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BSI Standards Publication

PUBLISHED DOCUMENT

Background information to the National Annex to BS EN 1991-1-4 and additional guidance

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Contents

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This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 92, an inside back cover and a back cover.

Foreword

Publishing information

This Published Document is published by BSI and came into effect on 31 December 2015. It has been prepared by Working Group 2 of BSI Subcommittee B/525/1, *Actions (loading) and basis of design*, under the authority of Technical Committee B/525, *Building and civil engineering structures*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This Published Document supersedes PD 6688-1-4:2009, which is withdrawn.

Information about this document

The new edition of this Published Document introduces the following principal changes:

a) Annex B inserted; and

b) further reading updated.

Relationship with other publications

This Published Document gives non-contradictory complimentary information for use in the UK with BS EN 1991-1-4:2005 and its UK National Annex.

NOTE BS EN 1991-1-4 contains guidance applicable to all structures. Therefore, B/525/10, which is responsible for Eurocodes for the design of bridges, was consulted in the drafting of this Published Document.

Use of this document

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

As a guide, this Published Document 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 Published Document is expected to be able to justify any course of action that deviates from its recommendations.

Presentational conventions

The provisions in this Published Document 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 Published Document. 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.

Notes and commentaries are provided throughout the text of this Published Document. Notes give references and additional information that are important but do not form part of the recommendations. Commentaries give background information.

This Published Document uses the decimal comma.

Contractual and legal considerations

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

This Published Document is not to be regarded as a British Standard

Introduction

When there is a need for guidance on a subject that is not covered by the Eurocode, a country can choose to publish documents that contain non-contradictory complimentary information that supports the Eurocode. This Published Document provides just such information and has been cited as a reference in the National Annex to BS EN 1991-1-4:2005.

1 Scope

This Published Document is a background paper that gives non-contradictory complementary information for use in the UK with BS EN 1991-1-4:2005 and its UK National Annex.

This Published Document gives:

a) background to the decisions made in the National Annexes for some of the Nationally Determined Parameters;

b) commentary on some specific subclauses from BS EN 1991-1-4:2005; and

c) additional data that can be used in conjunction with BS EN 1991-1-4:2005.

2 UK National Annex to BS EN 1991-1-4:2005

2.1 The fundamental value of the basic wind velocity $v_{b,0}$ [NA to BS EN 1991-1-4:2005, NA.2.4]

The fundamental value of basic wind velocity $v_{b,0}$ is defined as the 10-minute mean wind velocity with a 0,02 annual risk of being exceeded, irrespective of direction and season, at 10 m above ground level in terrain Category II, which is defined as open country with low vegetation and isolated obstacles with separations of at least 20 obstacle heights.

While the 10-minute averaging period is the meteorological standard for much of continental Europe, some individual countries use 1 hour, including the UK and Germany. Both these countries have adopted a factor of 1,06 to adjust the measured 1-hour average data to the 10-min period, based on empirical calibrations.

In the UK the basic wind velocity is obtained from: $v_{b,0} = v_{b,map} c_{alt}$

"Map" values, $v_{b,map}$ may be found in the UK wind map, which gives values that have been adjusted to sea level and to Category II roughness everywhere. The UK map is similar to the map in BS 6399-2:1997, except that the source data record has been increased from 11 years to 30 years and the original hourly-mean values have been factored up by 1,06 to represent 10-minute mean values. Thus the map in the National Annex is statistically more accurate.

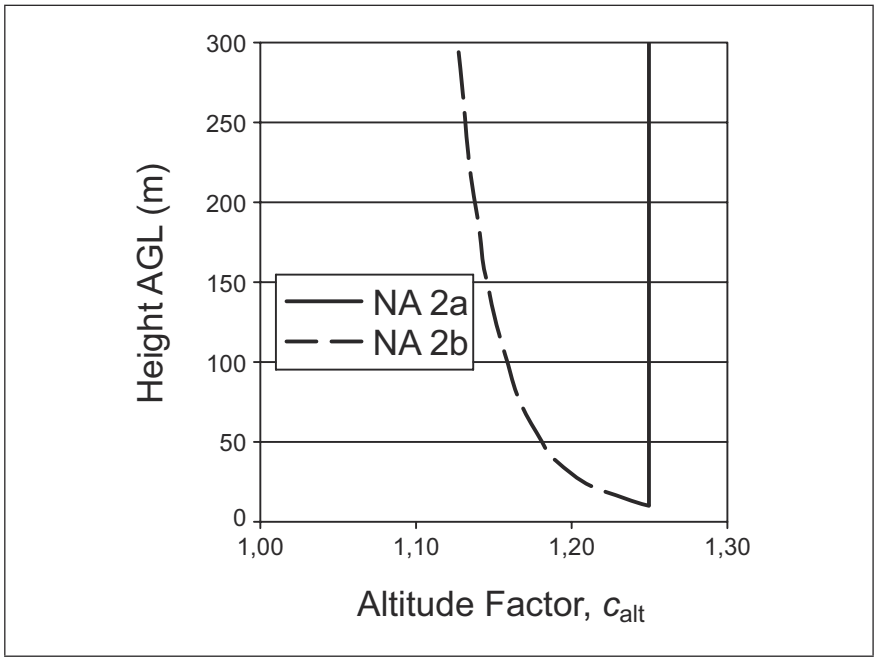
Altitude factor c_{alt} and corrections to account for changes of surface roughness are both National Choices. The former reduces the need to assess the effects of hills (orography) in many cases, while the latter allows conservatism to be reduced for sites further downwind of a coast or town boundary.

