

Lattice towers and masts —

Part 4: Code of practice for loading of guyed masts

UDC 624.97.074.5

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee B/525, Building and civil engineering structures, to Subcommittee B/525/32 upon which the following bodies were represented:

- Association of Consulting Engineers
- British Cement Association
- British Constructional Steelwork Association Ltd.
- British Masonry Society
- Building Employer’s Confederation
- Department of the Environment (Building Research Establishment)
- Department of the Environment (Construction Directorate)
- Department of Transport
- Federation of Civil Engineering Contractors
- Institution of Civil Engineers
- National Council of Building Material Producers
- Royal Institute of British Architects
- Timber Research and Development Association

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

- British Broadcasting Corporation
- British Telecommunications plc
- Department of Trade and Industry (Electricity Division)
- Meteorological Office
- Steel Construction Institute

This British Standard, having been prepared under the direction of the Technical Committee B/525, Building and civil engineering structures, was published under the authority of the Standards Board and comes into effect on 15 February 1995

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The following BSI references relate to the work on this standard:
Committee reference B/525/32
Draft for comment 92/15665 DC

Amendments issued since publication

Amd. No.	Date	Comments
13787	8 April 2003	See foreword
15979	17 November 2005	Correcting errors in Annex K and Annex M. See also foreword

ISBN 0 580 22706 5

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Foreword

This Part of BS 8100 has been prepared under the direction of Technical Committee B/525, Building and civil engineering structures. BS 8100 is a standard combining codes of practice with a guide covering the loading and design of lattice towers and masts of metallic construction.

It comprises the following Parts:

- *Part 1: Code of practice for loading;*
- *Part 2: Guide to the background and use of Part 1 “Code of practice for loading”;*
- *Part 3: Code of practice for strength assessment of members of lattice towers and masts;*
- *Part 4: Code of practice for loading of guyed masts.*

This Part of BS 8100 does not apply to other metallic structures. Other British Standards exist for some of those structures.

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

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

The start and finish of text introduced or altered by Amendment No. 1 is indicated in the text by tags **A1** **A1**.

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This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 81 and a back cover.

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Section 1. General

1.1 Scope

This Part of BS 8100 gives recommendations for procedures to be used to determine the loading for the design or appraisal of guyed masts of lattice construction.

The procedures given primarily apply to bolted, riveted or welded metallic structures composed of leg members and triangulated bracings. Section 5 may be inappropriate for masts of Vierendeel form, due to their stiffness characteristics. The response of such masts should be determined using published sources.

This Part of BS 8100 covers dead loads and wind and ice loading. Other superimposed loads are not covered and, where appropriate, should be considered.

This Part of BS 8100 is applicable to structures in the United Kingdom for which specific meteorological data are given. Guidance is also provided on the use of this Part of BS 8100 for structures in other countries.

This Part of BS 8100 is based on the principles of limit state design and the partial safety factors given are appropriate only for masts designed in accordance with this standard.

1.2 References

1.2.1 Normative references

This Part of BS 8100 incorporates, by dated or undated reference, provisions from other publications. These normative references are made at the appropriate places in the text and are listed on the inside back cover. For dated references, only the edition cited applies; any subsequent amendments to or revisions of the cited publication apply to this Part of BS 8100 only when incorporated in the reference by amendment or revision. For undated references, the latest edition of the standard applies, together with any amendments.

1.2.2 Informative references

This Part of BS 8100 refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover, but reference should be made to the latest editions.

1.3 Definitions

For the purposes of this Part of BS 8100, the following definitions apply.

1.3.1

wind resistance

the resistance to the flow of wind offered by the elements of a mast and any ancillary items that it supports, given by the product of the drag (pressure) coefficient and a reference projected area

1.3.2

linear ancillary item

any non-structural component extending over several panels

NOTE Examples of linear ancillary items are waveguides, feeders, ladders and pipework.

1.3.3

discrete ancillary item

any non-structural component, concentrated within a few panels

NOTE Examples of discrete ancillary items are dish reflectors, aerials, lighting and insulators.

1.3.4

projected area

the shadow area of the element considered when projected on an elevation normal to the face of the mast under consideration

NOTE For wind blowing other than normal to the mast, a reference face is used for the projected area.

1.3.5

panel

a convenient division of a mast into vertical elements for the purposes of deriving projected areas and wind resistance

NOTE Panels are typically, but not necessarily, taken between intersections of legs and primary bracings.

1.3.6**section**

a convenient division of a mast comprising several identical or nearly identical panels, for the purpose of deriving wind resistance

NOTE For the purposes of analysis it should be ensured that the mast column is subdivided into a sufficient number of sections between adjacent guy levels to model the mast loading and structural behaviour accurately. A minimum of four sections between adjacent guy levels should be used.

1.3.7**characteristic strength**

the strength of a component having a prescribed probability of not being exceeded

NOTE For the purposes of this Part of BS 8100 the characteristic strength may be taken as the strength given in BS 8100-3 or BS 5950. In BS 5950, strengths are referred to as design strengths because the partial factor γ_m in BS 5950 is taken as 1.0.

1.3.8**design strength**

the strength of a component obtained by dividing the characteristic strength (see 1.3.7) by a partial factor γ_m

1.4 Symbols**1.4.1 Main symbols**

The main symbols used in this Part of BS 8100 are as follows. For subscripts other than those given in this subclause, see 1.4.2. Symbols are further clarified as appropriate in the text.

A	projected area
<i>or</i>	cross-sectional area
b	width of mast
C	drag (pressure) coefficient
c	distance from leading edge of mast
D	diameter
<i>or</i>	distance
E	elastic modulus
F	load effect in a member (e.g. force, shear or bending moment)
G	gust response factor
g	cost ratio
H	overall height
<i>or</i>	height above mast base
h	height
I	inertia
i	service life
i_0	turbulence intensity
j	patch load pattern
K	factor
k	coefficient
L	projected length
l	length of guy
M	bending moment
m	mass per unit height
N	number
n	frequency
P	wind load

Q	parameter
R	wind resistance
R_e	effective Reynolds number
r	radial ice thickness
<i>or</i>	response
S	Strouhal number
<i>or</i>	wind factor
T	torque
<i>or</i>	wind factor
t	time
V	wind speed
$\bar{V}$	hourly mean wind speed
v	coefficient of variation
X	horizontal distance from crest of hill
<i>or</i>	spacing to upwind sheltered building
z	height
z_0	terrain roughness length
α	slope of guy to horizontal
β	parameter
γ_{DL}	partial safety factor on dead load
γ_m	partial safety factor on strength
γ_v	partial safety factor on wind speed and ice thickness
Δ	deflection
<i>or</i>	altitude
δ	logarithmic decrement of damping
η	shielding factor
θ	angle of wind incidence to the normal in plane
λ	factor
ν	kinematic viscosity of air
ρ	density
φ	solidity ratio
Ψ	angle of wind incidence to the longitudinal axis
<i>or</i>	tangent of upwind slope of topographic feature
ω	spacing ratio

1.4.2 Subscripts

Subscripts (and other symbols), where used in this Part of BS 8100, are as follows.

