DISCUSSION ON THE WIND CLIMATE OF KUWAIT AND DUBAI

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Historical wind data for Kuwait and Dubai have been analysed to determine the design wind speed for the region. Kuwait and Dubai are located near the northern and southern end of the Persian Gulf respectively. The winds in this region just north of the Tropic of Capricorn are dominated by the Shamal, literally 'north' in Arabic. The winds have traditional Bedouin names such as Al-Haffar (the driller), and Barih Thorayya (morning star). The Al-Dabaran is generally the strongest Shamal in late summer, and can last up to 40 days bringing sand and duststorms.

Wind Climate Of The Persian Gulf

The prevailing winds of the Persian Gulf region are generally dominated by large scale weather pressure patterns to the east and west and diurnal patterns. To the north-west is the arable flatlands of Iraq containing the Tigris and Euphrates rivers, to the east lies the Zagros mountains rising to 4000 m, and to the west is the desert landscape of southern Iraq, Kuwait, and Saudi Arabia. Thunderstorms winds, although infrequent at about 5-6 per annum, dominate the extreme wind climate.

The winter months are governed by cooler northerlies originating in Iraq and Turkey. Ahead of a winter Shamal strong, hot, dry south-easterly winds typically occur. The interaction of these weather patterns creates strong convective activity that spawns thunderstorms. As temperatures rise in the spring, storm activity increases and March is the wettest month. Extreme events such as golf ball sized hail have been recorded. Come June, relatively constant low pressure over the Zagros mountains in eastern Iran combines with high pressure over the desert of Saudi Arabia to produce the Al-Dabaran Shamal wind, which can last for up to six weeks. The Al-Dabaran is a diurnal Shamal with stronger winds during the day, decreasing in strength when the sun goes down. With day time temperatures rising to 55°C in the northern deserts, strong convective currents lift dust particles up to a height of 1500 m, which are then blown the full length of the Gulf creating sand and dust storms. Generally at night when the thermal currents are lowest, the flow becomes smoother and a thermal inversion develops below about 1500 m. The velocity profile during this thermal inversion can deviate significantly from a typical atmospheric boundary layer with a low-level jet occurring at about 150 m. When the thermal inversion coincides with the Shamal, stronger winds result. Typical velocity profiles are shown in Fig. 1, amended from Membery, 1983. Further from the centre of pressures located on the land masses, the wind speed decreases i.e. to the south of the Persian Gulf. The end of the Al-Dabaran occurs when the low pressure over the Zagros mountains decreases, due to the Indian monsoon moving northwards. Sea and land breezes dominate the coastal wind environment in late summer with the occasional thunderstorm on the coast but increasing in number inland especially if there are mountains. Towards the end of the year when the subtropical jet stream moves south the chances of the winter Shamal increase.

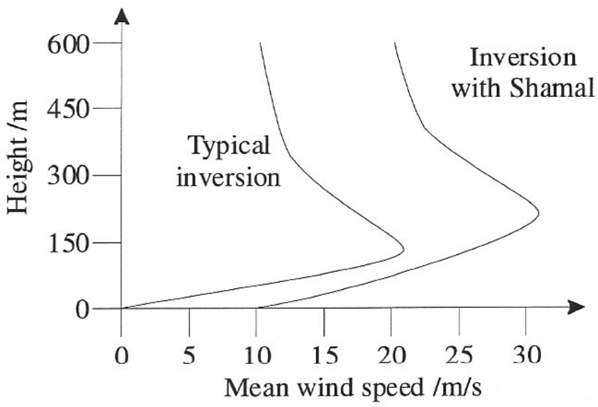

Fig. 1: Velocity profile during temperature inversion (after Membery, 1983)

The historic wind data analysed was from Kuwait and Dubai International Airports. The only available wind data from Kuwait International Airport (KWI) were ten minute mean wind speeds for the period 1983 – 2003, excluding the duration of the first Gulf War August 1990 – July 1991, when the anemometer was 'out of operation'. Ten-minute mean wind speeds were analysed for the period 1984 – 2003 from Dubai International Airport (DXB). Annual mean and peak maxima were available from 1974 – 2003. Thunderday data were available and therefore the mixed wind climate could be separated. The average number of thunderdays per annum was approximately 5 for both cities. Using the relationship from Durst (1960) hourly mean wind data have been calculated from the ten minute mean data.

