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Design of road lighting

Part 1: Lighting of roads and public amenity areas — Code of practice

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Contents

Summary of pages

This document comprises a front cover, and inside front cover, pages i to iv, pages 1 to 80, an inside back cover and a back cover.

Foreword

Publishing information

This part of BS 5489 is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 May 2020. It was prepared by Subcommittee EL/1/2, *Road lighting*, under the authority of Technical Committee EL/1, *Light and lighting*. A list of organizations represented on these committees can be obtained on request to their secretary.

Supersession

This part of BS 5489 supersedes BS 5489-1:2013, which is withdrawn.

Relationship with other publications

BS 5489 consists of two parts:

- Part 1: *Lighting of roads and public amenity areas*;
- Part 2: *Lighting of tunnels*.

This part of BS 5489 contains guidance and recommendations that are intended to support the BS EN 13201 series and to assist designers of lighting systems in using that standard.

Information about this document

This is a full revision of the standard. The principal changes are to align the standard with current best practice and with the BS EN 13201 series. New guidance is provided for lighting design when located within a "smart city" environment or when co-located with electric vehicle (EV) charging points.

The aim of this standard is to promote wider understanding of the lighting of roads and public amenity areas and to give guidance on the design decisions that need to be made. Rather than being prescriptive, it makes recommendations that are essential to the design process and that will enable production of designs that are appropriate and justifiable. The design of lighting for roads and public amenity areas can be a complex process with many different aspects, and therefore it is important that all relevant issues are taken into account.

This publication can be withdrawn, revised, partially superseded or superseded. Information regarding the status of this publication can be found in the Standards Catalogue on the BSI website at bsigroup.com/standards, or by contacting the Customer Services team.

Where websites and webpages have been cited, they are provided for ease of reference and are correct at the time of publication. The location of a webpage or website, or its contents, cannot be guaranteed.

Use of this document

As a code of practice, this part of BS 5489 takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this part of BS 5489 is expected to be able to justify any course of action that deviates from its recommendations.

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people for the task in hand, for whose use it has been produced.

Presentational conventions

The provisions in this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Commentary, explanation and general informative material is presented in smaller italic type and does not constitute a normative element.

The word “should” is used to express recommendations of this standard. The word “may” is used in the text to express permissibility, e.g. as an alternative to the primary recommendation of the clause. The word “can” is used to express possibility, e.g. a consequence of an action or an event.

Notes and commentaries are provided throughout the text of this standard. Notes give references and additional information that are important but do not form part of the recommendations. Commentaries give background information.

Where words have alternative spellings, the preferred spelling of the Shorter Oxford English Dictionary is used (e.g. “organization” rather than “organisation”).

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope

This part of BS 5489 gives recommendations on the general principles of road lighting and its aesthetic and technical aspects, and provides guidance on operation and maintenance. It also provides guidance on means of minimizing energy consumption and limiting the impact on the environment and adjacent property.

It gives recommendations for the design of lighting for all types of highway and public thoroughfare, including those specifically for pedestrians and cyclists, and for pedestrian subways and bridges. It excludes the lighting of vehicular tunnels and underpasses, which are covered in BS 5489-2.

It gives recommendations for the design of lighting for urban centres and public amenity areas. It gives recommendations and guidance for lighting relating to smart cities.

It gives additional recommendations for lighting around aerodromes, railways, coastal waters, harbours and navigable waterways, in order to minimize the possibility of the lighting interfering with these modes of transport.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes provisions of this document.[1)] For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Standards publications

BS 5266-1, *Emergency lighting – Part 1: Code of practice for the emergency escape lighting of premises*

BS 6100-2, *Building and civil engineering – Vocabulary – Part 2: Spaces, building types, environment and physical planning*

BS 7671, *Requirements for Electrical Installations – IET Wiring Regulations*

BS 8300-2, *Design of an accessible and inclusive built environment – Part 2: Buildings – Code of practice*

BS EN 40 (all parts), *Lighting columns*

BS EN 12464-1:2011, *Light and lighting – Lighting of workplaces – Part 1: Indoor work places*

BS EN 12464-2:2014, *Lighting of work places – Part 2: Outdoor work places*

BS EN 12665, *Light and lighting – Basic terms and criteria for specifying lighting requirements*[2)]

BS EN 12767, *Passive safety of support structures for road equipment – Requirements and test methods*

BS EN 13201-2:2015, *Road lighting – Part 2: Performance requirements*

BS EN 13201-3, *Road lighting – Part 3: Calculation of performance*

BS EN 13201-4, *Road lighting – Part 4: Methods of measuring lighting performance*

BS EN 13201-5, *Road lighting – Part 5: Energy performance indicators*

BS EN 60598-1, *Luminaires – Part 1: General requirements and tests*

BS EN 60598-2-3, *Luminaires – Part 2-3: Particular requirements – Luminaires for road and street lighting*

BS EN 62305 (all parts), *Protection against lightning*

1) Documents that are referred to solely in an informative manner are listed in the Bibliography.
2) This standard also gives an informative reference to BS EN 12665:2018.

PD 6547, *Guidance on the use of BS EN 40-3-1 and BS EN 40-3-3*

Other publications

[N1] COMMISSION INTERNATIONALE DE L'ÉCLAIRAGE. *Method of specifying and measuring colour rendering properties of light sources.* CIE 13.3. Third edition. Vienna: Commission Internationale de l'Éclairage, 1995.

[N2] INSTITUTION OF LIGHTING PROFESSIONALS. *Guidance notes for the reduction of obtrusive light*. GN01. Rugby: Institution of Lighting Professionals, 2020.[3)]

[N3] HEALTH AND SAFETY EXECUTIVE. *Avoiding danger from overhead power lines.* GS6. Fourth edition. London: HSE Books, 2013.

[N4] INSTITUTION OF LIGHTING PROFESSIONALS. *Code of practice for electrical safety in highway electrical operations.* GP03. Rugby: Institution of Lighting Professionals, 2011.[3)]

[N5] INSTITUTION OF LIGHTING PROFESSIONALS. *Safety during the installation and removal of lighting columns and similar street furniture in proximity to high voltage overhead lines.* GP10. Rugby: Institution of Lighting Professionals, 2004.[3)]

[N6] ELECTRICITY ASSOCIATION. *Model code of practice covering electrical safety in the planning, installation, commissioning and maintenance of public lighting and other street furniture.* Engineering Recommendation G39/1. Electricity Association, 1992.

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this part of BS 5489, the terms and definitions given in BS EN 12665, BS EN 13201-2:2015, BS EN 13201-3, BS 6100-2 and the following apply.

3.1.1 absolute photometry

process for measuring photometric quantities directly in SI units

NOTE 1 This term is often used in goniophotometry of luminaires, in contrast with relative photometry.

NOTE 2 Absolute measurements require instruments calibrated for the appropriate SI units.

3.1.2 arrangement

pattern according to which road lighting luminaires are sited in plan, e.g. staggered, opposite, single-sided or twin central

3.1.3 competent person

person who has training and experience relevant to the matter being addressed and an understanding of the requirements of the particular task being approached

NOTE A competent person is expected to be able to provide a reasonable interpretation of and advise on the best means by which the recommendations of this British Standard may be implemented.

3.1.4 conservation area

statutory, designated geographical area of architectural interest, the character or appearance of which it is desirable to preserve or enhance

[3)] Obtainable from the Institution of Lighting Professionals, Regent House, Regent Place, Rugby, CV21 2PN.

3.1.5 constant light output

functionality to constantly adjust the luminous flux of the light source based on the known or predicted depreciation behaviour of the light source to enable a constant luminous flux over time

[SOURCE: PD ISO/CIE TS 22012:2019, **3.5**]

3.1.6 cost

intended and unintended, financial or non-financial negative effect caused by a scheme

3.1.7 design spacing

required distance between the geometric centres of adjacent road lighting luminaires, calculated in accordance with BS EN 13201-3, for a straight and level section of the particular type of road

3.1.8 edge illuminance ratio (R_{EI})

average horizontal illuminance on a strip just outside the edge of a carriageway in proportion to the average horizontal illuminance on a strip inside the edge, where the strips have the width of one driving lane of the carriageway

NOTE This was previously known as surround ratio.

3.1.9 emergency lane

lane not normally or regularly used by road users except in emergency or during breakdown

NOTE The emergency lane is often referred to as a hard shoulder. Where a hard shoulder is regularly or has become permanently open to traffic, for the purposes of road lighting design it is not counted as an emergency lane.

3.1.10 footbridge

bridge over an obstacle to pedestrians, provided for the passage of non-motorized traffic only

3.1.11 geometry

interrelated linear dimensions and characteristics of the road lighting system, i.e. spacing, mounting height, transverse position and arrangement

3.1.12 high mast lighting

system of lighting for large areas using masts carrying clusters of luminaires

NOTE High mast lighting columns are typically greater than 18 m in height.

3.1.13 light source luminous flux factor (f_{LF})

ratio of the luminous flux of a lamp (or light source) at a given time in its life to the initial luminous flux

NOTE 1 Light source manufacturers can provide this information either in tabular or in graphical form.

NOTE 2 Further guidance is provided in PD ISO/CIE TS 22012:2019.

3.1.14 light source survival factor (f_S)

fraction of the total number of lamps (or light sources) which continue to operate at a given time under defined conditions and switching frequency

[SOURCE: BS EN 12665:2018, **3.3.17**, modified – Notes 1 and 2 have been omitted]

3.1.15 lifecycle

complete cycle of scheme, from decision to light and the provision of funds up to the decommissioning, removal and recycling or disposal of the scheme apparatus

3.1.16 lifetime

time from construction up to removal of a scheme

3.1.17 lighting designer

person who is suitably experienced and competent to undertake lighting design for public spaces

3.1.18 mounting height

nominal vertical distance between the photometric centre of a road lighting luminaire and the surface of the road

3.1.19 relative photometry

measurement obtained as a quotient of two photometric quantities

NOTE 1 This term is often used in goniophotometry of luminaires, where luminous intensity distribution is measured as relative values normalized by total luminous flux of the lamps used and reported in the unit cd/klm.

NOTE 2 This method is not applicable to LED light sources and LED luminaires with integrated LED light sources.

3.1.20 residential road

road that carries little vehicular traffic, other than that generated by residents

3.1.21 road bridge

structure carrying a road over another road, railway, river, etc.

3.1.22 set-back

shortest distance from the forward face of a lighting column to the edge of a carriageway

3.1.23 smart city

city that increases the pace at which it provides social, economic and environmental sustainability outcomes and responds to challenges such as climate change, rapid population growth, and political and economic instability by fundamentally improving how it engages society, applies collaborative leadership methods, works across disciplines and city systems, and uses data information and modern technologies to deliver better services and quality of life to those in the city (residents, businesses, visitors), now and for the foreseeable future, without unfair disadvantage of others or degradation of the natural environment

NOTE The term "sustainable cities and communities" is often used in place of "smart cities".

[SOURCE: BS ISO 37122:2019, **3.4**, modified – notes replaced]

3.1.24 S/P ratio

ratio of the luminous output of a light source evaluated according to the CIE scotopic spectral luminous efficiency function, $V'(\lambda)$, to the luminous output evaluated according to the CIE photopic spectral luminous efficiency function, $V(\lambda)$

3.1.25 traffic flow

number of vehicles passing a specific point, at a specific time, in a stated time

3.2 Symbols

For the purposes of this part of BS 5489, the following symbols apply.

$\overline{E}$	maintained average horizontal illuminance, in lux (lx)
E_{min}	maintained minimum horizontal illuminance at any point, in lux (lx)
E_v	vertical plane illuminance at a point, in lux (lx)
f_{LF}	light source luminous flux factor
f_{LM}	luminaire maintenance factor
f_M	overall maintenance factor
f_s	light source survival factor
f_{TI}	threshold increment (TI), as a percentage (%)
H	mounting height, in metres (m)
$\overline{L}$	maintained average road surface luminance, in candelas per square metre (cd/m^2)
L_x	LED rated life: length of time, in hours (h), during which LEDs will provide more than a claimed percentage (x) of initial light output
R_a	general colour rendering index as defined in CIE 13.3 [N1]
R_{EI}	edge illuminance ratio
r	reduced luminance coefficient
T_{CP}	correlated colour temperature (CCT)
U_l	ratio of the minimum to the maximum road surface luminance found in a line along the centre of a driving lane
U_o	ratio of minimum illuminance (luminance) to average illuminance (luminance) of/on a surface
v	speed limit, in miles per hour (mph) *NOTE 1 mph = 1.61 km/h.*
$V(\lambda)$	CIE photopic luminosity function that shows relative sensitivity of the human eye under photopic light conditions to different wavelengths of visible light
$V'(\lambda)$	CIE scotopic luminosity function that shows relative sensitivity of the human eye under scotopic light conditions to different wavelengths of visible light
W_L	width of driving lane, in metres (m)
W_r	width of relevant area of carriageway, in metres (m)
x	percentage of initial luminous flux of an LED
y	percentage of LEDs that will have failed at end of rated life
Φ	luminous flux of light source or lamp(s) in luminaire, in lumens (lm)
θ_f	luminaire tilt in application, in degrees (°)

4 General recommendations

NOTE Attention is drawn to the statutory requirements listed in references [1] to [15]. There is no statutory requirement to provide road lighting. Neither are there any statutory requirements to install a particular class of lighting if a decision is made to light a particular road. However, there are statutes that empower highway authorities to light roads. The provision of road lighting on a previously unlit road might involve statutory requirements and might cause the imposition of speed limits.

4.1 Reasons for road lighting

*COMMENTARY ON **4.1***

Road lighting encompasses the lighting of all types of highway and public thoroughfare, assisting traffic safety and ease of passage for all users. In this respect, good lighting can be one of the measures used to reduce night-time traffic collisions. It can allow pedestrians to see hazards, orientate themselves, recognize other pedestrians and feel more secure. It also has a wider social role, with the potential of helping to reduce crime and the fear of crime, and can contribute to commercial and social use at night, of town centres and tourist locations, by improving the daytime and night-time appearance.

Transport and environment policy is increasingly emphasizing the need to improve conditions for walking and cycling. One factor that potentially influences decisions to travel by these modes is the quality of walking and cycling routes. After dark, lighting has an important role to play in helping to create acceptable conditions. Traditionally, footway lighting has often been considered little beyond functional lighting for the space alongside the carriageway. However, lighting can offer more, and can contribute to creating an environment that is pleasant and interesting as well as satisfying the basic functional objectives.

The provision of traffic calming measures might require particular lighting arrangements. Further guidance relating to lighting for traffic calming features is given in ILP TR25 [16].

*Recommendations for the selection of lighting classes are given in Clause **5**, with additional guidance in Annex A.*

Road lighting should provide visual clues and reveal obstacles so that safe vehicular progress is possible. It should reveal all the features of the road and traffic that are important to all road users, including pedestrians.

Road lighting should not be proposed for the sole purpose of providing visual guidance for traffic; however, where practicable, lighting should be arranged to assist such guidance, and the components of the lighting installation should be arranged such as not to visually mislead motorists as to the route ahead (see **5.1.3** and **6.2.3**).

When lighting is provided on a previously unlit road, guidance should be obtained to determine whether any traffic signs will have to be illuminated, and the impact that the new lighting might have on ecology (see **4.2.4**) should be taken into account.

When lighting is added to an area previously unlit, the distance to other existing lighting should be arranged such there is not a light, dark, light effect created. The travelling speed should be determined using the 85th percentile of surveyed speed or the speed limit. If a section of road is to be left unlit then the minimum unlit section of road should be agreed with the Lighting Authority. A road safety review and a risk assessment should be undertaken prior to agreement of unlit section.

NOTE There is no recommended minimum distance between unlit sections of road. However, one "rule of thumb", which is already used for conflict areas, is that of the "five seconds rule". This is the distance travelled in 5 s at the travelling speed. For high speed roads, the distance advised within the draft DMRB TD501 [17] is "four times the safe sight stopping distance".

4.2 Environment

*COMMENTARY ON **4.2***

Environmental issues associated with road lighting are prime considerations when designing a new or replacement lighting scheme.

*The environmental impact of lighting can be reduced by varying the lighting level to allow the appropriate lighting class to be applied at the relevant time, even switching off at certain times if deemed appropriate. Further guidance is given in **4.3.5**.*

This subclause indicates some matters that need to receive attention and gives recommendations, but it is recognized that in aesthetics, subjective judgements can apply.

4.2.1 General

Designers should address at least the following environmental issues:

a) daytime and night-time appearance (**4.2.2**);

b) minimizing obtrusive light (**4.2.3**);

NOTE 1 Guidance is given in ILP GN01 [N2].

c) undertaking a visual impact assessment;

NOTE 2 Guidance is given in ILP PLG04 [18].

d) effect on ecology, flora and fauna (**4.2.4**); and

NOTE 3 Some species of flora and fauna are protected by legislation.

NOTE 4 Lighting for bats guidance is given in ILP GN08/18 [19].

e) specific environmental issues within local planning policies.

NOTE 5 Further information on environmental sensitivity is available from the DEFRA “MAGIC” website (magic.defra.gov.uk/magicmap.aspx) [20].

The safety of users should take precedence over aesthetics in the event of any conflict of interest between these two factors. Planning authorities or other appropriate organizations should be consulted on matters of appearance.

4.2.2 Appearance

4.2.2.1 Daytime appearance

*COMMENTARY ON **4.2.2.1***

The design and siting of road lighting and other road equipment can make a great difference to the street scene, even though this might not be consciously appreciated. In situations such as a processional way or monumental bridge, the design and placing of lighting columns can make a positive formal contribution to the scene.

More usually, however, buildings, trees, paved surfaces, grass and people provide all the interest required.

In cases where the siting of lighting columns is integral to the formality of a street scene, the columns should be designed and placed with due regard to the architectural or landscape setting.

In other situations, road lighting equipment should be made as unobtrusive as possible.

The designer should consult the client to determine whether there are opportunities to reduce street clutter.

4.2.2.2 Night-time appearance

*COMMENTARY ON **4.2.2.2***

An aspect of planning any lighting scheme is the positive contribution it can make to the improvement of the night environment.

While efficient lighting for traffic and pedestrian safety is essential, particularly in urban and residential roads, consideration of the whole visual scene at night is highly desirable.

The basic design should provide lighting that will be suitable and sufficient for traffic and pedestrian safety. It should also ensure as far as possible that the lighting directly helps to create a pleasant and attractive night-time atmosphere, especially for areas of civic importance (see **7.4**).

Factors such as amenity and environmental requirements, and the assistance in perception of a safe environment that lighting provides, should be taken into account.

The colour rendering index of the light source (R_a) should be suitable for the application.

Where the police use CCTV for prosecution relating to street crime, they should be consulted regarding the lighting requirements, including colour rendering and level.

The colour appearance of light sources should be suitable for the application or task. Lighting designers should undertake appropriate due diligence when choosing an appropriate correlated colour temperature (T_{CP}), and should take into account local legislation, policy and guidance which might limit the allowable colour temperature.

NOTE Colour appearance is quantified by the correlated colour temperature (T_{CP}), which describes the colour appearance of the light that is produced, in terms of its warmth or coolness. The T_{CP} relates the colour appearance of the light source to the colour appearance of a reference source when the reference source is heated to a particular temperature, measured on the Kelvin (K) temperature scale. A low colour temperature (≅ 3 000 K and lower) describes a warm source. A high colour temperature (≅ 4 000 K and higher) describes a cool source.

4.2.3 Obtrusive light

*COMMENTARY ON **4.2.3***

Control of the light distribution of installations is necessary in order to limit obtrusive light and sky glow. In some cases, lighting can be intrusive at night, e.g. in rural and open areas where lighting can be seen as an intrusion in an otherwise darkened environment.

Upward light should be minimized in all road lighting installations by controlling the intensity of light from luminaires as installed, at angles close to or above the horizontal and installing the luminaire horizontally.

