

OBSOLETE
SEPTEMBER 1998

Code of

Basic data for the design of buildings —

Chapter V: Loading —

Part 2: Wind Loads

UDC 721 + 721 624.042.41

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This part of this Code of Practice has been prepared by a Committee convened by the Codes of Practice Committee for Building. Having been endorsed by the Council for Codes of Practice it was published under the authority of the Executive Board on 15 September 1972

^a Resigned September 1970
^b From September 1970
^c Resigned October 1970

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First published (as CP 4)
November 1944
First revision
(as CP 3:Chapter V) August 1952
Reset and reprinted July 1965
Partial second revision
(as CP 3:Chapter V-1)
December 1967
Completion of second
revision (as CP 3:Chapter V-2)
July 1970
Reprinted with additional
information September 1972

The following BSI references
relate to the work on this Code
of Practice:
Committee reference BLCP/23
Draft for comment 68/33615

ISBN 0 580 07453 6

Amendments issued since publication

Amd. No.	Date of issue	Comments
4952	January 1986	
5152	March 1986	
5343	June 1986	
6028	September 1988	
7908	September 1993	Indicated by a sideline in the margin

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Foreword

Part 1 of the current edition of this Code of Practice, which deals with dead and imposed loads other than wind loads, was published in 1967; Part 2 deals with wind loads.

In 1970 a revision of the 1952 edition was published as Part 2 in which pressure coefficients and force coefficients for a limited range of building shapes were given. The present edition extends this range by the addition of pressure coefficients for all building shapes for which there is sufficient information available. It also gives force coefficients for unclad structures and additional appendices on ice formation and wind forces on circular sections.

The committee responsible for the preparation of this Code appreciates that there are many building shapes not covered, but the necessary data are not available for these to be included in a code and there is need for additional research, particularly on the relationship between wind tunnel conditions and those in reality, to enable figures to be given for further shapes.

As compared with the 1952 edition, this edition treats wind loading in more detail because changes in building design and construction have, for some types of buildings, increased the influence of wind loading in relation to other imposed loads. This edition also uses wind data that have become available since 1952.

An important change in this edition from the 1952 edition is the adoption of gust loadings as the basis for design in place of the mean load averaged over one minute, which had been the basis hitherto. There is evidence to justify this change which will lead to a more realistic assessment of the wind loads. At the same time the opportunity has been taken to assess the probable wind speeds on a statistical basis in accordance with the current advice of the Meteorological Office.

In this Code numerical values have been given in terms of SI units, details of which are to be found in BS 3763, "*The International System of units (SI)*". For the convenience of those who wish to use them, approximate equivalents are also given in metric technical units and in imperial units; more accurate conversions can be obtained from BS 350, "*Conversion factors and tables*". A wind speed and pressure conversion chart (SI: metric: imperial) is given in Figure 3. For the purposes of this Code, the principal difference between SI units and metric technical units lies in the measurement of force, load and load intensity. The SI unit of force and load is the newton (symbol, N); it is that force which, when acting on a mass of 1 kg, imparts to it an acceleration of 1 m/s². Thus, under conditions of standard gravity, the following relationships apply:

$$1 \text{ kgf} = 9.806 \text{ 65 N (exact value)}$$

$$1 \text{ lbf} \equiv 4.448 \text{ N (approximate value).}$$

This Code of Practice represents a standard of good practice and therefore takes the form of recommendations. Compliance with it does not confer immunity from relevant statutory and legal requirements.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 48 and a back cover.

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

1 Scope

This Part of this Code gives methods for calculating the maximum gust wind loads that should be taken into account when designing buildings or components thereof.

It does not apply to buildings that are of unusual geometric shape, or have unusual site locations warranting special consideration, the loading for which should be obtained by experimental methods.

