Thomas Pocklington Trust
for people with sight loss

Daylighting in older people's housing

A guide for housing providers, architects and associated professionals involved in housing design and development

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Editors: Deborah Brown and Lynn Watson **Designer:** Stewart Aplin

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About Thomas Pocklington Trust

Thomas Pocklington Trust is a national charity dedicated to delivering positive change for people affected by sight loss.

Research is central to Pocklington's work. We fund and collaborate on social and public health research initiatives aimed at identifying practical ways to improve the lives of people with sight loss, and seek to influence the services and facilities that they use.

Pocklington's research priorities are:

- the health and wellbeing of people with sight loss
- housing and environments that support the independence of people with sight loss
- building the capacity of organisations and services that work with people with sight loss to shape research and make use of research findings

Introduction

Scope and purpose of the guide

Good **daylighting** in the home can dramatically improve the lives of people with sight loss. This publication provides good practice guidance on daylighting in older people's housing. It will be useful to architects, housing providers and other professionals involved in the development and design of older people's housing. It also has more general suggestions and ideas on how to optimise **daylight** in a residential environment.

This Guide draws on:

- a previous survey of 165 dwellings in 23 extra-care housing schemes in England (2009)
- new research that explored the views and experiences of a range of experts involved in the design and development of older people's housing (2013-14)
- secondary information sources (primarily those listed at the end of the Guide).

How common is sight loss?

Sight loss affects the everyday lives of 1.87 million people in the UK. The prevalence of sight loss is particularly high in the older population and most people who lose their sight do so through the normal ageing of the eye or the onset of age-related eye conditions. From the age of 40, most people notice a decline in the ability to focus and they need more light as they carry out ordinary everyday tasks, such as reading and cooking.

Around one in five people in the UK aged over 75 and one in two aged over 90 have sight loss. The number of people with sight loss is likely to increase and projections show that nearly four million people in the UK could be living with sight loss by 2050. The most common eye conditions leading to sight loss in the UK are macular degeneration, glaucoma, diabetic retinopathy and cataract. Sight loss may be caused by other conditions, such as stroke.

The extent and nature of a person's sight loss is related to its cause. It is not possible to identify a single solution or response but general approaches, such as improved lighting and good use of colour and contrast, have proved beneficial. As sight loss is common in the older population, it is essential that older people's housing has good daylighting. Homes that are well designed in terms of daylighting will enhance occupants' independence, safety, health and wellbeing. Applying the advice in this publication will be of benefit to everyone, including people with and without sight loss.

Older people's housing

The UK has an ageing population and the private and public sectors have invested in housing designed specifically for the needs of older people; this is likely to continue. Appropriately designed housing will maximise this investment and can enhance older occupants' wellbeing and independence, reducing the need for care.

The importance of daylight

Daylight for vision

Daylight can help people to carry out daily tasks, such as reading, preparing food or selecting what clothes to wear. Daylight generally provides much greater light levels than domestic electric lighting. For example, it is recommended that G 100-200 **lux** is provided to enable a person to select clothes when dressing. While typical domestic lighting will provide less than 100 lux, in a reasonably daylit room (with a daylight factor of 2%) in southern England, light levels will exceed 100 lux for 78% of daylight hours and 200 lux for 60% of daylight hours. Close to windows, light levels will often be three to five times higher.

The contrast between a task and its background is usually much lower with daylight than with electric light. This means that a person's eyes do not need to readjust significantly to different light levels when they stop an activity and move away.

Additionally, it is generally easier to distinguish between colours in daylight than it is using electric light alone.

It is vital, however, to provide occupants with the means to control the amount of daylight that enters their home. While some people with partial sight will want high light levels, others will be sensitive to light or have problems with glare and want less light, and particularly less direct light.

Daylight for mobility, safety and orientation

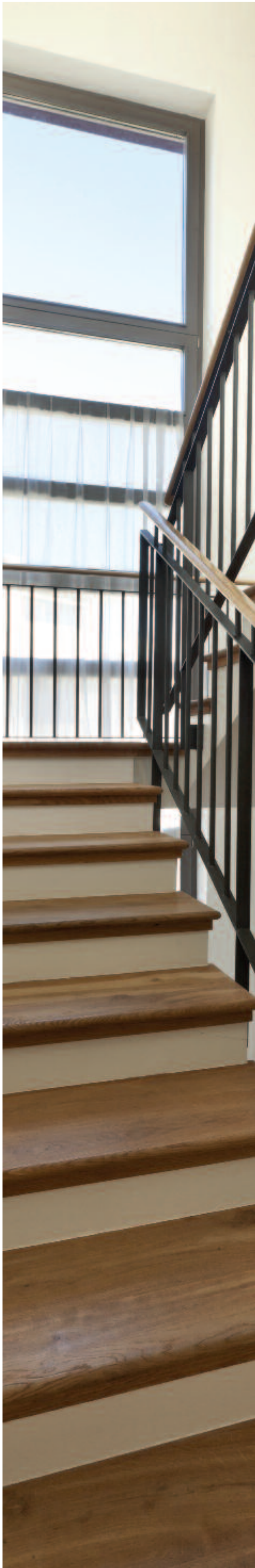
The presence of a window in a room can aid orientation by enabling people to tell how far they are from an external wall, or to distinguish between the north and south sides of a building. Also, the diffuse light from the side of a person is particularly good for making interior spaces clearer and easier to navigate.

Health benefits of daylight

Daylight helps to regulate the body's production of melatonin, which in turn helps to regulate sleep patterns. It also helps to stimulate the body's production of serotonin, which can reduce the symptoms of depression. Exposure to bright daylight within the natural 24-hour cycle of light and dark, including during the winter months, is therefore very important for health. It can be particularly difficult for older people to receive adequate exposure to strong daylight; people over 65 and those over 85 spend 80% and 90% of their time at home respectively. People who are visually impaired identify their sight loss as a barrier to getting out, e.g. the need to be accompanied and a lack of confidence may mean that they spend more time indoors than their sighted peers. In addition, some normal effects of ageing, such as the yellowing of the eye-lens, diminish the amount of light received by photoreceptors.

Connection to the outside world

Windows can give occupants a sense of connection to the outside world. Many people with impaired vision can detect changes in the weather, season and time of day, or be aware of the presence of human activity outside. People with sight loss



often appreciate this sense of connection to the external environment, particularly if they find it difficult to go out. An interesting view can have a therapeutic effect on occupants, improving their wellbeing.

