BRE Digest
Concise reviews of building technology
Digest 350
April 1990

Climate and site development

Part 3: Improving microclimate through design

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.

SIZE, FORM AND ARRANGEMENT OF BUILDINGS

The microclimatic performance of site layouts is influenced by a range of factors at various levels of detail (see Table 5). Some act as constraints against full optimisation of microclimate, and most need to be considered jointly with other aspects of design. However, if decisions about plot subdivision and road layout are taken without reference to their impact on microclimate, the prospects for producing a well-sheltered design with good solar access may be limited. Ideally, building, landscape and engineering factors should be considered together as early as possible.

In most designs there is likely to be some compromise between solar access and wind protection. Both microclimatic requirements and potential will vary with location. This reflects, for example, ground form, land values, property type, as well as differences in area climate (see Part 1 of this Digest).

Table 5 Site and layout factors influencing microclimate

Outside designer's control
- Area and local climate (see Part 1)
- Site surroundings (see Part 2)
- Plan shape of site
- Large-scale topographic features — *eg form, slope and aspect of ground*
- Retained existing buildings
- Road access
- Services access
- Planning constraints — *eg densities, building heights, tree preservation*
- Convenants restricting the form or character of development

Within designer's control
- Arrangement of buildings on the site
  - Spacing, orientation, juxtaposition and composite forms *eg courtyards*
  - Road pattern and access *eg to plots*
  - Location of open spaces, gardens, utility areas, garages, stores
- Design of Buildings
  - Form, height, roof profile
  - Orientation
  - Fenestration and type of glass
  - Insulation and thermal capacity
  - Air permeability
  - Cladding materials
- Other site features
  - Tree cover:
    - Major wind shelter planting
    - Local wind shelter planting
    - Decorative planting
  - Ground profiling *eg mounds, banks*
  - Walls and artificial windbreaks
  - Snow barriers
  - Ground surface *eg paving, grass*

Building Research Establishment
DEPARTMENT OF THE ENVIRONMENT

Technical enquiries to:
Building Research Establishment
Garston, Watford, WD2 7JR
Telex 923220 Fax 664010

SOLAR ACCESS

In the United Kingdom, making the most of solar warmth into and around buildings is desirable for a large proportion of the year. The range is from about seven months (mid-September to mid-April) in southern England to 10 months (August to May) in the north of Scotland. During these periods, solar gains benefit all types of buildings, but internal gains are put to maximum advantage in passive solar designs where they can significantly reduce heating demand, especially towards the beginning and end of the heating season.

Good solar access is needed for building facades and external features, in areas where and at times when solar gains will be of most benefit. This does not mean that no shade should be provided, but rather that it should be arranged in such a way that useful solar gains are not unduly reduced. For direct solar gains (bright sunshine), the shadows cast by buildings, trees, other landscape features and, where applicable, the terrain, need to be analysed in terms of their effects on both internal and external solar gains. Gains from diffuse solar radiation (received from the sky rather than direct from the sun) are also affected by obstructions, reducing progressively as the area of sky 'seen' by a surface is obscured.

The mechanisms involved in internal and external solar gains can be summarised as follows:

Internal solar gains comprise the radiant heat received in rooms or spaces, after losses when the radiation passes through windows. The gains can reduce heating demand in buildings both at the time they are received and subsequently due to heat stored in the building fabric ('thermal mass'). However, only a proportion of solar gains will be useful, since at times they will exceed heat demand and lead to overheating. The extent of the gains will depend on the areas, positions and type of windows, as well as on site layout factors. The significance of overshadowing will vary from window to window, and especially between different facades and storeys.

External solar gains comprise the radiant heat received in external spaces. In cold conditions human comfort is increased directly by radiant heat, including that reflected from nearby surfaces. The spaces around buildings will be more effectively warmed if the gains can be absorbed and stored in external thermal mass. This is typically provided by masonry external skins to buildings and 'hard' landscape features, eg, pavings, free-standing walls. In most cases, a space sufficiently sheltered to benefit fully from solar gains will receive direct sunshine for only part of the day in winter. The arrangement and intended use of spaces should therefore reflect whether warming occurs in the morning or afternoon.

While solar access is more simply assessed in terms of shading of direct solar radiation, this may not be fully representative, especially for internal solar gains. Averaged over all weather conditions in the UK, a substantial amount of energy is available from diffuse solar radiation. This is particularly significant for points shaded from direct sunlight for substantial parts of the day, eg north-facing facades and open areas adjacent to them. On the other hand, large obstructions may give some benefit by reducing long-wave radiation loss at night.

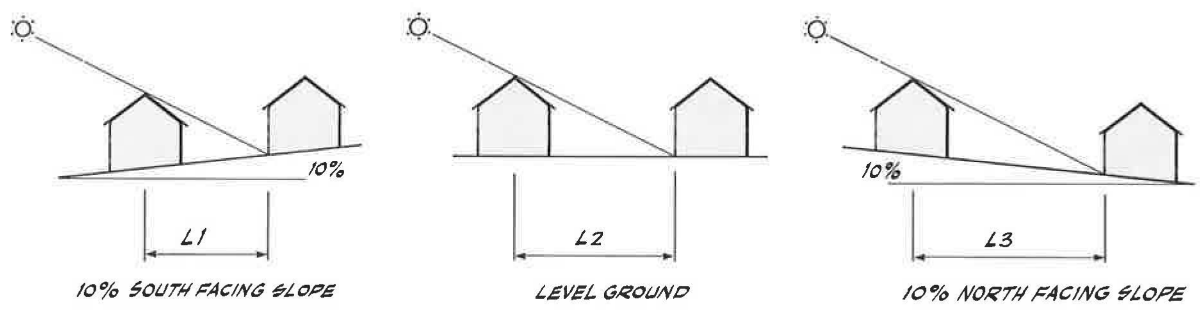
Daylight availability is a further component of microclimate, affecting the amount of energy needed for artificial lighting, particularly in domestic buildings. Daylight design techniques include methods for quantifying the effects of external obstructions and the reflectivity of external surfaces (see Digests 309 and 310). These are somewhat similar in concept to methods for assessing passive solar availability to buildings, but apply equally to any facade rather than just those receiving direct sunlight. Daylighting needs may possibly conflict with microclimate design if dark-surfaced materials are used to help absorb solar radiation and provide higher external surface temperatures, as opposed to light-surfaced materials to reflect daylight into rooms.

Design tools for solar analysis

Design for access to direct solar gains for energy savings and external thermal comfort has much in common with design for insolation as a physiological benefit. The criteria and design tools, particularly *Planning criteria for the design of buildings*[13], *Sunlight and daylight. Indicators*[14] and the related BS DD 67[15] can be used for general analysis of solar access. These contain some guidance on the penetration of sunlight into the spaces around buildings, as well as on insolation into rooms. These methods are based on potential sunshine amounts (as though the sky were always clear), rather than the more realistic probable sunshine, although it can be argued that the planning criteria take this into account. A more refined analysis of probable sunshine amounts is described in Reference 16, including the sunshine availability protractor[17].

