Proceedings of the 11th World Congress on New Technologies (NewTech'25)
Paris, France - August, 2025
Paper No. ICCEIA 152
DOI: 10.11159/icceia25.152

Wind Impacts on Buildings and Structures in the Republic Of Guinea

Traore Aboubacar Sidiki[1], Dr. Konstantinov Alexandr Petrovich [1], Girma Yordanose Mogse [2]
[1] National Research Moscow State University of Civil Engineering
129337, Yaroslavskoye highway, 26, Moscow, Russia
at@bdmproekt.ru; apkonst@yandex.ru
[2]Peoples' Friendship University of Russia
117198, Miklukho-maklaya, 6, Moscow, Russia
yordanosmoges1379@gmail.com

Abstract **–** Currently in the Republic of Guinea, high-rise buildings and structures construction projects are emerging in high rate. However, there is a lacks in codes of standard that take into account the wind parameters that is essential for the successful completion of a construction project. One of the major climatic factor is a wind load that is not accurately considered in calculating when designing buildings and structures in Guinea. The purpose of this study is to determine the estimated wind pressure for the whole territory of Guinea. The raw data for the last 25 years of wind speed were obtained from the databases of the National Directorate of Meteorology for 4 (four) meteorological stations. Then, based on the linear regression law, we were able to determine the probable values of the mean wind speed from the data of each meteorological station with a return period of 50 years. For areas of Guinea located outside the vicinity (200 km radius) of the meteorological stations, the values of mean wind speed were calculated using the OK (Ordinary Kriging) method. As a result, we were able to: - map the zoning of the Guinean territory according to the baseline wind pressure; - determine the coefficients that take into account the influence of altitude and roughness of the different types of terrain; - calculate the parameters that take into account wind turbulence. It assumed that the obtained results will help to minimize the risks of collapse of buildings and structures under construction in the considered meteorological zones by considering the wind load in the design of building structures.

Keywords**:** Meteorological station, Wind speed, Regression analysis, Return period, Ordinary Kriging, Wind pressure, Wind zone

1. Introduction

Wind force remains one of the most dangerous types of hazards that can directly or indirectly lead to building collapse. most local houses in the Republic of Guinea built mainly based on the client's budget without the use of appropriate standards. As for public projects or private projects of a certain category, they are realized using foreign standards such as the Eurocode [1], BAEL standard [2], which is a universal standard, allows the design of concrete structures without local climatic conditions consideration. Inaccurate load estimations are produced by ignoring wind loads or by applying inappropriate standards, which could lead to a poor choice of the structures' cross section. As a result, the built structure is exposed to natural disasters as high winds, heavy rains, high temperatures, etc.

Fig. 1: Ministry of Information in Conakry (left) [3]; A residential building in Conakry (right) [4]

The works of Markel B. [5] and Camila S. [6] stated that problems of wind load estimation are encountered in Albania and Cuba, respectively. As in Guinea, in these countries most engineers already use international standards for the design of buildings and structures, which has a significant impact on the safety of construction works. Authors [5,6] informed that due to the high demand for high-rise buildings, it is necessary to improve the accuracy of wind load determination, as they are significantly influenced by orography, making wind load even more critical in the design process.

2. Research Methodology

Climatic data for the last 25 years, i.e., values of the average hourly wind speed, were obtained from the National Meteorological Administration databases [7] of Guinea for four (4) Meteorological stations (Table 2.1): Conakry airport (Guinea), Kedougou (Senegal), Kenieba airport (Mali), and Odienne (Côte d'Ivoire).

Table 2.1: Climatic data [7]

	Meteorological stations			
	Conakry Airport	Kedougou(Senegal)	Kenieba airport (Mali)	Odienne (Côte d'Ivoire)
Year	Average hourly wind speed in m/s at a height of 10m			
2022	16,00	12,00	4,00	14,00
2021	19,00	20,00	4,00	6,00
2020	21,00	38,00	4,00	3,50
2019	24,50	11,50	12,30	12,00
2018	40,00	22,00	12,30	15,00
2017	26,00	32,00	12,50	13,33
2016	28,00	14,00	11,50	7,00
2015	21,00	9,50	14,80	16,11
2014	16,00	10,00	11,70	26,40
2013	41,00	10,00	12,50	13,89
2012	30,00	33,00	11,50	21,00
2011	25,00	40,00	9,50	25,00
2010	24,00	7,00	11,00	20,50
2009	34,00	34,00	21,00	20,50
2008	24,00	13,00	13,50	20,00
2007	22,00	10,00	13,50	20,00
2006	24,00	6,50	10,00	22,00
2005	16,00	17,00	15,00	24,00
2004	15,00	19,00	8,30	30,00
2003	13,00	17,00	16,00	18,00
2002	15,00	14,00	10,00	5,00
2001	15,30	19,00	19,00	23,00
2000	22,00	12,50	13,50	15,00
1999	12,22	20,00	10,00	8,10
1998	18,00	17,50	18,00	20,00

