Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte
Band: 74 (1996)

Artikel: National application document for the wind draft
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DOI: https://doi.org/10.5169/seals-56086

National Application Document for the Wind Draft

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Summary

The background to the production of the United Kingdom National Application Document for ENV 1991-2-4: Wind Actions is described in this Paper. Following positive voting by the CEN Committee TC250/SC1 on the draft document there was considerable discussion as to the application of the Rules contained therein. An informal ad-hoc panel was set up to try to set down a consistent framework for the preparation of each Member State's NAD. This framework has been used in the drafting of the United Kingdom NAD.

1. Introduction

The draft Eurocode on Wind Actions (ENV 1991-2-4) was drafted by the project team under the convenorship of Professor H. Ruscheweyh and published by CEN in March 1995. Such a complex subject inevitably led to much discussion in the Member States and to concerns that the National Application Documents (NAD's) may not reflect a consistent approach leading to problems of compatibility when the ENV document is converted to an EN Code.

To try to forestall this problem an informal ad-hoc panel was formed to set down a common basis for producing each country's NAD. This panel set down guidelines and advice on several aspects of ENV 1991-2-4[1] and in doing so identified areas where the Draft needed minor technical editing before publication as an ENV.

The United Kingdom NAD is presently being drafted and is using this framework, together with calibration exercises that have been undertaken against both the existing United Kingdom Code of Practice[2] and the recently published replacement Standard[3].

2. Outline of ENV 1991-2-4

The draft Eurocode ENV 1991-2-4 (hereinafter called 'the Draft') was developed with the intention of providing criteria for wind actions on all forms of structures. However during the course of the drafting it was recognized that certain forms of structure could not be adequately represented by the codified procedures. Specifically these were structures which respond under wind action to higher modes of vibration than the fundamental - such as cable supported structures like guyed masts, cable stayed and suspension bridges - and structures where specific guidance on pressure coefficients and wind response are required due to the nature of the structure - such as self-supported lattice towers. It was also recognized that specific Eurocodes are being developed for generic forms of structure, such as lighting columns, for which the Draft would not be used - although the procedures in such Codes should be compatible with the principles contained in the Draft.

It was also found that the basic wind data required from the Member States were in many cases obtained on different bases thus making the wind maps incompatible at borders between States.

The treatment of in-wind response to gust loading was based on work by Solari and others, leading to simplified codified procedures for the majority of 'normal' structures. Procedures are provided (in *Annex B* of the Draft) to deal with those structures which are likely to respond dynamically. The criteria for defining when the more complex rules are needed are given, although use of such procedures in any event will generally provide more economical solutions.

The pressure coefficients contained in the Draft are based on research work principally undertaken at the Building Research Establishment in the United Kingdom. The coefficients provided are upper bound values to be used for wind directions orthogonal to the building. To ensure that the most onerous conditions are covered, these pressure coefficients are the highest within a wind direction of $\pm 45°$ to the normal direction (see Figure 1). Inevitably this leads to a conservative approach. To overcome this an Annex was written during the drafting programme which contained directional pressure coefficients, appropriate to wind directions in 15° sectors around each building type considered. Indeed these directional coefficients provided the data for the orthogonal values provided in the main body of the Draft. At the voting stage, however, this annex was not included in the document, primarily it is suspected because the organization of the document at that time was somewhat unwieldy.

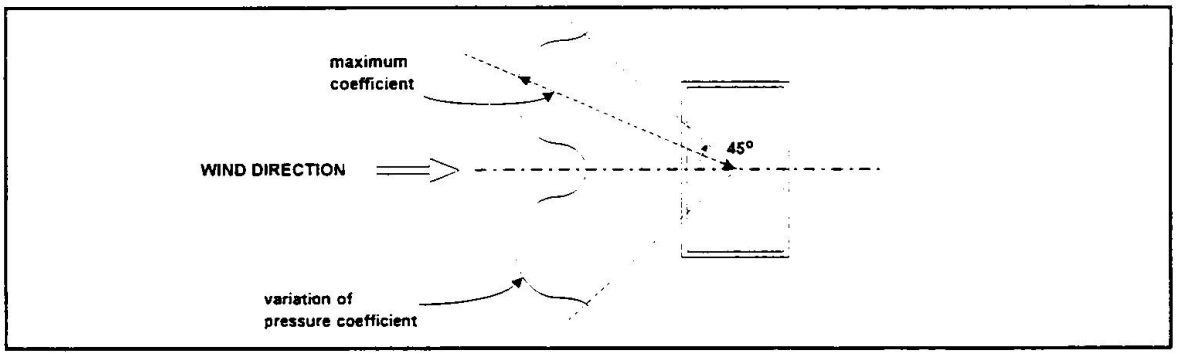

Fig. 1. Basis for orthogonal pressure coefficients.

