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The effects of SNOW AND WIND on structures

REGULATIONS

NV 65-67

WITH APPENDICES

as adopted by the

TECHNICAL DOCUMENTATION CO-ORDINATION GROUP

Amendments to December

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PRINCIPAL SIGNS USED IN THE SNOW AND WIND REGULATIONS NV 65—67

(1968 edition and amendments of 1970)

A — height above sea level.

SNOW

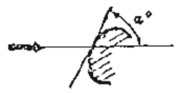
p_{no} — normal vertical imposed load } for altitudes from 0 to 200 m.
p'_{no} — maximum vertical imposed load } for altitudes from 0 to 200 m.
p_n — normal vertical imposed load } for altitudes from 200 to 2 000 m.
p'_n — maximum vertical imposed load } for altitudes from 200 to 2 000 m.

WIND. Regulations.

a — largest horizontal dimension of a structure with rectangular base.
b — smallest horizontal dimension of a structure with rectangular base.
c — coefficient of elementary pressure (instantaneous or mean), depending on the disposition of the structure.
c_e — coefficient for external forces.
c_i — coefficient for internal forces.

$$c = c_e - c_i$$

c_t — overall drag coefficient (in the direction of the wind).
c_{to} — overall drag coefficient (for a particular value of λ).
c_u — lift coefficient (or of upheaval).
c_1 — coefficient for forces on the face of a wall to windward.
c_2 — coefficient for forces on the face of a wall to leeward.
d — diameter of a cylinder, cable, sphere, or base of a spherical dome.
e — vertical distance (or isolation) from the ground to the base of a structure.
f — height (or rise) of a roof.
h — height of a structure, including the roof.
h_α — transverse dimension of a roof slope along the line of highest gradient.
l — length dimension of a building, of a roof, of a panel.
p — unit elementary force $p = c\,q$.
p_r — unit resultant force $p_r = (c_1 - c_2)\,q_r$.
q — elementary dynamic pressure $q = \dfrac{V^2}{16.3}$ daN/m²
q_r — mean value of dynamic pressure.
q_{10} — dynamic pressure at a height of 10 metres.
q_H — dynamic pressure at the level H: $q_H = 2.5\dfrac{H + 18}{H + 60}\,q_{10}$.
H — height above ground.
H_b — level of the base of a structure $H_b = e$.
H_s — level of the top of a structure $H_s = e + h$.
P — total resultant force on a wall $P = p_r \times S$.
S — total surface (or area) of a wall (possible openings closed).
S_a — surface area of the face of a building (the greatest length).

S_b surface area of the face of a building (the smallest length).
S_p surface area of the continuous parts (assumed to be uniformly distributed) of a perforated or latticed structure.
S_t area of the wind-plane of a building.
V wind-speed in metres per second.
$\alpha°$  angle of inclination (in degrees) of a wall or of the tangent of that wall with the horizontal direction of the wind.
β coefficient of dynamic magnification.
γ coefficient of correction, function of the slenderness or elongation of a building.
γ_0 value of γ for $e = 0$.
γ_e value of γ for $e < h$.
γ_h value of γ for $e \geqslant h$.
δ reduction coefficient for dynamic pressures on large surfaces.
θ overall coefficient of dynamic force (depending on type of structure).
λ ratio of dimensions $\frac{h}{d}, \frac{l}{d}, \frac{h^2}{S_t}$ or $\frac{l^2}{S_t}$.
λ_a ratio $\frac{h}{a}$.
λ_b ratio $\frac{h}{b}$.
μ coefficient of permeability:

$$\mu = \frac{\text{sum of the areas of openings in a wall}}{\text{total area S of the wall (apertures closed)}}$$

ξ response coefficient of a structure.
ρ specific volume of air (1.225 kg/m^3, on average).
τ pulsation or frequency coefficient.
ϕ

$$= \frac{S_p}{S} = \frac{\text{area of the continuous parts of a plane element (perforated panels, lattice girders)}}{\text{total area (apertures closed)}}$$

χ coefficient of magnification (for incidence along the diagonal of towers and latticed pylons).

