GUIDANCE NOTE 50

Natural light calculation methodology

Scope

This guidance note applies to:

Scheme	Version
BREEAM International New Construction	V7
BREEAM UK New Construction	V7
BREEAM Refurbishment and Fit Out	V7

Introduction

This guidance note describes the calculation methodologies that underpin the natural light issue (Hea 01) within BREEAM New Construction Version 7 (UK and International) and BREEAM Refurbishment and Fit Out Version 7.

Guidance is provided for methodologies relating to the daylight criteria and the evaluation of glare from daylight criteria. All the calculation methods outlined in the technical manual for these criteria are described in this guidance note.

Contents

1. Daylighting

There are three calculation methodologies that can be used to demonstrate compliance with the daylighting criteria. These are:

- Daylight illuminance (see Section 1.2)
- BS EN 17037:2018+A1:2021 (see Section 1.3)
- IES LM-83-23 (see Section 1.4)

Independent of which methodology is selected the daylight calculation guidance in Section 1.1 below must be used.

1.1 Daylight calculation

Calculating the percentage of assessed area

The percentage of the total floor area of all relevant rooms must comply where the criteria specify that a percentage of floor area must have adequate daylight illuminance. These criteria must be met in each relevant space or room. The floor areas of compliant spaces or rooms must then be added together, and the sum expressed as a percentage of the total relevant floor area. The resulting percentage must then be checked against the minimum relevant building area to comply referenced in the 'space type and illuminance requirements' tables. For example, six relevant rooms each have a floor area of 150 m² making a total relevant floor area of 900 m²; 80% of this floor area must meet the criterion, so 720 m² must comply. This is the equivalent to 4.8 rooms. The number of rooms must always be rounded up so, in this example, five rooms must comply to achieve the credit.

Where areas within a building have different daylighting requirements for the same credit, all relevant areas must meet the requirements to award the daylighting credit(s).

An example of how to calculate the percentage of assessed area is provided in Appendix A.

Calculation model

Daylighting calculations will require assessment via detailed computer modelling to simulate the daylight illuminance at calculation points within the assessed spaces. The calculation model should include all the room surfaces, and any surface outside the room that could affect the light received.

Calculations should be carried out using climatic data for the location of the site (via the use of an appropriate weather file within the software) at an at least hourly interval for a typical year and using appropriate simulation parameters as described in the following paragraphs.

Surface reflectance

In calculating daylight illuminances, internal and exterior surfaces and obstructions need to be modelled including appropriate values for surface reflectance. Fixtures and fittings need not be included. If trees would impact the daylight to the new development, they should be taken into account following the guidance in the BRE Report BR209 'Site layout planning for daylight and sunlight: a guide to good practice'.

Where surface finishes have been specified or measured on site, they can be used in the daylight calculations with appropriate factors for maintenance and furniture. To allow for these factors, maximum reflectance for the following surfaces have been outlined in Table 1.

Table 1: Maximum surface reflectance

Surface	Maximum reflectance
White painted surfaces	0.8 indoors, and 0.6 outdoors
Light pastel internal walls	0.7
Light wood internal floors	0.4

The surface reflectance values used should be presented in the assessment, along with a specification of the materials. Where surface reflectance values have not been measured or specified, default values should be used in the calculation as outlined in Table 2.

Table 2: Default surface reflectance

Surface	Default reflectance values
Internal walls	0.5
Internal ceilings	0.7
Internal floors	0.2
External walls and obstructions	0.2
External ground	0.2

External obstructions should be taken into account to include future buildings that have received planning permission.

Glazing transmittance

For clean, clear double glazing with a low emissivity coating, a value of 0.68 for diffuse transmittance can be used unless a specific value has been specified. For other types of glazing, the diffuse transmittance, if needed, can be found by multiplying the manufacturer's normal incidence light transmittance by 0.91. Care needs to be taken to apply the correct values within the calculation software; often software programs use the normal incidence transmittance, which is directly available from the glazing manufacturer, and have inbuilt correction for light coming from oblique angles.