At a sketch design stage obstruction of solar access needs to be considered in broad terms, taking account of solar altitudes and azimuths, land forms and slopes, retained existing trees and overshadowing from objects outside the site boundary. Within these constraints, the forms and arrangements of buildings giving high levels of useful solar gains can be explored. For housing, this can have a significant impact on the pattern of subdivision into plots and their relationship to road and services[18]. For complex arrangements of large buildings, the juxtaposition of built forms on the site may be the dominant factor.

A helpful starting point, but not necessarily the only criterion for solar access, is the north/south spacing of buildings in relation to their heights and any ground slope. Other things being equal, north/south spacing needs to be greater at higher latitudes where solar altitudes are lower. On the UK mainland, latitudes range from 50°N to 59°N. At these extremes the maximum solar altitudes at the winter solstice (December 21) are 16° and 8°. For parallel, east/west terraces or blocks, it will usually be impracticable to design for significant solar access on this date. A more reasonable basis might be October 30/March 1, when the corresponding altitudes are 24° and 17°, or September 30/April 1, when they are 35° and 28° respectively. Some sectional views are shown in Figure 11.



DATE	LATITUDE	L1 (m)	L2 (m)	L3 (m)
DEC 21	50°	18·1	24·4	38·6
	59°	29·1	49·8	121·8
OCT 30/MAR 1	50°	12·8	15·71	21·2
	59°	17·2	22·9	35·0
SEP 30/APR 1	50°	8·8	10·0	12·5
	59°	11·1	13·21	17·1

Fig 11 Minimum north/south spacings of a 7 m high east/west oriented building to achieve solar access at noon on various dates

Such methods are suitable as simple design and draughting aids, based on data on solar geometry for a particular latitude and day (drawn, for example, from References 2 and 15. A more comprehensive idea of the impact of shadow patterns on planning is given by manual or computer-based methods of assessing the cumulative effects of obstruction to solar access by buildings or other features, eg over the year, the heating season or a particular month. The methods available include:

- 'Sky maps' designed to assess the useful direct and diffuse radiation received in small buildings. Developed for the ETSU passive solar programme(19), these divide the are of sky 'seen' by a window or other vertical surface into a number of cells, each labelled with the useful radiation receivable from it. The heights and positions of obstructions affecting a point are first assessed on plan, then these data are plotted on to a sky map. The increase in auxiliary heating requirement can then be calculated by summing the radiation amounts from the cells in each column (Figure 12). Sky map diagrams have been produced for surfaces facing W, SW, S, SE and E, in two sets containing useful solar gain data for passive solar and conventional houses.
- Solar 'shadowprints', which show how much solar access would be lost at a stated point on an object of varying position placed in the shadow of an object of fixed size and position. These have been produced as manual design aids specific to a particular ground form (level or sloping) and scale of drawing (Figure 13). This example, taken from Reference 20, shows the reduction in useful radiation through a south-facing, vertical, single-glazed window (ie taking account of glass transmission at various angles of solar incidence).
- In the future, computer-based methods of assessing the distribution of radiation totals offer greater power and flexibility. Figure 14 shows the product of a system for calculating and plotting totals of direct radiation accumulated over any period, based on either potential (maximum) radiation, or on typical values based on real weather data. Such distributions may be assessed for the ground, as shown, or for any surface of a building. Further details are given in Reference 21.

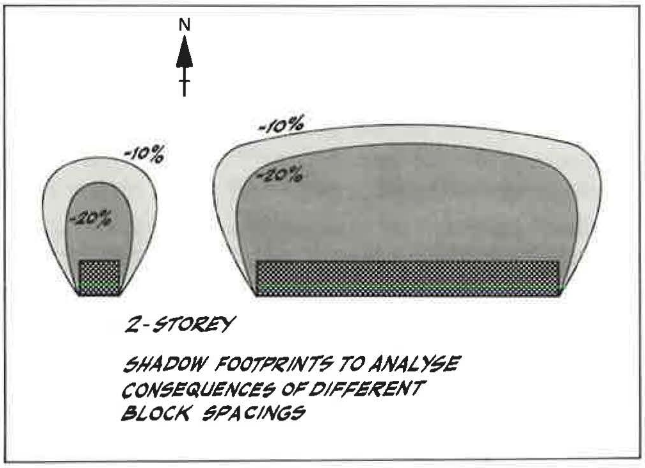


Fig 13 Solar 'Shadowprint' (flat ground)

