Desktop guide to daylighting – for architects
RIBA PLAN OF WORK

The process of creating a building can be divided into a number of definable stages which take the project from the early discussions and rough sketches through to more detailed design drawings and finally to the building operations on site.

The RIBA Plan of Work does just this and divides the whole process into stages A to M. It provides a model outline procedure for methodically working through the whole design and construction process by all the different members of the design team.

At each of the stages, a different level of daylighting design input is needed. This Guide is written to reflect this need. It is written to assist the designer at Stage C (Outline Proposals), Stage D (Scheme Design) and Stage E (Detail Design).

The stages of the RIBA Plan of Work that lead up to going out to tender are:

- **STAGES A AND B**  
  Inception and Feasibility for appraisal in order to decide whether and how to proceed.

- **STAGE C**  
  Outline Proposals to develop the brief and determine the general approach to layout, design and construction.

- **STAGE D**  
  Scheme Design to finalise brief, decide final direction using input from other consultants, complete a full design and submit for approvals.

- **STAGE E**  
  Detail Design to obtain the final decisions on all matters relating to design specification, construction, and cost.

- **STAGE F**  
  Production Information to produce the details of the design in order to complete the drawings, schedules and specifications in readiness for preparing the Bill of Quantities for tendering.

- **STAGE G**  
  Bill of Quantities to complete the documentation for tendering.

- **STAGE H**  
  Tender action to invite tenders from contractors.

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DAYLIGHTING BASICS

INTRODUCTION
This Guide gives a straightforward summary of daylighting practice in climates such as Britain’s. It describes the aims of good design, lists some useful rules of thumb and provides references to more detailed information. It links recommendations to the stages of the RIBA Plan of Work.

The work to prepare this Guide was undertaken in the following way. First, a survey was made of standards and codes of practice relating to daylighting. The primary items were those listed in the references, but the search also included CIBSE lighting guides, BRE publications, textbooks on lighting design, EU reports and some publications from other countries. It was directed towards two questions:
- what were the essential criteria of basic daylighting design
- what simple formulae or rules were available to guide the architect in practical design?

Next, discussions were held with a number of practising architects. The aim was to find what structure would be most appropriate for the presentation of the information. The outcome of this was a clear recommendation that the layout should be related to the different stages of work in the progress of a building design and, in particular, that the RIBA Plan of Work would provide a suitable categorisation.

User satisfaction and energy efficiency
People prefer rooms that appear daylit to interiors dominated by electric lighting. In addition, the use of natural lighting can significantly reduce a building’s use of energy. Neither result, though, is dependent on simply the quantity of daylighting in a room. Occupants’ judgements are based on several factors, including the quality of the view outside, the relative brightness of the various room surfaces, whether direct sunlight enters the space, and the amount of light falling on task areas. It is also found, in post-occupancy research, that the success of a scheme in reducing energy is not determined solely by the quantity of light from windows. For an energy-saving design to operate well, it is essential that there is a good control system for the electric lighting and that building users are motivated towards energy management.

Occupant satisfaction and energy use are related. If, for example, people in an office are troubled by glare or have visual difficulties with tasks, they tend to misuse any lighting control system. Research shows that they may also do so if they are too hot or the room is too noisy, or if they dislike their work for any reason. The various physical and social factors that affect people’s comfort and attitude are interlinked.

The primary reference in the UK for daylighting criteria is BS 8206 ‘Lighting for buildings: Part 2: Code of practice for daylighting’. This describes the qualities to be achieved in providing a view, in sunlight penetration, in general room lighting and in task lighting. In its recommendations the British Standard treats daylight as two distinct sources of light: skylight, the diffuse light from the whole sky, and sunlight, the direct solar beam. These have different criteria for quality and different methods of calculation, and must be considered separately by the designer.
**Outline Proposals**

**Skylight**

In cloudy climates, diffuse light from the sky is the main source of daylighting. At the site planning stage the aim is to ensure that there is a sufficient area of sky visible to give good interior lighting with windows of reasonable size. The availability of skylight at a window is determined primarily by the block form of the building and its surroundings, so wrong decisions at an early design stage are difficult to correct later.