A	ancillary item
a	aerodynamic
<i>or</i>	air
<i>or</i>	altitude
av	average
b	basic
C	cantilever
c	circular-section members
<i>or</i>	fetch

cr	critical
d	direction
e	effective
or	excitation
F	face
f	flat-sided members
G	guy
g	gradient wind
H	mast height
h	topography
i	with ice
k	characteristic
L	length
l	level
M	bare mast or mast only
m	mast
N	overall
n	single frame
o	in the absence of wind
or	obstruction
PL	patch load
R	resonant
r	reference
S	site
or	serviceability
s	seasonal
or	structure
or	span
t	town
TL	turbulent length
w	with wind
W	in the direction of the wind
X	in the crosswind direction
Z	in the vertical direction
z	height z above ground level
θ	angle of wind incidence
—	due to hourly mean wind effects, e.g. $\bar{V}$, $\bar{P}$, $\bar{F}$
'	due to fluctuating wind effects, e.g. V' , P' , F'

Section 2. Performance

2.1 Safety and service life

2.1.1 General

In order to select appropriate safety factors to be applied in design to the loadings defined in this Part of BS 8100, consideration should be given to the reliability required of a mast during its intended period of service. The factors adopted should take into account the risk to life in the event of a collapse and the potential economic or strategic consequences of failure. They should also depend on the quality of materials and workmanship specified and achieved in construction.

Appropriate values of the safety factors should be determined in accordance with 2.2, 2.3 and 2.4.

For many masts, simple static analysis of the structure under factored and patch loads is sufficient to determine the loading effects. For masts which are likely to exhibit dynamic sensitivity, the spectral analytical method should be adopted. The criteria for when such methods are required are set out in 5.1.2.

For modifications to existing structures, due account should be taken of any changed performance requirements since the original design of the mast.

2.1.2 Service life

For the purposes of this Part of BS 8100, the service life i , in years, is taken as the intended period of service of the mast. A mast designed in accordance with this Part of BS 8100 may, if adequately maintained, provide consistent reliability beyond the period of its service life, that period being used only as a basis for the economic assessment of the appropriate annual risk of failure. However, the fatigue life may limit the period of reliable service.

During the construction of masts, the loading effects can differ greatly from those in service, and should be assessed. For partly erected masts and temporary guys a lower partial safety factor γ_v than for the in-service condition may be justified, depending on the consequences of failure of the partly completed structure.

2.2 Classification of required reliability

2.2.1 General

The safety factors to be used, appropriate to the reliability required of a mast, should be selected on the basis of the most onerous of the following:

- a) the potential hazards resulting from failure of the mast, i.e. the environmental conditions near the mast (see 2.2.2); or
- b) the economic consequences of failure or the usage of the mast (see 2.2.3).

2.2.2 Environmental conditions

The environmental category of the mast should be selected with due consideration of the potential risk to life in the event of the mast's failure. This risk will depend on the location and size of the structure in relation to inhabited buildings, railways or roads and on the possible contingent effects of collapse.

Figure 1 indicates categories which should be used to select safety factors within the range appropriate to the environment of the mast.

2.2.3 Economic consequences or usage

2.2.3.1 General

Where the potential risk to life is small, e.g. for unmanned sites in open countryside, or where the economic consequences of failure are great, e.g. for a major link in a telecommunications network, the safety factors should be selected with regard to the potential cost in the event of collapse.

Reduced wind speeds can be used for temporary structures or during the erection of masts if the period of exposure is planned to be within summer months (see 3.1.3). Safety factors for masts may also be reduced during their erection if it can be determined that the consequences of failure are lower than for the in-service condition.

2.2.3.2 *Economic consequences of failure*

The potential total cost, at net present value, of failure within the design service life should be estimated. This should include the cost of removal and replacement of the mast and its ancillary attachments and all contingent costs such as loss of revenue, third-party claims and loss of amenity. The ratio g of this consequential cost to the initial cost of the mast should then be evaluated.

Figure 1 indicates categories of the potential economic consequence of failure, represented as the logarithm of gi , where i is the service life.

2.2.3.3 *Usage*

If the economic consequences of failure cannot be judged, the reliability should be selected on the basis of the usage of the mast as indicated in Figure 1.

NOTE The left-hand limit of the range shows the minimum factors of safety that should be used; higher factors than those given by the right-hand side of the range indicated may be appropriate.

2.3 Classifications of quality

2.3.1 General

The reliability of a mast depends in part on the quality of the materials and workmanship used in its construction and on the adequacy of the maintenance after its erection. It also depends on the degree of control checking of the design and installation. The quality categories to be adopted for use with this Part of BS 8100 are given in 2.3.2, 2.3.3 and 2.3.4. The method of assessment given in Annex A may be used as a guide to determine the appropriate quality classification.

2.3.2 Class A masts

Masts should only be considered to be of quality class A if they conform to all of the following conditions.

- a) The structural design should be in accordance with this Part of BS 8100 and BS 8100-3.¹⁾
- b) The design and detailing should be subject to a satisfactory comprehensive independent appraisal or type test.
- c) To ensure that the required standards are achieved and maintained, quality control procedures, agreed with the designer, should be adopted in all stages of the production, fabrication and erection of all structural components.
- d) The mast, including all guys and anchorages, should be subject to comprehensive inspection at agreed intervals to check for damage, bolt loosening, weld cracking, corrosion or any other deterioration and any deficiencies rectified in order to maintain the structure in good condition. The interval between inspections should not exceed 2 years for class A and 5 years for class B. Guy tensions and mast column verticality should be checked at regular intervals not exceeding 5 years. More frequent guy tension checks may be specified during the first 10 years of the life of the structure. Guy tensions should also be checked after major storms or significant loading changes.