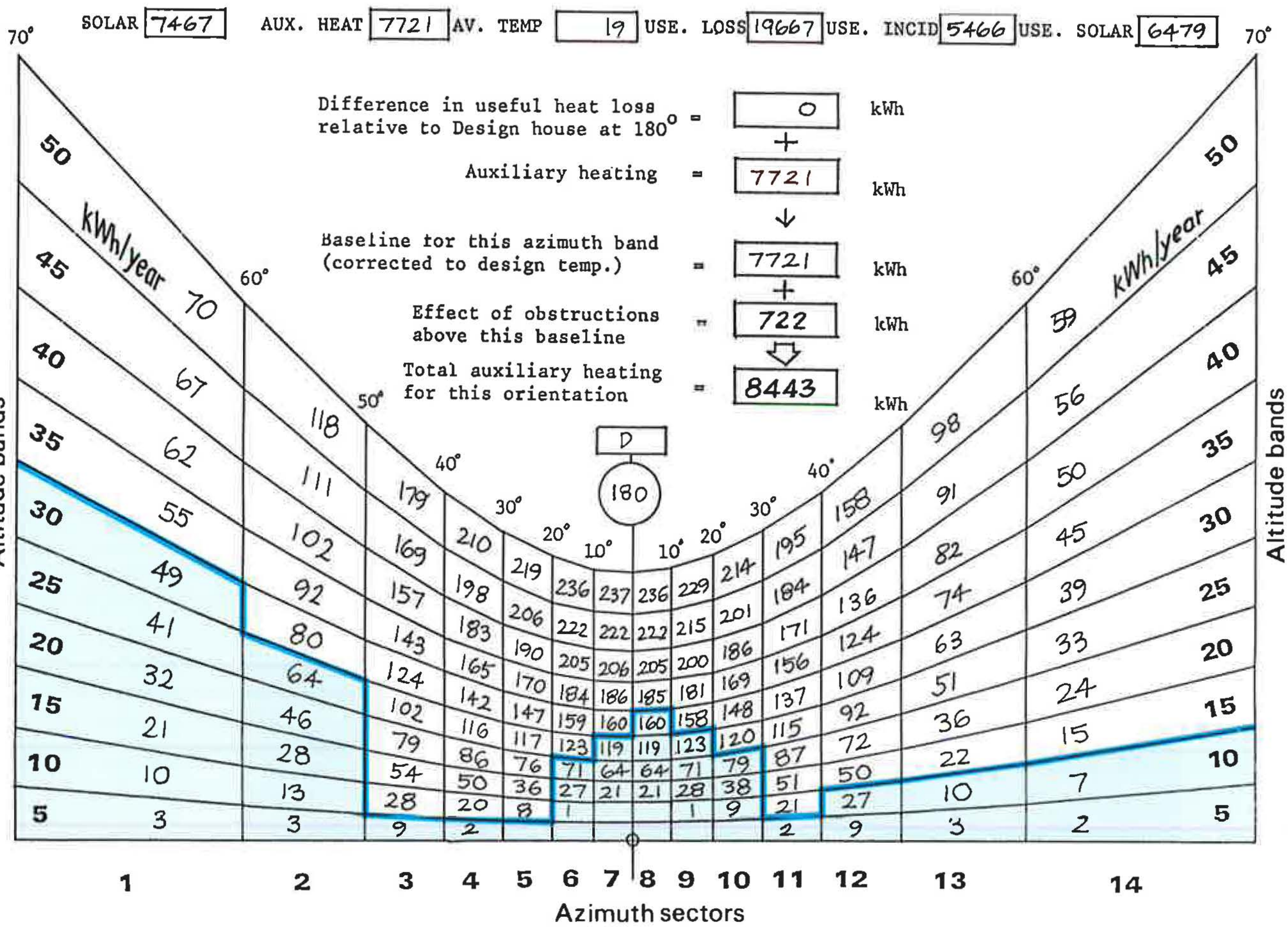


Fig 12 Obstruction profile drawn on ETSU sky diagram for south-facing house with passive solar features

Other graphical aids to assessing solar access and its consequence include:

- Determination of a 'solar envelope', which defines the volume that a building can occupy without overshadowing adjacent buildings or sites. This may be useful where solar access needs to be assured in planning control, or as a 'property right'. The envelope is usually based on the sun's paths on specified dates in winter and summer[22].
- Using a 'shadow mask' with a sunpath diagram to plot the obstructions surrounding a point on plan, allowing the period of overshadowing on various dates to be determined (Figure 15). Photographs taken with a special fish-eye lens can be used to help plot the obstruction profile (Figure 16);
- Use of photographic techniques to help assess the effects of obstacles on the radiation received from different parts of the sky[23].

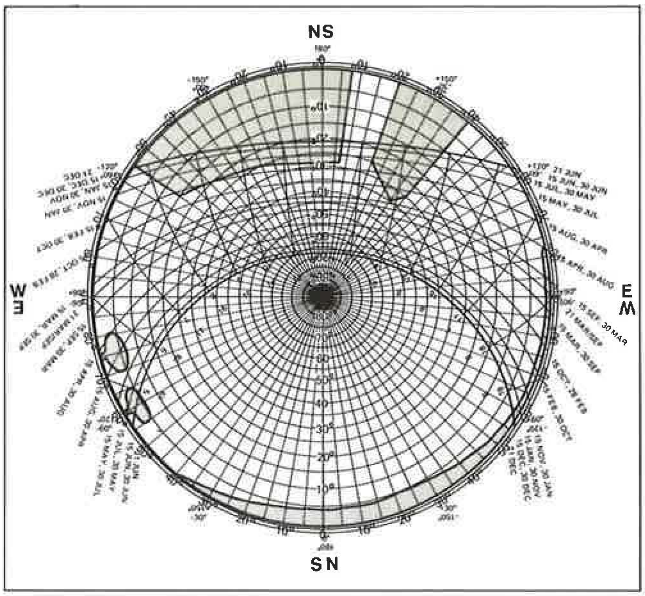
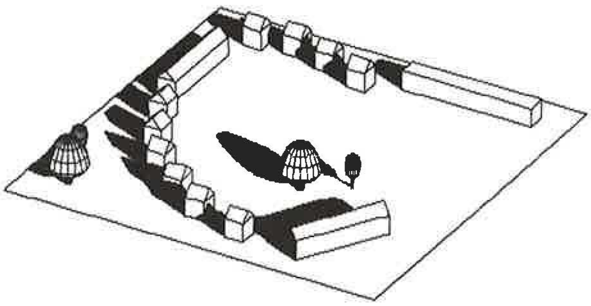
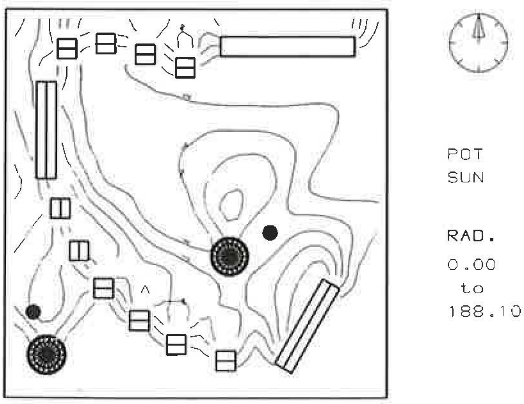


Fig 15 Sunpath diagram with shadow mask



a) View of shadows cast at 08:00, September 21 for latitude 51°N



b) Plan showing isopleths of accumulated direct irradiation (potential sunshine) during December and January, in MJ/m² (maximum (unobstructed) value 188.1)

Fig 14 Example of 'Shadowpack' output

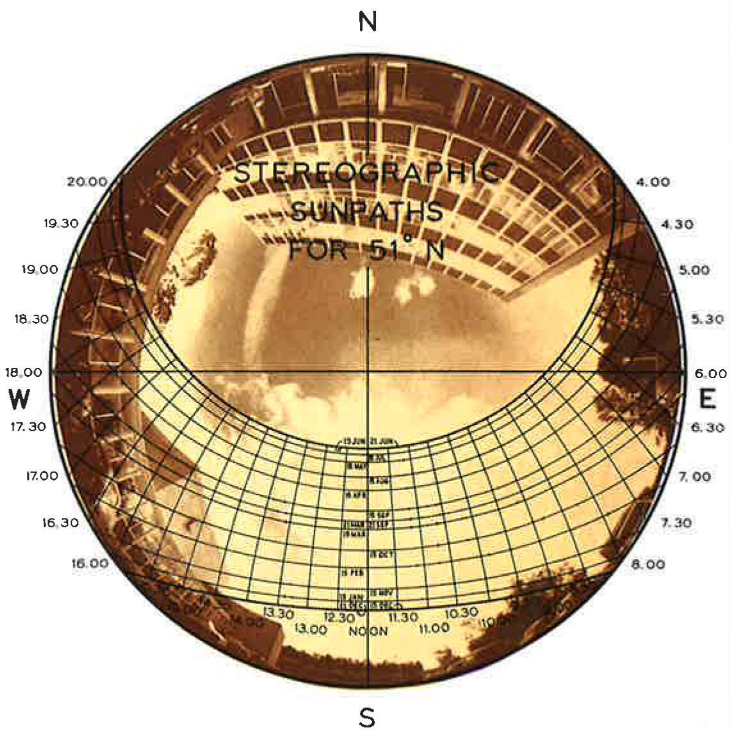


Fig 16 Fish-eye photograph used to create shadow mask

For accurate analysis of solar gains, account needs to be taken of the effects of partial shade from trees, and of reflected and emitted thermal radiation from adjacent buildings and other surfaces, eg walls, pavings. The transparency to solar radiation of the crowns of some common tree species, both in full-leaf and bare-branch conditions, is given in Table 6, while typical periods of foliation in England are shown in Figure 17. Reflection, absorption and emission of radiation from hard surfaces is of greatest significance in urban areas.