The reference point is taken to be the centre of the window opening and the angle of obstruction is measured perpendicular to the window, as in Figure 1.

Daylighting in the early stages of design is covered by the BRE publication ‘Site layout planning for daylight and sunlight’ (BR209). As well as considering daylighting for a new building, it describes how to assess the obstruction of daylight to existing buildings, and the needs of site layout for passive solar design.

**Sunlight**

People’s needs and preferences for sunlight depend on the type of building – incoming sunlight can give warmth and brightness but can also cause glare and thermal discomfort. It is the responsibility of the architect in the analysis of clients’ requirements to determine which parts of a building would benefit from direct sunlight – for visual reasons, thermal comfort or energy gains – and from which areas direct sunlight should be excluded.

BS 8206 states that in principle sunlight should be admitted unless it is likely to cause thermal or visual discomfort to the users, or deterioration of materials. It then gives the following guidance:

‘Interiors in which the occupants have a reasonable expectation of direct sunlight should receive at least 25% of probable sunlight hours; at least 5% should be received during the winter months (23 September to 21 March).’

‘Probable sunlight hours’ is the long-term average of the number of hours during the year in which direct sunlight would fall on unobstructed ground at that location. In London, for example, this is about 1500 hours per year (see BR209).
Using the block layout of a scheme, rule of thumb 2 checks that adequate sunlight is available at the positions of critical windows.

The rule is based on achieving 25% probable sunlight hours (including 5% in winter) on the face of the window. The angle of 25° is measured in the same way as for skylight (figure 1). The difference between the two rules is the need for orientation of windows for sunlight.

**Complex skylines**

It is possible for adequate skylight and sunlight to fall on a window where part of the opposite skyline lies above 25° and other sections are lower.

If there is only moderate variation, drawing a horizontal line at the average height provides a reasonable estimate, as in figure 2.

Where the skyline varies greatly in height – such as where a window looks into a courtyard – a more precise calculation is needed in critical cases. Techniques are described in BR209, which gives graphical methods for checking sunlight availability by estimating probable sunlight hours. For calculating skylight availability it gives a routine for finding the vertical sky component (this is the ratio of light received on a vertical surface from an overcast sky to that received by unobstructed ground).

The techniques enable the effects of complex obstructions to be compared with simple horizontal skylines.

**View**

Unless the function of the building requires the exclusion of daylight, views to the exterior should be provided. Windows give information about the outside – the weather and the time of day – and this is at least as important to the occupants of a building as the level of interior lighting. Almost any view is better than none, but the following points are found in research on users’ preferences.

- Views of natural objects are preferred to those of buildings and man-made objects.
- Preferred views include the horizon but not a high expanse of sky.
- Views of people and activities are needed by those confined in buildings such as residential homes and hospitals.
- Some views are considered essential for security and supervision – such as the approach to the front door of a dwelling, or clear supervision of children playing.
- If, in workplaces such as offices, there are windows in only one side of a room, a minimum glazed area of 20% of the inside...
Rule of thumb
A room can have a daylit appearance if the area of glazing is at least 1/25th of the total room area.

It is important to note that windows designed to give preferred views must usually look out at the horizon and below; therefore they may not alone give sufficient light in the room to achieve a bright daylight appearance or illuminate workplaces adequately.

Skylight and optimum window size
Achieving very high levels of daylight usually means large windows and tall rooms; these are associated with excessive heat gain and loss, and a high building cost. Conversely, with very small windows, little use is made of daylight as a source of energy; in addition, occupant satisfaction tends to be lower. For most buildings the graph of lifetime energy costs against window size is U-shaped, as in figure 3: the optimum is found where daylight and electric light complement each other during daytime hours.

Skylight and room appearance – the average daylight factor
An interior can look daylit even if the task lighting is predominantly electric. What is required is that the main room surfaces receive enough natural light. Daylight – direct and inter-reflected – on the walls and ceiling is important to users, not only because it enhances the overall brightness of the room but because it carries information. It changes continuously, and people can sense the outside even without a direct view.

