6 NATURAL LIGHT

6.1 Introduction

It cannot be stressed too highly how central is natural lighting to memorable architecture. Designers who rely too heavily upon electric lighting for illumination very often produce buildings which are uninteresting and somehow two dimensional. Why is it that a designer produces buildings that people perceive as quality architecture when they design for good daylight?

Consider the buildings that you regard as memorable. Ask yourself whether or not your response to them depends upon:

i) the way natural light interacts with the building form,
ii) the perceived texture of surfaces,
iii) the vistas through the building needed for daylight,
iv) the subtle changes observed under different lighting.

A person's response to buildings will depend upon their own experience and sensibilities, but generally people respond positively to those aspects that a designer is forced to consider when introducing natural light. Just by needing to consider natural light a designer is compelled to play with the form of a building, its spatial layout, the openness of the spaces and the solidity of the façade.

The changing nature of natural light is a part of life

The seasonal rhythms of natural light affect the life cycles of plants and animals. Both flora and fauna respond to the changing length of day and to the reduced levels of daylight seen in Winter. We as individuals appear to be less closely bound to the seasons because we can use electric light to work around the clock and import agricultural produce from around the world. However, there is increasing evidence that we too can be affected by the low levels of light and short days experienced in Winter. One effect that is now widely documented is referred to as Seasonal Affective Disorder – SAD - and this is believed to be partly the result of changing levels of melatonin in the body.

The diurnal rhythms of day and night are so much a part of our daily life that they are taken for granted. Daylight resets our body clock each day and our state of arousal is partly determined by our exposure to high light levels experienced during the day. Depriving people of exposure to daylight without proper compensation for that loss can disturb the physiology of the human body. The psychological need for daylight and its rhythms is even less well understood, although its need is widely recognised in the words of poets.

It is worthwhile considering that we increasingly spend the greater part of our day indoors. Indoors we might be exposed to light levels of the order of a 500 lx, whereas, even in mid-winter, an overcast sky might provide about 5000 lx – 10 times as much. Given this information, if we are receiving too little light during the day then the solution is to go outside for a while rather than to increase the level of electric light indoors. Any increase would be by only a small fraction and this simply would not fully make up for the difference.

The colour of daylight can vary widely from the warm rosy hues of the setting sun to the cool blue of a clear sky. Although plants react to different hues in the spectrum of light there is little direct evidence that humans respond to different colours. However there are those who believe that the colour of light does affect our mood and health and that the range of colours provided by daylight promotes health. Certainly, daylight is a continuous broad spectrum light source and therefore colours and materials appear well under it. For this reason natural light is often the preferred light source in art galleries and museums.

Recent evidence from surveys undertaken in the USA indicate that good levels of daylight in classrooms can materially improve the performance of students. The exact mechanisms through which this occurs is unknown, but the effect is significant and unlikely to have arisen by chance.

Utilising daylight embraces the heart of architecture

Introducing natural light forces designers to think in 3 dimensions. Light must enter through the building envelope, be it either the wall or the roof. The supporting structure may take a number of roles;

i) it can be minimised in order to aid the passage of light to an internal area,
ii) it may be utilized as a screen to filter the light,
iii) it may be positioned to intercept the light in order to create visual interest in itself and reflect light to other areas.

A small light source such as a lamp can be focused and redirected by lenses and mirrors and this is also possible with sunlight because it too is a relatively small source of light. However, the diffuse light from cloudy skies is an extended light source and can not be refocused. If the light from an extended light source is to be redirected by using a mirror, then it will be found that the mirror obscures the same amount of light as it reflects. If it is desired to accentuate the daylight level in one area then it is generally necessary to reduce it in another area. Thus 'obscuration' or shading is an important means of controlling the light from diffuse skies. This applies at all scales of detail within the building, from the design of small louvres within a window, through the design of roof profiles to the arrangement of gross building forms.

Because the main methods of controlling and redirecting diffuse light are those of obscuration and plane reflection, it is the architectural elements themselves which create the patterns of light. Thinking about lighting automatically ensures consideration of architectural form.

The drama of space is mediated through the flow of light

Light may come from any direction of the envelope. Decisions as to where openings in the envelope are positioned will determine the direction from which light arrives in the interior. This flow of light will naturally lead to a particular grading of light level through the room, it may be great or small depending upon the relative position and areas of the windows. Not only will the flow of light affect the appearance of the room's surfaces, but objects within the room will respond to the different directions and strengths of modelling throughout the room.

