WIND PRESSURE DISTRIUTION IN EGYPT

M. Swelem, H. Ghanem*, A.M. Ibrahim* and S. Gallo***

*Structural Engineering Department, Faculty of Engineering
Alexandria University, Alexandria, Egypt

** Department of Housing, Sidisalem, Kafr El-Sheikh

ABSTRACT

The main aim of this work is to determine the actual wind pressure and its distribution in Egypt. In order to determine the actual values of wind pressure, the actual values of wind velocity are obtained exactly from meteorological stations scattered all-over Egypt. The available data are used to carry out a statistical analysis in order to obtain contour maps of wind velocities for maximum expected wind velocity within return periods of 50 and 100 years. The results of the study revealed relatively higher values of wind pressure compared with those in the Egyptian code .

Keywords: Civil engineering, Structural analysis, Wind speed, Wind pressure contour maps

INTRODUCTION

Wind is one of the major forms of structural loading. Any structure which is built on the earth's surface must be capable of withstanding the wind loads .

These loads can be considered as the governing loading condition for special steel structures, such as broadcasting masts, cooling towers, suspension bridges , cranes, lightweight cladding and open sided buildings, such as sport grandstands.

In the first international conference on wind effects on buildings and structures which was held in London in 1963, Davenport presented his statistical approach for wind loading [1,2]. This conference can be considered the start of the modern era of wind engineering. The second conference was held in 1967 at Ottawa, Canada [3]. This conference has been repeated every four years: in 1971 at Tokyo, Japan [4], in 1975 at Heathrow, England [5], in 1979 at Fort Collins, USA [6] and in 1983 in two parts at the Gold Coast, Australia and Auckland, New-Zealand [7]. The International Association of Wind Engineering was formed in 1975 at the Fourth conference.

The proceedings of these conferences provide a rich source of data. On the other hand, the building research establishment has been very active in the field of wind engineering over the past two decades which turned its attention to low-rise buildings. Data from the Building Research Establishment (BRE) research programs [8] were used in 1970 and 1972 revisions and the 1985 amendments of the British Standard Code of Practice for wind loads [9]. In Egypt, several studies were made by many authors and researchers to study the wind effects on buildings and structures [10, 11] .

This paper is devoted mainly to the study of the extreme wind speed in Egypt. The wind speed data are collected from meteorological stations, then treated statistically in order to obtain contour maps for extreme wind distribution in Egypt. Such maps will be very useful for the design engineers for the analysis of special structures where the wind pressure is of vital importance.

CLIMATOLOGICAL ANALYSIS

Climatology may be defined as a set of probabilistic statements on long-term weather conditions. Wind climatology provides the designer and the codes with information on the extreme winds that might affect a structure during its lifetime. Such information is required for making rational decisions on the magnitude of the wind loads to be used in design.

The expected life-time of a building obviously depends on the purpose for which it is built; the more important the structure is, the longer the period it is expected to survive, such as monumental structures, which are generally built to last up to 100 years and more. On the other hand, low cost housing, ordinary industrial buildings and light weight roofs are built to last for only 50 to 100 years. The data of wind speed have been collected from meteorological stations scattered all over the country. There are over 55 meteorological stations scattered all over Egypt to record the direction and the wind speed every day. Any reliable forecast of maximum wind speed must be based on the data of the annual maximum wind at the building site and the statistics of the extreme values.

Wind codes must be based on the knowledge of the probability of occurrence of high wind velocities obtained from the statistical analysis of the wind velocity records. [12]. Davenport [13, 14] derived the following formula for the probability distribution of the extreme wind P.

$$P = 1 - e^{-e^{-a(V_{ext}-u)}} \quad (1)$$

Where

u is the mode shape or the modal wind speed;

1/a is the dispersion or is a scale wind speed;

and V_{ext} is the annual extreme wind speed .