It does not apply to buildings whose structural properties (weight, stiffness, frequency or damping) make them susceptible to dynamic excitation. These should be assessed using published sources, examples of which are given in Appendix J, or by experimental methods. It should be noted that if a building is susceptible to excitation by vortex-shedding or other aerodynamic instability the maximum dynamic response may occur at wind velocities lower than the maximum.

For the purposes of this Code, “experimental methods” include properly-conducted wind tunnel tests which meet the provisions given in Appendix K. These experimental methods are also recommended when wind loading data are required in more detail than is given in this Code, or when the form of the building can be changed in response to the test results in order to give an optimal design.’

2 Definitions

For the purposes of this Code, the following definitions apply:

2.1

breadth¹⁾

the dimension of the building normal to the direction of the wind

2.2

depth¹⁾

the dimension of the building measured in the direction of the wind

2.3

height

the height of a building above the ground adjacent to that building

2.4

length²⁾

the greater horizontal dimension of a building above the ground adjacent to that building; or the length, between supports, of an individual structural member

2.5

width²⁾

the lesser horizontal dimension of a building above the ground adjacent to that building; or the width of a structural member across the direction of the wind

2.6

height above ground

the dimension above the general level of the ground to windward

2.7

element of surface area

the area of surface over which the pressure coefficient is taken to be constant

2.8

effective frontal area

the area normal to the direction of the wind or “shadow area”

2.9

dynamic pressure of wind

the free stream dynamic pressure resultant from the design wind speed

¹⁾ Breadth and depth of a building are dimensions related to the direction of the wind.

²⁾ Length and width are dimensions related to the plan form.

2.10

pressure coefficient

the ratio of the pressure acting at a point on a surface to the dynamic pressure of the incident wind

2.11

force coefficient

a non-dimensional coefficient such that the total wind force on a body is the product of the force coefficient multiplied by the dynamic pressure of the incident wind times an appropriate area, as defined in the text

2.12

topography

the nature of the earth's surface as influenced by the hill and valley configurations

2.13

ground roughness

the nature of the earth's surface as influenced by small-scale obstructions such as trees and buildings (as distinct from topography)

3 Symbols

A = element of surface area

A_e = effective frontal area

b = breadth

C_f = force coefficient

C_{fn} = normal force coefficient

C_{ft} = transverse force coefficient

C_t = frictional drag coefficient

C_p = pressure coefficient

C_{pe} = external pressure coefficient

C_{pi} = internal pressure coefficient

d = depth

D = diameter

F = force

F_n = normal force

F_t = *transverse force*

F' = frictional force

h = height

H = height above ground

j = width of member as indicated in diagram

$j\alpha$ = width of member across direction of wind

k = a constant

K = reduction factor

l = length

p = pressure on surface

P_e = external pressure

P_i = internal pressure

P = total load intensity

q = dynamic pressure of wind (stagnation pressure)

R_e = Reynolds number

S_1 = topography factor

S_2 = ground roughness, building size and height above ground factor

- S_3 = a statistical factor
 V = basic wind speed
 V_s = design wind speed
 w = width of building
 w' = bay width in multi-bay buildings
 α = wind angle (from a given axis)
 β = aerodynamic solidity ratio
 η = shielding factor
 ν = kinematic viscosity
 ϕ = geometric solidity ratio

4 Outline of procedure for calculating wind loads on structures

4.1 The wind load on a structure should be calculated for:

- 1) the structure as a whole,
- 2) individual structural elements such as roofs and walls, and
- 3) individual cladding units and their fixings.

4.2 It is important to note that the wind load on a partially completed structure will be dependent on the method and sequence of construction and may be critical. It is reasonable to assume that the maximum design wind speed V_s will not occur during a short construction period, and a reduced factor S_3 can be used to calculate the probable maximum wind. The graphs of Figure 2 should not, however, be extrapolated to a period of less than two years.