Concern for the energy and environmental benefits of solar access during the heating season should not exclude the provision of summertime shade, often needed to improve comfort in both within buildings and in external spaces. Deciduous trees offer the advantage of shade in summer but moderate solar access in winter. Building designs can employ devices, such as overhangs, to discriminate against high-angle summer sun while admitting low-angle winter sun. Some blockage of solar access at the beginning and end of the heating season is not necessarily a disadvantage. During these periods, there may be more solar gain available than can be used to offset heating requirements, especially in low-energy designs. Partial blockage can help to avoid overheating, with a greater proportion of the remaining solar gain being useful.

Table 6 Transparencies of tree crowns to solar radiation

Botanical name	Common name	Transparency (% radiation passing) Full leaf	Bare branch
Acer pseudoplatanus	Sycamore	25	65
Acer saccharinum	Silver maple	15	65
Aesculus hippocastanum	Horse chestnut	10	60
Betula pendula	European birch	20	60
Fagus sylvatica	European beech	10	80*
Fraxinus exelsior	European ash	15	55
Gleditsia	Locust	30	80
Quercus roba	English oak	20	70
Tilia cordata	Lime	10	60
Ulmus	Elm	15	65

*The beech tends to retain dead leaves for much of the winter, reaching bare branch condition only briefly before new leaf growth in the spring.

Notes

These data apply to individual tree crowns; multi-row belts or blocks let virtually no radiation through when in leaf, and very little when in 'bare-branch' condition

Most of the data are based on measurement of light, but may be used for solar radiation generally

The values are averages from a range of sources which show large differences for some of the values. They must therefore be treated with caution, noting that in any case there will be considerable divergence in the transparencies of individual trees, especially in summer.

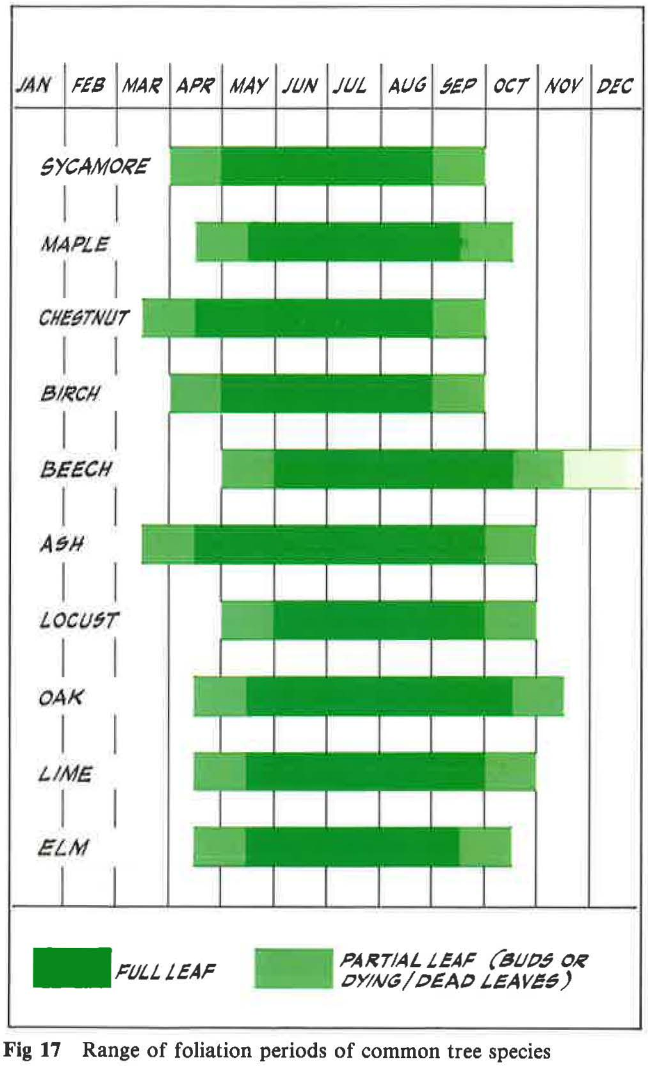


Fig 17 Range of foliation periods of common tree species

WIND CONTROL

The United Kingdom is subject to relatively high wind speeds with many areas severely exposed by virtue of altitude, topography or proximity to the coast — Fig 18. Most populated areas are in low-lying or sheltered locations, but a significant minority are not. In addition, much new building tends to be at the edges of built-up areas, and may be on higher, more exposed ground than older property. Although built-up areas can offer substantial protection from the wind, they may contain 'pockets' of exposed land, eg near rivers, playing fields, large roads or railways. The presence of high buildings can also expose nearby low-rise construction to high wind speeds.

In most situations it will benefit both energy economy and environmental comfort to provide as much shelter as possible from the wind during most of the year. During the hottest part of the year, air movement is desirable both for pedestrian comfort in open spaces, and to cool buildings by natural ventilation. It is difficult to fully satisfy these two aims in many parts of the UK, since wind directions differ little between winter and summer. A possible solution is to arrange built form and coniferous trees to give shelter from colder but less frequent northerly winds (see Part 1, Figure 7b and 7c), while providing shade from deciduous trees to help counter summer heat.

The wind environment around buildings and the wind pressures on them depend strongly on the 'roughness' of the ground over which the wind has passed, and on

Fig 18 An exposed site

Table 7 Reducing the sensitivity of individual buildings to the wind

- Reduce the dimensions, especially the height, of uninterrupted external walls, particularly those exposed to a dominant or critical wind direction.
- Multi-storey buildings, step back facades progressively with height.
- Avoid flat and low-pitched (up to 10°) roofs, especially in low-rise construction; use medium-pitched roofs (22° to 45°).
- Use hipped roofs in preference to gable-ended roofs.
- Where high wind speeds at the corners of a building cannot be avoided, provide substantial planting or windbreaks to reduce their impact.

the extent of the perturbation and redirection of the air flow induced by the buildings. In 'smooth', open countryside, wind speed increases rapidly with height above the ground. Built-up areas offer a much rougher surface to the wind: its speed increases less rapidly with height above the ground, but the flow is more turbulent. However, if the roughness of a built-up area is kept uniform and features inducing local accelerations and ground-level turbulence are avoided, it is possible to create a sheltered zone in the first 5 m or so above the ground.

Achieving this kind of shelter requires attention to the form of individual buildings, their arrangement on the site, the use of hard and soft landscape elements and the provision of wind shelter on any exposed edges of the development. Account may also need to be taken of local topography or the presence of high buildings.