Glazing transmittance, including maintenance factors, need to be included in the calculation along with account for, or modelling of, window framing. Where window frames are not specifically included in the calculation model, framing factors should be applied based on the ratio of glass to overall aperture area for the type of opening to be used. This will generally vary with aperture size and whether there are openable parts. Where opening types have not been specified, results for the overall aperture should be multiplied by a default framing factor as shown in Table 3.

Table 3: Default framing factors

Opening types	Default framing factors
Windows with small panes	0.5
Normal windows with openable parts	0.6
Patio doors	0.7
Horizontal rooflights	0.7

Daylight calculations should also include a glazing maintenance factor to allow for the decrease in daylight transmittance over time due to the accumulation of dirt. The visible light transmittance of the glazing should then be corrected by the glazing maintenance factor in the daylight calculations. The glazing maintenance factor should be determined on a case-by-case basis using Table 4, Table 5, and Table 6.

Table 4: Percentage losses of light in particular types of buildings (extracted from BS EN 17037:2018, Table NA.2)

Building type	Percentage loss of daylight compared with clean glazing (%)	
	Rural/suburban	Urban
Residential: private and communal. Rooms with few occupants, good maintenance	4	8
Commercial, educational. Rooms used by groups of people, office equipment	4	8 to 12
Polluted atmosphere. Gymnasia, swimming pools	12 to 24	12 to 24

Table 5: Exposure multiplying factors (extracted from BS EN 17037:2018, Table NA.3)

Exposure	Exposure multiplier		
	Vertical glazing	Inclined glazing	Horizontal glazing
Normal exposure for location	×1	×2	×3
Exposed to heavy rain	×0.5	×1.5	×3
Exposed to snow	×1	×3	×4

Table 6: Special exposure multiplying factors (extracted from BS EN 17037:2018, Table NA.4)

Condition	Multiplying factor
Vertical glazing sheltered from rain	×3
Weathered or corroded glazing	×3 (no correction for rain exposure)
Leaded glazing	×3

Note:

To determine the glazing maintenance factor for a particular situation the value for the percentage loss of light in the particular building type is first determined from Table 4, and then multiplied by the exposure factors given in Table 5 and Table 6 if necessary. Finally, the result is subtracted from 100% to give the glazing maintenance factor.

For example, considering vertical glazing in a city centre swimming pool located under a terrace (hence sheltered from rain). The loss of light will be at least 12% × 1 × 3 = 36%. The glazing maintenance factor will be 100% – 36% = 64% or 0.64.

Calculation grid

The calculation of daylight illuminance needs to be carried out on a grid of points on a reference plane within each area assessed. The reference plane is usually considered to be the horizontal working plane at 0.85 m above the floor level unless otherwise specified for the specific activities taking place in each of the assessed areas.

The calculation grid across a horizontal working plane can exclude a band along the walls unless it is part of the room area used by the occupants. This band should be no more than 0.3 m wide in residential applications and no more than 0.5 m wide in non-residential applications.

The grid spacing to be used in the calculation should be no more than 0.3 m in residential applications and no more than 0.5 m in non-residential applications.

Borrowed light

For areas where borrowed light is used to demonstrate compliance with daylighting criteria, calculations or results from appropriate lighting design software must be provided to demonstrate that such areas meet the BREEAM criteria (if the light from these sources is required in order for the room to comply). Examples of borrowed light include: light shelves, clerestory glazing, light pipes or internal translucent or transparent partitions (such as those using frosted glass).

1.2 Daylight illuminance

The methodology described above in 1.1 Daylight calculation must be followed.

Once daylight illuminance in a space has been calculated for each grid point and using an at least hourly interval for a typical year, either of the following methods can be used.