NOTE Guidance is provided in Annex A.

2.3.3 Class B masts

Masts should be considered to be of quality class B if they only conform to conditions 2.3.2a), 2.3.2c) and 2.3.2 d) or meet the appropriate criteria of Annex A.

2.3.4 Class C masts

Masts should be considered to be of quality class C if they only conform to conditions 2.3.2a) and 2.3.2c) or meet the appropriate criteria of Annex A.

¹⁾ The strength of masts designed in accordance with other relevant British Standards, may be deemed to be in accordance with this Part of BS 8100, provided that the factors of safety given in 2.5 are used in a), and compatible standards are used in a), c) and d).

2.3.5 Appraisal of existing masts

Where an existing mast is to be appraised, and the designer is satisfied by detailed site inspection and from documentary evidence that conditions 2.3.2a), 2.3.2b), 2.3.2c) and 2.3.2d) are satisfied as appropriate, then class A or B may be considered in accordance with 2.3.2 and 2.3.3. However, if no site inspection is undertaken or if the site inspection and documentary evidence show that conditions 2.3.2b) and 2.3.2d) are not satisfied then class C should be considered appropriate only if documentary evidence exists to show that conditions 2.3.2a) and 2.3.2c) were satisfied at the time of construction.

2.3.6 Reappraisal following significant loading changes

The design of the whole structure should be reappraised in the event of any significant increase or decrease in height or loading.

2.4 Safety factors

2.4.1 Wind speed and ice thickness factors

Partial safety factors γ_v should be applied to both wind speed and ice thicknesses in accordance with 3.2.1 and 3.5, respectively. An appropriate value should be selected by reference to Figure 1 using the greater value obtained from the most onerous performance requirement, i.e. according to environment, economic consequences or usage.

When spectral analytical procedures are used in accordance with 5.5, γ_v may be multiplied by 0.97.

2.4.2 Dead load and partial factors

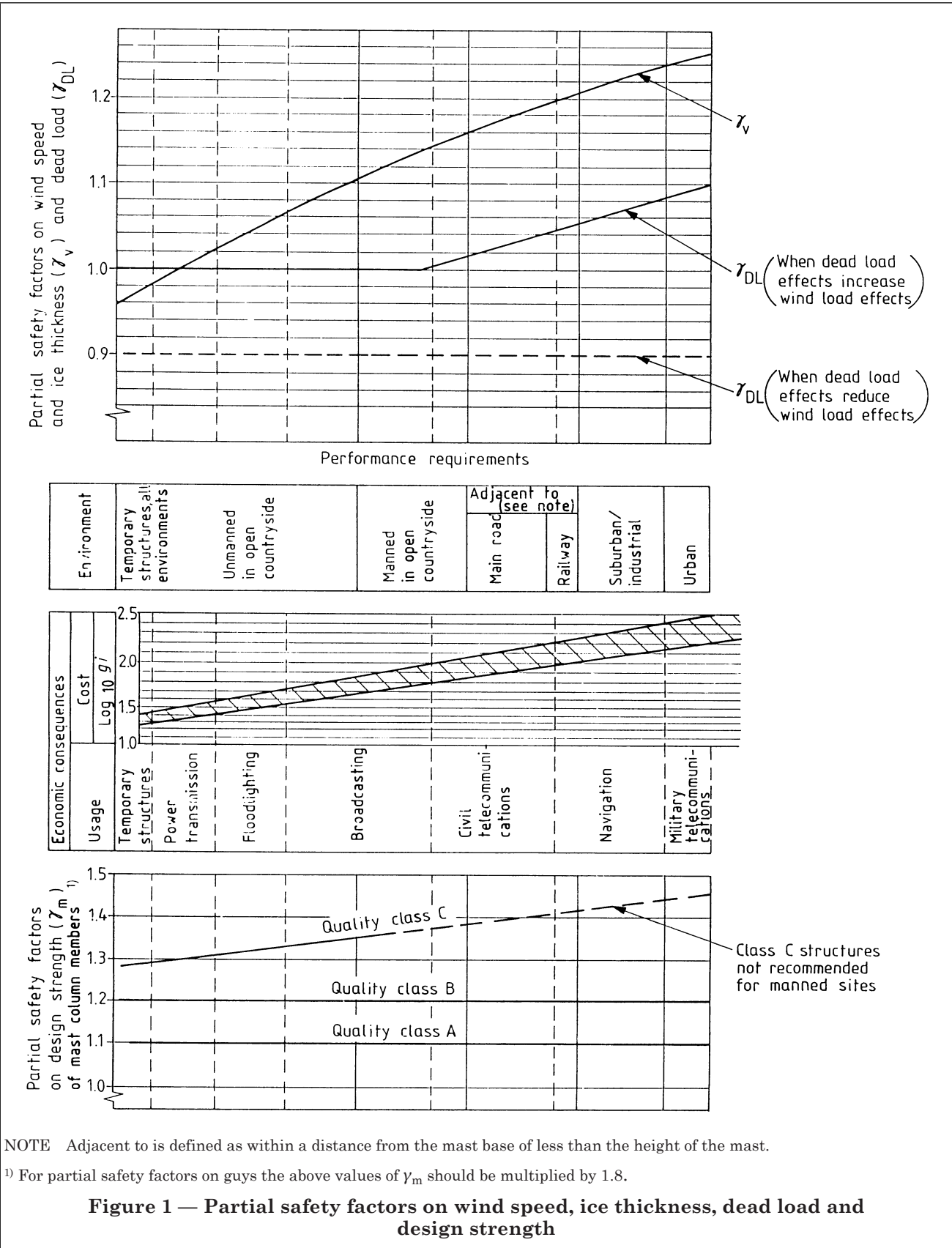
2.4.2.1 *Dead load factors*

Partial safety factors γ_{DL} should be applied to the self-weight of the structure including ancillary attachments (see 2.4.2.2). These should be selected by reference to Figure 1 appropriate to the performance requirements for the wind speed and ice thickness factors (see 2.4.1). When the dead load factors are additive to wind load effect, the factors are given by full lines. For conditions where the dead load effects reduce the wind load effects, the lower value given by the dashed line should be used.

2.4.2.2 *Calculation of dead loads*

The self-weight of the mast, including ladders, platforms and guys, should be based on nominal sizes of members, with an appropriate allowance for gussets, bolts, welds, insulators and linkages.

