

CLIMATOLOGICAL SERVICES (Met 0 3)CLIMATOLOGICAL MEMORANDUM No. 48THE RELATIONSHIP BETWEEN EXTREME WIND SPEEDS AND WINDDIRECTION IN THE LONDON AREA

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Introduction

Climatologists often receive requests for information on the maximum wind speeds and gusts likely to be encountered in various locations and at different heights above the ground. Enquirers also frequently ask whether any particular direction is favoured by the strong winds.

Shellard^{1,2} has investigated extreme mean hourly winds and extreme gusts over the United Kingdom using Gumbel's extreme value probability theory³ which enables the extreme wind speed likely to occur, on the average, only once in a given number of years to be estimated. This method of analysis has many advantages over the rather crude practice of selecting the highest wind speed so far recorded at a given site and multiplying it by some arbitrary 'safety' factor, and it has been thought worthwhile extending the earlier investigations to take account of wind direction.

Data Used and Method of Analysis

The station selected for this analysis was Kew Observatory (51°28'N, 00°19'W and 18 feet above msl) which has a long period of homogeneous records unlikely to be biased by topographical effects. The 25 years 1940 to 1964 were chosen and the highest mean hourly wind speeds and highest gust speeds (in knots) for all the days of each year were grouped into twelve ranges of wind direction, viz:- 350°-010°, 020°-040°, 320°-340°. The 25 highest yearly mean speeds and gusts thus obtained for each direction range were then tabulated in rank order from the smallest to the largest and plotted on extreme value probability paper, as described by Shellard¹. In all, 24 graphs were drawn (not reproduced here), one for mean hourly speeds and one for gusts for each of the 12 direction ranges. In each case the fitted straight lines were computed and drawn in and the plotted data were seen to fit Gumbel's theory quite well. The speeds likely to be exceeded only once in 10, 20, 50 and 100 years in each direction range were read off from the extrapolated straight lines. These values, which refer to 50 feet above the ground (the effective height of the Kew anemometer), were then reduced to the standard height of 33 feet using the power-law formulae derived by Carruthers⁴ and Deacon⁵.

Results

Table 1 shows the highest mean hourly winds and highest gusts for the different return periods in each direction range together with the highest values during the period of record and the mean annual maximum values. This table incidentally demonstrates the superiority of extreme value probability analysis over the mere extraction of the highest value on record. For example, in the present analysis, in almost every case the highest recorded values are exceeded by the 50-year return period value and in some cases even by the 20-year value.

In order to illustrate the relationship between wind direction and maximum speed, wind roses were drawn for mean hourly wind speeds and gust speeds for return periods of 50 and 100 years (Fig. 1).

/ Conclusions

Conclusions

The wind roses in Fig. 1 show a remarkably uniform distribution of extreme wind speeds with wind direction, although with an expected bias towards winds with a westerly component. A satisfactory result from the engineer's point of view is that the maximum wind speeds in any given direction range are not significantly higher or lower than those in neighbouring ranges. The highest maximum speeds at Kew do in fact occur in the direction range centring on 210° and the lowest maximum speeds in the range centring on 120° , the former being about 50% higher than the latter.

Although these results are for only one station in south-east England it is probable that a similar result, viz. that the highest wind speeds are liable to come from a rather wide range of directions, would be obtained at other places in the United Kingdom apart from those where the wind regime is very strongly influenced by local topography.

References

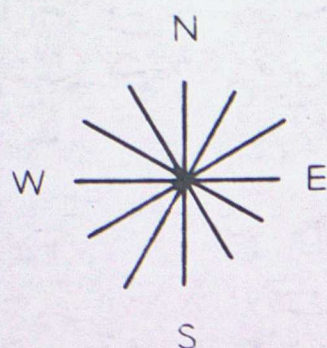
1. SHELLARD, H. C.; Extreme wind speeds over Great Britain and Northern Ireland. Met. Mag. London, 87, 1958, p. 257.
2. SHELLARD, H. C.; Extreme wind speeds over the United Kingdom for periods ending 1959. Met. Mag. London, 91, 1962, p. 39.
3. GUMBEL, E. J.; Statistical theory of extreme values and some practical applications. Appl. Math. Ser. U.S. Bur. Stand., Washington, D.C., No. 33, 1954.
4. CARRUTHERS, N.; Variations in wind velocity near the ground. Quart. J.R. Met. Soc., London, 69, 1943, p. 293.
5. DEACON, E. L.; Gust variations with height up to 150 m. Quart J.R. Met. Soc., London, 81, 1955, p. 562.

