DETERMINATION OF DYNAMIC PRESSURES AND ESTABLISHMENT OF WIND-REGION MAPS IN BENIN

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The purpose of the present study is to determine the dynamic pressures of the wind and to establish a wind-region map for Benin.
In order to do that, we have, after the collection of meteorological information (data of speed), carried out:
- *the analysis of average and instantaneous data (speed) of wind of the six main meteorological stations in accordance with the statistical methods recommended by the National Code of Building in Canada (NCB) and the Snow and Wind 65 Rules. These data cover a period of 23 years;*
- *the analysis of the speed variations speed by means of numerical techniques;*
- *the analysis, according to AFNOR norms, of the influence of the relief and vegetation on the sharing out of the coefficients of site and dynamic pressures.*

At the end of this study, we established:
- *Dynamic pressures and basic speeds to be taken into account during the assessment of wind overloads;*
- *That the basic speeds in the stations of Cotonou, Savè, Bohicon and Parakou are likely to be obsolete with time;*
- *The geographical distribution of the site coefficients and dynamic pressures in Benin;*
- *Appropriate region maps.*

KEY WORDS: winds, normal basic speed, extreme speed, dynamic pressure of the wind, wind-region map of Benin

Introduction

The wind is a mass of air in movement. This movement originates from the difference of temperature and the pressure of atmosphere in various points of the globe. Winds, by their circulation generally tend to redistribute the warmth unequally absorbed in the various places of the earth. This general, theoretical circulation is profoundly changed by the rotation of the earth. The latter leads to the creation of the belts of dominant winds. These dominant winds move and change direction with seasons, relief of the Earth and vegetation. Their actions are badly appreciated by Beninese Civil engineering actors because the consideration of the overloads that they generate was always made by simple transposition of data from other regions, in this case the French regions (rules NV65 [8]) or by the use of the punctual raw data of the national meteorological stations. And, according to the studies implemented [8], the value of wind pressure at a place has a certain value only in this place and can be used in a neighboring zone only with precaution. So wind overloads have a non transposable regional character.

In Benin and in most of the African countries, purely transposed climatic data are used for the technical study of structures. This way of processing doesn't reassure us on a correct evaluation of the real actions of the wind on building according to local aerodynamic conditions. Stability, ventilation and economic aspect of such an accomplished work, can probably be compromised.

It is therefore to remedy to these insufficiency and uncertainties in our African countries that these woks were initiated and started in Togo by researches performed by the students AVITY Hola Kwami [2] and MANZI Nika Méhéza [10]. The latter determined dominant directions and dynamic basic pressures of wind in the regions of Togo. The present works aim mainly at two specific objectives:

• to determine the speeds and the basic dynamic pressures of the wind;
• to determine the site coefficients.

1. Site of study

Located between parallels 6°30' and 12° 30'of latitude North and meridians 1° and 3° 40'of longitude East, of the intertropical zone, the Republic of Benin is among the coastal countries of West Africa.

With a surface area of about hundred fourteen thousand seven hundred sixty - three square kilometers (114.763 km2) [12], the Republic of the Benin enjoys a tropical climate characterized by two seasons in the North (a rainy and a dry) and four seasons in the South (two rainy and two dry). It completely belongs to the west-African climatic system. His major characteristic is the alternation of a monsoon, with a cool and humid season from the Atlantic ocean, and a harmattan (trade wind), with a dry season characterized by a strong daily range of temperature from Sahara. These two masses of air (monsoon and harmattan) repel each other alternately northward and southward. Their zone of contact called Inter-Tropical Front (IFT) is the seat of all the atmospheric disturbances that cause rainfall [12].

Benin has got a relief not much hilly, that is why one does not distinguish big differences in levels. The average altitude is two hundred meters (200m). The only high region is the chain of Atacora; located in the northwest of the country, it exceeds four hundred meters (400m) in altitude. The group is constituted by four main formation (see figure 1):

- The coastal , low, sandy plain,
- The plateau,
- The Crystalline peneplain,
- The chain of Atacora.

The vegetation of Benin is strongly degraded by man, especially in its southern part where the density of the population is quite high. It can be subdivided into five (5) big phyto-geographical zones [10] as figure 2 shows it.

2. Meteorological stations and Instruments of measure

Today, Benin counts six (6) main meteorological stations which regularly record wind data. They are divided in the following localities: Cotonou, Bohicon, Savè, Parakou, Kandi and Natitingou. Their geographical coordinates are given in picture 1.

Wind is a parameter which is characterized by two physical measures: its force and its direction. The force is measured by the anemometer and the direction by the weather vane (see figure 3).

The direction of the wind is spotted in comparison with the four cardinal points (North, South, West, East). The intermediate positions are pointed out by combining the cardinal points. These directions form the rose of winds (figure 4).

3. Method of studies

3.1. Collection of the raw data of wind

The collection of the wind rough data is done by using weather forecasts (manuscripts) called Monthly Climatological Tables (M C P). The period of observation is 23 years starting from from 1985 to 2007 for the stations of Cotonou, Bohicon, Parakou, Natitingou and of Kandi; and from 1977 to 1999 for the station of Savè.

