Seminar on Dynamic Thermal Behaviour of Buildings

(Dec 1984) in Paris

DETERMINATION OF REFERENCE WIND FOR THE CALCULATION OF HEAT LOSSES ASSOCIATED WITH CHANGE OF AIR IN BUILDINGS

Philippe DUCHENE-MARULLAZ and Dominique BEGUIN, engineers

Centre Scientifique et Technique du Bâtiment, Nantes

I. INTRODUCTION

1.1 GENERAL POINTS

Changes in the ventilation characteristics of a building due to wind may lead to a considerable increase in heat losses, especially during the winter. In fact, wind produces excess pressure and low pressure on the façades and roofs of buildings, both in the case of natural and mechanical ventilation, which may result in an increase in air change rates in buildings.

Because of the turbulent nature of wind, external pressure at any point on the facade of a building continually fluctuates. It is only necessary to take into account the mean pressure value in the case under consideration. This mean pressure value P_i is associated with the mean dynamic pressure P_h measured at height h above the ground by the relationship:

$$P_i = \overline{C}_{P_i} \cdot P_h$$

where $\overline{C}_{P_i}$ is the mean pressure coefficient at point i under investigation.

P_h is linked to the average wind speed $\overline{V}_h$ measured at height h at the building site by the expression:

$$P_h = \frac{1}{2} \rho \overline{V}_h^2 \quad (\rho = \text{specific mass of air})$$

P_h is in P_a, $\overline{V}_h$ in m/s and ρ = 1, 225 kg/m^3.

It is assumed that h relates to the height of the building under investigation.

Pressure values on the different façades and on the roof of the building under investigation can therefore be determined where values for $\overline{C}_{pi}$ and $\overline{V}_h$ are known. The heating engineer can then calculate air change rates and consequently corresponding heat losses from the ventilation characteristics and the building. An approach to this calculation has been demonstrated by J. Bietry (1).

1.2 DETERMINATION OF MEAN PRESSURE COEFFICIENTS $\overline{C}_{p_i}$

These coefficients can only be determined by means of a wind tunnel under "upper layer" conditions, whereby the characteristics of wind in the lower layers of the atmosphere (vertical gradient for average speed as a function of the ruggedness of the ground, vertical distribution of the degree of turbulence and turbulence ranges) are suitably reproduced.

They depend on many factors, in particular:

- the size and shape of the building,
- the point studied on the building,
- the immediate building environment,
- the ruggedness of the ground,
- the direction of the wind in relation to the building.

It is of course not possible to study combinations of all these parameters; a choice must be made. This has been achieved in the study by J. Gandemer (2). Table 1 lists the various types of buildings investigated and the characteristics of the environment in which these buildings were located.

Figure 1 shows the cartography for the relationship between pressure coefficients and 2 angles for wind with or without environment and a wind of the type found in open country.

1.3 DETERMINATION OF AVERAGE WIND SPEED $\overline{V}_h$

$\overline{V}_h$ can be determined by taking wind measurements on the building site, or by using data from the nearest meteorological station (which is by far the more common procedure). A good knowledge of the characteristics of the environment of the building site and that of the meteorological station is required, so as to be able to transfer measurements taken at this station to the building site. Data from the meteorological station cannot be directly applied, for the wind can be greatly influenced by the physical characteristics of the environment (relief, type of ground, various obstacles).

A model for wind has been developed at the C.S.T.B. (3) and (4) and this model is presented in Section II.

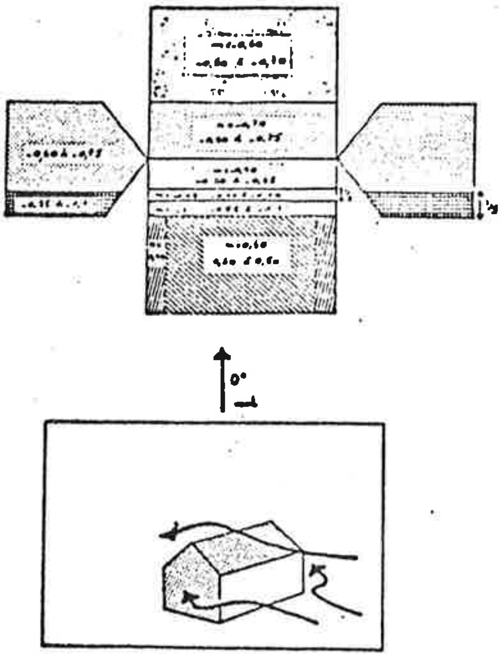
II <u>TRANSFER OF DATA FOR WIND</u>

2.1 SOME DEFINITIONS FOR WIND

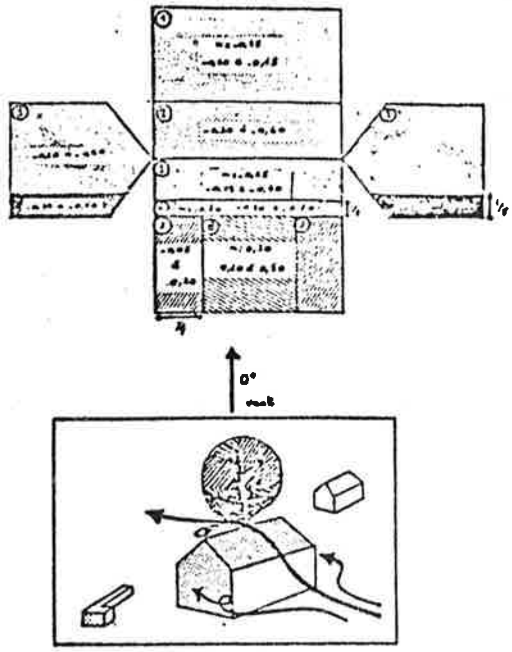
Wind is the flow of air which is due to differences in atmospheric pressure on the surface of the earth, which are

Table 1 (according to J. Gandemer)