Sustainability

G The use of **natural light** can greatly reduce a building's energy consumption, provided steps are taken to prevent excessive **solar gain** G or heat loss through windows.

How daylighting is evaluated

Daylight factor G

The daylight factor is a unit of measurement that is used to quantify the amount of daylight in a room. The average **daylight factor** in a room is G defined as the amount of **skylight** falling on a table top, relative to the amount of light that would be available if the table were outside under an unobstructed hemisphere, expressed as a percentage. In other words, it is approximately the ratio between the light available in a room and that available outside. The benefit of using the the daylight factor is that it provides a measure of the light in a room independent of variations in skylight level. The average daylight factor gives a good indication of whether a room will look bright or gloomy when lit by skylight alone.

In the UK, the daylight factor was first used in building standards in the 1940s, at a time when computers were not readily available. The daylight factor therefore contains a number of simplifications. In particular, it is assumed that the sky is overcast, in order to allow G **sunlight levels** to be calculated separately. Although the daylight factor is still the most commonly used daylight standard, some have called for it to be replaced with a computer-based standard, which would allow for greater sophistication in the calculation process. In particular, it would allow skylight and sunlight to be considered simultaneously.

Alternative metrics

One approach that is gaining popularity is climate-based **daylight modelling**, G which uses 3D computer models of buildings, in conjunction with data on the annual availability of daylight, to predict daylight levels. Climate-based daylight modelling has been adopted for guidance on the design of schools. However, this type of modelling requires specialist software not available to most architects, and so the guidance in this document is expressed in the form of average daylight factors.

Recent research

Since the current British Standard on daylighting was published, research has been conducted on the health benefits of daylight that suggest the British Standard might need some revision. The recommendations in this publication reflect these developments.

Currently there is limited research evidence on the preferences of people with sight loss for the amount of light in their homes. The needs and preferences of individuals will be widely variable, so in this publication it is recommended that high levels of daylight be provided in dwellings, along with the means to control daylight within each room, so that occupants can adjust light levels to suit their specific needs.

Barriers to good practice in daylighting

Sunlight and orientation

Decisions regarding the layout of a building, which are generally made early in the design process, will have a significant impact on daylighting in internal spaces. In a survey of 165 dwellings in 23 extra-care housing schemes, only 45% (74 of 165) of kitchens, and 8% (14 of 165) of bathrooms, had external windows. Just 37% (61 of 165) of dwellings were dual aspect, with windows on at least two sides. Given that **dual aspect** *G* dwellings are more likely to have direct sunlight for longer periods than **single aspect** *G* dwellings, the lack of dual aspect dwellings might explain why only 28% (46 of 165) of living rooms received direct sunlight throughout the whole day (i.e. in both the morning and afternoon), while 87% (144 of 165) of living rooms received direct sunlight for only part of the day.

It is easier to create dwellings that are dual aspect, and in which all rooms have daylight, in certain building types such as bungalows, cluster blocks (small apartment blocks) and deck access schemes (where apartments are accessed via an open walkway). These building types have a greater external-surface-area-to-volume ratio than normal apartment blocks, which increases the opportunities to provide rooms with windows. Apartments can also draw on borrowed light if accessed via an atrium or a glazed single-bank corridor (where apartments open off one side only). There are, however, a number of barriers to the use of these building types, as described below.

Financial viability

Financial returns from the development of an older people's housing scheme are generally dependent on the sale or lease of dwellings. Consequently, there is often pressure to maximise the number of dwellings on a site, with schemes generally requiring a minimum of 40 dwellings to be financially viable. There is therefore often pressure to minimise the space given over to communal facilities and circulation. Typically a housing scheme will be viable only if at least 65% of the floor area is given over to residential purposes, and no more than 35% to communal facilities, circulation and service areas, although there can be considerable variation depending on the circumstances.

Construction costs

As construction costs are calculated on the basis of floor area, it is often necessary to minimise the building's overall floor area, which is another driver for minimising circulation areas. Also, as external walls tend to cost more than internal walls, buildings with a higher external-surface-area-to-volume ratio tend to be more expensive to build. An apartment arranged such that the kitchen has an external window will often require a longer corridor and a greater area of external wall than an apartment where the kitchen has no window, making this type of layout more costly **(Figure 1)**.

Figure 1:
A kitchen designed with windows can require longer corridors.

If a housing scheme is to feature bungalows, cluster blocks, deck access, atria or single banked corridors, then the additional finance that will be necessary must be incorporated into the capital budget from the outset.

• Restricted aspect (window views)

In the survey of 165 extra-care dwellings, the view from the living room window included natural features in 79% (130 of 165) of cases, human activity in 82% (135 of 165) of cases, and both near and far features in 45% (74 of 165) of cases. While it is usually feasible to create views of natural features and human activity, views over distance are often difficult to achieve on level sites in densely built-up areas, particularly where it is necessary to prevent dwellings from overlooking neighbouring properties.

It is difficult to achieve low sills where it is necessary to position radiators under windows, place service conduits along external walls, or allow space for furniture under windows. Achieving sills below 800mm from floor level enables seated occupants to see out. This is made complicated by the Building Regulation requiring glass below 800mm to be robust or designed to break safely, which necessitates the use of more expensive types of glass. However, in the survey of extra care dwellings, 93% (154 of 165) of living room windowsills, and 78% (123 of 158) of bedroom windowsills, were less than 800mm from floor level.

Barriers to good pratice in daylighting

The British Standard on daylighting recommends that there is a minimum average daylight factor of 1.5% in living rooms, 2% in kitchens and 1% in bedrooms. In the extra care housing survey, 45% (74 of 165) of living rooms, no kitchens and 44% (69 of 158) of bedrooms complied with the British Standard recommendations. This alarmingly low level of compliance is a cause for concern, given the importance of adequate daylight for people with sight loss. Barriers to compliance with guidance on daylight factors can be divided into two categories: determinants of window size; and daylight prediction methods.

● Determinants of window size

A number of factors, unrelated to daylighting, can affect window size. These include the need for buildings to comply with predicted energy performance criteria, such as those set out in the Building Regulations. Improvements to window technology in recent years mean that there is now little concern about the need to keep windows small in order to minimise heat loss. Additionally, heat loss through windows can be offset through increasing thermal insulation in other parts of the building. The risk of excessive solar gain is an increasing concern, as buildings are insulated to ever higher levels to meet increasingly strict energy performance criteria and this can cause window sizes to be reduced at the design stage.