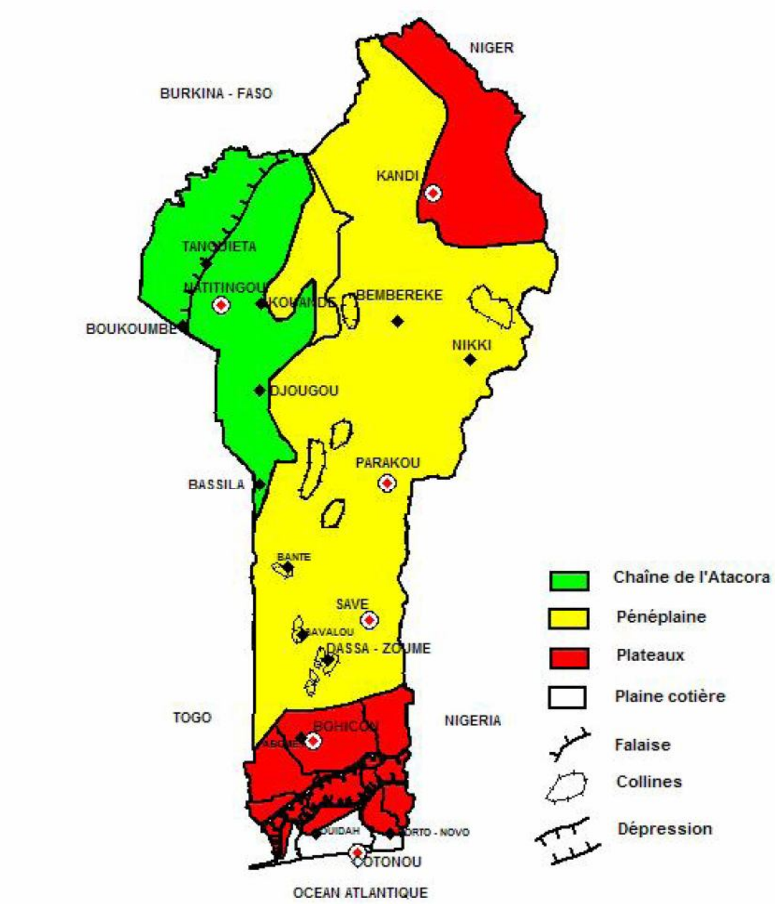

Figure 1: Map of the relief of Benin [1]

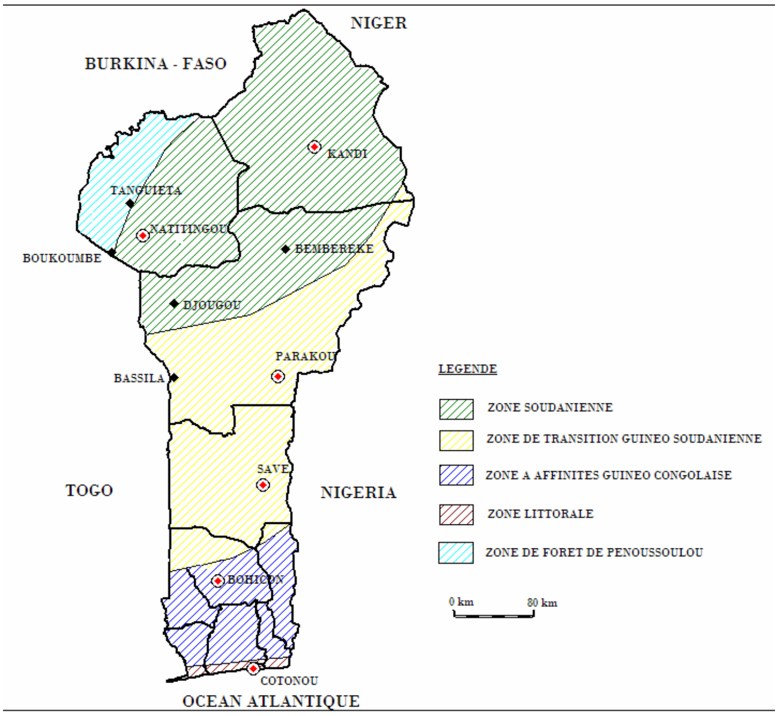

Figure 2: Map of Benin vegetation [10]

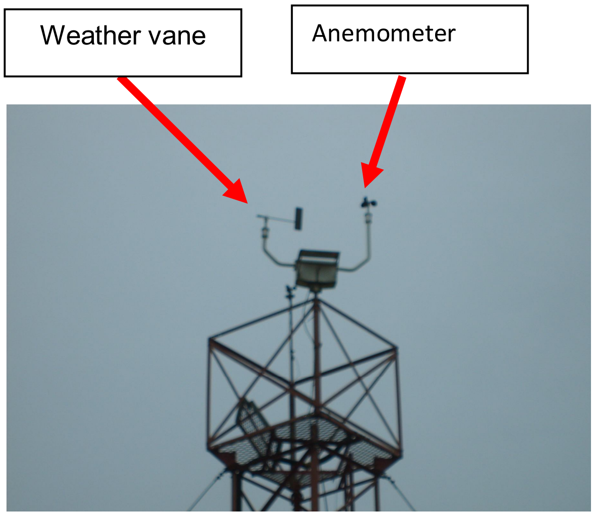

Figure 3: Anemometer and weather vane

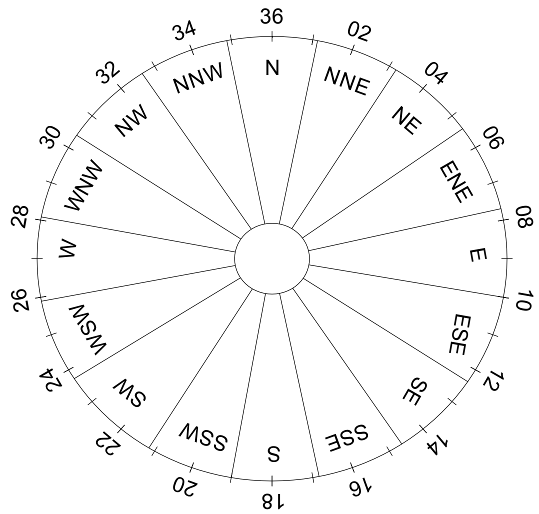

Figure 4: Rose of winds

3.2. Determination of speed and basic pressures

- **Speed**

Two methods of speed analysis of the wind are adopted according to the nature of available data:

• The method based on the analysis of the maxima of the average speeds per hour of CNB rules: it is applied to the data of the six (06) stations;

• The method based on the analysis of the maxima of the instantaneous speeds of NV 65 Rules: it is applied to the considered instantaneous speed in the station Cotonou – Airport.