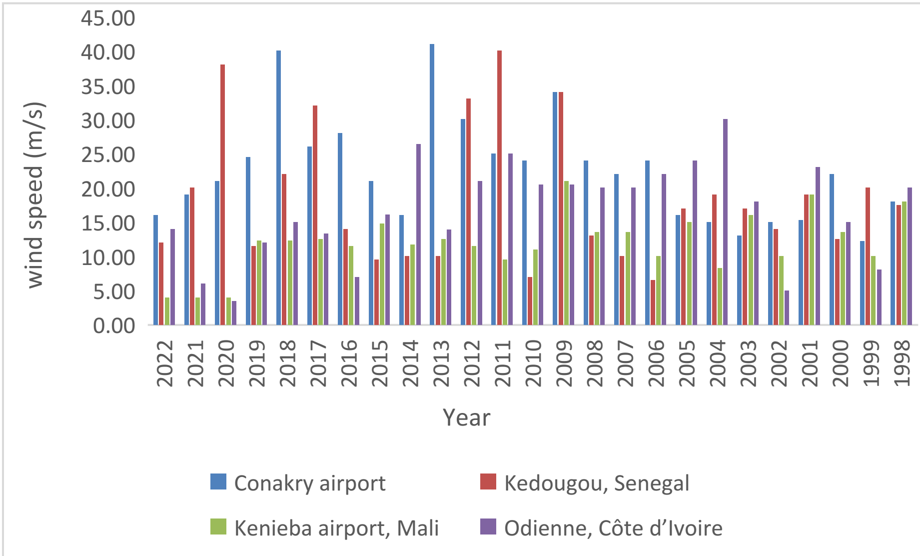

Fig. 2: Speed variation as a function of time [7]

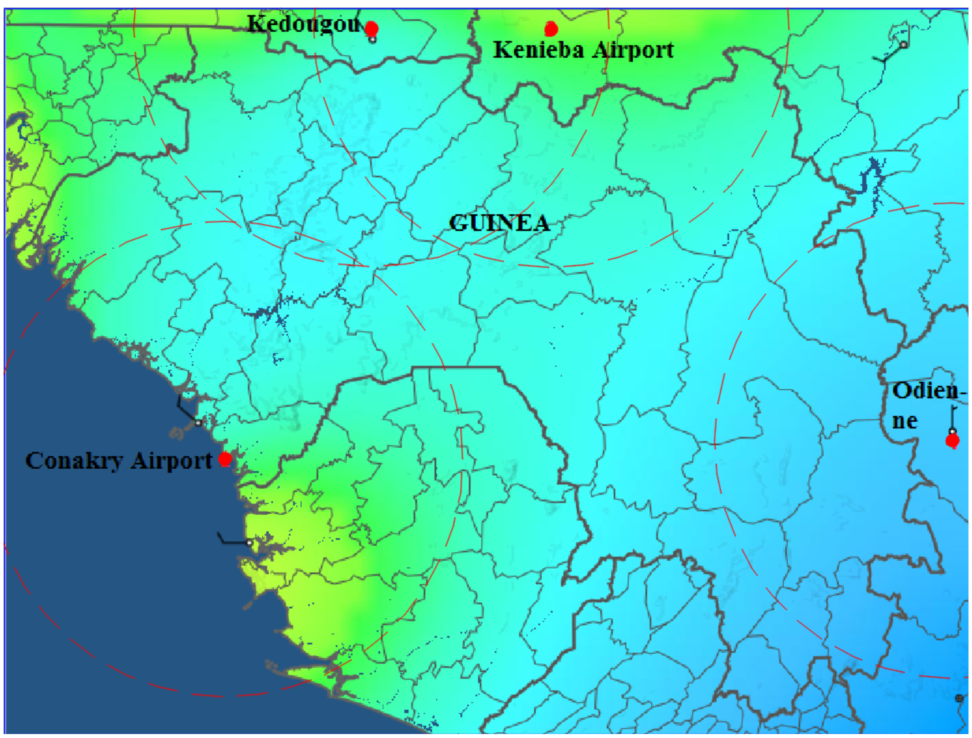

Fig. 3: Locations of meteorological stations [8]