3. Work Undertaken by Ad-hoc Panel

3.1 General

Following the positive voting of the document to proceed to ENV status, a small informal ad-hoc panel was convened to try to develop a common strategy in the writing of Member States' NADs. It was recognized that common procedures should be made available for the derivation of the basic wind speeds, for the adoption of the informative annexes and for the incorporation of additional information, such as the inclusion of the directional pressure coefficients. The membership of the panel and details of their meetings are shown in Annex A.

3.2 Meteorological Information

At the time of positive voting of the ENV the basic wind data had not been supplied by all Member States. In certain cases the data that had been provided were not consistent, thereby making production of a European wind map impossible.

The ad-hoc panel accordingly set down in a report [4] the parameters required to produce consistent information, compatible with the principles incorporated in the Draft. These could be considered by the relevant Meteorological Offices and thus amend the data already provided or indicate the equivalent parameters adopted in developing those data.

The wind maps for each Member State are intended to represent the 10 minute mean wind velocity at 10m above sea level in uniform terrain category II, that is open countryside such as farmland, having an annual probability of being exceeded of 0.02 (i.e. 50 year return period). Guidance is given in the Draft - and in the ad-hoc panel's report - on how to derive wind speeds for other probabilities of exceedance.

The basic wind speed data are then adjusted to determine the equivalent 10 minute mean wind velocity at the site by use of altitude and direction factors. Account also needs to be taken of the terrain roughness, if not category II, and also any change in roughness from one category to another. Procedures to account for these effects are given in the ad-hoc panel's report, together with photographs and diagrams of typical

terrains to assist in the selection of the appropriate category.

Detailed procedures were developed to account for the common case of sites being in areas where there is likely to be a transition from one category type to another, as these changes do not occur instantaneously. These procedures were considered to be of value to the engineer and were recommended by the panel to be adopted in each Member State's NAD.

The engineer, in using the Draft, needs to derive the peak wind load on the structure or structural component. This is achieved in the Draft by the use of an exposure coefficient which effectively converts the mean wind speed to a peak gust load, and depends on parameters defined in the Draft. It was considered possible that the site parameters as derived by the Meteorological Office differ from those assumed in the Draft - for example the turbulent intensity could be higher or lower. In that case the Meteorological Office should either:

a) determine the appropriate gust speed from mean wind data using their best estimate of the parameters for the site and then *by using Code parameters* work back to derive the appropriate value of mean speed for producing the map isotachs;
b) determine the appropriate gust speed from gust speed data and *by using the Code parameters* work back to derive the appropriate value of mean speed for producing the map isotachs.

3.3 In-line Gust Response

Concern had been expressed that some Member States might develop their own analytical procedures, rather than adopt the informative annexes contained in the Draft. These aspects were discussed at length in the ad-hoc panel, and comparative calculations were undertaken to assess the sensitivity of the results to the assumptions incorporated in the draft.

The general conclusion was that by minor editing of the draft to provide clarity to the reader the recommended procedures for in-line gust response provided answers within about ±5 per cent of other methods favoured by some panel members. However the scatter in predicting the appropriate wind speeds for the site - or in the value of the pressure coefficient for a structure or element not complying precisely with the tabulated configurations - would cause a much higher uncertainty in the wind loading.

3.4 Obstruction Heights

The effect of general roof top level, or obstruction height level, is represented simply in the Draft by the use of a parameter z_{min} which varies with terrain category and for which the wind speed is assumed to be constant at all levels from ground up to z_{min}. Thus for category IV, representing urban area, the wind speed is assumed constant up to a height of 16m above ground.

