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Concise reviews of building technology

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Climate and site development

Part 1: General climate of the UK

This Digest describes how microclimate is affected by the geography and topography of a site and its surroundings, and how it can be further influenced by the arrangement of buildings and landscape features. It reviews techniques for planning a climatically sensitive site layout, giving maximum benefit from fine weather and some protection from adverse weather. This can benefit building performance by reducing energy consumption and improving durability, and can make the spaces around buildings more attractive and useful by providing better conditions for outdoor activities.

This Digest is published in three parts. The other two parts are:
Part 1: General climate of the UK
Part 2: Influence of microclimate
Part 3: Improving microclimate through design.

The numbering of references, tables and illustrations continues through the three parts: references and further reading are listed in Part 3.

Climate is frequently regarded as an immutable 'given condition' that a building has to resist. In fact, designers can often exercise a measure of control over its impact, especially for buildings of relatively small size, such as most housing. This is possible if the form and layout of buildings and landscape elements are chosen deliberately to improve the climate of the spaces around the buildings — their microclimate. Designing to improve microclimate offers a range of benefits, including reduced space-heating energy costs and better comfort and usefulness of the spaces around buildings.

This Digest reviews how to assess the climatic setting and the microclimatic potential of a site, and how to reflect this in an energy-efficient arrangement of buildings and landscape features. It deals mainly with solar access and wind protection, but also notes some of the effects of driving rain, daylight, snow and the drying of wet surfaces. With such a wide scope the text cannot be exhaustive, but a list of references for further reading is given in Part 3.

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GENERAL CLIMATE OF THE UNITED KINGDOM

General climatic data give an idea of the severity of the climatic factors affecting energy use and external comfort at a site. Figures 1 to 5 illustrate the range of variation over the United Kingdom:

- Seasonal accumlated temperature difference — ATD — (degree-day) totals (Figure 1) vary by a factor of about 1.6 between south-west and extreme north, when values are reduced to sea level. Totals are considerably increased at higher altitudes. Standard ATD totals give a general indication of the geographic variation in energy needed for space heating but make only a small, fixed allowance for solar gains. Thus they do not reflect the full potential of the sun to warm buildings and the spaces around them, or of wind-induced losses. The use of ATD totals to building-specific base temperatures, as used in the BRE Domestic Energy Model, BREDEM[1] can take account of some of these factors. ATD data to a range of base temperatures are given for 13 locations in Reference[2].
- Typical wind speeds (Figure 2), reducing with distance from the coast and from north-west to south-east, indicate the relative potential of wind protection for energy saving and enhanced comfort. Values can be markedly affected by local exposure or shelter. Additional sources of data on wind speed and direction are given in References 3 to 5 and in Digest 346.
- Annual totals of global solar irradiation on a horizontal surface (Figure 3) vary by a factor of about 1.3 between south-west and extreme north. Totals over the heating season exhibit somewhat greater regional variation. However radiation totals on vertical surfaces are perhaps more useful as indicators of design opportunities, especially for passive solar gains in buildings and potential warming of external spaces during the cooler parts of the year. Figure 4 compares the average daily amounts of global solar irradiation received on horizontal and certain vertical surfaces, for four UK locations. These show that:
- differences between the south and north of the UK, in terms of the range of values in any month, are only of major importance during December and January;
- throughout the year, totals on E, W and S-facing surfaces are very little different in Aberdeen than in Manchester or London (although further north the reduction due to overshadowing may be greater since solar altitudes are lower);
- from October to February radiation totals on S-facing vertical surfaces exceed those on horizontal surfaces for all the locations shown.

  The data in Figure 4 are estimated values, drawn from Section 1.4 of Reference 5.

- The annual average driving rain index, DRI (Figure 5) is a composite measure of wind speed and rainfall that relates to the average moisture content of exposed walls of permeable materials. The thermal properties of such materials will vary with changes in moisture content[6]. The zones on this map are based on the highest values, irrespective of orientation, for the annual average directional driving rain index, as given in Reference 7. These differ in some respects from zones based on the original driving rain index, described in Digest 127.