In order to determine the probable mean wind speed values for each metrological station with a 50-year return period, the above climatic data (Table 2.1) were analysed using the linear regression method [9] (see Figure 4-7).

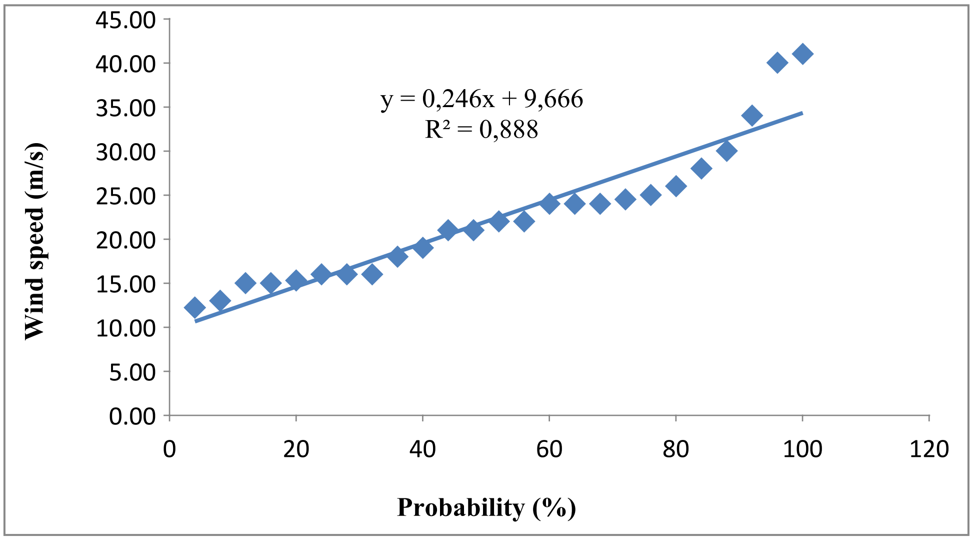

Fig. 4: Probability distribution of wind speed from Conakry airport meteorological station data

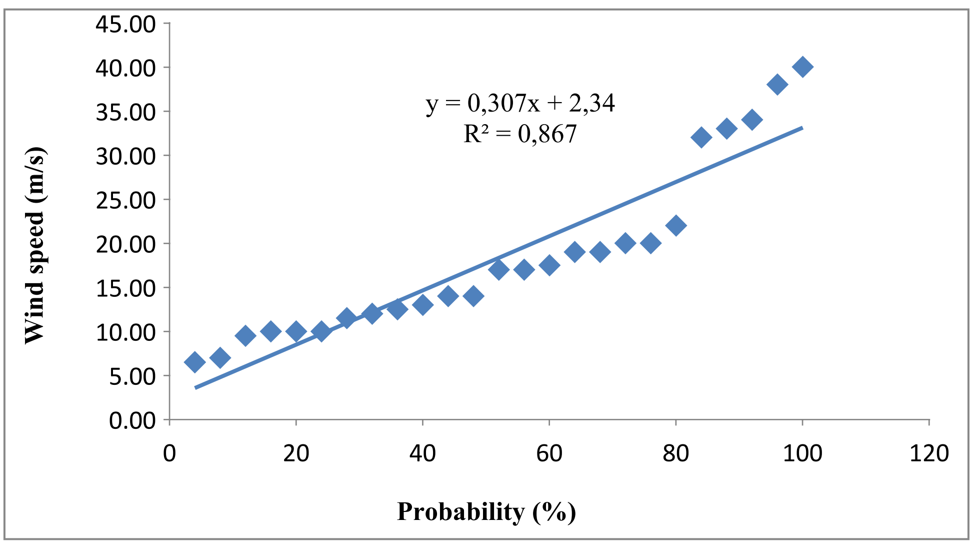

Fig. 5: Probability distribution of wind speed from Kedougou meteorological station data