Through a double logarithmic transformation [15], Equation 1 becomes

$$V_{ext} = u + \frac{1}{a}\left(-\ln\left[-\ln\left(1-P\right)\right]\right) \quad (2)$$

Putting $$y = -\ln\left(-\ln\left(1-P\right)\right) \quad (3)$$

Then, Equation 2 becomes:

$$V_{ext} = u + \frac{1}{a}y \quad (4)$$

The first, and most commonly used method of estimating the mode "u" and dispersion "1/a" from observed data is due to Gumbel [16].In this method, the maximum annual wind speed is extracted from the records of mean hourly wind speed, for all recorded years at a given site, then, the obtained extreme values are sorted into ascending order of magnitude, after which each is assigned a rank, m, where m=1 for the smallest and m=N for the largest of N values, then the value of P corresponding to each extreme is given by,

$$P = \frac{m}{(N+1)} \quad (5)$$

Plotting the straight line Equation 4, the parameters of extreme wind (mode "u" and dispersion "1/a" can be determined for any site, from the available data of maximum annual mean wind speed at that site [17].

On the other hand, the return period R is related to the probability P by the relation [15]. $P = 1/R$.

Then Equation 2 could be represented by the form:

$$V_R = u + \frac{1}{a}\left[-\ln\left|-\ln\left(1-\frac{1}{R}\right)\right|\right] \quad (6)$$

as $$\ln\left(1-\frac{1}{R}\right) \approx -\frac{1}{R}$$

Then $$V_R = u + \frac{1}{a}\ln R \quad (7)$$

Where V_R is the maximum expected wind speed within the period R .

There are about 80 meteorological stations scattered all over Egypt, fifty five stations of them have continuous records of wind speed for significant number of years from 1960 to 1992 (more than 30 years).

Table 1 presents the maximum wind velocities during the period from 1960 to 1977, for 28 stations, while Table 2 presents the maximum wind velocities during the period from 1978-1992, for 18 stations.

These data are extracted from the daily records of wind speed obtained from the meteorological stations. These stations are distributed over the geographic map of Egypt.

Table 1 Maximum annual wind velocity in Egypt during the period from 1960-1977 (data obtained from meteorological stations)

	Station	Max wind velocity m/sec
1	Cairo airport	30.90
2	Cairo west	27.80
3	Almaza	28.50
4	Bahtim	24.70
5	Ras El-Tin	30.90
6	El-Nuzha airport	29.90
7	El-Dekhila	34.00
8	Sidi Barani	31.90
9	Mersa Matruh	43.26
10	El-Sallum	31.90
11	Belbeis	32.45
12	El-Mansoura	28.80
13	Tanta	26.30
14	Rosetta	28.30
15	Damanhur	23.70
16	Tahrir	28.20
17	Siwa	33.50
18	El-Dakhla	30.90
19	Abu Suweir	36.10
20	Hurghada	36.65
21	El-Quoseir	25.75
22	Helwan	26.27
23	El-Fayoum	28.80
24	El-Minya	27.80
25	Asyout	39.14
26	Luxur	35.50
27	Aswan	29.87
28	El-Dab'a	43.26

Table 2 Maximum annual wind velocity in Egypt during the period from 1978-1992 (data obtained from meteorological stations)

	Station	Max wind velocity m/sec
1	Cairo airport	24.7
2	Bahtim	25.7
3	Tanta	23.6
4	Rosetta	25.7
5	El-Mansoura	25.7
6	El-Dakhla	22.6
7	El-Bahariya	21.1
8	Aswan	20.1
9	Asyout	22.6
10	El-Hurghada	21.1
11	El-Arish	24.2
12	Port-Said	29.3
13	Alexandria	32.9
14	El-Suez	29.3
15	El-Sallum	31.9
16	El-Fayoum	23.2
17	Beltis	27.8
18	Mersa Matruh	43.3

Contour maps

In order to develop contour maps for wind velocities in Egypt for return periods of 50 and 100 years, the mean and maximum values of wind velocity are collected from the meteorological stations scattered all over Egypt during the period from 1960 to 1992. Then, the following procedure is carried out:

Knowing the annual extreme wind speed at any site, and using Gumbel's method [16], which have already been used for developing the contour maps for wind velocities in the United Kingdom [17], the parameters u and 1/a are directly determined from the straight line Equation 4.