The flow of light may be clearly defined. A single window will produce a simple and consistent flow of light where the observer is conscious of how light is changing throughout the space. The indirect daylighting of baroque churches produces a much less distinct flow of light and this can lead to a lighting effect which is almost ethereal. Such effects are quite appropriate to reverie and religious buildings but may be perceived as soporific in a working interior.

A room of white surfaces will reflect the light all around so that no matter from where the light originated the resulting light will be uniform. This will soften if not completely eliminate shadows created by the original flow of light into the room. When considering the interior decor it therefore needs to be remembered that surface reflectance not only determines the appearance of a surface but also changes the nature of light in a room.

The sense of enclosure is inseparably linked with windows.

A window is an opening out to the world beyond and it increases the sense of spaciousness that we experience within interiors. This is not only the result of the window physically allowing the eye to gaze beyond the confining surfaces of a room, but it is also in part the result of a perceived link with outside world. This link does not depend upon the actual view seen through an opening, although its quality can affect our response to aspects such as discomfort glare.

One aspect of the experience of Architecture is the sense of enclosure and therefore it is essential that building designers appreciate the ways in which windows modulate the perception of space.

Solid or light, textured or plain, the windows create the façade.

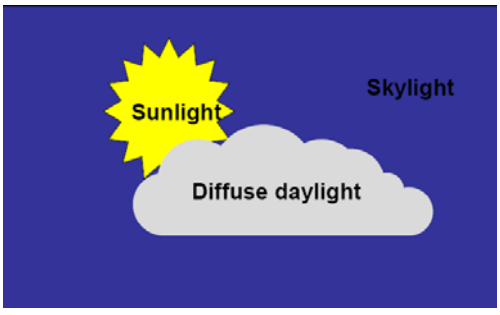
Windows are a major element in the pattern of the façade. If it is desired to bring order to the façade, then it may be necessary to add or omit windows, perhaps even change the proportions of windows. In doing this it may be that other design considerations are compromised. The particular type of glass used and the number of layers of glass may considerably alter the appearance of the glazing and hence the façade. Similarly the apparent transparency of the window will be affected by the light levels beyond the façade and the angles from which the building is to be viewed.

6.2 Simplification of Natural Lighting

Real skies change continuously. The sky becomes brighter towards noon as the sun rises in altitude and its light distribution changes as clouds gather, thicken and disperse. These changes in daylight occur in response to the predictable movement of the sun across the sky and the rather less predictable cloud cover. The almost continuous change that occurs in natural lighting provides good reasons to try and simplify matters. Designers need to appreciate how their buildings will respond to different lighting conditions, but if there is no focus on particular aspects of natural light, then it is difficult to make an assessment of the importance of any changes made to the design of a building.

The basic simplification adopted by designers is to initially consider only the two extremes of natural skies;

a) sunlight with a clear blue sky,
b) a completely overcast sky.



In these notes, the term *'natural'* will be used to describe the lighting under real skies and encompasses all the many unpredictable variations that occur in reality, *'sunlight'* will be used to describe the combined effects of sunlight and a clear blue sky, and *'daylight'* will be used to describe the light under a completely cloudy sky.

The rationale for taking these two extremes is that the building needs to accommodate them. In summer a sunlit building may need to be shaded in order to limit the upper temperature experienced within the building and also to control the experience of glare such that it does not hinder visual performance and comfort. In winter the building needs to provide sufficient daylight on fully overcast days in order to allow occupants to continue working effectively. By considering both cases the designer ensures that the building will perform at the extremes, and it is assumed that it is also likely to work during intermediate states of natural lighting throughout the rest of the year.

6.3 Sunlighting

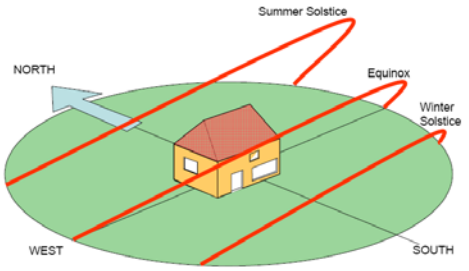
Sunlight can contribute to the working light within a room but it is difficult both to control the light and to estimate the extent of its contribution. For these and other reasons it is only recently that techniques of prediction and analysis have progressed sufficiently to incorporate sunlight illuminances into calculations of usable light within a room. Initially, sunlight will not be promoted as a working illuminant, but as a means of enhancing the quality of a room's environment and improving the outside areas around buildings.

From evidence available even the most primitive civilizations recognised the importance of the sun as a source of light to the world. Indeed, in some cultures the sun was seen as being such an important part in life that it became a symbol that was synonymous with life itself. Unfortunately in the world of today it is all too easy to forget about how necessary is sunlight to our well being because the sun is no longer the only practical source of light.

