

Lighting for buildings —

Part 2: Code of practice for daylighting

Committees responsible for this British Standard

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Foreword

This Part of BS 8206 has been prepared under the direction of the Basic Data and Performance Criteria for Civil Engineering Building Structures Standards Policy Committee. It supersedes DD67:1980 and DD73:1982, which are withdrawn.

The standard describes good practice in daylighting design and presents criteria intended to enhance the well-being and satisfaction of people in buildings, recognizing that the aims of good lighting go beyond achieving minimum illumination for task performance. Simple graphical and numerical methods are given for testing whether the criteria are satisfied, but these are not exclusive and computer methods may be used in practice. Sunlight and skylight data are given.

The aim of the standard is to give guidance to architects, builders and others who carry out lighting design. It is recognized that lighting is only one of many matters that influence fenestration. These include other aspects of environmental performance (such as noise, thermal equilibrium and the control of energy use), fire hazards, constructional requirements, the external appearance and the surroundings of the site. The best design for a building does not necessarily incorporate the ideal solution for any individual function. For this reason, careful judgement should be exercised when using the criteria given in the standard for other purposes, particularly town planning control.

The standard should be used in association with BS 8206-1: Code of practice for artificial lighting. Additional information on the design of windows is to be found in the CIBSE publications *Code for Interior Lighting* (1984)¹⁾ ²⁾ and *Applications Manual: Window design* (1987)²⁾.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 36, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

¹⁾ In course of revision: publication expected in late 1992.

²⁾ Available from the Chartered Institution of Building Services Engineers, Delta House, 222 Balham High Road, London SW12 9BS.

Section 1. General

1 Scope

This Part of BS 8206 gives recommendations regarding design for daylight in buildings. It includes recommendations on the design of electric lighting when used in conjunction with daylight. Section 1 describes the scope of the work and gives definitions of some of the terms used in the standard. Section 2 gives criteria for the provision of view, for the use of skylight and sunlight for general room lighting and for the design of daylighting for task performance. Section 3 comprises recommendations for the design of supplementary electric lighting and other related design issues. In Section 4, methods of calculation are given. Some data for calculations are listed in Appendix A. Standard service and design service illuminances are given in Appendix B, reproduced from BS 8206-1. Appendix C is a bibliography.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 8206, the definitions given in BS 6100 apply, together with the following.

2.1 General

2.1.1 daylight³⁾

combined sunlight and skylight

2.1.2 window⁴⁾

construction for closing a vertical or near vertical opening in a wall or pitched roof that will admit light and may admit fresh air

2.1.3 rooflight⁴⁾

construction for closing an opening in a flat roof or low pitched roof intended primarily for lighting and consisting of a frame and glazing

2.1.4 transom⁴⁾

horizontal member across an opening or frame of a window or door

2.1.5 obstruction

anything outside a building which prevents a direct view of the sky from a given reference point

2.1.6 no-sky line

the outline on a given surface of the area from which no sky can be seen

2.1.7 working plane³⁾

horizontal, vertical or inclined plane in which a visual task lies

NOTE If no information is available, the working plane may be considered to be horizontal and 0.7 m above the floor for offices; horizontal and 0.85 m above the floor for industry.

2.1.8 room reference point

the point in an interior for which the daylight factor is calculated

2.1.9 window reference point

the point in the centre of a window or rooflight opening on the plane of the inside surface of the window wall or roof. This is used in determining sunlight penetration, average daylight factor, and the internally reflected component

2.1.10 supplementary electric lighting

electric lighting used continuously in combination with daylighting

2.2 Sunlight

2.2.1 sunlight³⁾

part of solar radiation that reaches the earth's surface as parallel rays after selective attenuation by the atmosphere

2.2.2 possible sunlight hours⁵⁾

the total number of hours during the year in which the centre of the sun is above the unobscured horizon

2.2.3 probable sunlight hours⁵⁾

the long-term average of the total number of hours during the year in which direct sunlight reaches the unobstructed ground

2.2.4 solar altitude³⁾

angular height of the sun above the horizon

³⁾ Repeated from BS 6100-3.4.

⁴⁾ Repeated from BS 6100-1.3.5.