The form of individual buildings
Whether a building is isolated or in a group, it should present the least resistance to the passage of the wind over and around it. For normal, rectilinear buildings, this implies a shape as near as practicable to a pyramid. Cubical and 'slab' shapes will be the least satisfactory, since these are more likely to generate undesirable wind effects at or near ground level, eg turbulence both upwind and downwind, and high wind speeds at the corners of the buildings. Table 7 lists the main ways to avoid adverse effects.

The arrangement of buildings on a site
The presence of a group of low or medium-rise buildings will usually create a moderate level of wind shelter in the spaces between them. The outermost buildings, if reasonably close together, provide a first barrier to the wind and help to establish a 'built-up area' wind velocity profile over the group. The outermost buildings themselves, however, may experience severe exposure to wind and driving rain, and large pressure differences. The shelter within the group can be enhanced by arranging the buildings so that the ground roughness they create is as consistent as possible, and by allowing a relatively uniform passage of air through the spaces between them. The main principles are listed in Table 8, and Figure 19 illustrates some of the points.

Table 8 Reducing the sensitivity of groups of buildings to the wind

- Arrange buildings in an irregular pattern, rather than in regular lines or grids. Avoid long, uninterrupted passages between buildings, through which low-level wind could be channelled. Avoid placing large walls at right angles to a dominant or critical wind direction.
- Keep the heights of buildings in the group as uniform as possible; avoid abrupt changes of height, because they can induce downdraughts.
- Keep the distances between buildings fairly small, ideally in the range 1.5 to 2.5 times their overall height, but avoid small gaps (eg up to 3 m) which can act as wind 'funnels'.
- Overlap the ends of blocks that 'meet' at an angle, to limit the funnelling effect.
- Create courtyards where maximum shelter is required; orientate partly open courtyards for optimum shelter from the dominant or critical wind direction (but also with regard to needs for solar access).
- Limit the maximum length of blocks, especially those of 'plain' form, to about 25 m.
- Avoid tunnels through blocks; if essential, orientate for minimum wind sensitivity, and/or couple with windbreaks.
- Where straight streets are unavoidable, limit block length, provide gaps of 3 m to 5 m between blocks and introduce steps and staggers into facades.
- Use landscape techniques to maintain ground roughness in any open parts of the site, and to provide local wind shelter for buildings and open spaces; earth mounding, trees, bushes, fences and open or porous walls can all contribute. Mature trees with open space around their trunks may need extra, low-level planting to avoid channelling wind at ground level.

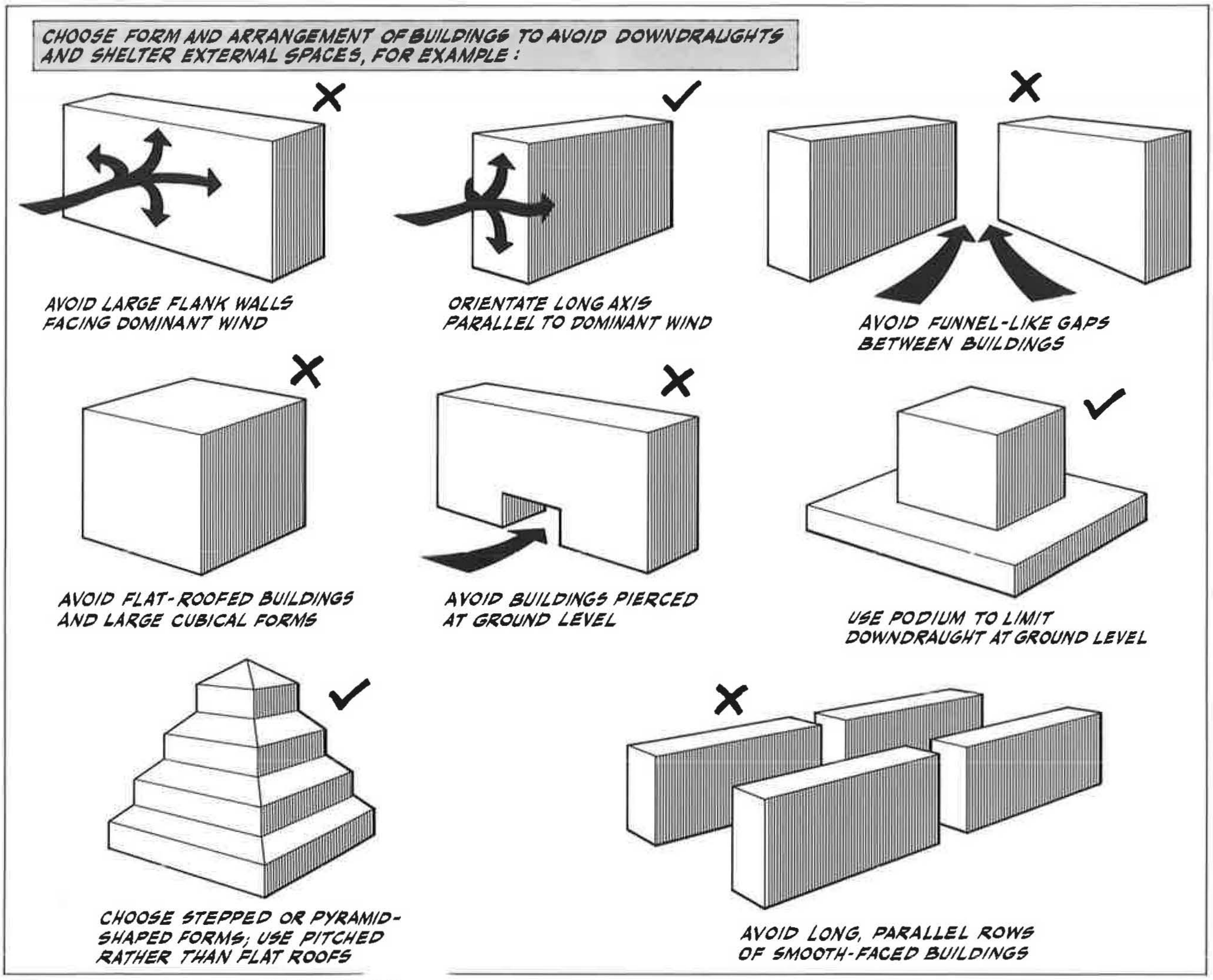


Fig 19 Reducing the wind sensitivity of buildings

Shelter from landscape features

Landscape design offers many practical benefits through its influence on microclimate. Trees, bushes, walls, fences and ground profiling (eg mounds and banks) can all contribute to wind shelter, in addition to their value in providing summer shade. For maximum benefit, landscape elements need to be designed in conjunction with the arrangement of buildings, following many of the same principles, eg avoiding channelling or funnelling of ground-level winds. Vegetation, being permeable to the wind, is less inclined to generate downdraughts than buildings; tall trees, suitably placed, can therefore offer substantial wind protection.

Uses of vegetation divide into:

- Major shelter belts to protect the edges of built-up areas, or placed at regular intervals within large developments;
- smaller-scale planting of trees and bushes to give local protection to buildings or open spaces, and to enhance ground roughness generally.