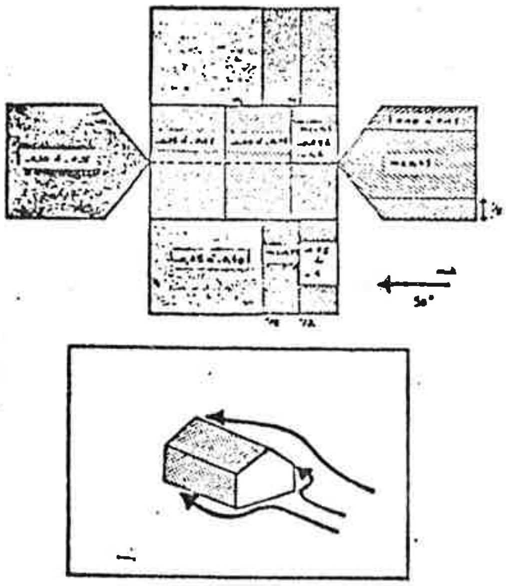
BUILDING	IMMEDIATE ENVIRONMENT	DISTANT ENVIRONMENT
Detached house R+1 with two roof sections sloping at an angle of 22°	Overall plan of house (R+0 and R+1)	Overall plan of house (R+0 and R+1) Overall plan in blocks (R+4) Overall plan in segments (R+4) Overall plan of industrial zones and large areas Note: vegetation has even been included in some overall plans
Parallelepiped block height 15 metres (R+4) Special cases . block connected to another block: L shape . block inserted into another block	Overall plan in blocks (R+4)	Overall plan of house (R+0 and R+1)
Parallelepiped section height 15 metres (R+4)	Half of overall plan in segments R+4 (same as that studied)	Overall plan of house (R+0 and R+1) Overall plan or blocks (R+4) small towers (R+10) and blocks (R+4)
Parallelepiped tower block height 40 metres (R+12) Recessed tower block height 40 metres (R+12)	Half overall plan of tower block R+12 (same as that studied) Overall plan comprising towers R+12 and blocks R+4)	Overall plan of house Overall plan in blocks (R+4) small towers (R+10) and blocks (R+4)
"Stepped" element fitted into a "staircase" structure same as the recessed tower in R+12 It is inserted into the compact unit at several positions	Overall plan of compact "staircase" structure	Overall plan of house (R+0 and R+1)
Effect of height of acroters (a_1 = 40 cm and a_2 = 15 cm) and ventilation superstructures on flat roof of tower block R+12	Half overall plan of tower block R+12	Overall plan of house (R+0 and R+1)



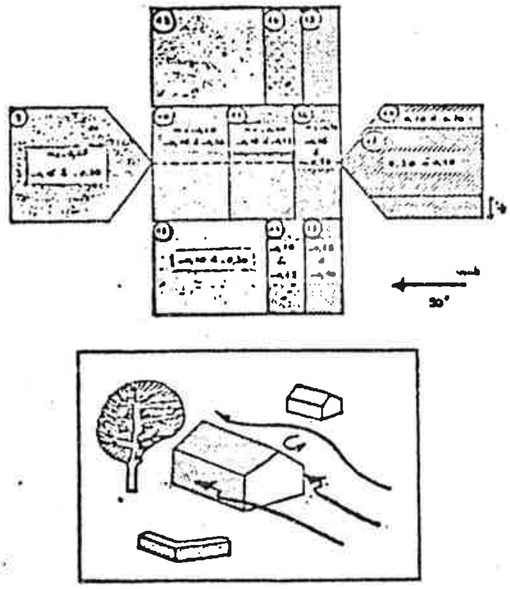
Angle of wind 0°.
Without environment



Angle of wind 0°.
With environment



Angle of wind 90°.
Without environment



Angle of wind 90°.
With environment

<u>Figure 1</u> Mean pressure coefficient for a house R + 1
(m = mean value for zone)
(according to J. Gandemer)

created by uneven heating of air according to latitude or the nature of the ground.

Far from the ground (1,500 m, for example), wind speed is due to the state of equilibrium of forces generated by the field of atmospheric pressure and Coriolis' forces (due to the rotation of the earth). The wind is then more or less parallel to the isobars.

Near to the ground (at less than 200 m, for example), friction forces due to the presence of the ground predominate and generally reduce the average wind speed: they also create turbulence, i.e. fluctuation in wind speed in time and space.

The effects of friction due to air on the ground increase with the number and size of the obstacles encountered, i.e. with increasing ruggedness of the ground. These effects decrease with increasing distance from the ground.

Wind speed in the lower layers of the atmosphere therefore varies with time according to two different scales:

- a slow variation which corresponds to changes in the field of atmospheric pressure; the associated time scale is considerably greater than one hour. Strong winds associated with cyclonic disturbance will therefore be observed for several consecutive days and will affect vast geographical zones on a national scale. Seasonal variations during the year are also well known.

- rapid fluctuation, which corresponds to turbulence; the corresponding time scale varies between approximately ten and fifty to sixty seconds. Its spatial range, i.e. the mean size of turbulent air movements, is of the order of ten to one hundred metres. It is strongly influenced by the nature of the obstacles encountered by the wind (nature of the ground, topography and isolated obstacles).

These two ranges for variation in wind speed are separated by breaking down the momentary speed V(t) at any point in space into two terms:

$$V(t) = \overline{V} + V'(t)$$

where $\overline{V}$ is the modulus of average speed over 10 minutes

$$(\overline{V} = \frac{1}{T}\int_{o}^{T} V(t)dt \text{ with } T = 10 \text{ minutes})$$

and V'(t) is the fluctuation in speed.

Only the modulus of average speed $\overline{V}$, the variation in which with height above the ground, ruggedness and topography and in the presence of an isolated obstacle is to be studied, is relevant with regard to the applications with which we are concerned. An average reference speed $\overline{V}_o$, measured at a height of 10 m on a flat, open site (which corresponds fairly often to the wind speed measured at meteorological stations) will also be used.

2.2 VERTICAL SECTION OF AVERAGE WIND SPEED ON A FLAT, LEVEL SITE

The variation in average wind speed $\overline{V}$ with height Z above flat, level ground, characterised by a ruggedness parameter Z_o, may be written as follows:

$$\overline{V}(Z) = 2.5\ V_x\ \ Ln(\frac{Z}{Z_o})$$

where V_x is the "rate of friction".