4.3 The assessment of wind load should be made as follows:

- 1) *The basic wind speed* V appropriate to the district where the structure is to be erected is determined in accordance with 5.2.
- 2) The basic wind speed is multiplied by factors S_1 , S_2 and S_3 to give *the design wind speed* V_s for the part under consideration (see 5.3, 5.4, 5.5 and 5.6)

$$V_s = V S_1 S_2 S_3.$$

- 3) The design wind speed is converted to *dynamic pressure* q using the relationship

$$q = k V_s^2.$$

Table 4, Table 5 and Table 6 give corresponding values of q and V_s in the three systems of units. See also Figure 2.

- 4) a) The dynamic pressure q is then multiplied by an appropriate pressure coefficient C_p to give the *pressure* p exerted at any point on the surface of a building.

$$p = C_p q.$$

If the value of the pressure coefficient C_p is negative this indicates that p is a suction as distinct from a positive pressure.

Since the resultant load on an element depends on the difference of pressure between opposing faces, pressure coefficients may be given for external surfaces C_{pe} and internal surfaces C_{pi} . The resultant wind load on an element of surface acts in a direction normal to that surface and then:

$$F = (C_{pe} - C_{pi}) q A$$

where A is the area of the surface.

A negative value for F indicates that the resultant force is outwards. The *total wind load* on a structure may be obtained by vectorial summation of the loads on all the surfaces.

4) b) There is, however, another and shorter method of finding the *total wind load on the building as a whole* by using a force coefficient C_r , where such is available.

The total wind load F is then given by:

$$F = C_r q A_e$$

where A_e is the effective frontal area of the structure.

The direction in which the force acts is specified in the tables for the force coefficients.

Pressure coefficients and force coefficients are given in **7** for a range of building shapes. Force coefficients are given in **8** for unclad structures.

5 Design wind speed

5.1 General. The design wind speed V_s should be calculated from

$$V_s = V S_1 S_2 S_3$$

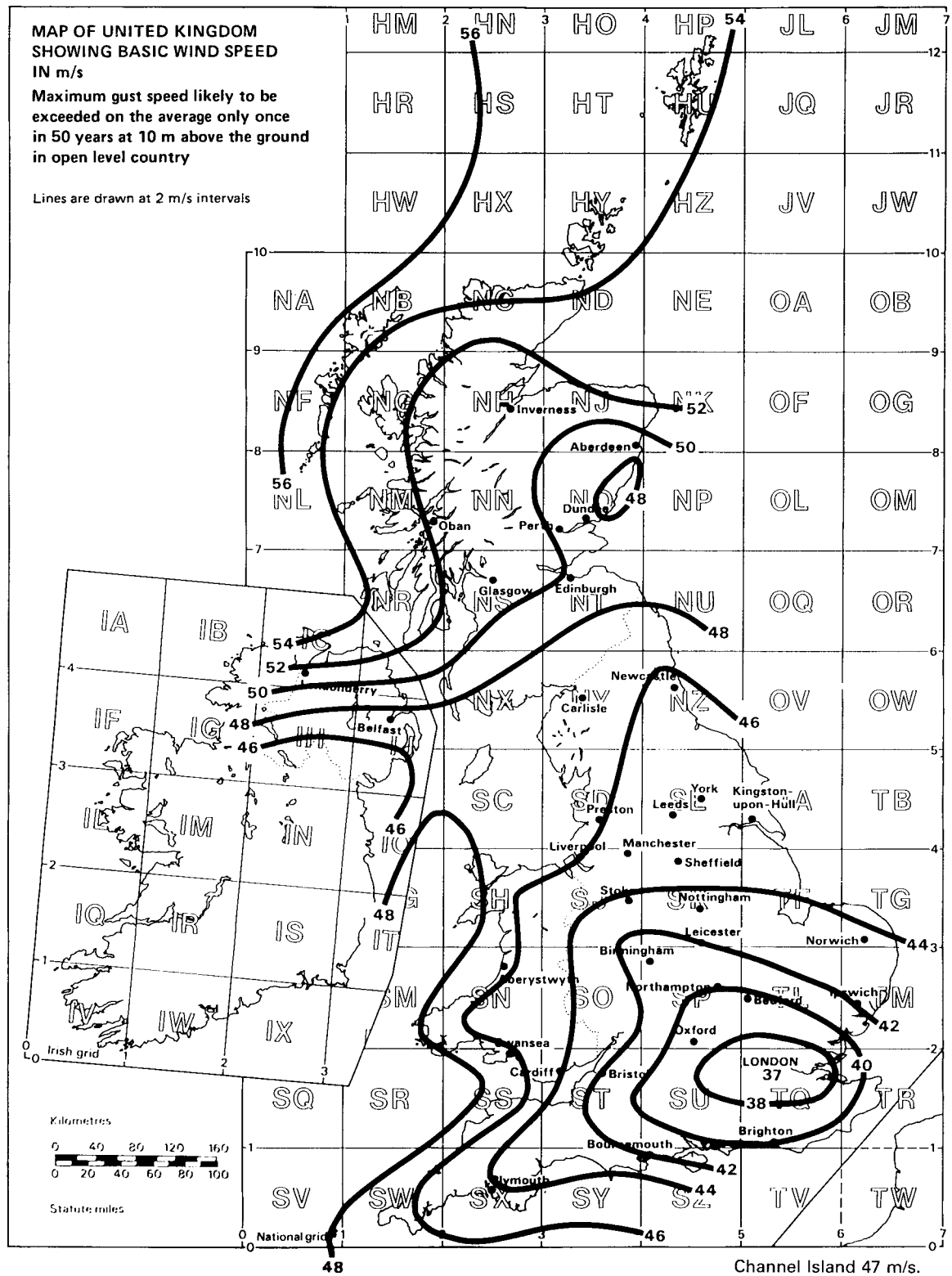
where V is the basic wind speed (see **5.2**), and S_1 , S_2 , S_3 are design wind speed factors (see **5.3** to **5.6** inclusive).