To those sensitive to the world about them the fundamental importance of sunlight is a self evident truth, however, intuitions do not necessarily provide firm foundations for design. Fortunately, there is much evidence that sunlight has both beneficial physiological and psychological effects which have a direct impact upon the quality of our lives. It is also true that utilizing natural light as a working illuminant is one of the most effective ways of making use of natural resources and the provision of natural lighting has been an essential aspect of planning buildings in the past. For these reasons it is worthwhile knowing how considerations of sun lighting contribute to the design of buildings.

6.3.1 Initial aspects of designing for sunlight

Considerations of sun lighting can be a great help in planning a building. They have the advantage that they can be both used effectively by the designer and appreciated by those using and viewing a building. A further advantage of using sun lighting as a primary design criteria is that the basic facts needed for design are simple and have probably been known to readers from their schooldays, i.e.:



i) the sun is almost due south at noon,
ii) the sun rises in the east and sets in the west,
iii) the sun is higher in the sky in summer than it is in winter.

Although simple, when they are considered in relation to the particular requirements of a design, these facts can be invaluable in helping to sort out the overall planning of a building. Consider the example of a house that is to be built in the temperate British climate.

Because of a perceived deficiency in the hours of sunlight, people will generally wish to make the most of whatever sunlight there is and under these circumstances the following points might be considered;

(i) it is pleasant to awake in the morning with sunlight streaming through the window and therefore as the sun rises in the east it might be worthwhile placing bedroom windows on an easterly aspect,

(ii) kitchens can be rather warm because of all the heat generated when cooking and therefore one should consider placing a kitchen or pantry on a northern facade in order to prevent sunlight further raising the room temperature. Also in a working room where one will be using sharp knives it is preferable to have an even light free from hard shadows across the working surface,

(iii) lounges are mostly used in the afternoon and evening and because they are places of relaxation the presence of sunlight is generally welcomed. By placing the lounge on a southern or western aspect the most can be made of the afternoon and evening sun.

(iv) the low altitude of the sun in winter makes northern slopes less favourable than southern slopes, and therefore southern slopes will normally be developed before northern slopes.

(v) obstructions to the south are that much more critical and where it is intended to plant trees on the boundary it is better that they are deciduous so that they loose their foliage in winter and thus admit sunlight onto the site.

These points make it quite clear that considerations of sunlight can, and indeed should play an important role in helping to generate the form of an architectural design.

Of course the above suggestions cover only a single aspect of the design and they should not necessarily override all other considerations. Also, the way in which the design is affected by considerations of sunlight will vary depending on the priority given to different environmental factors by the client. For example, it might well be that a client prefers a splendid view from the kitchen and this might only be available on a western aspect, or a client might be keen on watching television throughout the day and therefore the penetration of sunlight might need to be restricted in order to reduce glare on the television screen.

These last two examples illustrate the fact that even though the basic facts about sunlight are easily appreciated there is no simple recipe that can ensure a design will satisfy a client's wishes.

6.3.2 The need for more detailed design

Although these simple facts may help when planning a building, there is merit in knowing how to predict with a little more accuracy the sun's position at different times of day and year.

This is because there are buildings such as museums, art galleries, sports halls and libraries where it is necessary to closely control the sunlight entering the building in order that critical visual tasks are performed under good lighting conditions.

Also, the increased use of Visual Display Units has also increased the disruption to working caused by sunlight. The screens of VDU's are not very bright and the extremely high brightness of the sun and sunlit surfaces can considerably reduce the visibility of the display.

Additionally, shading devices might be crucial to achieving a comfortable thermal environment during the summer and in order to properly control the transmission of sunlight they may need to be designed to quite close tolerances.

There are a number of techniques that can be used to investigate the position of the sun. Although in architectural applications the accuracy required is less than that expected in astronomical or navigational work, there is a need for information to be readily understood by the designers and clients, and easily applied to design problems. These needs mean that there is no single method that can be recommended above all others and particular techniques will be appropriate for different circumstances. One method will better allow a client to appreciate a problem whilst another might prove easier as a design tool that will ensure the shading of sunlight at defined times.

An ability to use the more involved techniques will not only facilitate the detailed consideration of sun lighting on the more critical projects, but it also enables designers to predict the position of the sun at latitudes where they have no experience to guide their judgment.

Knowledge of the basic astronomical facts is not essential for the successful application of the prediction techniques, but they are briefly described later in order to help with understanding some technical terms.

