

Code of practice for strength assessment of members of lattice towers and masts

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Contents

	Page
Committees responsible	Inside front cover
Foreword	ii
1 Scope	1
2 Definitions	1
3 Axes of members	1
4 Main symbols	2
5 Structural configurations and buckling length	2
5.1 General	2
5.2 Leg members	2
5.3 Bracing patterns	2
6 Calculation of ultimate member stress	9
6.1 General	9
6.2 Calculation of reference stress	9
6.3 Calculation of slenderness parameter	9
6.4 Ultimate member stress	10
6.5 Selection of buckling curves for angles	10
6.6 Compound members as bracing	11
6.7 Selection of buckling curve for tubular members	11
7 Secondary members	11
8 Calculation of ultimate strength of member in tension	12
9 Bolted connections	12
9.1 Angle bolted connections	12
9.2 Tubular bolted connections	12
Appendix A Calculation of N	14
Appendix B Typical values of σ_u	20
Figure 1 — Axes of members	1
Figure 2 — Symmetrical and staggered bracing to legs	3
Figure 3 — Cruciform angle sections	3
Figure 4 — Types of lattice bracing	4
Figure 5 — Typical plan bracing	8
Figure 6 — K bracing horizontals without plan bracing	8
Figure 7 — Cranked K bracing	9
Figure 8 — Portal frame	9
Figure 9 — Location of bolts	13
Figure 10 — Strut curves 1, 3 and 4	15
Figure 11 — Strut curves 2, 5 and 6	16
Table 1 — Effective length factor, k , for horizontal of K brace (without plan bracing)	7
Table 2 — Applied force as percentage of leg load, F	12
Table 3 — Values of N	17
Table 4 — Typical values of σ_u for steel of 355 N/mm ² yield and $B/T < 13.79$	20
Table 5 — Typical values of σ_u for steel of 355 N/mm ² yield and $B/T = 15$	22
Table 6 — Typical values of σ_u for steel of 255 N/mm ² yield and $B/T < 16.27$	24
Publications referred to	Inside back cover

Foreword

This Draft for Development has been prepared under the direction of the Civil Engineering and Building Structures Standards Committee.

During the drafting of BS 8100-1 (which covers the loading of lattice towers and masts), calibration exercises were undertaken to assess the reliability of the various factors proposed in the new British Standard. This Draft for Development was used as a means of assessing member strength and is therefore compatible with the partial safety factors given in BS 8100-1.

This publication is not to be regarded as a British Standard.

It is being issued in the Draft for Development series of publications and is of a provisional nature because it is based on the European Convention for Constructional Steelwork “Manual on Stability of Steel Structures”, Chapter 9.2 which provides recommendations for the design of lattice towers and is not formally recognized as a standard. It should be applied on this provisional basis, so that information and experience of its practical application may be obtained.

A review of this Draft for Development will be carried out not later than two years after its publication. Notification of the start of the review period, with a request for the submission of comments from users of this Draft for Development will be made in an announcement in the appropriate issue of *BSI News*. Observations which it is felt should receive attention before the official call for comments will be welcomed.

According to the replies received, the responsible BSI Committee will judge whether the Draft for Development can be converted into a British Standard or what other action should be taken.

It has been assumed in the drafting of this Draft for Development that the execution of its provisions will be entrusted to appropriately qualified and experienced people.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 26, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This Draft for Development provides a basis for assessing the strength of members and connections for towers of lattice construction consisting of bolted, riveted or welded steel angle or tubular sections. The recommendations given are valid for both equal and unequal angles, either rolled or cold formed, compound members fabricated from these sections and tubular members. The strengths given are characteristic (95 % probability) values for use with BS 8100-1.

For all other aspects of the design, reference should be made to BS 5950-1 or BS 5400-10. Connection eccentricities assumed in this Draft for Development are those that are traditionally applied to lattice towers in the UK.

NOTE The titles of the publications referred to in this Draft for Development are listed on the inside back cover.

2 Definitions

For the purposes of this Draft for Development the following definitions apply.