The self-weight of ancillaries, including aerials, feeders, lighting, etc., should be assessed according to whether or not ancillary load effects increase or decrease wind load effect. Maximum ancillary dead loads predicted to occur during the design life of the structure should be used when their effects are additive to the wind load effects. Minimum ancillary dead loads should be used when their effects reduce the wind load effects.



2.5 Safety assessment

In assessing the safety of the design of a mast under extreme conditions, the mast loading derived from Section 3, Section 4 and Section 5 should be used to determine the forces in each component of the mast. The forces so obtained should not exceed the design strength of any of the components for the required reliability to be achieved by the design.

The partial safety factors γ_m should be selected from Figure 1 appropriate to:

- a) the quality class of the mast;
- b) the performance requirements used for the derivation of partial safety factors on loading (see 2.4).

The factors of safety applied to mast guys and to certain of their associated components of linkage and tension assemblies are usually related to breaking load. They are normally different from the factors of safety applied to the components of the mast column. This allows for the wider scatter in strength tests, the greater difficulty of inspection and maintenance and the greater susceptibility to fatigue of guy components. The appropriate partial safety factors on characteristic strength for guys are given in Figure 1. Characteristic strengths of components should be determined using the method given in BS 8100-3.

NOTE 1 British Standard components incorporated into the guy assembly are frequently specified in terms of safe working loads for lifting. In such cases it is necessary to derive a characteristic strength which is consistent throughout the guy assembly.

NOTE 2 For guy components which are specified in terms of manufacturer's minimum breaking load, this value may be assumed to be equivalent to the characteristic strength of the component, subject to the approval of the designer.

NOTE 3 Alternative methods for deriving design strengths of components not covered by BS 8100-3 may only be used where the strengths can be shown to be characteristic strengths derived on the same basis as given in BS 8100-3.

Additionally, the structure should be designed such that fatigue damage will not lead to failure during its service life; a basis for fatigue life assessment is given in 3.4.

2.6 Serviceability

When the performance of any system supported by a mast is dependent on the magnitude of movement or deformation of the structure, serviceability requirements should be related to the fraction of the annual operating period during which the performance is predicted to be unsatisfactory. The criteria to be assumed in calculating deflections are given in 5.1.5 and the period during which serviceability limits are exceeded due to excessive movement may then be estimated in accordance with Annex B.

2.7 Information to be provided by specifiers

Specifiers of masts should provide the information to enable the performance requirements to be determined by the designer. The specifier should select environmental conditions (see 2.2.2), the economic consequences or usage (see 2.2.3), the quality class (see 2.3) and serviceability required for the system (see 2.6).

NOTE Special consideration should be given by the specifier to whether the mast is required to survive under full or partial wind loading with any one guy broken. In such circumstances reduced partial safety factors may be appropriate.

Section 3. Meteorological parameters

3.1 Wind speed data

3.1.1 General

The atmospheric environment in which a structure is to be built may be considered for the purpose of design to be of one of the following types.

- a) *Regions that may be considered to be well-conditioned*, i.e. temperate climates in conditions of atmospheric neutral stability and where extremely localized and intense storms can be ignored in design [but see type c)]. The wind speed to be used in determining the design wind forces to be applied at any level of a structure located in such an environment is dependent upon the basic wind speed, the wind direction, the terrain roughness and the variation of wind speed with height. The speed at the reference level at the site should be determined in accordance with **3.1.2**, **3.1.3**, **3.1.4** and **3.1.5**, and its variation with height in accordance with **3.2**.
- b) *Regions subject to hurricanes or typhoons*. Design wind speeds should be determined as for type a) except that reference speeds should only be derived from the records of appropriate meteorological stations in the same region used in combination.
- c) *Regions where there is a risk of tornadoes or other local intense storms which need to be considered in design*. Wind speeds cannot be reliably predicted by the procedures of **3.1.2**, **3.1.3**, **3.1.4** and **3.1.5** and they should be derived by assessment of local records which have included such winds.

NOTE The safety factors given in **2.4.1** may be inappropriate for types b) and c), where higher values may be necessary to achieve the required reliability.

3.1.2 Basic wind speed

The basic wind speed $\bar{V}_b$ is the hourly mean wind speed at 10 m above ground level in flat open country, reduced to mean sea level, with an estimated annual probability of being exceeded of 0.02, irrespective of direction. It should be obtained from Figure 2. The method used to derive the basic winds from the meteorological data is described in Annex C.

3.1.3 Site wind speed

The hourly mean site wind speed $\bar{V}_S$ for any particular direction should be calculated from

$$\bar{V}_S = \bar{V}_b S_a S_d S_s$$

where

- $\bar{V}_b$ is the basic wind speed derived as in **3.1.2**;
- S_a is an altitude factor given in **3.1.4**;
- S_d is a direction factor given in **3.1.5**;
- S_s is a seasonal factor given in **3.1.6**.

In situations where the basic wind speed $\bar{V}_b$ cannot be derived in accordance with **3.1.2** and where the nearest meteorological stations are remote from the site, the site wind speed may be derived from the gradient wind speed $\bar{V}_g$ in accordance with Annex D. This procedure is approximate and should not be used for sites in the United Kingdom where wind map data are available.

3.1.4 Altitude factor

An altitude factor S_a should be used to adjust the basic wind speed $\bar{V}_b$ for the altitude of the site above sea level. For the United Kingdom it should be calculated from

$$S_a = 1 + 0.001\Delta$$

where Δ is the site altitude in metres above mean sea level of:

- a) the ground level of the site when topography factor S_h is not used; or
- b) the general level of the terrain when topography factor S_h is used.

The effects of local topographic features, such as hills and escarpments, are allowed for separately by the topography factor given in **3.2.4**.

3.1.5 Direction factor

A direction factor S_d may be used to adjust the basic wind speed $\bar{V}_b$ to produce wind speeds with the same risk of being exceeded in any wind direction. Values are given in Table 1 for the wind directions 0° to 330° . If the orientation of the structure is unknown or ignored, the value of the direction factor S_d should be taken as 1.0 for all directions. When the direction factor is used with other factors which have a directional variation, values from Table 1 which correspond to the specific direction under consideration should be used.

For conditions of wind combined with ice (see 3.5) a value of S_d obtained from Table 1 but not greater than 0.85 may be used.