5.2 Basic wind speed

5.2.1 The basic wind speed V is the 3-second gust speed estimated to be exceeded on the average once in 50 years. This speed has been assessed for the United Kingdom by statistical analysis of the continuous wind records from the meteorological stations after adjusting them, as necessary, to a common basis. The values are given as isopleths (lines of equal wind speed) drawn at 2 m/s intervals on the map in Figure 1. Values from this map represent the 3-second gust speed, at 10 m (33 ft) above ground in an open situation, that is likely to be exceeded on the average only once in 50 years.

5.2.2 The basic wind speed V is greatest from the direction of the prevailing winds, that is from the southwest to west in the United Kingdom. For buildings, whose design may be directionally dependent, a reduced windspeed may be used for other directions, at the designers discretion, by the use of Appendix L.

Table 1 deleted



Based on information provided by the Meteorological Office.

Figure 1 — Basic wind speed

5.3 Wind speed factors

5.3.1 The basic wind speed has been assessed to apply to open level country with no obstructions and should be adjusted to take account of variations from this standard. The map necessarily incorporates the effects of the general level of the ground above mean sea level. A topography factor, S_1 , described more fully in 5.4, takes account of large local variations in the ground surface; it deals with the effects of hills and the sheltering in valleys. The ground roughness, building size and variation of strong winds with height modify the basic speed and have been combined in the factor S_2 (see 5.5). Finally, the period of years over which there will be exposure to the wind should be considered in modifying the basic speed. For this the factor S_3 (see 5.6) may be used.

5.4 Topography factor S_1 . The basic wind speed, V , given in Figure 1, takes account of the general level of the site above sea level. This does not allow for local topographic 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. In all cases the variation of wind speed with height is modified from that appropriate to level terrain.

Where the average slope of the ground does not exceed 0.05 within a kilometre radius of the site, the terrain may be taken as level and the topography factor S_1 should be taken as 1.0.