The ‘total room area’ is the sum of the floor, ceiling and wall areas, including the window. Rule of thumb 3 works on the assumption that the room is approximately rectangular in plan and that there are no factors that significantly reduce the amount of light in the space, such as dark surfaces, low transmittance glazing or high external obstructions (more than 25°).

The rule of thumb is based on achieving an average daylight factor of 2% at table-top level in the room. (The ‘daylight factor’ is the amount of daylight at a point expressed as a percentage of the daylight falling on an unobstructed horizontal surface outside, excluding direct sunlight.)

In cloudy climates, the average daylight factor indicates the likely daylit appearance of a room:

- **less than 2%**
  - room looks gloomy under daylight alone
  - full electric lighting often needed during daytime
  - electric lighting dominates daytime appearance

- **2%-5%**
  - windows give a predominantly daylit appearance but supplementary electric lighting needed
  - usually the optimum range of daylighting for overall energy use

- **5% or more**
  - the room is strongly daylit
  - daytime electric lighting rarely needed
  - major thermal problems from large windows.
These daylight factors apply to rooms with side windows. With rooflights a room looks darker at a given daylight factor because relatively less light falls on the walls. To achieve a comparable appearance with rooflights, higher average daylight factors are needed, depending on the type of the openings and the shape of the room. In the extreme, with horizontal rooflights over a large open plan, the values in the table need to be almost doubled.

The average daylight factor can be used at an early design stage to estimate the total glazed area required. It is easily calculated:

$$D = \frac{A_g \theta T}{A \left(1-R^2\right)}$$

where the meaning of the symbols in the equation is as follows:

- $D$: average daylight factor
- $A_g$: glazed area of windows (not including window frames, glazing bars or other obstructions)
- $\theta$: angle of visible sky, measured in section from the centre of the window opening in the plane of the inside window wall, as in figure 4
- $T$: transmittance of glazing to diffuse light, including the effect of dirt
- $A$: total area of enclosing room surfaces: ceiling + floor + walls (including windows)
- $R$: mean reflectance of enclosing room surfaces.

The equation shows that the amount of interior daylight is directly proportional to glazing transmittance. Tinted glass absorbs light and can reduce daylight greatly, depending on the colour; low-emissivity (low-e) glazing is better. The reflectance of room surfaces affects both the total amount of light in the space and its distribution. For generous daylighting, surfaces need to be as light-coloured as possible.

Even if the average daylight factor is high, supplementary electric lighting may be necessary if a room is to be very deep or L-shaped.

It is necessary to distribute the calculated area of glazing so that daylight can reach all parts of the room; it is especially valuable to have windows in more than one wall. Unless the sky is visible, a point is lit only by interreflection. This rarely provides sufficient light for visual tasks, and the room appears gloomy unless surface reflectances are high (rule of thumb 4).

Sunlight control
Even in rooms where sunlight is desirable it is always necessary to provide a means of controlling this, to prevent overheating or damage to materials. The obstruction caused by shading devices must be estimated and taken into account in daylight factor calculations.

Where sunlight penetration needs to be restricted, this is best done by window orientation and by exterior obstructions. Trees can give good shading; deciduous trees are especially valuable in reducing sunlight more in summer than in winter.
Rule of thumb

Surfaces that are closer to a window than twice the height (2h) of the window head above desktop level, receive adequate daylight for tasks for most of the working year (see figure 5).

The rule of thumb assumes that there is no significant loss of light due to external obstructions, tinted glazing or interior screening. It then approximately defines a zone where the daylight factor is always above 2% on desktops. The rule illustrates the importance of window head height (and therefore ceiling height) to daylight distribution. The higher the window, the deeper the zone of strong daylight.

Lighting requirements of tasks, and the illuminances required, are given in the ‘CIBSE Code for interior lighting’. This also outlines a method for calculating the daylight factor at a point and then using it to find the number of hours during the year that daylight would provide sufficient task illuminance. BS 8206 also gives the method. Various computer programs are available, usually as part of larger software packages, to calculate daylight factors at points in a room; these can be used with the graphs of daylight availability given in the CIBSE Code and BS 8206 to predict hours of sufficient daylight.

