



STEEL INDUSTRY  
GUIDANCE NOTES

## Preloaded Bolt assemblies

**This note concerns the use of preloaded bolts in shear connections. BS 5950 refers to these as “Preloaded HSFG bolts”, and are commonly known as “high strength friction grip”. Connections using preloaded bolts are designed to transfer load without any slip. The connection components may be more expensive than those using non-preloaded bolts, and the connections are more costly to prepare and complete, but should be specified in circumstances where slip must be prevented.**

### How preloaded bolt assemblies work

Bolts are preloaded in tension to a predetermined level, which applies a considerable force between the mating surfaces (known as the “faying” surfaces). The slip resistance depends on the coefficient of friction between the surfaces and the preload. Thus the preparation and protection of the faying surfaces (to give a reliable coefficient of friction) and the installation of the assembly (to give a reliable preload) are both important in this type of connection.

Faying surfaces are generally shot blast or otherwise prepared, but then left untreated. In some cases, a light rusting will develop on the faying surfaces. This is not considered detrimental to the performance of the connection. Coefficients of friction between different surfaces are given in design Standards such as BS 5950 and BS EN 1993-1-8

The faying surfaces are generally masked to protect them from subsequent applications of protective coating. After assembly of the connection, there will need to be some local application of the protection coating(s) to the areas immediately around the connection.

Preloaded bolts are specified to BS EN 14399 *High strength structural bolting assemblies for preloading*. Some confusion arises because the same bolt may be used in an “ordinary” connection, simply without preloading the bolt.

Some method of achieving a reliable preload is needed. These methods include a combined or “part-turn method”, where a certain number of turns are applied to the assembly. Bolts may be tensioned by applying a specified torque, using a hand or power operated torque wrench after calibration to ensure the correct preload. Direct tension indicators (DTI) may be used, as illustrated in Figure 1. The bolt is tightened until

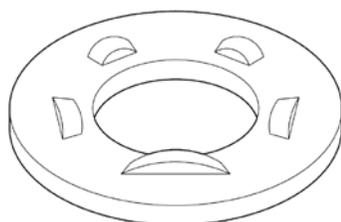


Figure 1 Direct tension indicator

the dimples on the washer are crushed to within a certain limit (but not completely crushed as this could mean that the bolts were over-tightened). Special hardened washers are used in the assembly, depending on which component is rotated (the nut or the bolt head) and the location and orientation of the DTI. Guidance is given in BS EN 1090-2 Annex J.

In any process that relates torque to pre-tension, the friction between the nut and the bolt is important – the ‘as delivered’ state of the components should be maintained. Bolt assemblies should not be lubricated, mistreated or exposed to inclement weather before use.

The bolts used in preloaded bolt assemblies may be special components, such as shown in Figure 2. For this component a special tool is used to grip both the nut and the shank of the bolt. At a certain torque (and therefore preload in the bolt) the splined end of the shank fractures, indicating that tightening is complete.

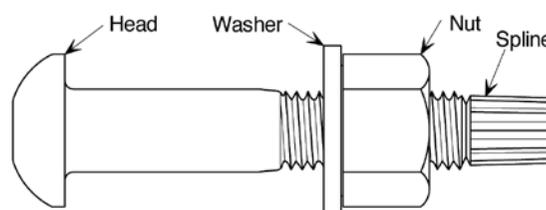


Figure 2 Tension control bolt

### Non-slip at SLS or ULS

Two situations are usually covered by design Standards – Non-slip at SLS and Non-slip at ULS. BS EN 1993-1-8 describes Category B: Slip-resistant at serviceability limit state and Category C: Slip-resistant at ultimate limit state. Similar categories are found in BS 5950.

Non-slip at SLS means that the connection will not slip at unfactored loads, but will slip into bearing before ultimate loads are reached. In this situation, the slip resistance is calculated, but the bearing resistance and shear resistance of the bolt must also be calculated. If the connection is designed to be non-slip at ULS, then according to BS 5950, only the

slip resistance is calculated. BS EN 1993-1-8 also requires the bearing resistance to be calculated.

The common case is to design the connection to be non-slip at SLS (Category B in BS EN 1993-1-8), and is recommended. Design to be non-slip at ULS may be employed on hybrid connections where load is shared between bolts and welds in the same connection, in connections using slots, and in connections that provide restraint to other members – i.e. where slip before ULS would lead to a loss of stability.

### Used assemblies

In some cases, connections are disassembled. In these circumstances, the assembly should not be re-used, because some of the bolt's (limited) elongation will have been irreversibly used. Preloading an assembly for a second time may take the assembly to (or very close to) its breaking point.

### Circumstances when preloaded bolt assemblies should be used

In general, non-preloaded bolts are perfectly satisfactory for the majority of orthodox connections, as the small amount of slip associated with clearance holes has no practical consequences for the structure. There are a few circumstances where the use of preloaded bolt assemblies, despite the perception of increased costs, should be considered:

1. Where slip must be avoided  
Examples include a bolted truss, where slip in a splice connection would lead to additional deflection and an unsightly kink in the member. A splice in a moment resisting member may require friction grip assemblies to prevent unsightly deflection.
2. Fatigue  
In structures where fatigue is a design consideration, the use of preloaded assemblies is recommended. The high level of preload means that the tension in the bolt does not vary significantly, provided the plies are stiff and in contact.
3. Vibration  
Severe, continued vibration has been known to lead to ordinary (non-preloaded) bolt assemblies becoming loose. Preloaded bolts may be used when vibration is a concern. Other effective solutions exist to prevent the nuts from coming loose, including the use of lock nuts, nuts with nylon inserts, or split pins. It should be noted that nuts working loose due to vibration is not normally a consideration in orthodox building structures, and in most cases no special measures are required.
4. Load Reversal  
When load reversal occurs (excluding reversal solely from wind loading) the possibility of slip in the connections (as the clearance holes allow movement to and fro) should be prevented. Significant reversal may take place in structures supporting moving loads such as cranes. Friction grip assemblies are recommended in these situations.

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## Key Points

1. Generally, for connections subject to shear, ordinary bolts in clearance holes are satisfactory – only use preloaded bolt assemblies where they are truly warranted.
2. Generally design the preloaded bolt connections to be non-slip at serviceability.
3. Faying surfaces should be protected until the connection is assembled – subsequent making good of protective coating will be required.
4. Installation of preloaded bolt assemblies should be carefully monitored on site to ensure the assemblies are correctly pre-tensioned and not over-tightened.
5. Preloaded bolt assemblies should be used in accordance with the manufacturer's instructions – they should not be lubricated or mistreated.
6. Used assemblies should be discarded.

## Further Sources of Information

1. Cosgrove, T.C **Tension Control Bolts, Grade S10T, in Friction Grip Connections, SCI, 2004**
2. Owens, G. W and Cleal, B. D, **Structural Steelwork Connections, Butterworths, 1989**
3. **Steel Details, BCSA, 2005**