Before the rough values of wind speeds may be analyzed, rules recommend their standardization at a height of 10 m. The used expression is the following ([3 and [5]):

$$\frac{V_H}{V_0} = \left(\frac{H}{H_0}\right)^{(1/7)} \quad (1)$$

With:

- V_H (in m /s), the measured speed of the wind in the anemometer at the height H on top of the soil;

Picture 1: Geographical coordinates of the meteorological stations of Benin

Administrative regions	Stations weather forecast main	Degree of latitude (North)	Degree of longitude (East)	Altitude (m)	Years of observation	
					Years	Periods
Atlanique-Littoral	Cotonou-Airport	06°21’	02°23’	9,56	1985-2007	23
Zou	Bohicon	07°10’	02°04’	166,12	1985-2007	23
Collines	Savè	08°02’	02°28’	198,51	1977-1999	23
Borgou	Parakou	09°21’	02°37’	391,96	1985-2007	23
Atacora	Natitingou	10°19’	01°23’	460,00	1985-2007	23
Alibori	Kandi	11°08’	02°56’	290,00	1985-2007	23

- V_0 (in m/s), these are measured reference speeds as high as reference H_0 that will be the object of the statistical analysis;
- H_0, the height of reference on top of the soil: $H_0 = 10$ m.

1st Method:

- **Statistical law**

The statistical analysis of the annual extreme values of speeds is made by means of the law of Gumbel. This law allows to forecast for a periodical phenomenon, the value that may be attained by the latter for a determined period. So, the speeds of gust are determined from the equation (2)

$$x = \bar{x} - \sigma\left(0{,}4897 + 0{,}9284\mathrm{Ln}\left(-\mathrm{Ln}\left(1 - \frac{1}{T_r}\right)\right)\right). \quad (2)$$

It is this equation which is applied for the calculation of basic speeds. The *x* indicates in our case the reference speed (V_r) for a given time of recurrence (T_n).

- **Speed of gust**

It is given by following expression:

$$V = \sqrt{2} \times V_r . \quad (3)$$

With:
- V_r (in m/s) the reference speed of the wind calculated by means of the law of Gumbel (equation 2); - V (in m/s) the speed of gust.

2nd Method:

- **The normal speed**

The normal basic speed (or speed of basic gust) is by definition the one that is attained or exceeded only three (3) days out of one thousand (1000) over a period of twenty five years (25 years) in principle. It is therefore the wind of frequency 3 ‰ which is researched [8].

Over the period of the considered observation, we deducted the numbers of observation of the wind speed and expressed them in the thousandth. The method giving expressions in the thousandth can be formulated as follows:

$$f_{ij} = 1000\frac{n_{ij}}{n_j}, \quad (4) \qquad n_i = \sum_j n_{ij}, \quad (5) \qquad f_i = 1000\frac{n_i}{n}. \quad (6)$$

With:
- f_{ij} the frequency of observation of the $i^{è}$ speed of the wind in the $j^{è}$ year of observation linked to the number of observation n_{ij};
- n_j the number of observation of the $j^{è}$ year of observation;
- n_i the total number of observation of the $i^{è}$ speed of the wind over all the considered period of observation; - f_i the frequency linked in n_i;
- n the total number of observation of the considered period.

- **The extreme wind speed**

According to NV65 Rules, the extreme wind speed is given by the following equation:

$$V_e = \sqrt{1{,}75}\, V_n . \quad (7)$$

- **PRESSURES**

The dynamic pressure (*q*) is determined thanks to the application of the theorem of BERNOUILLI by the expression:

$$q = \rho\frac{V^2}{20}. \quad (8)$$

With:
- q (in daN/m²) is the dynamic pressure of gust; V (in m/s) is the speed of gust; ρ (in kg / m^3) is the volumic mass of dry air.

By likening air with a perfect gas, its volumic mass is given by the equation:

$$\rho = \frac{P}{rT}, \tag{9}$$

- P is normal atmospheric pressure: P = 101325 Pa,
- r is the mass constant of the air considered as perfect gas: r = 287j / kg. K
- T (in K) is the absolute temperature in which the air can be considered as a perfect gas.

3.3. Study of the speed variation and dominant directions

The analysis was based on a numerical technology fulfilled by a curve called curve of tendency. For our scenario, we have by means of Microsoft Excel 2007, opted for a polynomial adjustment which assures a better approximation of the problem by the increase of the degree of the polynomial of interpolation. That's how we adopted 6 as the degree of the polynomial of interpolation. 6 is the maximum degree that Excel 2007 Microsoft gives.

Stations weather forecast			Cotonou Airport	Bohicon	Savè	Parakou	Natitingou	Kandi
Average			11,00	10,00	9,40	13,10	10,50	14,00
Distance Portrays			3,70	2,74	4,20	3,80	3,20	4,60
Time of recurrence (in years)	10	V	23,90	20,30	22,80	27,10	22,10	30,20
		Q	33,60	24,30	30,50	43,20	28,60	53,60
	20	V	27,40	22,90	26,80	30,70	25,10	34,60
		Q	44,10	30,90	42,00	55,40	37,00	70,10
	30	V	29,40	24,40	29,00	32,80	26,90	37,10
		Q	50,90	35,00	49,50	63,10	42,30	80,60
	40	V	30,90	25,50	30,70	34,20	28,10	38,80
		Q	55,90	38,10	55,20	68,80	46,30	88,40
	50	V	32,10	26,40	32,00	35,50	29,10	40,30
		Q	60,30	40,80	60,20	73,80	49,70	95,30
	60	V	32,80	26,90	32,90	36,30	29,80	41,30
		Q	63,30	42,60	63,60	77,30	52,10	100,10
	70	V	33,60	27,50	33,80	37,10	30,50	42,20
		Q	66,30	44,40	67,00	80,60	54,40	104,70
	80	V	34,30	28,00	34,50	37,70	31,00	43,00
		Q	68,90	46,00	69,90	83,50	56,50	108,70
	90	V	34,80	28,40	35,20	38,30	31,50	43,80
		Q	71,20	47,40	72,60	86,20	58,30	112,40
	100	V	35,30	28,80	35,80	38,80	32,00	44,40
		Q	73,30	48,70	75,00	88,60	60,00	115,70

3.4. Determination of the site coefficients, and establishment of wind-region maps region-wind.

The determination of the site coefficients and the establishment of wind-region maps have been done from an analogy with the case of France and the analysis of the influence of the relief and vegetation on the sharing out of the site coefficients and the wind speed, according to the AFNOR norm.

