

BS 8103-1:2011



BSI Standards Publication

Structural design of low-rise buildings

Part 1: Code of practice for stability, site investigation, foundations, precast concrete floors and ground floor slabs for housing

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This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 58, an inside back cover and a back cover.

Foreword

Publishing information

This part of BS 8103 is published by BSI and came into effect on 30 November 2011. It was prepared by Technical Committee B/204, *Structural design of low-rise buildings*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This part of BS 8103 supersedes BS 8103-1:1995 and BS 8103-4:1995, which are withdrawn.

Relationship with other publications

BS 8103 will be published in three parts:

- *Part 1: Code of practice for stability, site investigation, foundations and ground floor slabs for housing;*
- *Part 2: Code of practice for masonry walls for housing;*
- *Part 3: Code of practice for timber floors and roofs for housing.*

Information about this document

The scope and limitations of this part of BS 8103 are similar to A1/2 Section 2 of Approved Document A to The Building Regulations [1]. A particular exception is that the maximum clear span for roofs is up to 12 m rather than 9 m in Approved Document A.

A large proportion of the national building programmes is concerned with new housing and alterations in both the public and private sectors, where traditional methods of construction are used for the majority of houses, and it is to these that this part of BS 8103 is applicable.

Use of this document

It is assumed that this standard will be used by those with expertise in building construction but not necessarily in structural engineering design. Houses constructed within the limitations stated in the relevant clauses will not require additional specialist advice. For any conditions outside the limitations of this standard appropriate specialist advice has to be obtained.

When using this standard, it is important to ensure that the overall stability of the house is achieved and that the work of any specialist engaged is properly coordinated. The situations included in this standard which require the consultation of suitably qualified persons are identified in the clauses to which they relate.

All drawings in this document only show structural details. Other details, e.g. damp proof courses, are not included.

In particular, it is expected that changes in the regulatory requirements for energy conservation are likely to modify the use of the traditional details. Examples are providing insulation below ground bearing floors, or increased thicknesses of insulation in cavity walls. Such items are outside the scope of this British Standard, which deals only with the basic structural issues.

As a code of practice this part of BS 8103 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.

Any user claiming compliance with this part of BS 8103 is expected to be able to justify any course of action that deviates from its recommendations.

Presentational conventions

The provisions in this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is "should".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

The word "should" is used to express recommendations of this standard. The word "may" is used in the text to express permissibility, e.g. as an alternative to the primary recommendation of the clause. The word "can" is used to express possibility, e.g. a consequence of an action or an event.

Contractual and legal considerations

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

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope

This part of BS 8103 gives recommendations for the structural design of low-rise housing and covers the stability of the structure, site investigation and foundations and ground floor slabs used in the construction. Foundations comprising strip footings or trench fill founded in normal ground are the only type described.

Low-rise housing comprises detached, semi-detached and terraced houses and flats (with not more than four self-contained dwelling units per floor accessible from one staircase), of not more than three storeys above ground intended for domestic occupation and of traditional masonry construction with timber roofs and floors of timber or concrete. For the purposes of this standard, additional habitable accommodation in the roof space constitutes a storey of the house. The recommendations also apply to certain single storey, non-residential buildings, e.g. domestic garages and annexes to residential buildings with a floor area not exceeding 36 m². This standard does not include the design of basements but, providing the basement is of one level only and is designed to provide a firm platform at ground level, the provisions of this standard may apply to the superstructure.

Proprietary housing systems and houses of timber, steel or concrete framed construction are not covered by this standard.

The structural design recommendations described in this standard are not specifically intended to cover other considerations such as fire resistance, thermal and sound insulation, resistance to damp penetration and durability.

For the purposes of this part of BS 8103, the following limitations apply:

- a) roof: maximum clear span 12.0 m;
- b) floor: maximum clear span 6.0 m;
- c) a dynamic wind pressure not exceeding a value of 1.2 kN/m² (see 4.3);
- d) no part of wall or roof higher than 15 m above lowest adjacent ground level;
- e) storey height: maximum 2.7 m;
- f) maximum clear length of a loadbearing wall between vertical lateral supports of 9.0 m;
- g) maximum length of any opening in loadbearing walls: 3.0 m;
- h) only strip footings or trench fill foundations in normal ground conditions (see 6.1).

NOTE Where foundations other than those given in item h) have been designed by suitably qualified persons, the remainder of the building may be constructed in accordance with the relevant clauses of this standard.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 8000-2.2:1990, *Workmanship on building sites – Part 2: Code of practice for concrete work – Section 2.2 Sitework with in situ and precast concrete*

BS 8500-1, *Concrete – Complementary British Standard to BS EN 206-1 – Part 1: Method of specifying and guidance for the specifier*

BS 8500-2:2006, *Concrete – Complementary British Standard to BS EN 206-1 – Part 2: Specification for constituent materials and concrete*

BS EN 845-1:2003+A1:2008, *Specification for ancillary components for masonry – Part 1: Ties, tension straps, hangers and brackets*

BS EN 1991-1-1, *Eurocode 1: Actions on structures – Part 1-1: General actions – Densities, self-weight, imposed loads for buildings*

NA to BS EN 1991-1-1, *UK National Annex to Eurocode 1: Actions on structures – Part 1-1: General actions – Densities, self-weight, imposed loads for buildings*

BS EN 1992-1-1:2002, *Eurocode 2: Design of concrete structures – Part 1-2: General rules – Structural fire design*

NA to BS EN 1992-1-1, *UK National Annex to Eurocode 2: Design of concrete structures – Part 1-2: General rules – Structural fire design*

BS EN 13670:2009, *Execution of concrete structures*

PD 6697:2010, *Recommendations for the design of masonry structures to BS EN 1996-1-1 and BS EN 1996-2*

[N1]BUILDING RESEARCH ESTABLISHMENT. Concrete in aggressive ground (Special Digest 1). Watford: BRE, 2005 ¹⁾

3 Terms and definitions and symbols

3.1 Terms and definitions

For the purposes of this part of BS 8103, the following terms and definitions apply.

