DEPARTMENT OF TRANSPORT AND POWER
METEOROLOGICAL SERVICE

TECHNICAL NOTE No. 35

EXTREME WIND SPEEDS IN IRELAND

BY
J. J. LOGUE, B. Sc.

U.D.C.
551. 556.6 (415)

DUBLIN
OCTOBER 1971

Extreme Wind Speeds in Ireland

by

J.J. Logue, B.Sc.

Abstract: Autographic wind records of a number of stations have been analysed, using the statistical theory of extreme values, in order to derive estimates of extreme wind speeds for various return periods. Maps of Ireland showing the gust speed likely to be exceeded only once in 50 years and of the mean hourly speed likely to be exceeded only once in 120 years have been prepared.

1. Introduction

In connection with the design of such structures as radio and television masts, chimney stacks, bridges and tall buildings, meteorologists are frequently asked to provide the wind information necessary to enable the designer to take account of the effect of wind loading on the structure. For most purposes it is convenient to give this information in the form of an estimate of the greatest wind speed in a gust which will be exceeded on the average only once in a stated number of years at a height of 10 metres above the ground. (10 metres is the standard height at which wind speed is measured). In connection with the design of large bridges however, what is required is the greatest wind speed averaged over a period of one hour rather than the gust speed. The number of years to which the estimates refer is usually 50, 100 or 120.

Wind data for Ireland are provided by a network of Dines pressure tube anemometers situated where possible in open level country with the measuring head at an effective height of 10 metres. Gust speeds as read from the records of these instruments represent an average over a period of about 3 seconds.

The technique of analysing these data in order to provide the estimates referred to above is provided by the statistical theory of extreme values which has been developed by Gumbel (1954) and others.

2. Statistical theory of extreme values as applied to annual maximum wind speeds

The statistical variate to which the theory of extreme values is applied is in this case the annual maximum wind speed in a gust recorded at a particular station. The probability distribution used to fit the data is the Type I extreme value distribution which may be expressed:

$$p(x) = \exp(-\exp(-a(x-u)))$$

Here p is the probability that the extreme value is less than x and a and u are constants. It is convenient to express p in terms of the return period $T(x) = 1/(1-p)$. This gives:

$$(T-1)/T = \exp(-\exp(-a(x-u)))$$

or

$$x = u - (1/a)(\ln \ln (T/(T-1)))$$

This last equation gives the relationship between the extreme gust speed x and its return period T (years). For a particular station, the constants a and u may be evaluated by fitting the series of annual maximum gust speeds to the distribution. The maximum gust speed likely to be exceeded on the average only once in any given number of years may then be calculated.

3. Treatment of data

In order to provide a basis for dealing with enquiries of the type referred to in the introduction, the records for a number of stations were examined and the highest gust for each year for each station was extracted. Only stations with records exceeding 10 years were considered.

The effective heights of the anemometers did not differ significantly from 10 metres except at Malin Head, where the effective height was 18 metres during the period 1966-70. The values recorded at this effective height were reduced to 10 metres using a formula due to Deacon (1955):

$$x\ (10m) = x\ (18m) \times (10/18)^{0.085}$$

An extreme value Type I distribution was fitted to the data for each station using the method of Gumbel (1954). Gust speeds likely to be exceeded on the average only once in 10, 20, 50 and 100 years were then calculated and are given in Table I together with the highest gust actually recorded and the period of record.

The gust speeds for a return period of 50 years were plotted on a map and isolines at intervals of 2 metres per second were drawn. The result is shown in Figure I which gives the distribution of the gust speed likely to be exceeded only once in 50 years at 10 metres above the ground in open level country.

For the purpose of designing large bridges, it is necessary to consider wind speed averaged over a period of 1 hour. Also, because of the long projected lifetimes of many bridges, it is considered appropriate to give maximum speeds for a return period of 120 years rather than 50 years. Unfortunately, tabulated maximum mean hourly wind speeds are not readily available for the stations considered. However it has been found (Durst 1960) that maximum gust speeds may be converted to maximum mean hourly speeds by dividing by a factor which varies with the roughness of the terrain but which for open level country is about 1.5. Accordingly, the gust speed for a return period of 120 years was calculated and divided by 1.5 in order to give the 120-year mean hourly speed for each station. These results are shown in Table 2 and the distribution of the mean hourly wind speed likely to be exceeded only once in 120-years is shown in the map in Figure 2.