From Equation 6 and for a given return period R the maximum expected wind speed at the studied site is obtained .

Table 3 gives the maximum expected wind speed for return periods of 50 and 100 years (at a reference height 10m, above ground surface for open terrain) for 22 sites distributed all over Egypt.

The data given in Table 3 are used for drawing Figures 1 and 2 which represent the contour maps for the maximum expected wind speed for a return period of 50 and 100 years respectively.

The results of Table 4 indicate big variations of wind pressure intensities extracted from this study for a return period of 50 year, compared with those in the Egyptian code [18].

Table 3 Maximum expected wind speed, for return periods of 50 and 100 years

	Station	V_R m/sec R = 50 Years	V_R m/sec R = 100 Years
1.	Cairo airport	33.53	35.68
2.	Abbasiya	29.24	31.32
3.	Alexandria	36.15	38.10
4.	Sidi Barrani	34.02	35.41
5.	Mersa Matruh	45.60	48.72
6.	El-Sallum	36.55	38.50
7.	El-Dab'a	43.92	46.90
8.	Bilbeis	37.14	39.15
9.	El-Mansura	31.77	33.57
10.	Tanta	28.92	30.31
11.	Rosetta	31.87	33.57
12.	Damanhur	29.96	31.83
13.	Tahrir	27.29	28.03
14.	Siwa	33.54	35.29
15.	El-Dakhla	32.60	34.70
16	16. Abu Suweir	37.62	39.84
17.	Hurghada	35.76	37.63
18.	Fayoum	29.65	31.65
19.	Minya	28.88	30.36
20.	Asyout	38.73	41.64
21.	Luxur	36.75	40.04
22.	Aswan	33.93	36.08