Table 1 — Values of S_d for the United Kingdom

Wind direction Degrees	S_d
0 N	0.78
30	0.73
60	0.73
90 E	0.74
120	0.73
150	0.80
180 S	0.85
210	0.93
240	1.0
270 W	0.99
300	0.91
330	0.82

NOTE The wind direction is defined in the conventional manner; an east wind is a wind direction of 90° and blows from the east to the site.

3.1.6 Seasonal factor

A seasonal factor S_s may be used to reduce the basic wind speed for structures which are expected to be exposed to the wind for specific sub-annual periods. Values of S_s which give wind speeds with a risk of being exceeded of 0.02 in the stated period are given in Annex E.

3.1.7 Terrain categories

3.1.7.1 General

The site wind speed $\bar{V}_S$ derived in 3.1.3 refers to a standard open country exposure at a height of 10 m above ground. To obtain the design wind speed the effects of varying ground roughnesses and the height and density of obstructions upwind of the site and the effects of topography should be taken into account.

3.1.7.2 Ground roughness

The following three categories of terrain are considered in this Part of BS 8100.

- Sea.* The sea, and inland water extending more than 1 km in the wind direction when closer than 1 km upwind of the site.
- Country.* All terrain which is not defined as sea or town.
- Town.* Built-up areas with a general level of roof tops at least 5 m above ground level. (Permanent forest and dense woodland may be treated as this category.)

Terrain categories are explained in more detail in Annex F.

3.1.7.3 Effective height

For structures in country terrain the effective height z_e should be taken as the actual height z of the section under consideration.

For structures in town terrain some shelter is afforded by the general level of the height H_0 of the roof tops of the buildings or of the height of other permanent obstructions upwind of the site, and the upwind spacing X from the mast.

To account for this effect in towns the terrain factors given in 3.2.3 are determined with respect to an effective height z_e for the section of the structure under consideration.

The effective height in towns should be calculated as follows.

- a) Where the spacing to the upwind sheltering building or permanent obstruction is less than $X = 2H_0$:

$$z_e = z - 0.8H_0$$

or

$$z_e = 0.4z$$

whichever is the greater.

- b) Where the spacing is greater than $X = 6H_0$:

$$z_e = z$$

- c) For intermediate values in the range $2H_0 < X < 6H_0$:

$$z_e = z - 1.2H_0 + 0.2X$$

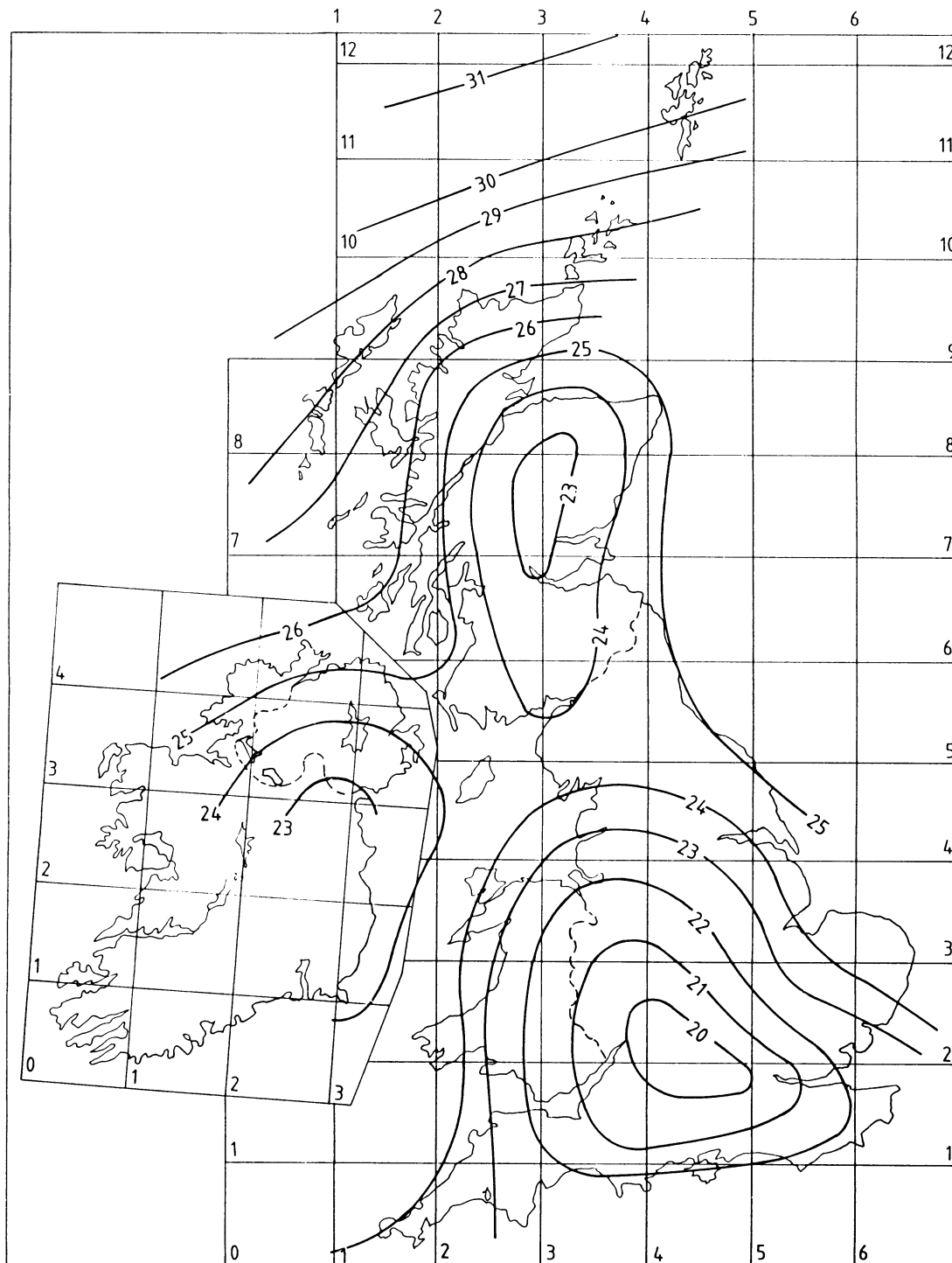
or

$$z_e = 0.4z$$

whichever is the greater.

In the absence of more accurate information, the obstruction height H_0 may be taken as $3 \text{ m} \times$ the typical number of storeys of upwind buildings.

The derivation of these values and further guidance is given in Annex G.



Wind speeds in metres per second.