Major shelter belts to protect building developments are rare at present, although they have a long history in agriculture. When fully grown they have the potential to provide wind protection over the entire height of low-rise buildings. However, their effectiveness in early years is more limited, since even quick-growing tree species take up to ten years before giving useful protection. Their establishment therefore calls for a long-term landscape planning strategy which extends to the development and maintenance of the plants over the lifetime of the buildings. In some cases advantage might be taken of public or common land to grow shelter belts for community benefit.

Effective wind protection by planted shelter depends on:

- soil type
- soil moisture availability
- climate
- the pattern of protection sought (eg high protection over a short distance downwind, or moderate protection over a longer distance downwind).

The belt may be designed to grow in several successive stages, with quicker-growing species offering early wind protection and acting as 'nursery' stock to protect slower-growing trees that will form the eventual belt. As the trees grow taller, infilling at their base with bushes becomes important; this prevents gaps that would channel the wind at low level. Fuller guidance on these points is given in the PSA *Landscape design guide.*

To ensure good and uniform performance, shelter belts need to be integrated into the design of a site or complex, and considered in decisions about road patterns, zoning and solar access. The layout and design of shelter belts needs to be attuned to local circumstances. In areas with a consistently strong wind from one direction, linear patterns may be appropriate (Figure 20). In other areas, protection may be required from several directions, suggesting 'interlocking' patterns that allow continuous passage for the wind (Figure 21).

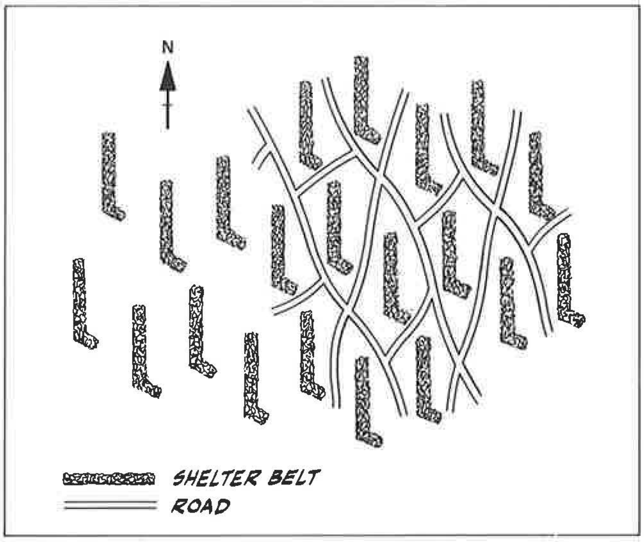


Fig 20 Idealised shelter belt layout for protection from westerly winds

Local, smaller-scale planting may take the form of shelter belts of limited height (6 – 8 m), that will not block too much solar radiation when placed near buildings. General, decorative landscape work can also be exploited, for example by placing trees and bushes in between buildings whose spacing is greater than desirable for wind shelter, and where roads might otherwise create channels for the wind. It may however be necessary to compromise on the density of planting close to buildings to avoid excessive obstruction of views or loss of daylight, even where solar access is not affected; the presence of trees will also influence foundation design in many areas (see Digest 298).

Artificial windbreaks can be used to create 'instant' shelter, either as a permanent solution or as an expedient until plants grow sufficiently to become effective. Solid walls and close fences can provide local protection, but they are inclined to generate excessive turbulence in their wake, rather like flat-roofed buildings. Wind protection over a wider area can be obtained with permeable walls or fences (Figure 22). This mimics the behaviour of planted shelter, which also should not be too dense if a large protected area is required. Optimum permeability is generally about 40 – 50%. If the design enables permeability to be varied, it should decrease from top to bottom, ie the windbreak should be more solid at the base, more open at the top. This is likely to be best for wind control in the 'human' zone, 0 – 2 m; agricultural windbreaks often have a gap at the base, to avoid possible frost damage to plants if cold air is trapped.

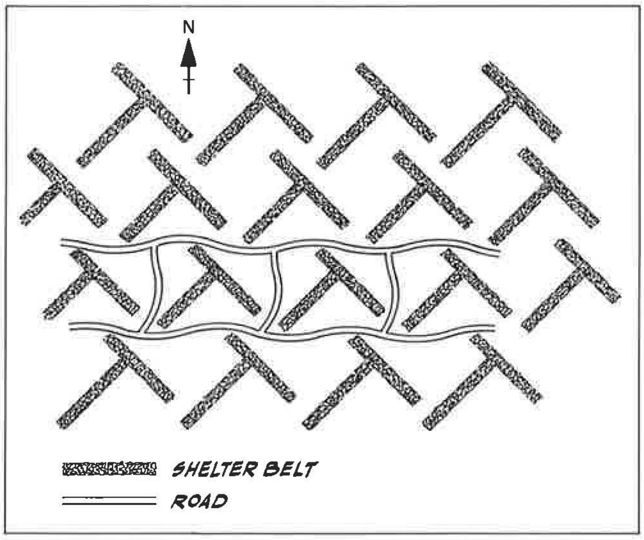


Fig 21 Idealised shelter belt layout for omni-directional wind protection

Fig 22 Permeable walling as windbreak and decorative screen

The aerodynamic performance of natural and artificial windbreaks can be predicted. It will vary with the form and porosity of the windbreak, and with the speed and turbulence of the incident wind. Detailed guidance is given in Reference 24, which provides data for assessing the areas of 'good, average and slight' wind protection (designated S3, S2 and S1.2 respectively) behind single or multiple windbreaks (see Figure 23). Given data on the frequency distribution of wind speed and direction, the durations of different wind speeds in the sheltered areas can be estimated. Guidance on assessing wind patterns around high buildings in somewhat similar terms is contained in Digest 141 and Reference 25.

The case for wind control will normally be judged in terms of its benefits for space heating energy consumption and external comfort (see Part 1). However, the provision of shelter and design to reduce wind sensitivity can also reduce the risk of structural damage from high winds and the degree of 'weather penetration' into buildings caused by driving rain. These objectives will usually need separate consideration in shelter design, since the directions of extreme and rain-bearing winds may be different from those of greatest importance to energy use and thermal comfort.

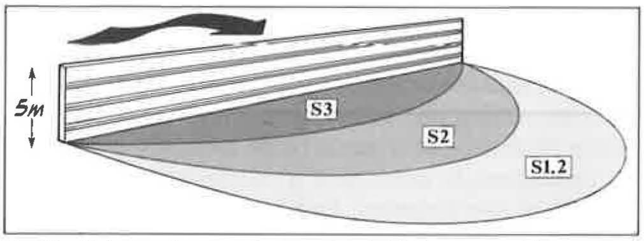


Fig 23 Calculated areas of protection behind a permeable windbreak

Various other issues can affect decisions about wind shelter. In heavily built-up areas, the need for air movement to disperse pollutants may outweigh the advantages of shelter. In regions liable to prolonged snow cover, reduced wind speeds in the vicinity of buildings can result in accumulations of deep snow: one way of managing the problem is to provide low, fairly open windbreaks specifically designed to trap snow where it will not form a nuisance. Wind noise is sometimes a problem; reducing wind sensitivity will tend to limit noise, but care should be taken to avoid aeolian effects and mechanical noise (resonances or rattling) in the design of artificial windbreaks.

