The Barn Raiser

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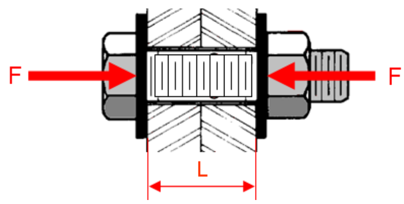
# Fasteners: Torque vs. Tension
## Back to the Basics

By: Kyle Manzer

Bolts, Capscrews, and Studs are used as fasteners for many applications in mechanical devices. On rotating machinery, we have critical fasteners for couplings and anchor bolts, etc. and also non-critical fasteners for holding side covers, etc. In these cases, the fasteners work using the same principle, by providing a clamping force to hold two or more pieces together in compression. Let us now do a brief review of the fundamentals of fastener theory and application.

The figure below shows the clamping compressive Force, F, applied to the pieces. An equal and opposite Force, F, acts on the fastener to put it in tension.




As a fastener creates the compressive clamping force which holds two or more pieces together, there is an equal and opposite force that acts on the fastener which places it in tension. This tensile force creates a stress, $\sigma$ in the fastener.

This tensile force on the fastener causes it to stretch or deform a small amount. This stretch or "strain" is denoted by the symbol, $\varepsilon$. Strain is the change in length of material divided by its original free-length.

As force is applied and strain occurs, a tensile stress occurs in the fastener. Within the "elastic range" of the material there is a relationship between stress and strain.

$\sigma = E\varepsilon$ ; where: E= constant, the Modulus of Elasticity

For steel E = 30.0 * 106 psi

= 20.7 * 104 MPa

The materials typically used in machinery fasteners (various steel alloys) have a Yield Strength, which is the amount of stress that can be applied to the material where it just begins to show plastic (or permanent) deformation. Depending on the material composition and heat treatment, there can be a wide range of Yield Strengths:

- Mild Steels : 20-50 ksi (~ 140-345 MPa)
- High Alloy Steels : 60-125 ksi (~ 415-860 MPa)

The material selection for the fastener is usually based on the application i.e. the force requirement/ corrosion resistance / etc. Typically, fasteners are designed be utilized anywhere from 50% to 90% of Yield Strength.

We can calculate this tensile force on the fastener, F, to be:

$$F = EA(\Delta L/L)$$

Therefore, if we know, or measure the fastener's:

- Material Composition i.e. Modulus of Elasticity, E
- Original Cross Sectional Area, A
- Original Length, L
- Change in Length, $\Delta L$

We can calculate the tensile force on the fastener and therefore, its equal and opposite clamping force imparted on the pieces it is holding together

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Why is this important to know?

There are many aspects of our daily activities that directly impact whether or not we end up with the proper force applied to by our fasteners. In some cases, such as: anchor bolts, saw blade fasteners or similar dynamic moving parts, etc. This is absolutely critical for success.

The equations tell us that the only way to truly know the clamping force applied by the fastener is to measure the change in length or stretch of the fastener.

When we use a hydraulic tensioning device, a calibrated torque wrench, or a hand wrench, we are only approximating this measurement with indirect approximations of stretch and we are always better off knowing rather than approximating on these critical aspects.

## Post Tensioned Slabs on Grade

By: Tyler Avery, Civil Engineer

Post tensioned slabs on grade have been in use for decades in residential applications where expansive/compressive soils are prominent, and they are beginning to become more popular in commercial and industrial applications in regions where these same poor soils are encountered. The way post tensioned slabs work is relatively simple. Post tensioning cables or tendons are placed inside the formed area to be poured in place of conventional reinforcing. The cables are cased in a sleeve that eliminates bond between the cable and the concrete allowing them to elongate freely. After allowing for the initial curing of the concrete, the tendons will be loaded and elongated to a length typically specified by the engineer. When the cables are released, the tension force in the cables pulling in from the outer edges of the slab put the concrete in a state of pre-compression. This pre-compression value typically ranges between 50-100psi after considering friction between subgrade and concrete as well as other losses. The theory is that this state of pre-compression allows the slab to better resist flexural stresses imposed by the expansion/compression of subgrade resulting from varying moisture contents that causes cracking and failure of conventional slabs, as well as stresses resulting from shrinkage in the concrete.

If properly designed and installed, a post tensioned slab on grade should out-perform and out-last a conventional reinforced slab on grade. There are also several economic advantages to post-tensioned foundations.

First, post tensioned slabs are often thinner than a conventional slab designed for the same application. This will obviously reduce material quantities and the associated cost. Secondly, post tensioned slabs often don't required any sawn joints.

In large applications, this can result in a large savings in labor cost as well as the cost savings associated with not having to do maintenance on those joints. Additionally, the longer life cycle of a post tensioned slab will reduce the overall cost.

Consequently there also some disadvantages to using post tensioned slabs. Though quite common, they require a specialized and extremely qualified contractor. Improperly installed cables can result in catastrophic failure when they are tensioned. Another significant disadvantage of post tensioned slabs is that there can be no future modifications to them. Many of Mid-South's projects involve retrofits or upgrades to existing facilities. Existing foundations are often broken out or sawn to allow for the installation of new foundations. This type of work cannot be performed on a post tensioned foundation. If a loaded cable is ruptured by a saw or core drill or jack hammer, it can result in not only failure of the slab, but also severe injury or even fatality.

As with any decision there are advantages and disadvantages to be carefully considered. Hopefully this can help you in understanding the function of post tensioned slabs on grade and also aid in weighing those pros and cons involved in making the decision.

Wire Strand & Anchor

Standard Post-Tensioning Reinforcing


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