$$f_n = f_y\left(1-\frac{f_y}{4f_{od}}\right) \qquad f_{od} > \frac{f_y}{2} \tag{7.21}$$

$$f_n = f_y\left[0.055\left(\sqrt{\frac{f_y}{f_{od}}}-3.6\right)^2+0.237\right] \qquad \frac{f_y}{13} \leq f_{od} \leq \frac{f_y}{2} \tag{7.22}$$

where f_{od} is the elastic distortional buckling stress. Eq. (7.21) is the same as Eq. (7.19) except f_n has been substituted for f_{id}. Eq. (7.22) is a parabolic fit to the Kwon and Hancock test results. A comparison of Eqs (7.21) and (7.22) with the test results is shown in Fig. 7.5. In plotting Fig. 7.5, the measured face yield stress has been used to nondimensionalise the test results. In general, Eqs (7.21) and (7.22) provide a reasonable mean fit to the test results.

Eqs (7.21) and (7.22) have been adopted in Clause 3.4.6 of AS/NZS 4600. The critical stress (f_n) is multiplied with the full section area (A) to compute the nominal member compression capacity for distortional buckling. The full area (A) rather than the effective area is used since significant interaction between local buckling and distortional buckling was not observed in the tests in Refs 5.13 and 5.16.

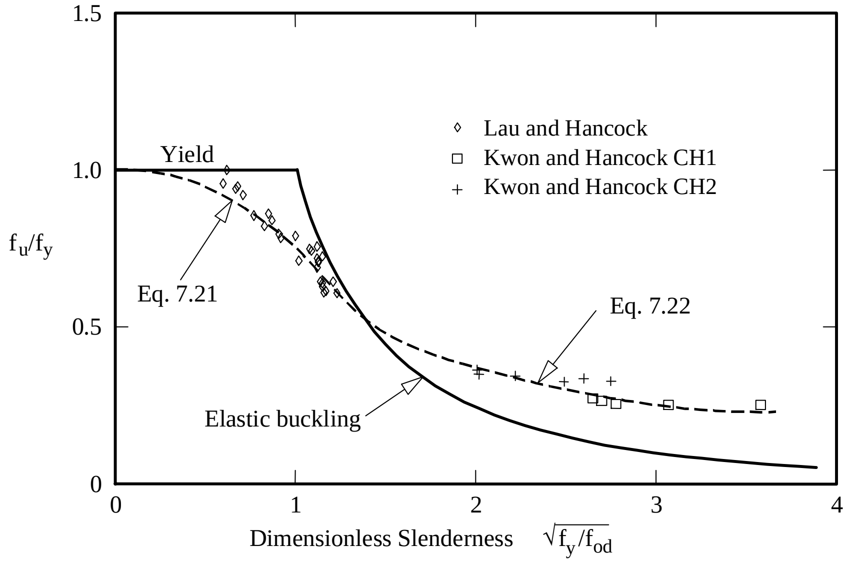

Fig. 7.5 Distortional buckling strength design curves for compression

7.5 Effect of Local Buckling

7.5.1 Monosymmetric Sections

As demonstrated in Fig. 7.2, local buckling of a monosymmetric section such as a channel will produce an effective section whose centroid (C_e) is at a different position from the centroid of the gross section. For columns axially loaded between pinned ends, the line of action of the force in the section will move as loading increases and will be eccentric from the line of the applied force. Hence the section will be subject to eccentric loading and so a bending moment will be applied in addition to the axial force. Clause 3.4 of AS/NZS 4600 requires the designer to allow for the moment resulting from the eccentricity of loading by stating that the axial load passes through the centroid of the effective section. Hence an initially concentrically loaded pin-ended monosymmetric column must be designed as a member subjected to combined compression and bending as described in Chapter 8 of this book.

For fixed-ended columns, it has been demonstrated (Ref. 7.5) that the line of action of the applied force moves with the internal line of action of the force which is at the effective centroid and so bending is not induced. Since most columns have some degree of end fixity, design based on loading which is eccentric from the effective centroid may be very conservative.