NOTE 1 Values are at sea level in country terrain.

NOTE 2 $\bar{V}_b$ for the Channel Islands is 24 m/s.

Figure 2 — Basic hourly mean wind speeds $\bar{V}_b$ for the United Kingdom

3.2 Effective wind speed

3.2.1 General

The effective wind speed $\bar{V}_z$ for each wind direction for a structure on a particular site for the effective height z_e at a height z above the ground should be calculated from

$$\bar{V}_z = \bar{V}_S S_o \gamma_v$$

where

$\bar{V}_S$ is the site wind speed for each wind direction (see 3.1.3);

S_o is the terrain factor appropriate to the wind direction being considered and should be obtained from 3.2.2 or 3.2.3;

γ_v is the partial safety factor on wind speed determined from Figure 1 appropriate to the type of structure.

The effective wind speeds for each section of the structure should be calculated at the centre of the section being considered.

Values of turbulence intensity are given in 5.3.2.2.

For serviceability requirements (see 3.3) the characteristic wind speed $\bar{V}_k$ should be calculated from

$$\bar{V}_k = \bar{V}_b S_a S_o$$

3.2.2 Sites in country terrain: terrain factor S_o

The terrain factor S_o should be used to correct the site wind speed to take account of the effective height z_e of the section being considered, local topography and the terrain upwind of the site.

It should be calculated from

$$S_o = S_c (1 + S_h)$$

where

S_c is the fetch factor determined as described in this subclause;

S_h is the topography factor defined in 3.2.4 and evaluated in accordance with Annex H.

The fetch factor S_c allows for the fetch change from sea to country terrain. Its value should be obtained from Figure 3 appropriate to the effective height z_e of the section under consideration and the distance of the site from the sea in the relevant direction.

3.2.3 Sites in town terrain: terrain factor S_o

The terrain factor S_o should be used to correct the site wind speed to take account of the height of the section being considered above ground level, the local topography and the terrain upwind of the site. It should be calculated from

$$S_o = S_c T_c (1 + S_h)$$

where

S_c is the fetch factor determined as described in this subclause;

T_c is the fetch adjustment factor determined as described in this subclause;

S_h is the topography factor described in 3.2.4 and evaluated in accordance with Annex H.

The fetch factor S_c allows for the fetch change from sea to country terrain. Its value should be obtained from Figure 3 appropriate to the effective height z_e of the section under consideration and the distance of the site from the sea in the relevant direction.

Adjustment factor T_c allows for a fetch change from country to town terrain by modifying the fetch factor S_c . Its value should be obtained from Figure 4 appropriate to the effective height z_e of the section under consideration and the distance of the site from the edge of the town in the relevant direction.

3.2.4 Topography factor

The topography factor S_h should be used to correct the terrain factor to allow for local topographical features such as hills, valleys, cliffs, escarpments or ridges which can significantly affect the wind speed in their vicinity. Near the summits of hills, or the crests of cliffs, escarpments or ridges, the wind is accelerated. In valleys or near the foot of cliffs, steep escarpments or ridges, the wind may be decelerated.

Where the average slope of ground does not exceed 0.05 over a kilometre radius from the site the terrain may be taken as level and the topography factor S_h taken as zero.

Corrections for topography are based on wind speeds at the altitude of the general surroundings. Therefore to ensure that the height correction is not applied twice, where a topography factor is to be applied, the value of the site wind speed should be calculated from **3.1.3** taking the altitude factor to be appropriate to the general height of the terrain for a distance of 8 km upwind of the site. A method of determining the appropriate altitude Δ to be used in **3.1.4** for this purpose is given in Annex J.

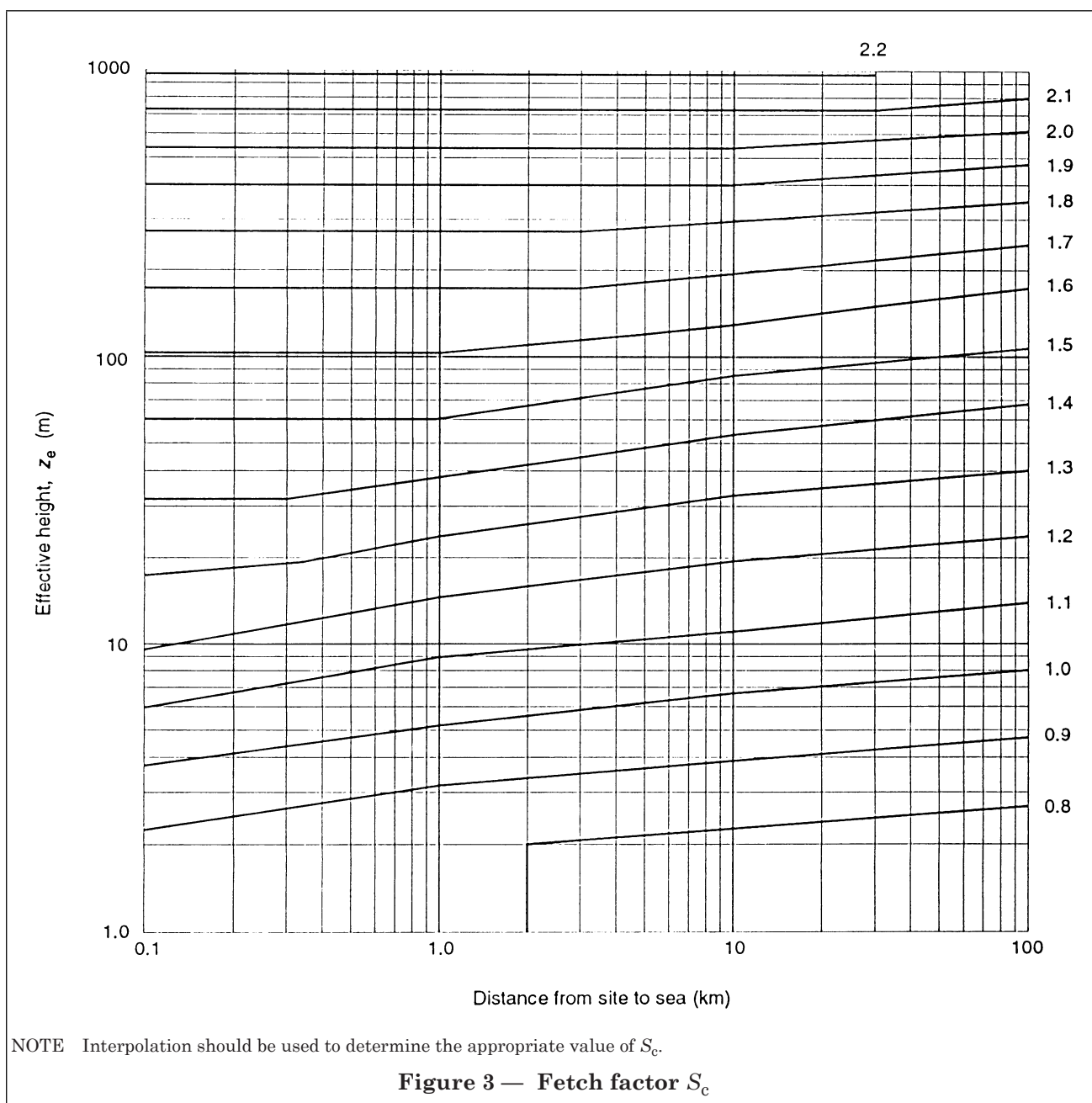
In the vicinity of local topographical features the factor S_h is a function of the upwind slope and the position of the site relative to the summit or crest and will be within the range of $0 < S_h < 0.6$. It should be noted that S_h will vary with the height above ground level from a maximum near to the ground reducing to zero at higher levels.

