Extreme wind speeds in the UK

Nicholas Cook, of Anemos Associates Ltd describes how the new wind speed maps have made use of recent weather data

The previous map of basic extreme wind speeds for design of structures in the UK in CP3-V-2 was based on annual maximum gust values observed at some 30 sites over 7 to 20-year periods. The UK Meteorological Office began archiving wind speeds for every hour from the beginning of 1970. The current map in BS 6399-2 and BS 8100, compiled in 1981, is based on around 150 storm maxima per year observed at 50 sites over an 11-year period from 1970 to 1980. While the use of storm maxima greatly improves the analysis accuracy, there was some concern that the 1970s may have been less windy than the average. The UK Meteorological Office has recently made the full data record to 2000 available for the preparation of the UK National Annex for Eurocode 1991-4.

Since 1981, some of the meteorological stations used in the original analysis have closed and others have opened. The opportunity was taken to select a new set of 50 stations that gave better geographical coverage, the majority with a 30-year record, and all but one (Cambourne, 17.5 years) greater than 20 years.

The locations of most of these stations have remained unchanged, but some have moved position and height – five times in the case of Manston. Fortunately, improved models for the recurrence of extreme winds and their response to changes in terrain roughness and topography allow variations in exposure to be corrected. Also, new methods of extreme-value analysis that minimise systematic bias and statistical variance allow the additional information inherent in sub-annual 'storm' maxima to be exploited.

The improved recurrence model acts on dynamic pressure instead of wind speed.

Fig 1 illustrates the improvements in data and analysis using the 'Gumbel plot' of hourly-mean and gust dynamic pressures from Jersey.

- The triangle symbols illustrate the 'Gumbel' analysis used when CP3-V-2 was compiled – at the minimum, just seven points representing the annual maxima – but here using the data from 1970 to 1976 (instead of the original period up to 1963) for comparison with the new analysis. The exposure was assessed by the 'equivalent height' method in use at the time. Scatter of the data is much greater for the gusts than for the means. A peculiar feature of extreme-value analysis is that scatter always increases the slope (dispersion) of the graph, exaggerating the design values. The maximum gust in the whole 30-year period happens to occur in these first 7 years, taking the design gust value off the scale of the graph.
- The diamond symbols show the same standard 'Gumbel' analysis of annual maxima for the full 30 years. The corresponding wind directions are not stated, so the best exposure corrections are applied for the prevailing wind direction. Scatter is much reduced by the additional data, but again greater for the gusts. The slopes are reduced, much more for the gusts than for the means, reflecting the reduced scatter. The maximum observed gusts is now ranked into the 1:30 year position, instead of the 1:7 year position, greatly reducing the design value.
- The circle symbols show the new 'storm'-based analysis, with the exposure corrected for the wind direction corresponding to each observation. Scatter is further reduced, but the accompanying reduction in slope is small, but significant.