The topography surrounding each of the anemometer locations was relatively flat. KWI is located approximately 16 km to the south of Kuwait city and surrounded by desert. DXB is located approximately 5 km from the coast embedded in suburbia. Appropriate terrain category corrections were made to the raw data in accordance with ESDU (1982, 1983) to make the data equivalent to 10 m, open category terrain, category 2 in the Australian wind loading standard, Standards Australia (2002).

Parent Distribution

A directional Weibull analysis was carried out to find the parent distribution. The directional distribution of all winds at KWI and DXB are shown in Fig. 2. The geographical influences are evident.

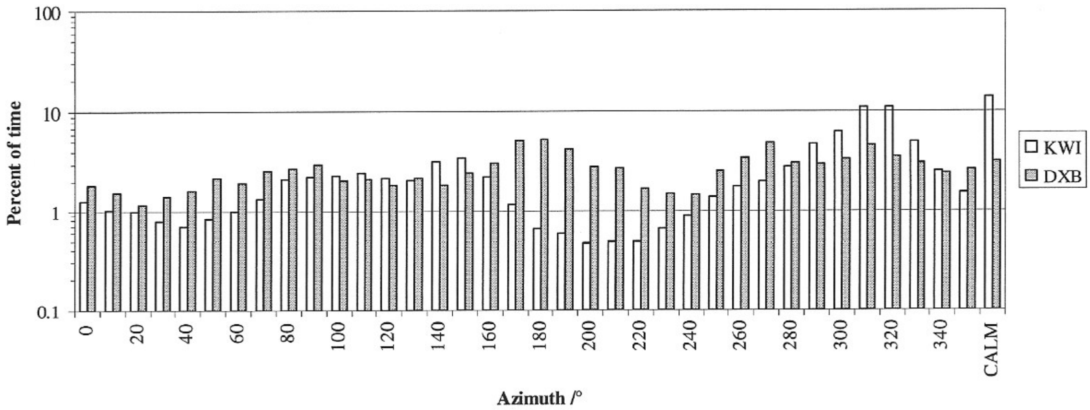

Fig. 2 Directional distribution of all winds at Kuwait and Dubai International Airports

One interesting outcome of the Weibull analysis was that the directions associated with the Shamals and sea breezes had significantly higher shape factors than would be expected for temperate climates. This is caused by the relatively large portion of time when there are light winds blowing and relatively few calm occurrences. This is of importance for calculations where the parent distribution required, such as fatigue analysis and care should be taken when developing the Weibull parameters. The actual and predicted Weibull distributions for winds in Dubai from the north-west are shown in Fig. 3 along with a more standard automatically generated distribution.

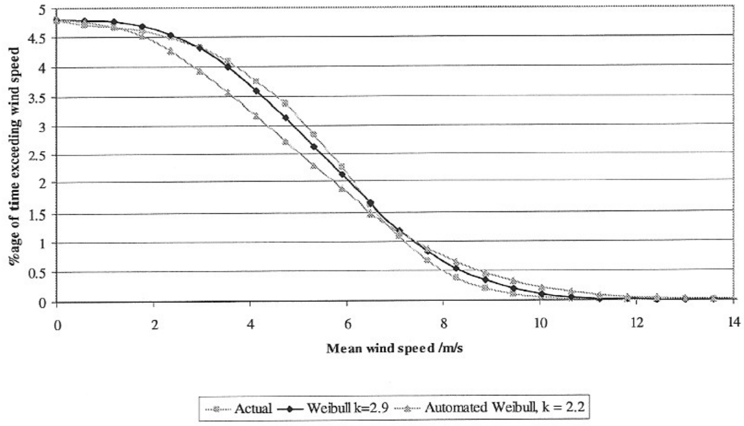

Fig. 3: Comparison of actual and predicted probability of exceedances for NW winds in Dubai

Extreme Value Prediction

Various standard techniques were used to predict the extreme value wind speed for both Kuwait and Dubai: Gumbel (1954) and Gringorten (1963) – type 1 extreme value prediction; using velocity squared (dynamic pressure) rather than velocity in the Gumbel analysis thereby introducing curvature to the type 1 prediction, Cook (1982); and the excess over threshold approach which allows the distribution to find its own curvature (Holmes & Moriarty, 1999). The details of these approaches are beyond the scope of this paper, but an excellent review is given in Holmes (2001).