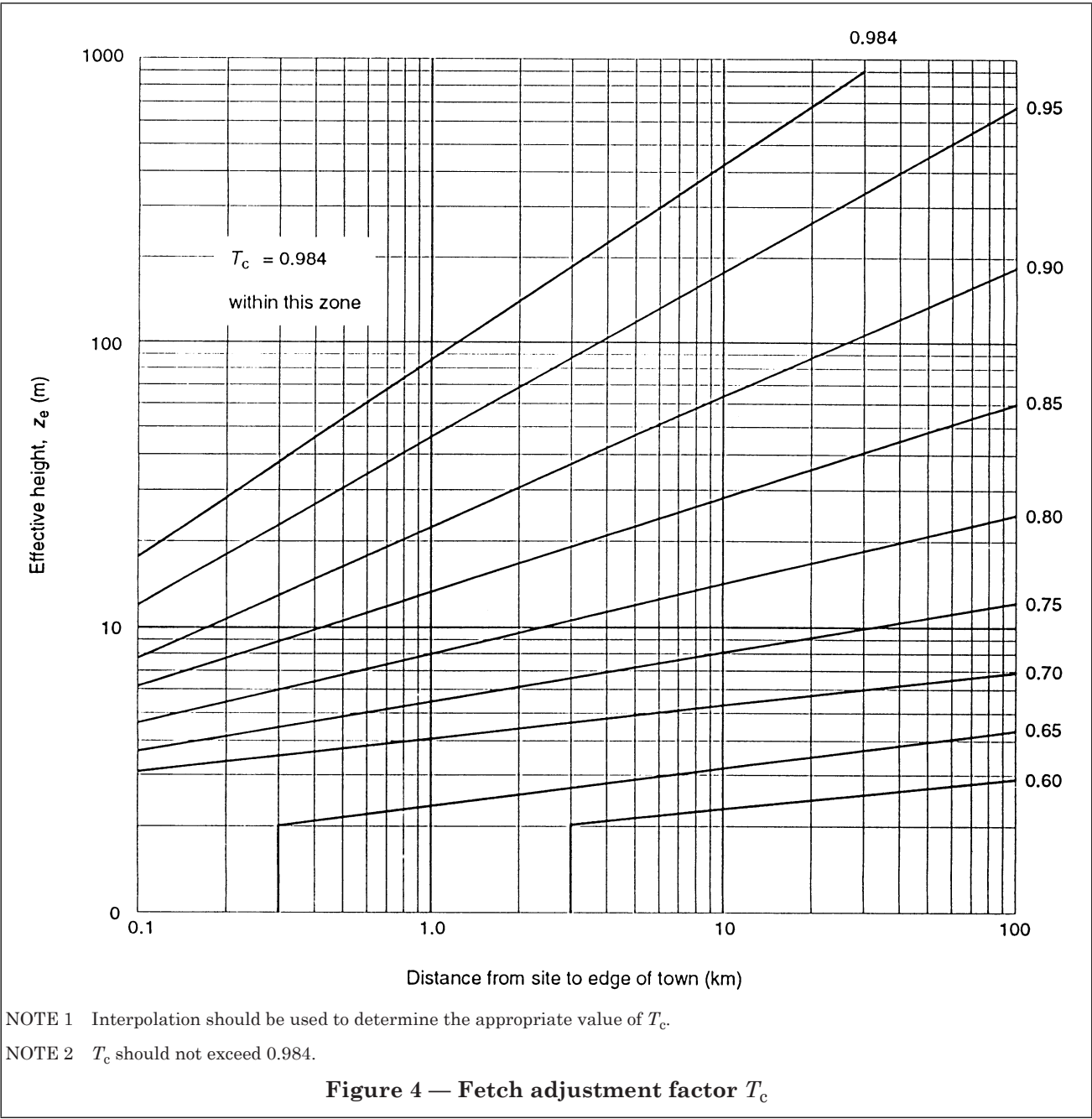
In certain steep sided valleys wind speeds may be less than in level terrain; however, before any reduction in wind speed is considered specialist advice should be sought.

A method of calculating S_h is given in Annex H.

3.3 Serviceability

For the purpose of assessing the duration of unserviceability due to excessive deflection and for an estimation of fatigue life in accordance with **3.4** the procedure set out in Annex B should be adopted for sites in the United Kingdom.





3.4 Fatigue life assessment

3.4.1 In-line vibrations

For masts entirely of bolted or riveted construction of steel of up to 450 N/mm² yield stress, the fatigue life under in-line wind loading in the absence of vortex-excited vibration (see 5.6) may be assumed to exceed 50 years.

Caution should be exercised in the design of all steel masts containing welded details. For such masts, the fatigue life should be evaluated when either:

- a) the service life is greater than 30 years; or
- b) steel of yield stress greater than 355 N/mm² is used in welded areas.

For masts constructed of other metallic materials, specialist advice should be sought with regard to fatigue life assessment.

The fatigue stress history due to wind gusts may be evaluated from Annex B to determine the annual durations of different mean wind speeds from different directions. The fluctuations about the mean values may then be assumed to have a statistically normal distribution with a standard deviation in stress corresponding to one-quarter of the peak fluctuating stress derived in accordance with Section 5.