2.1

leg members

members forming the main loadbearing chords of the structure

2.2

bracing members

members other than legs carrying the shear force due to imposed loads on the structure

2.3

redundant members

members used to reduce the effective length of the main legs and sometimes that of the bracing. They are nominally unstressed and are only loaded due to deformation of the structure

NOTE Redundant members are sometimes referred to as secondary members.

3 Axes of members

For the purposes of this Draft for Development the axes of members are as shown in Figure 1.

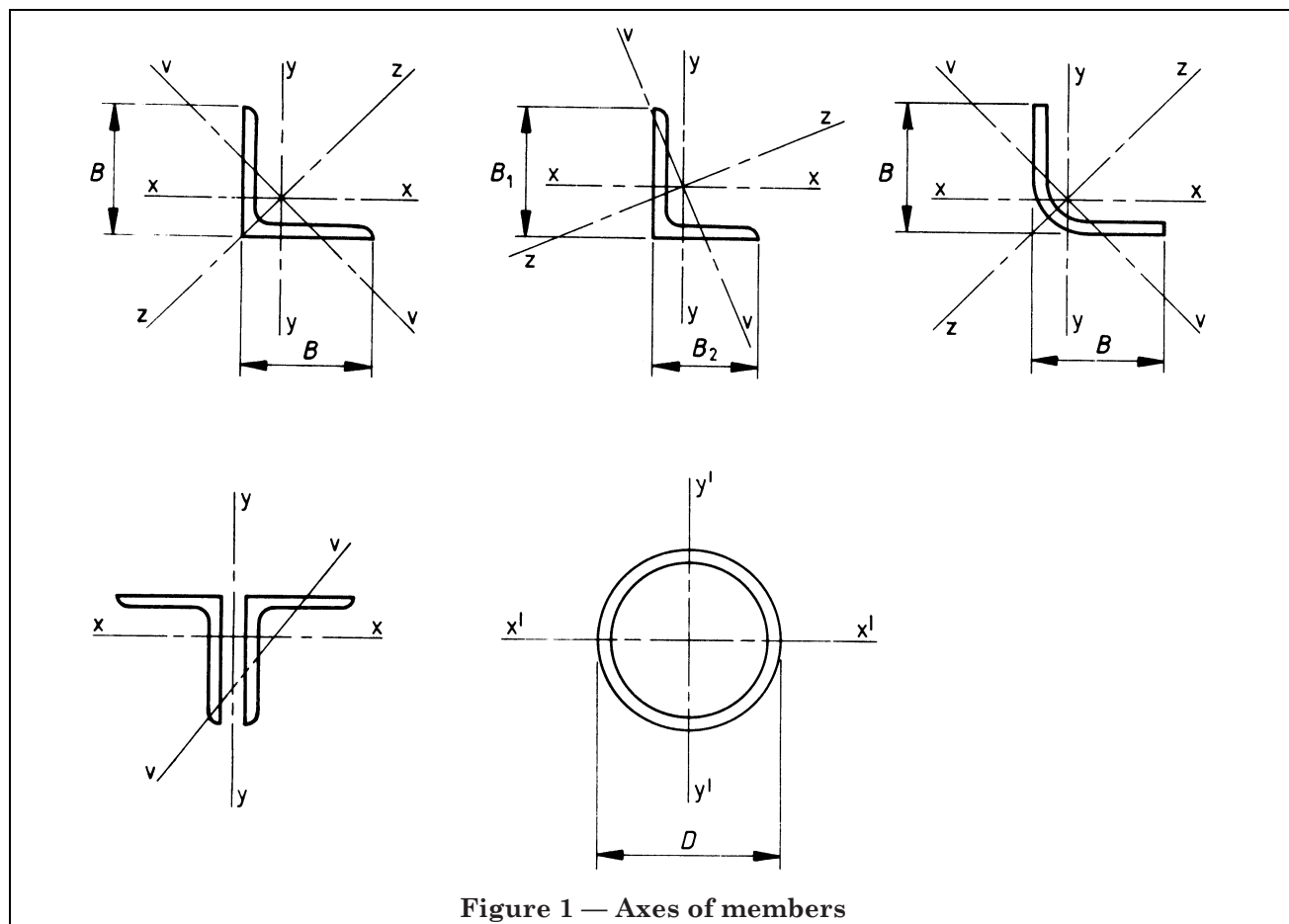


Figure 1 — Axes of members

4 Main symbols

For the purposes of this Draft for Development the following main symbols apply. Where possible, the symbols are based on those given in BS 8100-1 but it has not been possible to follow those conventions in all cases.