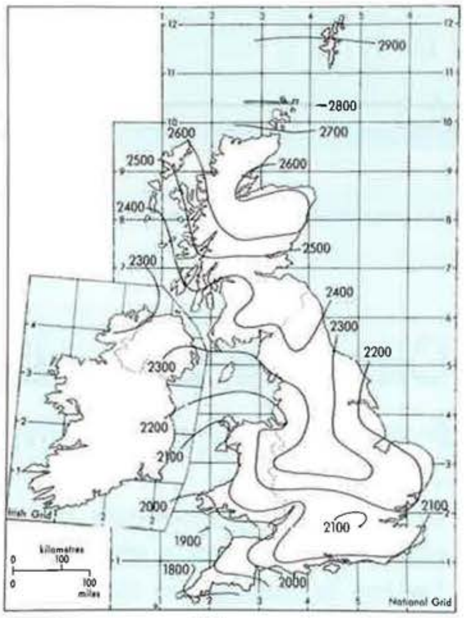


Fig 1 Accumulated temperature difference (degree-day) totals for base temperature of 15.5 °C, September to May (average, 1957 – 76; data reduced to sea level)

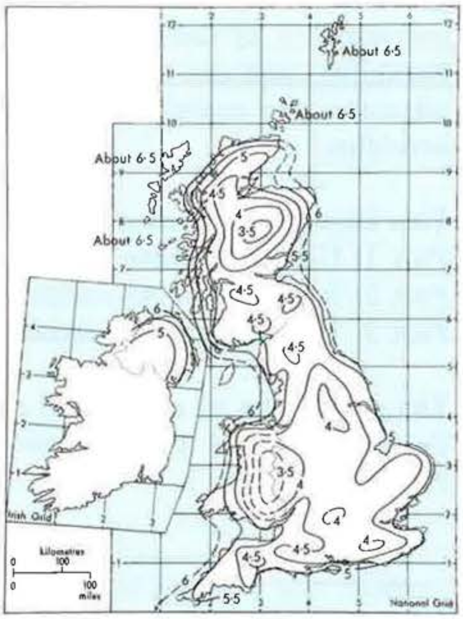


Fig 2 Isopleths of hourly mean wind speeds (m/s) exceeded for 50% of the time at a height of 10 m above open, level terrain (average, 1965 – 73; data reduced to sea level)

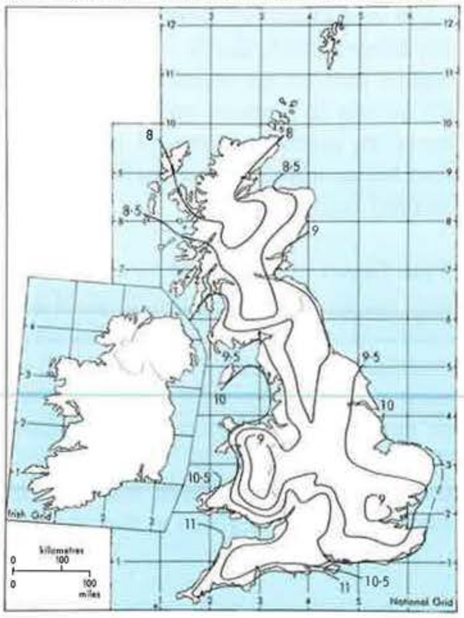


Fig 3 Annual mean daily irradiation on a horizontal surface (MJ/m^2) (average, 1951 – 70; data not reduced to sea level)