3.1.1 aspect ratio

longer span divided by the shorter span

3.1.2 buttress

section of wall or pier, bonded or securely tied to an adjacent wall providing support against lateral forces acting on the wall

3.1.3 cavity

space between two leaves of a cavity wall

3.1.4 cavity wall

two parallel single-leaf walls spaced at least 50 mm and not more than 300 mm apart and tied together with wall ties

3.1.5 clear span

distance between opposite faces of supports

NOTE See also Figure A.1.

3.1.6 foundation

part of a structure in direct contact with and transmitting loads to the ground

3.1.7 foundation depth

distance between the finished external ground level and the underside of the concrete in strip footings or trench fill construction

¹⁾ Available from the Building Research Establishment, Garston, Watford, Herts, WD2 7JR.

- 3.1.8 ground-supported slab**
concrete slab constructed directly on and supported by the ground to receive material forming or supporting the wearing surface
- 3.1.9 heave**
upward movement of the ground
- 3.1.10 hoggin**
inert natural mixture usually consisting of gravel, sand and clay
- 3.1.11 loadbearing wall**
wall that carries vertical and/or lateral loads in addition to its self-weight
- 3.1.12 longer span**
longer of the two clear spans of a rectangular floor slab
NOTE See also Figure A.1.
- 3.1.13 masonry**
assemblage of structural units that are bonded or solidly put together with mortar
- 3.1.14 nogging**
solid piece of timber between timber members to provide support for an attachment point
NOTE In Scotland a nogging is commonly known as a "dwang".
- 3.1.15 orographic factor**
multiplier to take into account the effect of hills, ridges, cliffs and escarpments
- 3.1.16 parallel partition**
partition which is supported by the floor slab and is aligned parallel to the shorter span
NOTE See also Figure A.1.
- 3.1.17 perpendicular partition**
partition which is supported by the floor slab and is aligned perpendicular to the shorter span
NOTE See also Figure A.1.
- 3.1.18 pier**
integral thickened section located in a wall
- 3.1.19 separating wall**
wall between two buildings that is common to both
- 3.1.20 shorter span**
shorter of the two clear spans of a rectangular floor slab
NOTE See also Figure A.1.
- 3.1.21 slab depth**
overall thickness of the slab
NOTE See also Figure A.1.
- 3.1.22 storey height**
underside to underside distance between floors or between a floor and roof or, in the case of a ground storey, the distance between the top of the ground floor and the underside of the floor above

3.1.23 strip footing

bed of concrete laid in the bottom of a trench, its thickness being less than its width, that forms a strip foundation to carry a masonry wall

3.1.24 trench fill

deep bed of concrete filling a trench that forms a strip foundation to carry a masonry wall

3.2 Symbols

For the purposes of this part of BS 8103, the following symbols apply:

a	retained height of ground
d	depth of fill material
h_1	height of main building measured to the highest part of the wall or roof
h_2	height of wing or annexe measured to the highest part of the wall or roof
l	length of wall to wing or annexe
p_1	projection of wing extending for more than one storey
p_2	projection of single storey wing or annexe
p_{sf}	projection of strip footing beyond face of supported wall
s	step height in foundations
t	overall thickness of wall
t_1	thickness of leaf 1 of cavity wall
t_2	thickness of leaf 2 of cavity wall
t_{sf}	thickness of strip footing
t_{tf}	thickness of trench fill
w_1	width of wall to main building
w_2	width of wall to single storey wing or annexe
w_3	width of wall to a wing extending for more than one storey

4 Stability and connections between elements**4.1 Stability considerations****COMMENTARY ON 4.1**

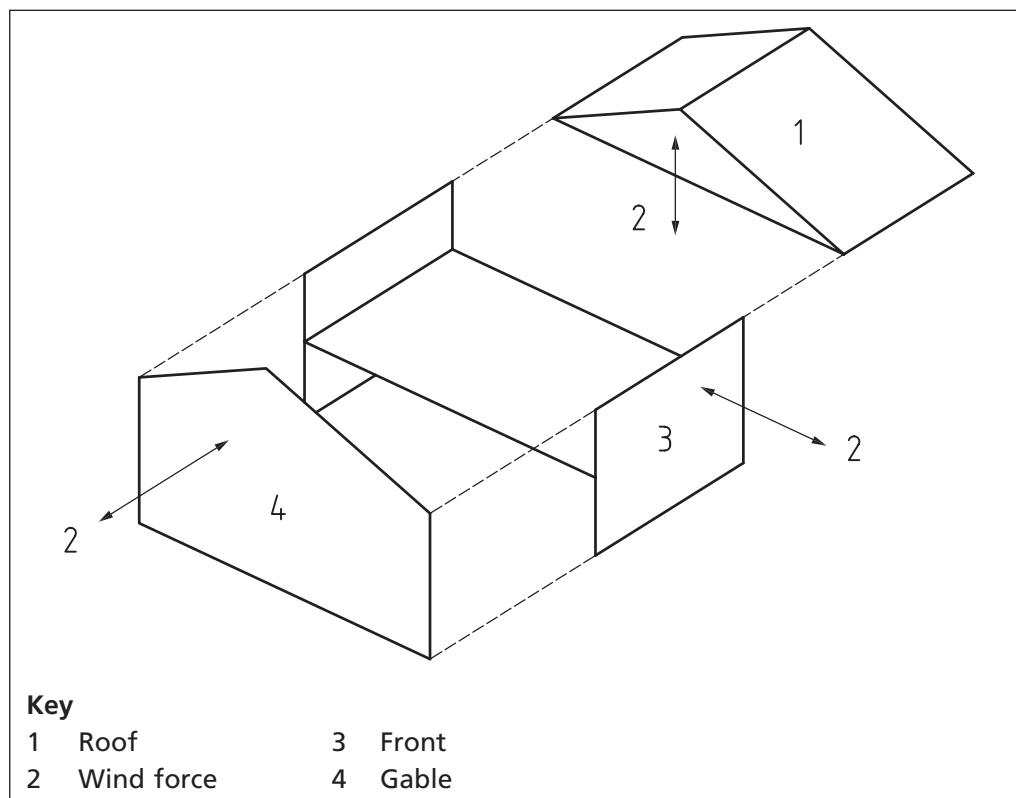
This part of BS 8103, together with BS 8103-2 and BS 8103-3, gives recommendations on the sizing of individual elements of a building: foundations, walls, floors and roof in relation to the forces acting on them due to self-weight and imposed loads.