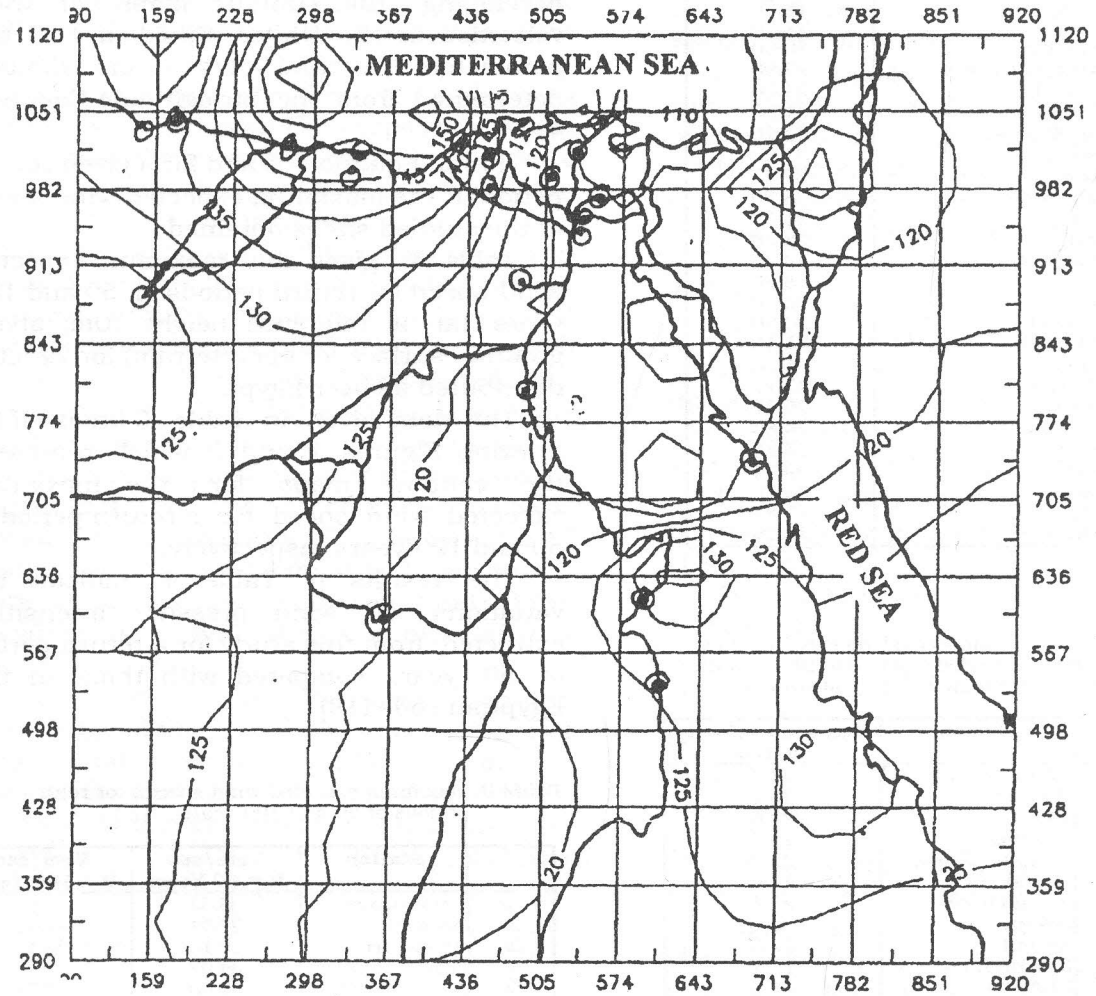

Figure 1 Contour map of maximum expected wind speed for return period of 50 years (V_{50}) in Egypt in km/hour. Based on information provided by Meteorological Authority (Scale 1 cm = 100 km)