Method 1

1. Determine at each grid point the number of annual hours the point receives at least the target for average daylight illuminance, and at least the target for minimum daylight illuminance at worst lit point (for example, 300 lux and 90 lux for occupied spaces in education buildings, respectively).
2. Calculate the average across the entire calculation grid of the numbers of annual hours when the target for average daylight illuminance (for example, 300 lux for occupied spaces in education buildings) is met. If the result is greater than or equal to the target number of annual hours (for example, 2000 hours in education buildings), then the space meets the average daylight illuminance criterion.
3. Take the grid point with the lowest number of annual hours when the target for minimum daylight illuminance at worst lit point (for example, 90 lux for occupied spaces in education buildings) is met. If this number of annual hours is greater than or equal to the target number of annual hours (for example, 2000 hours in education buildings), then the space meets the criterion for minimum daylight illuminance at worst lit point.
4. The space is compliant if both the average daylight illuminance and the minimum daylight illuminance at worst lit point criteria are met.

Method 2

1. Determine at each grid point the daylight illuminance that is received over the target number of annual hours (for example, 2000 hours in education buildings).
2. Calculate the average daylight illuminance across the entire calculation grid that is received over the target number of annual hours (for example, 2000 hours in education buildings). If the result is greater than or equal to the target for average daylight illuminance (for example, 300 lux for occupied spaces in education buildings), then the space meets the average daylight illuminance criterion.
3. Take the grid point with the lowest daylight illuminance that is received over the target number of annual hours (for example, 2000 hours in education buildings). If this daylight illuminance is greater than or equal to the target for minimum daylight illuminance at worst lit point (for example, 90 lux for occupied spaces in education buildings), then the space meets the criterion for minimum daylight illuminance at worst lit point.
4. The space is compliant if both the average daylight illuminance and the minimum daylight illuminance at worst lit point criteria are met.

1.3 Daylight illuminance (EN 17037)

The methodology described above in 1.1 Daylight calculation must be followed.

EN 17037 gives three levels of recommendation for daylight provision in interior spaces: minimum, medium and high. For compliance with the standard credits, a daylit space should achieve the minimum level of recommendation. For compliance with the exemplary credits, a daylit space should achieve the recommended level in NC V7 or RFO V7. The minimum area of compliance dependent on the building type must also be met in accordance with the standard and exemplary level credits.

For daylit spaces lit by vertical and inclined spaces, a target illuminance (E_T) should be achieved across at least half of the reference plane for at least half of annual daylight hours. Another minimum target illuminance (E_{TM}) should also be achieved across at least 95% of the reference plane for at least half of annual daylight hours. Table 7 gives these target illuminances for side lit spaces. A level of recommendation is achieved if the criteria for both the target illuminance (E_T) and the minimum target illuminance (E_{TM}) are met.

Table 7: Side lit spaces – Target illuminances from daylight over at least half of annual daylight hours in side lit spaces

Level of recommendation	Target illuminance E_T (lx) for half of reference plane	Minimum target illuminance E_{TM} (lx) for 95% of reference plane
Minimum	300	100
Medium	500	300
High	750	500

For daylit spaces lit by openings in a horizontal surface, a target illuminance (E_T) should be achieved across at least 95% of the reference plane for at least half of annual daylight hours. Table 8 gives this target illuminance for top lit spaces. No minimum target illuminance (E_{TM}) applies for such spaces.

Table 8: Top lit spaces – Target illuminances from daylight over at least half of annual daylight hours in top lit spaces

Level of recommendation	Target illuminance E_T (lx) for 95% of reference plane
Minimum	300
Medium	500
High	750

1.4 Spatial daylight autonomy (IES LM-83-23)

The methodology described above in 1.1 Daylight calculation must be followed.

