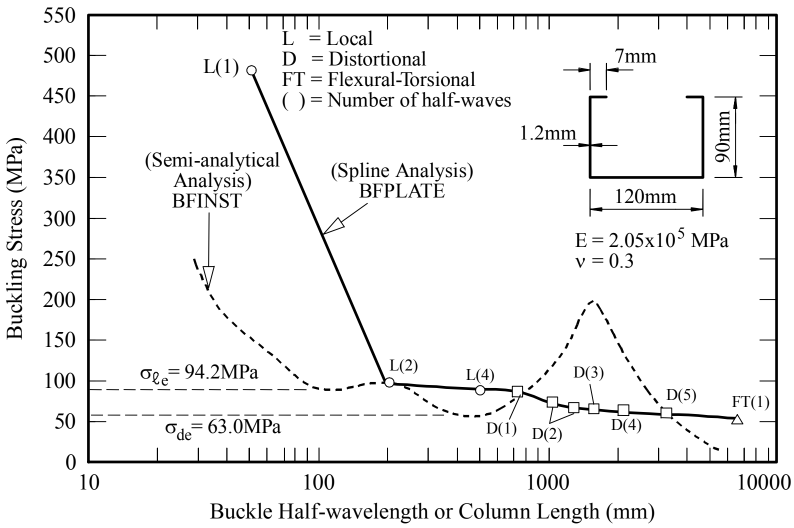

Fig. 3.10 Finite strip buckling analyses

3.3 Purlin Section Study

3.3.1 Channel Section

To demonstrate the different ways in which a channel purlin may buckle when subjected to major axis bending moment as shown in Fig. 3.11, a finite strip buckling analysis of a channel purlin of depth 150 mm, flange width 65 mm, lip size 14 mm, and plate thickness 1.5 mm has been performed and the results are shown in Fig. 3.12. This graph is similar to that for the lip-stiffened channel in Fig. 3.6 except for the shape of the buckling modes and their nomenclature.

The first minimum point (A) is again a LOCAL buckling mode which now involves the web, the compression flange and its lip stiffener. The second minimum point (B) is associated with a mode of buckling where the compression flange and lip rotate about the flange web junction with some elastic restraint to rotation provided by the web. This mode of buckling is called a FLANGE DISTORTIONAL buckling mode and is shown in a test specimen of a Z-section in Fig. 3.13. The value of the stiffener buckling stress is highly dependent upon the size of the lip stiffener.

At long wavelengths (point C) where the purlin is unrestrained, a flexural-torsional buckle occurs which is often called a LATERAL buckle. However if the tension flange is subjected to a torsional restraint such as may be provided by sheeting screw fastened to the tension flange, then a LATERAL DISTORTIONAL buckle will occur at a minimum half-wavelength of approximately 4000 mm as shown at point D in Fig. 3.12. The value of the minimum buckling stress and its half-wavelength depend upon the degree of torsional restraint provided to the tension flange.

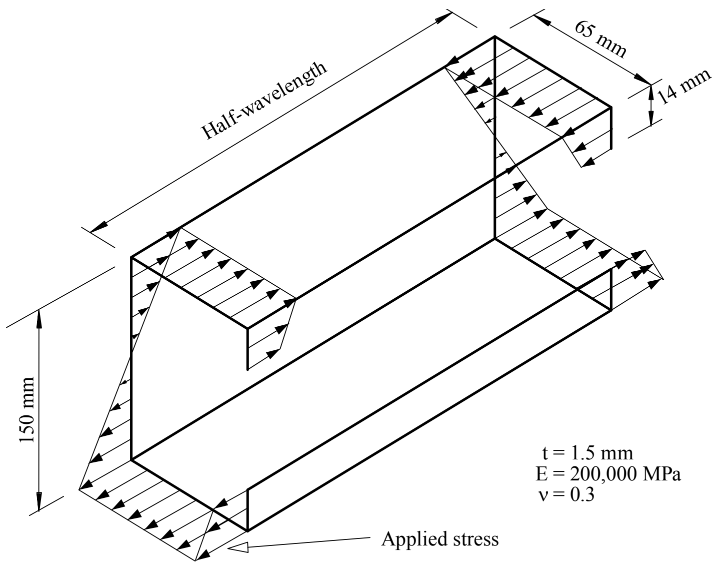

Fig. 3.11 Channel section purlin subjected to major axis bending moment

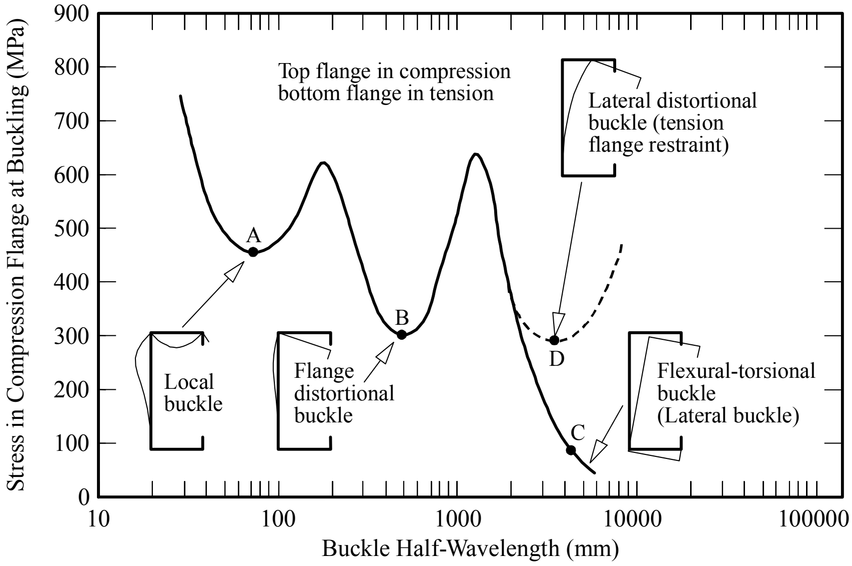

Fig. 3.12 Channel section purlin buckling stress versus half-wavelength for major axis bending