4. Results and Interpretations

4.1. Speed and dynamic Pressures

1st Method

The results of the statistical analysis of the wind speed are given in picture 2.

Picture 2: Dynamic Pressures (in daN/m²) from the analysis of the average wind speed wind

These pressures are likely to be attained at least once over the considered recurrence periods.

2nd Method

The results of the frequency analysis of the instantaneous speeds acquired in the station of Cotonou are recorded in picture 3

The normal speed is the one the frequency of which is as close as possible of 3 ‰. By referring to the data in picture 3, frequency f_i, the nearest of 3 ‰ is 3,10 ‰. Which corresponds to a normal speed of 18,00m / s. The calculated extreme speed is Ve 23,81 m/s. So:

- For the normal speed $V_n = 18,00$ m/s,
- Normal pressure is: $q_n = 19,02$ daN/m²,
- For the extreme speed $V_e = 23,81$ m/s,

The extreme dynamic pressure is: $q_e = 33,28$ daN /m².

Normal existent basic data of the wind speed analysis

The normal dynamic basic pressures are useful for calculation of the structural elements in the limit state of service.

Owing to the unpredictable character of adopted values for climatic overloads and mode of action of these overloads, NV65 rules consider the justification of structures under two (02) hypothesis:

First hypothesis

The generated solicitations don't have to cause damage in buildings (limit state of service). The surcharges to be taken into account are those which have a likelihood properly fixed to be attained to one or several times in year: it is normal surcharges.

Second hypothesis

The procreated solicitations don't have to put all the building or a part of this one "out of order". The surcharges to be taken into account are those which have a likelihood properly fixed to be only once attained for the duration of life of the building: it is extreme surcharges.

By trusting the first hypothesis, 18.0 m/s can legitimately act as normal basic speed. However, by considering the second hypothesis, the extreme basic speed must be superior to 26.0 m/s.

This 26.0 m/s can act as normal basic speed (or of basic gust) since it appeared already two (02) times in 23 years. This value would correspond by excess to the speed of gust of time of recurrence $T_n = 20$ years that is to say 27.4m / s (see picture 2).

However, given that the structures must be conceived for a life of 50 years at least (according to requirements of EUROCODE), we think that we can adopt the speed of wind of the time of recurrence of 50 years (see picture 4) as normal basic speed in situation Cotonou - airport.

Let be $V_n = 32.10$ m/s, $q_n = 60.30$ daN/m²

As a result we shall adopt for assigned localities to the main meteorological stations the data of the picture 4 as background information for the valuation of the actions of the wind on building in Benin.

<u>Picture 3</u>: Calculation of the normal basic speed

speed in m/s	Years of observation																						**Total of Obs**
	1985	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	2,75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27,4	0	1,31
3	2,74	10,96	8,22	24,7	27,4	19,2	22	0	21,9	16,4	2,74	5,46	2,74	5,48	0	2,74	0	8,22	5,48	10,9	19,2	118	19,2	15,37
4	43,8	24,66	35,6	38,4	90,4	96,2	55,1	46,4	65,8	145	41,1	19,1	65,8	46,6	52,1	11	19,1	60,3	76,7	98,4	90,4	266	115	69,69
5	115	137	123	148	247	255	196	126	137	211	159	126	222	134	181	129	104	162	200	246	340	238	282	183,33
6	214	232,9	156	175	255	280	242	246	241	233	238	254	353	310	230	225	311	263	312	311	247	211	197	249,51
7	230	290,4	197	148	211	198	149	317	293	186	290	279	222	263	301	307	306	277	244	202	195	84,9	205	234,59
8	178	147,9	225	79,5	68,5	76,9	88,2	210	140	142	167	199	71,2	175	153	173	148	137	112	65,6	68,5	35,6	76,7	127,77
9	52,1	54,79	121	101	38,4	22	52,3	30,1	52,1	30,1	57,5	79,2	21,9	30,1	27,4	79,5	38,3	30,1	27,4	13,7	16,4	8,22	79,5	46,21
10	68,5	32,88	68,5	68,5	13,7	16,5	85,4	5,46	24,7	5,48	16,4	8,2	8,22	5,48	5,48	19,2	24,6	19,2	5,48	5,46	2,74	8,22	11	23,01
11	21,9	30,14	13,7	68,5	8,22	0	41,3	0	2,74	5,48	8,22	8,2	11	0	5,48	8,22	5,46	5,48	0	10,9	0	0	8,22	11,44
12	19,2	10,96	16,4	65,8	5,48	2,75	27,5	0	11	5,48	2,74	0	8,22	2,74	0	2,74	8,2	8,22	0	2,73	2,74	0	0	8,82
13	19,2	8,219	5,48	16,4	0	8,24	11	2,73	0	0	0	2,73	0	2,74	0	0	2,73	0	0	2,73	2,74	0	5,48	3,93
14	8,22	5,479	11	8,22	5,48	8,24	8,26	8,2	5,48	8,22	2,74	2,73	0	2,74	8,22	13,7	0	2,74	0	10,9	2,74	2,74	0	5,48
15	5,48	5,479	2,74	21,9	5,48	5,49	2,75	0	2,74	0	5,48	5,46	5,48	2,74	5,48	8,22	8,2	8,22	2,74	8,2	2,74	0	0	5
16	0	0	2,74	0	2,74	5,49	5,51	0	0	5,48	0	2,73	2,74	2,74	11	5,48	2,73	5,48	5,48	5,46	0	0	0	2,86
17	8,22	8,219	8,22	5,48	2,74	0	0	0	0	0	0	0	0	0	0	0	2,73	2,74	5,48	0	2,74	0	0	2,02
18	2,74	0	2,74	5,48	8,22	2,75	2,75	2,73	0	5,48	2,74	0	2,74	2,74	5,48	5,48	5,46	2,74	0	5,46	5,48	0	0	**3,10**
19	2,74	0	0	2,74	5,48	0	2,75	0	0	0	2,74	2,73	2,74	0	2,74	5,48	2,73	2,74	2,74	0	0	0	0	1,67