⁵⁾ A period of *possible sunlight hours* is approximately the total time that sun would shine on the ground with a cloudless atmosphere. A period of *probable sunlight hours* is the mean total time of sunlight when cloud is taken into account.

2.2.5 solar azimuth⁶⁾

horizontal bearing of the sun measured in degrees, either in a clockwise direction from north or in relation to due south

2.3 Skylight

2.3.1 skylight⁶⁾

part of solar radiation that reaches the earth's surface as a result of scattering in the atmosphere

2.3.2 CIE standard overcast sky (Commission Internationale d'Éclairage)

a completely overcast sky for which the ratio of its luminance L_γ at an angle of elevation γ above the horizon to the luminance L_z at the zenith is given by the formula

$$L_\gamma = \frac{L_z(1 + 2 \sin \gamma)}{3}$$

2.3.3 daylight factor⁷⁾

ratio, expressed as a percentage, of illuminance at a point on a given plane due to light received directly or indirectly from a sky of known or assumed luminance distribution, to illuminance on a horizontal plane due to an unobstructed hemisphere of the sky

NOTE For the purposes of this standard, it is assumed that, unless stated otherwise, the sky has the luminance distribution of the CIE standard overcast sky.

2.3.4 average daylight factor⁷⁾

ratio of total daylight flux incident on a reference area to the total area of the reference area, expressed as a percentage of outdoor illuminance on a horizontal plane due to an unobstructed sky of assumed or known luminance distribution

NOTE For the purposes of this standard, it is assumed that the average daylight factor is the mean daylight factor over a horizontal working plane, unless stated otherwise.

2.3.5 sky factor⁷⁾

ratio, expressed as a percentage, of the parts of illuminance at a point on a given plane that would be received directly through unglazed openings from a sky of uniform luminance, to illuminance on a horizontal plane from an unobstructed hemisphere of this sky

2.3.6 sky component⁷⁾

ratio, expressed as a percentage, of that part of illuminance at a point on a given plane that is received directly from a sky of assumed or known luminance distribution, to illuminance on a horizontal plane due to an unobstructed hemisphere of this sky

2.3.7 externally reflected component⁷⁾

ratio, expressed as a percentage, of that part of illuminance at a point on a given plane that is received directly after reflection from external obstructions under a sky of assumed or known luminance distribution, to illuminance on a horizontal plane due to an unobstructed hemisphere of this sky

2.3.8 internally reflected component⁷⁾

ratio, expressed as a percentage, of that part of illuminance at a point on a given plane that is received after reflection from interior surfaces under a sky of assumed or known luminance distribution, to illuminance on a horizontal plane due to an unobstructed hemisphere of this sky

⁶⁾ Repeated from BS 6100-3.4.

⁷⁾ Direct and reflected sunlight are excluded from all values of illuminance.

Section 2. Aims and criteria for design

3 The contribution of daylight

Daylighting gives to a building a unique variety and interest. An interior which looks gloomy, or which does not have a view to the outside, when this could reasonably be expected, will be considered unsatisfactory by its users. The quality of daylight cannot be described by simple photometric measures alone. Good practice in design reflects a concern for the well-being and satisfaction of people in buildings, and the recommendations of this Part of BS 8206 recognize that a principal aim of the designer is to produce interiors which are comfortable and give pleasure to their occupants.

Windows serve several purposes, some of which are outside the scope of this standard. Even in the daylighting of rooms, the best size and shape of a window opening is rarely determined by one purpose alone. A window designed to give a good view outside may transmit little light to the back of the room and one that controls well the penetration of sunlight may give poor illumination on overcast days. There are various technological ways of transmitting daylight to an interior and each has different characteristics.

Recommendations are made in this section about three separate uses of windows, which are:

- a) for view;
- b) to enhance the overall appearance of interiors, using sunlight (the direct beam) and skylight (diffuse daylight);
- c) for illumination of visual tasks.

It is important to consider the primary function to be served by each window or rooflight in a building, because the criteria differ. Two of the functions, the overall illumination of the interior and the task illumination, may be fulfilled also by electric lighting, which has different qualities. For many buildings, the best design uses daylighting and electric lighting together during daytime hours.