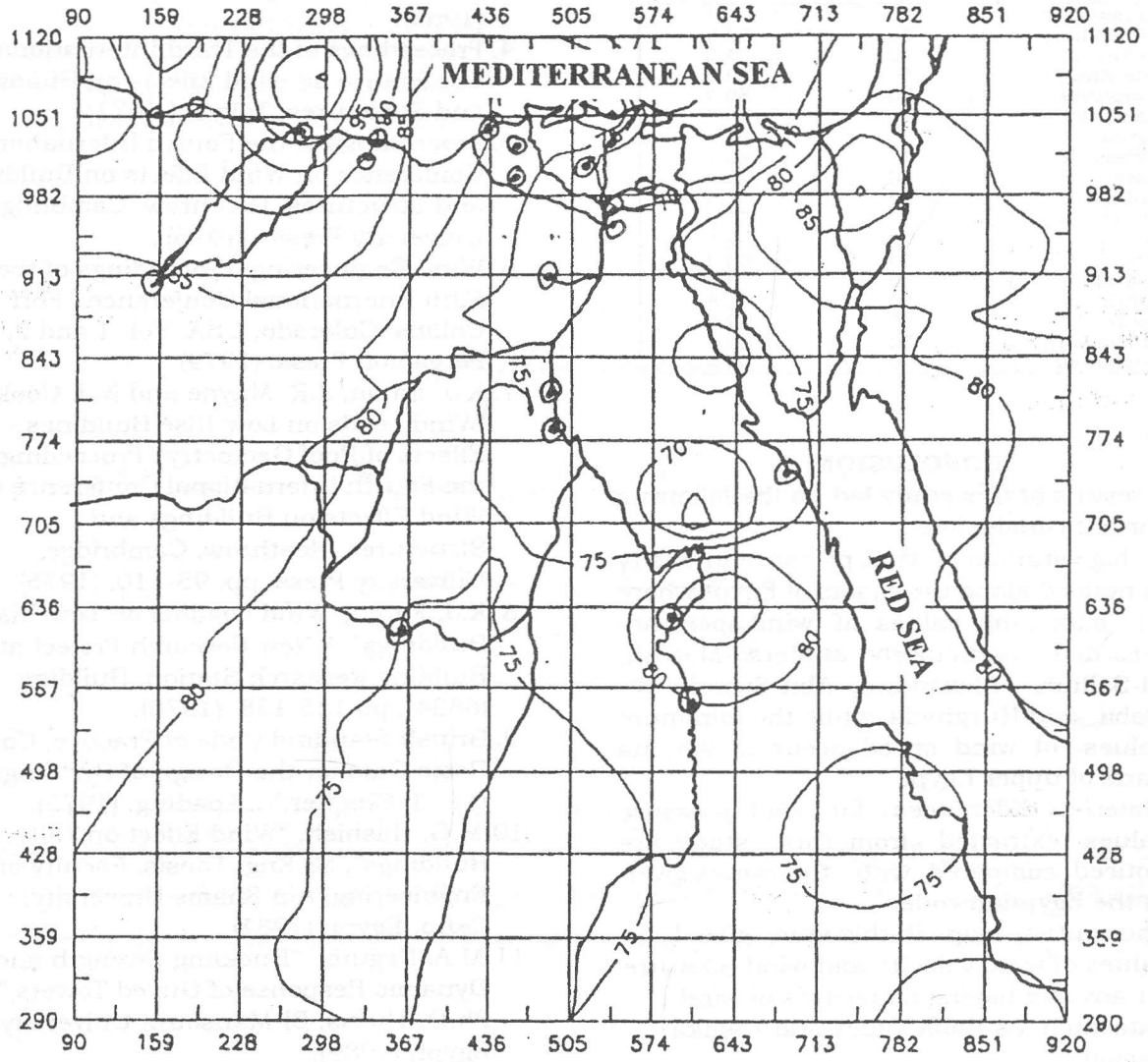

Figure 2 Contour map of maximum expected wind speed for return period of 100 years (V_{100}) in Egypt in km/hour. Based on information provided by Meteorological Authority (Scale 1 cm = 100 km)

Table 4 Values of wind pressure in Egyption code and the corresponding values from contour maps for a return period 50 year .

The site	Wind pressure in Egyptian code (kg/m^2)	Wind, pressure from contour maps (kg/m^2)
Mersa-Matruh	90	127.0
Alexandria	80	82.0
El-Sallum	80	84.0
Abu-Suweir	80	89.0
Hurghada	80	80.4
Cairo airport	70	70.7
Asyout	70	94.4
Bilbeis	70	86.7
Siwa	60	70.7
El-Dakhla	60	66.8
El-Fayoum	50	55.3
Minya	50	52.5
Luxur	50	84.9
Aswan	50	72.4
Tahrir	50	46.8
Tanta	50	52.6
El-Mansura	50	63.5
Damanhur	50	56.5

CONCLUSION

The results of this study led to the following important conclusions:

1. A big variation of wind pressure intensity is noticed along the coasts of Egypt where the maximum values of wind speed are recorded particularly at Mersa-Matruh, El-Sallum, Alexandria, Abu-Suweir, El-Daba and Hurghada, while the minimum values of wind speed occur at various parts of upper Egypt.
2. Material differences for wind pressure values extracted from this study are noticed compared with the values given in the Egyptian code.
3. The contour maps in this study give values of wind velocity and wind pressure for any site having no records of wind data such as Halfa Valley and Toshka Region.