The size and shape of windows can be affected by planning considerations, particularly if a housing scheme is in a conservation area, where windows might need proportions that match those of the surrounding buildings.

Windows are generally more expensive than masonry, when calculated by area. This is partly because of the need for associated structural elements, such as lintels. There is sometimes pressure to reduce window sizes in order to minimise construction costs. Also, there is often pressure to use 'off-the-shelf' components, as these tend to be cheaper than bespoke elements. **Curtain wall glazing**, G which is sometimes used in communal areas, is particularly expensive and often requires an additional supplier to be brought into the supply chain. This can make it difficult to achieve expansive areas of glazing.

Window sizes are further constrained by consideration of what an occupant can reach in cleaning reversible windows. Windows in communal areas can usually be cleaned by maintenance staff and so can be larger. However, where windows in communal areas are inaccessible to maintenance staff, self-cleaning glass will be required, which is more expensive than ordinary glass.

Window head height is often determined by the need to align window heads with brick and block courses, so that bricks do not have to be cut, thus minimising construction costs. Typically, window heads will be 2.1m above internal floor level, in line with the height of internal doors. This also allows space above windows for curtains and blinds. Ceilings are conventionally 2.4m above floor level, again determined by brick and block courses. There is often resistance to the use of higher ceilings, as this generally entails higher construction costs, and consequently this constrains window head height.

Daylight prediction

Few architects undertake daylight factor calculations at the design stage, relying primarily on experience when predicting whether a room will have sufficient daylight. Where it is necessary to undertake calculations in order to obtain the credits available under energy codes such as **BREEAM**, these are usually undertaken by other consultants such as Code Assessors or mechanical and electrical engineers. This partly reflects a lack of knowledge within the architectural profession about the mathematics of daylighting, but it also reflects a lack of resources. Undertaking daylight factor calculations or generating a digital model of a housing scheme often requires considerable time and resources. Architects' clients are often reluctant to pay for a housing scheme's technical development until planning consent has been secured, by which time most of the key decisions affecting daylighting have been made.

Given the low number of extra care housing schemes that comply with recommendations on daylight factors, as indicated by the survey of 165 extra-care dwellings, it is advisable to test schemes' daylighting standards at the design stage through calculating daylight factors manually, or digitally such as through the use of plug-in software for 3D modelling packages.

Criteria for Good Daylighting

This checklist shows the criteria for good daylighting and its importance in different areas of the home.

	Whole dwelling	Living room	Kitchen	Bedroom	Bathroom	Communal room	Circulation space	Stairs
Skylight								
The room has natural light		✓	✓	✓	✓	✓	✓	✓
The room has a minimum average daylight factor of 2%		✓	✓			✓		
The room has a minimum average daylight factor of 1%				✓				
It is dark outside the room at night to provide a 24-hour cycle of light and dark.				✓				
The room depth is not too large in comparison with the window height		✓	✓	✓		✓		
The room is painted in a light colour with a matt finish		✓	✓	✓	✓	✓	✓	✓
Sunlight								
The dwelling is dual aspect (i.e. has windows on more than one side)	✓							
The dwelling receives sunlight in both the morning and afternoon	✓							
G The room receives 25% probable **sunlight hours**, including at least 5% during the winter months (21 September to 21 March).		✓						

Prevention of glare

	Whole dwelling	Living room	Kitchen	Bedroom	Bathroom	Communal room	Circulation space	Stairs
There are shading devices for S, E, W facing windows (e.g. vertical or Venetian blinds)		✓	✓	✓	✓	✓		
Blinds are fitted to windows at the end of corridors							✓	
Blinds are fitted to windows at the top and/or bottom of stairs								✓
The shading devices fully cover the window(s)		✓	✓	✓	✓	✓	✓	✓
The blinds can be operated by people with sight or dexterity loss, or who use a wheelchair		✓	✓	✓	✓	✓		

Aspect

	Whole dwelling	Living room	Kitchen	Bedroom	Bathroom	Communal room	Circulation space	Stairs
The view from the window consists of natural features, such as trees and shrubs		✓	✓	✓		✓		
The window(s) overlook outdoor spaces where there is human activity		✓	✓	✓		✓		
The view from the window consists of near and distant features of interest		✓	✓	✓		✓		
There are external reference views which will help people to find their way around the building							✓	✓
The view from the window is free from obstructions, e.g. a blank wall		✓	✓	✓		✓	✓	✓
The sill height is less than 800mm above floor level		✓		✓		✓		
Neighbouring windows are more than 22m away, to maintain privacy		✓	✓	✓	✓	✓		

Supplementary electric lighting

	Whole dwelling	Living room	Kitchen	Bedroom	Bathroom	Communal room	Circulation space	Stairs
Fitted lights closest to the windows can be switched on and off independently of lights furthest from windows		✓	✓			✓		
Electric lighting is well distributed throughout the room with no areas of deep shadow		✓	✓	✓	✓	✓	✓	✓
The electric lighting can be dimmed		✓	✓	✓		✓		
Entrances are illuminated with downlighters		✓					✓	
There is lighting under wall-mounted cabinets located above worktops			✓					
There is a working light over the table or worktop where food preparation occurs			✓					
There is a working light over the hob/oven/stove area			✓					
There is a working light over the sink			✓					
There is task lighting over the washbasin					✓			
There is task lighting over the shower/bath					✓			
There are plenty of electrical sockets to enable portable task lighting to be used, positioned to minimise the need for trailing leads		✓		✓		✓		

How to meet the criteria for good daylighting

The structure of this section reflects the order in which decisions are typically made in the building design process.

Site layout: number of rooms with usable daylight

The number of rooms with windows, and whether the dwelling is dual aspect, will largely depend on financial constraints, such as the density at which the site needs to be developed and the size of the capital budget. In some circumstances, such as where property values are high and there is a market for high quality housing, or where a decision is made to invest more than the minimum, it is possible to develop a site at a relatively low density and incorporate features such as atria. In such circumstances, it might be possible to use building types such as bungalows, cluster blocks, cluster blocks and deck access apartments. This in turn should permit a greater number of rooms and other internal spaces to be provided with daylight and a greater number of dwellings to be dual aspect.

Site layout: skylight availability

As explained above, skylight and sunlight are often considered separately in order to simplify the design and evaluation process and because they differ greatly in their qualities. While the sun provides a strong light from a single source, which creates hard shadows, skylight is more diffuse. The best practice criteria for each should be satisfied.