NOTE 1 The installed intensity classes from BS EN 13201-2:2015 can be used for this purpose.

Precautions should be taken to avoid unnecessary light intrusion into adjacent properties (see Note 2).

NOTE 2 A limited level of illumination onto front gardens and the face of properties might in some cases, and at the discretion of the client, be allowed in order to enhance the appearance of the area and the protection of property.

NOTE 3 Further information is given in ILP GN01 [N2].

The sensitivity of an environment should be taken into account when designing lighting schemes, particularly in areas such as green belts, national parks, dark sky parks and areas of outstanding natural beauty.

In schemes where residential areas are adjacent to environmentally sensitive areas, the light distribution should be controlled to minimize light spill onto the adjoining areas by selection of an appropriate installed intensity class from BS EN 13201-2:2015.

NOTE 4 There are other advantages in controlling obtrusive light. Light spill affects ecological diversity, as night hunters are often placed at a disadvantage. The ILP/BCT publication ILP GN08/18 [19] provides specific guidance on lighting in areas where bats are prevalent.

In the following situations, luminaires should be used which, when installed, conform to classes G*4, G*5, or G*6, or threshold increment (TI or f_{TI}), or both, as specified in BS EN 13201-2:2015:

a) traffic routes and motorways in environmentally sensitive and open areas;

b) roundabouts and mini-roundabouts, particularly in environmentally sensitive areas and/or with unlit approach roads;

c) elevated roads and bridges; and

d) remote isolated junctions.

NOTE 5 Information on lighting in the vicinity of astronomical observatories is given in the joint IAU/CIE publication Guidelines for minimising urban sky glow near astronomical observatories [21] and the CIE publication Guideline for minimising sky glow [22].

4.2.4 Ecology

COMMENTARY ON ***4.2.4***

When designing a new or replacement scheme, it is important to consider the impact that the new lighting might have on ecology. There is increasing awareness and guidance available regarding the way that artificial lighting can impact flora and fauna. Some specific guidance is given in A review of the impact of artificial light on invertebrates *[23].*

An example of ecology which is impacted by lighting is areas where bats are roosting, foraging or commuting, for which there is published guidance (ILP GN08/18 [19]).

The minimum distance between unlit sections of road may vary from the guidance in ***4.1*** *where gaps are left in the road lighting to provide bat corridors. In some situations, it might be possible to provide the bat corridor by reducing the mounting height in conjunction with the use of a warmer white light source. Some specific guidance is given in ILP GN08/18 [19] recommending mitigation such as specifying the correlated colour temperature (T_{CP}) of the light source to be "a warm white spectrum" (ideally < 2 700 K).*

Designers should liaise with ecologists to understand specific ecological sensitivities for the site. The lighting should then be designed to take these into account.

4.2.5 Sustainability

COMMENTARY ON ***4.2.5***

There are measures which can be taken to improve the sustainability of a road lighting solution.

To achieve a sustainable solution does not require significant financial investment, but it does require appreciation of the impact of the scheme from different points of view. Through innovative and considered decision-making, sustainability can be achieved with little additional investment at the design and construction stage relative to the cost of operating the scheme over its lifetime. It might be the case that a sustainable solution will cost less over its entire lifecycle than a less sustainable solution.

Along with technological solutions such as energy-efficient light sources and controls, and using renewable energies for their electricity source, simple practices such as selection of the appropriate lighting class and use of variable lighting can help to make lighting more sustainable.

Sustainability also requires issues of waste, pollution and energy in the products' lifecycle to be addressed. The need for designs to be energy-efficient designs is covered in ***4.3****.*

When designing lighting schemes, the design should be as sustainable as possible whilst meeting the required design parameters.

NOTE Guidance on sustainable lighting solutions is given in Annex B.

4.3 Electrical energy

*COMMENTARY ON **4.3***

*Lighting accounts for a significant proportion of electrical energy usage within the built environment and electrical energy costs are forecast to trend upwards in the foreseeable future. The need for sustainable design (see **4.2.5**) is also relevant.*

Many authorities have targets to reduce electrical energy use, and consequently electrical energy targets often form part of the requirements for a lighting design.

4.3.1 General

Designers should develop appropriate energy-efficient designs in all schemes.

NOTE 1 Attention is drawn to Directive 2009/125/EC (the Ecodesign Directive) [24].

NOTE 2 Useful information can be found in the EU Green public procurement publication on street lighting [25].

4.3.2 Measures to minimize electrical energy use

Energy efficiency measures should be taken in accordance with BS EN 13201-5.

NOTE 1 BS EN 13201-5 defines the calculation and measurement of energy efficiency coefficients of road lighting installations. This is based on the system power necessary to light the relevant area based upon the selected lighting class. The coefficients apply for all traffic areas covered by the lighting classes as defined in BS EN 13201-2:2015.

Good lighting can contribute to electrical energy and carbon reduction strategies and should be at the forefront of any electrical energy and carbon reduction strategy developments. There are various strategies available, each of which should be assessed and an appropriate option chosen.

NOTE 2 These strategies include, but are not limited to, the following.

- ***Variable (or adaptive) lighting**. The road lighting standards classify the required lighting class based on usage; therefore, when the use of a road or area reduces, for example, between midnight and 0600hrs, and provided that the equipment is suitable, the lighting levels can be reduced. See **4.3.5** for further guidance.*
- ***Trimming**. Trimming can be applied to switch on and switch off ambient light levels. Modern light sources operated on the optimum electronic control gear do not require as much time to warm up to full output, therefore the lighting can be switched on closer to the time required, thus reducing the operating hours.*
- ***Part-night**. Lighting is turned off between certain hours such as midnight to 0600hrs. Longitudinal uniformity is maintained during the switch off and switch on that occur during the hours of darkness, that is, switching not occurring at dusk and dawn. The control system switches lights on and off in a contiguous order, as a random approach temporarily compromises longitudinal uniformity.*
- ***Switch off**. Lighting is switched off and removed.*
- ***Sensors**. These include passive infra-red (PIR), motion sensors, presence detection and push button switches. The sensors may be combined with any of the other strategies listed.*

If part-night, switch off or sensors are considered, the highway authority should be consulted to verify that road safety is not discernibly compromised. If moving to part-night or switch off, the authority should ensure that the highway signage, white lining and other features are assessed by a qualified highway engineer to verify that they are compliant for an unlit road. A full risk analysis and user consultation should be undertaken before either of these two options is implemented.

NOTE 3 The electrical energy tariff for public lighting is generally based on an operational profile; the majority of lighting installations operate all night, so the electrical energy rate is an average of the various rates over that *period. This profile makes use of the times when electrical energy demand is very low (e.g. midnight to 0600hrs) and hence electricity is very cheap compared to peak periods. Any change in operational profile needs to be advised to the electrical energy provider so that they can assess the impact on their supply. This might result in a change of tariff, which could increase the electrical energy rate, and whilst the installation load might be decreased, the overall cost of electrical energy might not reduce by the same level.*

4.3.3 Hours of operation

*COMMENTARY ON **4.3.3***

The question of whether to light a road is outside the scope of this part of BS 5489, which deals with technical matters, but the matters discussed in this subclause are relevant to its operation once the decision to light has been taken.

*Road lighting, where provided, is normally required during all the hours of darkness, in operation from about 30 min after sunset to about 30 min before sunrise, although the controls are usually related to daylight illuminance levels, rather than time (see **4.3.2** for guidance on trimming).*

Guidance on the selection of lighting classes is given in Annex A.

A risk assessment should be undertaken prior to making a decision for part-night lighting, taking the following factors into account.

a) Lighting throughout the hours of darkness is particularly important as an aid to crime prevention, policing, and the general safety and comfort of the community.

b) The level of lighting may vary during the night, dependent upon usage and other factors (see **4.3.5**).

c) In some limited situations, a lighting installation may be completely extinguished during certain periods of the night or the year when usage is very low.

4.3.4 Variable (or adaptive) lighting levels

*COMMENTARY ON **4.3.4***

Ever-improving technology allows for more flexibility in the variation of lighting level on all classifications of road dependent upon usage at any one time. As the usage is reduced, typically the lighting level can be reduced, unless there are overriding reasons not to do so (such as a high accident or crime rate). It might even be that it is appropriate to switch off for some periods of the night. Conversely, variable lighting can also allow the light level to be enhanced when traffic flows are increased.

Variable lighting is often referred to as dimming, but more appropriately is lighting to the correct lighting class to meet specific road parameters at a particular time. It might be that the highest lighting level an installation can achieve is only used on rare occasions, where traffic density is higher than normal (such as match days near to a football stadium), while the everyday lighting level might in reality be when the installation is operated at a lower lighting class.

There are additional environmental benefits of using variable lighting levels, including reduced light intrusion, light pollution, electrical energy consumption and carbon emissions.

Information on the selection of lighting classes is given in Annex A. In Annex A, parameters relevant to lighting are used in the selection of lighting classes. These parameters can vary during the night or over the year, and thus within the hours of operation the lighting class may be varied. This can be achieved by varying the lighting level or switching techniques. Annex A gives details of the lighting classes set out in BS EN 13201-2:2015 and gives guidelines on the application of these classes. For three categories of lighting (motorized traffic, conflict areas, and pedestrian and low speed areas) there are parameters which need to be assessed dependent on usage or local conditions. Many of these parameters remain fixed throughout the night, such as design speed, traffic composition and whether there are *parked vehicles, but some of the parameters, such as traffic density or ambient luminance, can change throughout the night. When these parameters change, this can result in the ability to select a different lighting class, thus allowing a variable lighting solution.*

ILP PLG08 [26] provides additional guidance on variable lighting.

If switching light sources off is the method used to vary the lighting level, the uniformity requirements should be met.

NOTE *This includes situations where individual luminaires are extinguished in order to reduce lighting levels.*

When varying the lighting, each lighting level should meet the requirements of a distinct lighting class from BS EN 13201-2:2015.

If a dynamic system is used, suitable delays for switching between levels should be put in place to avoid nuisance switching.

4.3.5 Controls

*COMMENTARY ON **4.3.5***

Lighting control systems enable the lighting level to be varied according to the specific needs of each location. The lighting can be programmed to vary its output at set times or under set conditions; lighting control helps to reduce costs and conserve electrical energy. The choice of lighting control is extensive, including time switches, photo-electric control units (PECU) and central management systems (CMS).

The choice of control system might depend on the functionality required, budgets and the size of the installation.

Autonomous controls, such as photo-electric control units (PECUs) and time switches, are generally used to switch the lights on as darkness falls and switch them off at dawn. Part-night PECUs can be used to switch off or reduce the light source output of the luminaires during the night, e.g. at 0100hrs when activity reduces.

Central management systems (CMS) offer much more control and flexibility, providing two-way communication between a remote server and each light point of an installation. The control of individual light points provides significant functionality, including:

- *individually programmable switching and the facility to vary the light source output using established digital protocols;*
- *the ability to remotely override programmed switching or adaptive lighting events on special occasions;*
- *remote monitoring of the status and fault reporting of light points (thereby removing the need for patrols);*
- *gathering of data for maintenance planning;*
- *monitoring electrical energy usage; and*
- *linking to GIS systems.*

Communication may be by mains-borne signals or wireless.

Designers of lighting schemes should choose or define the lighting control appropriate to the required functionality of the design, taking into account the need to balance flexibility, cost and energy consumption.

NOTE *Guidance on central management systems, which are one method of control, is given in ILP PLG01 [27].*

The decision on whether lights are to be switched or varied should be made only after full consultation with interested parties, including the police authority and users' representatives, and after undertaking comprehensive assessment of the risks.

4.4 Economics

Lighting schemes often show cost benefits over their lifetime and, where applicable, a whole life cost–benefit analysis should be completed to show the benefits of a particular lighting scheme.

NOTE When the analysis is completed in this way, it often highlights different solutions compared to a simple analysis based on capital cost. The effects of maintenance regimes, electrical energy costs and accident savings can all have a major impact on costs and benefits over the lifetime of the installation. The cost and benefits might not be constant across the lifetime of the installation.

4.5 Lighting and human health

When specifying a light source, designers should avoid light sources which produce excessive flicker.

NOTE The overall potential for artificial lighting to impact on public health is outside the scope of this part of BS 5489. Guidance can be found in Public Health England report CRCE-RDD 01:2016 [28].

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5 Lighting design criteria

5.1 Lighting design

*COMMENTARY ON **5.1***

Lighting design is a complex task, and there are many parameters which need to be taken into account in the development of a lighting design. Foremost of the parameters is the health and safety of users and others affected by the design (including road workers). Other considerations include maintenance, electrical energy and other lifecycle costs. Attention is drawn to the Construction (Design and Management) Regulations 2015 [15].

Information on the selection of lighting classes is given in Annex A.

5.1.1 Visual tasks for motorists

*COMMENTARY ON **5.1.1***

The motorist has to seek and absorb sufficient visual information in order to position themselves correctly on the road and match their speed to the driving environment. The gathering of information is key to early anticipation and negotiation of hazards, obstacles, changes in road geometry and events. That early anticipation allows road users to plan and execute actions that leave a safe margin of error in terms of distance, vehicle stability and motorist workload.

Whereas in most lighting situations the aim is to light objects rather than their backgrounds (positive contrast), in most road lighting situations for vehicular traffic the converse is true (negative contrast). As only a small part of the central field of vision of a motorist is in sharp focus, most information is received peripherally and, therefore, not in detail. A motorist is likely to focus directly on a significant object that appears in the field of vision, but for a motorist to detect the presence of an object, the object has to present sufficient contrast against its background. This is true both by day and night, but at night the motorist's ability to perceive contrast is considerably poorer at low lighting levels.

The ability to manoeuvre safely requires that objects and visual guidance information be perceived in time for the motorist to act comfortably and safely. Visual performance and the visibility of objects are related to the level and distribution of the road surface luminance. The higher the road surface luminance, the better is the visual performance (there is a ceiling to this effect). The uniformity of the road surface luminance also has a significant influence on object visibility.

The driver experience of road lighting is key to providing a positive night-time driving experience. While designing to meet a standard is a baseline requirement, merely designing to a standard or to minimize energy use can often fail to meet user quality expectations. Glare and the T_{CP} of the light source are significant factors which impact on the user experience. Designers also need to take into account the lighting needs of an ageing driver population who are particularly affected by glare and whose eyes transmit much less blue light than those of a young driver.

Road lighting should achieve the class of lighting, in accordance with BS EN 13201-2:2015, appropriate to the conditions normally found at a particular time, so as to provide adequate brightness of the general scene and to maximize the contrast between objects and their background.

The light available should be used to maximum effect by lighting the road surface and the immediate surrounds to reveal objects in silhouette, with the exception of subsidiary roads (see **7.2**), pedestrian areas and car parks in urban centres (see **7.4**), and some conflict areas (see **7.5**).

Good visual conditions should prevail over the entire road scene to enable the various levels of the driving task to be executed safely.

NOTE 1 The success of this method of lighting depends on designing the distribution of light from the luminaires to take advantage of the reflection properties of the road surface.

NOTE 2 The effectiveness of lighting with negative contrast is reduced when vehicle headlights are on.

5.1.2 Visual tasks of pedestrians – Recognition and personal safety

*COMMENTARY ON **5.1.2***

Lighting is needed to provide a street which is not only safe for people to use but is also perceived to be safe. The factors contributing to an environment perceived to be safe are a general feeling of safety which can result from an appropriately lit street; visual comfort, which can be defined as a pleasant environment in which glare is not considered to be a problem; and perceived ability to judge the intent and/or identity of other road users. The factors contributing to safe movement are the ability to detect obstacles on the pavement surface which could otherwise be a trip hazard, and to judge the intent and/or identity of other people at a distance sufficient to take avoiding action if necessary.

Pedestrians also need to be able to recognize signs and see potential hazards.

In situations where it is considered that the recognition of other people or their intent is particularly important, a lighting class from the EV series of lighting classes given in BS EN 13201-2:2015, Table 6, should be applied.

*NOTE Subclauses **5.3.2.3** and **7.2.5** provide further guidance.*

5.1.3 Visual guidance

The location of lighting columns should not give rise to confused visual guidance, particularly at junctions, roundabouts and bends. Lighting equipment should be positioned such as to complement the lane and edge of carriageway markings.

To avoid misleading patterns of luminaires, any change in lighting system along the carriageway should be visually linked with the road layout. For example, unexpected breaks should be avoided by continuing lighting for one or two lighting columns past any overbridges, gantries and large traffic signs until motorists have an unambiguous view of the road at the end of the lighting.

5.1.4 Lighting of the surrounds and footways

Objects on the footway, or to one side of the carriageway, or in the centre of the carriageway but on a bend, are seen at least partially against the surrounds of the road. These should therefore receive sufficient light to provide a light background against which objects can be seen in silhouette, or, if such a background is absent, to reveal objects by positive contrast.

NOTE 1 Adequate lighting on the surrounds helps the motorist to perceive more of the environment and make speed adjustments in time. The function of the edge illuminance ratio (R_{EI}) is to ensure that light directed on the surrounds is sufficient for objects to be revealed.

NOTE 2 Adequate lighting on the surrounds is beneficial to reveal people who might be about to step into the carriageway and vehicles emerging from side roads.

NOTE 3 This light is also of assistance to pedestrians, as it reveals the footway surface, obstructions and other pedestrians.

On all traffic routes except those with heavily trafficked adjacent footways and/or cycle tracks, and emergency lanes of motorways, lighting of the surrounds should be achieved by applying R_{EI} to the values given in BS EN 13201-2:2015, calculated in accordance with BS EN 13201-3.

For traffic routes with heavily trafficked adjacent footways and/or cycle tracks, an appropriate lighting class from BS EN 13201-2:2015 should be applied to a footway or other relevant area adjacent to the carriageway.

In the case of motorways with an adjacent emergency lane, the appropriate lighting class should be provided for the emergency lane to give a sufficiently bright background for revealing objects viewed towards the outer edge of the carriageway. This lane should be assumed to be a separate area for the purpose of calculation.

On motorways without an adjacent emergency lane, R_{EI} should be applied to the adjacent verge.

5.1.5 Glare

*COMMENTARY ON **5.1.5***

Disability glare reduces the contrast between objects and their background so that their visibility is decreased.

Glare should be calculated for a lighting design and should not exceed the limits as defined in BS EN 13201-2:2015 for the relevant task or application.

Glare calculations for traffic routes should be calculated in accordance with **5.3.1.4**.

Glare calculations for subsidiary roads should be calculated in accordance with **5.3.2.4**.

5.1.6 Maintenance factor

The luminance or illuminance levels in service should not fall below the maintained levels specified for the lighting class selected from BS EN 13201-2:2015. The calculation methods in BS EN 13201-3 should be used to determine luminance and illuminance levels and other quality criteria.

NOTE 1 These methods for determining the luminance or illuminance provided by a lighting installation incorporate a maintenance factor (f_m).

For road lighting design, the overall maintenance factor (f_m) for luminaires should take into account the following factors:

a) the luminous flux factor (f_{LF}) – the lumen maintenance of the light source(s) at the end of the rated life;

   NOTE 2 The luminous flux factor is also known as the lamp lumen maintenance factor (LLMF).

b) the survival factor (f_S) – the failure fraction of the light source(s) at the end of the rated life;

   NOTE 3 The survival factor is also known as the lamp survival factor (LSF).

NOTE 4 The survival factor is assumed to be 1.0 for the majority of road lighting applications where a failed light source is replaced. ILP GN11/19 [29] proposes a value of 0.97 unless otherwise agreed. In some applications, such as pedestrian subways, this factor is taken into account.

c) the luminaire maintenance factor (f_{LM}) – the reduction in light output owing to the accumulation of dirt on the light-emitting parts of the luminaire. Typical values are shown in Annex C, Table C.1.

NOTE 5 The luminaire maintenance factor is also known as LMF.

NOTE 6 Typical values of luminaire maintenance factors, f_{LM}, are given in Annex C. Alternatively, luminaire maintenance factors established by local testing may be used.

