Circular regarding the use of high strength bolting assemblies for pre loading

Historically in South Africa these bolts were commonly known as High Strength Friction Grip Bolts.

HSFG bolts were manufactured under SABS 1282 in grade 8.8 and 10.9. The 'S' on the head of the bolt indicated that it was a HSFG bolt for structural use. These bolts were used for non-slip applications (HSFG applications) as well as preloaded applications (i.e. important joints, crane structures, cyclically loaded structures (e.g. supports for vibrating equipment) and for impact loaded structures).

Why we were able to have only one standard is explained below.

An unusual bolted connection

This standard has now been replaced in South Africa with EN 14399-3, also in grades 8.8 and 10.9 and with a head marking HR. We have not established what HR stands for.

Also what has commonly been requested in South Africa over the last 5 years, particularly where there has been a European design influence for important structures such as power stations, has been the EN 14399-4 bolt; this comes in grade 10.9 only and replaces old standard of DIN 6914, which was rarely, if ever, used in SA. Based on European design philosophy the strength of the bolt is taken as being in the shear plane in the unthreaded stronger part of the bolt.
To ensure this happens these bolts typically have a shorter threaded part than the HR bolts.

The EN14399-4 standard bolt has the HV mark on the head. The V is associated with the symbol v used for shear in engineering calculations as these bolts are typically used in shear/ bearing type connections, hence the need for two standards i.e. HV and HR in the European environment.

In South Africa we assume that the shear plane of our bolts is in the (weaker) threaded parts. This assumption allows us to use friction grip bolts for all preloaded applications i.e. non-slip as in HSFG and also for those important connections mentioned above.

The EN14399-4 has a lower nut height than EN14399-3 and the proof loads are according to ISO 20898-2 and are only slightly above the ultimate strength of the bolt. The reason for this is that for the 14399-4 (HV shear) connections, it is the shear strength of the bolt that is important. For the 14399-3 (HR=HSFG equivalent) the clamping force and the friction between the plates transfers the load.

EN14399-3 nuts have a 9% higher proof load than EN 14399-4. In the event of over tensioning EN14399-3, the bolt will definitely break without the threads stripping whereas in the case of 14399-4, stripped nut threads could occur and a failed assembly will not have become evident.

A common complaint from the field, particularly from the 'old timers' who remember, is that the new EN 14399-3 nuts heights have been reduced. 'Dis nie soos die ou ding nie'. This reduction in height is as much as 2.7mm on a M24 nut, or 12%.

An assembly, as mentioned in the heading, is a new term which has been introduced into the equation. This relates to the requirement that bolt, nut and washers are to be supplied by one manufacturer as a complete assembly guaranteed suitable for use in pre-loaded connections.

The manufacturer has the obligation to perform certain testing on the assemblies to underwrite this guarantee. The first test involves determining the required torque to obtain the required tension (force) in the bolt.

The influence of lubrication between the threads of the nut and the bolt needs to be known to determine the torque. The manufacturer may supply pre lubricated nuts or if not, the nature of lubrication required to be used by the customer must be indicated and be in accordance with testing undertaken by the manufacturer.

The second test performed by the manufacturer is to ensure the performance of the assembly from the recommended pre load through additional tightening until pre determined angle turns have been achieved, thereby proving suitability to use for pre-loaded applications.

Certification on this front is required. This certification needs to be traceable, from the original wire used to manufacture the components, through the testing regime and right up to where the bolts have been used in the structures.

To this end identification numbers are marked on the components.

Should you be keen to have sight of a set of suitability test results and have a feel for how complex the testing is, please contact Rob Pietersma of CBC Fasteners (rob@cbc.co.za).

Hot dip galvanizing of grade 10.9 product

This has become a contentious issue, quite unnecessarily. The first risk is hydrogen embrittlement. This is overcome by shot blast cleaning which avoids acid contact.

Alternatively bolts can be cleaned in inhibited acid with specific time limits. Manufacturers have tended towards shot blasting route and most reputable galvanizers have excellent systems in place to ensure no acid contact. The second risk is the not too well known and understood one of Hydrogen induced stress corrosion cracking (HiSCC). The hydrogen comes from the localised corrosion at the break in the galvanized layer, where the steel is exposed. This can come from white or red rust or any other corrosion process. A corrosion reaction taking place and will also result in hydrogen being released at and into the breaks in the galvanized layer. White rust is a good example of a source of hydrogen and is simply the corrosion reaction which most readily takes place in the bolt holes closed environment.