In the vicinity of local topographic features the factor S_1 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 $1.0 \leq S_1 \leq 1.36$. It should be noted that S_1 will vary with height above ground level, at a maximum near to the ground, and reducing to 1.0 at higher levels.

In certain steep-sided enclosed valleys, wind speeds may be less than in level terrain. Caution is necessary in applying S_1 values less than 1.0 and specialist advice should be sought in such situations.

A method for calculating the value of S_1 for values greater than 1.0 is given in Appendix D.

Table 2 deleted

5.5 Ground roughness, building size and height above ground, factor S_2 . The factor S_2 takes account of the combined effect of ground roughness, the variation of wind speed with height above ground and the size of the building or component part under consideration.

In conditions of strong wind, the wind speed usually increases with height above ground. The rate of increase depends on ground roughness and also on whether short gusts or mean wind speeds are being considered. This is related to building size to take account of the fact that small buildings and elements of a building are more affected by short gusts than are larger buildings, for which a longer wind-averaging period is more appropriate.

5.5.1 Ground roughness. For the purposes of this Code the ground roughness is divided into four categories and buildings and their elements are divided into three classes as follows:

Ground roughness 1. Long fetches of open, level or nearly level country with no shelter. Examples are flat coastal fringes, fens, airfields and grassland, moorland or farmland without hedges or walls around the fields.

Ground roughness 2. Flat or undulating country with obstructions such as hedges or walls around fields, scattered windbreaks of trees and occasional buildings. Examples are most farmland and country estates with the exception of those parts that are well wooded.

Ground roughness 3. Surfaces covered by numerous large obstructions. Examples are well-wooded parkland and forest areas, towns and their suburbs, and the outskirts of large cities. The general level of roof-tops and obstructions is assumed at about 10 m, but the category will include built-up areas generally apart from those that qualify for category 4.

Ground roughness 4. Surfaces covered by numerous large obstructions with a general roof height of about 25 m, or more. This category covers only the centres of large towns and cities where the buildings are not only high, but are also not too widely spaced.

Further explanation of these ground roughness categories will be found in Appendix A.

5.5.2 Cladding and building size. The wind speed fluctuates from moment to moment and can be averaged over any chosen period of time. It has been found that the shortest time scale, 3 s, that is normally measured produces gusts whose dimensions envelop obstacles up to 20 m across. The longer the averaging time the greater is the linear length encompassed by the gust. For this reason three classes have been selected as described below.

Class A. All units of cladding, glazing and roofing and their immediate fixings and individual members of unclad structures (see 7.2, Note).

Class B. All buildings and structures where neither the greatest horizontal dimension nor the greatest vertical dimension exceeds 50 m (165 ft).

Class C. All buildings and structures whose greatest horizontal dimension or greatest vertical dimension exceeds 50 m (165 ft).

The values of S_2 for variation of wind speed with height above ground for the various ground roughness categories and the building size classes are given in Table 3.

The height should be taken to the top of the structure or, alternatively, the height of the structure may be divided into convenient parts and the wind load on each part calculated, using a factor S_2 that corresponds to the height above ground of the top of that part. The load should be applied at the mid height of the structure or part, respectively. This also applies to pitch roofs.

Further explanation of the relationship between gusts and wind speed averaging time is given in Appendix B.

5.6 Factor S_3 . The factor S_3 is based on statistical concepts, given in Appendix C, which take account of the degree of security required and the period of time in years during which there will be exposure to wind. Whatever wind speed is adopted for design purposes, there is always a probability, however small, that it may be exceeded in a storm of exceptional violence; the greater the period of years over which there will be exposure to the wind, the greater is this probability. Figure 2 shows values of S_3 equivalent to a period of exposure of 50 years plotted against this period of years.