The overall maintenance factor should be calculated as the product of all three elements, using the following formula derived from PD ISO/CIE TS 22012:2019:

$$f_m = f_{LF} \times f_S \times f_{LM}$$

NOTE 7 An alternative way of writing the above formula is: MF = LLMF × LSF × LMF.

NOTE 8 Annex D gives examples of maintenance factor calculations.

The luminous flux factor (f_{LF}) should be obtained from the luminaire manufacturer's data, taking account of light source type, controller type, constant light output (CLO), switching regime, operating environment and light source change policy.

When designing with a constant light output system, the correct values of initial luminous flux and luminous flux factor should be verified and used. In addition, the average power consumption (over the relevant period) should be verified and used in any energy calculations.

NOTE 9 Further guidance is given in ILP GN11/19 [29].

5.1.7 Absolute or relative photometry

*COMMENTARY ON **5.1.7***

Lighting design can be carried out using absolute or relative photometry, as described below. Both have advantages and disadvantages, and there is no preferred option as either method is expected to produce the same result.

*a) **Absolute photometry**. A luminaire is measured in a photometer, and the complete output from the lantern is included in the photometric file. Photometric standards (such as LM 63 [30] from the IES) suggest that −1 be placed in the flux field as an identifier that the file is absolute. The −1 is generally multiplied by −1 to remove the minus. Absolute photometry has become more common with the introduction of LED lighting.*

*b) **Relative photometry**. When creating relative photometry, the light source is removed from the luminaire and the light source is photometered to determine the output of the source. The source is then placed in the luminaire and the luminaire is measured in a photometer. The complete output from the luminaire is measured. As the output of the source is known, the output from the luminaire can be pro-rated per 1 000 lm and stored in the photometric file. The flux field then carries a multiplier which is included in the calculation to take the output back to the original measured output. Relative photometry has been used for many years and was common when multiple lamps were used in the same fitting. The flux in the photometric file could be altered to reflect the output of different lamps or sources used.*

The photometric file used to determine the performance of a luminaire should be an accurate representation of the luminaire.

5.2 Design strategy and road classification – Risk assessment

Designers should check whether a client has a specific lighting strategy, lighting policy or specification which relates to the area under consideration. If no such guidance is available then the designer should determine an appropriate design strategy and lighting class.

NOTE 1 Information on the selection of lighting classes is given in Annex A.

The design policy or lighting strategy should be developed by competent persons in accordance with the recommendations given in this part of BS 5489.

NOTE 2 Guidance on the creation of a street lighting policy is given in ILP TR24 [31].

A risk assessment should be undertaken to assess the particular risks asscoated with the road. The result of the risk assessment should then be used to inform the choice of lighting class.

NOTE 3 Annex E provides an outline of the lighting design process for all-purpose traffic routes.

NOTE 4 Annex F provides an outline of lighting design process for subsidiary roads and associated areas.

NOTE 5 Annex G provides an outline of the lighting design process for lighting urban centres and public amenity areas.

5.3 Lighting criteria

*COMMENTARY ON **5.3***

*This subclause provides information on the lighting criteria used for road lighting design. It can be categorized as relevant for traffic routes (see **5.3.1**), or for subsidiary roads including pedestrian areas, footpaths and cycle tracks (see **5.3.2**).*

5.3.1 Traffic routes

5.3.1.1 Average luminance of the road surface ($\bar{L}$)

*COMMENTARY ON **5.3.1.1***

The values of $\bar{L}$ are the minimum values to be maintained throughout the life of the installation for the specified lighting class(es). They are dependent on the light distribution of the luminaires, the luminous flux of the light sources, the geometry of the installation, and the reflection properties of the road surface.

Lighting designs for traffic routes should meet the $\bar{L}$ requirements of the selected class as defined in BS EN 13201-2:2015, and should be calculated according to the method in BS EN 13201-3.

Calculated values should take into account the luminaire maintenance factor (f_{LM}) and luminous flux factor (f_{LF}).

NOTE 1 Luminaire maintenance factors vary according to the intervals between cleaning, the mounting height and environmental zone and the IP rating of the light source housing. Annex C gives indicative values. Their values may alternatively be established by field measurements.

NOTE 2 Light source luminous flux factors (f_{LF}) vary according to light source type and power. Values are usually available from light source manufacturers.

5.3.1.2 Overall uniformity of road luminance (U_o)

The overall uniformity of road luminance, U_o, should be calculated in accordance with BS EN 13201-3.

NOTE This criterion is important with regard to the control of minimum visibility on the road.

5.3.1.3 Longitudinal uniformity of road surface luminance (U_l)

The longitudinal uniformity of road surface luminance, U_l, should be calculated in accordance with BS EN 13201-3.

NOTE This criterion relates mainly to comfort, and its purpose is to prevent the repeated pattern of high and low luminance values on a lit run of road becoming too pronounced. It applies only to long uninterrupted sections of road.

5.3.1.4 Threshold increment (TI)

*COMMENTARY ON **5.3.1.4***

TI is a measure of the loss of visibility caused by the disability glare from the road lighting luminaires. Disability glare results from the scattering of light within the eye, so reducing contrasts of the retinal image. The mathematical procedure is given in BS EN 13201-3, and the calculation is made for a clean luminaire equipped with a light source emitting the initial luminous flux.

In traffic route lighting, the parameter threshold increment (TI) should be used as a measure of discomfort or disability glare. Lighting designs for traffic routes should meet the TI requirements of the selected M class as defined in BS EN 13201-2:2015 and calculated according to the method in BS EN 13201-3.

At conflict areas on traffic routes, lighting designs should meet the TI requirements of the selected C class as defined in BS EN 13201-2:2015, Table C.1.

For conflict areas, TI cannot always be calculated, and in these situations, luminaire intensity limits classes in accordance with BS EN 13201-2:2015 should be used.

5.3.1.5 Edge illuminance ratio (R_{EI})

In situations where an alternative lighting system is already provided on the surrounds, the use of R_{EI} is unnecessary; however, the lighting class on the surrounds should be checked to verify that it meets the requirements of BS EN 13201-2:2015 in full.

Lighting designs for traffic routes should meet the R_{EI} requirements of the selected class as defined in BS EN 13201-2:2015 and calculated according to the method in BS EN 13201-3.

When a minimum requirement is made for the edge illuminance ratio of a lighting installation, each of the separate values should meet the requirement.

NOTE Separate values apply for each of the two sides of a carriageway, and for each of the two sides of both carriageways of a dual carriageway.

5.3.2 Subsidiary roads, including pedestrian areas, footpaths and cycle tracks

5.3.2.1 General

The road lighting should enable pedestrians and cyclists to discern obstacles or other hazards in their path and to be aware of the movements and/or intent of other pedestrians and cyclists in the proximity. To achieve this, the design should take account of lighting on horizontal surfaces, as well as the control of glare and the colour rendering. Environmental issues should also be taken into account.

NOTE 1 The lighting of such roads can provide some guidance and increased peripheral vision for motorists, but is unlikely to be sufficient for revealing objects on the road without headlights.

*NOTE 2 The visual tasks for pedestrians are described in **5.1.2**.*

5.3.2.2 Lighting of horizontal surfaces

The horizontal illuminance should meet the appropriate class in BS EN 13201-2:2015.

NOTE Horizontal illuminance is measured at ground level in terms of average and minimum values, and applies to the whole of the used surface, which usually comprises the footways and the carriageway surface, unless the carriageway is treated separately under the provisions for motorized traffic in Clause 7.

5.3.2.3 Lighting of vertical surfaces

*COMMENTARY ON **5.3.2.3***

Adequate lighting of vertical surfaces is necessary for visual recognition. The quantification of this presents a difficulty because of the multiplicity of planes at each measurement point which have to be taken into account. BS EN 13201-2:2015 defines lighting classes for vertical illuminance.

In cases where enhanced visual recognition is required on vertical surfaces, a lighting class for vertical illuminance should be selected from BS EN 13201-2:2015 and calculated in accordance with BS EN 13201-3.

5.3.2.4 Control of glare in subsidiary roads

*COMMENTARY ON **5.3.2.4***

The control of discomfort and disability glare is not as critical for pedestrians as for motorists, because speed of movement is much lower, giving a greater reaction time. Methods for quantifying and controlling glare in pedestrian, cycling and low speed traffic areas are given in BS EN 13201-2:2015.

For residential and subsidiary roads, one of the following two methods of calculating the effect of glare should be used:

a) threshold increment (f_{TI}) should be calculated in the roadway programme and should meet the limits as specified in BS EN 13201-2:2015, Table C.1 and Table C.2; or

   NOTE 1 The arrangement of the luminaire (staggered or single-sided) can have an impact on the f_{TI}.

   NOTE 2 The f_{TI} option is the preferred option.

b) if the f_{TI} option is not available, the luminous intensity classes should be used to calculate the output direct from luminaires. Direct glare from luminaires should meet an appropriate class as specified in BS EN 13201-2:2015, Table A.1, to provide adequate control of glare.

*NOTE 3 Further guidance on lighting of subsidiary roads is given in the Commentary on **7.2**.*

*NOTE 4 Further recommendations for lighting of residential and minor roads are given in **7.2.1**.*

6 Practical design considerations

6.1 Siting of lighting columns

6.1.1 General

*COMMENTARY ON **6.1.1***

One of the most difficult aspects of a lighting design is in the siting of lighting columns. Each street is different and presents differing challenges. Particularly on an established street, there are many topographical and physical features which can determine both suitable and unsuitable locations.

Intersections, pedestrian crossings, bends, gradients and crests of hills occur frequently, and their particular lighting might require compromise. In addition, there are constraints on the siting of lighting columns caused by overground and underground obstructions, as well as the need to consider the effect of road lighting equipment on the access to properties for occupation and maintenance.

Prior to finalizing lighting column locations, distributors' and statutory undertakers' service/plant drawings should be examined, and a site survey should be carried out by competent persons, to verify that the designed location is suitable. Factors that should be taken into account include, but are not limited to, the following:

a) overhead power lines or other obstruction (see **6.3.4**);

b) underground power lines or other utility services or obstructions;

c) trees, including potential growth and accounting for summer foliage (see **6.1.2**);

d) dropped kerbs;

e) preference for alignment with property boundaries;

f) need to minimize obtrusive light (see **4.2.3**), especially where it could affect residential property windows;

g) views from residential properties;

h) potential for vehicle impacts (see **6.1.3**);

i) provision of road restraint systems or use of passively safe lighting columns (see **6.1.4**);

j) accessibility for maintenance;

k) vehicle charging; and

l) active transport and active transport networks. Cyclists and pedestrians should not be inconvenienced by the siting of columns primarily provided for the benefit of motorized road users.

NOTE 1 Issues can be unnecessarily created when the designer has not appreciated the high level of use on such paths.

NOTE 2 Further guidance is given in HSE publication HSG 47 [32].

NOTE 3 Minor adjustments might be necessary for practical or aesthetic reasons, with care taken to ensure that these do not significantly affect the photometric performance of the installation.

NOTE 4 In some circumstances, public lights and associated equipment can be fixed to private buildings or sited on private land.

Lighting columns adjacent to bridges should be sited such that light from the luminaires is not obstructed and does not cause nuisance or glare to road users approaching or crossing the bridge. Lighting columns should if possible be sited such as not to interfere with the view of buildings or monuments of architectural interest, or with scenic views.

6.1.2 Effect of trees

Lighting columns when first installed should be sited such as not to require substantial cutting back of trees, taking into account the fully mature spread of the tree.

NOTE 1 In tree-lined roads, lower mounting heights than usual may be used to bring luminaires below the tree canopy.

In new streets where trees are to be planted, the lighting should be designed in consultation with the landscape architects and/or by taking into account the landscaping plan or the tree schedule.

NOTE 2 Careful siting of trees and luminaires can help to minimize interference with the performance and operation of the lighting by the foliage.

Lighting columns in the vicinity of trees should be sited such as to minimize any difficulties, including:

a) incorrect photocell operation;

b) impaired maintenance access; and

c) damage to luminaire, column, foundation and electrical cables.

NOTE 3 Recommendations for trees in relation to design, construction and demolition, including some guidance relating to lighting schemes, are given in BS 5837.

6.1.3 Lighting columns as hazards

*COMMENTARY ON **6.1.3***

Many accidents involve a motorized vehicle leaving the carriageway, and if the vehicle collides with a lighting column, the severity of the injuries to the occupants might be increased. The number of such collisions is likely to decrease with increased clearance of the lighting columns from the edge of the carriageway.

The recommended minimum clearances according to the design speed of the road given in Table 1 should be achieved wherever practicable. The set-back of lighting columns should be sufficient to allow the free passage of all people on any footway.

NOTE 1 Blind and partially sighted people, people with limited mobility, wheelchair users and people pushing prams need additional space.

Table 1 — *Recommended minimum clearances from edge of carriageway to face of lighting column*

Speed limit mph	**Horizontal clearance** m
≤ 30	0.8
40 to 50	1.0
60 to 70	1.5

In situations such as motorways, where lighting columns are often protected by safety barriers, the set-back should be determined by the design requirements of the safety barrier.

In some situations, where it is necessary to place columns at less than the recommended minimum clearances, a project-specific risk assessment should be carried out.

The set-back should also take into account the recommendations given in **6.1.4**.

The lowest point of overhang of luminaires or bracket arms that overhang the carriageway, or are within the respective horizontal clearances given in Table 1, should have a vertical clearance of at least 5.7 m from the level of the carriageway surface. Therefore, no part of a lighting column or luminaire should protrude over the carriageway of a public highway open to vehicular traffic (or be within the respective horizontal clearances given in Table 1) if less than 5.7 m in height, unless a height restriction applies. Similarly, the height clearance over a pedestrian-only area of a public highway not accessible to vehicular traffic should be not less than 2.1 m.

NOTE 2 Where there are cyclists or horse-riders, or in areas with high levels of vandalism, a greater height is likely to be necessary.

In residential roads having footways of width 3 m or less, and situated directly adjacent to the carriageway, lighting columns should, where practicable, be sited at the rear of the footway, i.e. away from the carriageway.

NOTE 3 In that position, lighting columns are less likely to suffer impact from passing vehicles; they also cause less restriction to the effective width of the footway, and less obstruction to vehicles using private driveways. Where there is a verge between the carriageway and the footway, this can be utilized to site lighting columns if adequate clearance from the carriageway can be maintained in accordance with Table 1.

NOTE 4 Some local authorities have a preference for in-column EV chargers, and some smart city devices, which can require the column to be placed kerb side. The risks of either approach need to be evaluated.

In cycle paths and shared paths, the lighting columns should be sited with sufficient clearance to avoid presenting a hazard to cyclists, particularly at night if the lighting is not functioning or is operating part-night.

NOTE 5 In the unlit state after dark, lighting columns can be made more visible to cyclists by having a reflective band at a suitable height above ground level.

6.1.4 Passively safe lighting columns

*COMMENTARY ON **6.1.4***

*As indicated in **6.1.3**, when vehicles collide with lighting columns the occupants can suffer severe injuries. On roads where traffic speeds are high and there are few pedestrians or cyclists, passively safe (also known as breakaway or energy-absorbing) lighting columns can be installed as an alternative to rigid lighting columns to reduce the severity of injury.*

The design of lighting installations should be such as to minimize the probability of collisions with lighting columns.

NOTE 1 BS EN 12767 gives guidance on a suitable risk assessment approach to design.

In situations where collisions with lighting columns are deemed likely, the problem should be designed out by relocating the lighting columns to a safer location if necessary, in consultation with an appropriately qualified highway design engineer. The appropriate class from BS EN 12767 should be specified when passively safe lighting columns are to be used.

NOTE 2 BS EN 12767 provides a system of classification in passive safety terms for support structures for road equipment, including lighting columns.

NOTE 3 ILP TR30 [33] provides additional guidance.

6.2 Arrangements

6.2.1 Mounting heights

When choosing the mounting height, technical and economical constraints and daytime appearance should all be taken into account.

For aesthetic reasons, the height of the lighting column and luminaire should not exceed that of nearby buildings.

NOTE 1 The typical height to the eaves of a two-storey house is approximately 6 m.

NOTE 2 Typical mounting heights are 5 m and 6 m for residential and subsidiary roads, 8 m, 10 m and 12 m for traffic routes, and 12 m and 15 m for high-speed dual carriageways and motorways; but in special situations where particular aesthetic or environmental factors apply, the use of other mounting heights might be more appropriate.

NOTE 3 If mounting heights are reduced, adjustments to other parameters might be necessary, e.g. an increase in the number of luminaires.

NOTE 4 Where a solid background is absent, the lighting columns and luminaires tend to be silhouetted against the sky in daytime. The conspicuousness of the installation as a whole can, in these circumstances, be reduced by increasing the mounting height and spacing (in order to decrease the number of lighting columns).

6.2.2 Lighting unit assemblies

6.2.2.1 General

Lighting columns should conform to BS EN 40 and PD 6547. When specifying lighting columns, the weight and windage area of the luminaire(s), the wind speeds to be expected at the location, and any loads imposed by additional items fixed to the lighting column (such as signs and banners), should all be taken into account. No additional items should be attached to the column, bracket or luminaire, without structural load calculations and a visual or NDT structural inspection being completed as appropriate.

The lighting unit should be designed as a whole, even though it consists of the separate parts of lighting column, bracket and luminaire; a luminaire that is aesthetically suitable with one lighting column might be incongruous with another. Luminaires and lighting columns are often made by different manufacturers, and therefore great care should be exercised in the choice of equipment to ensure a good aesthetic match.

For high mast lighting, the mast, head frame and luminaire assembly should be of good integrated design.

Low mount lighting systems incorporating luminaires which are designed for mounting heights of 1.0 m or less may be used in areas with design restrictions such as maintenance, access or visual impact. For such systems the supporting structures are not bound by the requirements of BS EN 40 as they are outside its scope; they should however be fit for purpose and should be set back such that the clearance of the luminaire from the edge of the carriageway is not less than 450 mm.

6.2.2.2 Size and type of luminaires

The dimensions and profile of the luminaire should be appropriate to its background.

6.2.2.3 Form of bracket

*COMMENTARY ON **6.2.2.3***

For low mounting heights in particular, post-mounted luminaires without brackets can be aesthetically advantageous. However, when brackets are to be used, large arc or quadrant brackets used to support the luminaire are usually more conspicuous than straight lines, because they contrast more with the surrounding lines of roofs. A straight horizontal bracket gives the illusion of sagging; a straight rising bracket is preferable.

A smooth line should be preserved, if possible, where there is a row of luminaires.

A very long bracket, such as might result from siting the lighting column well back from the kerb and using the maximum permissible overhang, can present a poor appearance. This should therefore be avoided unless essential for reasons of safety, or when surrounding objects effectively obscure its full length.

Bracket projection should be as short as possible.

NOTE 1 It is advisable that for the bracket does not exceed one quarter of the mounting height.

The bracket length should be suitable for the column and luminaire such that it does not cause undue vibration.

NOTE 2 Further information is given in BS EN 40.

6.2.2.4 Colour of lighting equipment

Colour and finish should be appropriate in the context of the environmental surroundings. Highly reflective finishes should be avoided where these could cause a traffic hazard, whilst taking account of the fact that dark matt finishes can create a hazard in the event of light source failure or part-night switch off.

6.2.2.5 Overall appearance

*COMMENTARY ON **6.2.2.5***

A combination of luminaire, bracket and lighting column that is satisfactory as a single unit might not look good when a number are seen together, especially in long straight or slightly sinuous roads and at complex junctions. In a long, straight road, an array of curved brackets can make a tunnel; in a slightly sinuous road such brackets appear to interlace and form a confusing and ugly pattern.

At complex junctions, the lighting equipment and arrangement should be as simple as possible in order to avoid an unsightly or confusing view for road users.

The lighting scheme as a whole should be compatible with its setting.

NOTE Possible solutions include using fewer lighting columns of increased height, each with multiple luminaires on short brackets, or using post-mounted luminaires.