In site layout planning, it is important to ensure that a sufficient area of sky will be visible at each window so that good internal lighting can be provided from windows of a reasonable size. This is largely determined by the window's proximity to obstructions, such as neighbouring buildings or large overhangs.

Skylight availability: rule of thumb

Site layout decisions can be difficult to change at a later date, so it is advisable to check what impact layout proposals will have on daylighting. As a rule of thumb, if the angle of visible sky

(Figure 2), measured perpendicular to the window from the window's centre, is:

- greater than 65°, then good daylight can be provided using conventional windows
- between 45° and 65°, then larger windows or room layout changes are usually required
- between 25°and 45°, it can be very difficult to provide adequate daylight unless very large windows are used
- less than 25°, then it is generally impossible to achieve adequate daylight

For more details, see the BRE document 'Site Layout Planning for Daylight and Sunlight'. *R*

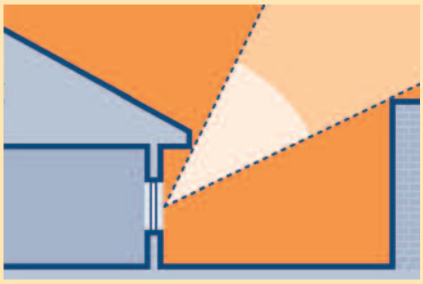


Figure 2:
Site layout planning: angle of visible sky

Site layout: sunlight availability

The direction the windows face, relative to south, will affect how much direct sunlight a room receives. It is for the architect, working in collaboration with the housing provider or developer, to decide which parts of the building require direct sunlight, and from which parts direct sunlight should be excluded. It should be recognised, however, that most people like to have some direct sunlight, provided they have some control over it. Sunlight can also be important for health, particularly in the winter months. Exposure to direct sunlight can be particularly important for people who are largely housebound.

A dwelling can be said to receive adequate sunlight if its principal room receives 25% probable sunlight hours, including at least 5% during the winter months (21 September to 21 March). This means the dwelling receives sunlight for a proportion of the total number of hours that sunlight would, in the course of an average year, fall on unobstructed ground at the same location.

Provision of direct sunlight must be balanced with the need to prevent excessive solar gain. To prevent excessive solar gain,
it is advisable to avoid west-facing windows, or provide effective screening. When the sun is in the west, external temperatures tend to be at their highest, and the sun will be low in the sky, making overhangs ineffective as solar shades.

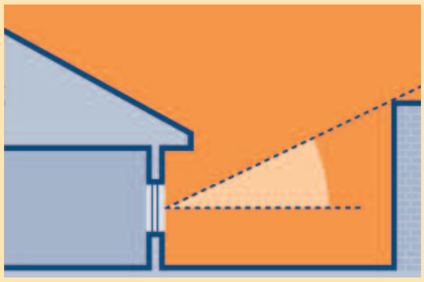


Figure 3:
Angle of obstruction above the horizon

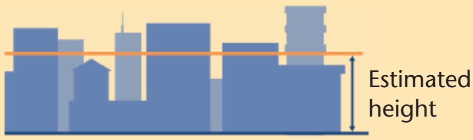


Figure 4:
Averaging the height of obstructions

Sunlight availability: rule of thumb

As with skylight availability, at the site layout planning stage it is advisable to check that direct sunlight will be available at windows to rooms that need to receive it. For a window to receive direct sunlight throughout the year, it must be within 90° of south. In addition, the **angle of obstruction** can be measured from the centre of the window, with the angle measured between the top of the obstruction and the horizon line **(Figure 3)**. As a rule-of-thumb, if this angle is less than 25°, then the window will be free from obstruction to direct sunlight. However, where a sunlight obstruction angle is 25°, there must be no overhangs above the window if a visible sky angle of 65° is to be achieved.

Where there is moderate variation in the skyline, the average obstruction height can be used **(Figure 4)**. Where there is much more variation in the height of obstructions, such as where a window faces onto a courtyard, more sophisticated techniques must be used, such as digital modelling.

Site layout: aspect

Research indicates that people with sight loss appreciate similar qualities in the view from the window as their sighted peers. While a spectacular vista might seem desirable, it is important to ensure that the view gives occupants a sense of connection to the outside world. Particularly important are natural features which change with the seasons, providing information abou the time of year. Equally, views of human activity can help prevent feelings of isolation. Depth of view is also important, ideally containing both near and distant features of interest.

A building's layout will significantly affect views out. Clearly, not every room will have a good view but priority should be given to living rooms, bedrooms and key communal spaces. Occupants' need for privacy should also be considered. Grouping apartments around a courtyard or garden space is one way of ensuring that dwellings have views of natural features or human activity but are not overlooked by neighbouring buildings.

Window design: aspect

As many older occupants might have impaired mobility or be affected by long-term illness, views should be visible to people who are seated or lying down. Particular consideration should be given to sill height. Most recommendations on sill height, such as those in the Lifetime Homes Standards, take into account the Building Regulation requirement that glass in windows, between the finished floor level and a height of 800mm, be robust or designed to break safely. However, even a sill 800mm from floor level can be too high to permit a clear view, for people living on the first floor or above, of natural features and human activity **(Figure 5)**. Floor-to-ceiling glazing or a patio door leading onto a terrace or balcony can permit a clearer view **(Figure 6)**. Some architects and housing providers argue that a low sill is better than no sill, as this can provide a sense of security and prevent vertigo **(Figure 7)**, although this belief is contentious. Where a sill below 800mm is used, construction costs can be minimised by putting a **transom** at 800mm, with toughened glass below and ordinary glass above; without the transom, toughened glass must be used for the whole window.

Figure 5:
Window with a high sill

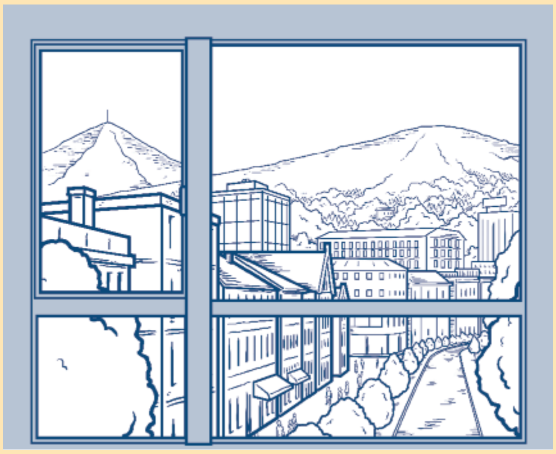


Figure 6:
Floor-to-ceiling glazing

Window design: daylight

Daylight is important for occupant satisfaction and health and for aiding vision. Clearly, the larger the window, the more daylight it will permit. Provided off-the-shelf components are used, specifying a reasonably large window is a cost-effective way of ensuring a room has adequate daylight. Although glazing is generally more expensive than masonry when calculated by area, the financial implications of using one window over another are not as extreme as those relating to building layout.

