AD 402:
Design of end plate joints made with preloaded bolts subject to coincident shear and tension.

Advisory Desk note AD373 gave a summary of the checks required on connections subject to combined shear and tension. This AD note discusses the behaviour of such a connection in more detail.

Where a preloaded bolt in a joint is subject to a tensile force, the preload is theoretically not affected but the clamping force between the plates is reduced. This is based on the assumption that the bolt acts as a spring and the plates are infinitely stiff. In reality, the plates are not infinitely stiff and the clamping force is only reduced by 80% of the applied tension. Where a bolted joint consisting of end plates and preloaded bolts is subject to both shear and tension, the applied tension reduces the clamping force between the faying surfaces and the shear resistance of the joint is therefore also reduced.

Bolted joints designed with preloaded bolts are categorized in Table 3.2 of BS EN 1993-1-8:2005 either as shear connections: B (slip-resistant at serviceability), C (slip-resistant at ultimate) or as tension connections: E (preloaded). If a joint of the type described is subject to both shear and tension, and it is necessary to eliminate slip at either serviceability or ultimate limit states (category B or C), additional preload is required in the joint which may mean additional bolts to ensure no slip occurs.

Clause 3.9.2 deals with this issue and formulae for the design slip resistance per bolt are given in equations 3.8a and 3.8b for category B and C connections respectively. In each case, the bolt preloading force is reduced by 80% of the tension force in the bolt as result of the design value of the loading (effect of actions), to allow for the flexibility of the end plates. For example, for the serviceability case, equation (3.8a) is:

$$F_{s,Rd} = \frac{k_s n \mu}{\gamma_{M3}} \left(F_{p,C} - 0.8F_{t,Ed,ser}\right)$$

Prying action results in an increased bolt tension and an equal and opposite compression between the plates in the joint. There is therefore no reduction in clamping force due to prying and $F_{t,Ed}$ does not need to include any prying force.

Consider an end plate joint made with eight M20 grade 8.8 bolts subject to a shear of 200 kN and a coincident tension of 500 kN. If we assume the holes are normal, there is one friction plane, the friction surface is class B and the joint is class C, the preloading force in a bolt is 137.2 kN. The tension per bolt is 62.5 kN so the reduction in preload per bolt is 50 kN.

The design slip resistance of a grade 8.8 or 10.9 preloaded bolt is given in clause 3.9.1(2) as:

$$F_{s,Rd} = \frac{k_s n \mu}{\gamma_{M3}} \left(F_{p,C} - 0.8F_{t,Ed}\right) = \frac{1.0 \times 1.0 \times 0.4}{1.25} \times (137.2 - 50) = 27.9\text{kN}$$

The design shear divided by the design slip resistance is 200/27.9 = 7.2 so eight bolts are required. If no tension were present, six bolts would be sufficient to carry the design shear force.

Contact: **Richard Henderson**
Tel: **01344636525**
Email: **r.henderson@steel-sci.com**

New and revised codes & standards

From BSI Updates October 2016

BS EN PUBLICATIONS

BS EN 16681:2016
Steel static storage systems. Adjustable pallet racking systems. Principles for seismic design
No current standard is superseded

BS IMPLEMENTATIONS

BS ISO 15787:2016
Technical product documentation. Heat-treated ferrous parts. Presentation and indications.
No current standard is superseded

CORRIGENDA TO BRITISH STANDARDS

BS 7910:2013+A1:2015
Guide to methods for assessing the acceptability of flaws in metallic structures
CORRIGENDUM 2

BRITISH STANDARDS WITHDRAWN

BS 4921:1988
Specification for sherardized coatings on iron or steel
This standard is withdrawn as it is no longer relevant

NEW WORK STARTED

ISO 11126-8
Preparation of steel substrates before application of paints and related products. Specifications for non-metallic blast-cleaning abrasives. Olivine sand
Will supersede BS EN ISO 11126-8:1998

ISO 11484
Steel products. Employer's qualification system for non-destructive testing (NDT) personnel
Will supersede BS ISO 11484:2009

ISO 12107
Metallic materials. Fatigue testing. Statistical planning and analysis of data
Will supersede BS ISO 12107:2003

ISO 15835-3
Steels for the reinforcement of concrete. Reinforcement couplers for mechanical splices of bars. Conformity assessment

DRAFT BRITISH STANDARDS FOR PUBLIC COMMENT – ADOPTIONS

16/30335964 DC
BS EN ISO 15612 Specification and qualification of welding procedures for metallic materials. Qualification by adoption of a standard welding procedure specification
Comments for the above document were required by 30 September, 2016

16/30340641 DC
BS EN 1993-1-6 AMD1 Eurocode 3. Design of steel structures. Part 1-6. Strength and Stability of Shell Structures
Comments on the above document were required by 10 October, 2016

16/30340644 DC
BS EN 1993-4-1 AMD1 Eurocode 3. Design of steel structures. Part 4-1. Silos
Comments for the above document were required by 10 October, 2016

16/30340647 DC
BS EN 1993-4-2 AMD1 Eurocode 3. Design of steel structures. Part 4-2. Tanks
Comments for the above document were required by 10 October, 2016