6.2.3 Luminaire arrangements

*COMMENTARY ON **6.2.3***

There are many variables to take into account when designing a lighting installation. Typical lighting arrangements are:

a) *opposite: used on wide roads or dual carriageways;*

b) *staggered: generally used on traffic routes, residential and subsidiary roads;*

c) *single-sided: used on narrow roads, widely separated carriageways, curved link roads and slip roads;*

d) *twin central: used on dual carriageways; provides clear visual guidance for the through route at junctions;*

e) *combined twin central and opposite: used for wide carriageway layouts and merge and divide areas where one type of lighting alone is inadequate;*

f) *axial median lighting: used for very wide carriageways and is an alternative to twin central or opposite. The luminaires have a light distribution with a strong transverse component and are either:*

   1) *suspended from catenary wires (catenary lighting); or*

   2) *supported above the central reserve on double arm lighting columns having brackets in line with the axis of the motorway;*

g) *high mast lighting: used where carriageway layouts, sight lines and lighting column mounting limitations on structures preclude conventional lighting, e.g. large junctions, grade-separated junctions and toll plazas.*

*For lighting on bridges, see **7.6**.*

6.2.3.1 General

When choosing a suitable arrangement, designers should appraise ease of maintenance, traffic management costs and road worker safety.

The pattern of luminaires for sections of road with special requirements such as conflict areas, bends or where physical features cross the road, should be laid out first. The pattern necessary for uninterrupted sections of road should then be added to the layout.

The layout should be examined in perspective to verify that the array of lighting columns does not form a visual pattern to motorists which gives a misleading impression of the route ahead, and if possible, should assist by giving route guidance.

NOTE This guidance can be especially significant on winding roads, at complex junctions and in fog.

Unless separate lighting is to be provided, the selected lighting arrangement should also meet the recommendations given in **5.1.4** for the lighting of adjacent areas such as footways and cycle tracks, using R_{EI} or a specific lighting class applied to the adjacent areas.

6.2.3.2 Luminaire arrangements for single carriageways

For single carriageways, one or more of the following three arrangements should be used for the arrangement of luminaires:

a) single-sided;

b) opposite;

c) staggered (see Note 3).

NOTE 1 For many road widths, depending on mounting height, luminaire, and light source type and output, two or all three of the arrangements can provide a system of lighting that meets the requirements of the selected lighting class.

NOTE 2 Choice of lighting arrangement may be made on the grounds of economy, also taking into account the appearance and environmental aspects.

NOTE 3 The use of staggered arrangements can have a reduction in the longitudinal uniformity.

6.2.3.3 Luminaire arrangements for dual carriageways

Where dual carriageways are separated by a wide central reserve (of more than 9 m), the carriageways should be treated separately.

NOTE 1 Where a concrete barrier is used in the central reserve in place of safety fence, the barrier can reduce the light contribution from the luminaires on the opposite side of the carriageway into the lane closest to the barrier.

The designer should take account of the shadowing effect of high-sided vehicles when selecting column height.

NOTE 2 Normally, when the distance between the outer carriageway edges is not excessive, dual carriageways can be lit as a single road.

NOTE 3 With the use of appropriate mounting height and luminaire and light source type, dual carriageways can be satisfactorily lit by means of staggered or opposite arrangements mounted on the outside edges of the road, or by twin luminaires on the central reserve only.

6.2.3.4 Luminaire arrangements for dips and crests of hills

*COMMENTARY ON **6.2.3.4***

At a dip, there is no specific lighting problem. At a crest, however, it is necessary to limit glare from luminaires beyond the crest; these can be viewed at angles where the intensity is high, and the more distant luminaires can appear low in the scene.

At crests of hills, luminaires should be used that conform to installed intensity classes G*4, G*5 or G*6 as specified in BS EN 13201-2:2015.

NOTE Similar considerations apply to the lighting of some bridges (see Commentary on ***7.6****).*

Steep hills where gradient is 10% or more require side entry mounting, and luminaires should be tilted sideways to be parallel to the road.

6.3 Designing for maintenance

6.3.1 General

Any lighting design should be safe for all users. In particular, future maintenance requirements should be taken into account and the design should minimize the risk to operatives undertaking any maintenance activities. The structural and electrical inspection and test regimes should be determined at the design stage.

NOTE 1 Attention is drawn to the Construction (Design and Management) Regulations 2015 [15] in respect of the requirement for the designer to consider designing for maintenance. There is a requirement to ensure that the information provided is sufficient to undertake future maintenance and operational duties of the asset, to provide information about residual risks, and to ensure any future construction work can be undertaken safely and without risk to health.

NOTE 2 On high speed roads, there is also a requirement to consider the traffic management (TM) arrangements.

On all roads, the design should take into account the ease of access to the lighting unit, road worker safety and the need for specialist equipment or personnel.

The maintained levels of the relevant lighting classes should be in accordance with BS EN 13201-2:2015. In order to achieve this, and to ensure the provision of the selected class, appropriate luminaire cleaning and light source replacement routines should be accounted for by the designer with reference to local policies. Maintenance programmes should include light source replacement, luminaire cleaning, renewal of failed parts, checking of gaskets, optical components, screens, baffles and alignment, and monitoring of operation.

NOTE 3 Monitoring for non-operable lighting can either be by means of night-time inspection, or alternatively via an electronic central monitoring system.

NOTE 4 The actual levels of lighting provided by a lighting system at a specific time can only be determined by on-site measurement, which can be costly and disruptive to traffic flows. Experience gained over many years indicates that cyclical maintenance, light source changing and other maintenance (see ***5.1.6****) carried out to criteria used in the design can generally maintain the lighting within acceptable levels.*

NOTE 5 Apart from the deterioration of those luminaire parts that can be corrected by cleaning, there is also a long-term deterioration that is permanent and cumulative. The rate of this deterioration depends on the quality of the original materials and the IP rating of the luminaire, but eventually the restoration of photometric performance might necessitate replacement of the optical system or even of the whole luminaire.

Decisions should not be made purely on economical grounds, but should take all the relevant factors into account, including:

a) the light source survival factor for its environment (from manufacturers' data);

b) the light source luminous flux factor (f_{LF}) for the specific light source and control gear combination (from manufacturers' data);

c) the system power consumption variation through the anticipated lifecycle;

d) possibility of interference with traffic;

e) ease of access and extent of traffic management required;

f) the required frequency of night inspection monitoring;

g) the required frequency of cleaning of luminaires, related to the local environment and the IP rating of the light source enclosure;

h) the overall proportion of outages that can be tolerated at any time without undue detriment to the level and quality of lighting;

i) the grouping of outages that can be tolerated at any time without undue detriment to the level and quality of lighting;

j) the required frequency of inspection for electrical safety;

k) the required frequency of inspection for structural safety of lighting columns and other supporting systems;

l) the impact of light source outages on safety and security;

m) the impact of light source outages on the electrical system, including controllers; and

n) if a central management system is used, the need to indicate that the light source is nearing end-of-life.

NOTE 6 The frequency of replacement of light sources is a matter of local policy, cost and light source type used.

6.3.2 Maintenance of high mast lighting

High mast lighting systems, and other specialized installations using more complex mechanical, hydraulic, or electrical equipment, should be inspected and maintained regularly in accordance with manufacturers' recommendations, and depending on local conditions. There should be a specific maintenance schedule and manual associated with such assets, and the maintenance should be carried out by competent persons with suitable specialist equipment.

NOTE 1 Detailed inspection regimes are given in ILP PLG07 [34].

NOTE 2 Attention is drawn to the Lifting Operations and Lifting Equipment Regulations 1998 [35] and the Provision and Use of Work Equipment Regulations 1992 [36] in respect of legal requirements relating to the maintenance of high mast lighting with integral luminaire mechanisms.

6.3.3 Roads with limited maintenance access or requiring non-minor traffic management

*COMMENTARY ON **6.3.3***

Motorways, dual carriageways, grade-separated junctions, bridges and other traffic-sensitive streets pose additional maintenance problems which are associated with particular means of access for maintenance and with particular routine and emergency operations. The safety issues and cost constraints imposed by these problems can affect the choice of lighting arrangements.

The safety issues and cost constraints imposed by roads that have limited maintenance access or require full traffic management should be taken into account at the design stage. Factors that should be taken into account include, but are not limited to:

a) the effect of narrow or repeatedly discontinuous emergency lanes;

b) the needs of contra-flow lane working, including the use of crossovers, for all types of highway maintenance work;

c) the need to minimize the risk to lighting maintenance personnel, other road workers and road users;

d) the need to minimize delays to traffic;

e) work on lighting mounted in the central reserve of a dual carriageway, which requires the diversion of traffic away from the right-hand lane in either one or both carriageways;

f) work on lighting mounted on the outside of a dual carriageway, which requires the diversion of traffic away from the left-hand lane in each carriageway;

g) work on lighting mounted on the outside of a dual carriageway with emergency lanes, which requires the occupation of the emergency lane (rather than a traffic lane) by maintenance vehicles;

h) the use of maintenance operations with less restricting effects on other traffic, such as mobile lane closures with vehicle-mounted signs; and

i) the implications and cost of traffic management.

Lighting assets should not be positioned or selected in locations that avoidably increase the risk for the traffic management operative.

NOTE 1 Roads which experience high traffic volumes and/or have a speed limit higher than 30 mph are likely to require full traffic management in order to provide a safe working space for lighting maintenance operatives. Setting out and retrieving traffic management assets, signs and cones is likely to be the highest risk activity undertaken by a roads operator. The lighting designer is well placed to minimize and mitigate that risk for the traffic management operative during lighting maintenance. The highest risk activities of the traffic management operatives are:

- *establishing and removing the lead taper;*
- *eworking in the outside lane rather than the nearside;*
- *coning off more than one lane per carriageway; and*
- *working on a high speed road without a hard shoulder.*

NOTE 2 Achieving a reduction in risk for traffic management operatives is largely a matter of avoiding poor practice such as:

- *swapping between verge mounted and central reserve mounted columns along a link, and vice versa;*
- *using central reserve mounted lighting for luminaires that require frequent visits for light source changes or other maintenance activity;*
- *siting columns close to the kerb edge such that the feet of the mobile elevated working platform extend out sufficiently to require more than a single lane closure; and*
- *where there is no hard shoulder on a high speed road, using luminaires that require frequent visits for light source changes or other maintenance activity.*

6.3.4 Safe working clearances near overhead electricity supply lines

Safe working clearances should be adhered to during design, erection, installation, commissioning and maintenance operations on all road lighting near overhead electricity supply conductors.

When undertaking a lighting design where overhead electricity supply lines are present; the design should be in accordance with the following documents:

a) HSE GN GS6 [N3];

b) ILP GP03 [N4];

c) ILP GP10 [N5] (supplement to GP03);

d) Electricity Association Engineering Recommendation G39/1 [N6].

If there is any doubt regarding the safety relating to any such installation, the operator of the line should be consulted to obtain the clearances that have been agreed with the distributor and the supply authority, and to establish the accurate position and height of the line.

When undertaking a lighting design where overhead electricity supply lines are present, a risk assessment should form part of the design process. This should assess the risks associated with design, installation, operation, maintenance and decommissioning. The results of the risk assessment should be made known to all relevant parties and included in the design pack.

NOTE Attention is drawn to the Electricity Safety Quality and Continuity Regulations 2002 [37].

6.4 Technologies

Designers should take account of new technology in order to provide lighting solutions which are future-proofed and cost-effective, and which minimize energy consumption and maintenance requirements.

NOTE 1 Some technologies available at the time of publication of this part of BS 5489 are:

- *central management systems – these are becoming more technology-focused providing more control and options for switching and managing luminaires;*
- *near field communication (NFC) – used for programming luminaire drivers;*
- *Bluetooth – used for giving updates to luminaires;*
- *traffic sensors – these allow integration of traffic systems and adaptive lighting;*
- *PIR sensors – more readily available for street scene applications; and*
- *ANSI 7 pin Nema sockets or Zhaga SR sockets.*

NOTE 2 Examples of factors that could be taken into account are:

- *whether adaptive lighting can be incorporated into the scheme to ensure lighting is at the required levels when needed, enhancing lighting through peaks of traffic flows. See ILP PLG08 [26] on adaptive lighting;*
- *what integration lighting can have with smart city applications such as increasing lighting levels when air quality/weather is hazardous.*

6.5 Light sources

NOTE 1 "Light source" is as defined in BS EN 12665 and is used throughout this part of BS 5489 in place of "lamp", but with the same meaning.

NOTE 2 Attention is drawn to EC Regulation No. 245/2009 [38].

There is a wide range of available light sources that are suitable for lighting roads and public amenity areas, and the light source should be chosen to be appropriate to the particular application or type of application. When determining the choice of light source, the following factors should be taken into account.

a) **Energy efficiency.** The energy efficiency of road lighting is not only a matter of light source efficacy in terms of lumens per watt (lm/W). The efficiency of the complete lighting installation should also be taken into account, including the effectiveness of the light source, control gear and luminaire optic combination in providing the selected class of lighting on the road, with the desired degree of colour rendering.

   NOTE 3 The requirement for creating energy-efficient designs is dealt with more comprehensively in BS EN 13201-5.

b) **Colour rendering.** The colour rendering attributes of the light source should be appropriate to the task. In general terms, higher colour rendering index values should be used where there is a high level of pedestrian activity or where the appearance of an area is important.

   NOTE 4 Further guidance on the colour rendering of light sources is given in ***4.2.2.2****.*

c) **Colour appearance**. Light sources can be of a warm, neutral or cool colour appearance (see **4.2.2.2**).

d) **Light source life and luminous flux depreciation.** Data on light source life and luminous flux depreciation should be obtained from manufacturers and affect the maintenance factor (see **5.1.6**).

e) **Mesopic vision and scotopic/photopic (S/P) ratio.** Human vision is a highly complicated process, and the spectral luminous efficiency of the eye is influenced by many factors. At lower lighting levels and for tasks associated with pedestrian visual requirements, light sources with a higher S/P ratio give improved visual performance for peripheral vision.

NOTE 5 Annex A provides guidance on how the S/P ratio of the light source can be used within the selection of lighting class for subsidiary roads. ILP PLG03 [39] provides further information.

6.6 Control gear and LED driver

6.6.1 General

The control gear used to power and control the light source should conform to BS EN 60598-1, BS EN 60598-2-3 and other specific standards as applicable to the particular technology used. Electronic control gear, which provides a more stable voltage and current supply to the light source, should be used on new installations. The control gear chosen should be suitable for its installed environment, withstanding the effects of both the vibration and the variation in moisture and temperature.

NOTE 1 Flexibility and future-proofing is achieved by the use of variable output control gear.

NOTE 2 Attention is drawn to the Directive 2009/125/EC (the Ecodesign Directive) [24], which gives minimum requirements for control gear, and to EC Regulation No. 245/2009 [38] in respect of requirements for energy efficiency of control gear.

6.6.2 Constant light output (CLO)

*COMMENTARY ON **6.6.2***

The luminous output of most light sources gradually reduces with time. Constant light output is a method whereby the power to the light source is gradually increased over time, with the aim of keeping the luminous output of the light source at a constant level. This is generally a more efficient means of controlling the light output, because at any time, the energy used to operate the light source is matched to the required luminous output to achieve the target light levels.

The initial luminous flux of the system when used in calculations is lower.

For energy calculations, as the energy consumed gradually increases over time, the calculation should use the average power for the relevant time period, rather than the initial power.

6.7 Luminaires

Luminaires should conform to BS EN 60598-2-3.

NOTE 1 The sealing of luminaires, and their resistance to the ingress of dirt and water, is indicated by their ingress protection code (IP rating). Further information is given in BS EN 60529.

Luminaires with an IP rating in the range IP 6X should be used. The higher numbers in this range should be used for optical compartments, as these reduce light output depreciation, reduce degradation of internal components and minimize the need for internal cleaning.

NOTE 2 If the optical compartment and the control gear compartment are separate, they might have separate IP ratings for each compartment.

7 Applications

7.1 Lighting traffic routes

*COMMENTARY ON **7.1***

This subclause gives guidance on the lighting of traffic routes (i.e. roads where the predominant users are motorized vehicles), including motorways and all-purpose traffic routes. The lighting requirements for traffic routes are strongly dependent on traffic density and mix. An outline of the design process for all-purpose traffic routes is given in Annex E. Typically for traffic routes, the aim of the lighting scheme is to create a bright background against which an object is seen in silhouette or negative contrast. This works best on relatively straight roads where the motorist's viewing distance is greater than 60 m.

7.1.1 General

An appropriate lighting class should be selected from those given in BS EN 13201-2:2015.

For the lighting of conflict areas, including junctions, pedestrian crossings and crossovers, the recommendations in **7.5** should be followed.

NOTE Information on the selection of lighting classes is given in Annex A.

7.1.2 Calculation procedure for straight roads

For straight roads, the calculation procedure given in BS EN 13201-3 should be used to determine the maximum spacing between luminaires.

NOTE 1 BS EN 13201-3 sets out the format of a table of road surface reflection data, but it does not provide a completed table.

The *r*-table used should represent the road surface that exists or is to be provided.

NOTE 2 There can be significant variations in reflection when different aggregates are used in standard asphalt, with porous asphalt, and with concrete surfaces.

NOTE 3 CIE 144 [40] gives standard r-tables for road surfaces.

NOTE 4 A representative British Road surface (standard asphalt) is defined as having a road surface CIE type C2 and an average luminance coefficient of $Q_0 = 0.07$.

NOTE 5 An r-table representing a dry road surface is normally used. In BS EN 13201-2:2015, the option is given to use a lighting class related to a wet road surface, where the road authority considers that the road surface is wet for a significant part of the hours of darkness. In this case, calculations need to be carried out for both the wet and dry conditions, with different r-tables used to represent those conditions. Generally, in the UK it is assumed that road surfaces are predominantly dry, so calculations do not need to be carried out for the wet condition. Calculating for a wet road surface can very easily be considered. An additional criterion, used in some countries, is the overall uniformity of luminance in a wet condition.

7.1.3 Calculation procedure for bends

7.1.3.1 General

The calculation procedure described in **7.1.2** should be used to determine the maximum spacing between luminaires on bends as though the road is straight. This spacing, which is the design spacing, should then be used to plan the installation around the bend.

It is common practice to reduce the spacing between lighting columns by 10% on a slight bend compared to a straight road. Where the bend is more severe (radius < 500 m), illuminance-based criteria should be used for the lighting design, and the road and potential objects should be lit in positive contrast to the appropriate C class from BS EN 13201-2:2015, Table 2.

When transferring straight road spacing to a bend, the criterion of overall uniformity should not fall below the recommended value for the selected lighting class in BS EN 13201-2:2015.

NOTE Transferring straight road spacing to a bend is unlikely to reduce the value of average luminance when the columns are located on the outside of the bend. Longitudinal uniformity is not a relevant criterion on bends, because the viewing distance is reduced, and the normal direction of view of the motorist changes continuously. However, the criterion of overall uniformity is applicable to bends.

7.1.3.2 Lighting column location on bends

When locating lighting columns on a bend, lighting columns should not be located in vulnerable locations. A risk assessment should be carried out in consultation with a road safety engineer to ascertain the best locations and whether passively safe lighting columns would be appropriate.

NOTE 1 This might mean that in certain circumstances instead of locating lighting columns on the outside of a bend, it is better to locate them on the inside of the bend.

Overall uniformity criteria should still be achieved, and the preferred location of columns is on the outside of a bend.