In fact in rough terrain such as towns and cities the wind tends to behave as if the ground level was raised to a height just below the average roof height, h_o leaving an indeterminate region below which is often sheltered known as the displacement height, h_d. However this is not applicable where the building to be designed is a similar height or lower than its surroundings where the displacement height is a fraction of the building height, h.

To allow for this effect the height z defined in *Clause 4.2* of the Draft as the height above ground should be replaced by an effective height z_e which is defined in the ad-hoc panel's report.

The displacement height reduces with separation distance between buildings, X, particularly across open spaces within, or at the edge of, a built up area. Rules to account for this effect are given in the panel's report and are illustrated in Figure 2.

It should be emphasized that these Rules are direction dependent, and the most onerous loading direction needs to be considered. The criteria set out in these proposals clearly depend on the continued existence of the buildings around the site. Care must be exercised to ensure that the loading is not sensitive to the dependency on the continuing existence of one or two adjacent buildings.

Accelerated wind speeds occur close to the base of buildings which are significantly taller than the displacement height. When considering low-rise buildings which are close to other tall buildings the rules for effective height will not necessarily lead to conservative values and specialist advice should be sought.

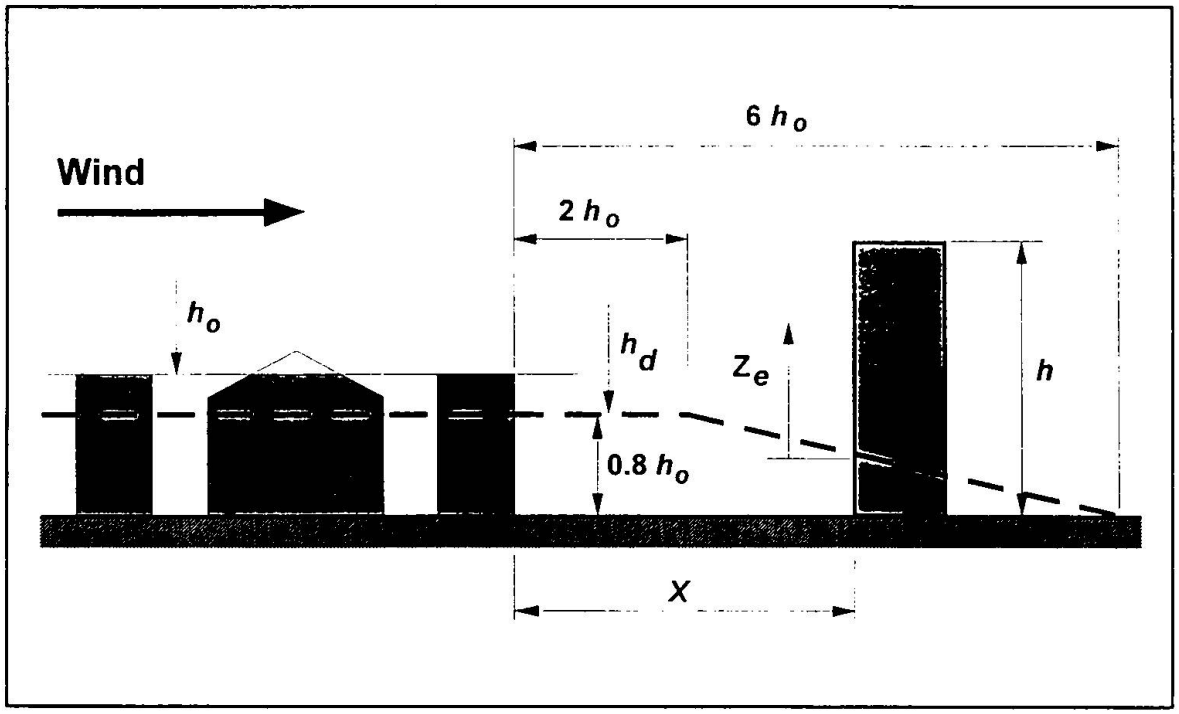

Fig. 2. Effective heights.

3.5 Direction Pressure Coefficients

The external pressure coefficients for buildings in the Draft depend on the size of the loaded area. They are given for loaded areas of $1m^2$ and $10m^2$. For areas less than $1m^2$ or greater than $10m^2$ the coefficients were assumed to be constant and with a logarithmic variation for intermediate areas.