Fig. 3.13 Purlin flexural-torsional buckle with distortional buckle (foreground) and local buckle (background)

3.3.2 Z-Section

A similar study to that of the channel section in bending has been performed for the two Z-sections shown in Fig. 3.14. The first section contains a lip stiffener which is perpendicular to the flange and the second has a lip stiffener which is located at an angle of 45 degrees to the flange. In Fig. 3.14, the buckling stresses have been computed for buckle half-wavelengths up to 1000 mm so that only the local and stiffener buckling modes have been investigated.

As for the channel section study described above, the distortional buckling stresses are significantly lower than the local buckling stresses for both Z-sections. For the lip stiffener turned at 45 degrees to the flange, the flange distortional buckling stress is reduced by 19 percent compared with the value for the lip stiffener perpendicular to the flange thus indicating a potential failure mode of purlins with sloping lip stiffeners.

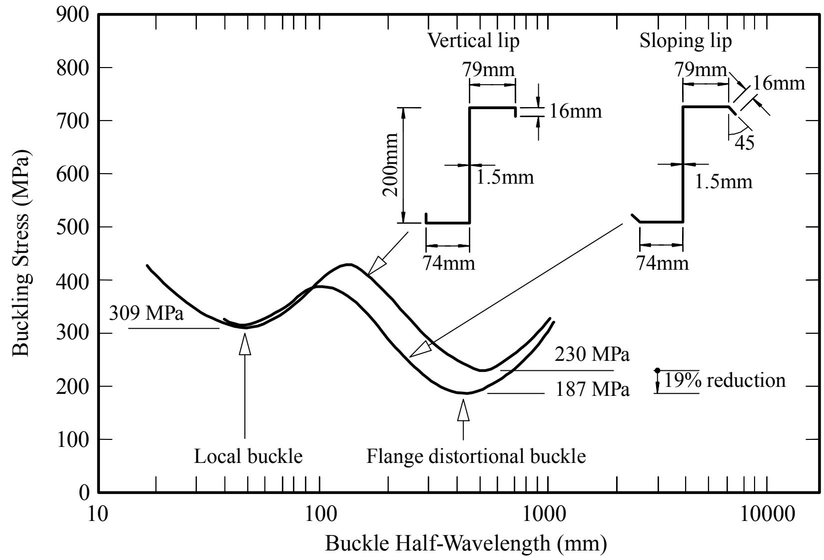

Fig. 3.14 Z-Section purlin - buckling stress versus half-wavelength for bending about a horizontal axis

3.4 Tubular Flange Sections

3.4.1 Hollow Flange Beam in Bending

The Hollow Flange Beam (HFB) section in Fig. 1.13 has been investigated using the semi-analytical finite strip buckling analysis. Two sections have been analysed to demonstrate the effect of the ERW weld on the section buckling behaviour. These are the section with closed flanges called ("HBS1"), and the section with open flanges (called "HBS2"). Fig. 3.15 shows graphs of buckling stress versus buckle half-wavelengths for the two sections subjected to pure bending about their major principal axes so that their top flanges are in compression and their bottom flanges are in tension as in a conventional beam. The buckling stress is the value of the stress in the compression flange farthest away from the bending axis when the section undergoes elastic buckling.

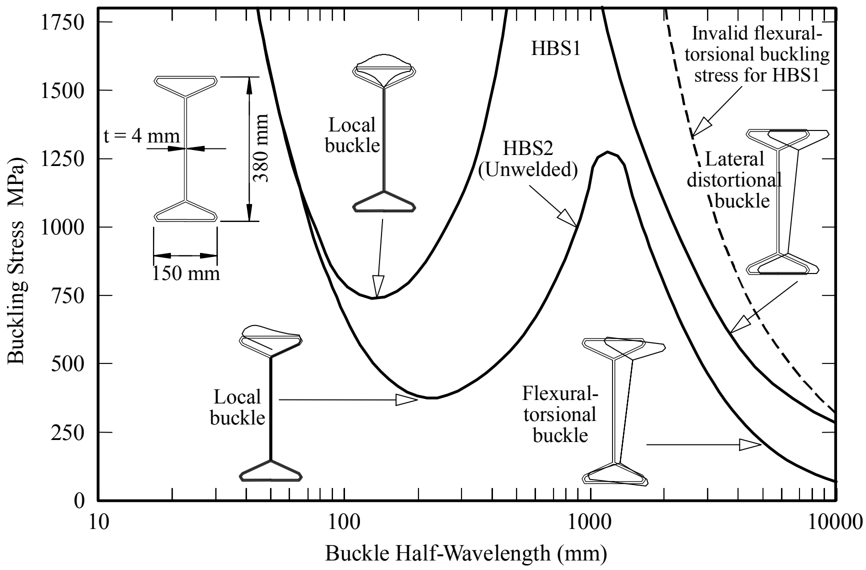

Fig. 3.15 Hollow flange beam - buckling stress versus half-wavelength for major axis bending

At short half-wavelengths (50 mm - 500 mm in Fig. 3.15), the effect of welding the flange to the abutting web clearly demonstrates the changed buckling mode from LOCAL BUCKLING in the unattached flange for HBS2 to LOCAL BUCKLING of the top flange at a higher stress for HBS1.

At long half-wavelengths (2000 mm - 10000 mm in Fig. 3.15), the increased torsional rigidity of

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by

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