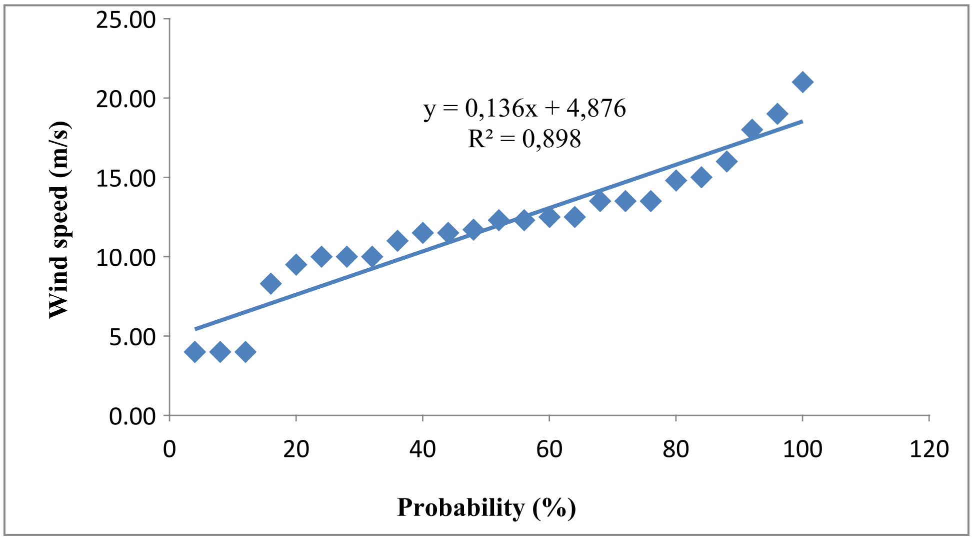

Fig. 6: Probability distribution of wind speed from Kenieba airport meteorological station data

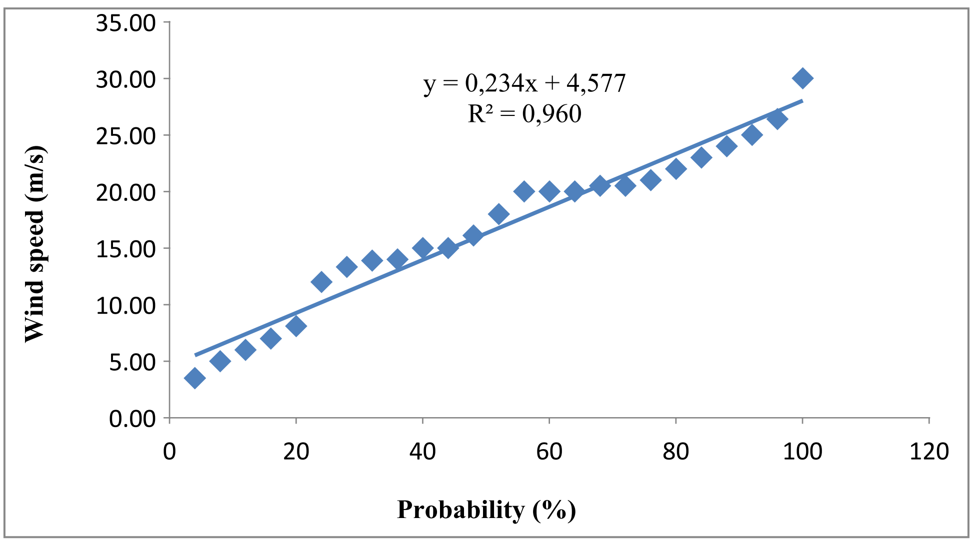

Fig. 7: Probability distribution of wind speed from Odienne meteorological station data

The probability corresponding to a 50-year return period could be determined using Equation 1 [10]:

$$P = 100\,\% \left(1 - \frac{1}{50}\right) = 98\,\% \tag{1}$$

The analyses showed that most wind-induced damage would have occurred in a shorter time intervals, i.e., less than 1 hour. According to Tun T. N. [11], showed that the wind with a shorter averaging period is stronger in intensity than the one with a long averaging period. Considering SP 20 [12], average speed values were employed in this study at 10-minute intervals. We applied equation (2), which was suggested by ISO 19901 [13], to get 10-minute wind speed figures based on hourly measurements:

$$V_{10} = V_{60}\left[1 - 0.41\left(0.06 + 0.00258 \cdot V_{60}\right) ln ln \frac{t}{t_0}\right] \tag{2}$$

where $V_{10}-$ 10-minute speed at a height of 10m, (m/s); $V_{60}-$ Average hourly velocity at a height of 10m, (m/s); $t = 60s-$ duration corresponding to 10 minutes; $t_0 = 3600s-$ duration corresponding to 1 hour.