REFERENCES

1. National Physical Laboratory, 'Wind effects on buildings and structures'. Proceedings of the Conference Held at the National Physical Laboratory, Teddington. Vol. I and II. London, HMSO, (1963).
2. A.G, Davenport, "The Application of Statistical Concepts to the Wind Loading of Structures", Proceedings of the Institution of Civil Engineers, London, Vol. 19, pp. 449-472, (1961).
3. Proceedings of the International Research Seminar on wind Effects on Buildings and Structures, Ottawa, Canada, Vol. I and II. University of Toronto Press, (1968).
4. Proceedings of the Third International Conference on wind Effects on Buildings and Structures, Tokyo, (1971).
5. Proceedings of the Fourth International Conference on Wind Effects on Buildings and Structures, Heathrow, Cambridge University Press, (1975).
6. Wind Engineering: Proceedings of the Fifth International Conference. Fort Collins, Colorado, USA. Vol. 1 and 2, Pergamon Press, (1979)
7. K.J. Eaton, J.R. Mayne and N.J. Cook, 'Wind Loads on Low-Rise Buildings - Effects of Roof Geometry'. Proceedings of the Fourth International Conference on Wind Effects on Buildings and Structures, Heathrow, Cambridge University Press, pp. 95-110, (1975).
8. K.J. Eaton, 'Wind Loading on Low-Rise Buildings'. A New Research Project at the Building Research Station, Building, 219 (6634), pp 135-138, (1970).
9. British Standard Code of Practice, Code of Basic Data for the Design of Buildings, C.P. 3, Chapter V., Loading, (1972).
10. M.G. Hashish, "Wind Effect on Tall Buildings", M. Eng. Thesis, Faculty of Engineering, Ain Shams University, Cairo, Egypt, (1981).
11. M.A. Neguib, "Buckling Strength and Dynamic Response of Guyed Towers," Ph.D. Thesis, El-Mansoura University, Egypt, (1989).
12. H.C.S. Thom, "New Distrbutions of Extreme Wind Speeds in United States", J. Struct. Div., ASCE, No-ST7, Proc. Paper 6038, July 94, pp 1787-1801, (1968).
13. J.R. Mayne, "The estimation of extreme winds",. Journal of Industrial Aerodynamics, Vol. 5, pp 109-137, (1979).
14. N.J. COOK, "Towards Better Estimation of Extreme Winds", Journal of Wind Engineering and Industrial Aerodynamics, Vol. 9, pp 295-323, (1982).

15.J. Liblein, "Efficient Methods of Extreme-Value, Methodology", Report NBSIR 74-602 Washington, National Bureau of Standards, (1974).
16.E.J. Gumbel, "Statistics of Extremes". New York, Columbia University Press, (1958).
17.P.G.F. Caton, "Maps of Hourly Mean Wind Speed Over the United Kingdom", 1965-73 Climatological Memorandum 79, Bracknell Meteorological Office, (1976).
١٨.الكود المصرى لحساب القوى والأحمال على المبانى والمنشآت فى جمهورية مصر العربية.

Received July 22. 1998
Accepted October 1. 1998

توزيع ضغط الرياح بمصر

مصطفى سويلم*، حسام غانم*، عبد العزيز محمود* و سعد جالو**

* قسم الهندسة الإنشائية، جامعة الاسكندرية
**مديرية الاسكان – سيدى سالم – كفر الشيخ

ملخص البحث

يتعرض هذا البحث للتحليل المناخى لسرعة الريح فى مصر وذلك من خلال البيانات الحقيقية التى تم تجميعها السرعات الريح من محطات الارصاد فى أثنين وعشرين موقعا منتشرة فى انحاء الجمهورية وأجراء التحليل الإحصائى لهذه البيانات للتوصل للقيم الحقيقية القصوى للمتوسط الساعى سنويا فى كل موقع والذى تم من خلاله عمل خرائط كنتورية للسرعة القصوى لفترة ٥٠ سنة و ١٠٠ سنة ومنها يمكن تحديد ضغط الرياح فى أى موقع فى جمهورية مصر العربية وقد قورنت النتائج مع مثيلتها بالكود المصرى.