PASSIVE SOLAR DESIGN

The aims of passive solar design are:

- To maximise the benefits to be gained from the radiant heat and light that come to a building from the sun.
- To minimise the unwanted effects – in particular, summer overheating.

Excellent insulation is a pre-requisite. Some say that natural ventilation is desirable, too.

The design is 'passive' in that no account is taken of the active gathering of solar energy, neither directly via PV and thermal panels, nor indirectly via heat pumps.

Windows in moderation

A key objective is the maximising of solar gain through windows during spring, autumn and winter. On the other hand, in summertime there is a need to avoid solar overheating.

To achieve these objectives:

- Build with high thermal mass
  A concrete floor is preferable to a timber joist floor. Walls can be either masonry, or else timber-frame lined with PCM boards. (PCM = Phase Change Material – see my article last month. For more about thermal mass, see my last three articles.)

- Install a moderate amount of glazing, with little of it facing northwards.
  Too much glazing leads to summer overheating. Too little results in poor daylighting. Generally, designers recommend that the total window area should be 20% - 30% of the total floor area. And that the northwards facade should have about half the window area of the southwards facade.

  Of course, windows are primarily required for daylighting, not for harvesting solar heat. Big windows are needed to illuminate big rooms. So to reduce the area of glazing on the north facade, position smaller rooms (bathroom, small bedrooms, study, utility room, etc.) on that side of the building. And if a garage is to be attached to a house, attaching it on the north side would be good.

Building orientation and form

The axis of the house should be East-West so that a long facade faces south (or within, say, 30° of south). Much will depend, though, on the plot and the planners.

For one of my builds, I wanted to orientate the house so that it faced southwards. But planning permission was refused, even on appeal. Though the house would have been hardly visible from the road, it was considered that it would not fit in with the existing street-scape.

  Fortunately, the National Planning Policy Framework, introduced by the Government in 2012, states that:
Local planning authorities should not refuse planning permission for buildings or infrastructure which promote high levels of sustainability because of concerns about incompatibility with an existing townscape...

So let your house design include a longer facade facing southwards – this may be the back of the house, of course. A compact building form minimises heat losses in winter.

(A snippet about Active Solar Design:
The optimum roof orientation for PV panels has a pitch of 30° facing south. The same pitch facing east or west results in a 22% drop in output.)

Collecting winter sunshine

BRE publish an Information Paper, Site Layout Planning for Sunlight and Solar Gain. (See Further Info.) This suggests that from any particular window you ascertain the maximum elevation of any obstruction towards the south, eg, a garage, and use this to check that the window will receive at least three hours of sunshine around the middle of the day, even in midwinter.

For example, for a window in Nottingham the maximum elevation of any obstruction within 30° of south should be less than 12° if the window is to receive its quota of midday sunshine in midwinter. (See the Information Paper for details of the method. The maximum elevation obviously decreases with the latitude of the site.)

Sun orientation

Passive Solar Design requires an understanding of how the path of the sun in the sky varies with the seasons. The latitude of Nottingham is 53°. So what is the elevation of the sun there at midday in midsummer? The answer is 60.5°. (60.5 = 90 – 53 + 23.5. At midsummer, the axis of the earth tilts 23.5° towards the sun.)

And the elevation of the sun in Nottingham at midday in midwinter? Answer – 13.5°. (13.5 = 90 – 53 – 23.5. At midwinter, the earth’s axis tilts 23.5° away from the sun.)

The sun is due south at midday, due east at 6am (GMT), and due west at 6pm. (During the winter, of course, the sun is below the horizon at 6am and 6pm.) Longitude has an effect on the precise timings. Going westwards by 15° delays noon by one hour. (The earth completes one spin in 24 hours, and 15 = 360 / 24.) The most westerly place in England, Lands End, has a longitude of 5.7° W, so solar time there is about 23 minutes later than clock time. (Greenwich Mean Time is set for Longitude 0°, which passes through the Royal Observatory at Greenwich, London.)

On the website of the University of Oregon, there is a 'Sun path chart program'. If you enter the latitude and longitude for any place, the website produces a chart of sunpath lines at monthly intervals showing the sun’s elevation during the course of a day. (See Further Info.)

See the chart for Bristol (Latitude 51.5°N, Longitude 2.6°W):
Daily sun paths for Bristol at monthly intervals from June 21 to December 21

Readers may be interested in a photographic illustration of the above chart. A pinhole camera at a fixed position in Bristol has captured the path of the sun during the course of various clear sunny days. The photos for these diverse days are merged into one, giving the image below.