Table 2 lists 6 categories for nature of ground and the corresponding ruggedness parameter Z_o.

Table 2 — Ruggedness parameters Z_o and a for the law of vertical variation in average wind speed $\overline{V}(Z)$ with height above the ground (Z) in relation to an average wind speed $\overline{V}_o$ at a height of 10 m in open country (category III)

Category		Z_o(m)	a
I	Large expanse of water (ocean, sea, lake)	0.005	0.166
II	Flat meadows with short grass and no trees or buildings	0.02	0.182
III	Flat or slightly undulating, open country with scattered obstacles (houses, trees, hedges). Low vegetation	0.07	0.202
IV	Countryside with tall crops (maize, vines, small fruit trees), sparsely wooded copses, scattered settlements	0.25	0.229
V	Thickly wooded copses, orchards, small woods, suburban areas	0.40	0.240
VI	Urban zones, woods and forests	1.00	0.266

N.B.

- This law of logarithmic variation in wind speed with height is only strictly applicable under stable and more or less neutral atmospheric conditions.

- Moreover, when rugged elements are close together, i.e. they occupy more than 25 % of the total surface area, the apparent ground level is raised in respect of flow. It is then justifiable to include a "displaced height" d in the formulation of the vertical speed section:

$$\frac{\overline{V}(z)}{V_x} = 2.5 \text{ Ln } \left(\frac{Z-d}{Z_o}\right)$$

In France, measurements of wind speed which may be used for reference purposes are generally taken at a height of 10 m above ground level at meteorological stations (type III ruggedness (open country) may be considered to be applicable to these stations, which are often situated at airports). It is then interesting to express the relationship between the vertical variation in wind speed at any site and the average wind speed $\overline{V}_o$ at a height of 10 m at a reference site in open country (Z_o = 0.07 m by convention). The following relationship is then obtained:

$$\frac{\overline{V}(Z)}{\overline{V}_o} = a \, \text{Ln} \left(\frac{Z}{Z_o}\right)$$

Values for a have been listed in Table 2.

The ratio $\frac{V(z)}{\overline{V}}$ can then easily be determined if the ruggedness value for the site and height Z on the site are known.

Table 3 below gives the values for this ratio for 4 heights above the ground.

Table 3 Variation in the ratio $\overline{V}/\overline{V}_o$ with height above the ground Z and ruggedness

Ruggedness	I	II	III	IV	V	VI
Z = 10 m	1.26	1.13	1.00	0.85	0.77	0.61
Z = 20 m	1.38	1.26	1.14	1.00	0.94	0.80
Z = 30 m	1.44	1.33	1.22	1.10	1.04	0.90
Z = 40 m	1.49	1.38	1.28	1.16	1.11	0.98

2.3 STRUCTURE OF WIND NEAR THE GROUND ON SITES WHICH DO NOT HAVE UNIFORM FEATURES

The structure of wind varies and changes due to a change in the nature of the ground, or a rise in the level of the ground, or even because of the presence of isolated obstacles.

2.3.1 Effect of a change in ruggedness

Disturbance in air flow (in the plane formed by the ground and the height above the ground) when passing over a discontinuity in ruggedness (X = 0 in Figure 2) varies according to the relative significance of this discontinuity in the wind and behind the wind on the basis of ruggedness lengths Z_{01} and Z_{02}.

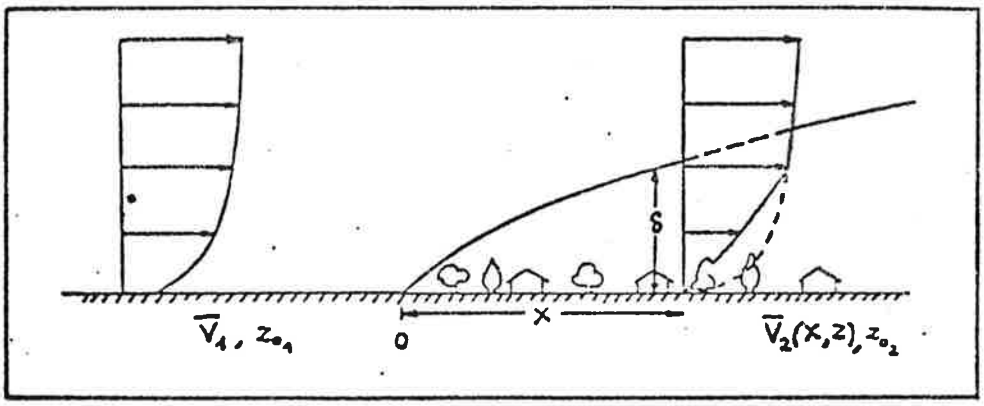


Figure 2 Change in ruggedness

An increase ($Z_{02} > Z_{01}$) or a decrease ($Z_{02} < Z_{01}$) in ruggedness causes a decrease (increase) in the average wind speed in the layer affected by the change in ruggedness (this layer is known as the "internal boundary layer"); the disturbance in speed is at a maximum near the ground and negligible at the top of the layer. The thickness of the internal boundary layer δ increases with the distance from the wind of the discontinuity in ruggedness.

The average speed $\overline{V}_2(x,Z)$ where the discontinuity in ruggedness is behind the wind for a height Z which is less than the height of the "internal boundary layer" can be estimated by referring to the standard speed $\overline{V}_o$ measured at a height of 10 m in open country (category III, Table 2):

$$\frac{V_2(x,Z)}{\overline{V}_o} = \frac{a \text{ Ln } \frac{\delta(x)}{Z_{01}}}{\text{Ln } \frac{\delta(x)}{Z_{02}}} \cdot \text{Ln } \frac{Z}{Z_{02}}$$

a, relative to ruggedness in the wind (Z_{01}), is given by Table 2 and (x), the height of the "internal boundary layer", is given by the following experimental formula:

$$\delta(x) = 0.35 \, x^{0.8} \, Z_o^{0.2}$$

where Z_o is the greater of the two ruggedness values Z_{01} and Z_{02}.

