AD 382
Bending resistance and moment-shear interaction limits for longitudinally stiffened beams designed to EN 1993-1-5

The Advisory Desk is aware that the Evolution Group for EN 1993-1-5[1] is currently investigating the existing rules for longitudinally stiffened plated members, which are thought to be not sufficiently safe. Two aspects are being considered: the application of a partial material factor when using the effective width method of EN 1993-1-5 and the interaction between moment and shear when the webs have longitudinal stiffeners.

First, in Section 4.5 of EN 1993-1-5, the effective area of a longitudinally stiffened element depends on slendernesses determined from gross geometric properties; the effective area of the element is calculated by the application of reduction factors to the gross area. One of the reduction factors depends on a 'strut' buckling curve in the same way as for compression members in EN 1993-1-1 (the other depends on the width/thickness of the plate element). Member verification in clause 4.6 of EN 1993-1-5 thus depends on a resistance that may be limited by column buckling of longitudinally stiffened elements but only the γ_{M0} factor is applied in expression (4.14) of that clause, there is no application of the γ_{M1} factor. Parametric studies have suggested that a factor of 1.1 should be applied as a divisor for the resistance of open longitudinal stiffener elements. The studies also suggest that a factor of perhaps 1.2 is needed for closed stiffeners when elastic critical buckling analysis is used to determine slenderness (although such stiffeners are not explicitly covered in Section 4); the greater reduction needed is due to the beneficial consideration of the torsional stiffness in determining slenderness.

As an interim measure, the Advisory Desk recommends the application of a divisor of γ_{M1} = 1.1 (the same value as used for member buckling in the NA to BS EN 1993-2), rather than γ_{M0}, when verifying sections with open longitudinal stiffener elements in accordance with clause 4.6 of EN 1993-1-5. No recommendation is offered at the present time for sections with closed stiffeners.

Second, moment-shear interaction (M-V) studies have suggested that the Eurocode interaction in 7.1 of EN 1993-1-5 is unsafe for longitudinally stiffened webs with high shear (but there was no evidence it was unsafe for girders without longitudinal stiffeners). For Class 3 sections, without longitudinal stiffeners, the limitation of elastic response imposes a cut-off to the interaction limit curve, as shown by the red curve in Figure 1. For Class 4 sections without longitudinal stiffeners, the same cut-off may be used but for Class 4 sections with longitudinal web stiffeners, that limit curve is unconservative above $V/V_{bw,Rd} = 0.5$. The advice being considered by the Evolution Group is to use a linear relationship from $M_{el,Rd}$ to $M_{f,Rd}$ for higher shears, as shown by the blue curve in Figure 1. However, the advice in Section 6.2.9.2.3 of Hendy and Murphy[2] for M-V interaction in beams with longitudinal web stiffeners can be safely followed until an improved interaction follows from the Evolution Group. That advice is to use η_1 in place of $\overline{\eta}_1$ in the criterion of (7.1) in EN 1993-1-5; this curve is shown in purple in Figure 1.

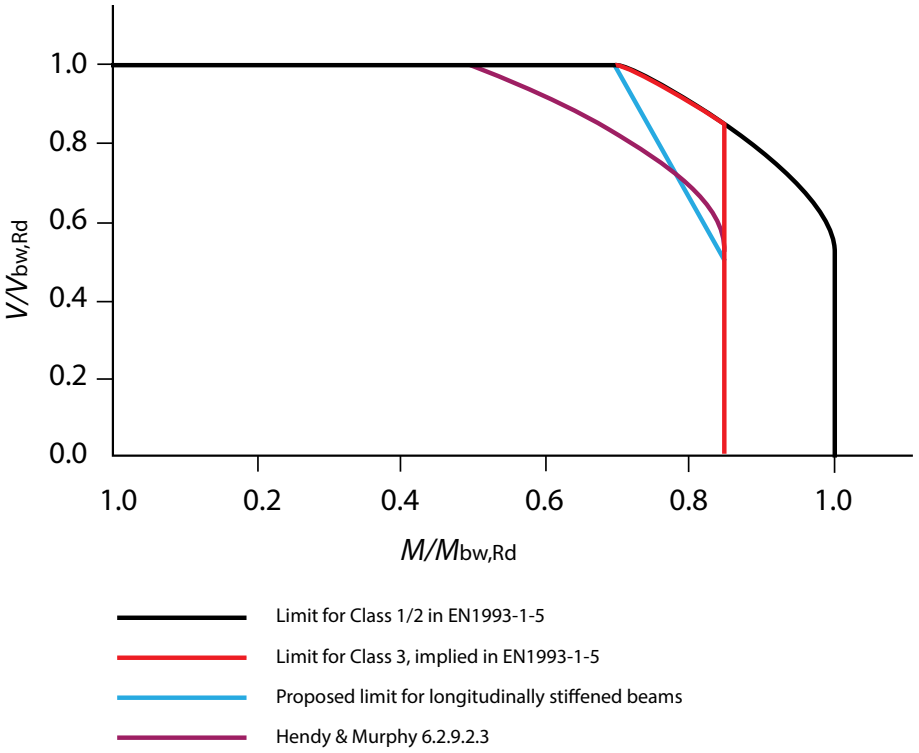

Figure 1. Graphical presentation of limits to bending moment/shear force interaction in EN 1993-1-5 (Illustrated for $M_{el,Rd}/M_{pl,Rd} = 0.85$ and $M_{f,Rd}/M_{pl,Rd} = 0.7$)

[1] EN 1993-1-5:2006 (Incorporating corrigendum April 2009), Eurocode 3 – Design of steel structures – Part 1-5: Plated structural elements.

[2] Hendy C R, Murphy C J, *Designers' Guide to EN 1993-2, Eurocode 3: Design of steel structures, Part 2: Steel bridges*. Thomas Telford, 2007

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