*NOTE 2 Additional guidance is given in **6.2.3**.*

7.2 Lighting residential and minor roads

*COMMENTARY ON **7.2***

*This subclause gives recommendations for the lighting of subsidiary roads, namely access roads, residential roads and associated pedestrian areas, footpaths and cycle tracks. It does not cover the lighting of urban centres, which are covered in **7.4**. An outline of the design process is given in Annex F.*

*The main purpose of lighting for subsidiary roads and areas associated with those roads is to enable pedestrians and cyclists to orientate themselves and detect vehicular and other hazards. It can allow pedestrians to recognize other pedestrians and feel more secure. It also has a wider social role, with the potential of helping to reduce fear of crime and to discourage crime against people and property. It can contribute to commercial and social use at night of town centres and tourist locations by improving the daytime and night-time appearance. The lighting on such roads can provide some guidance for motorists, but is unlikely to be sufficient for revealing objects on the road without the use of headlights. The visual tasks of pedestrians on subsidiary roads are described in **5.1.2**.*

The main purpose of lighting footpaths and cycle tracks not directly associated with roads is to show the direction that the route takes, to enable cyclists and pedestrians to orientate themselves, to reveal the presence of other cyclists and pedestrians and other hazards, and to discourage crime against people and property.

At road junctions on subsidiary roads it can be advantageous to position one luminaire opposite to a busy T-junction and another at a reduced distance into the T. Similarly, it can be advantageous to position a luminaire at T-junctions on footpaths or cycle tracks not directly associated with roads. The lighting of the junction needs to be treated as a whole, rather than looking at individual roads. Further guidance is given in ILP PLG02 [41].

*Guidance for roundabouts on subsidiary roads is given in **7.5**.*

Due to the lower speeds encountered, no particular recommendations apply to junctions on subsidiary roads, but the requirements of the selected lighting class from BS EN 13201-2:2015 need to be met by the lighting design at any junction.

7.2.1 General

The criteria for average and minimum horizontal illuminance classes should be used to determine the general lighting for pedestrians and cyclists. The design should be such as to ensure that the road edge and immediate surrounds are illuminated.

NOTE 1 The provision of lighting designed to meet the requirements of the appropriate horizontal illuminance class might not necessarily provide a vertical illuminance at the height of the human face that would be adequate to ensure a high possibility of recognition.

The appropriate lighting class should be selected from BS EN 13201-2:2015.

NOTE 2 Information on the selection of lighting classes is given in Annex A.

When designing lighting for roads with associated areas, it is possible to regard the carriageway and adjacent footways as separate areas for the application and calculation of lighting classes. However, a single lighting class should normally be applied to the carriageway and any adjacent footway and verge defined as being within the same relevant area.

When designing lighting for footpaths and cycle tracks not directly associated with roads, the relevant area for the application and calculation of the lighting class should, if necessary, be extended beyond the defined width of the actual footpath or cycle track, in order to give a wider field of view for pedestrians and cyclists and provide more confidence for such users of the route.

NOTE 3 PD CEN/TR 13201-1:2014 gives information on definition of the relevant area.

In respect of the P series lighting classes as given in BS EN 13201-2:2015, Table 3, the average illuminance ($\bar{E}$) should not exceed more than 1.5 times the minimum value of $\bar{E}$ indicated for the specified lighting class. For any lighting system, this recommendation should be applied at the maximum design spacing, at the actual average design spacing of the lighting system, and to any group of three consecutive luminaires. Where the spacing along a road varies significantly, an area calculation should be used to verify that the design is suitable.

Direct glare from luminaires in subsidiary roads and associated areas, footpaths and cycle tracks should be controlled. Where luminaires have clear bowls or refractors, these should conform to class G*1 as specified in BS EN 13201-2:2015, Table A.1, or a higher class, to provide adequate control of glare.

NOTE 4 BS EN 13201-2:2015 states that limitation of glare can be achieved by the selection of luminaires according to the classes given in Table A.2 of that standard. In practice, this solution is only suitable for luminaires with completely diffusing or frosted bowls.

7.2.2 Calculation procedure

The calculation procedure defined in BS EN 13201-3 should be used for illuminance in the design of lighting for subsidiary roads and associated areas, footpaths and cycle tracks.

NOTE Methods are given for roads and areas to which a regular grid can be applied, and for irregular areas.

7.2.3 Mesopic vision and white light

*COMMENTARY ON **7.2.3***

It is accepted with scientific research that there is a correlation between the spectral power distribution of a light source and the visual performance of peripheral vision under low lighting levels associated with mesopic vision.

For the lighting levels associated with lighting residential and minor roads in accordance with the P classes from BS EN 13201-2:2015, Table 3, the target illuminance for a class can be adjusted according to the S/P ratio of the light source and the illuminance levels.

The S/P ratio of the light source should be obtained from light source manufacturers. If the S/P ratio is < 1.0, it may be used to amend the lighting class selected.

NOTE 1 The adjustment factor varies with S/P ratio and also with illuminance.

NOTE 2 Guidance on the use of S/P ratios is given in ILP PLG03 [39].

NOTE 3 Annex A provides guidance on how the S/P ratio of the light source can be used within the selection of lighting class.

7.2.4 Roads with traffic calming measures

An appropriate lighting class should be selected from BS EN 13201-2:2015 for areas of traffic calming measures.

NOTE 1 Traffic calming measures are often provided on subsidiary roads, particularly in residential areas, and can include speed restriction humps.

NOTE 2 The information on selection of lighting class in Annex A takes account of traffic calming measures, and in some circumstances can indicate the need for a higher lighting class at the area of traffic calming than on the approaching road.

NOTE 3 Further guidance relating to lighting for traffic calming features is given in ILP TR25 [16].

7.2.5 Crime prevention and detection, and pedestrian safety

In areas where there is a high crime risk, any potentially dark areas, which could provide cover for a criminal, or which have little natural surveillance, should be included within the relevant area to which the selected lighting class will be applied.

Lighting levels in such areas should not be reduced at any time of the night.

*NOTE 1 Guidance on recognition, visual tasks and personal safety is given in **5.1.2**.*

NOTE 2 Attention is drawn to the Crime and Disorder Act 1998 [42], Section 17.

NOTE 3 An EV lighting class using vertical illuminance, from BS EN 13201-2:2015, Table 6, can be specified in addition to the general lighting class when there are particular concerns about crime and personal safety.

7.2.6 Overall uniformity of illuminance

*COMMENTARY ON **7.2.6***

Whilst not explicitly stated in the P-series of lighting classes, the overall uniformity of illuminance, U_o, of the lighting on a subsidiary road, footpath or cycle track is an important attribute. Pedestrians and cyclists need an acceptable level of overall uniformity of illuminance to aid orientation and detection at night, as well as to provide a sense of security. This need is generally satisfied by the levels of illuminance set in the P-series of lighting classes in BS EN 13201-2:2015.

The overall uniformity of illuminance, U_o, should be not less than that derived from the ratio of the minimum illuminance level to the maintained average horizontal illuminance level recommended in BS EN 13201-2:2015.

When determining the desired level, account should be taken of the effect on the environment due to increased emissions, light pollution and lighting column height.

NOTE 1 Where there are high levels of street crime or pedestrian movement, or high numbers of elderly people, a higher level of overall uniformity of illuminance might be beneficial in addition to providing suitable levels of vertical Illuminance.

NOTE 2 As a general principle, a higher overall uniformity is usually a contributing factor towards a good design, especially when applied to an area layout using multiple luminaires. A lower overall uniformity could mean that the relationship between the mounting height, class and optic might not be appropriate, and another optic or distribution might be preferable.

NOTE 3 The most economical lighting scheme is obtained by ensuring that the lighting levels provided are as close as possible to those specified in BS EN 13201-2:2015 for the specific P-series lighting class being used.

7.3 Lighting cycle tracks and footpaths

COMMENTARY ON ***7.3***

The purpose of lighting on cycle tracks or footpaths is to enable users to orientate themselves, identify other users, detect potential hazards, discourage crime and engender a feeling of safety and security. Cycle tracks are either adjacent to the carriageway or are segregated and remote from the carriageway.

When cycle tracks are adjacent to the carriageway, the lighting design should take into account the needs of all users including motorists.

When the cycle track is segregated from the main carriageway, the lighting class should be chosen specifically for the cycle track.

NOTE 1 Information on the selection of lighting classes is given in Annex A.

When locating lighting columns, the set-back should be sufficient to avoid the potential for cyclists colliding or coming into contact with the lighting column.

NOTE 2 Further guidance is found in ILP TR23 [43].

7.4 Lighting town centres and public amenity areas

COMMENTARY ON ***7.4***

This subclause gives recommendations for the lighting of urban centres and public amenity areas for all road users. Vehicular, cycle and pedestrian traffic is involved and, therefore, all exterior public areas open to the public after dark are included. As visual orientation and location are important to motorists, cyclists and pedestrians within urban centres, recommendations are also given for the illumination of landmarks at night.

In urban and amenity areas, people are likely to be attracted by a pleasant visual scene. During the hours of darkness, people and the surrounding environment need to be easily recognized. During the hours that business and commercial concerns are open, a relatively high level of lighting is likely to be necessary, with a combination of the appropriate class of public lighting and some private lighting.

In view of the diverse nature of each particular site, no uniform method of lighting provision is suggested, and an individualized approach needs to be taken for each site. For this reason, only basic guidance is given with regard to the overall lighting provisions related to each area. This guidance is given in Annex A.

7.4.1 General

In those parts of urban centres and public amenity areas with significant pedestrian traffic, lighting should be provided on vertical planes in addition to horizontal planes to assist in the identification of pedestrians.

In areas of high crime or where CCTV is present, lighting designs should be based upon vertical illuminance classes in addition to horizontal illuminance classes.

NOTE Areas that are monitored by CCTV might need a higher level of overall uniformity of illuminance for the surveillance of individuals to maintain the image whilst panning across a scene. Poor overall uniformity can lead to lack of image resolution and delays in the re-formation of the picture.

All lighting equipment should complement rather than detract from the appearance of the area. The general lighting should define the area rather than the traffic route. During the early evening when all shop windows and signs are illuminated, this should all be factored in as part of the lit environment. However, during the late evening and during the night when shops are closed and the commercial light is reduced or extinguished, the public lighting should aid the security of property and the safety of pedestrians, as well as the safe passage of any vehicular traffic.

7.4.2 Determination of objectives

*COMMENTARY ON **7.4.2***

In urban and amenity areas, the efficient lighting of the road surface for traffic movement is not the only or even the main consideration. Urban centres serve many users, each with differing and sometimes conflicting needs. A balance with many other aspects therefore has to be achieved.

A function of lighting in urban centres, in addition to that of general safety and security, is to enhance the night-time environment. The provision of appropriate and attractive lighting can assist in stimulating trade and commerce.

A master plan should be drawn up which contains all the relevant objectives in order of their perceived importance and emphasis. These should include as many of the following as are appropriate:

a) lighting to provide safety for pedestrians from moving vehicles and to deter antisocial behaviour;

b) lighting commensurate with the character and volume of vehicular traffic, including cyclists;

c) lighting design and choice of equipment in relation to the architectural scene and urban landscape;

d) control of illuminated advertisements in the interests of amenity;

e) control and integration of permanent floodlighting and architectural lighting installations into the visual master plan;

f) control of temporary special lighting effects, such as floodlighting and festive decorations;

g) control of road and other direction signs and their relationship with other illuminated material;

h) control and blending of light from both public and private sources, e.g. bus shelters and telephone kiosks;

i) protection of the environment and property from obtrusive light;

j) protection of installations from accidental or deliberate damage;

k) reduction of street clutter; and

l) maintenance of installations.

7.4.3 Lighting to meet traffic needs

7.4.3.1 Categories of traffic

*COMMENTARY ON **7.4.3.1***

*The relative balance of the lighting objectives listed in **7.4.2** depends on the type of traffic, which can be divided into the following categories:*

- *primarily vehicular;*
- *mixed vehicular and pedestrian;*
- *pedestrians and cyclists only.*

The appropriate lighting class for each category of traffic should be selected from BS EN 13201-2:2015.

NOTE Further information on the selection of lighting classes is given in Annex A.

7.4.3.2 Primarily vehicular traffic areas

The appropriate lighting class for primarily vehicular areas should be defined in terms of average carriageway luminance and uniformity, and selected from BS EN 13201-2:2015, Table 1.

The lighting of footways, other pedestrian areas and cycle tracks adjacent to the carriageway might need to be designed separately from that of the carriageway. In such areas, an appropriate lighting class defined in terms of horizontal illuminance and uniformity should be selected from BS EN 13201-2:2015, Table 3.

NOTE Lighting can be used to accentuate the change in use from that where the motorist is the prime road user to that where a growing number of pedestrian activities are occurring. Ways to mark this change of use could include altering the appearance of the lighting equipment to a more decorative type, changing the height and/or changing the colour appearance of the light source.

7.4.3.3 Mixed vehicular and pedestrian areas

The appropriate lighting class for mixed vehicular and pedestrian areas should be defined in terms of horizontal illuminance and uniformity, selected from BS EN 13201-2:2015, Table 2.

NOTE 1 In some situations it can be appropriate to apply the same lighting class to the whole vehicle and pedestrian area, treating it as one relevant area for design and calculation. In other situations, particularly where separate vehicle and pedestrian areas are well defined, it can be appropriate to treat the different areas as separate relevant areas for the selection of lighting classes and for design and calculation.

NOTE 2 Further information on the selection of lighting classes is given in Annex A.

Luminaire intensities should be controlled in order to prevent glare, using an installed intensity class selected from BS EN 13201-2:2015, Table A.1.

NOTE 3 At night, decorative floodlighting can assist traffic movement. A local landmark, known and used during the day by both motorists and pedestrians, can be lost during the hours of darkness. This may be overcome by a purpose-designed floodlighting scheme, a single spotlight attached to an adjacent road lighting column, or even by "spill light" from strategically positioned road lighting luminaires.

7.4.3.4 Pedestrian areas

In pedestrian areas, the lighting should create a feeling of general security and well-being and encourage people to visit and make use of the facilities. Recognition of the behaviour and intentions of other pedestrians is important, and for this purpose good colour rendering as recommended in **4.2.2.2**, and adequate visual recognition as recommended in **5.1.2** and **7.4.4**, should be provided.

NOTE 1 Pedestrian areas, while excluding motorized vehicles, can sometimes include cyclists.

The appropriate lighting class should be defined in terms of horizontal illuminance and uniformity, selected from BS EN 13201-2:2015, Table 3.

NOTE 2 Further information on the selection of lighting classes is given in Annex A.

7.4.4 Lighting for security and safety

*COMMENTARY ON **7.4.4***

*The lighting classes referred to in **7.4.3** in most cases serve the needs of security and safety. Additionally, it is beneficial to utilize any public lighting installation throughout the hours of darkness rather than simply during times of major traffic movement.*

The lighting should be designed to meet the most onerous situation with regard to traffic flow. There should also be provision to vary the lighting level according to the varying traffic flow through the night or year.

*NOTE 1 This can be achieved by the "variable lighting" approach detailed in **4.3.5**, by switching light sources in multi-light source luminaires, or by varying the lighting level.*

When light sources are switched on or off to vary the lighting level, the uniformity requirement should still be met for the appropriate class.

To provide a sense of security, sufficient vertical illuminance should be provided at face level so that it is possible to recognize whether a person is likely to be friendly, indifferent or aggressive, in time to make an appropriate response.

NOTE 2 A lighting class using vertical illuminance, from BS EN 13201-2:2015, Table 6, can be specified in addition to the conventional horizontal illuminance lighting class when there are particular concerns about crime and personal safety. However, this is not recommended other than in exceptional circumstances, due to the difficulty in defining the appropriate observer position(s).

NOTE 3 One method of improving vertical illuminance without increasing glare is to increase the mounting height.

7.4.5 Visual appreciation

COMMENTARY ON ***7.4.5***

The use of imaginative lighting can give added interest to areas that people might wish to see, and can also do much to subdue the less visually attractive features within an urban environment, by highlighting the more attractive and worthwhile features.

Information on the lighting of buildings, monuments and fountains can be found in the ILP publication The outdoor lighting guide [44] and CIBSE LG06 [45].

Lighting designers should consult the town planner or landscape architect prior to and whilst undertaking a lighting design in a town centre or public amenity area.

7.4.6 Lighting of covered shopping arcades and canopied areas

The lighting of covered shopping arcades and canopied areas should be to at least the levels given in Table 2, and should match that of the adjacent windows. Light sources with colour rendering $R_a \geq 60$ should be used.

Table 2 — *Lighting levels for covered shopping arcades and canopied areas*

Values in lux

Type	Day		Night	
	$\bar{E}$	E_{min}	$\bar{E}$	E_{min}
Open arcade	—	—	75	50
Completely enclosed arcade or canopied area	250	150	150	75

7.4.7 Lighting of subways, footbridges, stairways and ramps

7.4.7.1 General

Subways, footbridges, stairways and ramps should be lit to the appropriate level given in Table 3.

NOTE 1 Table 3 applies to lighting in urban or suburban areas. The levels in Table 3 are not appropriate when the approaches are unlit or when there is little ambient lighting in the vicinity.

Rural footbridges and subways should be lit to lighting levels appropriate to the ambient luminance in the vicinity and the usage by day and by night.

NOTE 2 The decision on whether to light a rural subway also depends on the following:

- *length of the subway;*
- *visibility of the exit when entering the subway; and*
- *usability of the approach paths at night without a torch.*

A risk assessment should be undertaken to assist with the decision-making process of whether and when to light.

Lighting on stairways and ramps giving exterior access for disabled people to buildings should be in accordance with BS 8300-2. In subways, vertical surfaces should be sufficiently illuminated to create a pleasant and safe environment for pedestrians.

Table 3 — *Maintained lighting levels for subways, footbridges, stairways and ramps*

Values in lux

Type	**Day**		**Night** [A]	
	$\overline{E}$	E_{min}	$\overline{E}$	E_{min}
Subways				
• open [B]	—	—	20	10
• enclosed [C]	350	150	20	10
Footbridges				
• open [B]	—	—	20	10
• enclosed [C]	350	150	20	10
Stairways/ramps				
• open [B]	—	—	20	10
• enclosed [C]	350	150	20	10

[A] The night time levels should be lit in proportion to the approach lighting, i.e. not more than 2 classes higher and not lower than the actual levels of the approach lighting.

[B] "Open" equates to major daylight penetration.

[C] For "enclosed" areas emergency lighting might be needed. It is essential that it is installed if the area forms part of an escape route from a shopping centre, car park or transport interchange.

NOTE 3 It is also advantageous that all surfaces are as light coloured as is practicable.

Light source colour appearance and colour rendering should be taken into account.

Lighting should be designed at the outline design stage of any structure to determine the location of the chosen luminaires relative to their performance, so that the electrical intake cabinets, wiring conduits and mounting facilities can be incorporated into the construction.

Subways are particularly susceptible to vandalism, and luminaires should be fit for purpose in terms of strength and rigidity of glazing and body. For an existing subway, the design of the lighting and the type of luminaires and cable conduits should be such as to minimize the scope for damage from vandalism.

In long or complex subways, the lighting should be operational over a 24 h period.

NOTE 4 The installation may be designed to give higher levels during daylight hours, which can be switched to lower levels of illuminance during the hours of darkness. Switching can be carried out by either time switch or photocell.

During the daytime, the brighter surroundings of a subway entrance area, relative to a low level of subway interior lighting, can create a "black hole" effect if the subway is very long and daylight penetration poor. At night, a reversal of this effect can be experienced when emerging from the subway into lower levels of exterior lighting. In order to overcome this undesirable situation during daytime, the illuminance in the entrance should be increased to twice the values given in Table 3. At night, the illuminance should be reduced to the values given in Table 3.

For footbridges and stairways, the risers should be illuminated differently to the treads so as to provide visual contrast and accentuate the steps, even if the difference is already highlighted by the use of different materials.

On footbridges, the lighting units should be installed in such a manner as to complement the structure but ensure future ease of maintenance.

*NOTE 5 Additional guidance for the lighting of footbridges is given in **7.6.3**.*

7.4.7.2 Emergency lighting

On longer, complex subways, it should be determined whether emergency lighting is required, using the guidance in BS 5266-1, and appropriate lighting should be installed where necessary.