Note

- The effect of ruggedness behind the wind (Z_{02}) is not taken into account at a short distance from the discontinuity in ruggedness ($x < 200$ m); only ruggedness against the wind (z_{01}) is used.

- $\overline{V}_2(Z)$ is calculated from the following expression at a great distance from the discontinuity in ruggedness ($x > 5000$ m):

$$\frac{\overline{V}_2(Z)}{\overline{V}_o} = a \text{ Ln } \frac{Z}{Z_{02}}$$

where a relates to ruggedness Z_{02}.

2.3.2 Effect of a rise in the level of the ground

When a mass of air strikes a hillock or a hill of moderately high relief crosswise, a large part of the air flow rises on the side of the obstacle facing the wind and then falls on the side sheltered from the wind.

Flow in the plane formed by the ground (in the direction of flow) and height Z is again studied (Figure 3).

zone of increased speed

Side facing the wind

Side sheltered from the wind

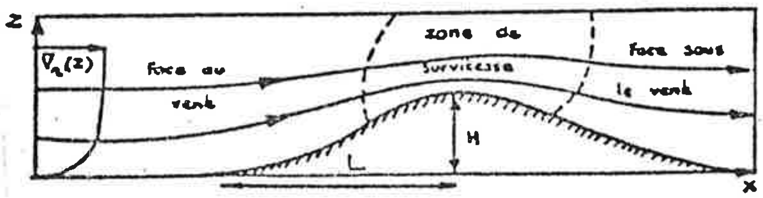


Figure 3 Air flow above a hill of height H and half width L (Z_o ruggedness on the hill, $V_r(Z)$ reference speed)

The existence of a depression over the top of the hill causes an increase in the horizontal velocity of air near the top of the hill. The effect of increased velocity is mainly proportional to the gradient of the obstacle facing the wind $\frac{H}{L}$. It increases slightly with ruggedness and becomes negligible at a height above the hill of the order of L. The average wind speed $\overline{V}(\Delta Z)$ may be written approximately as follows for a height ΔZ above the ground level with the top of the hill (where $\Delta Z >> Z_o$):

$$\frac{\overline{V}(\Delta Z)}{\overline{V}_r(\Delta Z)} = 1 - C\left\{ 1 - 0.025 \; Ln \left(\frac{L}{Z_o}\right)\right\} \frac{H}{L} \; Ln\left\{\frac{\Delta Z}{L}\right\}$$

$\overline{V}_r(Z)$ is the reference speed observed at the same height ΔZ above the ground, where the obstacle is a long way from the wind.

"C" is a parameter associated with the shape of the obstacle. The effect of increased speed is greater for a "bell-shaped" obstacle like that shown in Figure 3 (C = 1) than for an obstacle in the form of a "plateau" where C = 0.5.

When the gradient of the obstacle increases ($\frac{H}{L} > 0.3$) or the ruggedness of the ground becomes significant in relation to the obstacle ($\frac{L}{Z_O} < 10^3$), a separation phenomenon occurs at the foot of the slope which limits the effect of increased speed at a level close to that observed for $\frac{H}{L} = 0.3$. Separation of flow directly beneath the wind at the top of the hill is also noted.

2.3.3 Effect of an isolated obstacle

When an isolated obstacle occurs on a particularly open site, there will be severe disturbance in the flow of wind in the direction of this obstacle. The nature of this disturbance will vary according to the obstacle encountered (building or row of trees).

Flow around a building is extremely complex; the diagram in Figure 4 shows the measurements for the wake zone.

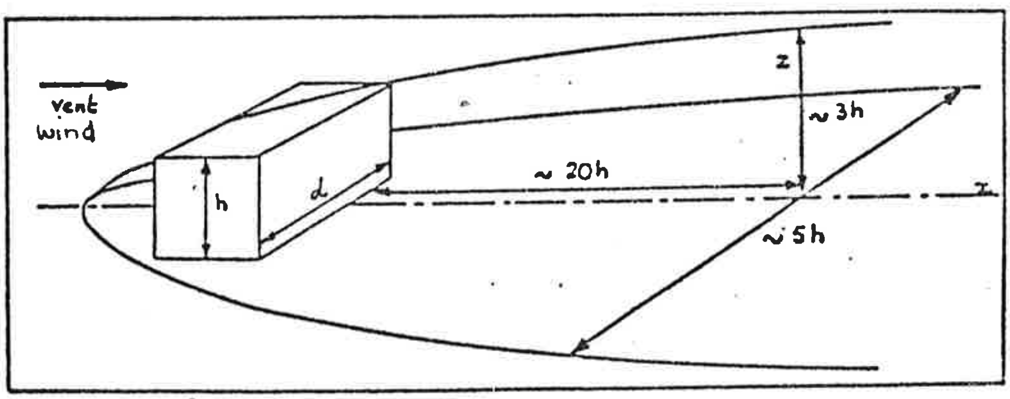


Figure 4 Wake zone behind an isolated building
(not to scale)

The reduction in average speed for normal flow in the wake zone on the widest side of the building (d), according to the axis of the wake, at a height z = h and where $x > d$ is given by the following expression:

$$\frac{\overline{V}(z)}{\overline{V}_r(z)} = 1 - \alpha \left(\frac{x}{h}\right)^{-m}$$

where parameters and m are functions of $\frac{d}{h}$ (Table 4).

$\overline{V}_r$ is the reference value for average speed in a zone where the wind is not affected by the obstacle.

$\frac{d}{h}$	α	m
4	3.92	1.48
3	2.13	1.37
1	0.72	1.18
0.25	0.095	0.97

Table 4 Parameters characterising the wake zone behind a building (according to Peterka and Cermak)

The speed of the wind behind a hedge of height h and porosity ψ acting as a "windbreak" and placed crosswise in the direction of the wind, where (ψ is equivalent to the area of gaps on the total front surface area expressed as a percentage, is given in Table 5; the horizontal extent of the wake zone is of the order of 20 - 30 h and its thickness is 3 - 4 h.