A_s	cross-sectional area of bolt shank in shear plane (in mm ²)
B	leg length of angle, i.e. breadth
C	length of individual angle between stitch bolts
D	bolt or tube diameter
E	modulus of elasticity of steel
F	leg load
k	effective length factor for horizontal of K brace with no plan bracing
L	length
N	ratio of the ultimate strength of a member to its reference stress
p_1	compressive force in horizontal of K brace
p_2	tensile force in horizontal of K brace
Q_u	ultimate strength of bolt
r_{vv}	radius of gyration about vv, xx and yy axes,
r_{xx}	respectively
r_{yy}	
T	thickness of angle leg
t	thickness of tube wall
x	distance from centre line of bolt to end of member
y	distance from centre line of bolt to edge of member
z	spacing between bolts
α	maximum B/T ratio for which $\sigma_r = \sigma_y$
η	Perry factor (non-dimensional)
λ	slenderness ratio, i.e. effective length divided by radius of gyration
Λ	non-dimensional slenderness parameter
$\bar{\Lambda}$	effective non-dimensional slenderness parameter
σ_b	specified minimum yield strength of bolt steel
σ_t	specified minimum ultimate tensile strength of bolt steel
σ_y	specified minimum yield strength of steel member
σ_r	reference stress of member (obtained from 6.2)
σ_u	ultimate or limit strength of member

5 Structural configurations and buckling length

5.1 General

There are a number of different configurations which are commonly used in lattice towers and each requires separate consideration.

5.2 Leg members

5.2.1 Single members. Single angles or tubular sections may be used for leg sections. The capacity of the leg will be dependent on the type of bracings used to stabilize the leg. For legs or chords with axial compression load braced symmetrically in two normal planes, the effective slenderness ratio should be determined from the length between nodes, i.e. intersections of bracings, and the radius of gyration about the vv axis for angle sections and about the xx axis for tubular sections [see Figure 2(a) and Figure 2(b)].

When the bracing is staggered in two normal planes, the effective length should be taken as the length between nodes on one face and the radius of gyration about the rectangular axis should be used to calculate the slenderness ratio [see Figure 2(c) and Figure 2(d)].

Where angle members are used, to compensate for the simultaneous deflections of the leg about the vv and zz axes (see Figure 1), a lower buckling load should be obtained for the case shown in Figure 2(d) by the use of a different buckling curve given in 6.5.3.

5.2.2 Compound members. Compound members for legs may be built up with two angles in cruciform section and then taken as fully composite if welded continuously [see Figure 3(a)]. When bolted [see Figure 3(b)] the possible additional deformations due to shear should be taken into account by modifying the slenderness ratio in accordance with the following:

$$\lambda^2 = \lambda_0^2 + \lambda_1^2$$

where

λ_0 is the slenderness ratio of the full member;