IES LM-83-23 uses Spatial Daylight Autonomy (sDA), or the percentage area of a space which meets a minimum daylight illuminance for a specified fraction of operating hours. It gives the following sets of recommendations:

Table 9: Accepted daylight sufficiency

Accepted daylight sufficiency	Spatial Daylight Autonomy (sDA)		Equivalent BREEAM rating*
Nominal	$sDA_{300,55\%}$	Daylight illuminance across at least 55% of the reference plane area (or grid points analysed) exceeds 300 lux for at least half of annual operating hours.	Standard credits
Preferred	$sDA_{300,75\%}$	Daylight illuminance across at least 75% of the reference plane area (or grid points analysed) exceeds 300 lux for at least half of annual operating hours.	Exemplary credits

* The minimum area of compliance, dependent on the building type, must also be met in accordance with the standard and exemplary level credits.

Unless otherwise specified, annual operating hours can be taken to be 8am to 6pm local clock time every day of the year. As such, the percentage of the space for which 300 lux is exceeded for more than 1825 hours between 8am and 6pm over a year (10 x 365 x 50%) should be determined and compared with the above criteria.

2. Evaluation of glare from daylight

There are two calculation methodologies that can be used to demonstrate compliance with the exemplary level evaluation of glare from daylight criteria. These are:

- Daylight Glare Probability
- Annual Sunlight Exposure

2.1 Daylight Glare Probability

Daylight Glare Probability (DGP) is a discomfort glare metric developed for side lit spaces. It factors in vertical daylight illuminances at the eye as well as brightness and position of potential sources of glare in the visual field of an observer. Whilst it can be calculated with an empirical equation, DGP calculations are performed in practice using daylight analysis software.

Values of DGP can be categorised with the following ranges in Table 10.

Table 10: DGP range categorisation (extracted from BS EN 17037:2018)

Criterion	DGP
Glare is mostly not perceived	DGP ≤ 0.35
Glare is perceived but mostly not disturbing	0.35 < DGP ≤ 0.40
Glare is perceived and often disturbing	0.40 < DGP ≤ 0.45
Glare is perceived and mostly intolerable	DGP ≥ 0.45

EN 17037 uses DGP to assess protection from glare for spaces where the activities are comparable to reading, writing, or using display devices and the occupants are not able to choose position and viewing direction. As a minimum level of recommendation for glare protection, EN 17037 requires that a DGP of 0.45 is not exceeded for more than 5% of the annual occupancy hours. A medium level of protection is achieved for a maximum DGP value of 0.40, and a high level of protection for a maximum DGP value of 0.35, in both cases for no more than 5% of the annual occupancy hours, as outlined in Table 11.

Table 11: Levels of threshold $DGP_{e<5\%}$ for glare protection

Glare protection level	$DGP_{e<5\%}$	BREEAM exemplary glare performance
Minimum	0.45	No
Medium	0.40	Yes
High	0.35	Yes

Default annual occupancy hours are taken to be 8am to 6pm local clock time on Monday to Friday. Different occupancy hours can be used as applicable.

DGP calculations should be carried out using a computer model of the assessed areas developed as described above in 1.1 Daylight calculation. The calculation should be undertaken for each observer position inside relevant building areas in a vertical plane at 1.2 m above floor level in the typical direction of view.

Compliance with the BREEAM exemplary level criteria is achieved if for all workstations in all relevant building areas the calculated DGP value does not exceed 0.40 over more than 5% of annual operating hours, as outlined in Table 11.

Exclusions

The DGP assessment can be applied to a space with vertical or inclined daylight openings but is not applicable for a space with daylight openings in a horizontal surface.

Additionally, DGP cannot be applied to cases where vertical illuminance is not expected to be a good indicator for the perception of glare; for example, vending areas of shops, sports halls and deep or dark spaces with very small daylight openings. Furthermore, DGP cannot be applied to positions in a space which are far away from daylight openings or receive low daylight levels.

2.2 Annual Sunlight Exposure (IES LM-83-23)

Annual Sunlight Exposure (ASE) is a measure of sunlight to suggest if a space is over-sunlit with the potential for glare or heat gains. Whilst ASE is not a direct measure of glare, it can indicate the potential for glare if sunlight exposure exceeds a certain limit.