PRACTICAL EFFECTS ON SITE LAYOUTS

Solar access and wind control/design for microclimate are both likely to have significant effects on the size, form, massing and orientation of buildings. However, this does not necessarily mean that site densities need to be lower: it is more a question of using the available land in a way that recognises microclimatic needs. Road layout is an important determinant of solar access potential in housing, and is usually decided early in the design process. Microclimate needs to be considered at an equally early stage, and its benefits balanced against other factors such as economy in utility networks and paved areas.

The balance of factors will differ with circumstances. Shelter from northerly winds would seem the most appropriate in general inland sites with no strong directionality. In other cases (where there is funnelling, or on or near coasts, or where protection from driving rain is sought) other criteria could apply. In all cases the test should probably be related to how much useful solar gain is blocked by non-northerly wind protection. Where wind speeds are higher, wind protection assumes greater importance and this may justify to the use of shelter in sun-blocking situations.

Solar access may be more compatible with other aims, since in many respects it will complement the desire for sunlight, daylight and view. Wind control may produce conflicts with some visual aspects of design, eg the desire for variety in form, scale and space, and for distant views. Both solar access and wind control/design for microclimate raise issues of the rights of, and constraints upon, property developers and users, since one person's building or wind shelter can be another's solar obstruction.

The main implications of solar access for the site layout of dwellings[17][18] are:

- Make as much road length as possible run within 15° of E-W
- Arrange plot shapes to allow wide, south-facing frontages, to maximise solar gain through windows.
- Plant coniferous trees to the north of houses, deciduous trees to the south.
- Choose dwelling type and form to limit overshadowing

    place high blocks towards the north of sites, preferably near corners or road intersections to limit overshadowing of adjacent sites

    place two-storey houses to the north of bungalows

    place terraces on E-W roads

    place detached houses on NE-SW roads

    place roof-collector houses on N-S roads

    arrange entrance to dwellings from north where feasible, to allow full-width south-facing living rooms

    make greater use of side-entry house plans where access is from directions other than north

    site houses sited on north of plots, so that overshadowing is more under user's control

An imaginary layout illustrating how many of these points can be incorporated in a landscaped design is shown as Figure 24. Figure 25 shows a recent housing scheme where a passive solar design was matched to the orientation and shelter offered by the setting and existing vegetation of the site.

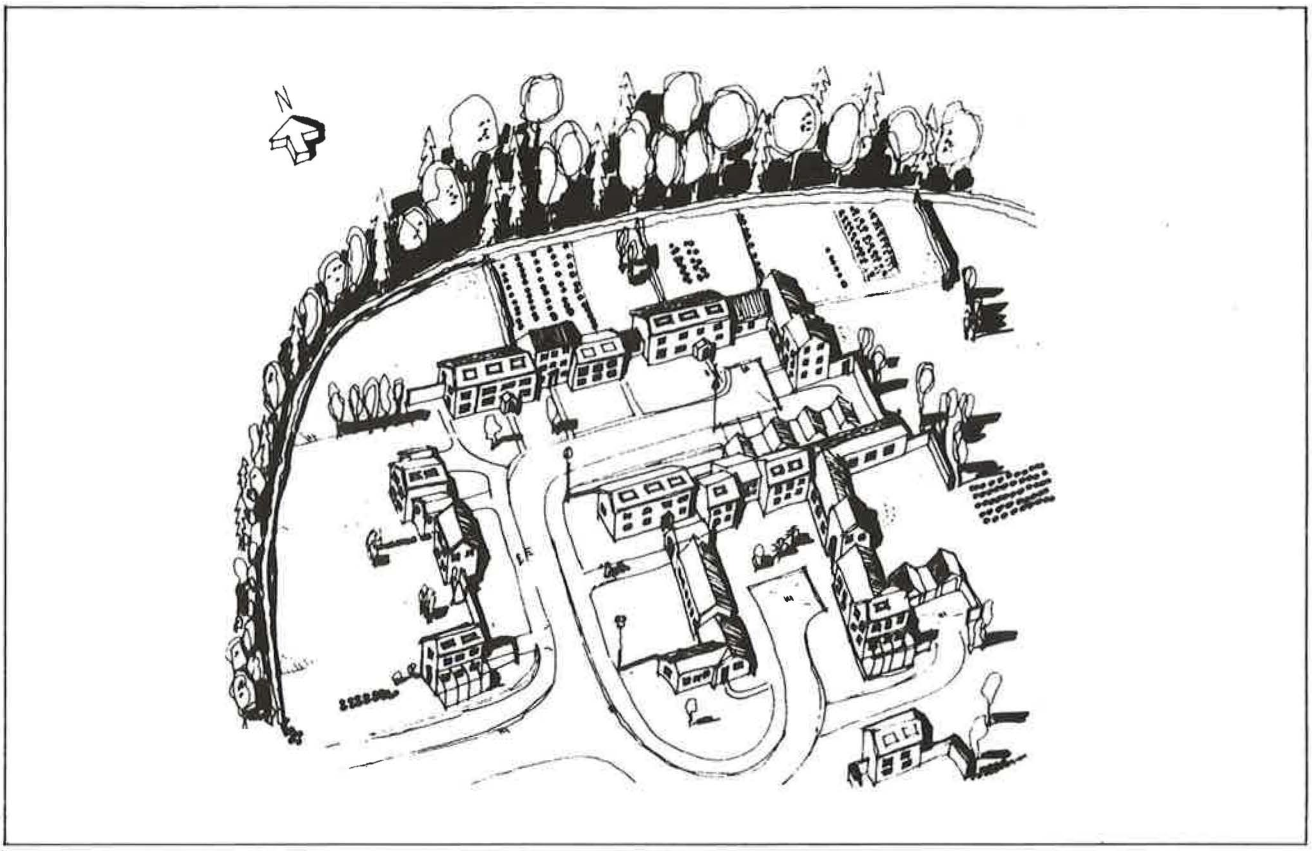


Fig 24 A site design providing substantial tree shelter to north, with good solar access to buildings and spaces

Fig 25 Spinney Gardens housing; view looking NW. *Courtesy of PCKO Partnership and ETSU*

REFERENCES AND FURTHER READING

1 ANDERSON B R, CLARK J A, BALDWIN R, MILBANK N O. BREDEM — the BRE domestic energy model: background philosophy and description. BRE Report (BR 66), 1985.

2 PAGE J, LEBENS T (Editors). Climate in the United Kingdom: a handbook of solar radiation, temperature and other data for thirteen principal cities and tows. Department of Energy/Energy Technology Support Unit. HMSO, London; 1986.

3 Meteorological Office Publications, including:

Met 0.792: Tables of surface wind speed and direction over the United Kingdom. 1968.

Met 0.856a: Tables of temperature, relative, humidity precipitation and sunshine for the world: Part 3: Europe and the Azores. 1973.