4 Windows and view

4.1 Principle

Unless an activity requires the exclusion of daylight, a view out-of-doors should be provided irrespective of its quality.

All occupants of a building should have the opportunity for the refreshment and relaxation afforded by a change of scene and focus. Even a limited view to the outside can be valuable. If an external view cannot be provided, occupants should have an internal view possessing some of the qualities of a view out-of-doors, for example, into an atrium.

4.2 Analysis of view

In planning the position of windows, the following factors are important.

- a) Most people prefer a view of a natural scene: trees, grass, plants and open space.
- b) A specific close view may be essential, particularly for security and supervision of the space around dwellings.
- c) There is often a need for privacy. This varies with the building type and with the expectations of the users. The view into a building should be considered when the view outwards is determined.

Most unrestricted views have three “layers”, as follows:

- 1) upper (distant), being the sky and its boundary with the natural or man-made scene;
- 2) middle, being the natural or man-made objects themselves;
- 3) lower (close), being the groundscape forming the foreground of the view.

Views including all three “layers” are the most completely satisfying.

4.3 View in urban areas

In densely built-up areas, a view of the natural scene may not be available. When only buildings, sky and street can be seen, it is especially desirable that the view be dynamic, i.e. including the activities of people outside and the changing weather, but even a static view is usually better than none.

4.4 Size and proportion of windows

The size and proportion of windows should depend on the type of view, the size of the internal space, and the position and mobility of occupants. Some circumstances may suggest a tall window which allows occupants anywhere to enjoy the full vertical span of the view. A narrow horizontal window will only offer a similar prospect to those close to it; a narrow vertical window is also restrictive yet will admit a deeper penetration of daylight. For a given area of window, the more exaggerated the horizontal or vertical proportions, the more restricted will be the position of occupants who can experience the views. A view of the immediate foreground will be experienced normally only by those close to the window.

Unless a view of the sky is to be deliberately excluded (and the penetration of daylight severely limited) window heads should be above standing eye height. Sills, normally, should be below the eye level of people seated. Transoms should not obstruct significant parts of the view from normal standing or sitting positions. Special consideration should be given to window heights in rooms used by the elderly or the handicapped.

The most limited views occur in a deep room when windows are confined to one wall only. Table 1 gives guidance on minimum window area for a satisfactory view when fenestration is restricted to one wall: higher proportions are recommended. The table gives total window area of the room as a percentage of the internal window wall area. When there are windows in two or more walls, the total area of glazing should not be less than the area that would be recommended if the windows were restricted to any one wall. The openings should be distributed to give views from all occupied areas of the room.

Table 1 — Minimum glazed areas for view when windows are restricted to one wall

Depth of room from outside wall (max.)	Percentage of window wall as seen from inside (min.)
m	%
< 8	20
8 – 11	25
11 – 14	30
> 14	35

NOTE Windows which are primarily designed for view may not provide adequate task illumination.

5 Daylight and room brightness

5.1 General

The value of daylight goes beyond the illumination of tasks: a daylit room varies in brightness with time; colours are rendered well; architectural form and surface texture can be enhanced by the direction of illumination. Above all, windows give information to the people in a building about their surroundings. Weather and the time of day can be inferred from the changing light.

The user’s perception of the character of a daylit interior (often described in terms like “bright and well-lit”, or “gloomy”) is related to the brightness of all the visible surfaces. This overall luminance depends on the quantity of light admitted and the reflectance of interior surfaces. The reflected light within the room is as important as the direct illumination.

Sunlight and skylight are both important in general room lighting, but they differ greatly in their qualities. The criteria for each should be satisfied. Sunlight gives patches of high illuminance and strong contrasts; adequate skylight ensures that there is not excessive contrast between one area of the room and another, or between the interior and the view outside.

If the total glazed area cannot be made large enough for adequate general daylight, supplementary electric lighting is needed to enhance the general room brightness in addition to any need there may be for task illumination (see 7.2).

5.2 Sunlight: principle

Sunlight should be admitted unless it is likely to cause thermal or visual discomfort to the users, or deterioration of materials.