If a subway forms part of an escape route from a shopping centre, car park or transport interchange, emergency lighting should be provided to the same standard as escape routes within non-residential public premises.

NOTE Attention is drawn to the Construction (Design and Management) Regulations 2015 [15] in respect of the legal duty for the building owner or operator, or their appointed representative, to undertake a risk assessment.

7.4.8 Lighting of car parks

*COMMENTARY ON **7.4.8***

The purpose of lighting car parks is to enable all users, including motorists and pedestrians, to proceed safely, and to allay the fear of crime.

7.4.8.1 General

The variation in character of car parks in terms of size, structure, location and access means that different lighting techniques should be assessed to find those suitable to the conditions.

At pay stations, additional task lighting of good colour rendering, to identify coinage and to deter crime, should be adopted where appropriate. The lighting of ticket offices should be in accordance with BS EN 12464-1:2011, Clause **5**.

Lighting should be contained within the general curtilage of each car park to save electrical energy and for the avoidance of light pollution.

NOTE Vertical illuminance is important in car parks, for facial recognition, personal security and CCTV.

7.4.8.2 Enclosed car parks

*COMMENTARY ON **7.4.8.2***

The average illuminance in enclosed car parks is not as important as the uniformity. Good uniformity produces easy viewing conditions and gives the impression of a space with a much higher illuminance.

A welcoming atmosphere helps to allay the fear of crime, and measures can be taken to provide such an atmosphere by the use of light-coloured finishes to all surfaces in the field of view and the use of light sources with warm colour appearance.

The protrusion of luminaires below the ceiling surface can make the ceiling appear dark. Floor surfaces with a light finish reflect light onto the ceiling.

For lighting purposes, the open roof level of an enclosed multi-storey car park should be regarded as an outdoor car park, and the lighting of this level should be in accordance with **7.4.8.3**.

The spacing of luminaires and reflectance factors in enclosed car parks should be chosen to achieve a uniformity that is as high as possible. The lighting levels recommended in BS EN 12464-1:2011, Clause **5** should be provided and maintained throughout all hours of use.

The design, orientation and location of luminaires in the motorist's line of sight should be arranged such that glare is minimized and conforms to BS EN 12464-1:2011, **4.5**.

NOTE 1 Linear light sources mounted crossways to the motorist's line of sight can be a glare source unless baffles are used.

The normal pedestrian escape routes from enclosed car parks should be easily identifiable and should be provided with emergency lighting to the same standard as escape routes within non-residential public premises, in accordance with BS 5266-1.

NOTE 2 Emergency lighting on the open roof level is not needed as long as means of egress via stairways are visible. Guidance is given in BS 5266-1.

7.4.8.3 Outdoor car parks

For lighting purposes, both surface car parks and the open roof level of multi-storey car parks should be regarded as outdoor car parks.

In many instances, surface car parks are close to properties and roads. Lighting from these can contribute to the illumination of the car parking area, but, as this lighting cannot be assured in terms of quality and duration, surface car parks should have independent lighting provisions.

Luminaires in outdoor car parks should be selected and mounted such as to avoid obtrusive lighting, following the guidance in **4.2.3**.

The design, orientation and location of luminaires in the motorist's line of sight should be arranged such that glare is minimized. In order to limit glare, an appropriate intensity class should be selected from BS EN 13201-2:2015, Table A.1.

The appropriate lighting level should be selected from Table 4, taking into account the type and location of the car park, and should be provided and maintained through all the night-time hours of use.

NOTE 1 A different level may be selected at periods of night when the usage is significantly different to normal usage.

NOTE 2 Table 4 is extrapolated from BS EN 12464-2:2014, Table 5.9.

Table 4 — *Maintained lighting levels for outdoor car parks*

Values in lux

Type of area and usage	$\bar{E}$	U_o
Light traffic, e.g. parking areas of shops, terraced and apartment houses; cycle parks	5	0.25
Medium traffic, e.g. parking areas of department stores, office buildings, plants, sports and multipurpose building complexes	10	0.25
Heavy traffic, e.g. parking areas of major shopping centres, major sports and multipurpose sports and building complexes	20	0.25

In areas with low ambient luminance or environmental sensitivity areas, car park lighting levels should be appropriate to the adjacent highway lighting levels.

Lighting for open roof level car parks should be planned to avoid visual domination of the skyline by the components used to mount the luminaires during the day and by the light sources at night.

NOTE 3 Further information is given in ILP GN01 [N2].

The boundary of open roof level car parks should be well defined by illumination of the perimeter and rails. When selecting the location of luminaires and mounting components, the need for access for maintenance should be taken into account.

7.4.8.4 Calculation procedure

The calculation procedure for the illumination of car parks should be in accordance with BS EN 13201-3, except as recommended below.

All parts of a car park should be included in the area under consideration. The area of calculation for each part should be that area of the working plane having a boundary of not more than 0.5 m (for enclosed car parks) or not more than 1.0 m (for outdoor car parks) from the wall or perimeter. The working plane to be used should be floor or ground level. The first calculation grid points should be no more than 0.5 m (for enclosed car parks) or 1.0 m (for outdoor car parks) away from the wall or the perimeter of the area.

The calculation should take into account the presence of any permanent obstructions, as these can affect the illuminance level and uniformity.

Where there are significant obstructions or irregular areas, a series of grids should be used to ensure that the design illuminance and uniformity are achieved over the whole area under consideration.

7.4.9 Lighting of service areas

*COMMENTARY ON **7.4.9***

A service area is an area where goods are loaded and unloaded from lorries to shops, stores and restaurants.

For areas not associated with the public highway, lighting classes should be selected from the relevant table in BS EN 12464-2:2014.

NOTE For areas that are part of the public highway, classes are given in Annex A, Table A.6.

7.4.10 Lighting within conservation areas

*COMMENTARY ON **7.4.10***

The declaration of a conservation area does not necessarily preclude the provision of lighting in a previously unlit area, or establish a prerequisite for period-style lighting. Modern equipment of good functional design is often suitable. Conventional lighting forms often prove most economical, in terms of both provision and future upkeep. However, an unconventional approach or a blend of various light forms might be more appropriate to the particular character of a conservation area.

Attention is drawn to the Public Health Act 1961 [46] in respect of the fixing of public lights to buildings.

A lighting class should be selected from BS EN 13201-2:2015 that relates to the needs of vehicular and pedestrian traffic, in accordance with **7.1**, **7.2** or **7.4** as appropriate.

The daytime appearance of any installation in a conservation area should relate to the surroundings, so individual appearance, location and scale should all be taken into account in the design. Advice on these points should be sought from the local planning authority conservation officer at an early stage.

For night-time appearance, the quality of lighting, observed effect, light source colour temperature and colour rendering properties should all be taken into account in the design.

NOTE The best lighting effect might be achieved by careful blending of the various lighting measures chosen for individual features within the conservation area.

Visual intrusion should be minimized during the design and execution of all installation work, with the routing of all wiring and cables, and location of electricity service equipment, being planned accordingly.

When it becomes necessary to replace equipment following damage or other causes, equipment should be replaced with identical or higher specification equipment.

7.4.11 Lighting of parks and landscaped areas

*COMMENTARY ON **7.4.11***

The lighting at night of parks, gardens and landscaped areas can change what would otherwise be a dark zone into an attractive amenity that enhances the environment and encourages use as a source of pleasure in comparative safety and security.

With the availability of a wide variety of luminaires and coloured light sources, the opportunity to create a visual night scene by the subtle use of illumination on foliage and features can produce a dramatic impact. Variation of light, shadow and silhouette can offer a pleasing effect that changes with the direction of view, inviting visitors to enjoy the ever-changing shape of their surroundings.

Although there has to be an interrelationship for the lighting of flora, features and forms to produce an artistic composition, the specific illumination of foliage can give a spectacular effect. This can be carried out by using projector floodlights remotely positioned to create an effective background if viewed from a distance. If adjacent to trees with descending branches, floodlights can be placed underneath or within the trees.

When a landscaped area includes water features, the surface of the water does not respond to direct lighting but does reflect that of its surroundings, adding a further effect to the overall scene.

*The presence of fauna also needs to be taken into account (see **4.2.4**).*

General guidance on outdoor environments is given in ILP publication The outdoor lighting guide [44] and CIBSE LG06 [45].

Lighting in landscaped areas should be designed in consultation with the landscape architect.

Lighting design should be in accordance with ILP GN01 [N2].

The recommendations given in **7.3** should be followed when lighting footpaths and cycle tracks in landscaped areas.

7.4.12 Site and installation requirements of the design

7.4.12.1 General

The needs of all people who might be affected by the location and/or design of the lighting scheme should be identified by a design risk assessment, and factored into the design.

NOTE 1 Some people might have specific visual or accessibility needs, for example, the residents of a care home, or pupils of a school.

The area concerned should be subjected to detailed daytime and night-time site appraisal prior to detailed design work.

NOTE 2 A recommended outline of the design procedure for lighting urban centres and public amenity areas is given in Annex G.

Lighting is a vital part of the environment and should be complementary to the surroundings. Multidisciplinary teamwork should be undertaken by planners, architects and lighting designers to achieve good effective and economical lighting design. Preference should always be given to good quality, well-designed equipment with low maintenance needs. Predicted operating costs should include light source life and replacement costs, luminaire cleaning cycles, and electrical energy costs.

7.4.12.2 Site appraisal

Site appraisals should be carried out before, during and soon after installation, by day and by night, to verify that all design objectives are met.

NOTE 1 For special or particularly sensitive locations, it can be advisable to arrange trial installations to evaluate the correct interpretation of objectives.

NOTE 2 If wall-mounted units are to be used, site appraisals are particularly important in order to ascertain cable runs that are as inconspicuous as possible.

The site visits that are carried out during installation should attempt to identify and rectify any unforeseen problems as well as appraise the overall design objectives.

7.4.12.3 Measurement of lighting installations

COMMENTARY ON ***7.4.12.3***

In some contracts, there is a requirement or a desire for the lighting performance of new lighting installations to be measured to verify that the design requirements have been met.

When verifying lighting, the measurements should be undertaken in accordance with BS EN 13201-4.

NOTE Further guidance is given in ILP TR28 [47].

7.4.13 Light sources and luminaires

7.4.13.1 Basic needs

Lighting equipment should be appropriate to the lighting task, the environment and the maintenance requirements.

NOTE 1 In urban centres and public amenity areas, the needs are twofold. The first criterion is the ability to illuminate the area and objects concerned in the most effective manner possible. The second is the appearance of the lighting equipment.

The lighting equipment should be aesthetically pleasing in itself as well as being in harmony with its surroundings (see **6.2.2**). At all times, and especially at night, it should add to the attraction of the urban scene rather than detracting from it.

NOTE 2 Colour rendering is important in most aspects of urban centre lighting. In areas of mixed vehicular and pedestrian traffic, the ability to distinguish objects is considerably improved by the differentiation of colours. This is a benefit both to the public and to the police. Recommendations on the colour rendering index of light sources are given in ***4.2.2.2****.*

NOTE 3 The different colour appearances of light sources can be exploited by the lighting designer to bring planned variety to the night-time urban scene. While long life and high efficacy are important economical factors, other characteristics of the light source are equally important.

7.4.13.2 Appearance

Style, shape and choice of materials play an important part in daytime appearance and should be chosen to complement the surroundings.

If period-style luminaires are used, historical periods should be matched as far as is practicable.

NOTE 1 Consultation with the local planning authority is advisable.

NOTE 2 If a higher level of lighting is required than can be obtained without detracting from the visual appearance, variable lighting as described in ***4.3.5*** *can be used.*

7.4.14 Vehicular charging points

COMMENTARY ON ***7.4.14***

Electricity charging points for electric vehicles (EV charging points) are becoming a feature on some urban streets.

It is assumed that the vehicle charging hatch is illuminated independently of the road lighting. The lighting in the vicinity of the EV charging points needs to be assessed to verify that the light levels *(both horizontal and vertical illuminance, as appropriate to the task) provide adequate visibility of the additional obstructions, such as trailing cables.*

In some cases, the lighting column is also used to house the EV charging point. Particular care is needed to ensure the electrical and structural safety of the installation, particularly as it is likely to be maintained by different groups of operators.

EV charging points should be lit to the same lighting class as the adjacent road.

7.4.15 Smart cities

*COMMENTARY ON **7.4.15***

Smart cities (also known as "sustainable cities or communities") are becoming an integral part of town and city planning with the aim of making the urban spaces more connected and citizen-centric. Whilst this urban planning is generally outside the scope of activities of the road lighting designer; the implementation often utilizes lighting assets and it is important that the designer has an understanding of the future requirements, particularly as the road lighting infrastructure often plays an integral part within a smart city, which can be a combination of providing power, communications and a structure for mounting hardware.

Further guidance on smart cities, including terminology, is given in BS ISO 37100, BS ISO 37105, BS ISO 37106 and BS ISO 37122.

The lighting designer should verify that the electrical and structural requirements of the installation are fit for purpose and should also verify that the design installation has some future-proofing based on anticipated smart city requirements.

The designer should take the following factors into account.

- Columns need to be able to take additional structural loads for future additions of signage, sensors or other equipment. This includes assessing the reduction of strength caused by drilling holes into a column.
- It should be determined who will be maintaining the smart equipment, and whether a second door on the column is required to segregate interaction with the power supplies.
- The locations in which columns are likely to need additional attachments should be determined. Typically, columns in town/village centres or in shopping parades can be expected to have smart equipment. A specification of columns that are used in these areas might be useful.
- Equipment placed on the highway for a purpose that is not a function of the Highway Authority might require a street works licence. It is advisable to check with the Highway Authority's Traffic Manager to determine whether a street works licence will be required for the installation and maintenance of attachments that are not related to highway authority functions.

7.5 Lighting conflict areas

*COMMENTARY ON **7.5***

Conflict areas are typically junctions, intersections, roundabouts and pedestrian crossings, where significant streams of motorized traffic intersect with each other or with other road users such as pedestrians and cyclists. At conflict areas, the visual task is generally more difficult than on straight roads, and a higher luminance or illuminance class may be selected at the conflict area.

The use of a smaller number of luminaires at higher mounting heights than 12 m, or high mast lighting, can be practical and economical solutions for complex or large single level junctions.

For roundabouts, such solutions can be particularly appropriate in the case of:

a) very large central traffic islands;

b) exceptionally wide gyratory carriageways around the roundabout;

c) small central traffic islands or ghost islands, including mini-roundabouts; and

d) roundabouts with unlit approach roads.

Roundabouts can often be effectively lit from the perimeter, the lights thus forming a ring around the perimeter.

Although the selected lighting class provides the overall criteria, in terms of average illuminance and uniformity, the position of luminaires can be important. Conflict areas often present difficulties in the choice of the best positions for the luminaires to reveal both the layout of a junction and the movement of traffic, particularly where the widths of the entry roads might necessitate long spacing between luminaires.

Multiple positions of lighting columns of standard height, a smaller number of higher lighting columns each with multiple luminaires, or high mast installations, are all potential solutions that can be assessed in the design process.

Information on the selection of the appropriate class of lighting, related to the class on the approach roads, is given in Annex A.

Guidance on the lighting of conflict areas is given in ILP PLG02 [41].

Guidance on lighting of pedestrian crossings is given in ILP TR12 [48].

Conflict areas should be lit to a C series lighting class chosen from BS EN 13201-2:2015, Table 2.

*NOTE Annex A, **A.3.2** provides guidance on the selection of lighting classes for conflict areas.*

7.6 Lighting roads on bridges and elevated roads

COMMENTARY ON **7.6**

This subclause gives recommendations for the technical and aesthetic considerations of designing lighting for road bridges, footbridges and elevated roads.

The lighting designer needs to consult other relevant parties, which might include the bridge engineer and the architect. Further guidance can be obtained from the Highways Agency Design manual for roads and bridges, Volume 1, Section 3, Part 11 (BA41/98) [49]. Where bridges carry the road system without significant change of gradient or direction, it is likely that the lighting system on the bridge approaches can be continued across the bridge.

However, bridges lacking in significant surrounding landscape features or background, or those arched to create central crests, can create conditions of glare with reduced luminous foreground or confusing forward scene, each of which reduce the forward view of the motorist. Motorists approaching the bridge can experience glare from lights on and beyond the crest and have a reduced length of visible lit road before them. Beyond the crest, their forward view can be confused by the presence of road, vehicle and building lights occurring in the near and/or distant fields of view.

*Further technical maintenance access problems can arise from features spanned by or in the vicinity of the bridge. Railways and navigable waterways, for example, can impose restrictions on the distribution and colour of light. Detailed advice on the design of road lighting to avoid interference with other forms of transport is given in **7.8**. In general, it is inadvisable to place columns on bridges directly above rail lines.*

7.6.1 Structural considerations

*COMMENTARY ON **7.6.1***

Difficulties are sometimes encountered in obtaining fixings for lighting columns on existing bridges, and the desired positions might be partially or completely obstructed by services or features, or the structure might not be strong enough. However, the mechanical loads imposed on the bridge by road lighting equipment are usually small, even when heavy wind loads are taken into consideration.

A structural engineer should be consulted to ascertain the possible locations of lighting equipment on bridge structures and the limitations on weight and windage.

On large steel structures, vibration can be an issue, and the bridge's technical approval authority should be consulted on the presence of vibration hotspots.

The strength and natural frequency of the assembly of lighting column, bracket and luminaire, when checked using the method of calculation given in BS EN 40 and PD 6547, should be such as to minimize the possibility of detrimental oscillations occurring.

NOTE 1 Structural and other considerations often lead to the siting of lighting columns at the back of the footway, on or outside the parapet.

NOTE 2 It might be necessary to provide air and/or water navigation lights if they are required by the relevant authority.

Lighting columns should, where possible, be mounted over piers and abutments, to render their height more aesthetically acceptable. With long spans it is sometimes necessary to have additional lighting columns between piers, but all luminaires should be at the same mounting height.

NOTE 3 An opposite arrangement may be used to complement the bridge structure, and can make possible a lower mounting height.

NOTE 4 A central arrangement appears as a regularly spaced array of lighting columns from any viewpoint and needs fewer lighting columns than an opposite arrangement.

NOTE 5 On a very short bridge, it might be possible not to have lighting columns on the bridge itself, even if this means a greater mounting height for the luminaires at either end.

7.6.2 Bridges of special, historical or architectural interest

When bridges have historical interest, other special architectural qualities or are scheduled as ancient monuments, the necessary consent should be obtained from the appropriate authorities before installing equipment.

The lighting designer should ascertain whether the bridge is an ancient monument.

7.6.3 Lighting for footbridges

There should be good visual contrast between the step and the riser on the steps (see **7.4.7.1**).

Where a footbridge crosses a lit road, illuminance calculations should be carried out in accordance with BS EN 13201-3, on a grid overlaid on the footbridge walking surface, to verify that the lighting on the footbridge is sufficient. Additional lighting should be installed where necessary to supplement the existing highway lighting.

Where a footbridge crosses an unlit road, any lighting on the footbridge should be designed to minimize its visible intrusion and glare on the road below.

In all cases, the lighting equipment should be kept as inconspicuous as possible in daytime, and both its design and its siting in relation to the footbridge structure should be suitable. In new footbridges, lighting equipment should be incorporated as an integral part of the design and not added as an afterthought. Provision should also be made for the inconspicuous placing of supply cables and switchgear.

NOTE Special precautions against damage or theft might be necessary.

7.6.4 Lighting for elevated roads

COMMENTARY ON ***7.6.4***

Maintenance of the lighting asset can be made very difficult if it is not adequately planned for during the design phase. Parking for maintenance vehicles, higher wind speeds and access to and opening of maintenance access doors are particular problems. The Commentaries on ***7.6*** *and* ***7.6.1*** *are normally applicable to elevated roads.*

Where practicable, lighting columns should be placed in the ground below the elevated road, rather than on the elevated road itself.