In the situations shown in Figure 1 with the force derived from wind action at right angles to the gable, the gable in isolation is extremely vulnerable. The front and rear walls in combination with the floor, offer substantial lateral support provided that the wind forces from the top of the gable can be transferred to them. A braced roof, if adequately connected, laterally restrains the top of the gable and transfers the loads to the front and rear walls.

Likewise, the front and rear walls depend upon the lateral support provided by the floors and roof connected to the gable walls.

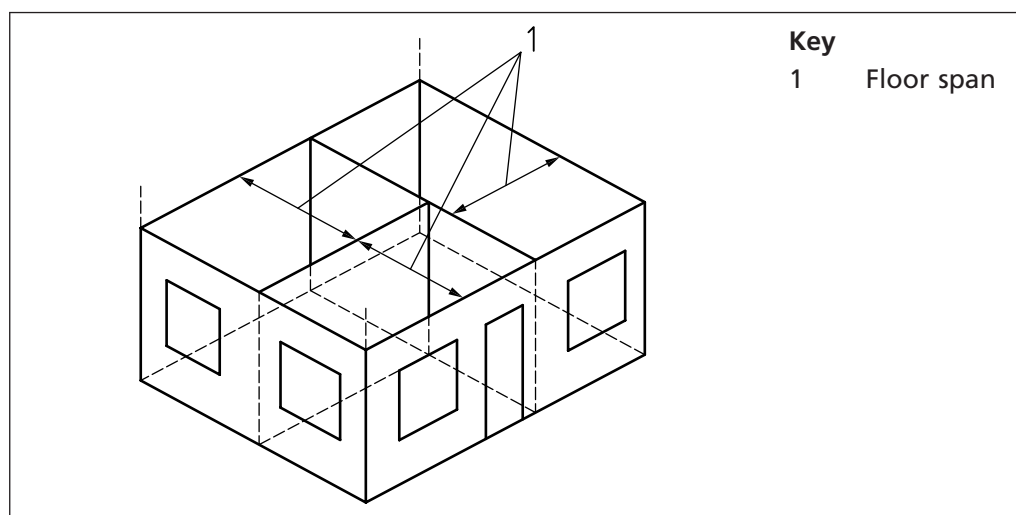
A building is not totally resistant to the excessive forces that might arise due to extreme causes such as earth tremors, explosion or impact by vehicles. Provided that the design procedures recommended in this standard are correctly followed, particularly the recommendations for connections between elements, then the effects of the excessive forces will be minimized if they occur.

Figure 1 Diagram illustrating the action of wind forces



In order to provide overall stability to the structure in any likely loading condition, it is essential that the foundations, walls, floors and roof are properly joined together. In the plan form of the building, for the ground floor, it is essential that the external walls interact to form the sides of a rigid box completed by the floors and roof (see Figure 2). In these forms of construction, the planes of the roof should be braced in order to contribute to the overall stability.

Figure 2 Box construction plan form to give stability



Internal masonry walls should be connected to interact with external walls and brace the structure. Internal lightweight partitions should also be connected so that they contribute to the overall stability but they should be discounted in the design of the masonry. The connections between structural elements described in 4.4 should be used as necessary to ensure that the elements of the box interact fully in order to transfer and share loads placed on one element with other elements.

It is particularly important to ensure that wind loads are transferred to buttress walls, piers and chimneys.

4.2 Dimensional limits to ensure stability

4.2.1 Ground levels either side of walls

Where a wall is subjected to a lateral load from retained material due to a difference in levels on opposite sides, the difference in level above fully compacted backfill should not exceed the dimensions shown in Figure 3.

NOTE Figure 3b does not apply where there is an adjacent roadway on the upper level, used other than by private cars, and where the roadway for such vehicles is closer than a distance equivalent to 1.25 times the retained height. Such situations are outside the scope of this standard.

4.2.2 Building shape

For residential buildings, adequate stability against wind forces is achieved if the building dimensions, as shown in Figure 4 and following the recommendations in 4.3, do not exceed the following values.

- a) The height of the main building (h_1) should not be greater than twice the width of the building. The width should be taken as w_1 if p_1 is equal to, or less than w_3 , or as w_3 if p_1 is greater than w_3 .
- b) The width of an annexe (w_2) should not be less than half the height of the annexe (h_2) if its length (p_2) is greater than twice its width (w_2).

