AD 475:
Buckling of cruciform columns

The SCI's Advisory Desk has been asked about the design of cruciform columns to Eurocode 3. This structural shape is sometimes adopted for architectural reasons. Its behaviour is unusual when the section is made of plates without flanges and has rotational symmetry of four, in the respect that the likely critical buckling mode is torsional, not flexural.

Unusually, the formula for the elastic critical torsional buckling force for an I section is given in BS EN 1993-1-1 and appears in para BB.3.3.1:

$$N_{crT} = \frac{1}{i_s^2}\left(\frac{\pi^2 E I_z a^2}{L_t^2} + \frac{\pi^2 E I_w}{L_t^2} + G I_T\right)$$

In this formula, $i_s^2 = i_y^2 + i_z^2 + a^2 =$ and a is the distance between the axis of rotation and the shear centre of the section. L_t is the length between torsional restraints. The intersection of the rectangular elements that form the cross section is its shear centre and when rotation occurs about this axis, the value of a is zero. As the section is bi-symmetric, the shear centre coincides with the geometric centroid of the cross section.

The absence of flanges at the ends of the plates remote from the shear centre results in a zero value for the warping constant I_w.

Making these simplifications means that the formula for N_{crT} reduces to:

$$N_{crT} = \frac{A}{I_y + I_z} G I_T$$

For a cruciform column with end moments, a lateral torsional buckling check can be carried out using the general formula for lateral torsional buckling in BS EN 1993-1-1. The value of M_{cr} can be determined using the same formula as that for a flat plate:

$$M_{cr} = \frac{\pi}{L}\sqrt{E I_z G I_T}$$

This formula is relevant to a uniform moment. Useful references are Design of cruciform sections using BS 5950-1:2000[1], AD391[2] and Timoshenko and Gere[3].

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1. Charles King, *Design of cruciform sections using BS 5950-1:2000*, NSC, April 2006
2. AD391: *Lateral torsional buckling of rectangular plates in accordance with BS EN 1993-1-1*, SCI
3. Timoshenko, SP and Gere, JM, *Theory of elastic stability, 2nd Edition*, Dover Publications Inc, 2009.