To investigate the effect of the moving centroid in more detail, both pin-ended and fixed-ended tests were performed on plain channel columns by Young and Rasmussen (Refs 7.6, 7.7). For the more slender sections tested (P48 with 48 mm wide flanges), the test results for the fixed-ended tests and for the pin-ended tests are compared with AS/NZS 4600 in Fig. 7.6. The fixed-ended tests underwent local and flexural buckling at shorter lengths and flexural-torsional buckling at longer lengths as shown in Fig. 7.6(a). The nominal member compression capacity (N_c) given by Clause 3.4.1 of AS/NZS 4600 compares closely with the test results. There is no need to include load eccentricity in the design of fixed-ended monosymmetric sections. The pin-ended tests underwent local and flexural buckling at shorter lengths and flexural buckling at longer lengths as shown in Fig. 7.6(b). The test results are considerably lower than the nominal member compression capacity (N_c) given by Clause 3.4.1 of AS/NZS 4600. Hence the effect of loading eccentricity must be included for the pin-ended tests. However, the design curves based on combined compression and bending (as discussed in Chapter 8) are considerably lower than the test results and are thus very conservative.

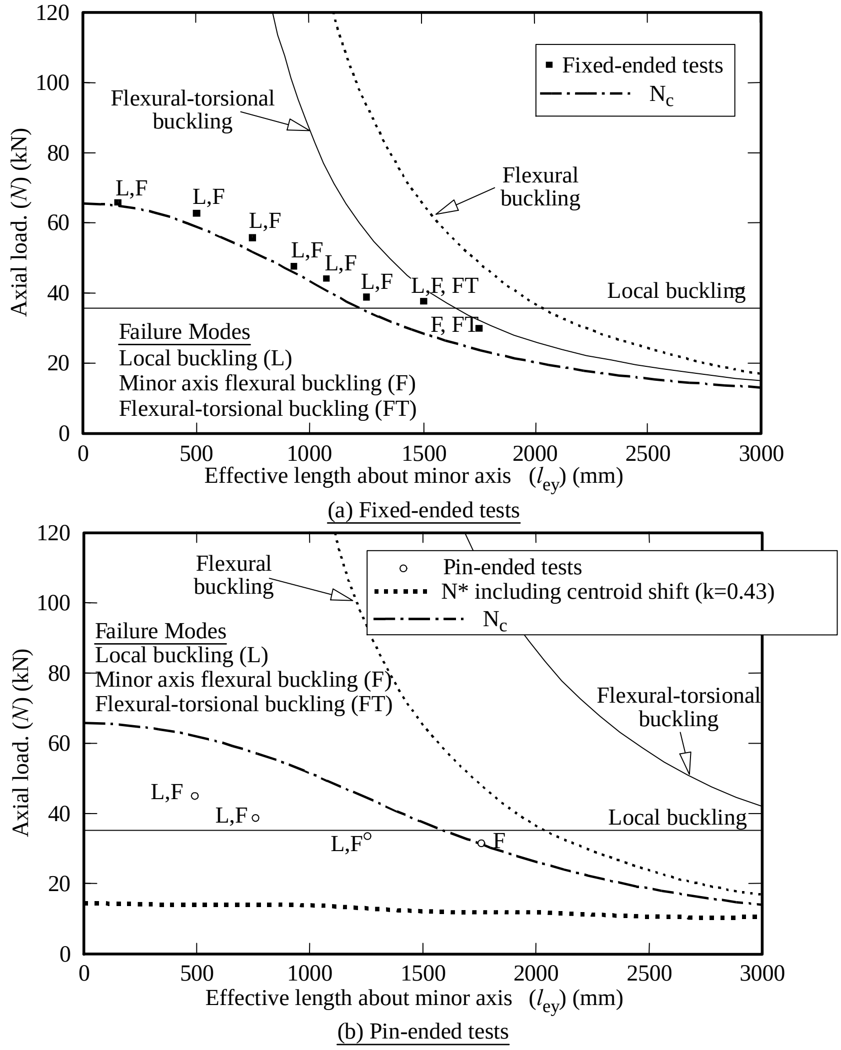

Fig. 7.6 Unlipped channel tests (Young and Rasmussen)

A similar investigation was performed by Young and Rasmussen (Ref. 7.8) for lipped channel columns. For the more slender sections tested (L48 with 48 mm wide flanges), the test results for the fixed-ended tests and pin-ended tests are compared with AS/NZS 4600 in Fig. 7.7. The fixed-ended tests underwent local and distortional buckling at shorter lengths and flexural/flexural-torsional buckling at longer lengths as shown in Fig. 7.7(a). The nominal member compression capacity (N_c) given by Clause 3.4.1 of AS/NZS 4600 is slightly lower than the test results probably as a result of a conservative prediction of the stub column strength. As for the unlipped specimens, there is no need to include load eccentricity in the design of fixed-ended monosymmetric sections. The pin-ended tests underwent local and flexural buckling at shorter lengths and flexural buckling at longer lengths as shown in Fig. 7.7(b). The test results are comparable with the nominal member compression capacity (N_c) given by Clause 3.4.1 of AS/NZS 4600. The design curves based on combined compression and bending (as discussed in Chapter 8) are lower than the test results. The position of the moving centroid as predicted by Clause 2.4.3.2 needs further investigation. The need to take account of the moving centroid does not appear to be as significant for the pin-ended lipped channels in Fig. 7.7(b) as for the pin-ended unlipped channels in Fig. 7.6(b).