NOTE 1 In most cases this provides easier and safer access to the maintenance access door, and removes the need to install a lighting column on the elevated road structure. If it is not practicable and columns need to be attached to the structure, the designer needs to be aware of the following issues:

- *cable routing in troughs and the ability to achieve bend radius in the confined space;*
- *the possibility of cable theft, especially the portion between ground level and deck level; and*
- *the inspection interval of the chosen column base detail.*

Where traffic management costs for accessing columns are likely to be significantly higher than for a non-elevated road, long-life sources should be used.

Elevated roads are often susceptible to high wind speeds, and this should be taken into account when selecting an appropriate column, bracket arm, luminaire and associated equipment.

NOTE 2 Shorter columns can reduce the risk to roadworkers in high wind speeds, and can also reduce the visual intrusion of the structure as a whole.

The lighting design and selection of components should be such as to minimize the night-time impact of the road lighting on the community.

NOTE 3 Road lighting on elevated roads in residential areas often causes light intrusion into domestic properties and, where the road is above roof top level, pollution of the night sky.

7.7 Lighting by high mast techniques

COMMENTARY ON ***7.7***

The principal use of high mast lighting is to light a number of roads or a large area such as an approach to a motorway toll, rather than a single road. Where junctions involve a complex system of roads at different levels, high mast lighting can provide good uniformity and improve the scene by reducing the amount of street furniture. The mast can support fixed geometry or variable geometry luminaires or floodlights, and usually incorporates a means of lowering the luminaires to ground level for maintenance. Individual luminaires can provide a symmetric or an asymmetric light distribution tailored to match the area to be lit from each mast.

7.7.1 General

Individual luminaires should provide a light distribution with zero luminous intensity above 90° from the downward vertical when installed for use, and negligible intensity at angles above 85°.

NOTE Further guidance on high mast design is given in ILP PLG07 [34].

7.7.2 Design considerations

The following recommendations should be met when using high mast techniques.

a) Since the area illuminated by a single high mast can be large, each mast should, if possible, carry more than one light source or luminaire.

NOTE 1 Multiple light sources or luminaires minimize the extent of carriageway left in darkness in the event of failure of a single light source.

b) In determining the height of the mast, account should be taken of the size and shape of the area to be lit and the difference in road levels of the project. The effective mounting height, i.e. the actual height of the luminaires above the carriageway that they are intended to light, should be not less than 18 m. The effective mounting height should be used in any calculations of illuminance or luminance.

c) In grade-separated junctions, shadows occur where one road passes over another, and the size and density of the shadow depends upon the siting of the masts. It should be determined at the design stage whether such a shadow is likely to cause the uniformity of the illuminance or luminance to fall outside the requirements of the selected lighting class from BS EN 13201-2:2015. If this occurs, some form of supplementary lighting at a lower level should be provided.

NOTE 2 Inevitably there will be some light on adjacent areas. This can help to define the visual scene by providing surround lighting, and the lighting of areas adjacent to the carriageway that might otherwise require separate consideration.

7.7.3 Engineering considerations

The position of the mast and mast foundations should be appropriate for both the ground and overhead conditions and the layout of the complete scheme.

Neither the mast nor its headframe in the lowered position should present a traffic hazard.

The area around the base of the mast and where luminaires are serviced should be a level hard-standing such that the operator has adequate space to carry out maintenance.

On sites where a mast has to be placed where it could be struck by a vehicle leaving the carriageway, a safety fence should be provided.

NOTE Further guidance on engineering considerations is given in ILP PLG07 [34].

7.7.4 Lightning protection

The need for lightning protection should be evaluated in accordance with BS EN 62305 (all parts) and BS 7671.

7.8 Lighting areas around aerodromes, railways, coastal waters, harbours and inland waterways

*COMMENTARY ON **7.8***

This subclause gives guidance on road lighting within areas around aerodromes, railways, harbours and navigable waterways, as such lighting can affect the safe use of these areas.

7.8.1 General

When the potential impact of a new road lighting installation is assessed at the design stage, account should be taken of all the modes of transport that could be affected.

Consultation should be carried out with all appropriate authorities regarding any special provisions that are necessary for a new road lighting installation. Provisions should be mutually acceptable, and fully documented for incorporation at the design stage.

Any lighting that interferes with clear vision and ability to recognize signals of transport operators should be eliminated.

NOTE Interference can be caused by:

- *disability glare from luminaires or installations;*
- *variations in contrast and reflected light; and*
- *road or street lighting of the same colour as railway signals during warm-up or normal operation.*

Luminaires should be carefully selected and sited to prevent confusion of visual information.
If screening of a light source is necessary, this should be achieved by choice of luminaire. If external baffles/screens are necessary, they should be designed to be compatible with the luminaire in terms of fixings and performance.

7.8.2 Lighting in the vicinity of aerodromes

NOTE 1 The Civil Aviation Act 1982 [50], Section 105 defines an aerodrome as any area of land or water designed, equipped, set apart or commonly used for affording facilities for the landing and departure of aircraft and includes any area or space, whether on the ground, on the roof of a building or elsewhere, which is designed, equipped, and set apart for affording facilities for the landing and departure of aircraft capable of descending or climbing vertically.

NOTE 2 Attention is drawn to the Air Navigation Order 2016 [51], Article 224 in respect of lights liable to endanger aircraft. A light can endanger aircraft when:

- *the intensity causes glare in the direction of an approaching aircraft;*
- *the colour (e.g. advertising signs) causes it to be mistaken for an aeronautical light;*
- *if viewed from the air, lights make a pattern (e.g. a row of street lights) similar to an approach or runway lighting pattern; and*
- *the overall amount of illumination near the approach to a runway detracts from the effectiveness of the visual aids provided by the aerodrome for use by aircraft, particularly in poor visibility conditions.*

7.8.2.1 Design considerations

COMMENTARY ON ***7.8.2.1***

Road lighting can present a hazard due to the effect of lighting upon the pilot's visual picture within the flight paths around an aerodrome. For instance, where a road lies in the vicinity of an aerodrome that has approach lighting and the road has a similar alignment to the runway, the road lighting can present a pattern to the pilot that is similar to the runway lighting.

Where a light or lighting is deemed by the relevant authority to present a possible hazard to aircraft, measures are usually taken by the CAA to require the operator of the light(s) to remove the hazard. This can involve a reconfiguration of the pattern of lights, and/or their colour, intensity and visibility from an aircraft.

When designing road lighting in the vicinity of aerodromes, lighting designers should consult the relevant aerodrome operator and obtain safeguarding maps to assess whether the design will have special requirements (see **7.8.2.2**).

Lighting designers should address each of the following issues separately and prepare a lighting design which identifies the hazards and minimizes the residual risks.

a) Road lighting in the vicinity of aerodromes can present a hazard to pilots due to:

- the effect of lighting upon the pilot's visual picture (e.g. creating disability glare or confusing lighting arrays); or
- the creation of physical obstacles within the airspace manoeuvring area around the aerodrome.

b) A road lighting scheme could prejudice the safe movement of aircraft on either or both grounds.

Where an aerodrome has instrument landing systems (ILS), account should be taken of runway visual range (RVR) sensor equipment when designing lighting installations.

NOTE 1 Aerodromes with ILS need to determine RVR during operating hours.

NOTE 2 Further details regarding dangerous and confusing lights are contained in the Civil Aviation Authority publication CAP 168:2001, Chapter 6 [52]. Attention is particularly drawn to the areas described in Chapter 6, paragraph 1.3 of that document.

Road lighting in the vicinity of aerodromes should be designed in such a way as to eliminate interference with the pilot's visual picture and with RVR equipment.

On those roads that have been agreed with the aerodrome operator as having potential for causing such hazards, the luminaires used should conform to the installed intensity requirements of BS EN 13201-2:2015, class G*4, or a higher class.

NOTE 3 Attention is also drawn to the provisions regarding road lighting of the Air Navigation Order 2016 [51].

The Ministry of Defence should be consulted regarding lighting installations in the vicinity of a military site.

NOTE 4 Some military aerodromes undertake operations involving the use of night vision goggles. Therefore, in order to overcome potential risk of disturbance to pilot vision, any development near to these aerodromes might require additional design considerations to be taken into account.

7.8.2.2 Safeguarded obstacle limitation surfaces

*COMMENTARY ON **7.8.2.2***

The areas within which structures such as lighting columns and masts used for road lighting schemes can affect safe use of an aerodrome are called obstacle limitation surfaces (OLS). The OLS form a complex set of three-dimensional surfaces that extend upwards and outwards from the runway(s) of the associated aerodrome. The OLS completely encircle the aerodrome, but those surfaces protecting the landing or take-off flight paths can be more limiting than the rest. Generally, the extent of the OLS varies between 10 km and 15 km, according to the length of the runway(s). Full details of the OLS are contained in the Civil Aviation Authority publication CAP 168:2001, Chapter 4 [52].

At any aerodrome, the "approach", "take off climb" and "transitional" surfaces are most sensitive and should not be infringed. Safeguarding maps define safeguarded areas around aerodromes, and these maps should be obtained from the aerodrome operator. The local planning authority and/or the aerodrome operator should be consulted on any road lighting proposal within this area.

NOTE 1 If a planning application includes lighting, the planning authority will sometimes give advice and consult the aerodrome operator before the application is determined.

NOTE 2 The safeguarded area generally restricts the height of structures relative to the distance from and direction of the runway(s), using a series of zones, and can therefore restrict the height of lighting columns or masts.

7.8.3 Lighting in the vicinity of railways

NOTE 1 The area within which a road lighting scheme can affect the safe use of a railway is not defined because of the diversity of fixing locations for signals and curvature of railway lines.

Lighting close to the field of view of a train driver should be designed in such a way as to avoid compromising the visibility of signals. In particular, the following recommendations should be met.

a) Light spill should be minimized above the "limit of work" line of a railway bridge crossing/ passing above a road.

b) Columns should be placed as far away as practicable from a rail bridge or the fence line of railway track.

c) Unwanted glare should be minimized for the train driver by the use of luminaires conforming to an appropriate G* class selected from BS EN 13201-2:2015, Table A.1, or by shielding.

Where light might spill on to rail property, or luminaires might be mistaken for railway signals by train drivers, or lighting operatives risk falling on to rail property, then the rail authority should be contacted to determine the appropriate measures to be taken.

NOTE 2 Further information, related in particular to level crossings, can be found in Part 2, Section E of the HSE publication Railway safety principles and guidance [53].

Any lighting scheme should not affect track visibility for railway operatives. In addition, when planning the location of lighting columns adjacent to railways, the design should be such that any likely foreseeable collision with a lighting column by road traffic will not then lead to a hazard on the railway caused by the lighting column falling onto the railway.

Colours in a lighting scheme should not conflict or cause confusion with colours used for signal lights.

NOTE 3 Information on colours and colour classes is given in BS 1376.

7.8.4 Lighting in the vicinity of coastal waters

If a road lighting scheme is planned that could interfere with observation of navigation marks, buoys and ships' navigation lights, or could affect night vision of crew members, the relevant maritime authorities should be consulted.

NOTE At the time of publication of this edition of BS 5489-1, the relevant authorities are the Marine and Coastguard Agency and the General Lighthouse Authority.

7.8.5 Lighting in the vicinity of harbours

If a road lighting scheme is planned that could affect safe use of a harbour, the local harbour master should be consulted.

Lighting schemes near to and inside a harbour boundary should not interfere with observation of navigation marks, buoys or ships' navigation lights. Lighting should not affect night vision of mariners in the vicinity of a harbour.

NOTE The lighting for dock roads, terminals and other facilities is an application where the installation and maintenance benefits of high masts can provide an alternative solution.

7.8.6 Lighting in the vicinity of navigable inland waterways

If a road lighting scheme is planned adjacent to navigable inland waterways, the relevant national authorities or local navigation authority should be consulted.

NOTE At the time of publication of this edition of BS 5489-1, the relevant authorities include the Environment Agency, the Canal and River Trust in England and Wales, and Scottish Canals in Scotland. Waterways Ireland is the responsible body in both Northern Ireland and the Republic.

Lighting schemes adjacent to navigable inland waterways should not interfere with observation of navigation lights, marks, buoys or signs.

Lighting should not affect night vision of crews on unlit waterways.

The distance, angle and intensity of lighting adjacent to inland waterways should take into account the need for safe navigation of vessels.

Annex A (informative) Selection of lighting classes

COMMENTARY ON ANNEX A

This annex provides guidance on the selection of lighting class for different lighting scenarios using the M, C and P series of lighting classes defined in BS EN 13201-2:2015. The scenarios covered are lighting for traffic routes, conflict areas, subsidiary roads including pedestrian areas, and city and town centres.

The concepts in this annex are derived from PD CEN/TR 13201-1:2014 and CIE 115:2010 [54], an internationally used standard. These concepts have been adapted for UK conditions and the particular applications described in this part of BS 5489-1.

An important outcome of the selection process is to ensure that the area is neither overlit nor underlit. This is a difficult balance to achieve and it is therefore advised that the selection process is undertaken by a competent person. It is furthermore advised that a risk assessment is included along with consultation with relevant stakeholders.

Another important outcome is to achieve a consistent approach to the level of lighting provision within a locality, such that there are no sudden step changes in lighting class between different areas. If necessary, the lighting level may be adjusted to strike an appropriate balance between compatibility with existing lighting and compliance with policy.

The use of lighting classes as indicated in this annex is based on a light source with a colour rendering index $R_a \geq 20$.

A.1 General

A.1.1 Selection process

The selection process is as follows.

a) Select the lighting class from the relevant table (Table A.2 to Table A.6).

b) Carry out a risk assessment to identify specific lighting needs for the road, as defined in the relevant subclause below.

c) If necessary, adjust the lighting class up or down based on the assessed risks. The adjustment would normally not be more than one class up or down.

d) If choosing a P class (as defined in BS EN 13201-2:2015) and using a light source with $R_a < 60$ or S/P ratio < 1.0, increase the light level using the methodology in ILP PLG03 [39].

e) Assess the lighting requirements to judge whether different lighting classes are applicable at different times of the night due to changes in traffic flow or other parameters. If applicable, create a lighting profile for the scheme by varying the lighting level at different times during the night. Subclause **4.3.5** and ILP PLG08 [26] provide more guidance on this.

Table A.1 to Table A.6, giving information on the selection of lighting classes, make use of a number of primary criteria including traffic speed, traffic density, traffic composition, task complexity and ambient luminance. In addition, the risk assessment might highlight the need to take into account other criteria specific to the road or area under consideration.

Where an area is used by more than one user group, the visual needs of each have to be taken into account.

A.1.2 Risk assessment

A benefit of undertaking a risk assessment for each road is that the local specific conditions, local custom and practice and topography are taken into account.

With this approach, the onus is placed upon the competent person with good knowledge of local conditions and the site, to assess the specific risks associated with night-time activity and make an appropriate judgement on the lighting class.

A.1.3 Variable (or adaptive) lighting

The selection of lighting class needs to be based on the time period of highest traffic flow. There are likely to be times during the hours of darkness when the usage varies significantly from the peak or highest volume. In such cases it might be appropriate to vary the lighting class.

The benefits of variable lighting are dealt with in more detail in **4.3.5**.

Further guidance on the application of variable lighting is given in **4.3.5** and ILP PLG08 [26].

A.2 Comparability of lighting classes

Within an overall area to be lit there can be adjacent areas to which different parameters might apply, such as footways and cycle tracks adjacent to a carriageway within the boundaries of a road. In some situations, it might be appropriate to apply different lighting classes or concepts to such adjacent areas. Table A.1 shows lighting classes from BS EN 13201-2:2015 and indicates those of comparable level, whether using luminance or illuminance criteria. However, lighting classes of comparable levels are not intended to be used in place of the appropriate M, C or P class related to the road type. This is particularly relevant for the design of M class lighting as there are no comparable parameters for U_o and U_l.

Table A.1 — *Lighting classes of comparable level*

M class	C class	P class
—	C0	—
M1	C1	—
M2	C2	—
M3	C3	P1
M4	C4	P2
M5	C5	P3
M6	—	P4
—	—	P5
—	—	P6

NOTE The data in this table are extrapolated from PD CEN/TR 13201-1:2014.

A.3 Specific situations

A.3.1 Traffic routes

A.3.1.1 General

The lighting design of traffic routes is covered in **7.1** and is based upon the luminance concept. Traffic routes are defined as those roads where the predominant users of the road are motorized vehicles. The lighting class for traffic routes is the M class, which is detailed in BS EN 13201-2:2015. This series of classes is applicable for lengths of road which are predominantly straight. Curved roads are covered in **7.1.3**.

For the determination of an M lighting class to be applied to a given situation with a specific traffic composition, either Table A.2 or Table A.3 needs to be used. The appropriate lighting class is selected for the most onerous conditions encountered during the hours of darkness.

A.3.1.2 Selection of lighting class M

Table A.2 and Table A.3 assume the following conditions:

- ambient luminance: moderate;
- visual guidance: good;
- parked vehicles: not present.

If the conditions differ from these, then the lighting class might be varied following a risk assessment as detailed in **A.3.1.3**.

Table A.2 gives lighting classes for motorways and traffic routes in terms of the lighting classes in BS EN 13201-2:2015, Table 1, to be used for the following situations:

- motorways: $v \geq 60$ mph; users: motorized traffic only;
- traffic route: speed $40 < v < 60$ mph; users: motorized traffic, slow-moving vehicles, cyclists and pedestrians.

Table A.2 — *Lighting classes for traffic routes (v > 40 mph)*

Traffic flow	Lighting class		
	Dual carriageway		Single carriageway
	Junction density: high	Junction density: low	
High to very high[A)]	M2	M3	M2
Low to moderate[B)]	M3	M4	M3
Very low[C)]	M4	M5	M4

NOTE 1 High junction density would be junction centres spaced < 3 km apart.

NOTE 2 Where a single carriageway has a high density of junctions, a risk assessment can determine whether some of the junctions constitute conflict areas (see ***A.3.2****).*

NOTE 3 Grey highlighting indicates situations that would not usually occur in the UK.

[A)] High to very high traffic flow might be defined as either having an average daily traffic (ADT) > 40 000, or where the flow exceeds 65% of the lane maximum capacity for dual or multi-lane carriageways or 45% for single carriageways.

[B)] Low to moderate traffic flow might be defined as either having an ADT of between 7 000 and 40 000, or where the flow is between 35% and 65% for dual or multi-lane carriageways or between 15% and 45% for single carriageways.

[C)] Very low traffic flow might be defined as either having an ADT of < 7 000, or where the flow is < 35% for dual or multi-lane carriageways or < 15% for single carriageways.

Table A.3 gives lighting classes for traffic routes in terms of the lighting classes in BS EN 13201-2:2015, Table 1, to be used for the following situations:

- speed: $v \leq 40$ mph;
- users: motorized traffic, slow-moving vehicles, cyclists and pedestrians.

Table A.3 — *Lighting classes for traffic routes (v ≤ 40 mph)*

Traffic flow	Lighting class		
	Dual carriageway		Single carriageway
	Junction density: high	Junction density: low	
High to very high[A)]	M3	M4	M3
Low to moderate[B)]	M4	M5	M4
Very low[C)]	M5	M6	M5

NOTE 1 High junction density would be junction centres spaced < 3 km apart. A risk assessment can determine whether some of the junctions constitute conflict areas (see ***A.3.2****).*

NOTE 2 Grey highlighting indicates situations that would not usually occur in the UK.

A) High to very high traffic flow might be defined as either having an ADT of > 40 000, or where the flow exceeds 65% of the lane maximum capacity for dual or multi-lane carriageways or 45% for single carriageways.

B) Low to moderate traffic flow might be defined as either having an ADT of between 7 000 and 40 000, or where the flow is between 35% and 65% for dual or multi-lane carriageways or between 15% and 45% for single carriageways.

C) Very low traffic flow might be defined as either having an ADT of < 7 000, or where the flow is < 35% for dual or multi-lane carriageways or < 15% for single carriageways.