6.3.3 Additional factors in sun lighting design

One feels intuitively that sunlight is an important element in people's lives and there have been attempts to establish just how important by surveying people's responses to sunlight in buildings. However, because of the complexity of our interactions with the environment, these surveys rarely do more than confirm that sunlight is indeed an important factor. In many ways this absence of a clear hierarchy in the priorities of various environmental factors is heartening to

designers, for it presents them with the freedom to make decisions according to the circumstances. However in order to utilise this freedom the designer must be aware of the benefits and problems associated with the different aspects of the environment.

Benefits of Sunlight

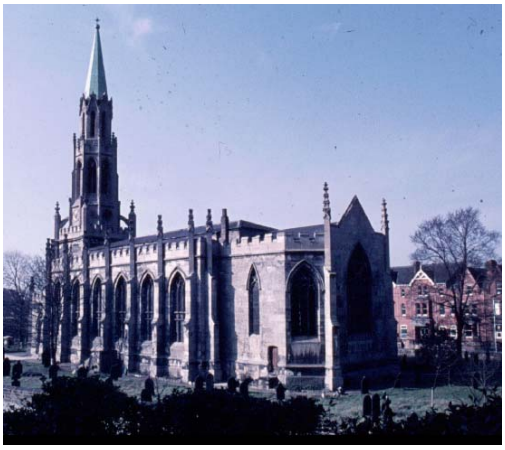
a) the sheer intensity of sunlight provides a sparkle and brilliance that can transform what might otherwise be a dull scene,

b) the directionality of sunlight means that there is often the added feature of heightened contrasts between areas in sunlight and those in shadow,

c) that same directionality of light will reveal the texture of building surfaces and the form of a composition,

d) the movement of the sun across the heavens ensures that it will reveal different aspects of building form at different times of day,

e) the regular nature of its course across the sky means that it can act as a timekeeper,

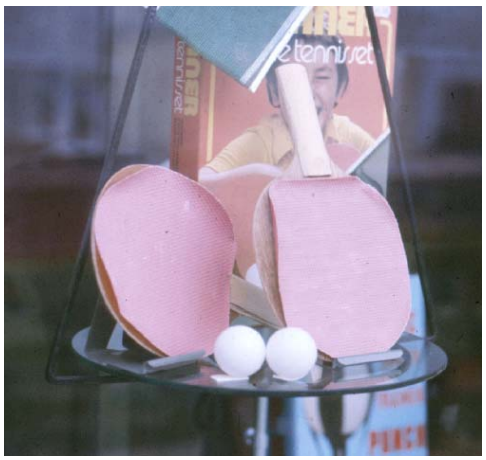


f) the changing nature of sunlight through clouds provides a variety of appearance which gives life to a perhaps otherwise static scene,

g) a shaft of sunlight piercing through a window can provide a tangible link to the outside world for those cocooned within a building,

h) the sun also has non visual effects which are of benefit to humans, it is a bactericidal agent against pathogens, is necessary for the synthesis of vitamin D and possibly has other direct physiological effects upon the body,

i) there is a warmth to the sun which can be utilized to help heat a building and ensure that external areas do not become dank and mouldy.



Possible problems :

a) direct sunlight generally makes written material too bright to read,

b) sunlight can cause excessive direct glare and even when reflected from glass it can be uncomfortably bright,

c) shadows cast by sunlight can cause mis-perceptions of form and shape,

d) material in shadow may be difficult if not impossible to see,

e) excessive insolation will result in buildings overheating,

f) it is uncomfortably hot to work in sunlight if there is little or no breeze to cool one down,

g) the heat and UV in sunlight can be harmful to materials and cause a deterioration of their physical properties,

h) excessive UV can harm living organisms.

6.4 Simple guidance for sun lighting

In the past guidance was provided in codes of practice for certain building types, such as houses and schools, but these were not enforceable by law and are no longer current. However they are listed here as guidance.

BS CP 3 1b Sunlight

a) Domestic buildings

Living rooms: 1 hour/day for 10 months from Feb. to Nov.
Kitchen and bedrooms: some insolation if possible

b) Teaching spaces

Two hours a day throughout the year.

The codes of practice have been superseded by a BRE report,

" Site layout planning for daylight and sunlight - a guide to good practice " by P J Littlefair.

Here it is suggested that a building will receive reasonable sunlight if;

i) At least one main window faces within 90° of due south,

ii) on this wall, all points on a line 2m above ground level are within 4m sideways of a point which receives at least a quarter of annual probable sunlight hours, including at least 5% during the winter months between 21 September and 21 March;

and a garden will appear adequately sunlit throughout the year if;

i) less than 40% and preferable no more 25% of the garden is shaded on 21 March.