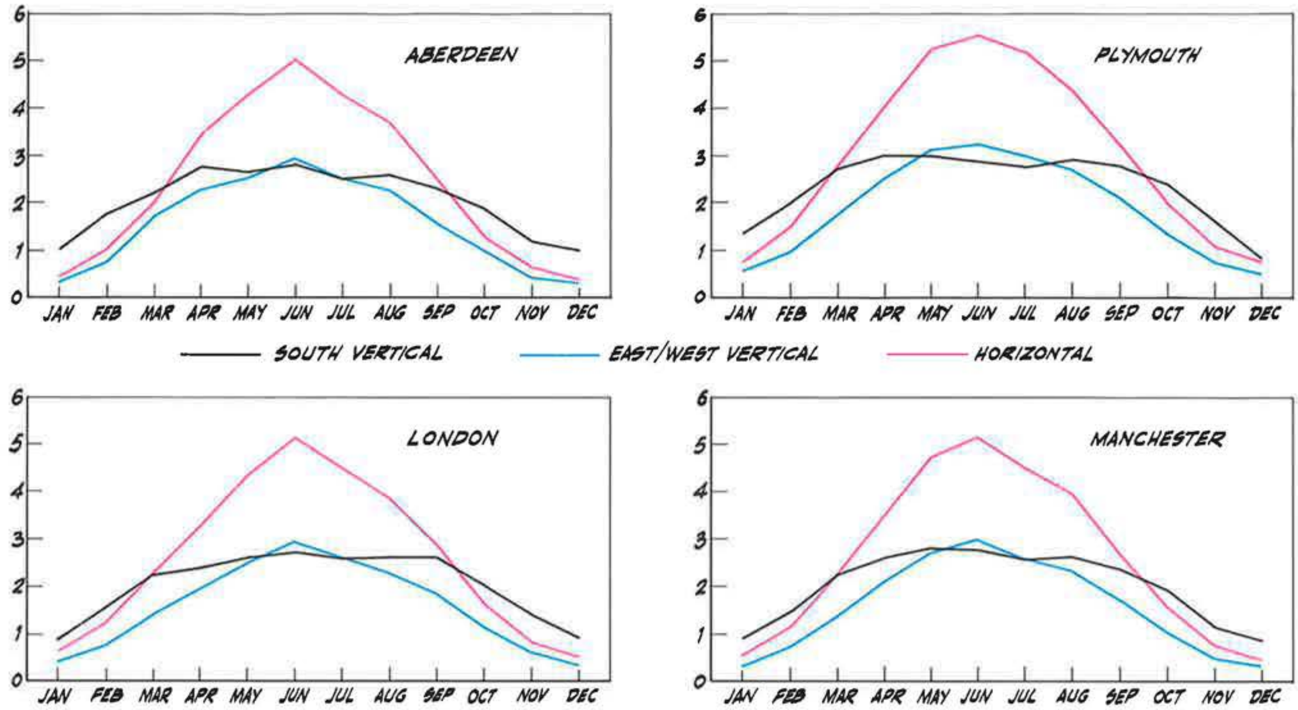
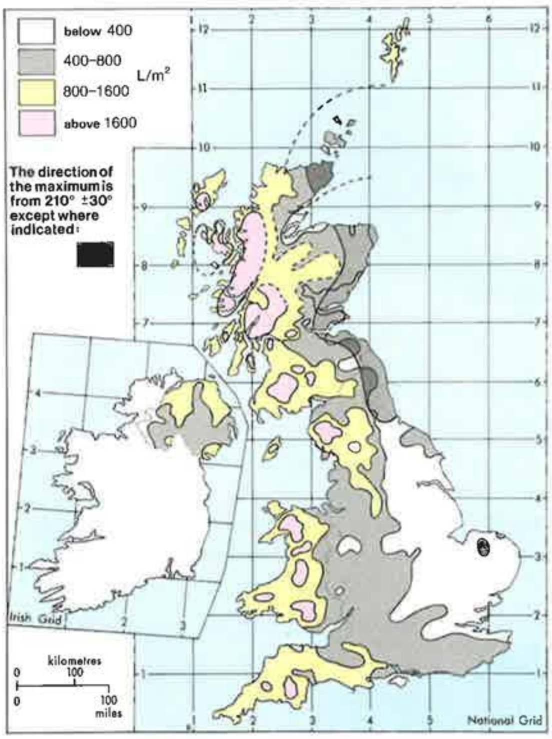


Fig 4 Average daily solar irradiation

Fig 5 Zones of exposure based on average annual directional driving rain index (m^2/s) for the worst direction in each location (average, 1959 – 73); data not reduced to sea level)



Most climatological data relate to meteorological stations, which are intended to resemble 'open, level countryside'. These are more severely exposed than many building sites, with no wind shelter and little opportunity for the air temperature to be raised by 'trapped' heat. Moreover, all wind speed data refer to the standard height of 10 m, which is above the rooftops of two-storey buildings; wind speeds in the immediate 'boundary layer' around such buildings will in most cases be lower. On the other hand, there is likely to be little obstruction of solar access at meteorological stations, so that recorded radiation amounts will tend to be greater than in wooded or built-up areas.

It is also necessary to check which published data, whether maps, tables or other forms of presentation, are 'reduced to sea level' and require correction for altitude. Of the maps shown, those for degree-days and wind speed (Figures 1 and 2) require such correction: the 'lapse rates' (rates of change of value with altitude) can be taken as follows:

Such generalised data give a broad picture of climatic severity and design opportunities. Many further national climatic maps are available[8]. When a particular site is under consideration, it is often useful to obtain more detailed data for the area, eg showing climatic elements in combination, indicating year-to-year variation or illustrating different patterns of weather. If needed, the Meteorological Office can compute any required combination of available climatological statistics, on a consultancy basis.

- *Degree-day totals, to base 15.5 °C:*
  +200°degree — days C per 100 m altitude
  (Based on a lapse rate for mean air temperature of + 0.6°C per 100 m altitude)
- *Hourly mean wind speeds*:
  mapped value + 7% per 100 m altitude.