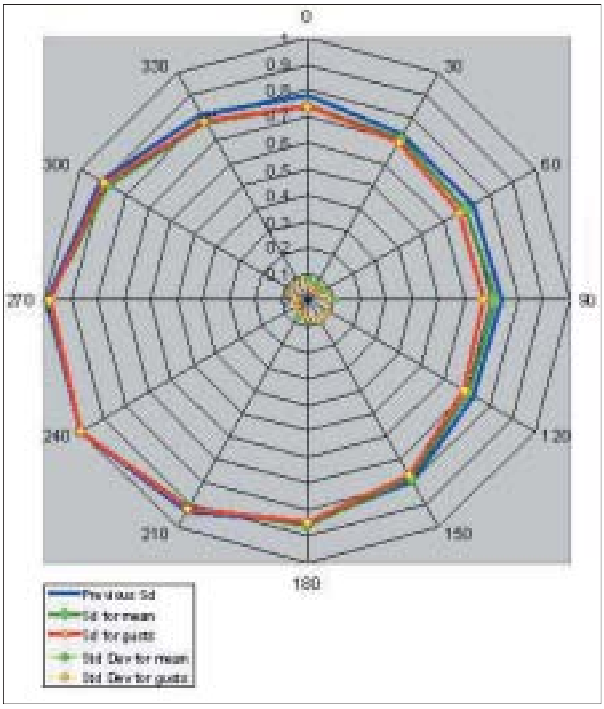


Fig 2. Directional factor, Sd, and standard deviation of estimates

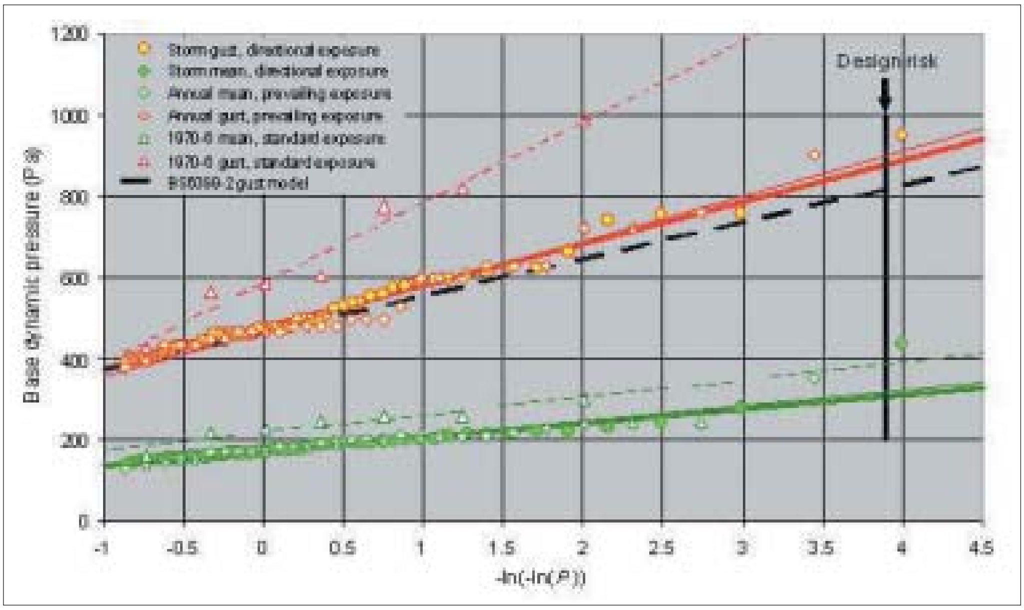
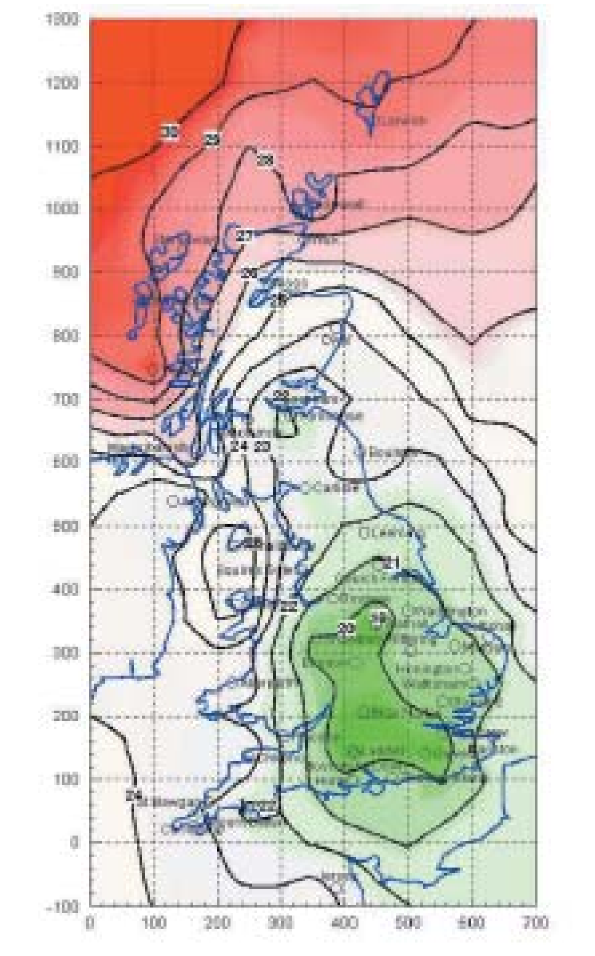


Fig 1. Analysis of annual maximum dynamic pressures at Jersey

In the past, gust speeds were favoured over mean speeds because they are less sensitive to site exposure. However, Fig 1 shows that their susceptibility to bias errors outweighs this advantage which is, in any case, diluted by the improvements in exposure corrections. The heavy black dashed line shows how well the gusts are predicted from the mean values by the gust factor model of BS 6399-2 – the line passes through the observed modal value (-ln(-ln(P)) = 0), but has a smaller slope, due to the reduced scatter (bias error) in the mean data.

