Strength and break prior to the Pin Tail shearing off. (This has been known to happen as well.) Additionally, atmospheric conditions like high or low humidity and rain can affect the performance of Tension Control Bolts. If parts are deemed to require re-lubrication, specifications prohibit that being done by anyone except the original manufacturer.

Some additional disadvantages include the need for special installation tools and local energy sources to power them, a more limited selection of lengths, diameters, and finish choices, and the need for tool clearance on the Pin Tail side.

Obviously storage and handling is exceptionally important. These parts are always supplied as assemblies which have been validated by the manufacturer to meet the required minimum tension. They are then immediately sealed into air tight containers, primarily to prevent the evaporation or loss of any of the lubricant, but also to protect against wetting conditions from rain or other sources of moisture. While at the manufacturer or fastener distributor, storage is maintained in well controlled, ambient environments. However, when parts reach a job site, it is up to the construction workers to maintain best practices and store parts in a cool, dry location. It is also imperative that once containers are cracked open, parts are consumed quickly. The lubricant will start to diminish within a couple of days so that it is critical to keep the lid as tightly sealed as possible and out of the rain or sun.

Conclusions

Tension Control Bolts are an ingenious solution for structural bolting applications. Because they rely entirely on a pre-established and validated torque tension relationship, it is critical that nothing change from when they leave the factory to when they are installed into service. This is probably asking a lot of the average construction worker, so that education and instruction in proper storage, validation, and installation procedures is not only important but essential. When controlled in these ways, Tension Control Bolts, make a nice addition to the fastener options that steel erectors and construction companies have at their disposal.