<u>Picture 3</u>: Calculation of the normal basic speed

speed in m/s	Years of observation																							**Total of Obs**
	1985	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	
20	2,74	0	0	5,48	2,74	2,75	0	2,73	0	0	2,74	2,73	0	2,74	2,74	0	5,46	0	0	0	2,74	0	0	1,55
21	0	0	2,74	5,48	0	0	2,75	0	0	0	0	0	0	11	2,74	0	0	0	0	0	0	0	0	1,07
22	2,74	0	0	5,48	0	0	0	2,73	0	0	0	0	0	0	2,74	2,74	0	0	0	0	0	0	0	0,71
23	2,74	0	0	2,74	0	0	0	0	0	0	0	0	0	0	0	0	2,73	0	0	0	0	0	0	0,36
24	0	0	0	2,74	2,74	0	2,75	0	2,74	0	0	0	0	0	0	0	0	2,74	0	0	0	0	0	0,60
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,74	2,73	0	0	0	0	0	0	0,24
26	0	0	0	0	0	0	0	0	0	0	0	2,73	0	0	2,74	0	0	0	0	0	0	0	0	0,24
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,74	0	0	0	0	0	0,12
Total :	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

Picture 4: Normal Basic pressures q_{nb} (daN/m^2) and normal basic speed V^{nb} (m/s)

Stations weather forecast		Cotonou – Airport	Bohicon	Savè	Parakou	Natitingou	Kandi
Basic normals	V_{nb}	32,10	26,40	32,00	35,50	29,10	40,30
	q_{nb}	60,30	40,80	60,20	73,80	49,70	95,30

These speeds have a back period of 50 years.

The analysis of the drawn curves shows a variation of speeds in general. The linear tendency curves are diminishing for all the stations. As for polynomial tendencies, they drop for the stations of Natitingou and Kandi, as their equations (has <0) point it out. On the contrary, for the stations of Cotonou, Bohicon, Savè and Parakou, the equations of the curves of polynomials tendencies allow to foresee a future growth of speed (a> 0). Of what precedes, it emerges that the determined dynamic basic pressures in the stations of Natitingou and Kandi will not probably be exceeded and therefore can serve legitimately for the calculation of structures.

Concerning the stations of Cotonou, Bohicon, Savè and Parakou, their values of dynamic basic pressures can be used since linear evolution shows a decline of the curve, but with caution. Caution because the curve of tendency polynomial which gives a better approximation of phenomenon is growing (a> 0). The research for these stations of the critical year it is – to say the year when the speed of the wind will exceed the speed of calculation, by the study of representative functions of their curves of tendencies, allowed to find:

• For Cotonou year 2016; • For Bohicon year 2013; • For Savè year 2015; • For Parakou year 2025.

This result allows to think that determined dynamic basic pressures for these stations probably have certain values only for the above mentioned period and that beyond, the prediction is not obvious. It will be needed therefore in the course of this probable margin to notice the behavior of the speed of the wind to redefine dynamic pressures for these different stations.

4.3. Coefficients of site

The analysis of the relief of Benin highlights two zones of altitude such as introduced on the map below, figure 10:

The site coefficients are identical for the protected and normal sites (Regulations) no matter the nature of the environment in which it is.

For a displayed site, it is:

• 1,35 in a bare region (lower altitude in 200m);

• 1,30 on the coastal region (up to a depth of 40km) and in the chains of mountain (the upper altitude in 200m);

• 1,25 for a partly protected region.

For reasons of simplification and security we adopted for Benin a medium altitude of 400m. So, we shall have as sites displayed in Benin:

• Ks = 1,30 in the regions of the upper altitude in 400m and forming a chain of hilly on the card of the represent, and on the coastal region;

4.2. Study of the variation of speed

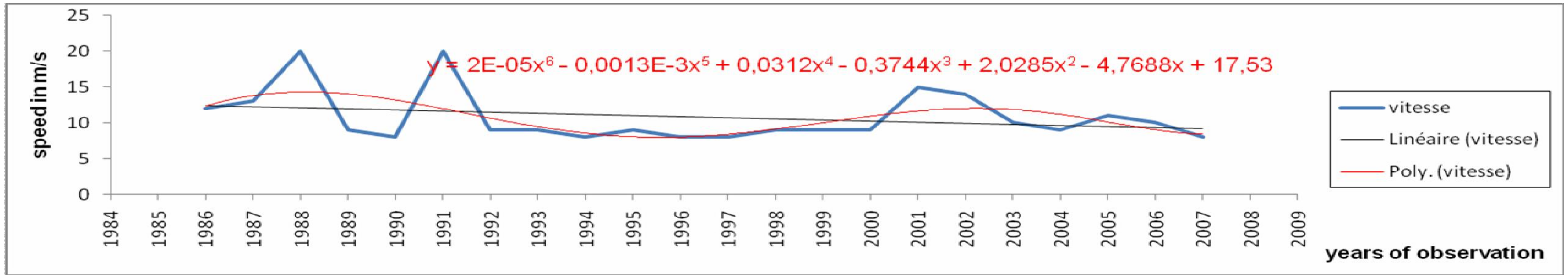

Figure 4: **Variation of the annual maximum speed according to the years in Cotonou**