TABLE 1. MAXIMUM MEAN HOURLY WIND AND GUST SPEEDS IN KNOTS AT 33 FEET ABOVE THE GROUND, RELATED TO WIND DIRECTION. BASED ON 25 YEARS (1940-64) DATA FOR KEW

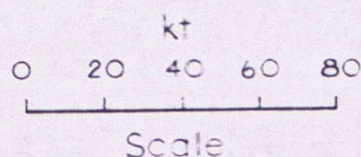
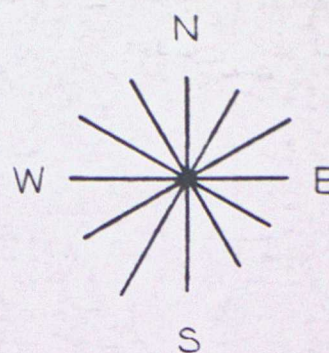
WIND DIRECTION	Mean Hourly Winds					Highest on Record	Mean Annual Max.	Gusts					Highest on Record	Mean Annual Max.
	Speeds likely to be exceeded only once in stated no. of years							Speeds likely to be exceeded only once in stated no. of years						
	10	20	50	100				10	20	50	100			
350°-010°	21	23	26	27	23	17.6	48	53	58	62	55	38.3		
020°-040°	22	24	26	27	25	18.5	45	49	53	57	56	36.4		
050°-070°	25	27	30	31	27	20.3	45	48	52	55	47	37.7		
080°-100°	22	23	25	26	22	18.5	40	43	47	50	45	33.4		
110°-130°	19	20	23	24	19	13.8	36	38	42	44	37	28.9		
140°-160°	20	22	24	26	23	15.3	42	46	52	56	47	32.6		
170°-190°	24	26	28	29	24	19.8	51	55	60	64	57	41.8		
200°-220°	29	31	33	35	32	24.4	58	62	66	69	60	49.2		
230°-250°	26	27	29	31	27	22.2	56	60	64	68	62	47.2		
260°-280°	24	26	28	30	27	18.9	55	58	62	66	58	44.8		
290°-310°	24	27	30	32	26	18.6	55	59	65	69	58	44.3		
320°-340°	23	25	28	30	26	17.8	53	58	64	69	57	41.5		

(a) Maximum Mean Hourly Wind Speeds

Return Period 50 Years

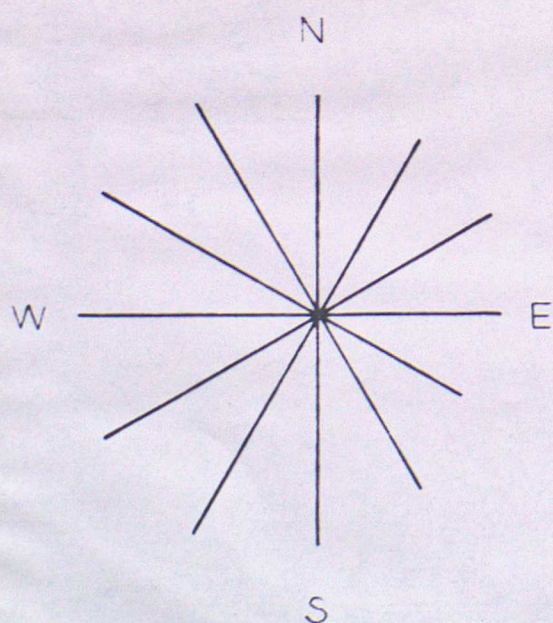


Return Period 100 Years



(b) Maximum Gust Speeds

Return Period 50 Years



Return Period 100 Years

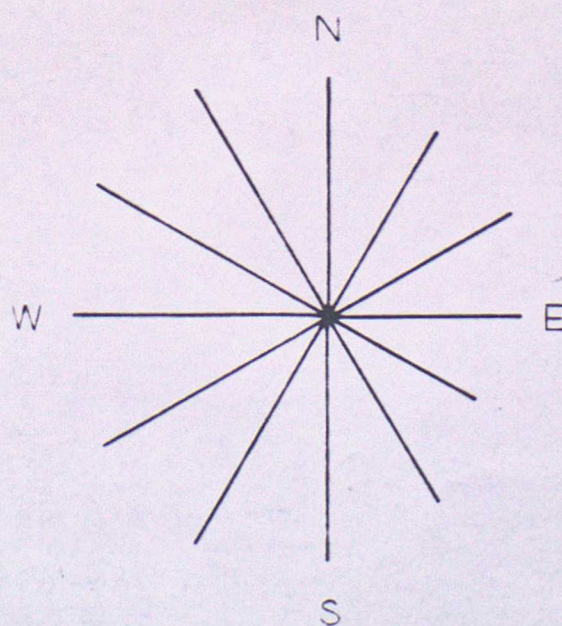


FIG 1 WIND ROSES OF MAXIMUM MEAN HOURLY WINDS AND MAXIMUM GUSTS AT 33 FEET ABOVE THE GROUND FOR RETURN PERIODS OF 50 AND 100 YEARS BASED ON 25 YEARS (1940-64) DATA FOR KEW