Larger windows will, however, lead to increased risk of excessive solar gain and, to a lesser extent, greater heat loss. A building's energy consumption is usually optimal if the lighting strategy requires a combination of daylight and electric light. Typically, this is when rooms are reasonably well daylit but electric lighting is required for some tasks during the daytime.

Figure 7:
Window with a low sill

Daylight: rule of thumb

As a rule of thumb, the room will have sufficient daylight if the area of glazing is equal to approximately 1/25th of the total surface area of the room, including the combined surface area of the floor, ceiling, walls and glazing. This approximation is true provided the room is approximately rectangular in shape, has light-coloured surfaces, has glazing with a normal **transmittance** (i.e. it is clean and not tinted) and the windows are unobstructed. G

Calculating the daylight factor

A more precise check can be undertaken by calculating the average daylight factor in a room. This can be done manually or by using software, such as that available for evaluating a building's predicted energy performance or plug-in software that can be used in conjunction with a 3D digital model. The average daylight factor generally provides a good indication of a room's appearance. If a room has an average daylight factor of:

- less than 2% – the room will look gloomy, will require electric lighting during the day, and electric lighting will dominate the room.
- between 2% and 5% – the room will seem to have adequate daylight, although electric lighting might be needed for some tasks.
- more than 5% – the room will seem brightly lit and electric lighting will rarely be needed during the daytime but there is a significant risk that the room will be subject to excessive solar gain.

This guidance is true only where daylight enters a room through side windows. With roof lights, less light will be reflected from the walls and ceiling and consequently rooms with roof lights look darker at a given daylight factor. In some instances, a room with roof lights requires an average daylight factor approximately twice that of a room with side windows in order to give the equivalent appearance.

Average daylight factor is calculated at the design stage using the following formula:

$$\overline{D} = \frac{A_w \, \Theta \, T}{A\,(1 - R^2)}$$

Where:

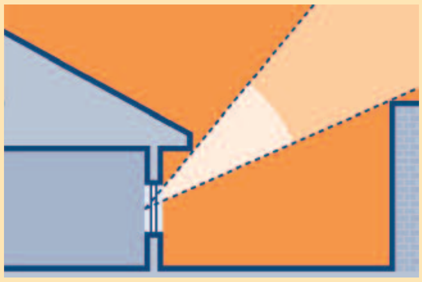


Figure 8: Window design: angle of visible sky

D average daylight factor (%)

A_w the total area of glazing, excluding window bars and frames (m2)

Θ the angle of visible sky, as measured in section from the centre of the opening, with the centre of the arc in line with the surface of the internal wall **(Figure 8)** (degrees)

T the transmittance of glazing to diffuse light, including the effects of dirt*

A the total internal surface area of the room, including the floor, ceiling, walls and glazing (m^2)

R the room's area-weighted internal **reflectance**** G

*Transmittance: For double-glazing with clear glass, a coefficient of 0.65 can be used, but the value for tinted glazing will be much lower (see BS-8206-2 and manufacturer's literature for details). Note that dirt will typically cause a further reduction of approximately 5-10%. R

**Internal reflectance: During the design stage an estimate must be made. Assuming the room has light coloured walls, a value of 0.5 can be used. Where surfaces are likely to be darker, a value of 0.3 would be appropriate.

The formula indicates that the greater the size of the window relative to the internal surface area of the room, and the greater the angle of visible sky at the window, the higher the daylight factor. Also, a higher internal reflectance (where the ceiling, walls and floor are light in colour) will permit higher daylight levels, as well as affecting the distribution of light. Tinted or solar control glazing will have a lower transmission than ordinary glass and will lead to a room having a lower average daylight factor.

Daylight factor: examples

Figures 9-12 provide some examples, based on real cases, indicating how the daylight factor can be affected by window size and the extent of visible sky. In all cases the walls, floor and ceiling were of a light colour and the windows were double-glazed with ordinary glass. In each case, the extent of visible sky is shown using a drawing made from a photograph taken with a fisheye lens, with the camera placed in line with the glazing and pointing vertically upwards. The drawings show how projections over windows, such as balconies to rooms above or overhanging eaves, greatly diminish the amount of daylight in a room.

In **Figure 9**, a small window combined with overhanging eaves contributes to a daylight factor of approximately 0.3%. The room in **Figure 10** has a much larger window, but a balcony over the window reduces the daylight factor to approximately 0.4%. **Figure 11** shows a room that is slightly larger than that in Figure 10, but with a similarly sized window. In this case, although there is some obstruction, the extent of visible sky is significantly greater, contributing to an approximate daylight factor of 1.6%. **Figure 12** shows a room with a bay window, which increases the area of glazing, and which has a large area of visible sky, contributing to an approximate daylight factor of 3.8%. These values should be regarded as indicative only.