To limit the potential for glare in a daylit space, IES LM-83 recommends that no more than 10% of the regularly occupied area receives 1000 lux or more for 250 hours per year (ASE1000,250 ≤ 10% of regularly occupied space).

ASE calculations should be carried out using a computer model of the assessed areas developed as described above in 1.1 Daylight calculation. The calculation should be undertaken using a grid on the horizontal reference plane as described in that section. Unless otherwise specified, default annual occupancy hours can be taken to be 8am to 6pm local clock time on Monday to Friday. Daylight analysis software should be used to determine at each grid point either the daylight illuminance exceed for 250 hours per year, or the number of hours per year when daylight illuminance exceeds 1000 lux.

Compliance with the BREEAM exemplary level criteria is achieved if in all relevant building areas no more than 10% of the regularly occupied space can receive a daylight illuminance of 1000 lux or more for 250 hours per year or more. In other words, at least 90% of the regularly occupied space in all relevant building areas can receive no more than 1000 lux from daylight over no more than 250 hours per year.

Appendix A: Example of minimum compliance area calculation

This appendix provides guidance on how to consider the minimum percentage area to comply in line with the BREEAM manual with the different calculation methods.

The following section presents an illustrated example, describing the information already in this guidance note and the technical manual.

A1. Example asset

A new construction office building in France has a total occupied area of 120 m². The occupied area is split up into six different rooms all of which are 20 m². See Figure 1.

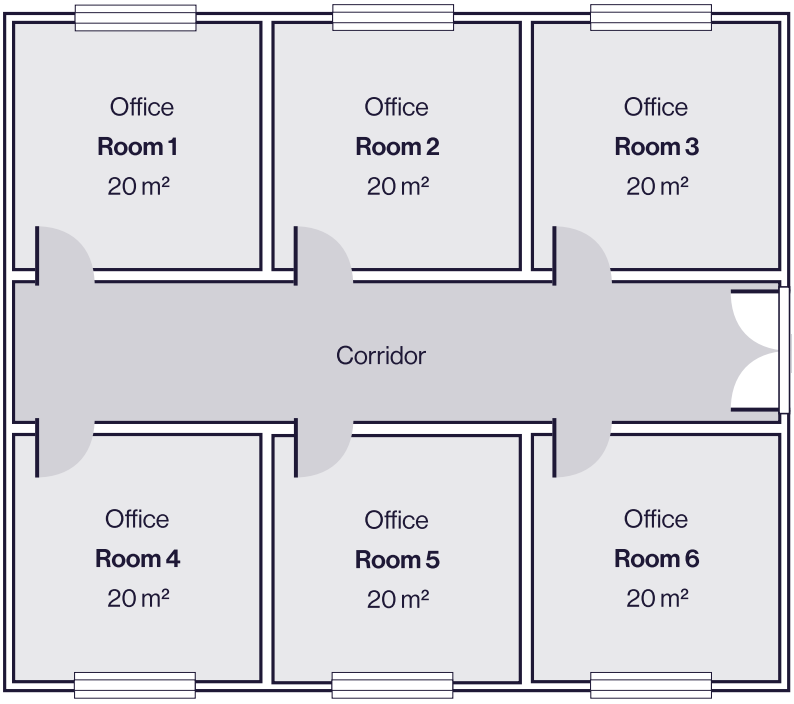

Figure 1: Example asset

A2. Technical manual criteria

In line with the 'Space type and illuminance requirements' table in Hea 01 of the BREEAM NC V7 technical manual, in order to achieve two credits, all occupied spaces of the office building must meet the minimum area to comply of 80%.

Either option 1, 2 or 3 can be used to demonstrate alignment with the criteria. In this example option 2, following the EN 17037 method is selected.

A3. Assessment area

For any option selected, each room is assessed separately. For the room to comply, the whole room must meet the criteria set out in option 1, 2 or 3. See Figure 2.