2.2 Procedure for determining the influence of altitude [NA to BS EN 1991-1-4:2005, NA.2.5]

In the current UK practice, the altitude factor is taken as constant with height above ground and its value depends only on the altitude of the site. The factor was calibrated empirically against measured data over sites of varying altitude (although generally limited to altitude values below about 200 m). Whilst the simple constant conservative value would be appropriate for structures that are less than 50 m in height and built on sites less than 100 m altitude, it becomes conservative for, say, a 300 m high guyed mast built on a 250 m high hill. Computational Wind Engineering analyses of several high altitude sites, calibrated against known terrain characteristics, confirm this to be the case. Clearly at large heights the altitude effect decreases so that, eventually, at the gradient wind speed height, the factor reduces to zero.

Accordingly, two formulae have been introduced in NA to BS EN 1991-1-4:2005. For the majority of building structures, the simple formula, NA to BS EN 1991-1-4:2005, Equation NA.2a) may be used, without undue conservatism. Figure 1 illustrates the comparison of the two formulae in the NA to BS EN 1991-1-4:2005 for heights up to 300 m above ground level for a site at 250 m above mean sea level. Altitude factor is a simplified substitute for the full orography assessment. The correction that varies with height [formula NA.2b)] removes a small double counting in BS 6399-2:1997; but makes the orography assessment more critical.

Figure 1 **An example of altitude correction factors**



2.3 Procedure for determining the roughness factor $c_r(z)$ [NA to BS EN 1991-1-4:2005, NA.2.11]

The roughness factor $c_r(z)$ accounts for the effect of the rough ground surface on the vertical profile of wind velocity. An approximate logarithmic profile is used in BS EN 1991-1-4:2005, which states that the expression given is valid when the upstream distance with uniform terrain roughness is sufficient to stabilize the profile sufficiently. It has been established that a "fetch" of over 100 km is required to achieve complete equilibrium. The coastline in the UK is such that equilibrium conditions do not generally occur in the UK. Therefore NA to BS EN 1991-1-4:2005 provides an alternative procedure to that indicated in BS EN 1991-1-4:2005. It defines the upstream distance as 100 km and provides a method that accounts for all intermediate values. The values of the roughness factor $c_r(z)$ are presented graphically for ease of use (NA to BS EN 1991-1-4:2005, Figure NA.3 and Figure NA.4).

It is recommended that all inland lakes extending more than 1 km in the direction of wind and closer than 1 km upwind of the site should be treated as "Sea" for the purposes of terrain classification.

2.4 Procedure for determining the orography factor c_0 [NA to BS EN 1991-1-4:2005, NA.2.13]

2.4.1 General

NA to BS EN 1991-1-4:2005, **NA 2.9** specifies that the recommended procedure given in BS EN 1991-1-4:2005, **A.3** should be used to determine the orography factor $c_0(z)$.

This procedure provides formulae (and graphs) to determine $c_0(z)$ for clearly defined cliffs and escarpments and hills and ridges. Unfortunately in the U.K. the majority of escarpments, hills and ridges occur in undulating terrain – only sea edge cliffs can clearly meet the configurations given in BS EN 1991-1-4:2005, **A.3**. In such cases, in the absence of reliable published documents or of verified computer methods, the procedure set out in **2.4.2** may be used. Alternatively, and conservatively, the site may be taken as an isolated hill, or escarpment, with a base level taken at the lowest level of the surrounding terrain within 8 km of the site, but with a slope taken as appropriate to the hill on which the structure is sited.

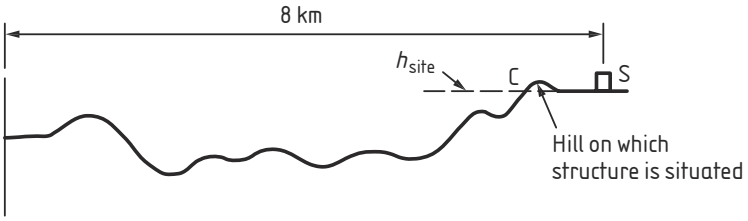
In all cases a check using the altitude factor alone, appropriate to the site altitude, should be undertaken and the resulting mean wind profile used if this is more onerous, (recognizing that both the altitude factor and orography factor vary with height above ground.)