In preparing the maps, the exposure of the stations was taken into account. Valentia Observatory, for example, is sheltered by hills in its vicinity and may be expected to give values which are too low. Clones weather station, on the other hand, is somewhat overexposed, being situated on top of a hill, and may be expected to give too high values. Another point taken into consideration was that the more recently opened stations gave values which were somewhat too high because the period 1957-68 was very stormy over Ireland.

The drawing of the maps over the northern part of the country is in agreement with that of similar maps prepared by the British Meteorological Office and used by the British Standards Institution. Data for some stations in that area were kindly supplied by the Director General of the British Meteorological Office.

4. <u>Application of results</u>

The once in 50 years gust speed the distribution of which is shown in Figure I constitutes a basis for estimating the design wind speed for most structures. For the design of large bridges, the once in 120 years mean hourly speed given in Figure 2 may be considered more appropriate.

In applying the data of Figure 1 to the design of a particular structure, it is necessary for the designer to apply corrections for various non-meteorological factors. Figure 1 refers to wind speed in a gust, which in effect is an average over a period of 3 seconds. However, the averaging time appropriate for large structures is a function of their size and is in general not equal to 3 seconds. It is therefore necessary to apply a correction factor characteristic of the size of the structure. Correction must also be made for the height of the structure which will not usually be equal to the standard 10 metres.

A further correction factor may have to be applied if the structure is not situated in the open level country for which Figure 1 applies. If it is situated on top of a ridge or hill for example, it may be necessary to increase the design wind speed whereas if it is sheltered by the surrounding topography it may be allowable to reduce it.

A correction factor of a different kind may be necessary where it is desired to reduce the risk of failure of the structure due to excessive wind loading to a low value. According to extreme value theory, there is a 63% chance that the estimated extreme wind speed will be exceeded within the specified period. If, for reasons of safety, it is desired to reduce the risk to a lower value, it will be necessary to increase the design wind speed by an appropriate factor.

The evaluation of these correction factors, which is outside the scope of this paper, is described in the regulatory publications related to building standards (e.g. British Standard Code of Practice. CP 3: Chapter V: Part 2 1970).

References

British Standards Institution	1970	British Standard Code of Practice. CP 3: Chapter V: Part 2: 1970
Deacon, E.L.	1955	Gust variation with height up to 150 m. Q.J.R. Met. Soc. 81, p. 562.
Durst, C.S.	1960	Wind speeds over short periods of time. Met. Mag. 89, p. 181.
Gumbel, E.J.	1954	Statistical theory of extreme values and some practical applications. Appl. Maths. Ser. 33, Nat. Bur. Stand.
Shellard, H.C.	1958	Extreme wind speeds over Great Britain and Northern Ireland. Met. Mag. 87, p.257.

Table 1. Gust speeds (m/s) likely to be exceeded only once in the stated number of years at 10m above the ground at a number of stations

Station	Period of record	Return period (years) 10	20	50	100	Highest on record
Belmullet	1956-70	48	51	55	59	48
Birr	1955-70	38	40	43	45	42
Claremorris	1944-70	41	43	46	49	47
Clones	1950-70	44	48	52	55	45
Dublin Airport	1946-70	38	40	42	44	38
Glenamoy	1959-70	45	48	52	54	44
Kilkenny	1958-70	38	41	44	47	39
Malin Head	1956-70	49	52	57	60	51
Mullingar	1944-70	37	39	42	44	41
Roche's Point	1956-70	46	49	53	56	47
Rosslare	1957-70	42	44	48	51	45
Shannon Airport	1940-70	43	45	49	51	48
Valentia Observatory	1932-70	42	44	47	49	45

Note: The figures have been rounded to the nearest whole number in the individual cases

Table 2. Gust speeds and mean hourly wind speeds (m/s) likely to be exceeded only once in 120 years at 10m above the ground at a number of stations

Station	Gust Speed	Mean Hourly Speed = Gust / 1.5
Belmullet	59	40
Birr	46	31
Claremorris	50	33
Clones	56	37
Dublin Airport	44	30
Glenamoy	55	37
Kilkenny	48	32
Malin Head	61	41
Mullingar	45	30
Roche's Point	57	38
Rosslare	52	34
Shannon Airport	52	35
Valentia Observatory	50	33

Note: The figures have been rounded to the nearest whole number in the individual cases.