λ_1 is the slenderness ratio of one component angle = C/r_{vv}

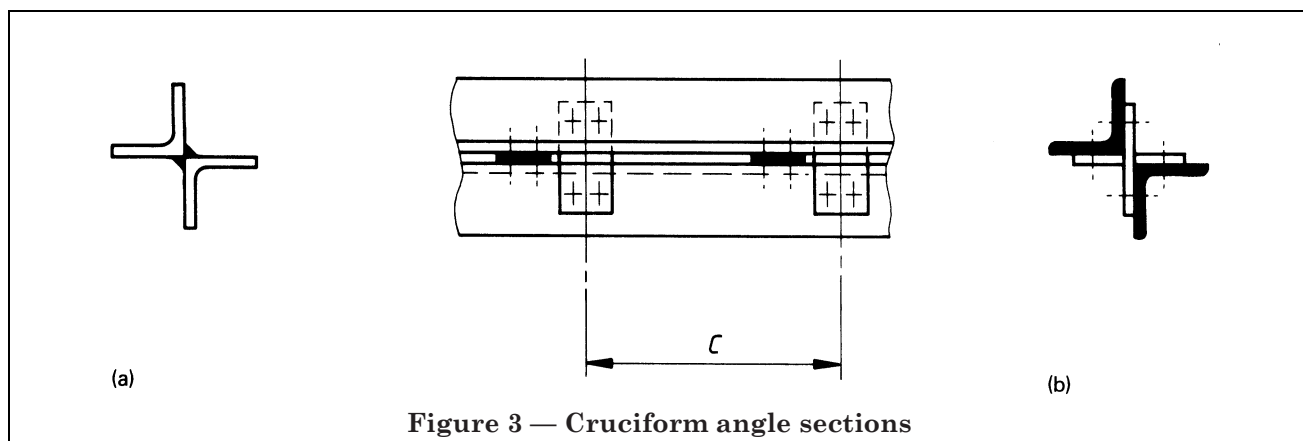
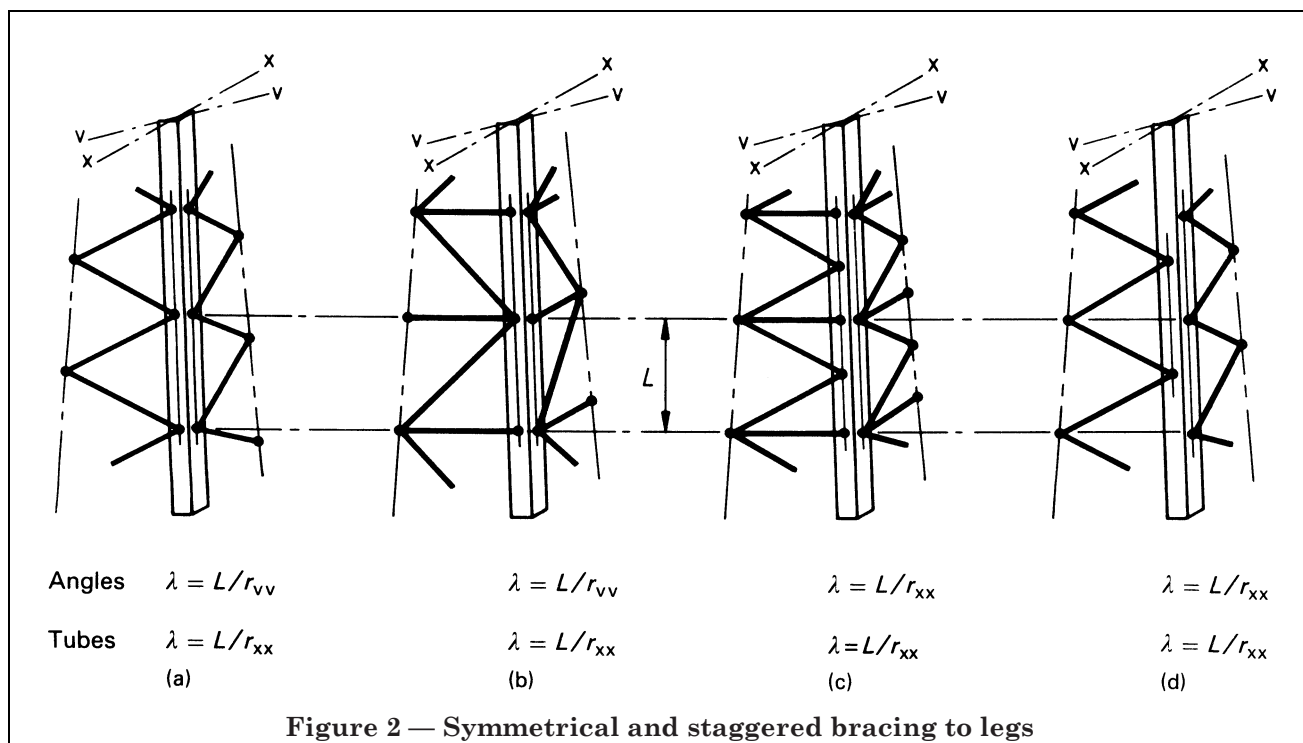
NOTE It is good practice to have $\lambda_0 > \lambda_1$ and $\lambda_1 < 40$ to 50.