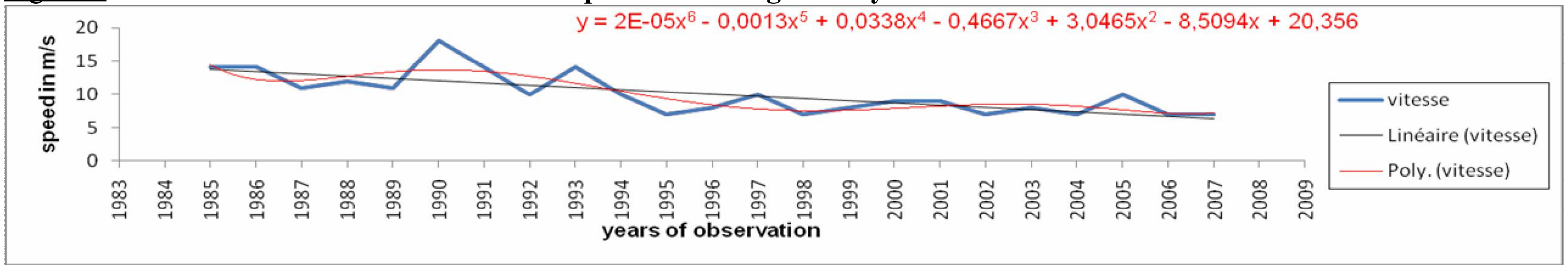

Figure 5: **Variation of the annual maximum speed according to the years in Bohicon**

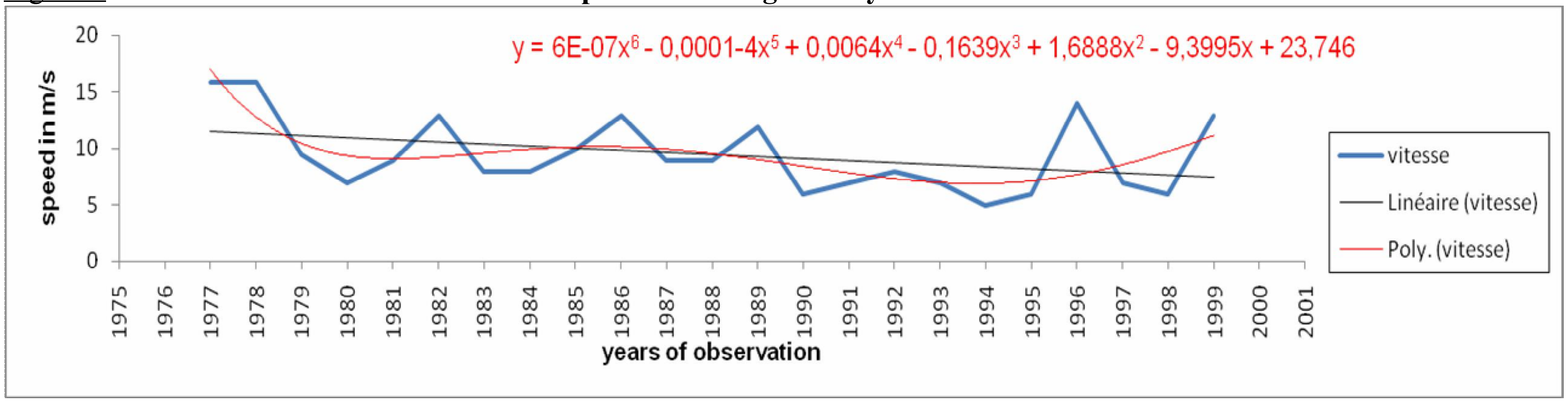

Figure 6: **Variation of the annual maximum speed according to the years in Savè**

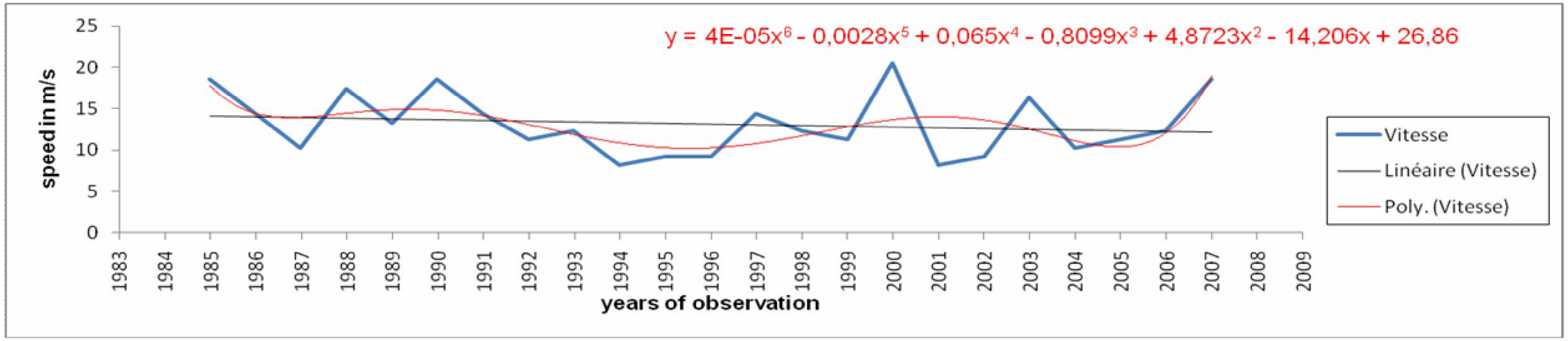

Figure 7: **Variation of the annual maximum speed according to the years in Parakou**