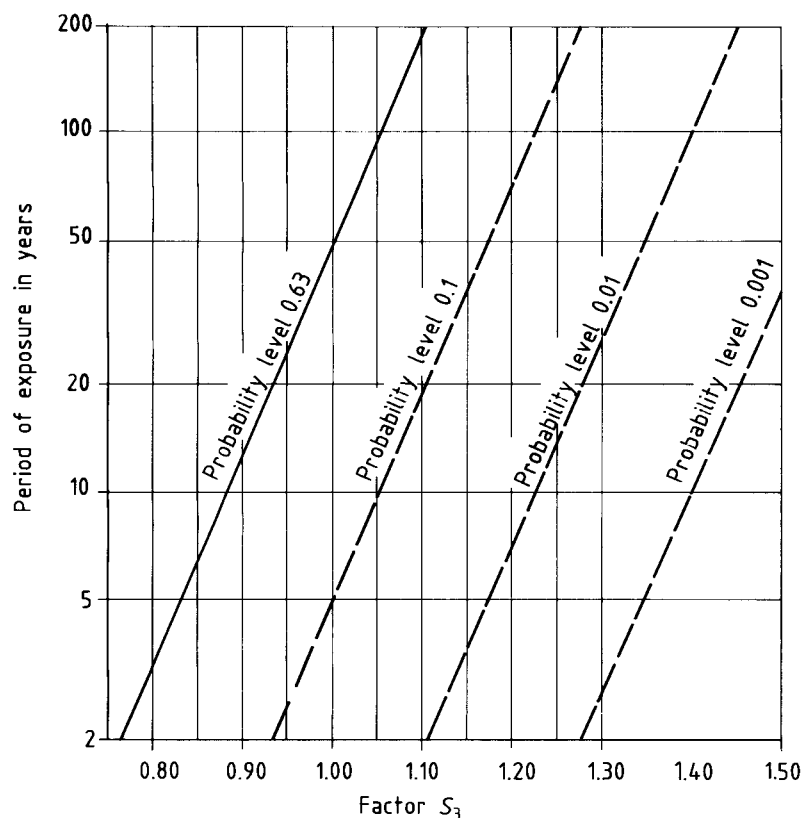
Normally wind loads on completed structures and buildings should be calculated at $S_3 = 1$ with the following exceptions.

- 1) Temporary structures.
- 2) Structures where a shorter period of exposure to the wind may be expected.
- 3) Structures where a longer period of exposure to the wind may be required.
- 4) Structures where greater than normal safety is required.

For these special cases both the period of exposure to the wind and the probability level may be varied according to circumstances. In no case is the period of exposure to be taken as less than 2 years. Some examples are given in Appendix C.

Table 3 — Ground roughness, building size and height above ground, factor S_2

H	(1) Open country with no obstructions			(2) Open country with scattered windbreaks			(3) Country with many windbreaks; small towns; outskirts of large cities			(4) Surface with large and frequent obstructions, e.g. city centres		
	Class			Class			Class			Class		
	A	B	C	A	B	C	A	B	C	A	B	C
m												
3 or less	0.83	0.78	0.73	0.72	0.67	0.63	0.64	0.60	0.55	0.56	0.52	0.47
5	0.88	0.83	0.78	0.79	0.74	0.70	0.70	0.65	0.60	0.60	0.55	0.50
10	1.00	0.95	0.90	0.93	0.88	0.83	0.78	0.74	0.69	0.67	0.62	0.58
15	1.03	0.99	0.94	1.00	0.95	0.91	0.88	0.83	0.78	0.74	0.69	0.64
20	1.06	1.01	0.96	1.03	0.98	0.94	0.95	0.90	0.85	0.79	0.75	0.70
30	1.09	1.05	1.00	1.07	1.03	0.98	1.01	0.97	0.92	0.90	0.85	0.79
40	1.12	1.08	1.03	1.10	1.06	1.01	1.05	1.01	0.96	0.97	0.93	0.89
50	1.14	1.10	1.06	1.12	1.08	1.04	1.08	1.04	1.00	1.02	0.98	0.94
60	1.15	1.12	1.08	1.14	1.10	1.06	1.10	1.06	1.02	1.05	1.02	0.98
80	1.18	1.15	1.11	1.17	1.13	1.09	1.13	1.10	1.06	1.10	1.07	1.03
100	1.20	1.17	1.13	1.19	1.16	1.12	1.16	1.12	1.09	1.13	1.10	1.07
120	1.22	1.19	1.15	1.21	1.18	1.14	1.18	1.15	1.11	1.15	1.13	1.10
140	1.24	1.20	1.17	1.22	1.19	1.16	1.20	1.17	1.13	1.17	1.15	1.12
160	1.25	1.22	1.19	1.24	1.21	1.18	1.21	1.18	1.15	1.19	1.17	1.14
180	1.26	1.23	1.20	1.25	1.22	1.19	1.23	1.20	1.17	1.20	1.19	1.16
200	1.27	1.24	1.21	1.26	1.24	1.21	1.24	1.21	1.18	1.22	1.21	1.18