WIND. Appendices.

c_L coefficient of deflection (Bénard-Karman eddies).
c_x drag coefficient of a section in the direction of the wind.
c_y coefficient of deflection of a section (in a direction normal to that of the wind).
c_N, c_T coefficients corresponding to the components of strain due to the wind following the two directions of the principal faces of a section $\quad c_x{}^2 + c_y{}^2 = c_N{}^2 + c_T{}^2$
d width of the wind-plane of a building.
e_α width of the wind-plane of a constituent bar of a latticed structure.
p slope of the ground.
q_0^h mean equivalent dynamic pressure, between 0 and H.
q_{cr} critical dynamic pressure of resonance.
R_e Reynolds number.
S Strouhal number.
T natural period of vibration of a structure (fundamental method).
T_k period of Bénard-Karman eddies.
V_{cr} critical wind-speed at which Bénard-Karman eddies are formed.
β' coefficient of dynamic magnification depending on the damping.
ν coefficient of kinematic viscosity of a fluid.
Δ logarithmic decrement.

INTRODUCTION

Up to 1944, the official French Regulations laid down a uniform wind pressure on structures whatever the shape, height, or situation might be. Apart from the Air Ministry Regulations, they did not envisage the existence of suctions. They therefore conveyed very inaccurately the actual effects of wind on buildings and structures, and led either to an insufficient or an excessive factor of safety depending on cases. At the request of the Ministry of Reconstruction, a Commission was set up to establish regulations taking into account the scientific and statistical data known at that time. Unfortunately, these data for buildings were, with rare exceptions, limited to aerodynamical tests carried out abroad, and for wind speeds, to those which had occurred within the experience of the meteorologists of the Météorologie Nationale, the archives having been destroyed during the war. Nevertheless, the Regulations N.V. 46 were drawn up on the basis of this incomplete information, in response to the desire to put quickly into the hands of builders a document which would enable them to make headway, safely and without squandering materials, with the task of reconstruction.

It had been envisaged from the start that these Regulations would be revised after a certain number of years. To prepare their revision, an enquiry was launched in February 1956 among their users. This enquiry did not show any serious omissions in the Regulations; it did show that their use had never led, during those ten years, to any real difficulties, but had led to appreciable economies.

A new revisory Commission was then set up. Aware that certain improvements were necessary, its work has been guided by a certain number of leading ideas:

1) To facilitate the use of the Regulations:

In response to the desiderata from the enquiry, the Commission drew up a better plan for the chapter 'Effects of Wind'. The first article forms a sort of guide. It indicates, in particular, the order in which quantities have successively to be determined in order to calculate the stresses. The other five articles each deal with a particular type of structure having specific aerodynamic characteristics.

Further, the Commission has introduced a special section of the text, III-2.9, dealing with parallelepiped structures, which, in practice, represent the majority of buildings in current use. The simplicity with which these rules can be used, based on the concept of the envelope, has at times to be paid for in a slight increase in the calculated stresses.

2) To extend the field of application of the Regulations:

To enable users to find the aerodynamic coefficients corresponding to the largest possible number of cases, the Commission has abstracted the main results of foreign tests, and has had carried out in France an important series of tests to fill up the gaps (Ann. I.T.B.T.P., November 1960, July—August 1961, January 1963, June 1963, October 1964). It has also taken note of various researches which their authors have been kind enough to communicate. It has therefore been possible to make many paragraphs of the Regulations more complete and to add new paragraphs.

3) To take account of new types and methods of construction

The trends which were already apparent in 1946 have been accentuated and developed in the past years; these are an ever greater number of tall buildings and structures of great height, often executed in prefabricated elements, and more and more frequent recourse to light-weight materials, especially for roofs and the cladding of façades.

The complete destruction by the wind of structures of traditional type has proved in the past to be quite rare. But this might not be true for certain elevated, light-weight structures with a low damping coefficient, which are very susceptible to strong gusts and to Karman vortices. Moreover, as regards cladding of roofs and façades, it appears that more or less considerable damage has been confirmed during the past score of years.

These considerations have led the Commission to study the problem of local and dynamic forces, and to revise the Regulations in the direction appropriate for ensuring safety.

4) To take account of the development of methods of calculation and of the determination of the safety factor:

Recourse to two types of imposed load, already envisaged in the Regulations N.V. 46, seems to be inevitable with the methods of calculation based on the theory of limiting states, which has been developed in France and abroad. The Commission has attempted to define normal imposed loads corresponding to a structure's being in a serviceable state, and maximum imposed loads corresponding to its being 'unserviceable'. The maps of the snow and wind loads have been revised from this point of view. They take account of the heaviest falls of snow and of the highest wind speeds observed on 31 December 1964.