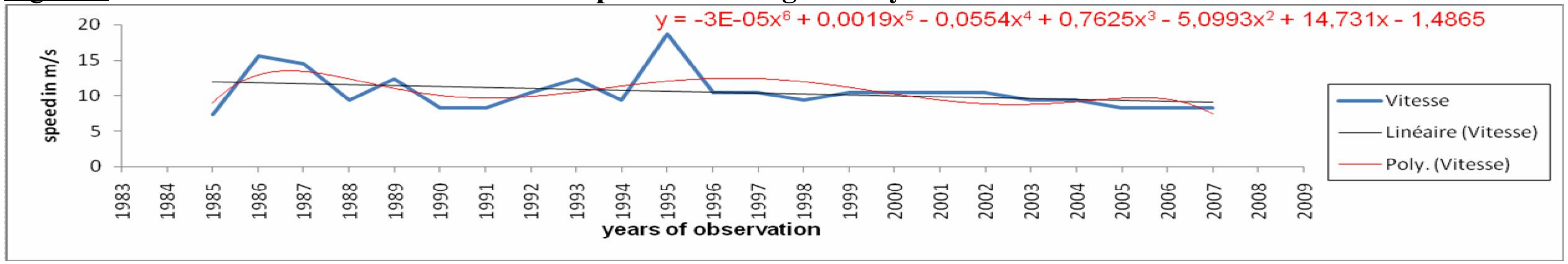

Figure 8: **Variation of the annual maximum speed according to the years in Natitingou**

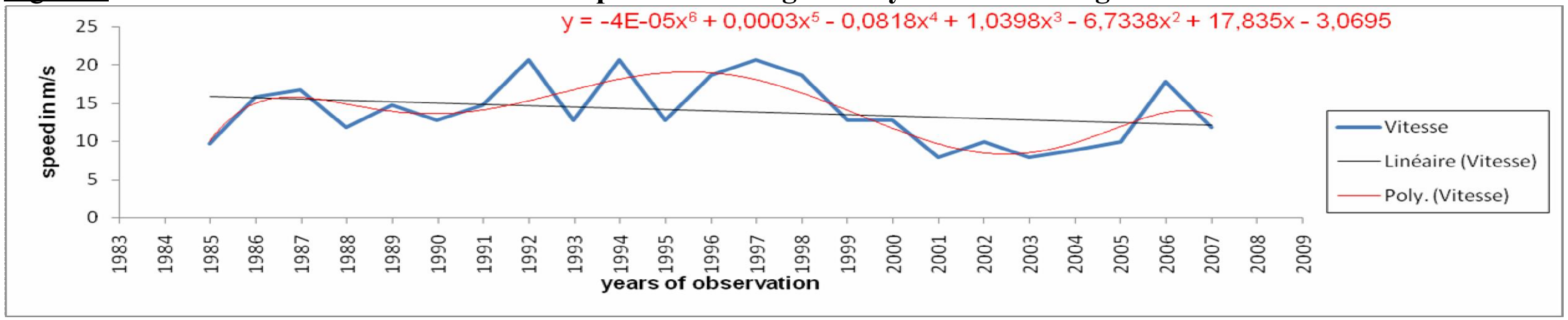

Figure 9: **Variation of the annual maximum speed according to the years in Kandi**

• Ks = 1,35 in quite other region.
In summary the picture 5 gives for the represent 11 the sharing out of the coefficient of site of Benin.

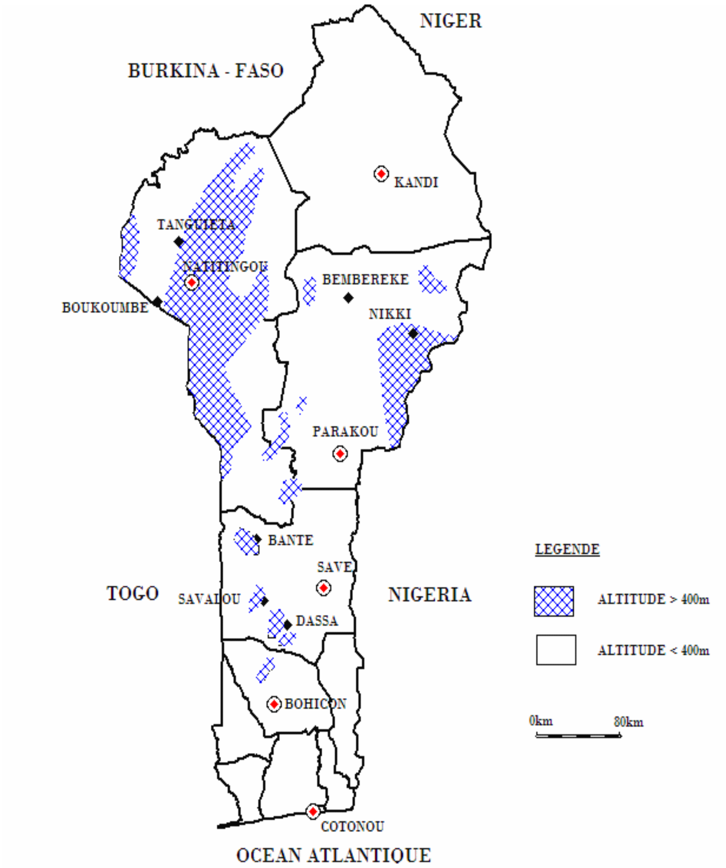

Figure 10: Distribution of both zones of different altitude

Picture 5: value of the site coefficients of Benin

Nature of the site	Zones	
	Zone I_s	Zone II_s
Protected Site	0,80	0,80
Normal Site	1,00	1,00
Displayed Site	1,30	1,35

4.4. Establishment of wind-region maps

It results from the study of the relief and the vegetation the map of dynamic pressures (figure 12):

Conclusion

The study of the effects of the wind on buildings in Benin allows to realize structures in a reassuring and competitive way by taking local climatic conditions into account. It is logical to establish proper norms in Benin following the example of Togo, France of Canada etc…

The objective of our study was to give, for Benin, information on the dynamic basic pressures of the wind on the one hand; the geographical distribution of the site coefficients, dynamic pressures, on the other hand.