Figure 2 — A statistical factor S_3

6 Dynamic pressure of the wind

From the value of the design wind speed V_s obtained from 5 the dynamic pressure of the wind q above atmospheric pressure is obtained from Table 4, Table 5 or Table 6 according to the units being used; these are derived from the equation:

$$q = kV_s^2 \text{ } ^3).$$

Values of k are as follows for the various units used in this Code:

$k = 0.613$ in SI units (N/m^2 and m/s)

$k = 0.062\ 5$ in metric technical units (kgf/m^2 and m/s)

$k = 0.002\ 56$ in imperial units (lbf/ft^2 and mile/h).

Any vertical line traversing the scales on Figure 3 indicates approximately the direct conversion between velocity and pressure on all three systems of units.

³⁾ The design wind speed and therefore q depends on S_2 , which varies with height (see 5.5.2).

Table 4 — Values of q in SI units (N/m²)

V_s m/s	0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
10	61	74	88	104	120	138	157	177	199	221
20	245	270	297	324	353	383	414	447	481	516
30	552	589	628	668	709	751	794	839	885	932
40	981	1 030	1 080	1 130	1 190	1 240	1 300	1 350	1 410	1 470
50	1 530	1 590	1 660	1 720	1 790	1 850	1 920	1 990	2 060	2 130
60	2 210	2 280	2 360	2 430	2 510	2 590	2 670	2 750	2 830	2 920
70	3 000									

Table 5 — Values of q in metric technical units (kgf/m²)

V_s m/s	0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
10	6.3	7.6	9.0	10.6	12.3	14.1	16.0	18.1	20.3	22.6
20	25.0	27.6	30.3	33.1	36.0	39.1	42.3	45.6	49.0	52.6
30	56.3	60.1	64.0	68.1	72.3	76.6	81.0	85.6	90.3	95.1
40	100	105	110	116	121	127	132	138	144	150
50	156	163	169	176	182	189	196	203	210	218
60	225	233	240	248	256	264	272	281	289	298
70	306									

Table 6 — Values of q in imperial units (lbf/ft²)

V_s mile/h	0	1	2	3	4	5	6	7	8	9
30	2.3	2.5	2.6	2.8	3.0	3.1	3.3	3.5	3.7	3.9
40	4.1	4.3	4.5	4.7	5.0	5.2	5.4	5.7	5.9	6.1
50	6.4	6.7	6.9	7.2	7.5	7.7	8.0	8.3	8.6	8.9
60	9.2	9.5	9.8	10.2	10.5	10.8	11.2	11.5	11.8	12.2
70	12.5	12.9	13.3	13.6	14.0	14.4	14.8	15.2	15.6	16.0
80	16.4	16.8	17.2	17.6	18.1	18.5	18.9	19.4	19.8	20.3
90	20.7	21.2	21.7	22.1	22.6	23.1	23.6	24.1	24.6	25.1
100	25.6	26.1	26.6	27.2	27.7	28.2	28.8	29.3	29.9	30.4
110	31.0	31.5	32.1	32.7	33.3	33.9	34.4	35.0	35.6	36.3
120	36.9	37.5	38.1	38.7	39.4	40.0	40.6	41.3	41.9	42.6
130	43.3	43.9	44.6	45.3	46.0	46.7	47.3	48.0	48.8	49.5
140	50.2	50.9	51.6	52.3	53.1	53.8	54.6	55.3	56.1	56.8
150	57.6									