The C coefficients shown in Table 3.1 are the results of the ratios of 10-minute velocities to hourly velocities V_{60}. The equality of the coefficients is explained by the fact that all velocities were calculated for a height of 10 m above the ground.

The wind pressure could be determined using a combination of well-known equations [14-15]: Bernoulli's law of conservation of kinetic energy (Equation 3) and the Mendeleev-Clapeyron ideal gas equation (Equation 4). The latter formula (Equation 4) consider climatic parameters such as temperature and atmospheric pressure:

$$P_m = \frac{1}{2}\rho \cdot V_{10}^2 \tag{3}$$

$$\rho = \frac{P_{abs}}{RT} \tag{4}$$

where P_m- Basic wind pressure, (Pa);$\rho-$ Air density, (Kg/m^3); $V_{10}-$ 10-minute wind speed at a height of 10m, (m/s); $P_{abs}-$ Absolute pressure, (Pa), $R-$ Specific gas constant, about 8.314 J/mol $\cdot$ k; $T-$ Temperature, (K).

It's necessary to keep in mind that, the recommended default value for air density in the European Standard [1] is 1.25 kg/m^3 compared to 1.225 kg/m^3 in France. However, in order to simplify the calculations as well as to improve safety, this air density value suggested by the Eurocode [1] have been used in this study. Since the Republic of Guinea is located in a hot part of the planet, the air density in this area is unlikely to reach the European average. This is because temperature is inversely proportional to air density (equation 4).

Then, we determined the parameters that change the value of the wind pressure, namely the coefficients K_z and I_z: by using the logarithmic approximation, the coefficients K_z determined (Equation 5) [1]:

$$\frac{V_z}{V_{10}} = K_z = \frac{k_{r1}\frac{z}{z_0}}{k_{r2} \cdot ln ln \frac{10}{z_0}} = \frac{ln ln \frac{z}{z_0}}{ln ln \frac{10}{z_0}} \tag{5}$$

where for the same locations $k_{r1} = k_{r2} = k_r-$ terrain coefficient; V_z- Wind speed at height Z m, (m/s); $V_{10}-$ Wind speed at height 10 m, (м/s); K_z- coefficients that take into account the effect of altitude and roughness of different types of terrain; z_0- roughness of terrain categories, (m).

- Wind turbulence record effects is justified by Equation 6 [1,16,17]:

$$I_z = \frac{\sigma}{V_z} = \frac{\sqrt{\frac{\sum_{i=1}^{n}\left(V_i - \bar{V}\right)^2}{n-1}}}{C_0(z) \cdot ln \frac{z}{z_0}} = \frac{\sqrt{\frac{\sum_{i=1}^{n}\left(V_i - \frac{\sum V_i}{n}\right)^2}{n-1}}}{ln \frac{z}{z_0}} \tag{6}$$

where $I_z -$ Turbulence coefficients at Z m height; $\sigma -$ Average square deviation, (m/s); $V_i -$ Wind speed in point i, (m/s); $\underline{V} -$ Arithmetic mean value of velocity, (m/s); $C_0(z) = 1 -$ Orographic coefficient for more or less flat areas.

This study identified Republic of Guinea territory zoning depend on the obtained equivalent wind load values. Thus territory zoning drawn by a software package (AutoCAD). It is essential to remind that each methodological station covers a set of towns located at a distance not greater than 200 km [7]. The Conakry airport station is located in the center of the circle that was used to draw the border between zones IV and III. In a way, the first curve that was thus produced ended up being parallel to the the coast and slightly in the direction of the Atlantic Ocean due to a concavity. The intersection of the circles with the Kedougou (Senegal) and Keniba (Mali) stations at their centers could be used to outline the border between zones III and I. The intersection of circles centered on the stations of Odienne (Côte d'Ivoire) and Keniba (Mali) forms the border between zones II and I.

