5.5 Design Methods for Purlins

5.5.1 No Lateral and Torsional Restraint Provided by the Sheeting

If there is neither lateral nor torsional restraint provided to the purlins, then channel sections will twist substantially unless they are loaded through the shear centre, and Z-sections will deflect laterally unless they are loaded in a principal plane. If either of these situations is achieved, then a model based on flexural-torsional buckling can be applied to the design of that purlin. A detailed review of design methods for this case is given in Ref. 5.10. In general, channel- and Z-sections unrestrained by sheeting are unlikely to undergo section distortion during flexural-torsional buckling unless they are very thin, and so the U Model is applicable to their design.

For eccentrically loaded channels, substantial torsion will occur. For Z-sections not loaded in a principal plane, biaxial bending will occur. A new approach to the design strength of cold-formed channel- and Z-section beams using interaction equations is given in Ref. 5.10.

5.5.2 Lateral Restraint but No Torsional Restraint

The basic behaviour of purlins laterally restrained by sheeting but not torsionally restrained was presented in Section 5.4.1.2. The theoretical linear elastic analysis demonstrated that channels will twist substantially unless they are loaded through the shear centre, since there is no torsional restraint to resist the twisting action. Z-sections will also twist substantially unless the line of action of the load is such as to cause terms 2 and 3 of Eq. (5.29) to cancel. As discussed in Section 5.4.1.3, this may occur if the line of action of the load coincides approximately with the centre of the restrained flange.

On the assumption that these conditions were met, a model was developed by Ings and Trahair (Ref. 5.3) for computing the lateral buckling capacity of channel- and Z-section purlins. Ings and Trahair based their model of the deformation of a purlin under wind uplift on the assumption that purlins bend normal to the plane of the sheeting until elastic buckling occurs. The sheeting is assumed to effectively prevent lateral deflection of the top flange, but provides no torsional restraint to the purlin so that only the sheeting shear stiffness shown in Fig. 5.5(b), is included. The model applies to undistorted sections (U Model) and is based on a finite element flexural-torsional buckling analysis (Ref. 5.4 and Section 5.2.2) with the stiffness matrix augmented to include the effect of the continuous lateral restraints. The model was applied to the uplift purlin tests described in Refs 5.23 and 5.24 to predict the strengths of the purlins. For purlins without bridging (bracing), the average ratio of the test failure load to the predicted failure load using Eqs (5.19) - (5.21) was 2.41, for purlins with one row of bridging the ratio was 1.33 and for purlins with two rows of bridging the ratio was 1.13. It can be clearly seen that when there is no torsional restraint except from sheeting, the model ignoring torsional restraint from sheeting is very conservative. However, the model is more accurate for purlins restrained from twisting by bridging. The model forms the basis of Clause 3.3.3.2.1(b) of AS/NZS 4600.

The model was also applied to the downwards loading purlin tests described in Refs 5.23 and 5.26 to predict the strengths of the purlins. For purlins without bridging (bracing), the average ratio of the test failure load to the predicted failure load was 3.50 and for purlins with one row of bridging, the ratio was 1.01. As for the uplift tests, it can be clearly seen that when there is no torsional restraint except from sheeting, the model ignoring torsional restraint except from sheeting is very conservative. However, when torsional restraint is provided by way of bridging, the model is fairly accurate.

Design of Cold-Formed Steel Structures
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