The inclusion of the effect of loading eccentricity from the moving centroid is also shown for the slender-angle sections in Fig. 7.4(a). It can be seen to produce conservative design values when compared with the test results.

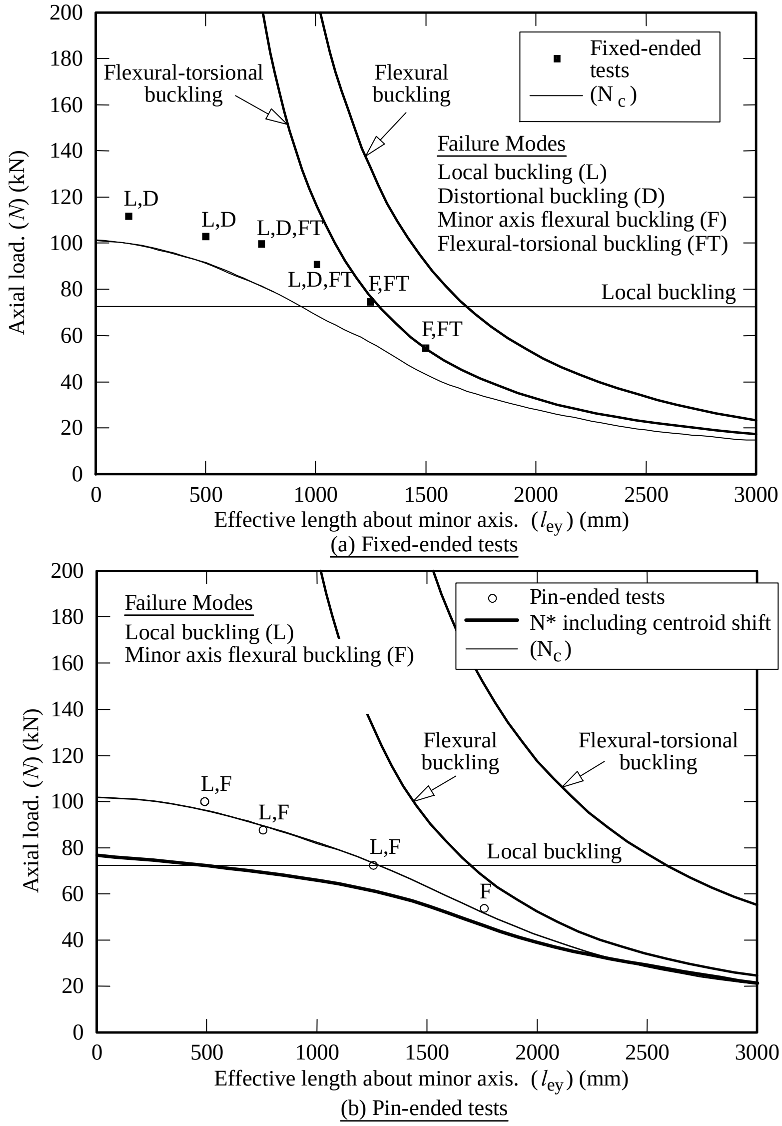

Fig. 7.7 Lipped channel tests (Young and Rasmussen)

7.5.2 High Strength Steel Box Sections

Pin-ended column tests were performed on closed sections brake pressed from aluminium/zinc-coated Grade G550 structural steel sheet to AS1397 in 0.42 mm and 0.6 mm thickness (Refs. 7.9, 7.10). Epoxy was used to close the LB-sections which were constructed from hat sections glued toe to toe. The lengths of the LB sections ranged from 450 mm to 1100 mm for the 0.60 mm sheet steel and 550 mm to 1700 mm for the 0.42 mm sheet steel.

Design of Cold-Formed Steel Structures
(To Australian/New Zealand Standard
AS/NZS 4600:2005)

by

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