Figure 3 Walls with a difference in level on opposite sides

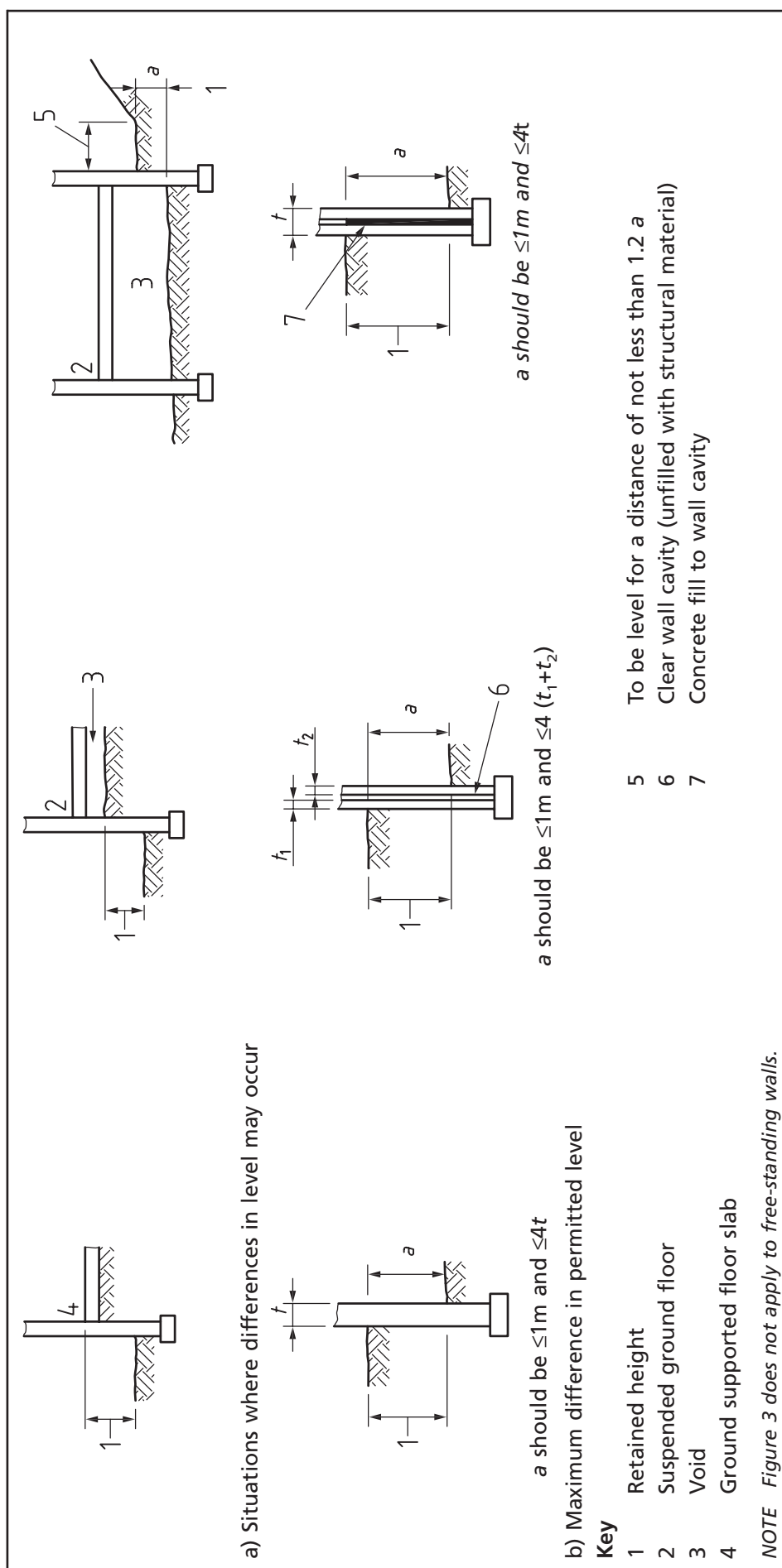
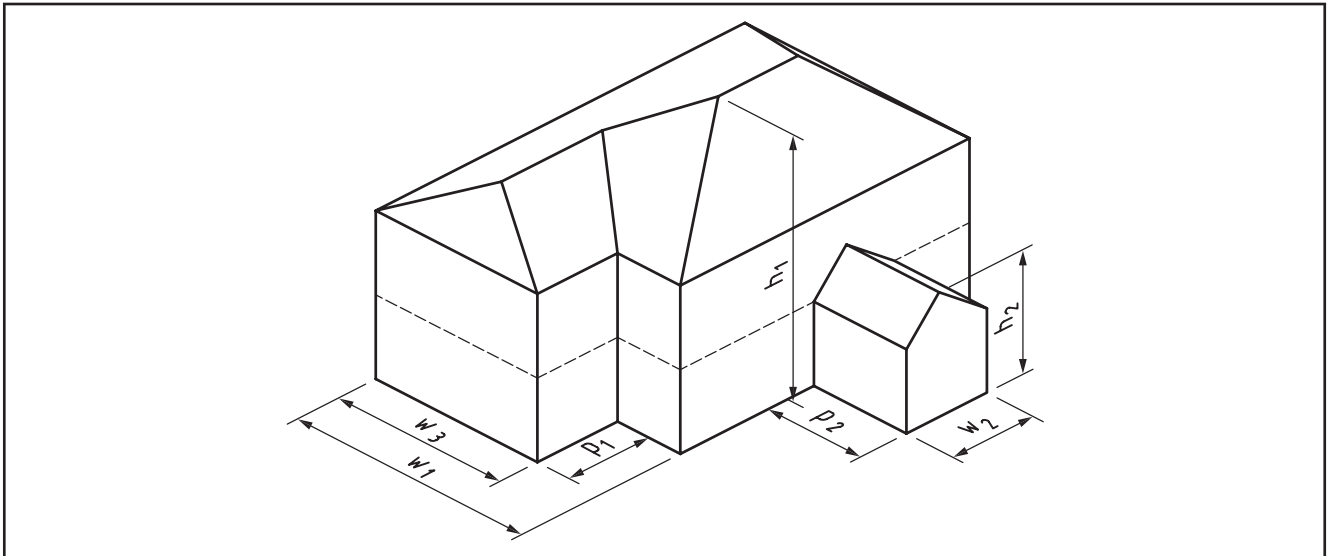


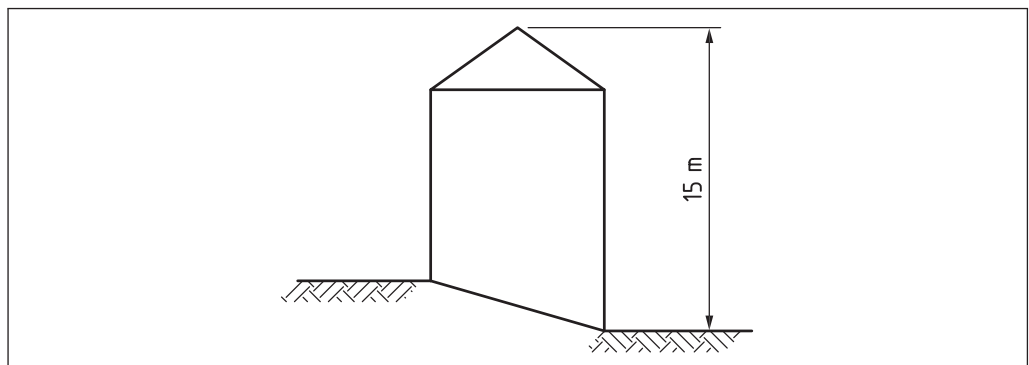
Figure 4 Building shape



4.2.3 Height of building

The maximum height above the lowest finished ground level adjoining the building should not exceed 15 m as shown in Figure 5.