It is a known fact that steel and hydrogen are 'mortal enemies'. Exposure to hydrogen can lead to cracking of what was otherwise crack free steel. The development of the cracks is thought to be further promoted in hard steel such as 10.9 bolts by being subjected to enough hydrogen entering cracks at high enough stress intensities.

CBC follows the German Guideline on galvanizing which requires that surface hardness is limited to maximum HV375 and bolt tensile strengths are held below 1140Mpa. This reduces the susceptibility of the steel to the influence of HiSCC. CBC Fasteners' bolts manufactured under these guidelines were tested at Darmstadt University last year. The bolts were subjected to a mixture of diluted acid in the thread area and tensioned to above 90% of the ultimate strength of the bolts. The bolts all passed the minimum required period of 48 hours (some 60 hours) without breaking and subsequently passed tensile tests.

Whilst at CBC we are confident of our hot dipped galvanizing grade 10.9 bolts, which we manufacture to German galvanizing guideline standards, it is noted that the Southern African Institute of Steel Construction (SAISC) remains silent on the hot dipping of grade 10.9 bolts. The American Institute of Steel Construction prohibits the hot dip galvanizing of grade 10.9 bolts, their reasoning that whilst it is possible to galvanize the 10.9 bolts correctly, there are many ways in which the process can go wrong and decided not to expose their engineers to this risk.

The nut is pre lubricated thus giving it an apparent different finish to the traditional HDG finish which is on the bolt and washer.

It has been suggested that the German approach to the HiSCC problem was that in Germany and other parts of Europe, they were locked into grade 10.9 (EN 14399-4) with no grade 8.8 alternative and therefore had to find a solution to HiSCC. It is noteworthy mentioning that in South Africa where we have had an incident of HiSCC, two factors were present; surface hardness above HV 375 and extremely poor installation practice. Where installation practice improved, no subsequent failures were experienced. Total failure rate was a mere 0.000225%. The sample size was in the order of 258 000 bolts. The concept of HiSCC is unfortunately being used as an excuse to focus negatively on bolt manufacturers whereas the causes are in reality probably design faults and or installation errors.

Site related issues

It is our experience that there is a general lack of understanding by so many construction businesses regarding correct installation and tensioning of construction bolts. This results in, inter alia, the use of impact wrenches where torque/tension cannot be verified, not using washers where required, no lubrication of hot dip galvanised assemblies , incorrect torque being applied and not maintaining batch control. In many instances there is a rush to take short cuts only to find out later when things go wrong, that replacement of bolts is required by the main contractor.

"Problems identified with poor site procedures include (but not limited to) the following:

1. Thick end plates in heavy connections are sometimes not straight when they come out of the wokshops. Site personnel then "over tighten" the bolts to pull the plates straight. They do not replace the bolts used for this process.

2. From a safety point of view it is common to assemble a group of steel components into a large sub-assembly. A big crane is the used to hoist the assembly.

In order to assist making the connections between the assembly and the previously erected elements bolts are often left loose and tightened once the connections have been mated. We do not know that the bolts have been damaged because they have been loaded in unexpected ways."

Bolted connection at Bakubung Platinum Mine Headgear

Quality checks on a connection

Bolt availability issues

A common mistake made by end users is to assume that construction bolts will come straight off the shelf. Bolts are a lot easier but may still require a manufacturing lead time of 6 to 8 weeks. Nuts are more difficult as certain of these have to be imported and if there is a pre lubrication requirement, this will always be the case.

Because of the concept of these bolts being supplied as assemblies, it will be unacceptable for bolt distributors to have nuts galvanized and to supply them with other manufacturers' bolts as conforming assemblies or vice versa. It will not help the contractor who did not order his bolts timeously to the correct specification.

CBC Fasteners has acquired a huge amount of experience over the last six years, including some scars. We are willing to share our experience by offering installation training and are always willing to offer solutions to user requirements.

The SAISC is planning a feedback breakfast in 2015 to present more information regarding structural bolting.

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