Pinhole photos of sun paths at Bristol for various days of the year

Avoiding summer overheating

Better insulation leads to more heat being trapped inside a house, and in summertime this can lead to overheating – unless steps are taken to combat it. In the UK, passive solar design can obviate any need for air conditioning, both now and in decades to come. Plenty of thermal mass with plenty of night-time ventilation during the
summer should keep indoor temperatures below, say, 24°C. (For night cooling, a much higher than normal ventilation rate is required. The Energy Saving Trust suggest 5 air changes an hour – about ten times the normal rate.) In the UK, the typical diurnal range of temperatures is about 10°C, so even during the peak of the summer, the night air is cool enough to carry away the heat that builds up indoors during the daytime. (See the Footnote about keeping cool with MVHR.)

The rooms that are most likely to overheat are those that face westwards, rather than south. Why? – During the afternoon, when the sun is at a lower elevation, the beam of sunlight that enters the room is bigger than that at midday – see the diagrams. (In the morning, temperatures both inside and outside the house are likely to be cooler from the night before, so overheating with eastwards windows is unlikely.)

There are several ways of producing shade to reduce summer overheating:

- Deciduous tree
  A garden tree in the right position can give useful shade. If it is deciduous, then its bare branches in wintertime will allow through plenty of much needed light.

- Awning
  A retractable awning fixed above a window can reduce the amount of sunshine entering the window. When retracted in wintertime, it does not reduce daylighting. (You could leave the fixing of awnings to some time in the future. Awnings can easily be retrofitted if summer overheating is found to be a problem.) Occasionally, PV panels are fixed at an angle above a window or patio door, and so do extra service as an awning.

- Brise-soleil
  A brise-soleil is a panel of slats that is fixed above or in front of a window to give it shade. It is an alternative to an awning. (Brise soleil is French for 'Breaks sun'.) This fashionable architectural feature more commonly adorns offices and hotels rather than homes.
• Louvred shutters
These are a feature of homes in warmer climates, but maybe their time is coming here, too. They not only give shade, but they also allow ventilation. So at night-time, with the windows opened inwards and the shutters securely closed, incoming air ventilates and cools the house. (To achieve good natural ventilation, windows should be opened on both storeys – warm air rises.)

• Roller shutters
External roller shutters are available, though they are primarily for security.

• Blinds
Roller blinds or Venetian blinds can be easily fitted internally. Blinds with a rear surface that is reflective are effective at reflecting sunshine back out through low-e glass. Thin and lightly coloured blinds allow some light through, while keeping out some heat. Some blinds are designed to be good insulators, keeping heat in during winter, and keeping heat out during summer. (See Further Info.)

Sunspaces
A sunspace is a 'room' with lots of glazing that is outside the thermal envelope of a house. Common examples are a conservatory and a sun room. The glazing captures solar energy. In spring and autumn, or even possibly on sunny days in winter, warm air from the sunspace can warm the house. It enters the house via:

• An open door or window between the sunspace and house;
  Or:
• Built in vents at floor and ceiling levels.

A good use of sunspaces is to be found at the Hockerton Housing Project in Nottinghamshire. (See Further Info.)

Even a loft can be used as a sunspace! Some of the roof covering is glass, and a fan blows warmed, fresh air through ducting into the living space below. (See 'University of Ulster' in Further Info.)

FOOTNOTE:

MVHR systems in summertime
If you install Mechanical Ventilation with Heat Recovery, make sure that the fan unit has an automatic bypass. This is often called a 'summer bypass', which is a misleading name. Much of the time in summer you want the heat exchanger to be operational. During a hot day, you need to conserve 'coolth', just as in winter you need to conserve warmth. So the heat exchanger should not be bypassed.

At night, though, you may well wish to bring in cool air from outside to cool the house – and then the bypass should be used.

So whether or not the bypass is required to operate depends on the temperatures of the incoming and outgoing airstreams and the set temperature you require in the house. This can all be catered for with an automatic bypass – manual summer bypasses are obsolete.

Note also that you may well have to boost the flow rate during summer nights to obtain sufficient cooling.
FURTHER INFO:

**Thermal Mass for Housing**
Published by the Concrete Centre, 2008. 26 pages.

**Reducing Overheating – a designer's guide**

**The Hockerton Housing Project: a case study**

**Site Layout Planning for Sunlight and Solar Gain**

**University of Oregon**
Look for their Sun Path Chart program under Software tools. solardat.uoregon.edu.

**Pinhole photography**
By Justin Quinnell. See his website: www.pinholephotography.org.

**Faber Blinds**
Produce a wide variety of internal and external blinds, awnings, and brise-soleils. www.faberblinds.co.uk.

**Duette**
Energy saving blinds. www.duette.co.uk.

**Window Film Company**
Solar control window film. www.windowfilm.co.uk.

**University of Ulster**
Academic course notes about Passive Solar Design. (Published 2004, 99 pages.) The latter parts of the notes cover wacky ideas such as:
Thermosyphoning Air Panels.
(The idea was patented in 1881. More recently, the panels have been applied to some refurbishments.)
Roof Space Solar Air Heating Collectors.
Use some of your loft as a sunspace!

Words: 1980

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