The area of each compliant room is then added together to determine the overall percentage of compliant area, i.e. 80%. This is in line with 1.1 Daylight calculation and the methodology on 'Calculating the percentage of assessed area' in Hea 01 in the BREEAM NC V7 technical manual.

Area type	Minimum area to comply		Option 1: Good practice criteria		Option 2: EN 17037	Option 3: IES LM-83
	1 credit	2 credits	Average daylight illuminance (averaged over entire space)	Minimum daylight illuminance at worst lit point		
Office buildings (2 credits)						
All occupied spaces, unless indicated in Definitions	-	80%	At least 300 lux for 2000 hours per year or more	At least 90 lux for 2000 hours per year or more	Any level of recommendation using the daylight illuminance criteria in EN 17037	At least 'nominally accepted' daylight sufficiency as per IES LM-83

Figure 2: Extract from table 'Space type and illuminance requirements' in Hea 01 in BREEAM NC V7

A4. Daylight requirements

Using option 2 Daylight illuminance EN 17037, each room must meet the below, in line with Section 1.3:

- ETM (lx) - 95% of the area needs to have 100 lux or more during 50% of the daylight hours.
- ET (lx) - 50% of the area needs to have 300 lux or more during 50% of the daylight hours.

The criteria must be met in each room based on 100% of the relevant area within the room.

A5. Daylight assessment

Each room is assessed separately; in this example, in Figure 3, all six rooms meet the criteria; therefore, 120 m², or 100% of relevant area, complies.

Looking at each room, this means that over half of the annual daylight hours:

- 95% or 19 m² per room ≥ 100 ETM (lx)
- 50% or 10 m² per room ≥ 300 ET (lx)

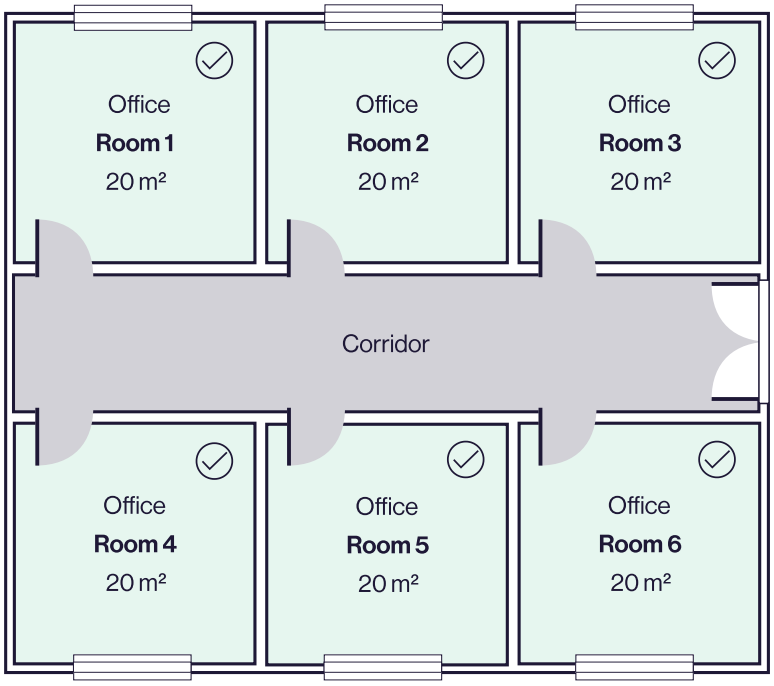

Figure 3: Example asset - Daylight assessment (full compliance)

A6. Alternative daylight assessment

In this alternative example in Figure 4, four rooms meet the criteria; therefore 80 m², or 67% of relevant area, complies.

This does not meet the 80% minimum area to comply for offices.

Figure 4: Example asset - Alternative daylight assessment (partial compliance)

Schedule of changes

Version	Release date	Description of change
0.0	Jul 2024	First issue.
1.0	Jul 2026	Added example calculation (Appendix A). Updated 'Scope' and 'Introduction' to include reference to BREEAM Refurbishment and Fit Out V7.

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