5.5.3.4 R-Factor Design Method

The design procedure for purlins in Clause 3.3.3.4 of AS/NZS 4600 is based on the use of reduction factors (R-factors) to allow for the flexural-torsional or nonlinear distortional behaviour of purlins with screw-fastened sheeting. The R-factors have been based on tests performed on purlin-sheeting systems in Australia and described in Refs. 5.23, 5.24 and 5.26. The test program included simple spans, continuous lapped double spans, continuous lapped triple spans, all under wind uplift, and continuous lapped triple spans under simulated gravity loading. The purlins were tested with 0, 1 and 2 rows of bridging (bracing). The computation of the *R*-factors is given in Johnston and Hancock (Ref. 5.32).

The R-factor design method simply involves applying a reduction factor (R) to the bending section capacity ($Z_e f_y$) as given by Eq. (5.35) to give the nominal member moment capacity.

$$M_b = R\, Z_e\, f_y \tag{5.35}$$

The resulting design moment (($\phi_b M_b$) is compared with the maximum bending moment in the span determined from a simple elastic beam analysis. The capacity reduction factor (ϕ_b) for use with Eq. (5.35) is *0.90*.

The reduction factors depend upon the loading and span type, and the direction of loading. They only apply for the range of sections, sheeting and screw fasteners tested as set out in Clause 3.3.3.4 of AS/NZS 4600. The *R*-factor design method is used for purlin sheeting systems with screw-fastened sheeting in lieu of Clause 3.3.3.2, Lateral Buckling.

5.6 Bracing

As described in Section 1.4.2, bracing of beams can be used to increase the flexural-torsional buckling load. In addition, non-doubly symmetric sections such as channel and Z-section purlins twist or deflect laterally under load as a consequence of the loading which is not located through the shear centre for channels or not in a principal plane for Z-sections. Consequently bracing can be used to minimise lateral and torsional deformations and to transmit forces and torques to supporting members. A photo of bolted bridging attached to a Z-section purlin with failure between the bridging points is shown in Fig. 5.17.

Fig. 5.17 Bridging bolted to purlin
(failure under test between bridging points)

For channel- and Z-sections used as beams, two basic situations exist as specified in Clause 4.3.3 of AS/NZS 4600. These are when:

(a) the top flange is connected to sheeting material in such a way that the sheeting effectively restrains lateral deflection of the connected flange as described in Clauses 4.3.3.2 Wind Uplift and 4.3.3.3 Gravity Load; and

(b) neither flange is so connected and bracing members are used to support the member as described in Clause 4.3.3.4.

The means by which the forces which accumulate in the sheeting or bracing are transmitted to the supporting structure or are eliminated are described in Clause 4.3.3.2 of AS/NZS 4600. These methods have been summarised diagrammatically in Fig. 5.18 for which the four cases described are:

(a) A system of bridging or bracing members sufficiently strong to carry the forces to a stiff support as shown in Fig. 5.18(a). The sheeting in this case does not need to be connected to the support or screw fastened along its laps to form a diaphragm.

(b) Arrangement of alternating members to oppose each other as shown in Fig. 5.18(b) so that forces do not accumulate in the sheeting or bracing. This method is particularly useful when a perimeter support system is not available. If the sheeting is sufficiently well screw-fastened to the purlins, then the bridging between pairs of opposed members may be omitted, although this may reduce the capacity of the individual members as described in the previous section.

(c) By a diaphragm with sufficient shear rigidity to transfer the forces to a stiff perimeter member as shown in Fig. 5.18(c). The perimeter member need not be connected to a rigid support if cleats are provided to prevent twisting of the members at the supports. In addition, lap fastening should be provided between the sheets to transmit shear forces through the sheeting.

(d) By direct axial stress in the roof sheets or bridging which is opposed by a balancing set from another roof plane as shown in Fig. 5.18(d). Alternatively, bracing may be used in the same way without direct connection to a stiff support.