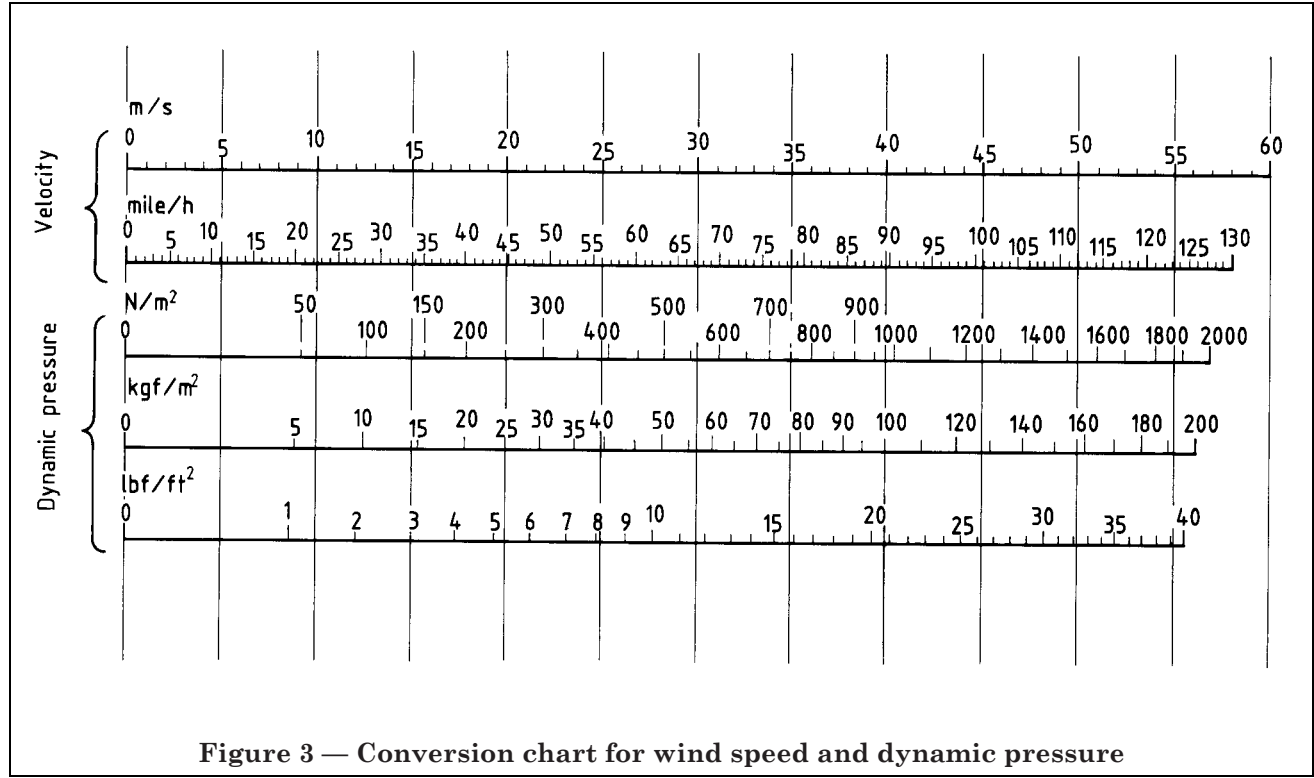


Figure 3 — Conversion chart for wind speed and dynamic pressure