Table 5 Disturbance in the speed of wind behind a hedge

$100 \frac{\overline{V}}{\overline{V}_r}$ where Z_o = 0.4 m (according to Nägeli)

x	5 h		10 h		15 h		20 h	
z \ ψ	0.40	0.20	0.40	0.20	0.40	0.20	0.40	0.20
0.5 h	50	40	55	60	70	75	85	85
1.0 h	65	45	70	65	75	75	85	90
1.5 h	90	65	80	75	80	80	85	90
2.5 h	105	100	95	90	90	90	95	95

Note

The greater the porosity and the less significant the surrounding ruggedness, the greater will be the rate of increase for the disturbance zone created by the hedge.

2.4 PRACTICAL METHOD

In order to be able to calculate the coefficient of transfer of average wind speed measured at the meteorological station used for reference purposes applicable to the site where the building in question is located, it is first of all necessary to obtain details of the characteristics of the building environment (and possibly those for the meteorological station if this is not situated in open country) and then to determine the ratio between the average wind speed $\overline{V}_h$ level with the building and the speed at a height of 10 m in open country $\overline{V}_o$, according to the direction of the wind, by means of the following expression:

$$\frac{\overline{V}_h}{\overline{V}_o} = C_R \cdot C_T \cdot C_S$$

where C_R, C_T and C_S are coefficients of ruggedness, topography and wake respectively, which may be calculated from the expressions given in sections 2.2 and 2.3.

This method is only applicable for the following sites:

- <u>site with uniform features</u>

  This represents a flat or slightly undulating area covered with natural or artificial obstacles uniformly distributed in every direction over a distance of several kilometres (at least 5 km) from the site. Moreover, there are no obstacles nearby which may produce wake zones. The agricultural areas of the Beauce and Northern France and the farmland in Normandy and Brittany are examples of large areas with uniform features.

- <u>site without uniform features</u>

  As in the previous case, this represents a flat or slightly undulating area, but where the nature of the ground may vary, according to the direction of the wind, and where there may also be topographical obstacles of moderate size (hills and plateaux where the difference in height is less than 150 m and which have a gradient of less than 30 %); there may also be a change in the nature of the ground for one or more wind directions and possibly a few obstacles nearby, which cause isolated wake effects.

  Flat coastal areas, areas on the fringe of town or woods are examples of sites without uniform features.

In the case of complex sites however (mountainous regions, numerous, high hills, steep slopes, many changes in ruggedness etc...) it is advisable to take wind measurements at the site and compare them with values for the nearest meteorological station.

In practice, the environment may be characterised in the following manner:

- <u>immediate environment</u>

  It will be necessary to prepare a detailed diagram, within a circle with a radius of 200 m around the point where the building is located, on which the site, horizontal measurements and the height of the main obstacles (buildings, trees) which may affect wind flow are noted, as well as any variation in height of the ground, if this is significant.

- <u>distant environment</u>

  The nature of the ground within a circle with a radius of 5000 m, divided up into sectors of 40^{o}, is examined with the aid of IGN maps, scale: 1/25000 or 1/50000, using the classification given in Table 2. Changes in the nature of the ground and their distance in relation to the site of the building are indicated, together with isolated topographical obstacles situated at a distance of less than 10 times their height. The proximity of very hilly zones or mountain massifs is also noted.

  An example of this characterisation of the environment is given in Figure 5 for a site in the Vendée. This figure is an extract from the IGN map, scale: 1/50000; circles with a radius of 1 - 5 km around the site are shown and 9 sectors have been defined. Ruggedness categories for land encountered by the wind before reaching the site are also shown for each sector.

  The following characteristics are applicable to the respective sectors:

  10-50 (NNE) : ruggedness IV (dense vineyards, trees) up to 2500 m; ruggedness III (open country) beyond this point

50-90 (ENE)	:	same type of landscape; ruggedness IV up to 1400 m and ruggedness III beyond this point
90-130 (ESE)	:	village of Bourgneuf-en-Retz, scattered settlements and dense vineyards up to 3000 m (ruggedness V); ruggedness IV beyond this point
130-170 (SSE) 170-210 (SSW)	:	fen land (flat meadows with no obstacles); ruggedness is uniform (category II)
210-250 (SW)	:	fen land (ruggedness II) up to 1800 m and ruggedness I (sea) beyond this point
250-290 (W)	:	same type of land; ruggedness changes at 2000 m
290-330 (NW)	:	fen land (ruggedness II) up to 1500 m and very rugged zone (type V) beyond (villages, vineyards, trees)
330--10 (N)	:	dense vineyards with hedges and trees (ruggedness IV) up to 3000 m; open country (ruggedness III) beyond

It is assumed that there is no obstacle within a radius of 200 m.

Note

The determination of ruggedness categories from IGN maps requires a very careful study of the type of vegetation and the area occupied by this vegetation. Visual integration of the various categories of land found is essential in order to be able to determine overall ruggedness for a fairly large area and avoid splitting up each sector into a large number of zones. The areas of the different types of land must be allowed for in this spatial integration: high ruggedness values which cause greater disturbance of air flow are of greater "weight" than low ruggedness values over the same area. It must also be noted that the "weight" of the environment within a radius of 1500 m - 2000 m is of prime importance: visual integration will have to be even broader beyond this limit.