The Gumbel and Gringorten analyses only use the annual maximum wind speeds. These peaks are ranked and a probability assigned based on the rank and number of observations. Graphs of various design wind speeds from Kuwait are shown in Fig. 4 using the maximum peak regardless of wind type. Thunderstorm events were separated from the data set and the predictions repeated except for the thunderstorm excess over threshold technique where there was insufficient data, Fig. 5.

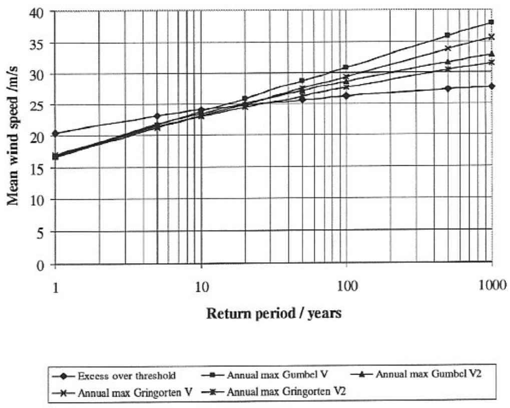

Fig. 4: Design mean wind speed versus return period, 10 m height, terrain category 2 for KWI

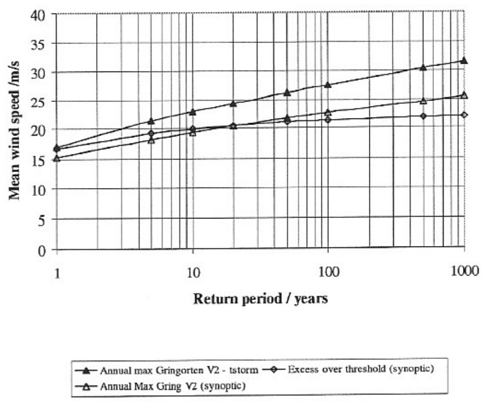

Fig. 5: Separated wind climate design mean wind speed versus return period, 10 m height, terrain category 2 for KWI

For Dubai, the thunderstorm data were separated from the synoptic data and the analyses repeated for mean wind speeds. Annual maxima peak wind speeds were also analysed using velocity squared and the Gringorten probability distribution. The results of the analyses are shown in Fig. 6.

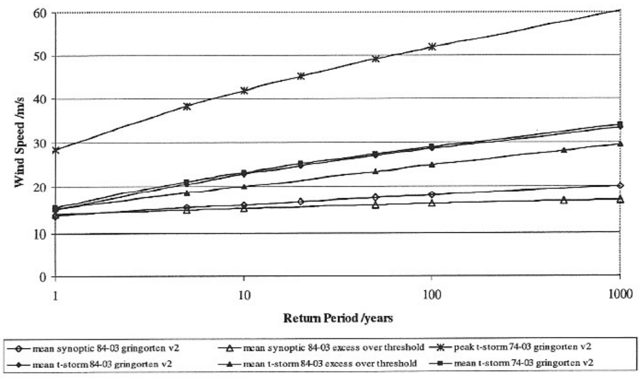

Fig. 6: Separated wind climate design mean wind speed versus return period, 10 m height, terrain category 2 for DXB

Discussion

It is evident from Figs 5 and 6 that the dominant design wind speeds for the region are associated with thunderstorms: either the gust front, or a localized event such as a downburst. For direct comparison the 50-year return period design hourly mean wind speed at 10 m, terrain category 2, assuming a Gringorten probability distribution on velocity squared is 26 m/s for Kuwait and 27 m/s for Dubai. This design wind speed is associated with thunderstorms and would appear to be constant regardless of position in the Persian Gulf. The corresponding synoptic deign wind speed would be 21 m/s for Kuwait and 18 m/s for Dubai. The only reliable information on peak wind speeds was for Dubai where annual peaks from 1974 were available. These are expected to be associated with thunderstorms and result in a 50-year return period design 3-s peak wind speed of 49 m/s. It is of interest to note that the peak wind speed is significantly greater than that which would be assumed using the standard synoptic factors proposed by Durst (1960): 1.81 compared to 1.67. This is expected to be caused by the transient nature of thunderstorms, where the peak event of relatively short duration.

This has significant design implications, as the velocity profile during such thunderstorm events is not well understood. Wind tunnel testing assuming an atmospheric boundary layer profile and turbulence profile may therefore not give a true representation of the structural response.

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