Rarely is the controlled entry of sunlight unwelcome in buildings in the UK. Dissatisfaction can arise as much from the permanent exclusion of sunlight as from its excess. However, uncontrolled sunlight is unacceptable in most types of building. Good control is particularly important in working interiors and other rooms where the occupants are unable to move around freely. Generally, sunlight should not fall on visual tasks or directly on people at work. It should, on the other hand, be used to enhance the overall brightness of interiors with patches of high illuminance.

Considerations of sunlight should influence the form of the building from the early stages of design, because incorrect decisions about the orientation of rooms or the geometrical shape of the building may preclude the admission of sunlight or cause excessive overshadowing of surroundings. The orientation of windows should take into account the periods of occupancy and any preferences for sunlight at particular times of day. The provision of sunlight is important in dwellings, particularly during winter months. Sunlight is especially valued in habitable rooms used for long periods during the day and in buildings, such as those for the elderly, where the occupants have little direct contact with the outside. In some cases, it is important that there should be direct sunlight on external surfaces seen from a window.

NOTE Sunlight entering a room can have a significant effect on thermal comfort and on the energy consumption of the building. In winter it can be an important contribution to the heating; but excessive solar gain causes serious discomfort and, in air-conditioned buildings, unnecessary use of energy in cooling. Sunlight as a source of thermal energy is considered in BS 8207 and in BS 8211-1.

5.3 Sunlight duration

Interiors in which the occupants have a reasonable expectation of direct sunlight should receive at least 25 % of probable sunlight hours (see 2.2.3). At least 5 % of probable sunlight hours should be received during the winter months, between 23 September and 21 March. Sunlight is taken to enter an interior when it reaches one or more window reference points. A calculation procedure is given in 12.2.

The degree of satisfaction is related to the expectation of sunlight. If a room is necessarily north-facing or if the building is in a densely-built urban area, the absence of sunlight is more acceptable than when its exclusion seems arbitrary. It is the duration of sunlight in an interior, rather than its intensity or the size of the sunny patch, which correlates best with the occupants' satisfaction.

NOTE In many buildings, discomfort and overheating may occur if the annual penetration of sunlight exceeds one-third of probable sunlight hours.

5.4 Skylight: principle

The general illumination from skylight should be such that there is not excessive contrast between the interior and the view outside.

The interior of a room will appear gloomy not only if the total quantity of light entering is too small but also if its distribution is poor. If, in addition, there is high contrast between the surfaces surrounding windows (or rooflights) and the sky, there will be glare.

5.5 Average daylight factor

5.5.1 General

Where a predominantly daylit appearance is wanted, the criteria given in 5.5.2 and 5.5.3 should be adopted. The average daylight factor (see 2.3.4) is used as the measure of general illumination from skylight.

5.5.2 Interiors without supplementary electric lighting

If electric lighting is not normally to be used during daytime, the average daylight factor should be not less than 5 %.

5.5.3 Interiors with supplementary electric lighting

If electric lighting is to be used throughout daytime, the average daylight factor should be not less than 2 %.

5.6 Minimum values of average daylight factor in dwellings

Even if a predominantly daylit appearance is not required in dwellings, it is recommended that the average daylight factor be at least 1 % in bedrooms, 1.5 % in living rooms and 2 % in kitchens.

5.7 Uniformity

Surface reflectances and the disposition of glazing should be such that inter-reflected light in the space is strong and widespread.

Even if the average daylight factor satisfies the criterion of 5.5.2, supplementary electric lighting will be needed if:

a) a significant part of the working plane lies behind the no-sky line;

or

b) in a room lit by windows in one wall only, the depth of the room is too large in comparison with the height and the width of the windows.

(A procedure for calculating this is given in 13.3.)

In the case of rooflights, unsatisfactory variation in general lighting occurs when the distance between adjacent openings is large in comparison with the ceiling height. The maximum acceptable ratio between rooflight spacing and ceiling height depends on the type of rooflight. In interiors lit primarily by rooflights, the reflectances of the floor and ceiling should be as high as possible.

