AD 373

Connections using preloaded bolts, subject to combined shear and tension

Queries have been raised regarding the verification of connections subject to combined shear and tension when using preloaded bolts, for connections designed in accordance with BS EN 1993 1 8:2005 (Amd 2010) and the UK National Annex.

This Advisory Desk note gives a summary of the checks required, where in BS EN 1993 1 8 the check is identified and where appropriate, provides guidance for such connections.

All the references are to BS EN 1993 1 8 unless otherwise stated. SLS refers to Serviceability Limit State (i.e. verify against SLS loads). ULS refers to Ultimate Limit State (i.e. verify against ULS loads).

**Combined shear and tension, slip-resistant at SLS**

For shear:
- Category B: Slip resistant at SLS (3.4.1 (1) (b))

For tension:
- Category E (3.4.2 (1) (b))

\[
F_{v,Ed,ser} \leq F_{s,Rd,ser} \quad \text{SLS}
\]

\[
F_{v,Ed,ser} \leq F_{b,Rd,ser} \quad \text{ULS} \quad \text{(see comment below)}
\]

\[
F_{t,Ed,ser} \leq F_{t,Rd,ser} \quad \text{ULS} \quad \text{(see comment above)}
\]

\[
\frac{F_{v,Ed} + F_{t,Ed}}{1.4F_{t,Rd}} \leq 1 \quad \text{ULS} \quad \text{Table 3.4}
\]

** The design tensile force, \( F_{t,Ed,ser} \), should include any force due to prying action. Alternatively in some cases, the design tensile force can be calculated by ignoring prying action, but in these cases the tensile resistance should be reduced. For more guidance, see Advisory Desk note AD354 (Resistance of bolted connections in tension for design to BS EN 1993 1 8), available at www.steelbiz.org.

**The verification of bearing resistance is required as a fail safe in case slip does occur in the connection. No separate verification is required for bolt shear resistance as it will always exceed the slip resistance, but the interaction between bolt shear and tension should be verified.**

**Slip resistances, Clause 3.9.2**

\[
F_{s,Rd,ser} = \frac{k_{s}n_{p}(F_{p,c} - 0.8F_{t,Ed,ser})}{\gamma_{M3,ser}} \quad \text{SLS} \quad \text{(Eq. 3.8a)}
\]

\[
F_{s,Rd} = \frac{k_{s}n_{p}(F_{p,c} - 0.8F_{t,Ed})}{\gamma_{M3}} \quad \text{ULS} \quad \text{(Eq. 3.8b)}
\]

**Combined shear and tension, slip-resistant at ULS**

For shear:
- Category C: Slip resistant at ULS (3.4.1 (1) (c))

For tension:
- Category E (3.4.2 (1) (b))

\[
F_{v,Ed} \leq F_{s,Rd} \quad \text{ULS} \quad \text{(see comment below)}
\]

\[
F_{v,Ed} \leq F_{b,Rd} \quad \text{ULS} \quad \text{(see comment below)}
\]

\[
N_{net,Rd} = \frac{A_{net}f_{y}}{\gamma_{M0}} \quad \text{ULS} \quad \text{(Eq. 6.8, BS EN 1993 1 1: 2005)}
\]

**Combined shear, bearing and tension resistances**

\[
F_{v,Rd} = \frac{\alpha_{v}f_{ub}A}{\gamma_{M2}} \quad \text{ULS} \quad \text{Table 3.4}
\]

\[
F_{b,Rd} = \frac{k_{1}\alpha_{b}f_{ub}d_{t}}{\gamma_{M2}} \quad \text{ULS}
\]

\[
F_{t,Rd} = \frac{k_{2}f_{ub}A_{s}}{\gamma_{M2}} \quad \text{ULS}
\]

\[
N_{net,Rd} = \frac{A_{net}f_{y}}{\gamma_{M0}} \quad \text{ULS}
\]

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New and revised codes & standards

From BSI Updates February and March 2013

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>BS EN ISO 4035:2012</td>
<td>Hexagon thin nuts chamfered (style 0). Product grades A and B.</td>
</tr>
<tr>
<td>BS EN ISO 4036:2012</td>
<td>Hexagon thin nuts un chamfered (style 0). Product grade B.</td>
</tr>
<tr>
<td>BS EN ISO 8673:2012</td>
<td>Hexagon regular nuts (style 1) with metric fine pitch thread. Product grades A and B.</td>
</tr>
<tr>
<td>BS EN ISO 8674:2012</td>
<td>Hexagon high nuts (style 2) with metric fine pitch thread.</td>
</tr>
<tr>
<td>BS EN ISO 8675:2012</td>
<td>Hexagon thin nuts chamfered (style 0) with metric fine pitch thread.</td>
</tr>
<tr>
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<td>Hexagon high nuts (style 2) with metric fine pitch thread. Product grades A and B.</td>
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Advisory Desk