3.4.2 Crosswind vibrations

3.4.2.1 Overall response

Crosswind amplitudes should be calculated in accordance with 5.6 for masts supporting cylindrical aerials or stacks. For each mode considered, the duration of such vibrations should be estimated as described in Annex B. The resulting duration of each mode of vibration, within the design life of the mast, should then be used to assess the accumulated fatigue damage appropriate to the class of detail, in accordance with BS 8100-3.

3.4.2.2 Individual member response

For structures composed of welded circular sections, consideration should be given to the possibility of crosswind excitation of individual members. The critical wind speed and amplitude of the fundamental mode of vibration may be calculated in accordance with 5.6 and the fatigue assessment undertaken as for overall response.

3.5 Ice loading

3.5.1 General

For design against ice loading, four combinations should be considered using the appropriate ice thickness and density.

- a) *Extreme symmetrical icing in the absence of wind.* The weight of ice should be determined in accordance with 3.5.2, 3.5.3 and 3.5.4.
- b) *Extreme asymmetrical icing in the absence of wind.* The weight of asymmetric ice on the guys should be determined by applying the appropriate ice thickness from 3.5.2, 3.5.3 and 3.5.4 to all guys apart from:
 - 1) one lane of the top guy level; and as a separate case
 - 2) two lanes of the top guy level.

In conjunction with each of these, ice loading on the mast column should be considered to be applied to all faces of the mast, determined in accordance with 3.5.2, 3.5.3 and 3.5.4.

NOTE Asymmetric ice on the guys can cause critical stresses in the mast column. Clearly there are numerous combinations of iced and un-iced guys which could be considered in design. The conditions specified above have been found to be the most critical in many cases. However, if such conditions are found to dictate the design of any element of the mast, then further combinations of iced and un-iced guys (either in one guy level, or two lanes, or in any combination) should be considered.

- c) *Combination of symmetrical icing with wind.* The weight of ice should be determined in accordance with 3.5.2, 3.5.3 and 3.5.4. The wind resistance (see 4.6) should be based on projected areas increased to allow for a uniform coating of ice thickness determined in accordance with 3.5.2 and 3.5.3.

The site effective wind speed $\bar{V}_i$ to be used should be taken as

$$\bar{V}_i = 0.8\bar{V}_z$$

where $\bar{V}_z$ is the site effective wind speed determined in accordance with 3.2.1 but with due allowance for the limiting value of 0.85 for the wind direction factor S_d in accordance with 3.1.5, if appropriate.

The variation of $\bar{V}_i$ with height should be determined in accordance with 3.2 but using $\bar{V}_i$ in place of $\bar{V}_z$.

NOTE At sites where severe icing is known to occur, caution should be exercised in the choice of both wind speed and ice thickness if local records indicate that specified values are less than those experienced in practice.

d) *Combination of asymmetric icing with wind.* The combinations of ice on the mast column and guys should be taken as for item b) using the appropriate thickness and density of ice determined from 3.5.2, 3.5.3 and 3.5.4 and wind speed in accordance with item c).

NOTE Local records should be studied to try to ascertain the extremes of asymmetric icing and wind speeds in combination, as the specified values are based on limited data.

3.5.2 Basic ice thickness

3.5.2.1 General

The formulae given in 3.5.2.2 and 3.5.2.3 are based on limited data and local records should be studied to ensure that the thicknesses quoted are not likely to be exceeded. Where such records are available statistical analyses should be undertaken as outlined in 3.5.2.2 and 3.5.2.3.

3.5.2.2 Ice thickness in the absence of wind

The basic ice thickness r_b in the absence of wind, for the United Kingdom, should be taken as

$$r_b = K_i \left(r_o + \frac{\Delta - 200}{25} \right)$$

but not less than $K_i r_o$

where

K_i is a coefficient that is either:

- a) 1.0 for structural sections other than round bars, circular tubes, cables or guys; or
- b) $(\frac{2}{3} + 4/D)$ but not more than 1.2 for round bars, circular tubes, cables or guys, where D is the diameter of the member (in mm);

Δ is the altitude of the mast top above sea level (in m);

r_o is the radial ice thickness in the absence of wind to be obtained from Figure 5 (in mm), appropriate to the position of the site. Alternatively, where data are available r_o may be derived from a statistical analysis assuming an extremal distribution based on records of the annual maximum thickness of ice formation on components of form and size similar to those to be used in the mast or its attachments at the latitude and altitude of the site and having an annual probability of occurrence of 0.02.

NOTE Ice formation is sensitive to the location of the mast within the topography of the site.

3.5.2.3 Ice thickness in conjunction with wind

The basic ice thickness r_b in conjunction with wind, for the United Kingdom, should be taken as

$$r_b = K_i \left(r_w + \frac{\Delta - 200}{25} \right)$$

but not less than $K_i r_w$

where

K_i and Δ are as defined in 3.5.2.1;

r_w is the radial ice thickness in conjunction with wind to be obtained from Figure 5 (in mm), appropriate to the position of the site. Alternatively, r_w may be derived from records (see 3.5.2.1) but should have an annual probability of occurrence of 0.5.

3.5.3 Reference ice thickness

The reference ice thickness r_r to be considered for design should be taken as

$$r_r = \gamma_v K_G r_b$$

where

- γ_v is the partial safety factor to be obtained from Figure 1, appropriate to the type of mast (see 2.2);
- r_b is the basic radial ice thickness determined in accordance with 3.5.2;
- K_G is a guy or cable factor which should be taken as either:
 - a) 1.0 for all mast members, guys and ancillaries; or
 - b) $(N_G + 0.3)/1.3N_G$ for any multiple guys or cables supported by the mast in parallel formation;
- N_G is the number of guys or cables.

3.5.4 Ice weight

The weight of ice deposited on the mast should be calculated assuming that all structural sections and ancillary parts are uniformly coated in ice of thickness r_r and that the following apply.

- a) The unit weight of ice in the absence of wind should be taken as 5 kN/m³.
- b) The unit weight of ice in conjunction with wind should be taken as:
 - 1) 9 kN/m³ for design against compression or where its application to guys increases their tension;
 - 2) 5 kN/m³ for design against tension.
- c) The weight of ice deposited should include an allowance for gaps of less than 75 mm to be completely filled with ice in accordance with 4.6.