5.8 Contrast between the interior and the view outside

Glare from windows can arise from excessive contrast between the luminance of the visible sky and the luminance of the interior surfaces within the field of view. The window walls, the window reveals, and the interior surfaces adjacent to rooflights should be of high reflectance (white or light-coloured). Walls generally should not be glossy.

In addition, glare from the sky and bright external surfaces can be reduced by:

a) providing additional illumination on the window wall, from other windows or from electric lighting;

b) reducing the luminance of the sky as seen from the interior, with translucent blinds, curtains or tinted/solar-control glazing, if adequate illumination can be provided by other sources;

c) splaying window reveals, to give a larger area of intermediate brightness between the exterior view and the window wall.

The aim should be to achieve a subtle gradation of luminance from the darker parts of the room to the visible sky.

Glare from direct sunlight, or from sunlight reflected in glossy external surfaces should be controlled with shading devices (see clause 8).

The use of tinted glazing can affect colour perception. External colours can appear distorted, especially when the view outside is seen simultaneously through different types of glass. The perception of internal colours can be altered, unknown to the viewer, when the main source of light is a window of tinted glazing. Care should be taken in the use of tinted glazing materials when safety or task performance requires good colour recognition.

6 Daylight for task lighting

6.1 General

When there are visual tasks to be carried out, the principles of lighting design using daylight are the same as those for electric lighting: it is necessary both to achieve a given level of illumination and to take account of the circumstances that determine its quality.

Daylight has the following characteristics as a task illuminant.

- a) A constant illuminance on the task cannot be maintained. When the sky becomes brighter, the interior illuminance increases; and, although control is possible with louvres, blinds and other methods, fluctuations cannot be avoided. Conversely, in poor weather and at the ends of the working day, daylighting needs to be supplemented with electric lighting.
- b) The direction of light from windows, which act as large diffuse light sources to the side of a worker, gives good three-dimensional modelling. Rooflights, which give a greater downward component, have a modelling effect similar to that from large ceiling-mounted luminaires.
- c) The spectral distribution of daylight varies significantly during the course of a day, but the colour rendering is usually considered to be excellent.

6.2 Quantity of daylight

6.2.1 Illuminance

The task illuminance should be selected from Tables 1 and 2 of BS 8206-1:1985, reproduced in Appendix B as Table 10 and Figure 16 respectively. Procedures for calculating daylight illuminance are given in clause 14.

6.2.2 Uniformity

Over the task area of an individual worker, the uniformity in illuminance should be that recommended for electric lighting in clause 5 of BS 8206-1:1985. An appropriate criterion indicated in that clause is that the minimum illuminance should not fall below 0.8 of the average illuminance. Where there are several working areas in an interior, the particular task illuminances should be attained on each, care being taken that the recommendations on uniformity in general room lighting are followed (see 5.7).

6.3 Quality of daylight

6.3.1 General

The considerations of lighting described in BS 8206-1 and in the CIBSE *Code for Interior Lighting* apply both to daylight interiors and to those with electric lighting. The quantity of illumination is not the sole criterion of good task lighting.

There are two aspects of task daylighting which need particular attention: glare and specular reflection.

6.3.2 Glare

Windows may fill a greater part of a worker's field of view than electric light fittings. Distraction, a poor luminance balance between task and background, and discomfort glare can all occur if the visual task is viewed directly against the bright sky. Although a view outside should be provided, it is usually better if the glazing is at the side of workers, rather than directly facing them.

There is no standard procedure for calculating discomfort glare from skylight. Sky luminance can be very high, and the size of the apparent source is large; so by the criteria adopted for electric lighting most windows cause glare. It should be reduced by ensuring that the sky is not in the immediate field of view with the task, and by following the recommendations given in 5.8.

Highly reflective sunlit external surfaces are more likely to add vitality to a scene than constitute an objectionable glare source. This stimulus will be welcomed in all but the most demanding visual situations. However, glare from the sun, viewed directly or specularly reflected, can be unacceptable in a working environment. If the sun or its mirrored image is likely to lie within 45° of the direction of view, then shading devices should be used (see 8.1). Low transmittance glazing is unlikely to attenuate the beam sufficiently to eliminate glare; diffusing glazing materials, in scattering the beam, may cause the window or rooflight itself to become an unacceptably bright source of light.