5.3 Bracing patterns

5.3.1 Single lattice. A single lattice is commonly used where the loads are light and the lengths relatively short, as for instance near the top of lattice towers [see Figure 4(a)]. The slenderness ratio should be taken as

$$\lambda = L/r_{vv} \text{ for angles}$$

$$\lambda = L/r_{xx} \text{ for tubes.}$$



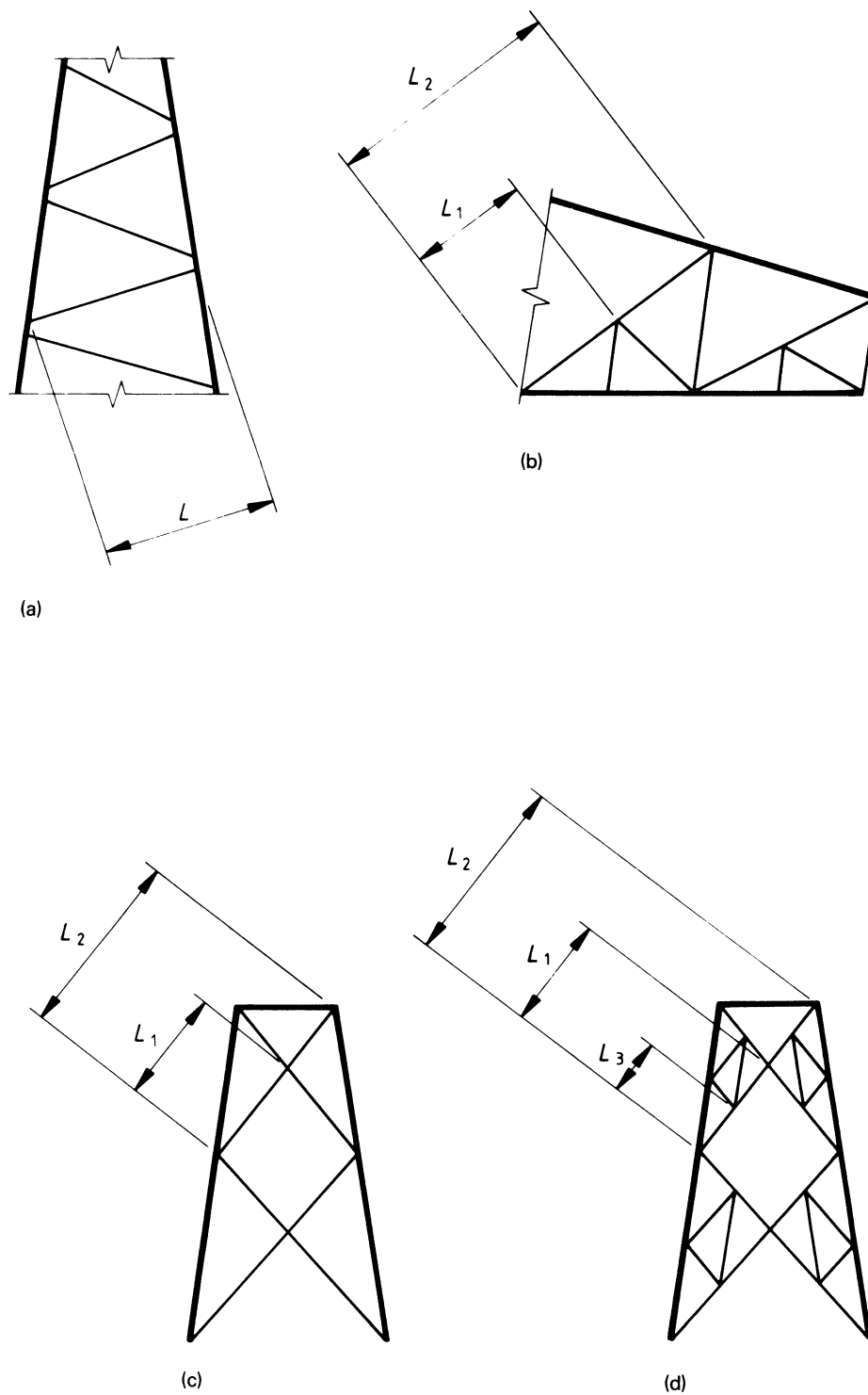


Figure 4 — Types of lattice bracing

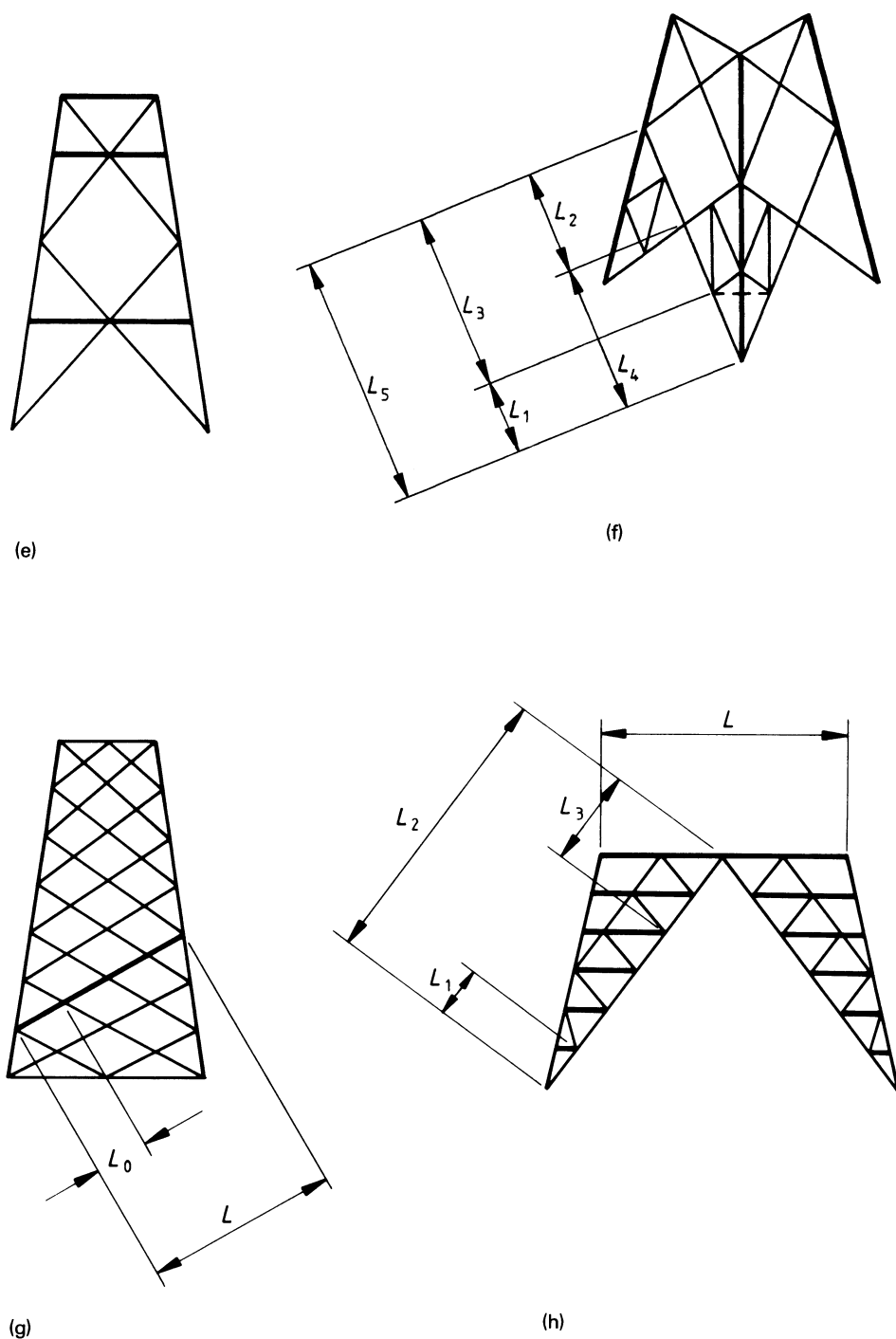


Figure 4 — Types of lattice bracing (concluded)

5.3.2 Single lattice with redundant members. A single lattice with redundant members should be used where it is necessary to provide intermediate restraints to one chord but not to the other, as for instance in cross arm designs [see Figure 4(b)]. The redundant members, in addition to stabilizing the chord, provide a restraint in one plane to the bracing lattice at the point of attachment.