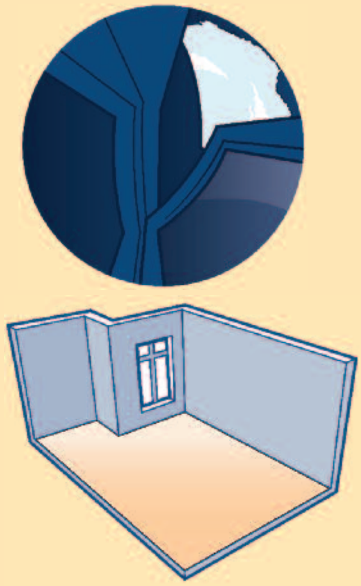


Figure 9:
Daylight factor = 0.3%

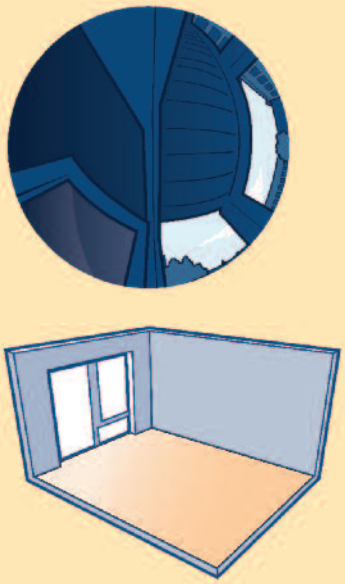


Figure 10:
Daylight factor = 0.4%

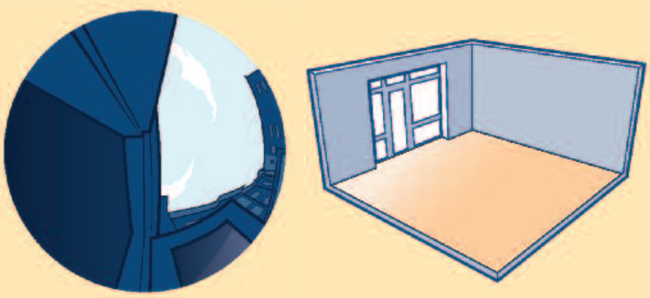


Figure 11: Daylight factor = 1.6%

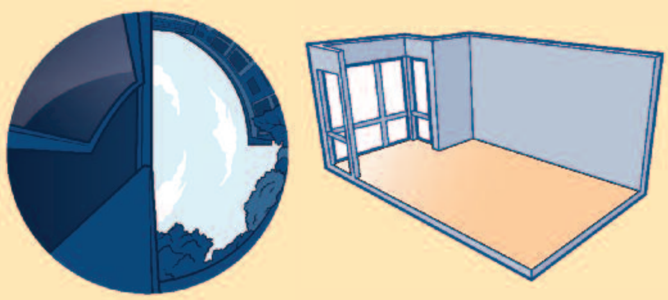


Figure 12: Daylight factor = 3.8%

Distribution of daylight

Consideration should also be given to the distribution of daylight, which is affected by the number and position of windows in a room. Providing windows in more than one wall is a good way of ensuring that all parts of a room will receive daylight. Window head height will affect the depth to which light penetrates the room **(see Figures 13-15)**, with higher head heights allowing for a greater distribution of light. Direct skylight is particularly important for tasks, as inter-reflected light alone is rarely sufficient.

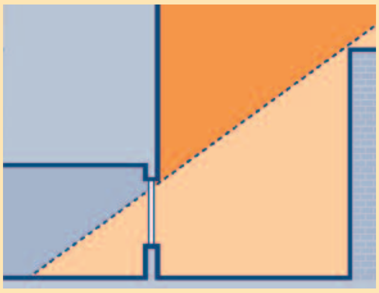


Figure 13

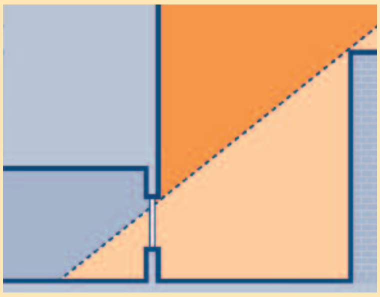


Figure 14

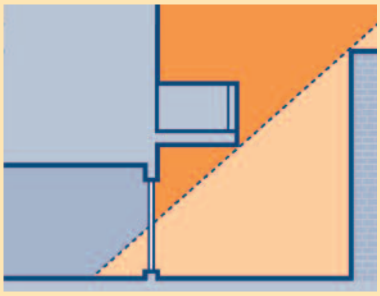


Figure 15

Figures 13, 14, 15: Effect of window head height and external obstructions on distribution of light

Solar shading

In order to minimise heat loss, and thus reduce carbon emissions, recent years have seen buildings constructed to increasingly higher standards of thermal insulation and airtightness. One consequence is that overheating is an increasingly common problem in new-build developments, as excess heat becomes trapped. One potential cause of overheating is excessive solar heat gain.

Solar gain can be minimised through careful layout planning and window design (see above), but also through the use of solar shading. While internal shading can reduce solar gain, external shading is generally more effective for minimising heat gain from the sun. External shading devices can be fixed or movable.

Fixed external shading

Fixed shading devices include **brise soleil**, projecting eaves or balconies placed over windows. Brise soleil can be effective in reducing solar gain but might be unsuitable for buildings that need to have a more traditional appearance, perhaps in order to fit with surrounding buildings. Also, brise soleil is often considered an unnecessary extravagance on housing in the UK, so a strong case would need to be made for the use of such shading.

Projecting eaves can be cost effective and can be suitable for buildings that require a traditional appearance. Large overhangs, such as where balconies are placed over windows, can significantly reduce the amount of skylight entering a room and should be avoided.

With south-facing rooms, fixed shading generally has the advantage of permitting direct sunlight in winter, when the sun's warmth is beneficial, while excluding direct sunlight in the summer. West and east-facing windows will receive little benefit from fixed shading, as even in summer months the sun is generally too low in the sky for fixed shading to act as an effective barrier.

Movable external shading

Movable shading devices include awnings, external roller blinds and shutters. Movable shading has the advantage of minimising the loss of skylight, as shading can be withdrawn on dull days and in winter months. However, it often requires more maintenance, and can be difficult to operate, especially for people with arthritis or sight loss. It is currently uncommon for movable external shading to be used in UK-based housing, but it is widely used in Continental Europe **(Figure 16)**. While this possibly reflects differences in climate between mainland Europe and the UK, arguably there should be greater uptake of movable shading devices given the increasing incidence of overheating in UK housing. Movable external blinds should, however, be selected carefully; in Continental Europe inward-opening windows are commonly used, which do not interfere with external shading. However, many older people experience difficulties in reaching up high, and therefore might find inward-opening tilt-and-turn windows difficult to open and close. Where easily operable outward-opening windows are required, care must be taken to ensure that external blinds or shutters do not impede window opening.