Due to the lack of weather stations in the region of southeast Guinea that could offer accurate climatic data for the last 25 years, the curve that separated zones III and II was the most challenging to construct. To this end, our first approach was to compared the historical mean velocities of each city in this region of the nation with those of other cities that had already undergone classification. The velocity values in the nearest cities were the similar. The regression-Kriging method was the second strategy. This is a geostatistical theory known as OK (Ordinary Kriging) is to make predictions by calculating weighted averages of observations [18]:

$$V(s_0) = \sum_{i=1}^{n} \lambda_i \cdot V(s_i) \tag{7}$$

where $V(s_0) -$ Predicted wind velocity values in s_0 zone; $\lambda_i -$ Forecasting factors, which can be positive or negative; $n -$ total observations; $V(s_i) -$ Known values of wind speed.

The curve thus obtained, i.e. the curve separating zones III and II, turned out to be parallel to the sea coasts, which shows that the Atlantic Ocean has an impact on the microclimate of the zones that are nearest to it (Fig.8).

3. Analysis of results:

The results of this work showed that there are four (4) geographical areas in the Republic of Guinea that differ based on the wind pressure (Table 3.1). The resulting wind zones were ranked in ascending order, that is from zone I (the area where the lowest wind intensity was recorded) to zone IV (the area with the highest wind pressure intensity). Further, the values of K_z and I_z coefficients were categorized accordingly in Table 3.2. As well Figure 8 presents a map of the zoning of the territory of the Republic of Guinea according to wind pressure.

Table. 3.1: Wind pressure and zones

	Meteorological stations			
	Conakry Airport	Kedougou(Senegal)	Kenieba airport (Mali)	Odienne (Côte d'Ivoire)
Return period for 50 years, P(%)	98,00	98,00	98,00	98,00
Hourly wind speed, V_{60}(m/s)	33,81	32,49	18,25	27,56
Conversion factor, C	1,08	1,08	1,08	1,08
10-minute wind speed, V_{10}(m/s)	36,52	35,09	19,71	29,76
Wind pressure, P_m(kPa)	0,83	0,77	0,24	0,55
Wind zones	IV	III	I	II

Table 3.2: K_z coefficient to account for the effects of altitude and roughness of different types of terrain. I_z coefficients of turbulence at altitude

	Coefficients K_z according to terrain categories			Coefficients I_z according to terrain categories		
Высота, м	A (z_0 =0,2)	B (z_0 =0,5)	C (z_0 =1)	A (z_0 =0,2)	B (z_0 =0,5)	C (z_0 =1)

10	1,00	0,65	0,50	1,06	1,39	1,80
20	1,18	0,80	0,65	0,90	1,13	1,39
30	1,28	0,89	0,74	0,83	1,01	1,22
40	1,35	0,95	0,80	0,78	0,95	1,13
50	1,41	1,00	0,85	0,75	0,90	1,06
60	1,46	1,04	0,89	0,73	0,87	1,01
70	1,50	1,07	0,92	0,71	0,84	0,98
80	1,53	1,10	0,95	0,69	0,82	0,95
90	1,56	1,13	0,98	0,68	0,80	0,92
100	1,59	1,15	1,00	0,67	0,78	0,90
150	1,69	1,24	1,09	0,63	0,73	0,83
200	1,77	1,30	1,15	0,60	0,69	0,80