6.3.3 *Specular reflection*

The visibility of tasks can be seriously impaired by bright reflections of the sky in glossy surfaces. With windows, troublesome reflections occur predominantly in vertical surfaces. With rooflights, horizontal task areas are the most seriously affected. However, openings of either type can affect surfaces of all orientations if the geometry is incorrect. Special attention should be given to the avoidance of reflections of windows in VDU screens, chalkboards, and pictures in galleries, and it is preferable that these surfaces do not face a window directly.

Section 3. Further design issues

7 Electric lighting used in conjunction with daylight

7.1 Functions of supplementary electric lighting design

Electric lighting has two distinct functions in a daylit building, which are:

- a) to enhance the overall appearance of the room, by improving the distribution of illuminance and by reducing the luminance contrast between the interior and the view outside;
- b) to achieve satisfactory illuminance on visual tasks.

These two functions correspond with the recommendations about room brightness and task illumination in daylight, described in clauses 5 and 6. The electric lighting should be designed for both functions.

7.2 Enhancement of room brightness

7.2.1 Balance of daylight and electric light

Unless the purpose of the windows is only to provide a view, daylight should appear to the users to be dominant in the interior. This is normally achieved when the average daylight factor is 2 % or more, even though the horizontal illuminance from electric lighting may be greater than the daylight illuminance in parts of an interior.

The design of electric lighting should be such that occupants are aware of the natural gradation of daylight across interior surfaces and of changes in the light outside.

7.2.2 Modelling

The sideways component of light from windows is important in the enhancement of modelling. It is apparent in the articulation of mouldings and in the highlights and shadows of three-dimensional features. The electric lighting should be designed with the daylighting to achieve optimum modelling, reinforcing the directionality where the natural illumination is too diffuse, and providing infill lighting where windows alone would give harsh modelling.

7.2.3 Contrast between interior and exterior

When the general level of inter-reflected light is low, or the surfaces surrounding a window or rooflight are of low reflectance, electric light is needed on these surfaces to reduce the luminance contrast with the view outside. The brighter the view, the higher should be the luminance of the room surfaces which frame the view.

7.2.4 Illuminance from electric light

In an interior where there is a noticeable amount of daylight but where uniform electric lighting is needed in some parts, the average working plane illuminance from electric lighting in the poorly daylighted areas should be not less than 300 lx.

The optimum balance between electric light and daylight occurs when the horizontal illuminance from electric lighting in areas remote from windows is approximately the same as the daylight illuminance 2 m from the windows.

7.2.5 Colour appearance of lamps

The sky varies in colour with time and in azimuth and altitude. These variations are considerable and no electric lamp matches continuously the colour appearance of daylight. For instance, the appearance of a lamp with a colour temperature close to that of light from a clear sky at midday may seem excessively blue as evening approaches. Sunlight reflected into a room from vegetation or brightly coloured surfaces outside can have a noticeable hue and can affect the colour appearance of lamps.

Apparent discrepancies between the colour of electric light and of daylight may be reduced by:

- a) using lamps of Intermediate class correlated colour temperature (see BS 8206-1);
- b) screening lamps from the view of occupants. For this purpose, louvres with a cut-off at 45° to the horizontal are preferable to any form of translucent diffuser.

7.2.6 Sequences of spaces

Individual spaces can be satisfactory with low levels of daylighting and correspondingly low illuminances from supplementary electric lighting or, alternatively, with high levels of both. However, adjacent rooms usually should not contrast harshly with each other in either brightness or in the colour of the illuminant. The building should be planned to avoid passing directly from a brilliantly sunlit space into one with a low level of combined lighting. A transitional space will help the eye to adapt in comfort from one to the other.

7.3 Task lighting

7.3.1 Illuminance

The total illuminance from daylight and electric light should satisfy the illuminance criteria for the visual task (see 6.2.1). Care should be taken that a task is not viewed against the sky or a very bright area of the room. If this is unavoidable, its illuminance should be such that there is a satisfactory brightness contrast between task and surroundings, depending upon the nature of the task.