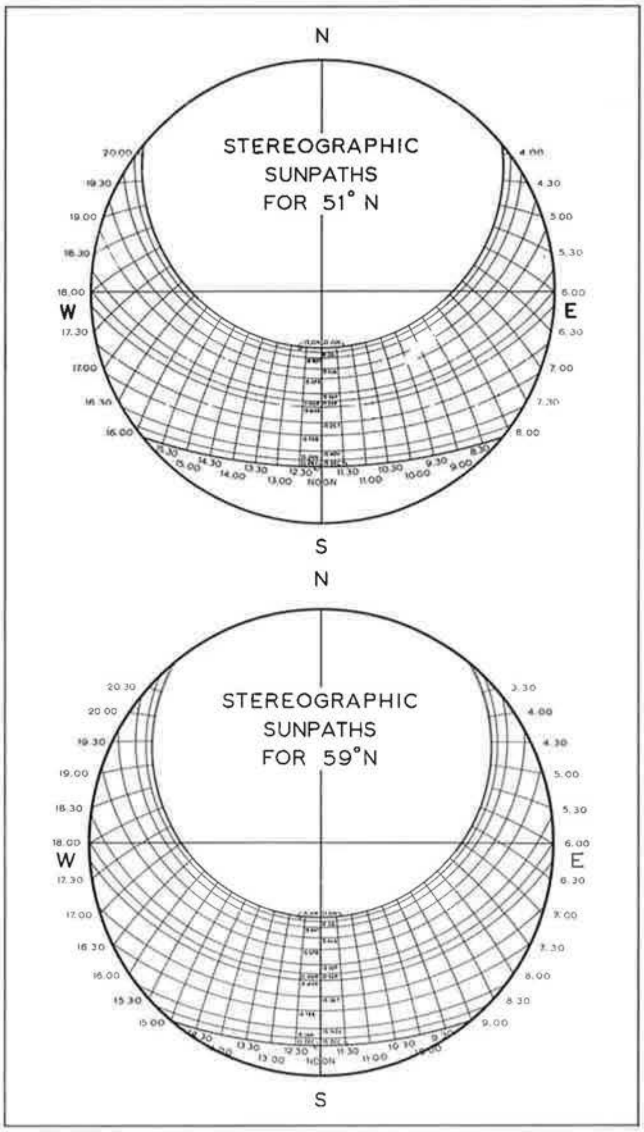


Fig 6 Sunpath diagram

Figures 3 and 4 show data that are corrected for altitude, within the limits of resolution of the maps: no general altitude corrections are needed. Where there are marked local changes in altitude, a limited amount of correction may be needed, in relation to the general altitude of the area.

For site planning, the directionality of solar radiation and wind must be considered. Sun angles can be assessed for various times of year using sunpath diagrams (Figure 6). Sunpath diagrams for various latitudes, together with graphical overlays to determine the angle of incidence on differently oriented surfaces, are given in Reference 9. Alternatively, sun angles for Plymouth, London, Manchester, Glasgow and Aberdeen are given in tabular form in Reference 5. Sun angle data are included in several computer programs for analysing energy use and summertime overheating, and in routines specifically for plotting shadow patterns (see Part 3 of this Digest).

Directional data on wind are available in tabular form, but it is often more convenient to use a wind 'rose', which shows the relative frequency of different wind directions (and, often, wind speeds). The length of each 'arm' in most roses is proportional to the frequency of wind recorded blowing from that direction (wind directions being recorded to the nearest 30°). This 'map' of direction frequency can be related visually to wind-sensitive and wind-protective features on site plans. A simple wind rose, giving annual data, is shown in Figure 7a; wind directions during the heating season only can be similarly presented.

Another way is to plot accumulated totals of 'wind-chill' directly on a rose, as shown in Figure 7b, emphasising the directions of the colder winds that are likely to have a greater impact on energy consumption and external comfort. The quantities used to express 'wind-chill index' (W/m^2) relate to the rate of heat loss from the body, not from buildings. A further method is the 'wind heat-loss' rose shown in Figure 7c, expressed as the product of windspeed and deficit of air temperature below 16°C: in practice the pattern of directionality is very similar to wind-chill. All the roses shown are expressed in terms of percentage of time, so that the totals for different arms of the rose can be added or compared.

Wind speeds and directions may vary over small areas due to the influence of local topography and the presence of other buildings.

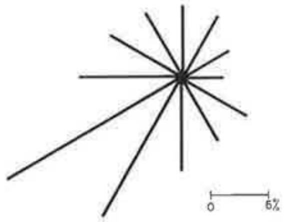


Fig 7a Wind rose *Mean wind speed: percentage of all directions, October-April*

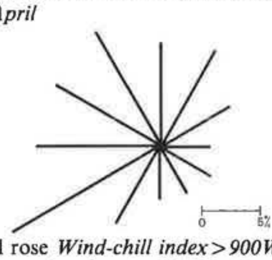


Fig 7b Wind-chill rose *Wind-chill index > 900W/m²: percentage of all directions, October-April (Siple-Passel formula)*

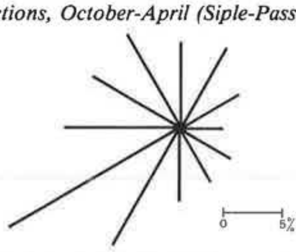


Fig 7c Wind-heat loss rose *Product of hourly mean wind speed and deficit of air temperature below 16°C: percentage of all directions, October-April*

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