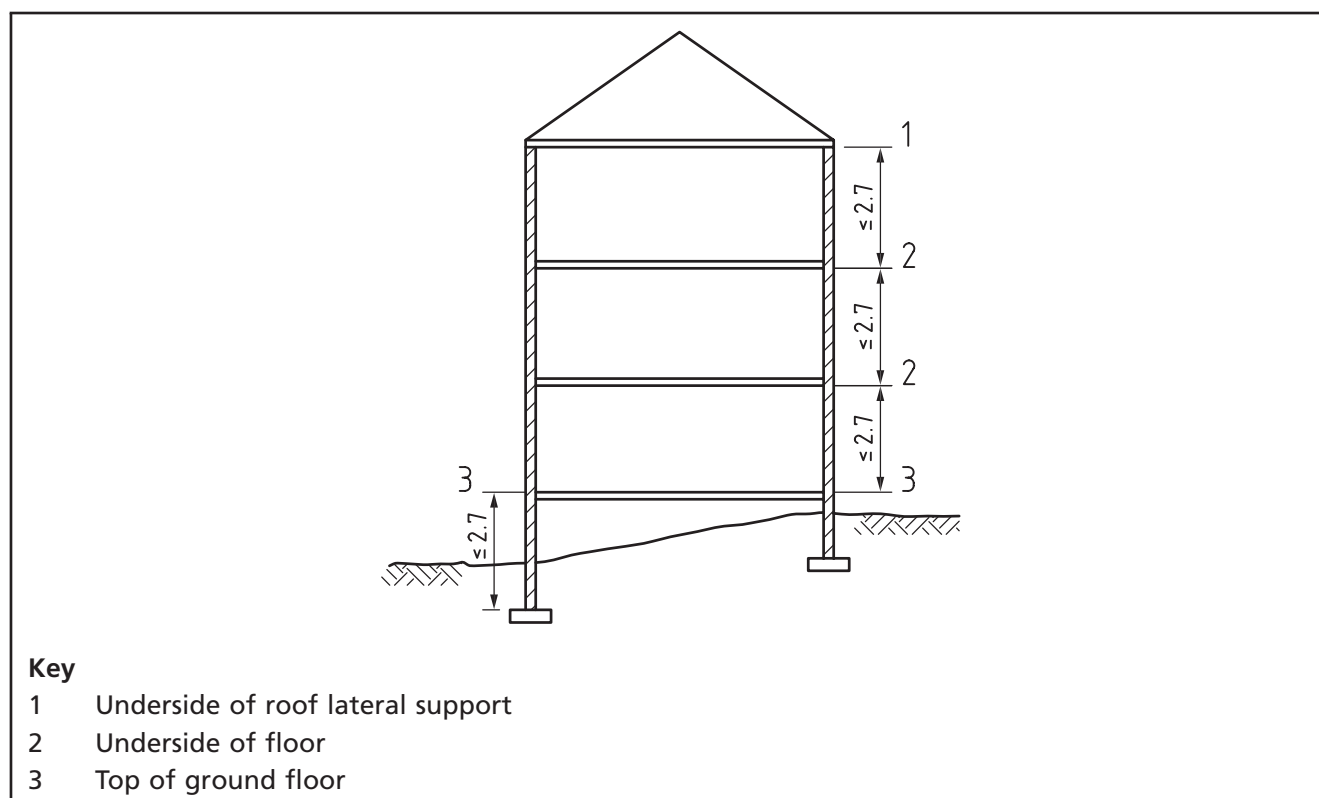
Figure 5 Maximum height of building on sloping ground



4.2.4 Storey height

The maximum height should not exceed 2.7 m measured as shown in Figure 6. The height of substructure walls, measured between the top of the foundation and the top of the ground floor slabs, should not exceed 2.7 m.

Figure 6 Measurement of storey height of walls in metres



4.3 Wind loading

A simplified method of checking that the dynamic wind pressure does not exceed 1.2 kN/m^2 is given in Table 1, Table 2 and Table 3 and is as follows.

- a) Determine the basic wind speed, V , at the site of the building from the map in Figure 7.
- b) Determine the altitude factor, A , from Table 1 for the altitude of the site.
- c) Determine, the orography factor, O . It can be taken as 1.0 for normal level sites. For sites on hills and escarpments determine factor O from Table 2 and Figure 8 taking into account the slope of the whole hillside and the position of the building in relation to the ridge of the hill or edge of the escarpment. Alternatively, a more accurate value for factor O may be determined using Figure 9 or Figure 10.
- d) Calculate the value of S by multiplying together basic wind speed, V , by factor A by factor O .
- e) Determine the maximum permissible height of the building from Table 3 depending on the value of S , whether the building is within a town or country location and the distance to the coast.

NOTE The magnitude of wind pressure to which a building is exposed is dependent on its height, geographical location and degree of exposure. This simplified method cannot take into account all local variations and the results might differ from local experience. Where a more accurate estimate of the allowable building height is desired, appropriate advice can be sought. BS EN 1991-1-4 and NA to BS EN 1991-1-4 can be used to do this, by calculating the peak velocity pressure, q_p , for the site at the desired building height of up to 15 m. If q_p is $\leq 1.2 \text{ kN/m}^2$ then that building height is allowed within the scope. If q_p is $> 1.2 \text{ kN/m}^2$ then incrementally reduce the building height and repeat the calculation until q_p is $\leq 1.2 \text{ kN/m}^2$ this then gives the maximum allowable building height.