2.4.2 Guidance

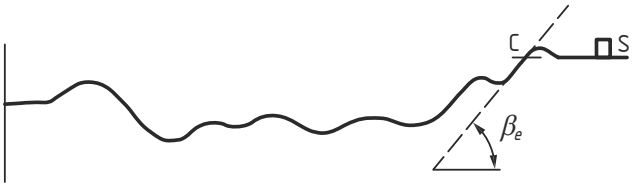
The procedure is shown in Figure 2. The procedure can be used for all wind directions and hence the downwind parameters can be determined in the same manner.

Figure 2 **Hill parameters in undulating terrain**

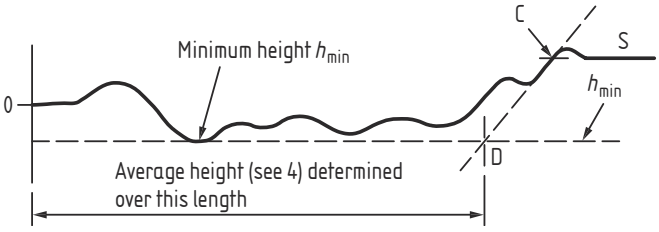
1. Plot a profile for 8 km in front of the site in the windward direction



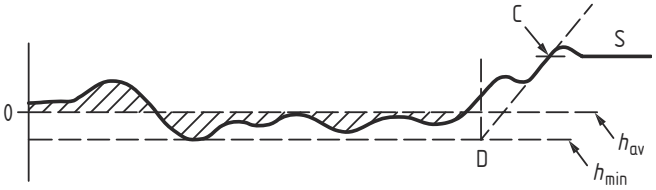
2. Draw a typical slope Øe from the hill on which the structure is situated (through C). If the site is behind the brow of the hill, draw an average slope in the windward direction



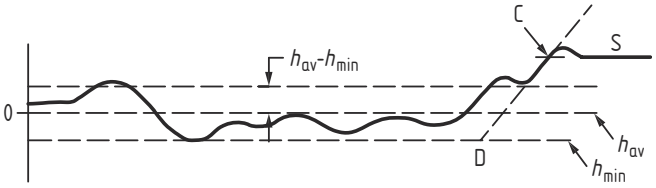
3. Draw a horizontal through the minimum height level h_{min} within the 8 km distance



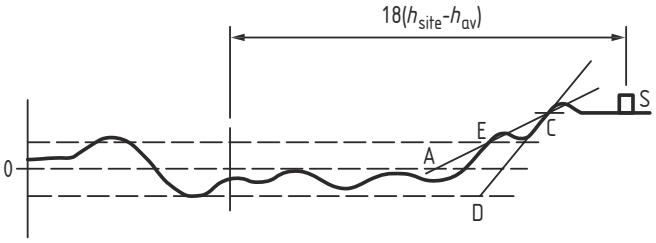
4. Find the average height h_{av} over the distance between the 8 km position (O) and the intersection of the slope line with the minimum height line (D)



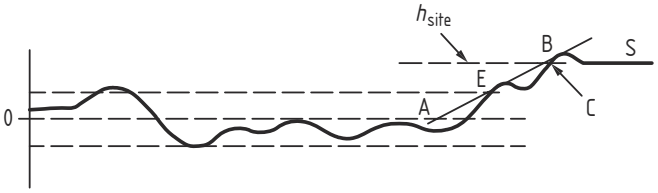
5. Draw a horizontal at height ($h_{av} – h_{min}$) above the average height level



6. Where this line intersects the profile within a distance 18($h_{site} – h_{ave}$) from the site, draw a slope through the intersection point (E) to the profile of the hill on which the structure is situated. This meets the average height level at A. (If there is more than one intersection, use the point furthest from the structure within the prescribed distance)



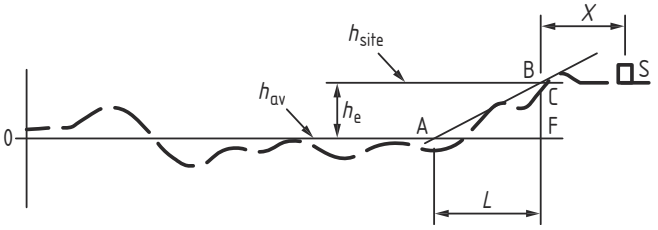
7. Draw a horizontal through the site level to intersect this slope h_{site} at B



8. The hill is then defined as OABS, with the effective hill parameters, for the purposes of NA to BS EN 1991-1-4:2005, Figure NA.2 and BS EN 1991-1-4:2005, Annex A, taken as:

$A = h_{av}$, L_u = AF, $H_e = h_{site} – h_{av}$,
$\phi = H/L_u$, X = BS

where ϕ is the mean upwind hill slope.



X is the distance of the site downwind from the crest.