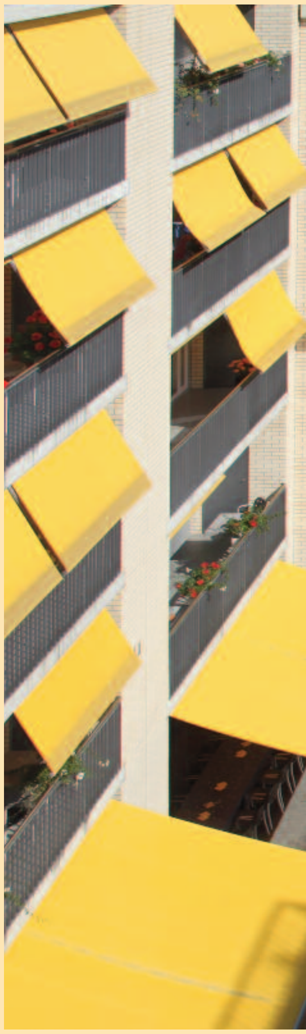


Figure 16: Movable external shading

Tinted glazing

Tinted glazing can help to reduce solar gain, but will reduce the amount of daylight permitted overall and will cause a room to look gloomy. The use of tinted glazing is therefore inadvisable, unless required for other health conditions.

Mid-pane blinds

Mid-pane Venetian blinds provide more protection from the sun's heat than internal blinds, and can help reduce glare **(Figure 17)**. Venetian blinds in ventilated double windows will require regular cleaning, and provision should be made for access. Blinds in sealed glazing units will get dirty less quickly but might not be retractable, thus reducing daylight and views out.

Figure 17: Mid-pane Venetian blinds

Internal blinds

It is essential that occupants have some means of preventing visual glare from direct sunlight. Internal blinds, such as Venetian or vertical blinds, are generally effective for this purpose. Opaque shading is usually more effective for preventing glare than perforated or loose-weave fabric shades, which can be uncomfortably bright. Internal blinds should be fitted as part of any construction project, rather than left to occupants' discretion.

Movable shading: controls

Where movable shading is used, either externally or internally, consideration should be given to the control mechanisms. The controls for shading devices should be operable by people with dexterity loss or who use a wheelchair. Consideration should also be given to people with sight loss, who might have difficulties in seeing a thin pull-cord. Automated blinds should be avoided, as these can be perceived as threatening by people with dementia.

Electric lighting

A room with a daylight factor between 2%-5% will not necessarily provide occupants with sufficient light to perform specific tasks. This is because, as described above, daylight factor is not an absolute measure of the amount of light falling on a surface, but rather a measure of the light on the **working plane** relative to that available under an unobstructed hemisphere, and daylight levels are constantly changing.

Quantity of light required

British Standards document BS 8206-2:2008 provides a method for calculating the percentage of a year for which the daylight level at a given point is likely to exceed a specified quantity. There are also a number of software packages that can be used for this type of calculation.

It is difficult to specify how much light a person with sight loss will require for a particular task, partly because lighting needs are dependent on a person's condition and can vary hugely between individuals; therefore controllability of light is essential. An indication of how much light is required for particular activities is provided in the publication, 'Housing for People with Sight Loss: A Thomas Pocklington Trust Design Guide' (Goodman, 2008).

Supplementing daylight with electric light

Daylight should be supplemented by electric lighting to enhance the general brightness of a room and to provide sufficient light for tasks. Optimumenergy efficiency is usually achieved when daylight is supplemented by electric light.

Tasks that require daylight for illumination must be located near to a window. It should be possible for lights furthest from windows to be switched on and off independently from lights closest to windows, to allow the darkest areas of a room to be illuminated. This can be especially important in living rooms and communal spaces. Dimmer switches should be used wherever possible.

Fitted electric lights should be provided over kitchen work surfaces, cookers and sinks, over showers, over or to both sides of bathroom mirrors and over entrances. Fluorescent luminaires should be high frequency to prevent flicker. All electric lights should be positioned or fully enclosed within diffusers in order to minimise glare. Living rooms and bedrooms should have plenty of electrical sockets to enable portable task lighting to be used, positioned to minimise the need for trailing leads.

Issues to consider in designing a window

Sunlight

- Direct sunlight is often welcome, especially during the winter, provided the occupant has the means to exclude it to prevent problems with glare and excessive solar gain
- Moveable shading devices can be withdrawn on overcast days, minimising the loss of daylight, but (unlike fixed shading) can require more maintenance and be difficult to operate for some people

Diffuse light (from overcast sky)

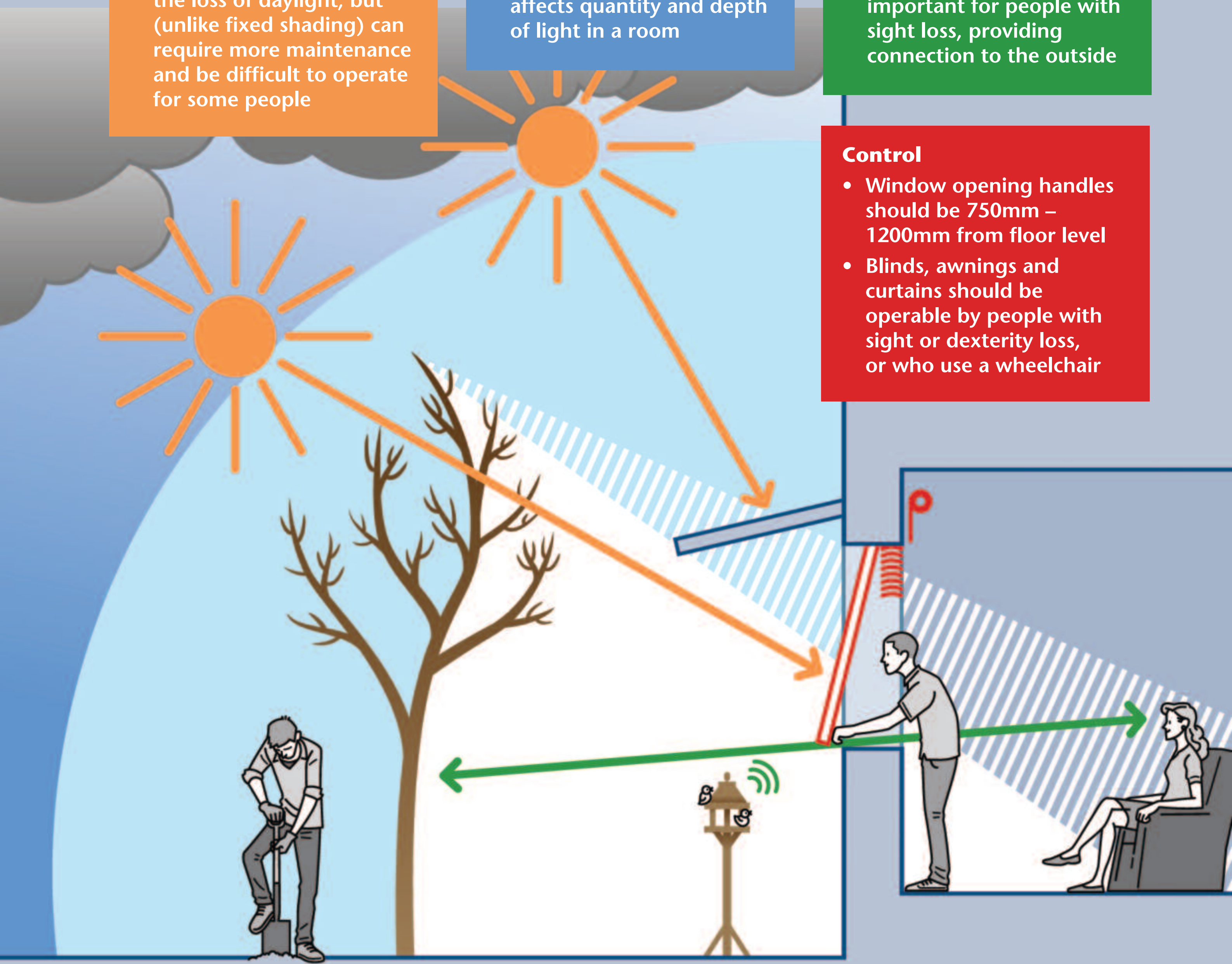
- Light from **zenith** brighter than that from horizon
- External obstructions (including those over the window) will affect the quantity and depth of light in a room
- Size and shape of window affects quantity and depth of light in a room