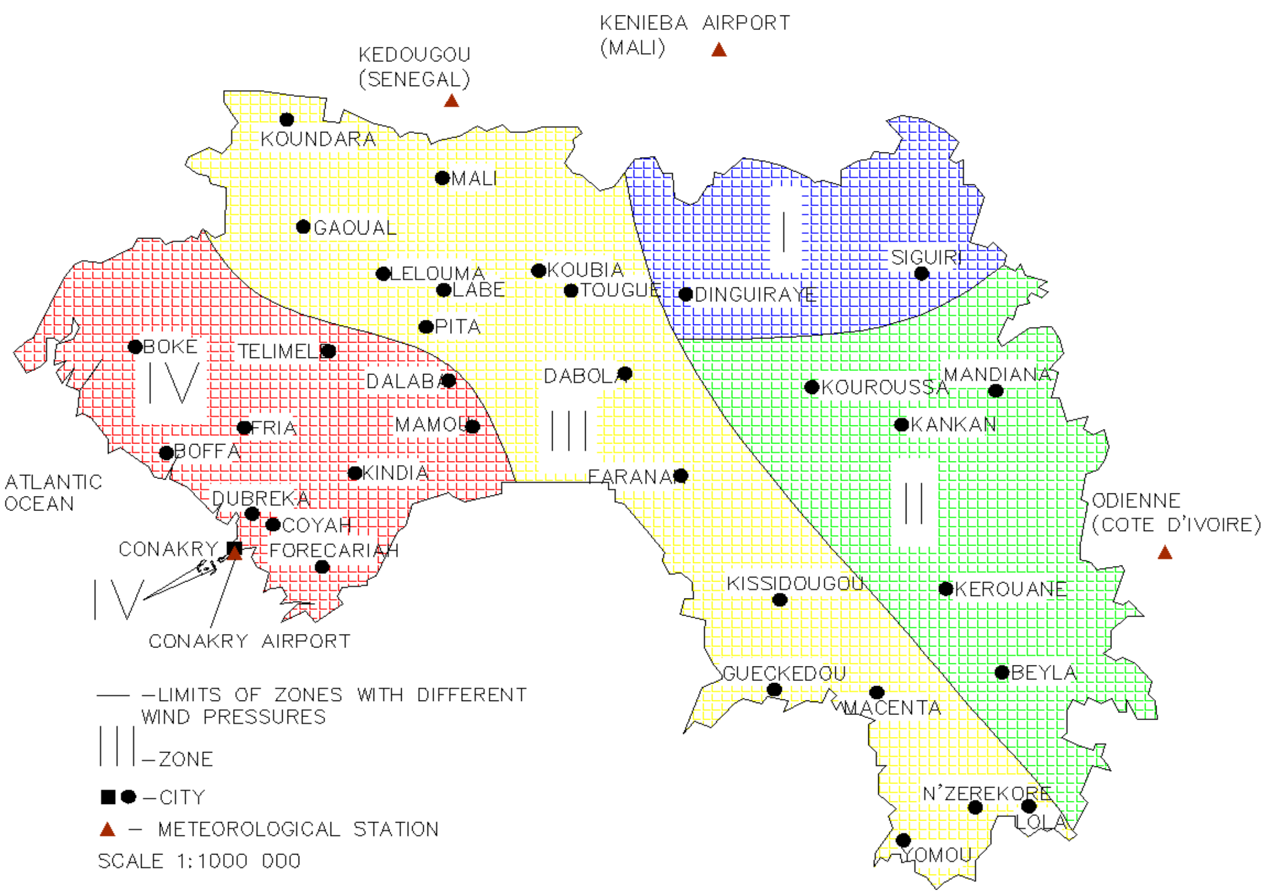

Fig. 8: Zoning of the territory of Guinea according to wind pressure

4. Discussions

The findings of the study confirmed the theory that wind pressure rises with closer to the sea coast. Since the strongest winds frequently occurred in Conakry and the surrounding area, this finding is completely consistent with reality (Fig 1). It is suggested to use the following formula to calculate the total wind pressure in order to reduce these damages [12]:

$$W= \left(W_m + W_p\right) \cdot \gamma_f = \left(W_m + W_m \cdot I_z \cdot \nu\right) \cdot \gamma_f = W_m \cdot \left(1 + I_z \cdot \nu\right) \cdot \gamma_f = P_m \cdot K_z \cdot C \cdot (1 + I_z \cdot \nu) \cdot \gamma_f \quad (7)$$

where $W_m -$ Average wind load component; $W_p -$ Pulsation component of wind load; $P_m -$ Wind pressure (Table 3.1); $K_z -$ coefficients that take into account the effect of altitudes and roughness of different types of terrains (Table 3.2); $C -$ Aerodynamic coefficients; $I_z -$ Turbulence coefficients at height Z m (Table 3.2); $\nu -$ Correlation coefficients between wind direction and facade orientation; $\gamma_f -$ Load reliability factor.

Since the aerodynamic parameters depend mainly on the building shape than the microclimate, it is recommended to adopt the coefficients from other standards. As for the load reliability coefficients, they can be taken in the range 1.2-1.4 according to [1, 12].

5. Conclusion

Civil engineers in the Republic of Guinea will therefore be able to choose which wind loads to apply when designing high rise buildings and structures. In addition, new standardization data is represented by the results. Data that will surely contribute to the protection of individuals and their belongings by means of performance condition compliant structures. The input from this study may contribute to the improvement of the government's quality control strategy.