Table 1 Altitude factor

Site altitude m	Factor A
0	1.00
50	1.05
100	1.10
150	1.15
200	1.20
300	1.30
400	1.40
500	1.50

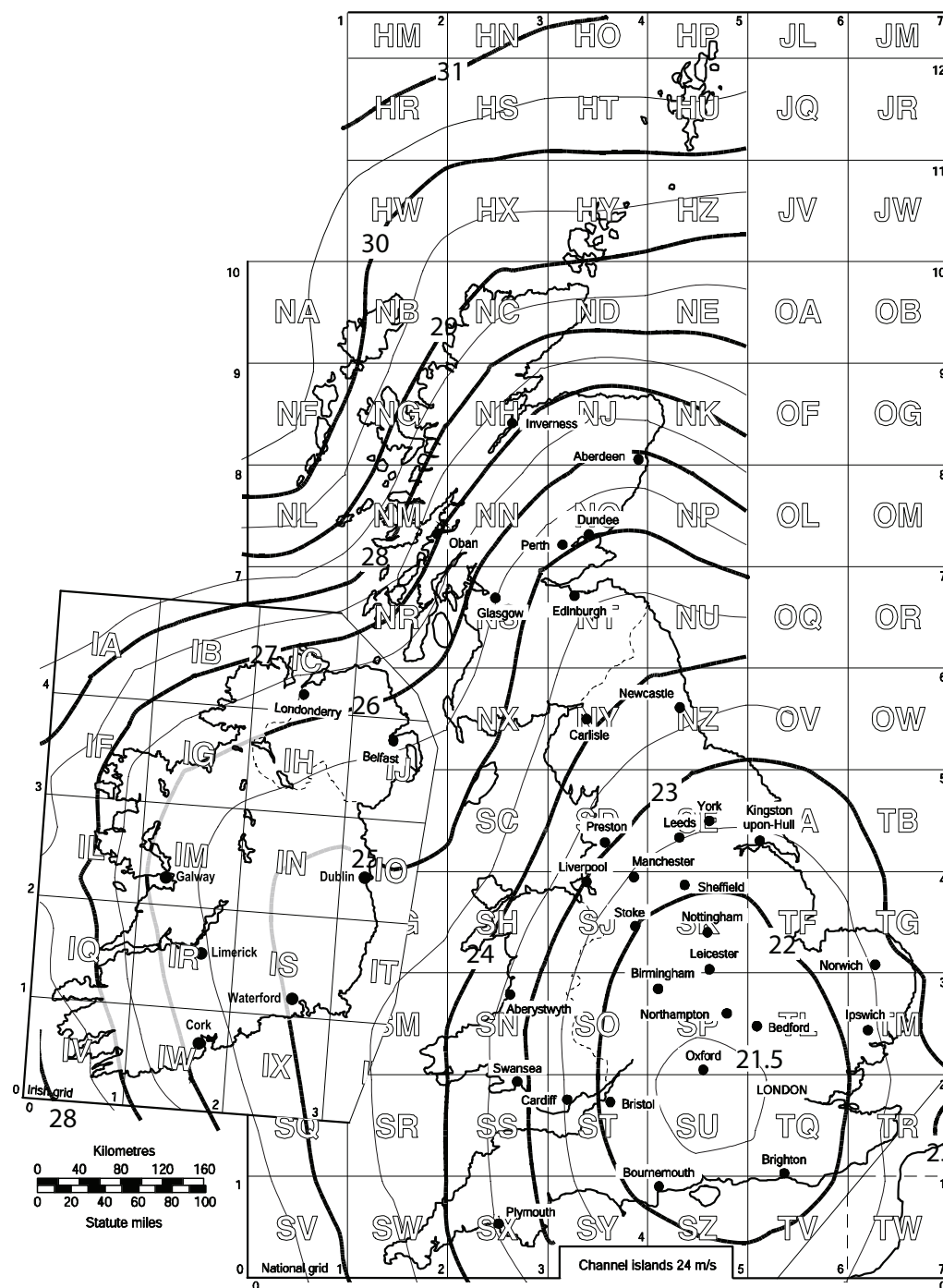
NOTE 1 When sites are elevated on hillsides or similar topographic features and fall within the shaded zones identified on Figures 9 and 10, orography is significant and a more accurate assessment of Factor A can be obtained by using the altitude of the general land level at the base of the topographic feature instead of the altitude at the site (see Figure 8).

NOTE 2 Interpolation may be used.

Table 2 Factor O

Topographic category and average slope of whole hillside, ridge, cliff or escarpment	Factor O		
	Zone 1	Zone 2	Zone 3
Category 1: Nominally flat terrain, average slope $<1/20$	1.0	1.0	1.0
Category 2: Shallow terrain, average slope $<1/10$	1.12	1.07	1.05
Category 3: Moderately steep terrain, average slope $<1/5$	1.24	1.13	1.10
Category 4: Steep terrain, average slope $>1/5$	1.36	1.20	1.15

NOTE Outside of the zones the factor O = 1.0.

Figure 7 Basic wind speed, V , map (m/s) before the altitude correction is applied

NOTE 1 This map is intended for sites in the United Kingdom, Isle of Man and Channel Islands only.

NOTE 2 The isopleths in the Irish Republic are shown for purposes of interpolation only.