As noted above they are also given for orthogonal wind directions but represent the highest values obtained in a range of wind directions 45° either side of the relevant orthogonal direction.

The panel considered that the directional coefficients, redrafted as an Annex to the Draft but excluded from the voted document, should be included in the NADs. The information contained in the Annex not only provides less conservative values but also gives values for generalised configurations which cannot be dealt with by the coefficients given in the Draft.

The Annex was thus re-examined and updated in the light of the most current information. However the coefficients provided are peak values, independent of loaded area, in the sense that they apply to different zones of the building or component. A separate adjustment for loaded area will needed to provided, for compatibility with the Draft.

4. Production of the United Kingdom's NAD for ENV 1991-2-4

The United Kingdom's NAD for ENV 1991-2-4 is presently being drafted and is following the framework of the ad-hoc panel, incorporating the proposals outlined in 3 above.

In advance of this a textual examination of the Draft was undertaken[5] to examine differences between the Draft and both the recently published British Standard BS 6399 Part 2 and its predecessor CP3 Chapter V Part 2. This identified typographical and technical errors in the Draft available at that time which were corrected prior to the publication of the ENV.

One major difference between the latest United Kingdom Wind Code, BS 6399 Part 2, and the Draft is that the United Kingdom use hourly mean wind speeds rather than 10 minute wind speeds. However the basic terrain in the United Kingdom has a z_o = 0.03 compared with a z_o = 0.05 in the Draft. It so happens that these two effects are self-cancelling, thus the map wind speeds in the Draft for the United Kingdom are identical to those in the British Standard.

Following this textual examination of the Draft a calibration exercise was undertaken to compare the results of using the draft with those obtained from BS 6399 Part 2 and CP3 Chapter V Part 2 on a series of buildings at selected locations in the United Kingdom[6]. This exercise, whilst not a comprehensive review, concentrated on the differences identified in the textual examination report. Comparative exercises were thus undertaken on:

a) terrain effects, including obstruction heights and changes in terrain category close to the site;
b) cladding pressures;
c) internal pressures;
d) overall building loads.

This exercise highlighted certain aspects of both the British Standard and the Draft which need to be addressed. Where interpretation of the Draft was found to be ambiguous, it was considered that clarification will need to be provided in the NAD. The initial conclusions from the calibration exercise were that the Draft gave higher total forces on buildings over 100m high which may be up to 30% greater than those calculated by BS 6399 Part 2 for a 200m building.

The team involved in writing the NAD are considering the conclusions of the calibration report whilst it is being finalized.

One problem faced in the production of the NAD is that no clear guidance is available on how to co-ordinate the ENVs on Actions with the already published ENVs, with their associated NADs, on design (e.g. ENV 1993-1). The latter NADs, of necessity, refer to the National Standards for loading, as ENV 1991 was not published at the time these were written. Unless amendments to these NADs are made there is, at present, no formal procedure whereby the Action and Design ENVs, with their associated NADs, can be used together.

Annex A

Membership of Ad-hoc Panel:

N. Cook	R. Sandvik
S. Desai	B. W. Smith
K. Handa	G. Solari
S. O. Hansen	P. Spehl
J. A. Hertig	G. Steinthorsson
E. Hjorth Hansen	

Meetings of Panel:

12th/13th April 1994	-	Brussels
13th June 1994	-	London
12th August 1994	-	Copenhagen

5. References

1. Recommendations of an Ad-hoc Panel for the production of National Application Documents, Report 386/1/95, Flint & Neill Partnership, January 1995.

2. Code of Practice: CP3 Chapter V Part 2: Wind Loads, British Standards Institution, London, 1970.

3. British Standard: BS 6399 Part 2: Code of Practice for Wind Loads, British Standards Institution, London, 1995.

4. Guidance for National Meteorological Offices to provide wind data for incorporation into the Eurocode for Wind Actions, Report 386/1/94, Flint & Neill Partnership, May 1994.

5. Textual Examination of Eurocode 1 Part 2.4: Wind Loads and Formulation of a Suitable Calibration Method, Report 434/11/95, Flint & Neill Partnership, July 1995.

6. Calibration of ENV 1991-2-4 Eurocode 1 Part 2.4: Wind Actions. Report AM 2949/RO1 (Preliminary), W. S. Atkins Safety and Reliability, January 1996.