The direction factor, S_d, for means and gusts from all 50 stations are shown in Fig 2. There is no perceptible change for the sector of prevailing winds, centred on south-west, but a small reduction in values for the sector around north-east. The effectiveness of the exposure corrections is illustrated by the standard deviation of the individual station values which lies in the range 4% to 9%.

Fig 3 shows the preliminary map of base wind speeds. The contours over the mainland UK and Northern Ireland are interpolated from the new analysis and over Eire from the values provided for BS 6399-2. The contours shown over the



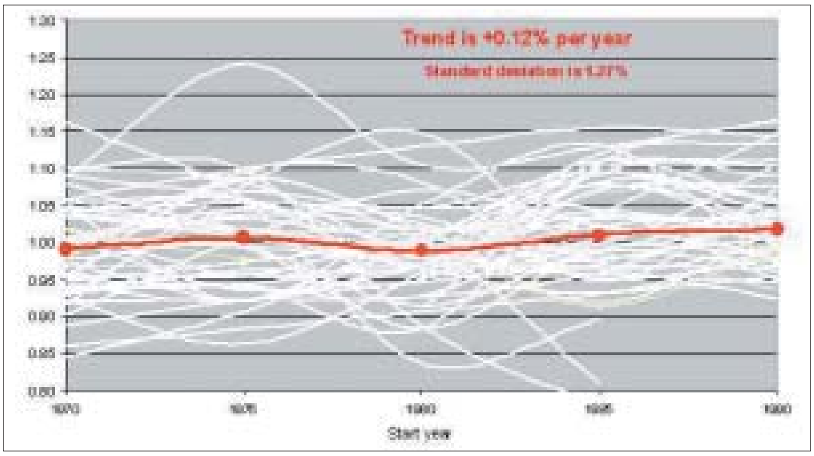


Fig 3. (left)
Preliminary map of base wind speed
Fig 4. (above)
Trend in decennial extreme winds, 1970-1999

North Sea are not reliable because they are extrapolated outside the envelope of the observations. Wind speeds in Scotland, Ireland and down the western coast of northern England and Wales do not change significantly, but the values in southern and eastern England are reduced. Contours in the final map are likely to be smoothed and simplified (and erased over the North Sea).

Finally, Fig 4 shows the design values predicted from a 'decennial' analysis, using five 10-year sub-periods, each overlapping by 5 years: i.e. 1970-79, 1975-84, etc., expressed as a ratio of the 30-year predictions. This is an attempt to see whether any long term trends are visible in the data. The individual station trends are shown in white and the average trend for all stations as the red curve.

The average trend, increasing at 0.12% per year, is exceeded by its standard deviation of 1.27%, i.e. by 10:1. The standard deviation of the individual stations is 7.2%, or 70 times the trend, so this average trend is not likely to be significant. This does not mean that the observed climate changes over the last few decades have no effect on extreme wind speeds, just that the tiny observed effect is swamped by the natural variation. se

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benevolent fund

The Institution of Structural Engineers Benevolent Fund
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Notice is hereby given

that the eighth Annual General Meeting of members will be held at 11 Upper Belgrave Street, London SW1X 8BH, United Kingdom on Thursday 22 May 2003 at 6:15 pm (or immediately following the conclusion of the Annual General Meeting of the Institution of Structural Engineers at 6:00 pm) for the transaction of the business set out below.

1 To read the notice convening the meeting.

2 To read, confirm and sign the minutes of the 2002 Annual General Meeting (published in The Structural Engineer, 18 June 2002).

3 To receive and, if thought fit, to adopt the financial statements, the Directors' and Trustees' report and the Auditors' report for the year ended 31 December 2002.

4 To appoint Auditors for the ensuing year and to fix their remuneration. (The Trustees recommend the appointment of BDO Stoy Hayward, chartered accountants and registered auditors, at a fee to be agreed with them by the Trustees.)

5 To appoint Trustees. (Dr K J Eaton, Dr J M Roberts and Mr C E Short retire as Trustees by rotation but offer themselves for reappointment.)

By order of the Trustees
H S KITCHING, FCIS, FInstAM, MCMI
Secretary

15 April 2003

Note 1 – The Trustees consider that the period of appointment of the Benevolent Fund's auditors should not exceed three years. It is on this basis alone that the recommendation to change auditors this year is made.

Note 2 - Copies of the 2002 report and accounts may be obtained on application to the Secretary, the Institution of Structural Engineers Benevolent Fund, 11 Upper Belgrave Street, London SW1X 8BH, United Kingdom.