Careless torque makes trouble

Critical fasteners on bridges must be tightened with care if failures and unwanted torsional stresses are to be avoided, argues Rob Gregory

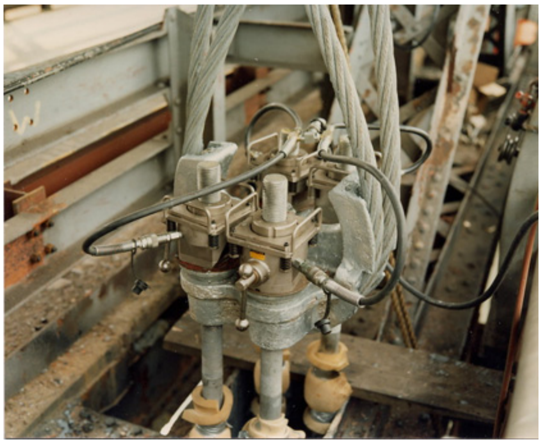
High strength bolts, studs, and tie rods form part of virtually all bridge designs. Many are used in critical, load-bearing bolted joints where precise, repeatable, and verifiable fastener loading is required. In such cases, fastener preloads are often relatively high in relation to their size, a situation where conventional methods of bolt loading using torque introduce unwanted torsional stresses in addition to the required preload tensile stress. This stress combination can lead to overstressing the bolt and premature failure of the fastener. And in cases where multiple fasteners are sharing a load, repeatable, consistent loading is essential, since unevenly or under-loaded fasteners could lead to failure of the joint. For critical fastener applications like these, bolt tensioning, rather than torquing, is often the preferred method of tightening, since a direct, axial and easily repeatable load is introduced to the fastener, and unwanted torsional stresses are eliminated.

In the use of torquing, the applied torque produces a tensile load in the fastener through the inclined plane of its threads. The final bolt load is a function of the amount of torque applied and the amount of friction that develops between the nut and bolt threads and between the nut face, washer, or flange. Although applied torque can be accurately controlled, some portion of the torque must inevitably work to overcome this friction, reducing the efficiency of this process as a bolt loading method. The amount of friction can vary from bolt to bolt depending on the surface quality of parts and type, quantity, and quality of lubricants used. Thus, bolt loads produced by torque on a given joint can vary considerably, especially when commercial-grade fasteners are used. As noted above, undesirable torsional stresses are often introduced while overcoming friction, especially when high fastener loads are required. It is therefore very difficult to produce accurate and consistent bolt tension when relying on torque, even when the torque applied to the fastener is accurately controlled.

By contrast, a bolt tensioner is pressurized hydraulically to apply a direct, axial load to the fastener. The tensioner has a fixed internal hydraulic area, so the load applied to the bolt is a direct function of the tensioner's operating pressure, which can be easily and precisely controlled. Applied tensioning loads to within 2% of the target load are achievable, and bolt loading can be precise, consistent, and repeatable.

The tensioning procedure begins with the tensioner being threaded to the bolt or stud and pressurised to a predetermined value. When this pressure is reached, the operator seats the nut, which functions only to maintain load introduced into the bolt by the bolt tensioner, not to produce it; this means that friction is eliminated. The pressure produced by the tensioner is now released, and the bolt load is maintained by the nut.

In addition to accuracy and safety, bolt tensioners can be optimised to meet the unique demands of specific applications and to make the tensioning process easier and faster for the operator. This is an important consideration



Above: Bolt tensioning carried out during refurbishment of the Williamsburg Bridge in New York

Below: Equipment being used on the Delaware Memorial Bridge

for work performed in less than ideal conditions, and where timely performance is crucial. A geared nut seating feature enhances the precision and repeatability of hydraulic bolt loading by permitting consistent and positive nut seating torque, and is easy and fast to use. It is rugged and integral to the bolt tensioner, so there are no separate parts to drop or lose. The capacity of a tensioner can be matched to specified bolt load requirements, so the user doesn't pay for capacity or added tooling weight he doesn't need. Similarly, these tools can be customized to fit in tight spaces or accommodate unusual application geometries where initially tensioning may not appear possible. They can be provided with extra stroke in cases where anticipated bolt elongation or compression of structural members demands it, or furnished with a positive piston stop to prevent tensioner overstroke and potential downtime. Finally, bolt tensioners can be provided with automatic piston return, saving the operator the task of manually returning the piston after each tensioning cycle per bolt. This feature speeds the tensioning process, and reduces the chance of overstroking the tensioner.

This procedure may not be appropriate for every bolted joint in bridge construction, but for critical bolted joints where bridge designers demand accurate, predictable, repeatable loading, it should be considered.

One such typical application is anchor bolting, of which many applications are well suited to the tensioning method. Controlled and verifiable preloading is generally specified, yet required bolt loads are frequently high, often approaching 80% or more of the minimum yield point of the bolt material. Loading bolts with torque to values this close to the yield point risks fastener damage, as the aforementioned torsional stresses combine with tensile stresses. Uneven loading can overstress some of the bolts when the joint is subjected to service loads, but because stud tensioning permits very precise loading of the bolts, even loads approaching minimum yield can be safely applied without danger of bolt damage. Geared nut turning provides further bolt load control, as nut seating torque can be easily controlled.

Specialist Biach Industries was recently awarded a contract to provide anchor bolt tensioning equipment for critical anchor bolts as a part of a seismic refurbishment of a major bridge in California. High loads are specified for these anchor bolts, and little space has been provided for tooling. Biach developed custom bolt tensioners that provided the necessary load and fitted into the available space around the bolts. Specially designed anchor rod threads and nuts were accommodated by the tensioner design, and the tensioners were fitted with a geared nut seating system and automatic piston return described above.

Contractors demonstrate use of bolt tensioning equipment on the Brooklyn Bridge in New York

Other applications for bridge projects that Biach has addressed over the years have included cable band bolts on suspension bridges, tie rods for adding stiffness and support, main cable anchorage bolting, suspender cable tie rods used to level the roadway, pin and hanger retrofits, and seismic retrofits. Bolts, studs and tie rods for these applications have ranged in size from 25mm to 188mm diameter, and were used on a variety of different bridge designs and projects in the United States and overseas.

Efficient results for most of these projects were achieved by using bolt tensioners tailored specifically for the project, rather than by attempting to make “off-the-shelf” tooling fit. Penalty clauses in most bridge construction contracts encourage timely completion, so what may initially seem the most cost-effective approach to tooling may prove expensive when time is wasted with equipment that is badly suited or simply unable to do the job. The design expertise for the tailored approach requires experience and the ability to consider the entire problem and develop its optimal solution to rather than simply specify a tool based solely on load capability or bolt size.

Rob Gregory is technical sales coordinator for Biach Industries
75 Chestnut St. Cranford, NJ 07016 Tel. (908)276-3110
Visit our website at www.biach.com

Biach Industries, Inc.
75 Chestnut Street
Cranford, NJ 07016