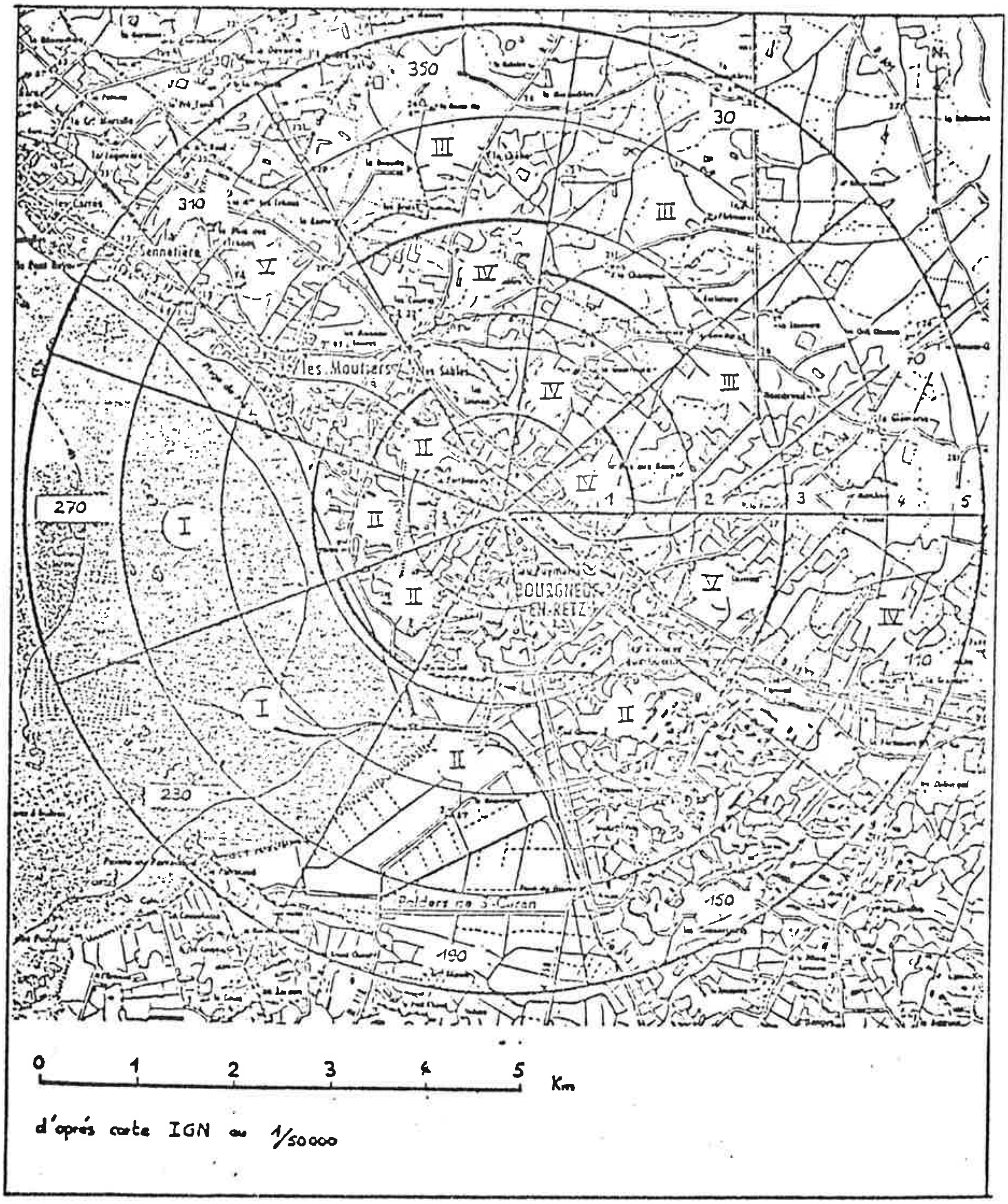


Figure 5 Zoning of a site in the Vendée

III DETERMINATION OF DIFFERENCES IN EXTERNAL PRESSURE VALUES BETWEEN WALLS

3.1 CONDITIONS OF APPLICATION OF THE METHOD

It is necessary to identify the following two cases when determining differences in external pressure values:

- mechanical ventilation

  In this case, it is assumed that wind does not disturb the flow of air extracted mechanically to any significant extent. It is only necessary to calculate the additional airflow between the facade against the wind (1) and the facade behind the wind (2). The difference in pressure is calculated $(P_1 - P_2)$.

- natural (or mixed) ventilation

  In this case, there is no permanent mechanical extraction; thermal extraction and wind then intervene. Several situations may occur as shown in Figure 6.

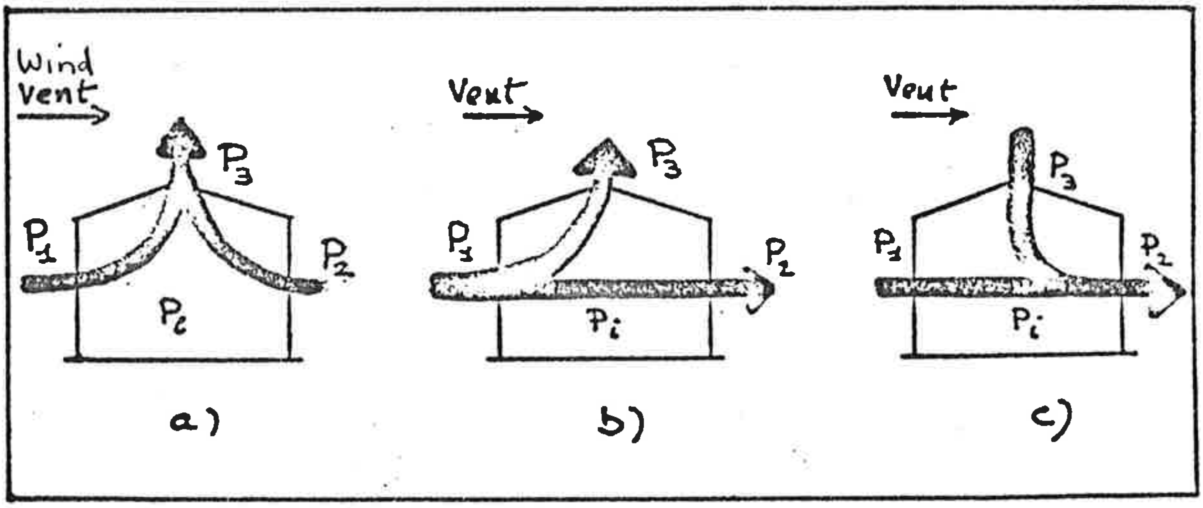


Figure 6 Natural ventilation

In situation c) there is backflow; this situation must be avoided; the risk of its occurrence is estimated according to the sign for the difference between P_3 and internal pressure P_i. In the case of the other two situations a) and b), the inflow of air must be calculated according to differences for ($P_1 - P_3$) and ($P_2 - P_3$) evaluated simultaneously.