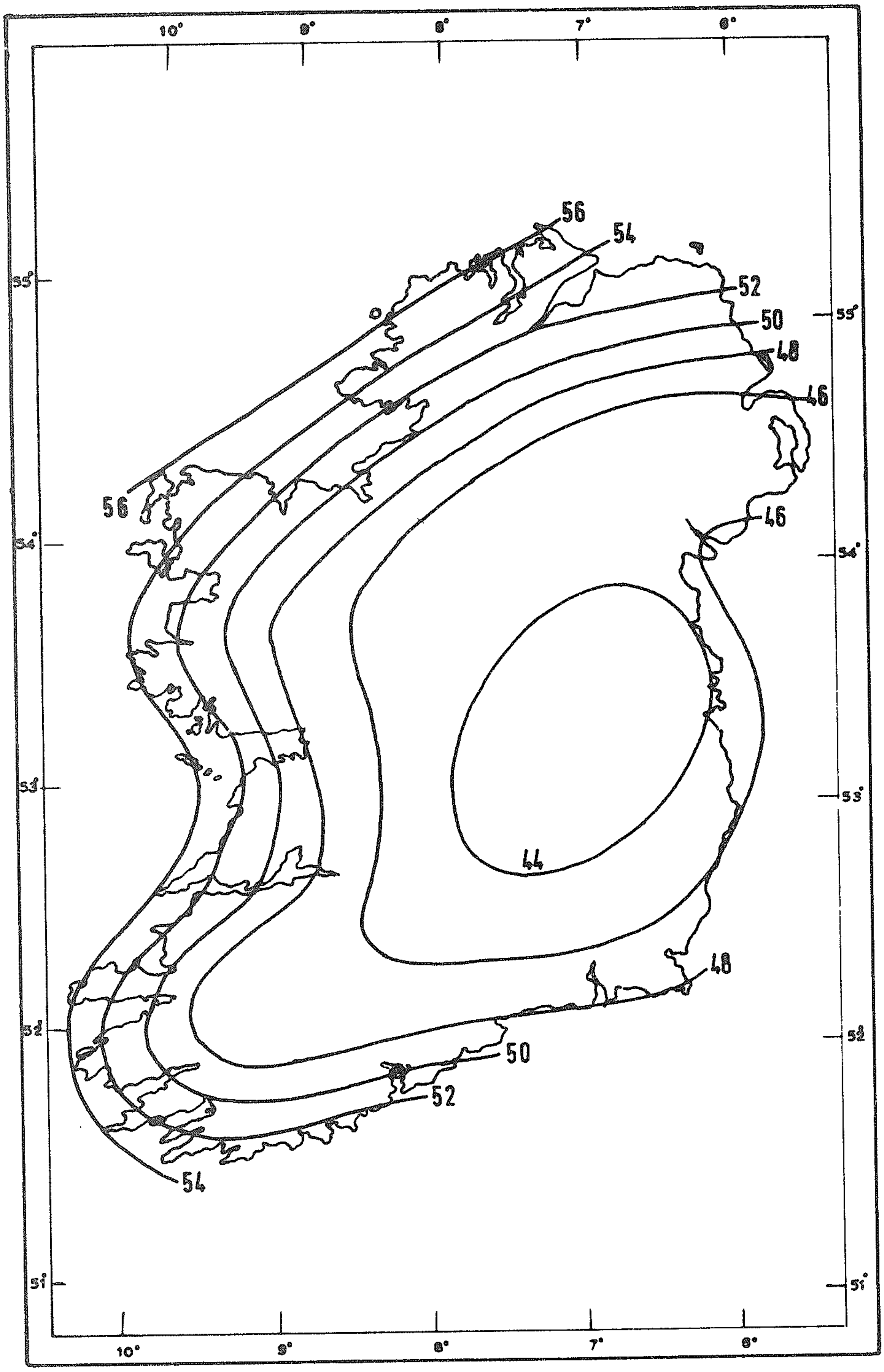

Fig. 1. Wind speed in a gust (m/s) likely to be exceeded only once in 50 years at 10 m above the ground in open level country.

