AD 390: Lateral Torsional Buckling of channels in accordance with EN 1993-1-1

Questions have been asked about how the lateral torsional buckling resistance of a channel should be calculated and how the effect of the load position can be accommodated. This Advisory Desk Note offers guidance on the design of these sections.

Channels have only one axis of symmetry, so the immediate question concerns the calculation of M_{cr}. The 'standard' expression, given below, is generally offered for use with bi-symmetric sections, such as I and H shapes, with load applied at the shear centre.

$$M_{cr} = C_1 \frac{\pi^2 EI_z}{L^2} \sqrt{\frac{I_w}{I_z} + \frac{L^2 GI_t}{\pi^2 EI_z}}$$

In fact, this expression is also appropriate for channel sections. Although a channel is monosymmetric, the shear centre and centroid are not displaced perpendicular to the bending axis, as shown in Figure 1(a). In Figure 1(b), an asymmetric beam is shown, where the centroid is displaced with respect to the shear centre – in this case the calculation for M_{cr} would need to be modified.

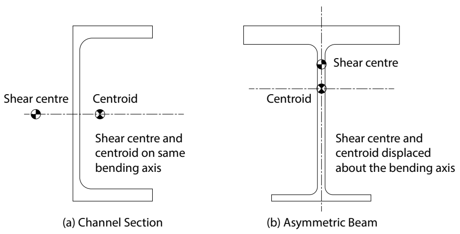

Figure 1 Channel section and asymmetric beam

In P363 (the Blue Book)[1] the 'standard' expression given above is used to calculate M_{cr}, and the lateral torsional buckling calculated using curve 'd', in accordance with Table 6.5 of the UK National Annex, where channels are covered by "All other hot rolled sections". In the Blue book, the reduction factor for lateral buckling resistance is calculated using clause 6.3.2.3.

The unsaid assumption in completing the preceding resistance calculation is that the vertical load is applied at the shear centre, as shown in Figure 2(a). If the load is applied in line with the web (Figure 2(b)), an additional torque is applied, which must be allowed for. The Eurocode is silent on how this should be accommodated.

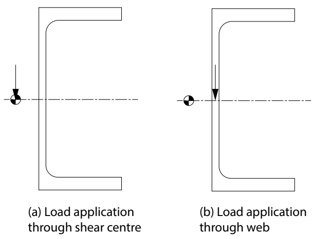

Figure 2 Point of load application

Several European researchers have looked at this problem. SCI recommend Snijder *et al*[2] who provide a recommendation for dealing with this issue in accordance with the Eurocodes. The research investigated several possible solutions and compared the results to an extensive set of non-linear analyses of members.

The recommendation from Snijder *et al* applies to all positions of eccentric load application between the shear centre and the web. The recommended approach is to modify the slenderness of the section with an adjustment for torsion. Then, the approach uses the "general case" expression of clause 6.3.2.2, but with buckling curve 'a'. This curve has been selected because it gives a good fit for the numerical results.

The rather strange observation when comparing the resistances in the Blue Book with the resistances calculated following the recommendations of Snijder *et al* is that the calculated resistances are almost the same. The 'advantage' of the 6.3.2.3 expression, combined with the 'penalty' of curve 'd' used in the Blue Book is balanced by the 'penalty' of 6.3.2.2 and the 'advantage' of curve 'a' used by Snijder *et al*.

Snijder *et al* do have a maximum cut off value for χ_{LT} = 0.67, but this seems to be for historic reasons rather than the evidence of the results. For the present, SCI see no reason to provide more details of the Snijder *et al* approach, or to provide additional resistances in the Blue Book for channels with vertical loads applied at the web. By strange coincidence, it appears that the resistances in the Blue Book are adequate for all vertical load application lines between the shear centre and the web.

1 SCI P363 Steel Building Design: Design Data (Updated 2013)

2 Snijder, H. H; Hoenderkamp, J. C, D; Bakker, M. C. M; Steenbergen, H. M. G. M and de Louw, C. H. M.
Design rules for lateral torsional buckling of channel sections subject to web loading. Stahlbau, Volumn 77, Issue 4, Pages 247-256, April 2008

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New and revised codes & standards

From BSI Update August 2015

BS EN PUBLICATIONS

BS EN 13381-9:2015
Test methods for determining the contribution to the fire resistance of structural members. Applied fire protection systems to steel beams with web openings
No current standard is superseded

CORRIGENDA TO BRITISH STANDARDS

BS EN 1993-1-1:2005+A1:2014
Eurocode 3. Design of steel structures. General rules and rules for buildings
AMENDMENT 1

DRAFT BRITISH STANDARDS FOR PUBLIC COMMENT – ADOPTIONS

15/30303377 DC
BS EN ISO 17635 Non-destructive testing of welds. General rules for metallic materials. Complementary element
Comments for the above document were required by 18 August 2015

15/30310964 DC
BS EN ISO 10675-1 Non-destructive testing of welds. Acceptance levels for radiographic testing. Steel, nickel, titanium and their alloys
Comments for the above document were required by 2 September 2015

15/30314901 DC
BS EN ISO 14343 Welding consumables. Wire electrodes, strip electrodes, wires and rods for arc welding of stainless and heat resisting steels. Classification
Comments for the above document were required by 25 August 2015

15/30320416 DC
BS EN 1090-2 Execution of steel structures and aluminium structures. Technical requirements for steel structures
Comments for the above document are required by 18 September 2015

15/30323235 DC
BS EN ISO 14171 Welding consumables. Solid wire electrodes, tubular cored electrodes and electrode/flux combinations for submerged arc welding of non-alloy and fine grain steels. Classification
Comments for the above document were required by 25 August 2015

CEN EUROPEAN STANDARDS

EN 1993-1-4:-
Eurocode 3. Design of steel structures. General rules. Supplementary rules for stainless steels.
AMENDMENT 1: June 2015
to EN 1993-1-4:2006