Acknowledgements

The completion of this research paper would not have been possible without the support and guidance of Dr Konstantinov Alexandr Petrovich, Lecturer at National Research Moscow State University of Civil Engineering. His dedication and overwhelming attitude towards helping his students is solely responsible for completing my research paper. Special thanks to the National Meteorological Administration databases of Guinea for providing input data.

References

[1] Actions du vent sur les bâtiments selon l'Eurocode 1 – Partie 1-4.

[2] Règles BAEL 91 révisées 99.

[3] M. Y. Diallo (2021, October 30). Ministère de l’information et de la communication : le toit emporté par un vent violent [Online]. Available: https://guineematin.com/2021/10/30/ministere-de-linformation-et-de-la-communication-le-toit-emporte-par-le-vent/.

[4] N. M. Mansaré (2023, july 10). Matoto: un étage en construction s’effondre sur plusieurs ouvriers [Online]. Available: https://kalenews.org/matoto-un-etage-en-construction-seffondre-sur-plusieurs-ouvriers/.

[5] Markel Baballлku, Ani Verzivolli2, Rikard Luka1, Rezeart Zgjanolli. Fundamental Basic Wind Speed in Albania: An Adoption in Accordance with Eurocodes. “Journal of Transactions in Systems Engineering”. Volume 1, Issue 2, pp. 1-2. DOI: doi.org/10.15157/JTSE.2023.1.2.56-72.

[6] C. Aldereguía-Sánchez, I. F. Lorenzo, K. Luis-García, J. Ballote-Álvarez and V. B. Elena-Parnás. Methodology for obtaining a new map of basic wind speeds, Revista Facultad de Ingeniería Universidad de Antioquia. [Online]. Available: https://www.doi.org/10.17533/udea.redin.20240513.

[7] OULAYE S., CAMARA M. C., CONTE A., CONTE N., TOURE Y. S., SOUMAH M., BARRY O., SAVANE S., FOFANA F., SANGARE A., CISSOKO B., DIALLO T. B., SOUMARE N. Y. *Annuaire statistique 2022*. Conakry, Institut national de la statistique, 2023.

[8] Infoclimat.fr (Accessed: 2025, january 10). Wheather in real-time [Online]. Available: https://www.infoclimat.fr/fr/cartes/observations-meteo/temps-reel/temperature/carte-interactive.html.

[9] E. Sreehari and G. S. Pradeep Ghantasala. Climate Changes Prediction Using SimpleLinear Regression. ‘Journal ofComputational and Theoretical Nanoscience’. February 2019, pp. 1-2.

[10] V. Elena, G. Salvatore, F. Aldo, L. Federico. Hundred years of return period. ‘Water Resources Research’. 2015, October, pp. 9-12.

[11] 7. TUN T. N., THANT A. A., Comparison of Wind Averaging Conversions between Gust Factor and Statistical Approaches. “International Journal of Scientific Engineering and Technology Research” Vol. 03, May-2014, pp. 2070-2076.
[12] SP 20.13330.2016 ‘Charges et impacts’.
[13] ISO 19901-1:2015 ‘Petroleum and natural gas industries — Specific requirements for offshore structures’.
[14] K. Nirmaladevi, M. Mythilee, M. Navein, K. Manikandaprabhu. A Study on Bernoulli’s Equation & Its Application in Fluid Mechanics. ‘IJSRD - International Journal for Scientific Research & Development’. December 2019, Vol. 6, pp 1-2.
[15] YarongWang1 and Peirong Wang. Analysis of the application of ideal gas equation of state.2021, pp. 1-2. https://doi.org/10.1051/e3sconf/202125203019.
[16] Mirhosseini, M., Sharifi, F., and Sedaghat, A., 2011. Assessing the wind energy potential locations in province of Semnan in Iran, ‘Renew Sustain Energy Rev’. Vol. 15, pp. 449-59.
[17] Adebanji William Ayeni. Empirics of standard deviation. ‘*Conference Paper*’ May 2014. DOI: 10.13140/2.1.1444.6729.
[18] Tomislav H., David G. R. and Gerard H. About regression-kriging: From equations to case studies. ‘Computers & Geosciences 33’. October 2007, pp. 1302-1314.