The view from the window

- Views of natural features and human activity are often preferred, but consideration should also be given to the need for privacy
- Sill height can affect what can be seen by a seated person
- Sound can be particularly important for people with sight loss, providing connection to the outside

Control

- Window opening handles should be 750mm – 1200mm from floor level
- Blinds, awnings and curtains should be operable by people with sight or dexterity loss, or who use a wheelchair



Glossary

Aspect – the view from the window

Average daylight factor – the average daylight factor over a horizontal working plane (as opposed to the daylight factor at a given point – see Daylight factor).

BREEAM – Building Research Establishment Environmental Assessment Methodology. An environmental assessment method and rating system for buildings first launched in 1990. It sets the standard for best practice in sustainable building design, construction and operation and is widely recognised as a measure of a building's environmental performance.

Brise soleil – an unmovable and permanent feature of a building, usually consisting of slats or louvres, designed to provide shading from sunlight.

Climate-based daylight modelling – a computer-based approach to predicting daylight levels using information on sky and sun conditions derived from standard meteorological datasets.

Curtain wall glazing – The curtain wall method of glazing allows glass to be used in large uninterrupted areas creating consistent facades. Typically curtain wall systems are non-load bearing and comprise a lightweight aluminium frame onto which glazed panels can be fixed.

Daylight – skylight and sunlight combined (also see Natural light).

Daylighting – the practice of designing a building in order to provide effective internal lighting from natural light.

Daylight factor – the skylight available at a given point on the working plane relative to the amount of light that would be available if the surface were under an unobstructed hemisphere, expressed as a percentage.

Dual aspect – where there are windows on two sides of a dwelling.

Lux – Lux is the unit of illuminance (measure of the density of light falling on a surface).

Natural light – skylight and sunlight combined (also see Daylight).

Obstruction angle – the angle between the top of an obstruction (such as a neighbouring building) and the horizon, as measured in the vertical plane perpendicular to the window wall, from a reference point in the window wall (usually the centre of a window – see Figure 3).

Probable sunlight hours – the long-term average of the total number of hours that sunlight would fall on unobstructed ground at the same location over the course of an average year, when clouds are taken into consideration.

Reflectance – a coefficient expressing the proportion of light reflected by a surface, relative to that which falls on the surface.

Single aspect – where a dwelling's windows face in one direction only.

Solar gain – heat acquired from sunlight.

Sunlight – direct light from the sun (as opposed to diffuse light from the sky).

Skylight – diffuse light (as opposed to direct light) from the sun that has been scattered by the atmosphere.

Transmittance – a coefficient expressing the ratio of light energy transmitted through a body to that falling on it.

Transom – a horizontal bar between panes of glass in a window.

Working plane – the surface on which work is undertaken, normally taken to be a horizontal surface at table height (assumed to be 0.85m in dwellings).

Zenith – the highest point of the hemisphere (as opposed to the horizon, which is the lowest point).

Useful resources

The criteria for good daylighting set out in this guide are taken from a range of sources, particularly those listed below. Details of the sources used can be found in Lewis A (2015). Daylighting in older people's housing: Barriers to compliance with current UK guidance.

British Standards Institution (2008) BS-8206-2: 2008 *Lighting for Buildings – Part 2: Code of practice for daylighting*, London: BSI

Goodman C (2008) *Housing for People with Sight Loss: A Thomas Pocklington Trust Design Guide*, EP 84, IHS BRE Press

Greasley-Adams C, Bowes A, Dawson A and McCabe L (2014), *Good practice in the design of homes and living spaces for people with dementia and sight loss*, University of Stirling and Thomas Pocklington Trust

Lewis A (2015) Daylighting in older people's housing: Barriers to compliance with current UK guidance, *Lighting Research and Technology*

Littlefair P (2011) *Site Layout Planning for Daylight and Sunlight: A Guide to Good Practice*, IHS BRE Press

Littlefair P (1999) *Solar Shading of Buildings*, London: Construction Research Communications Ltd.
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Thomas Pocklington Trust (2015) Good Practice Guide 5 *Good Housing Design - Lighting: A practical guide to improving lighting in existing homes*

Thomas Pocklington Trust (2014) Pocklington for Professionals *Homes and living spaces for people with sight loss: A guide for interior designers*

Thomas Pocklington Trust (2014) Good Practice Guide 4 *Housng for People with Sight Loss: A practical guide for improving existing homes*

Tregenza P and Wilson M (2011) *Daylighting - Architecture and Lighting Design*, London and New York: Routledge

Thomas Pocklington Trust
for people with sight loss

Pier House
90 Strand on the Green
London W4 3NN
Tel 020 8995 0880

Email info@pocklington-trust.org.uk
Website www.pocklington-trust.org.uk
Registered Charity No. 1113729
Company Registered No. 5359336

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