The calculation is performed for the following cases:

- 3 types of building: tower block (R+12), block of flats (R+4) and detached house (R+1)

- 8 possible positions (45°, 90°, 135°, 180°, 225°. 270°, 315°, 360°

- 5 characteristic situations

  Ruggedness for towns - with environment - town wind
  Ruggedness for country - without environment - country wind
  Ruggedness for country with environment - country wind
  Ruggedness for sea - without environment - (country wind)*
  Ruggedness for sea - with environment - (country wind)*

- 30 meteorological stations uniformly distributed over the area.

(*) The selection of country wind is associated with the selection of this type of wind for the determination of pressure coefficients in a wind tunnel

3.2 SOME RESULTS

As the study has not yet been completed, only a few results for the calculation of differences in external pressure values for a block of flats (R+4, h = 16 m, L = 60 m and l = 12 m) fitted with a VMC are given below.

Zoning of pressure coefficients on the façades of this block of flats for the 8 positions and 5 characteristic situations was determined from the study by J. Gandemer (2).

Data for wind comprises mean three-hourly values for speed and direction measured over a period of 10 years (1970 - 1979) at selected meteorological stations. Only data for the heating season (October - April) was retained.

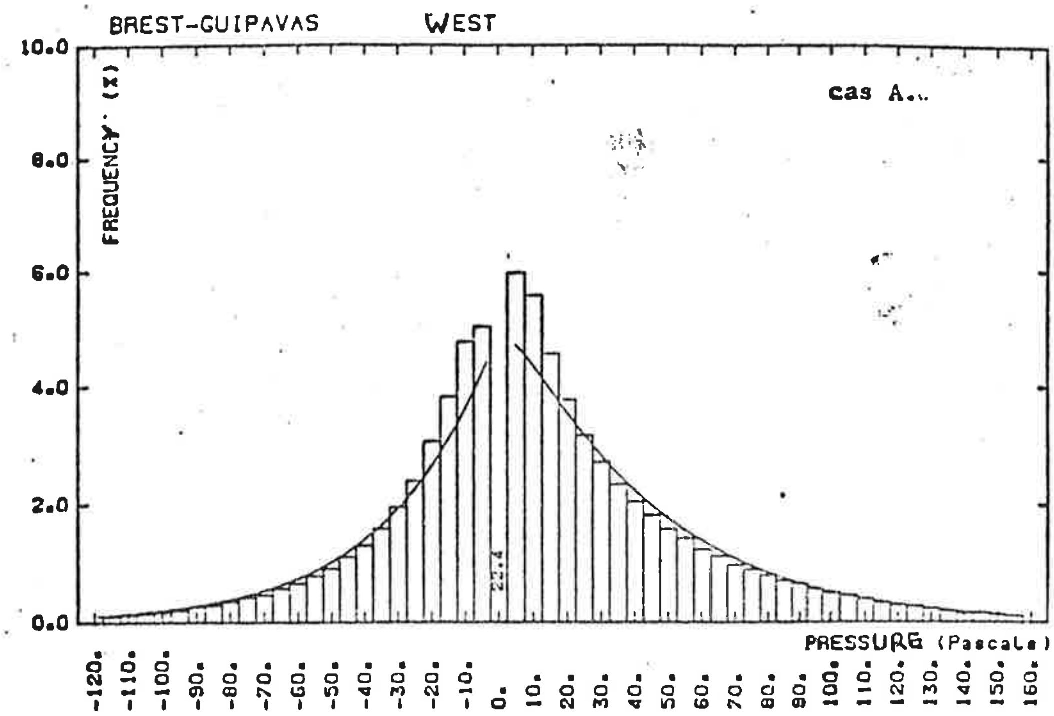
Corrections for height, ruggedness and topography shown in section II were made in order to relate speed $\overline{V}_h$ to the site of the building.

The results of the calculations are shown in the form of a histogram indicating variations in pressure (ranges for categories 5 P_a, frequencies greater than 1°/oo, categories based on value 0) (Figures 7 and 8) for two stations at Brest and Montelimar.

A study of these figures yields the following information:

- High number of categories where the difference in pressure Δp is nil or low
- Significance of the position of the building in relation to prevailing winds (Montelimar)
- High Δp categories are well represented in windy areas (Brittany, Languedoc-Roussillon, Rhone Corridor)
- The presence of an immediate environment has a significant effect on results (see Figure 7)

- A very satisfactory adjustment of Weibull's distribution to histograms for variation in pressure values can be obtained. This permits modelling of the results which facilitates their use at a later stage.