Met 0.883: Averages of temperature for the UK, 1941 – 1970. 1973.

Met 0.912: Solar radiation data for the United Kingdom, 1951 – 1970. 1980.

Climatological Memoranda (various) on the climates of regions of the UK.

4 CIBSE Guide, Part A2: Weather data. Chartered Institution of Building Services Engineers, 1982.

5 British Standard Code of practice CP 3: Ch V: Part 2:1972. Wind Loads. British Standards Institution.

6 PENMAN J A. The thermal performance of rain-wetted walls. Property Services Agency, Croydon, 1968.

7 Draft for Development 93: 1984. Methods for assessing exposure to wind-driven rain. British Standards Institution.

8 LACY R E. Climate and Building in Britain. HMSO, London 1977 (particularly Chapter 4 'Climate and Town Planning'); Building Research Establishment Report, 1977.

9 MARKUS T A, MORRIS E N. Buildings, climate and energy. Pitman, 1979.

10 GERRY UK, HARVEY GP. The abatement of wind nuisance in the vicinity of tower blocks; Review and Studies Series No 18. Greater London Council, 1983.

11 WHITE E J, SMITH R I. Climatology maps of Great Britain. Institute of Terrestial Ecology, Cambridge, 1982.

12 O'FARRELL F, LYONS G, LYNSKEY G. Energy conservation on exposed domestic sites. Final report of contract No EEA-05-054-EIR (H). European Communities Energy R and D and Demonstration Programmes, Brussels, 1987.

13 Sunlight and daylight. Planning criteria for the design of buildings. Dept of the Environment/Welsh Office; HMSO, 1971.

14 Sunlight and daylight. Indicators. Dept of the Environment/Welsh Office; HMSO, 1971.

15 Draft for Development DD 67:1980. Basic data for the design of buildings: sunlight. British Standards Institution.

16 NE'EMAN E, LIGHT W. Availability of sunshine. BRE Current Paper 75/75; 1975.

17 Sunshine availability protractor. Accessory to BRE CP 75/75.

18 FI NBOW M, PICKERING M. A study of passive solar site layout. ETSU Final Report S-1126; NBA Tectonics Limited, London, for Energy Technology Support Unit, Harwell, 1986 April.

19 Energy Technology Support Unit. Passive solar design programme leaflets. 18: Housing estate layout - an assessment study. 19: Housing estate layout — a design aid. ETSU, Harwell, 1987.

20 EVERETT T. Passive solar in Milton Keynes. Open University Energy Research Group, Milton Keynes, 1980.

21 PECKHAM R J. Shading evaluations with general three-dimensional models. Computer-Aided Design, 17 (7), 1985, 305 – 310.

22 KNOWLES R L. Sun rhythm form. MIT Press, Cambridge, Massachusetts, USA, 1981.

23 MCINTYRE D A, CASTLE D A. Solar shading of windows: a simple photographic technique. Building Services Engineering Research and Technology, V5 (3), pp 111 – 114, 1985.

24 GANDEMER J, GUYOT A. Wind protection — the aerodynamics and practical design of windbreaks. BRE Translation; 1985 (to be published).

25 PENWARDEN A D, WISE A F E. Wind environment around buildings. BRE Report, 1975

FURTHER READING

HUNT D R G. Availability of daylight. BRE Report; 1979

ROBINETTE G O (Ed), CRANDALL D, PAULO F X. Energy-efficient site design. Van Nostrand Rheinhold, New York, USA; 1983

WATSON D, LABS K. Climatic design: energy efficient building principles and practices. McGraw Hill, New York, USA; 1983

McPHERSON E G (Ed). Energy-conserving site design. American Society of Landscape Architects, Washington DC, USA; 326 pp; 1984

LITTLER J, THOMAS R. Design with energy: the conservation and use of energy in buildings. Chaper 2 Site planning and analysis, pp 14 – 41. Cambridge University Press, Cambridge, England; 368 pp; 1984

ACHARD P, GICQUEL R (Editors). European passive solar handbook. EUR 10 683; Commission of the European Communities, DG XII, Brussels; 1986.

SEALEY A. Introduction to building climatology. Commonwealth Association of Architects; 44 pp; 1978.

TABB P. Solar energy planning: a guide to residential settlement. McGraw-Hill, New York, USA; 1984. ISBN 0 – 07 – 062688 – X.

ORESZCZYN T, JONES B. Milton Keynes energy park: wind study. Report to Milton Keynes Development Corporation; June 1984.

OWENS S. Energy planning and urban form. Pion Limited, London, via Methuen and Co; 118 pp; 1986.

HAWKES D, OWERS J, RICKABY P, STEADMAN P (Editors). Energy and urban built form. Proceedings of international seminar on Urban built form and energy analysis, Darwin College, Cambridge, 1986 – 06 – 26/27 Butterworths, London; 1987.

WALKER H V (Editor). Energy conservation design resource handbook. Royal Architectural Institute of Canada, Ottawa; 1979.

ENERGY SAVING THROUGH LANDSCAPE PLANNING (PSA SERIES)

1 DODD J. An introduction
GERRY K. Microclimate and shelter
GERRY K, HARVEY G: Tower blocks, wind and microclimate

2 PENMAN J. The thermal performance of rain-wetted walls

3 FINBOW M. The contribution of shelter planting

4 BAKER N, MULLIGAN H. Existing housing

5 WILTSHIRE J, WARREN B. An empirical study of microclimate and energy use

6 COLLINS M, BARNSLEY M. A study of the urban edge

Property Services Agency, Croydon, 1988.

BRE MICROCLIMATE SEMINAR SERIES (where additional to PSA reports)

The Milton Keynes Energy Park. A full-scale test of integrated landscape design. Neil Higson, Chief Landscape Architect, Milton Keynes Development Corporation.

Light attenuation by trees. Geoff McKennan, Dept of Architecture and Landscape, Manchester Polytechnic.

BRE studies of local influences on driving rain. Tony Newman; BRE Organic Materials Division.

SHADOWPACK: A design aid for assessing the consequences of overshadowing for available solar energy. Bob Peckham, CEC Joint Research Centre, Ispra, Italy.

Canterbury Crown Courts. A case study of a public building designed for natural ventilation; Earle Perera, BRE Environmental Systems Division.

BRE Digests

127 An index of exposure to driving rain
141 Wind environment around tall buildings
298 The influence of trees on house foundations in clay soils
309 Estimating daylight in buildings: Part 1
310 Estimating daylight in buildings: Part 2
346 The assessment of wind loads: Parts 1 to 7

Printed in the UK and published by Building Research Establishment, Department of the Environment.

Price Group 3. Also available by subscription. Current prices from:
Publications Sales Office, Building Research Establishment, Garston, Watford, WD2 7JR (Tel 0923 664444).
Full details of all recent issues of BRE publications are given in *BRE News* sent free to subscribers.

ISBN 0 85125 430 6

Printed in the UK for HMSO. Dd.8245088, 3/90, C170, 38938.