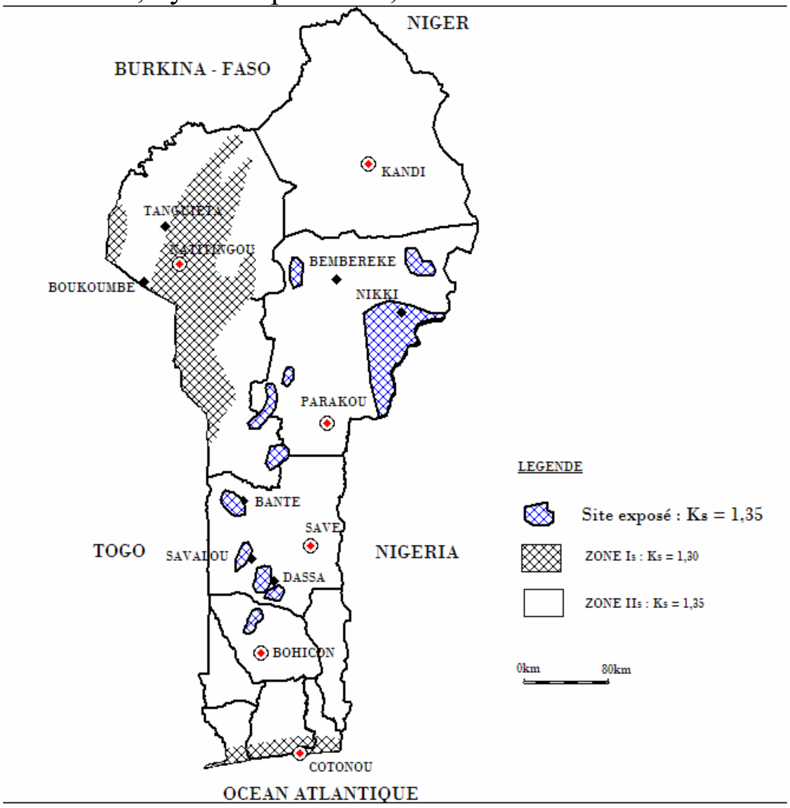

Figure 11: Distribution of the site coefficients in Benin

To achieve this goal, after the collection of rough data, we undertook, by means of statistical and numerical techniques, first the analysis of speeds and their variations; then the analysis of the influence of the relief and vegetation on the geographical distribution of the site coefficients and dynamic pressures according to AFNOR norms.

At the end of this study, we reached an evaluation of dynamic basic pressures, the determination of site coefficients in Benin, with the establishment of wind-region maps.

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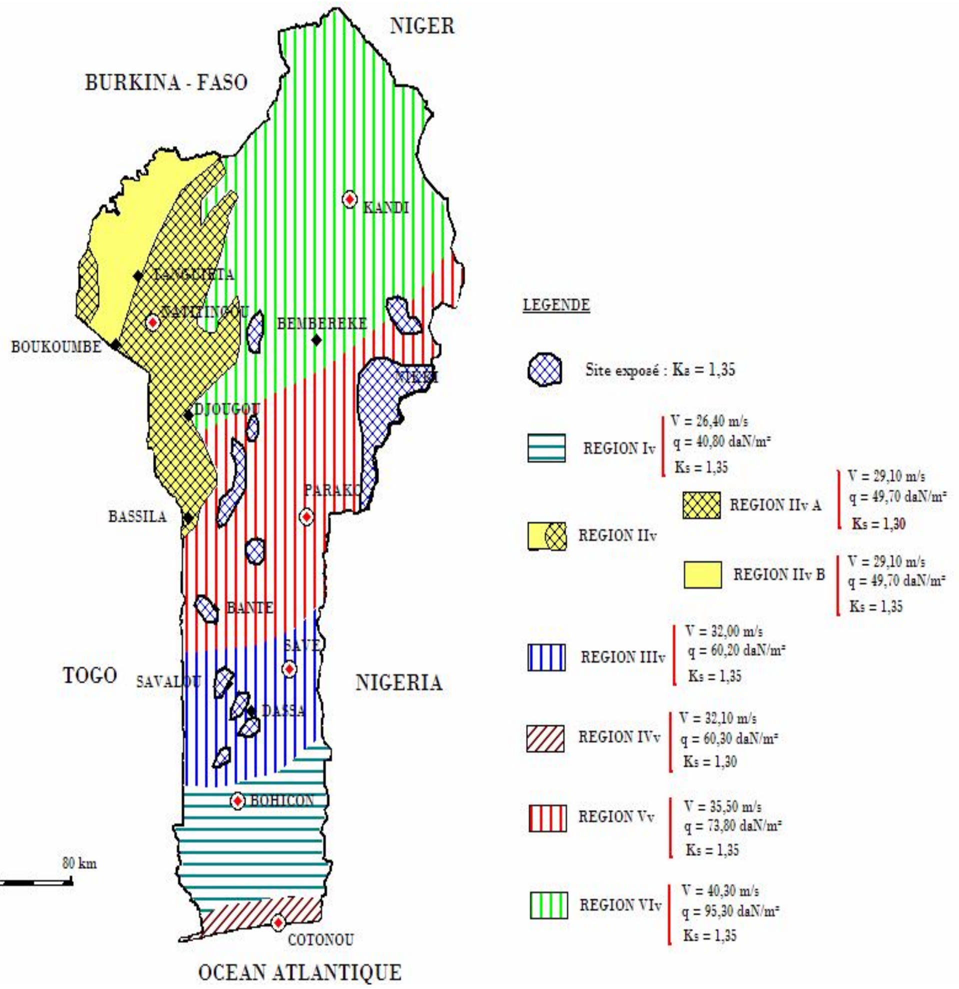

Figure 12: speed map, dynamic basic pressures and site coefficient

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