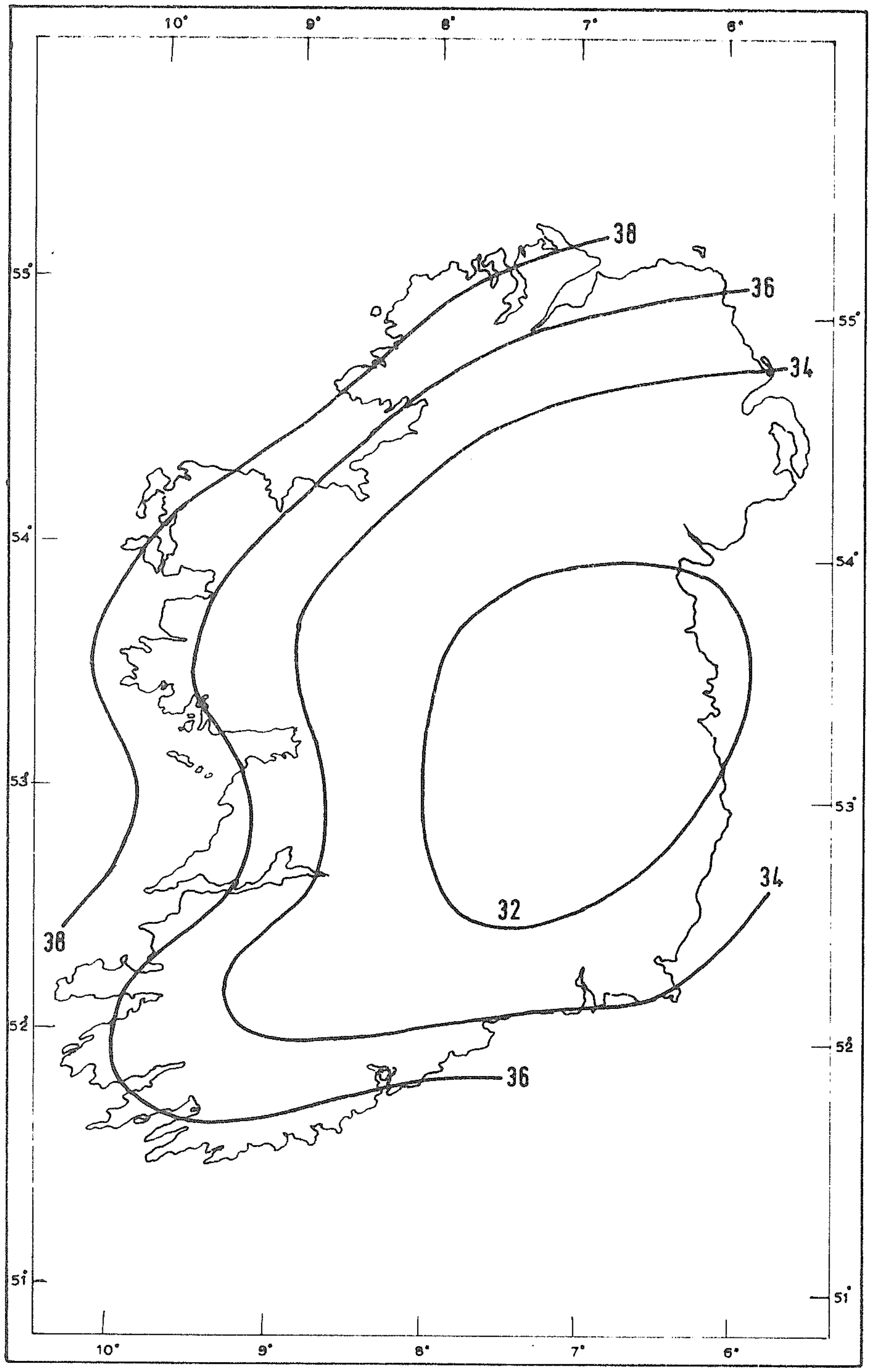

Fig. 2. Mean hourly wind speed (m/s) likely to be exceeded only once in 120 years at 10 m above the ground in open level country.