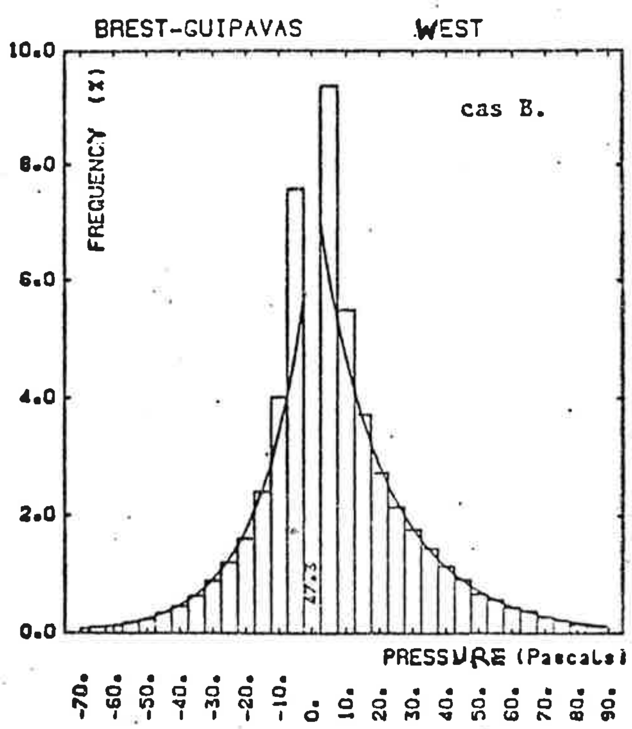
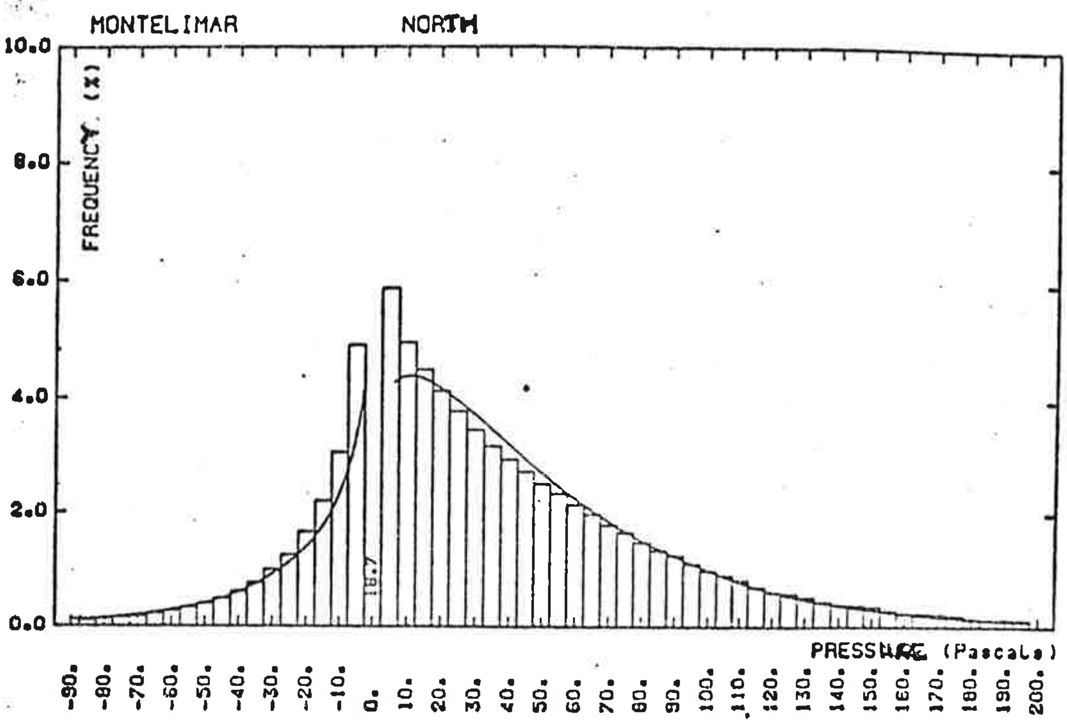


Figure 7 Histogram for differences in pressure values between façades for a block of flats
A. without environment
B. with environment



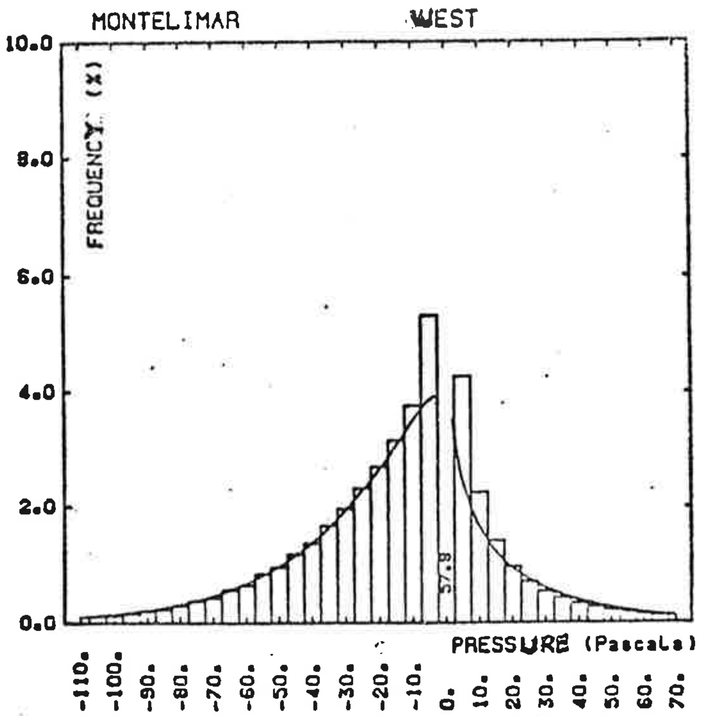


Figure 8 Histogram for differences in pressure values between façades for a block of flats without environment

CONCLUSION

The method described enables differences in external pressure values between walls to be estimated from known mean pressure coefficients on the facades and roof of the building in question and from the determination of wind values on the site and at the same height as the building.

The heating engineer can then calculate air change rates and consequently heat losses for the building from these variations in pressure values, where the ventilation characteristics (mechanical, natural, mixed), internal pressure and the permeability of the facades and air inlets are known by referring to the different standard types of building and environment shown in this study.

BIBLIOGRAPHY

1. BIETRY J. - Influence du vent sur les deperditions par renouvellement d'air (Effect of wind on losses for change of air). CSTB Note EN-D 81.2 R (1981)

2. GANDEMER J. - Champ de pression moyenne sur les constructions usuelles - Application a la conception des installations de ventilation (Mean pressure field for standard buildings - Application to the design of ventilation systems). CSTB Journal, No. 1492, part 187 (1978)

3. BIETRY J., SACRE C., DUCHENE-MARULLAZ PH. - Climatology REEF Volume II Sciences du Batiment, CSTB (1979)

4. DUCHENE-MARULLAZ PH., SACRE C. - Traitement statistique des donnees de vent pour la determination de l'energie produite par les systemes eoliens (Statistical treatment of data for wind for the determination of energy produced by wind systems). AFME Symposium "Meteorology and renewable energy sources" Valbonne (March 1984)