Detail Design

Lighting for task performance

The daylight factor indicates the balance between the daylight outside and the amount of natural light within a room. It can be used as a measure of the brightness appearance because the eye adapts to the ambient level of lighting. For good working conditions it is necessary also to ensure that the task illuminance is above a minimum level. (‘Illuminance’ is the amount of light falling on a surface; it is measured in ‘lux’.) The required illuminance depends on the purpose of the room – from 100 lux typically in corridors and changing rooms to 2000 lux for tasks involving minute detail and low contrast. To achieve high levels of daylight it is necessary to plan the room so that workplaces are related to window positions. A rule of thumb is illustrated in figure 5.
Good task lighting involves more than providing a sufficient level of illuminance. Also important are the directionality of the lighting and the avoidance of glare – direct and reflected.

Most working surfaces are partly glossy, so special care must be taken with the placing of horizontal tasks in relation to luminaires and rooflights and of computer screens in relation to side windows – as in rule of thumb 6 and figure 6.

**Daytime electric lighting**

With some room shapes and layouts, full daylighting leads to the lowest lifetime costs of money and energy. But with many buildings, particularly those above domestic scale, it does not – the best value is given where daylight is supplemented by controlled electric lighting.

The electric lighting must then serve two distinct purposes during daylight hours:
- to enhance the general brightness of the room, reducing glare and gloominess
- to increase illumination on visual tasks.

Daytime electric lighting is usually required for a bright room appearance when the average daylight factor is less than 5%. It should supplement the daylight and not swamp its natural variation. The amount needed depends on the type of task and hence the illuminance required.

No energy saving is made from daylight availability if the use of electric lighting does not respond. In a medium-size rectangular room this means, typically, that lights distant from the window wall are always on during the day, those close to the windows are switched on only after dusk, and intermediate lights react to changing conditions (see figure 7).

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**Rule of thumb**

Imagine that surfaces on and around the task are mirror-like. If the person at work would see a light source reflected then in practice there may be reflected glare.

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**Figure 6 Sightlines to computer screens are best parallel to windows**
Where activities permit, good value is given by local task lighting instead of overall workplace illumination.

Local manual switching is an alternative to automatic control but full energy savings occur only when electric lights are continuously dimmable in response to changing daylight. The high-frequency electronic ballasts required to dim fluorescent lamps smoothly have at present a higher initial cost than conventional controls but can give lower long-term costs. They offer other efficiency savings too and are likely to become the normal solution.

With all types of environmental control in buildings, user acceptability is essential to energy-saving success.

Figure 7 Control of electric lighting. (A lighting layout such as this must be checked in plan to ensure that desktop reflections are avoided.)
REFERENCES


Introductory guides for architects


Technical references


NOTES

[1] Transmittance

The diffuse transmittance of clear single glazing is approximately 0.8; clear double glazing approximately 0.7. Low-emissivity double glazing has a diffuse transmittance of about 0.65 but the value for tinted glazing can be even lower (eg 0.4 for 6 mm grey glass). Other types of glazing are listed in BS 8206 and in manufacturers’ literature but care must be taken to use values of diffuse transmittance, which is lower than the transmittance of a beam perpendicular to the glazing. Dirt typically gives a further 5% reduction with normal cleaning in an urban setting but this can become 20% or more with horizontal rooflights in industrial areas.

[2] Reflectance

During design, this can often be only an educated guess; typical values are 0.5 for a room with white ceiling and light-coloured walls, 0.3 for a normal office or living room.

DETR ENERGY EFFICIENCY BEST PRACTICE PROGRAMME PUBLICATIONS

The following publications are available from BRECSU Enquiries Bureau. Contact details are given below.

Thermie maxibrochure: ‘Energy Efficient Lighting in Buildings’

General Information Report

27 Passive solar estate layout
35 Daylighting for sports halls

Good Practice Guide

160 Electric lighting controls – a guide for designers, installers and users

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