Figure 8 Orographic zones for factor O

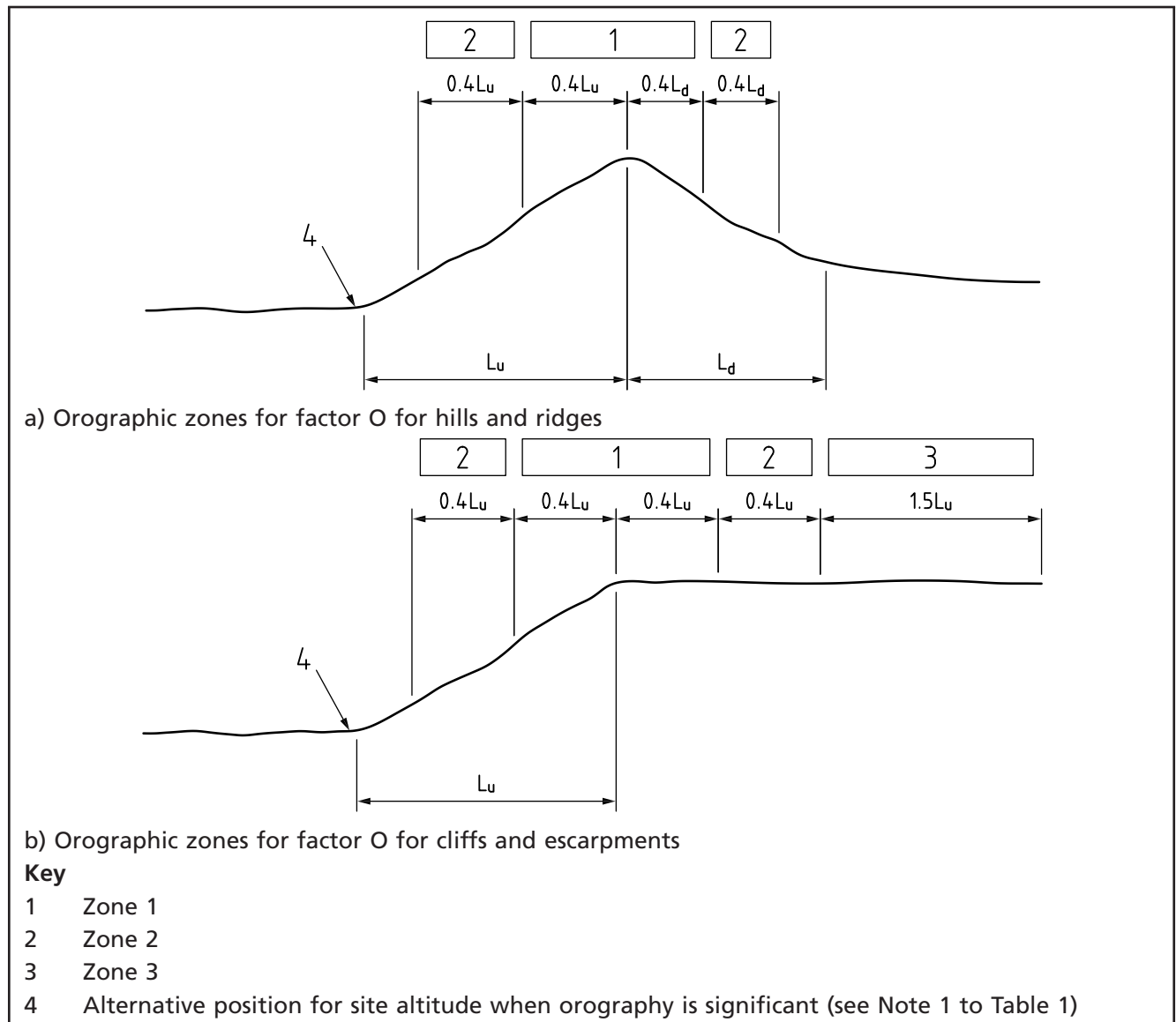


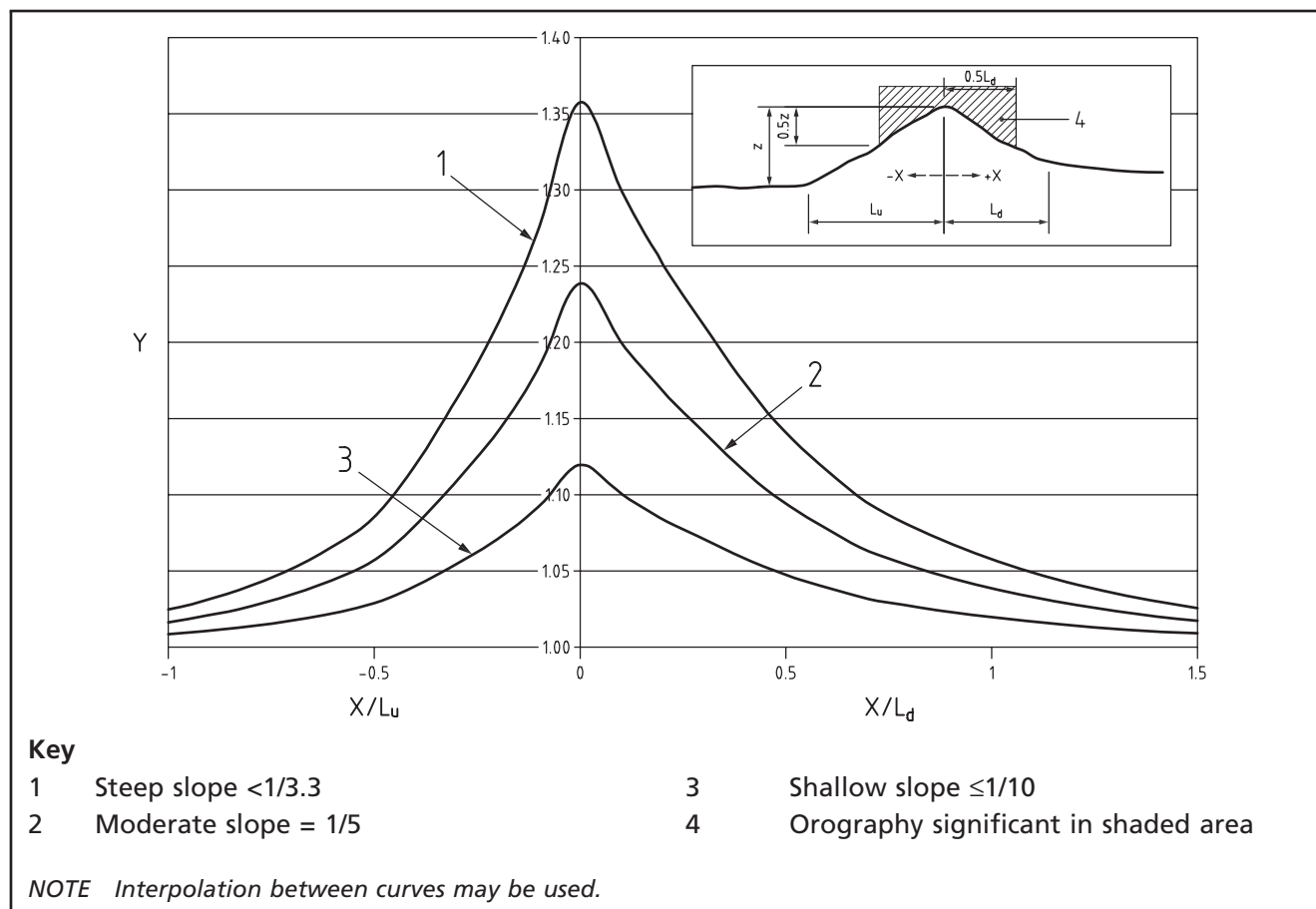
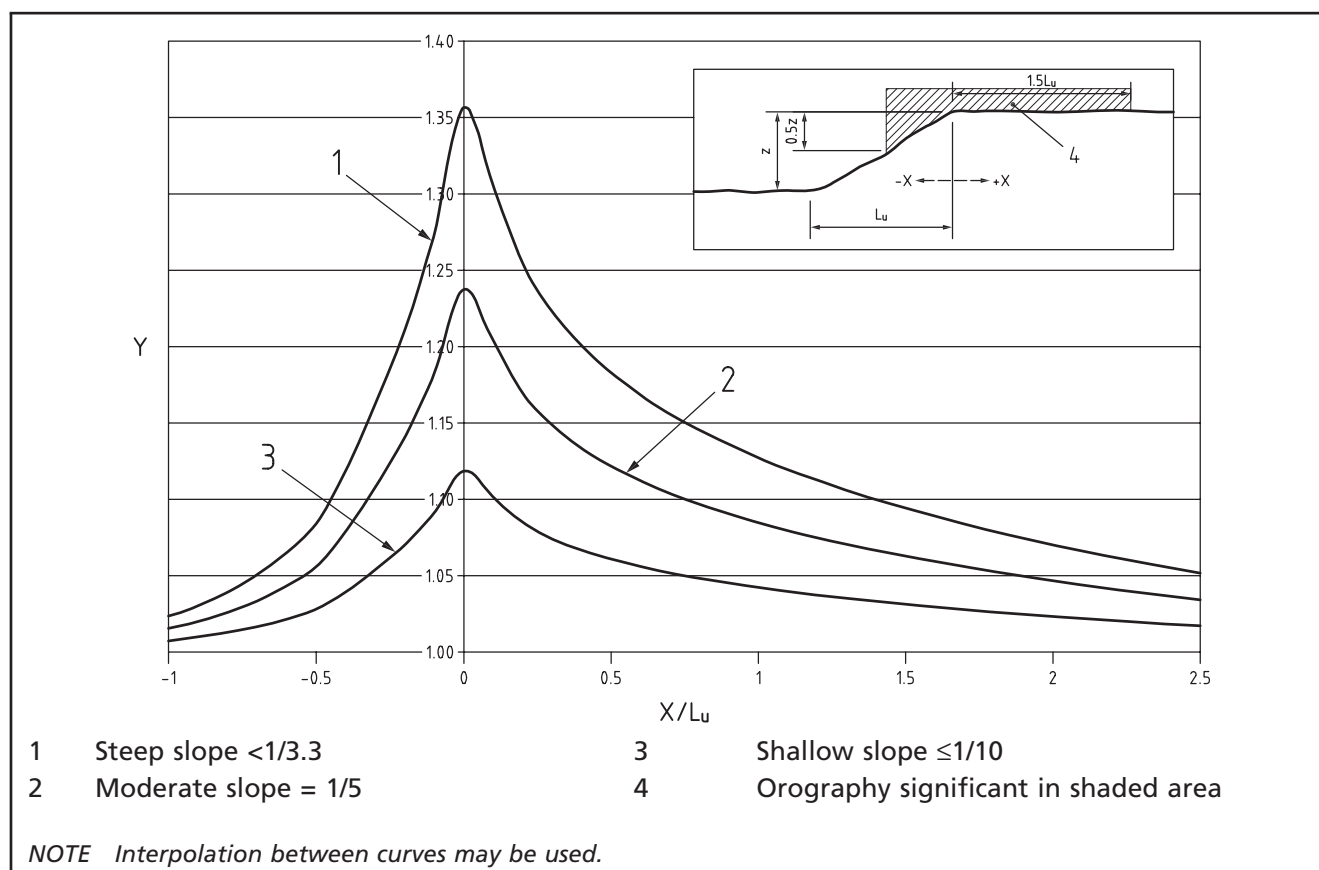
Figure 9 Orography factor O for hills and ridgesFigure 10 Orography factor O for cliffs and escarpments

Table 3 Maximum allowable building height, m

Factor S	Country sites			Town sites		
	Distance to the coast			Distance to the coast		
	<2 km	2 to 20 km	>20 km	<2 km	2 to 20 km	>20 km
≤ 25	15	15	15	15	15	15
26	11.5	13.5	15	15	15	15
27	8	11	14.5	15	15	15
28	5.5	8	11	15	15	15
29	4	6.5	8.5	12.5	15	15
30	3	5	6.5	10	12.5	15
31	—	4	5.5	8.5	11	13.5
32	—	3.5	4.5	7	9.5	11.5
33	—	3	3.5	6	8	10
34	—	—	3	5.5	7	8.5
35	—	—	—	4.5	6.5	7.5
36	—	—	—	4	5.5	6.5
37	—	—	—	3.5	5	6
38	—	—	—	3	4.5	5.5
39	—	—	—	—	4	5
40	—	—	—	—	3.5	4.5
41	—	—	—	—	3	4
42	—	—	—	—	—	3.5
43	—	—	—	—	—	3.5
44	—	—	—	—	—	3

NOTE 1 Sites in towns less than 300 m from the edge of the town are assumed to be in country terrain.

NOTE 2 Where a site is closer than 1 km to an inland area of water which extends more than 1 km in the wind direction, the distance to the coast is taken as <2 km.

NOTE 3 Interpolation may be used.

4.4 Connections between structural elements

4.4.1 General

NOTE The details of connections of floor- or roof-to-wall given in 4.4.2 provide for the tying together of elements recommended by this standard to achieve overall stability and lateral restraint for walls.

All rafters/roof joists should be fixed to the wall plate, e.g. by framing anchors, and other connections should be made at the positions shown in Figure 11 with the exception of the cases listed in items a) to f).

Connections, where provided, should be inserted throughout the length of the wall at that level. Depending on the roof or floor construction and the location of the connection, the relevant detail indicated in Figure 11 should be chosen from Figure 12 to Figure 19.