Since the sole purpose of the Regulations N.V. 65 is, of course, to provide a basis for determining the effects exerted by snow and wind on structures, the Commission has abstained from indicating the conditions for checking safety, leaving this to the care of the Regulations pertaining to each type of material.

5) To take account of the development of ideas regarding the determination of the wind speed for purposes of calculations:

In estimating the wind for purposes of calculations, two lines of thought show up: one uses the wind gradient, taking into account the type of terrain (seas and lakes, bare meadowland, fields with hedgerows and clumps of trees, agglomerations); the other is based on the wind speed at the standard meteorological height of 10 m.

Whatever the criterion adopted, the estimation of the maximum wind speed which a structure will have to resist during its lifetime will always present a considerable degree of uncertainty, due to:

—the correlation of records made during a given previous period and those which will be obtained during the future lifetime of the structure;

—the duration and magnitude of gusts;

—the variation in their speeds as a function of height;

—local topographical conditions;

—the transfer of experimental results obtained from models in wind-tunnels to structures situated in natural wind and subject to all the effects of the environment (interaction, 'wake' effects, Venturi effects).

The Commission decided that it did not have sufficient and definite elements of appreciation to warrant changing the bases of the Regulation N.V. 46, viz.:

—the dynamic pressure at 10 m;

—the mean law of variation with height;

—the classification into regions;

—coefficients measured in a wind-tunnel in an air current of constant speed.

However, the Commission has sought to incorporate the variation of the mean overall force of the wind as a function of the biggest dimension of an element, panel, or structure considered in the calculations. In consequence, the standard dynamic pressure in the present Regulations is defined as that which is exerted on an element whose greatest dimension is 0.50 m. It is therefore higher than that of the Regulations N.V. 46, which corresponded to an element with an area equal to or greater than 15 m² (with an increase of the local forces for areas between 15 and 5 m²). But it would be inexact to compare these dynamic pressures with one another, since the determination of the dynamic pressures for the calculations which start from the standard dynamic pressures takes account of the effect of the actual dimensions by means of a reducing coefficient which does not appear in the Regulations N.V. 46.

The application of the Regulations N.V. 65 over more than a year has given rise to numerous requests for information and justified observations. The drafting Commission considered it appropriate to arrange the Regulations in accordance with these observations. The final version of the Appendices has at the same time been completed taking into account these adjustments.

In conclusion, the Commission has used for the best the actually available knowledge in order to arrive at a better evaluation of the stresses which are actually applied to structures, and consequently to a more adequate appreciation of the resistance of structures to those stresses for which the wind effects are a big and a sometimes determinative factor. Although these Regulations constitute an advance on preceding ones, the Commission considers that it would be expedient to intensify meteorological and aerodynamical research into the problems, to proceed to direct tests on actual structures, and to develop international liaisons in order to have available more complete and reliable information when a future revision is made.

N. ESQUILLAN

EXPLANATORY NOTE

The divisions and sub-divisions of the various articles are indicated by a decimal notation, with the following two special features:

—a zero indicates either a general paragraph or a preliminary section;

—the number nine indicates a conclusion relating to the sub-division which it ends.

For ease of reading, a dash is introduced after the third decimal digit. Also, within the corresponding paragraph, reference to such a sub-section is given simply by, e.g., '-2'.

The diagrams are numbered separately for the Regulations and for the Commentary. Each serial number of a diagram consists of three parts:

—a letter R or C indicating that the diagram refers to the Regulations or to the Commentary;

—a roman numeral I, II, or III, indicating the chapter;

—an arabic numeral indicating the serial number itself of the diagram.

E.g., Fig. C-III-21 is the 21st diagram of the Commentary on Chapter III.

Mechanical magnitudes are expressed in the SI system of units (metre, kilogram-mass, second), the use of which became obligatory on 1 January 1962. To keep to the usual orders of magnitude, the imposed loads are expressed in daN/m², since the decanewton is almost equal to 1.02 kgf. On occasion, in the tables for the imposed loads, the values are also given in the M.Kf.S system of units.

IN THIS TRANSLATION, the Commentary is typed in italics and the Regulations-proper in roman type.

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