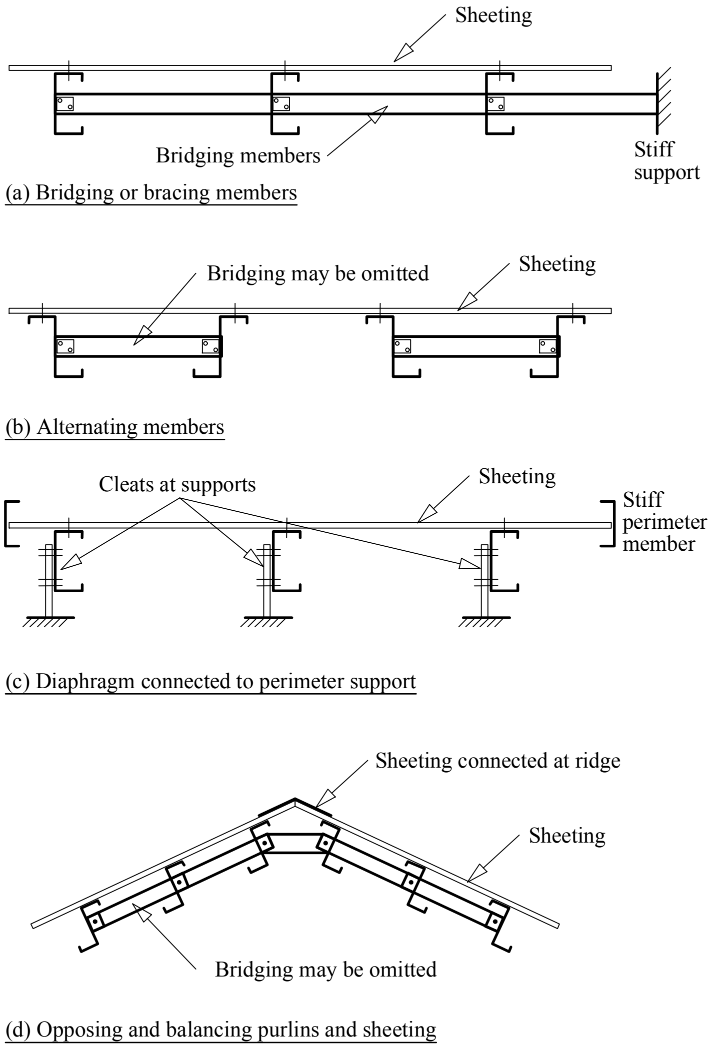

Fig. 5.18 Bracing systems

In the purlin tests with screw-fastened sheeting in the vacuum test rig described in Refs 5.23 and 5.24, it was found that side lap fasteners were sufficient to transfer membrane forces to cleats at the ends of the purlins, and the need for attachment of the bridging to stiff supports was not apparent during testing. Hence Clause 4.3.3.2 allows beam systems which satisfy the cleat and screw fastening requirements of Clause 3.3.3.4, Items (ix) to (xiv) to have bracing which is not connected to a stiff member but must be capable of preventing torsional deformation at the point of attachment. However purlins with concealed fastener sheeting still require bracing according to Clause 4.3.3.4.

Clause 4.3.3.3 of AS/NZS 4600 is taken directly from the AISI Specification. It applies to purlin-sheeting systems without cleats for which the bracing system is the main resistance to lateral bending and rolling of the purlins.

The formulae for the design of braces specified in Clause 4.3.3.4 are based on an analysis of the torques and lateral forces induced in a channel- or Z-section respectively assuming that the braces completely resist these forces. For the simple case of a concentrated load acting along the line of the web of a channel as shown in Fig. 5.19(a), the brace connected to the channel must resist a torque equal to the concentrated force times its distance from the shear centre. For the case of a vertical force acting along the line of the web of a Z-section as shown in Fig. 5.19(b), the brace must resist the load tending to cause the section to deflect perpendicular to the web. For the restraint at the centroid, no twisting occurs provided that the load is concentric. However for restraint at the load point on the top flange, considerable twisting of the section occurs. Consequently, if the lateral brace is not located at the centroid, then a pair of braces should be used at the top and bottom flange. It is also prudent to ensure that a single brace at the centroid can resist torsional deformation of the Z-section to allow for any loading eccentricity.

Clause 4.3.3.4 also specifies how the bracing forces should be calculated when the loads are not located at the brace points or are uniformly distributed loads.

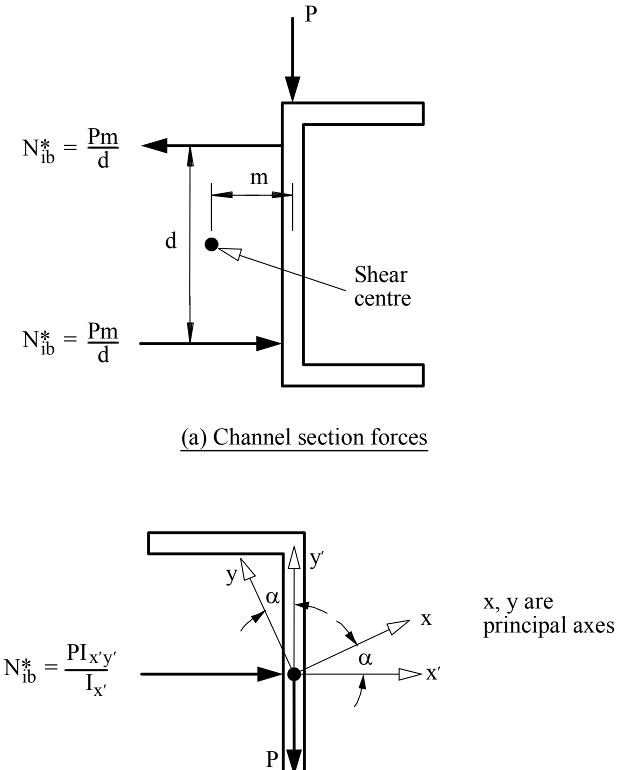

Fig. 5.19 Theoretical bracing forces at a point of concentrated load

Design of Cold-Formed Steel Structures

(To Australian/New Zealand Standard AS/NZS 4600:2005)

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