STEEL INDUSTRY GUIDANCE NOTES

European Standard for Preloadable Bolts

The launch of the new European standards for design (the Eurocodes) and fabrication (BS EN 1090-2) of structural steelwork is associated with the introduction of a set of European standards for Non-preloadable (ordinary) and preloadable (High Strength Friction Grip) bolts. This SIGNS provides a brief description of the different types of European pre-loadable bolts and the major issues that are likely to be encountered when using these bolts.

Preloadable bolts have advantages if vibration is present, if slip between joining parts must be avoided and if the applied load through the joint frequently changes from positive to a negative value. Otherwise standard, non-preloadable, grade 8.8 bolts will prove more economical.

Throughout this SIGNS the term 'preloadable bolt' is used to describe High Strength Friction Grip assemblies.

Types of preloadable bolt

In Europe there are two approaches to achieving the necessary ductility in preloaded bolt, nut, and washer assemblies. Therefore in developing the series of European product standards, BS EN 14399, it was agreed to develop two parallel systems. The HR (British/French) and the HV (German) systems reflect these two approaches and the differences between the two are explained below.

With both types of bolt, the fact that the thread may be subject to plastic strains during tightening means that bolts and nuts that have been fully preloaded must not be re-used if removed.

HR (British/French) bolt

The British/French approach following BS EN 14399-3 and BS 4395 is to use thick nuts and long thread lengths in the bolt assembly to obtain ductility predominantly by plastic elongation of the bolt. The longer thread length is necessary to ensure that the induced strain is not localised. These bolts are relatively insensitive to over-tightening during preloading although suite control is still important. Furthermore if severely over-tightened during preloading the ductile failure mode of the bolt assembly is predominantly by bolt breakage, which is readily detectable.

HV (German) bolt

The German approach following BS EN 14399-4 and DIN 6914 is to use thinner nuts and shorter thread lengths to obtain the required ductility by plastic deformation of the threads within the nut. In Germany, the HV bolt assembly is used in both preloaded and non-preloaded applications and it can be argued that in the event of failure by thread plastic deformation the assembly still acts as a non-preloaded assembly. These assemblies are more sensitive to over-tightening during preloading and therefore require more site control. If severely over-tightened during preloading the mode of failure by plastic deformation of the engaged thread of the bolt assembly offers little indication of impending failure.

Marking

It is vital to avoid mixing up the components of both systems and this is not helped by the same standard covering both types of bolt. Bolts and nuts for both systems are standardized in separate parts of the product standard BS EN 14399 and clearly marked as components for the separate systems. Bolts and nuts from the same system will be stamped with their system designation, HR or HV, in order to avoid confusion. In addition bolts and nuts will be stamped with their property class (i.e. grade 8.8 or 10.9 for bolts and 8 or 10 for nuts as appropriate). For the HR system the following possibilities exist:

- Bolts to class HR 8.8 with nuts to class HR 8, or HR 10
- Bolts to class HR 10.9 with nuts to class HR 10

The HR 8.8 bolt is very similar (in dimensions and properties) to the Part 1 general grade HSFG bolt to BS 4395 and likewise, the HR 10.9 bolt is very similar to the Part 2 higher grade HSFG bolt to BS 4395.

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Installation

The European fabrication standard, BS EN 1090-2, allows three methods of tightening. These are briefly described below.

a. Torque control method

In the torque control method the torque is applied in two steps. The first step, after bedding of the joint, is to apply a torque of up to 75% of the required torque value to all the bolts. The second step is to apply an additional torque to each bolt such that the total applied to the bolt is up to 110% of the required nominal torque value. The extra 10% is to offset the subsequent torsional relaxation of preload in the connection when the tightening wrench is removed.

b. Combined method

This method is a combination of torque control and the traditional 'part-turn' method. After the joint is bedded the preloading takes places in two steps. The first step is to apply a torque of up to 75% of the required torque value to all bolts. The second step is to apply to each bolt a predetermined rotation or 'part-turn' to a specified angle, depending on the bolt length.

c. Direct tension indicator method

This method is the most popular in the UK and relies on protrusions on direct tension indicators previously known as load indicating washers. These protrusions create a gap prior to preloading in the installed assembly. After the joint is bedded down, the DT I is initially tightened until the protrusions start to deform, at this stage approximately 50% of the preload has been applied. When the gap is closed to the specified value the bolt force will not be less than the specified preload.

CE Marking

The requirements for CE Making preloadable fasteners are given in BS EN 14399-1. This harmonised standard came in to force on 1st January 2006 and became mandatory in most European Countries on 1st October 2007. CE Marking is a regulatory mark that gives assurance to the market that preloadable bolts satisfy certain minimum health and safety requirements.

The Construction Products Directive requires the manufacturer to place the CE Marking on the product, the packaging or the accompanying commercial documentation. For structural bolts the CE Marking is generally on the packaging.

Key Points

1. There are two types of preloadable bolt assembly, the British/French HR bolts covered by BS EN 14399-3 and the German HV assembly covered by BS EN 14399-4
2. The HR assembly is similar to the BS 4395 bolt and is generally less sensitive to over-tightening.
3. The HV assembly is more sensitive to over-tightening and requires more control on site
4. Components from both types of bolt assembly must not be mixed up.
5. Three methods of tightening are given in the European fabrication standard BS EN 1090-2; torque control method, 'combined 'method and the direct tension indicator method
6. The direct tension indicator method is popular in the UK
7. The requirements for CE Marking of preloadable fasteners are given in BS EN 14399-1.

Further sources of Information

1. **National Structural Steelwork Specification for Building Construction, 5th Edition, BCSA & SCI publication No. 203/07**
2. **Steel Details, BCSA Publication No. 41/05**
3. **BCSA Model Specification for Structural Bolts and Holding Down Bolts, BCSA.**