For single angle bracing, this restraint may be assumed to be such that the buckling on the minimum axis (vv) will only take place over the length L_1 . Buckling over the whole length L_2 may take place on the appropriate rectangular axis (xx or yy) for angles and the xx axis for tubes. When additional loads are introduced to the bracing at the intermediate support, buckling on the minimum axis should be calculated by taking the maximum load in the bracing over the appropriate short length; buckling on the rectangular axis is the buckling of a strut with a variable load and may be approximated by taking the sum of $0.75 \times$ the heavier load and $0.25 \times$ the lighter load as being the effective load acting for buckling over the whole length of L_2 on the rectangular axis. The slenderness ratio should be taken as:

$$\lambda_1 = L_1/r_{vv} \text{ or } \lambda_2 = L_2/r_{yy} \text{ for angles;}$$

$$\lambda_2 = L_2/r_{xx} \text{ for tubes.}$$

5.3.3 Cross bracing. Provided the load is equally split into tension and compression and provided also that both members are continuous [see Figure 4(c)], the centre of the cross may be considered as a point of restraint both transverse to and in the plane of the bracing and the critical buckling length becomes length L_1 on the minimum axis. The slenderness ratio should be taken as:

$$\lambda_1 = L_1/r_{vv} \text{ for angles;}$$

$$\lambda_1 = L_1/r_{xx} \text{ for tubes.}$$

When the load is not equally split into tension and compression and provided both members are continuous, the compression members should be checked in the same way for the worst compressive load. In addition, it should be checked that the sum of the load carrying capacities of both members in compression is at least equal to the algebraic sum of the loads in the two members.

For the calculation of the load carrying capacities, the buckling length is the whole length L_2 and the radius of gyration is that about the rectangular axis parallel to the plane of the bracing. The slenderness ratio should be taken as:

$$\lambda_2 = L_2/r_{xx} \text{ or } L_2/r_{yy} \text{ for angles;}$$

$$\lambda_2 = L_2/r_{xx} \text{ for tubes.}$$

5.3.4 Cross bracing with redundant members.

Where redundant members are inserted to stabilize the legs [see Figure 4(d)], they also reduce the buckling length on the minimum axis to L_3 . The slenderness ratio should be taken as:

$$\lambda_3 = L_3/r_{vv} \text{ for angles;}$$

$$\lambda_3 = L_3/r_{xx} \text{ for tubes.}$$

Buckling should be checked over length L_1 on the rectangular axis for buckling transverse to the bracing and then over length L_2 for the algebraic sum of the loads (see 5.3.3).

5.3.5 Discontinuous cross bracing with continuous horizontal at centre intersection. The horizontal member should be sufficiently stiff in the transverse direction to provide restraints for the load cases where the compression in one member exceeds the tension in the other or both members are in compression [see Figure 4(e)]. This criterion should be satisfied by ensuring that the horizontal member will withstand (as a strut over its full length on the rectangular axis) the algebraic sum of the load in the two members of the cross brace resolved in the horizontal direction.

5.3.6 Cross bracing with diagonal corner stays. In some types of cross bracing where the length is rather longer than desirable, a corner stay is inserted to reduce the buckling length transverse to the plane of bracing [see Figure 4(f)]. A similar procedure to that used for 5.3.3 may be used to determine whether this will provide a satisfactory restraint.

In this case five stability checks should be carried out.

- Stability of member against the maximum load over length L_1 on the minimum axis.
- Stability of member against the maximum load over length L_2 on the transverse rectangular axis.
- Stability of two members in cross brace against the algebraic sum of loads in cross brace over length L_3 on the transverse axis.
- Stability of two members (one in each of two adjacent faces) against the algebraic sum of loads in two members connected by diagonal corner brace over length L_4 on the transverse axis.
- Stability of four members (each member of cross brace in two adjacent faces) against the algebraic sum of loads in all four members over length L_5 on the transverse axis.