

Discussion

Joint type and the stability behaviour of steel frame beams by A Masarira in Journal 44(4), 2002

Comments received from Dirk P du Plessis MSAICE

The author is to be commended for his very interesting and thought-provoking paper.

The paper centres on the DIN equation for lateral-torsional buckling of steel beams and its use of the β coefficients for bending and warping. Using a finite element program the author was able to determine relative warping stiffnesses for ten joint types beam-to-column connections. He then determined the critical loads for several rectangular portal frames keeping the beam size constant but varying the joint types. By then comparing the critical loads so obtained with those determined for the same beam size using the equivalent member method and various combinations of β values, the author assigned β coefficients to the joint types.

The author's comments on certain aspects listed below would be appreciated.

Comment 1: From equation 2 in the paper it is clear that the β coefficients in the DIN equation are effective length factors, but when the author gives his explanation of these coefficients one gets the impression that he is assigning the coefficients to the joints. This impression is reinforced by the phrase 'for different conditions of support' in the subscript under table 1. When the author finally compares the critical loads of the rectangular portal frame in column P1 of table 4 with those in table 1 and then assigns β coefficients to the joints, as shown in tables 5 and 6, it becomes clear that he is misinterpreting the β coefficients. Perhaps the misinterpretation is a result of the fact that only symmetrical frames were analysed. Had he also analysed unsymmetrical frames, for example, with the beam having a type VIII joint at one end and a type II at the other end, he would have realised that one cannot assign β coefficients to the joints.

What the author should have done is to follow the same procedure but assign the β coefficients to the beams, not the joints. For example, using the author's results and conclusions, beams with types I to III joints have β coefficients (effective length factors) in the range 0,8 to 1,0, beams with types IV and V joints have β coefficients in the range 0,6 to 0,7, etc. In fact, he could even extend his investigation to include unsymmetrical frames such as the example quoted above and assign β coefficients to those beams.

Comment 2: In equation 3, should it not be $(\beta L)^2$?

Comment 3: What is the significance of specifying an 8 m long column in table 1? Are the critical loads in table 1 not applicable to an IPE 500 beam of 20 m length regardless of the column size or length?

Comment 4: This reader believes that a major contribution was made in the investigation of the different joints and demonstrating, in table 3, the effect of joint detail on the warping stiffness. In determining the warping stiffness of each joint, one wonders whether, in lieu of two bimoments, it would it not have been more appropriate to use two horizontal shears acting in opposite directions in the two flanges? The horizontal shears would have had the further advantage that they are directly related to the warping torsion and it would have been possible to compare the C_{ω} values thus determined directly with the warping stiffness of the beam section. The units in table 3 would have been slightly different.

Comment 5: The critical loads presented in table 4 are very informative and give the designer a good insight into the role played by the various variables. An inspection of the table shows that many of the critical loads are very high and would cause inelastic behaviour. For example, a critical load of 46,8 kN/m (the maximum in the table) corresponds to a bending stress in excess of 800 mPa! Had cognizance been taken of inelastic behaviour, then many of the critical loads would have been much smaller.

Author's response

Comment 1: Equation 2 is from DIN4114 (1952), which is still valid in Germany and defines c as a function of the β_0 and β_1 (rotational and warping stiffness factors). This is based on the fact that each beam's end has rotational and warping stiffnesses which depend on their structural configuration. This has been subject to investigation over many years, although the research has proven to be quite complex. The work done by Krenk and Damkilde (1991) cited in the paper was quite valuable in this regard and expanded on that by including more

joint types rather than just limiting it to the four types they looked at. I think there is no question about the fact that different joints have different stiffness values but the question is, can these be assigned as isolated values to the joints (as I have done) or should they be assigned to beams? Can connections be studied independently of the beams to which they are attached? In determining stiffness values of these connections we can isolate them and look at the arrangement of the plates that form these connections as was done in this paper and hence the assigning of β values to each connection. I agree with Mr Du Plessis that the investigation should have been broadened to analyse unsymmetrical frames. Such frames were deliberately left out in order to limit the number of variables in the analysis. This is still work in progress and these aspects will be looked at in future.

Comment 2: Correct. That's an error – my apologies.

Comment 3: These are indeed applicable regardless of column size as long as the column is braced such that failure only occurs in the beam. This investigation was part of a wider project that looked at frames and hence the presence of columns.

Comment 4: That is exactly how the bimoments were modelled – as two horizontal shear forces acting in opposite directions in the two flanges. The bimoment is the couple moment of these forces, that is, shears force multiplied by the distance between them.

Comment 5: I am aware of the fact that this research ignored inelastic behaviour and hence some bending stress values are very high (beyond the elastic limit). This again was done in order to limit the complexity of the problem. The main objective of this work was not primarily to present results that will find immediate application in design but to determine qualitative relationships between joint design and structural behaviour. Therefore simplified assumptions were made, for example symmetrical frames and elastic behaviour. The next step would now be to generate models that take into account the specific characteristics of real frames and material properties.