A.3.1.3 Risk assessment

The designer needs to undertake a design risk assessment for the road which evaluates the risks associated with a number of parameters as detailed below. Additional lighting classes can be chosen if a variable lighting regime is to be used and if there is sufficient variation in traffic usage or other relevant parameters.

The relevant parameters are as follows.

- **Traffic composition**: where the traffic consists of a mixture of slow-moving vehicles, cyclists and pedestrians, it might be beneficial to increase the lighting level.
- **Parked vehicles, bus stops and pedestrian crossings**: where there are bus stops, frequent parked vehicles or pedestrian crossings, the driving task becomes more complex and a higher lighting level might be justified.

  NOTE 1 For urban roads, the Highways Agency Design manual for roads and bridges, Volume 5, Section 1, Part 3 (TA 79/99) [55] lists factors affecting road traffic capacity.

- **Ambient luminance or environmental zone**: Table A.2 and Table A.3 assume a moderate ambient luminance. If the ambient luminance is high or very high, a higher lighting class might be justified; conversely if the ambient luminance is low or very low then a lower lighting level might be justified.

  NOTE 2 Definitions of ambient luminance and indicative examples of environmental zones are given in ILP GN01 [N2], Table 1.

- **Visual guidance/traffic control**: Table A.2 and Table A.3 assume good visual guidance. If visual guidance is poor, then a higher lighting level might be justified.

Following the risk assessment, the designer needs to make a judgement on whether the lighting class may be adjusted by one class higher or lower.

A.3.1.4 White light (mesopic vision)

ILP PLG03 [39] provides details of the use of different light sources. The report concludes that for the visual tasks and lighting levels associated with lighting traffic routes, there is not sufficient evidence to specify the situations in which the trade-off between light level and S/P ratio can be safely applied.

A.3.1.5 Variable lighting

The lighting requirements are assessed to judge whether different lighting classes are applicable at different times of the night or year due to changes in traffic flow or other parameters. If applicable, a lighting profile is created for the scheme by varying the lighting level at different times during the night or year. Subclause **4.3.5** and ILP PLG08 [26] provide more guidance on this.

A.3.2 Conflict areas

The C lighting classes are intended for motorists on conflict areas within traffic routes as defined in **7.5**.

Table A.4 gives lighting classes for conflict areas on traffic routes, using the C lighting classes in BS EN 13201-2:2015, Table 2, related to the lighting class on the roads approaching the conflict area.

Where traffic routes having different lighting classes meet, the higher lighting class normally determines the class at the conflict area.

NOTE Further guidance on the selection of lighting class for conflict areas is given in ILP PLG02 [41].

Table A.4 — *Lighting classes for conflict areas*

Traffic route lighting class	Conflict area lighting class
M1	C0
M2	C1
M3	C2
M4	C3
M5	C4
M6	C5

A.3.3 Subsidiary roads including pedestrian areas, footpaths and cycle tracks

A.3.3.1 General

The parameters relevant for the selection of an appropriate P lighting class for a given pedestrian or low speed traffic area are summarized in Table A.5. The lighting classes P1 to P6 are defined by the lighting criteria given for each class in BS EN 13201-2:2015, Table 3. They are for subsidiary roads and are related to pedestrian and cyclist traffic flow, as the needs of such users normally have priority on such roads. They include footways, cycleways and other road areas lying separately or along the carriageway of a traffic route, and for residential roads, pedestrian streets and parking places.

Guidance on glare control is given in **5.3.2.4**.

Table A.5 — *Lighting classes for subsidiary roads*

Traffic flow	Lighting class		
	E1 to E4[A)]	E1 to E2[A)]	E3 to E4[A)]
	Pedestrian and cyclists only	Speed limit $v \le 30$ mph	Speed limit $v \le 30$ mph
Busy [B)]	P5	P4	P3
Normal [C)]	P5	P5	P4
Quiet [D)]	P6	P5	P4

NOTE 1 Table A.5 assumes no parked vehicles; see risk assessment in A.3.3.2.

NOTE 2 An EV lighting class using vertical illuminance, from BS EN 13201-2:2015, Table 6, can be specified in addition to the general lighting class when there are particular concerns about crime and personal safety. EV is calculated at the typical height of a human face (1.5 m) and in relevant viewing orientations.

NOTE 3 To ensure adequate uniformity, the actual value of the maintained average illuminance is not to exceed 1.5 times the value indicated for the class.

NOTE 4 The actual overall uniformity of illuminance, U_o, needs to be as high as reasonably practicable (see 7.2.6).

NOTE 5 The ambient luminance descriptions E1 to E4 refer to the environmental zone as defined in ILP GN01 [N2].

NOTE 6 The illuminance classes are suggested minimum levels. A risk assessment needs to be carried out to ensure that the light levels are adequate, particularly for pedestrians and cyclists.

A) Environmental zone, as given in ILP GN01 [N2].

B) Busy traffic flow refers to areas where the traffic usage is high and can be associated with local amenities such as clubs, shopping facilities, public houses, etc.

C) Normal traffic flow refers to areas where the traffic usage is of a level equivalent to a housing estate access road.

D) Quiet traffic flow refers to areas where the traffic usage is of a level equivalent to a residential road, and is mainly associated with the adjacent properties or properties on other equivalent roads accessed from this road.

A.3.3.2 Risk assessment

The designer needs to undertake a design risk assessment for the road which evaluates the risks associated with a number of parameters as detailed below. Additional lighting classes can be chosen if a variable lighting regime is to be used and if there is sufficient variation in traffic usage or other relevant parameters.

The relevant parameters are as follows.

- **Traffic composition**: where the traffic composition consists of a mixture of motorized traffic or cyclists and pedestrians, the potential for impact is higher than for non-mixed usage. In such cases the risk assessment could lead to an increase in lighting level conforming to a lower lighting class.
- **Complexity of task**: factors which increase the complexity of the visual task include parked cars, school entrances and traffic calming features. If one or more of these factors are present, the risk assessment could lead to an increase in lighting level conforming to a lower lighting class.
- **Risk of crime or need for recognition of other people or their intent**: where there is a need for better recognition, an additional illuminance class (EV) from BS EN 13201-2:2015, Table 6, might be chosen.

Following the risk assessment, the designer needs to make a judgement on whether the lighting may be adjusted by one class higher or lower.

A.3.3.3 Adjustment of lighting class due to the light source (mesopic vision)

In the 2013 edition of BS 5489-1, the benchmark light sources were assumed to be sodium-based with a low S/P ratio. In the 2020 edition, it is assumed that the benchmark light source is white light with an S/P ratio > 1 and a high R_a. The lighting class selection process and Table A.5 are based upon the light source having an S/P ratio ≥ 1.0. For any such source, the updated guidance is not to make an adjustment for S/P ratio.

If, however, the design incorporates a light source with an S/P ratio < 1.0, and a low R_a then it would be appropriate to design to a higher light level in order to achieve a comparable visual performance. In this case the designer may make adjustments for the light source in accordance with ILP PLG03 [39] or simply raise the light levels to the next class.

CIE 191:2010 [56] provides a system for visual performance based mesopic photometry, and ILP PLG03 [39] provides details of the use of different light sources and S/P ratios.

A.3.3.4 Variable lighting

The lighting requirements are assessed to judge whether different lighting classes are applicable at different times of the night or year due to changes in traffic flow or other parameters. If applicable, a lighting profile is created for the scheme by varying the lighting class at different times during the night or year. Subclause **4.3.5** and ILP PLG08 [26] provide more guidance on this.

A.3.4 City and town centres

A.3.4.1 General

Table A.6 gives lighting classes for city and town centres having a combination of pedestrians, cyclists and/or motorized traffic, in terms of the P classes from BS EN 13201-2:2015, Table 3, or the C lighting classes in BS EN 13201-2:2015, Table 2.

To provide adequate control of glare, an installed luminous intensity class (G* class) from BS EN 13201-2:2015, Table A.1 would be appropriate. Alternatively, threshold increment (TI) can be calculated. Further guidance is given in **5.1.5**.

To provide adequate illuminance on vertical surfaces, an additional vertical illuminance lighting class may be chosen. Further guidance is given in **5.3.2.3**.

NOTE 1 For roads within city and town centres that carry primarily vehicular traffic, refer to Table A.2.

NOTE 2 In some areas of town centres, it might be more appropriate to light an area using a P class rather than a C class. An example is where the area is a thoroughfare from one area to another area.

Table A.6 — *Lighting classes for city and town centres*

Type of traffic	**Lighting class**			
	Normal traffic flow		**High traffic flow**	
	E3[A)]	**E4[A)]**	**E3[A)]**	**E4[A)]**
Pedestrian thoroughfare	P2	P1	P2	P1
Pedestrian only	C4	C3	C3	C2
Mixed vehicle and pedestrian with separate footways	C3	C2	C2	C1
Mixed vehicle and pedestrian on same surface	C2	C1	C1	C1

A) Environmental zone, as given in ILP GN01 [N2].

A.3.4.2 Risk assessment

The selection of lighting class for a specific city or town centre road type may be varied up or down from the classes indicated in Table A.6, taking account of:

- vehicular traffic use;
- pedestrian and cyclist use;
- slow moving vehicles including mobility scooters;
- on-street parking;
- amenities such as shops, public houses etc.;
- level of crime;
- CCTV requirements; and
- competition from shop front and other off-road lighting.

A.3.4.3 Variable lighting

The lighting requirements are assessed to judge whether different lighting classes are applicable at different times of the night or year due to changes in traffic flow or other parameters. If applicable, a lighting profile is created for the scheme by varying the lighting class at different times during the night or year. Subclause **4.3.5** and ILP PLG08 [26] provide more guidance on this.

Annex B (informative) Sustainability

COMMENTARY ON ANNEX B

To achieve a sustainable lighting solution requires appreciation of the overall impact of the scheme over its lifetime.

This annex gives guidance on how to achieve a sustainable lighting solution.

The EU Green Public Procurement (GPP) publication on street lighting [25] gives general principles for street lighting. These include good design supported by consideration of a whole life costing approach combined with energy-efficient equipment under EC Regulation No. 245/2009 [38] and circular economy compliant luminaires.

A scheme lifecycle consists of several stages that might include:

- policy: where and when to light and to what level;
- design: how the area will be lit;
- installation and commissioning: all work on site prior to operation, including confirmation that the installed scheme is in accordance with the design and programming of controls;
- operation: the lifetime between installation and decommissioning;
- maintenance: planned and unplanned activities to ensure that the scheme continues to function as designed; and
- decommissioning: the removal and disposal of some or all of the lighting infrastructure from the site at the end of life.

The following factors need to be taken into account for each stage of the scheme lifecycle.

- **Economical sustainability:** ensuring that the lighting scheme is cost-effective over its anticipated lifetime. Some factors to be considered are capital costs, electrical energy costs, maintenance costs, operational costs, decommissioning costs and safety costs.
- **Environmental sustainability:** ensuring that the scheme does not adversely affect the environment over its anticipated lifecycle. Some factors to be considered are habitat destruction, material usage and toxicity, lifecycle energy (manufacture, operation and waste disposal), obtrusive light, CO_2 emissions, and materials disposal and reuse.
- **Social sustainability:** ensuring that the scheme improves social sustainability over its anticipated lifetime. Some factors to be considered are visual impact, CCTV installations, road user safety and workforce safety, fear and perception of crime, and economical considerations.

The lifecycle stages and their associated sustainability criteria are outlined in Table B.1.

Table B.1 — *Lifecycle stages and associated sustainability criteria*

Lifecycle stage	Sustainability criteria		
	Economical	**Environmental**	**Social**
Policy	Check that the benefits will outweigh the costs; the scheme has to be affordable over its entire lifecycle Ensure the efficient use of electrical energy; light at the right level, at the right place at the right time incorporating the right control systems Utilize BS EN 13201-5 energy performance indicators Promote the use of circular economy products	Minimize environmental impact; factors include sky-glow, obtrusive light and effects on wildlife Undertake a light impact assessment in accordance with PLG 04 [18]	Optimize the visual impact by day and night Consider the benefit of lighting as an amenity
Design	Ensure that intended benefits will be realized through understanding the task to be lit and its requirements Optimize costs of construction, operation, maintenance and electrical energy Optimize function of lighting controls Consider need for vandal resistance	Consider both positive (e.g. road user safety) and negative (e.g. CO_2 emissions) environmental effect Minimize sky-glow, obtrusive light and effects on wildlife Optimize use, quantity and type of construction materials to minimize environmental impact	Consider the benefits including safety (actual and perceived) and commercial (e.g. increased footfall) Minimize potential adverse effects (e.g. poor access for maintenance)
Installation and commissioning	Optimize material costs Optimize installation costs Commission lighting controls to function as designed	Minimize impact of temporary equipment, plant and machinery Dispose of packaging safely and correctly (reuse and recycle)	Minimize adverse effects on nearby residents Consider the safety of road users and the workforce
Operation	Ensure that lighting equipment and controls operate as designed Select optimum electrical energy tariffs	Consider adaptive lighting and/or trimming to minimize obtrusive light and CO_2 emissions Ensure that environmental targets are achieved Consider green energy tariffs	Ensure that the amenity benefits identified at the policy stage are realized

Table B.1 *(continued)*

Lifecycle stage	Sustainability criteria		
	Economical	**Environmental**	**Social**
Maintenance	Adhere to the maintenance policy established at the design stage	Reuse, repair or recycle replaced components	Minimize adverse effects on nearby residents and on road users
	Review the maintenance policy to take account of changing circumstances (e.g. technology and legislation)	Use energy-saving and circular economy components wherever possible	Consider the safety of road users and the workforce
Decommissioning and disposal	Consider reuse or repair of equipment	Disassemble, recycle and dispose of unwanted equipment and materials in accordance with best practice and legislation	Minimize adverse effects on all road users and on nearby residents

Annex C (informative) Typical luminaire maintenance factors

Table C.1 shows typical luminaire maintenance factors, which may be used in design calculations. It takes into account environmental zone, mounting height and cleaning interval.

NOTE 1 Table C.1 is only valid for luminaires with a minimum IP rating of IP65.

NOTE 2 Table C.1 is derived from Review of luminaire maintenance factors [57] with interpolated values extending to 72 months and an upper limit included of 0.96.

NOTE 3 Values may otherwise be obtained from site measurement or other researched data.

Table C.1 — *Luminaire maintenance factors*

Environmental zone	**Mounting height**	**Maintenance factor**					
		Cleaning frequency					
		12 months	**24 months**	**36 months**	**48 months**	**60 months**	**72 months**
E1/E2	≤ 6 m	0.96	0.96	0.95	0.94	0.93	0.92
E1/E2	> 6 m	0.96	0.96	0.95	0.94	0.93	0.92
E3/E4	≤ 6 m	0.94	0.92	0.90	0.88	0.86	0.84
E3/E4	> 6 m	0.96	0.96	0.95	0.94	0.93	0.92

NOTE 1 This table is not valid if cleaning is not undertaken within the maximum 6 year scope of the table.

NOTE 2 Each site experiences different levels of pollution, so it is advisable to assess local conditions through measurement in accordance with ILP document TR28 [47].

*NOTE 3 The relevant value from this table is combined with the luminous flux factor to provide a combined maintenance factor (see **5.1.6**).*

Annex D (informative) Calculating maintenance factors: design examples with CLO and non-CLO luminaires

D.1 Example 1: Non-CLO public lighting traffic route – M class

Project information is as follows:

- installation lifetime: 100 000 h;
- burning hours per year: 4 100 h;
- repair strategy: spot replacement;
- luminaire cleaning interval: 6 years;
- mounting height: 10 m;
- environmental zone: E3/E4.

Luminaire information is as follows:

- luminaire type: LED luminaire with integrated driver;
- luminous flux: 12 000 lm;
- median useful life, L_{90}: 100 000 h;
- luminaire flux: 12 000 lm;
- IP class: IP66;
- driver failure rate: 0.5% per 5 000 h.

The calculation is carried out as follows.

a) **Luminous flux factor**: Installation lifetime is equal to the given median useful life at L_{90}. As such, the luminous flux factor f_{LF} = 0.90.

b) **Survival factor**: Project employs a spot replacement strategy. As such, the mentioned failure rate is not relevant, and the survival factor f_S = 1.00.

c) **Luminaire maintenance factor**: Based on Table C.1, an E3/E4 environmental zone and a 10 m mounting height with an IP66 luminaire, with a 6 year cleaning cycle, results in a luminaire maintenance factor f_{LM} = 0.92.

This results in maintenance factor f_m = 0.90 × 1.00 × 0.92 = 0.828 (rounded to 0.83)

D.2 Example 2: CLO public lighting residential street – P class

Project information is as follows:

- installation lifetime: 100 000 h;
- burning hours per year: 4 100 h;
- repair strategy: spot replacement;
- luminaire cleaning interval: 6 years;
- mounting height: 6 m;

- environmental zone: E3/E4.

Luminaire information is as follows:

- luminaire type: LED luminaire with integrated CLO driver;
- luminous flux: 6 000 lm;
- median useful life, L_{90}: 100 000 h using CLO based on L_{90};
- luminaire flux given as both non-CLO luminous flux (case A) 6 000 lm and CLO luminous flux (case B) 5 400 lm (90%);
- IP Class: IP66;
- driver failure rate: 0.5 % per 5 000 h.

The calculation is carried out as follows.

a) **Luminous flux factor**: Installation lifetime is equal to the given median useful lifetime at L_{80}. However, as this is a CLO luminaire, this warrants further investigation. Depending on how the luminaire is specified, there are two options.

   1) Luminous flux is specified as if no CLO is used. This means that the luminous flux depreciation needs to be taken into account in the maintenance factor. As such, the installation lifetime is similar to the given median useful life at L_{90}, and the luminous flux factor (f_{LF}) = 0.90.

   2) Flux is specified with the CLO correction already applied. As such, depreciation is already accounted for in the luminaire and is not taken into account in the maintenance factor, and the luminous flux factor (f_{LF}) = 1.00.

b) **Survival factor**: Project employs a spot replacement strategy. As such driver failure rate is not relevant, survival factor (f_S) = 1.00.

c) **Luminaire maintenance factor**: Based on Table C.1, an E3/E4 environmental zone and a 6 m mounting height with an IP66 luminaire, with a 6 year cleaning cycle, results in a luminaire maintenance factor (f_{LM}) = 0.84.

This results in:

- Case A maintenance factor f_m = 0.90 × 1.00 × 0.84 = 0.756 (rounded to 0.76)
- Case B maintenance factor f_m = 1.00 × 1.00 × 0.84 = 0.84

Both case A and case B are expected to result in the same light level. To illustrate this, the effect can be observed when applying the maintenance factor as if it were a correction on the luminous flux.

- Case A: luminaire/photometry with initial output: 6 000 lm × 0.756 = 4 536 lm;
- Case B: luminaire/photometry is reduced for CLO: 5 400 lm × 0.84 = 4 536 lm.

In the case of CLO luminaires, the power increases over time as set in the driver to ensure that the flux stays constant. This is not a part of the maintenance factor determination but does warrant attention during the lighting and installation design.

The manufacturer/supplier needs to state which of the two approved methodologies has been utilized, in order to avoid potential misrepresentation of data.

Annex E (informative) Outline of lighting design process for all-purpose traffic routes

E.1 General

The lighting design process for all-purpose traffic routes consists of the following six main stages:

a) definitions of the areas to be lit;

b) selection of lighting class(es) and definition of relevant area(s) (see E.2);

c) gathering of preliminary data (see E.3);

d) calculation of design spacings for straight roads (see E.4);

e) plotting of luminaire positions (see E.5);

f) determination of lighting column positions (see E.6).

E.2 Selection of lighting class and definition of relevant area

E.2.1 Carriageway

The lighting class for the carriageway is selected from BS EN 13201-2:2015, Table 1.

If additional light control is required to further limit glare, or for environmental reasons, an installed intensity class is selected from BS EN 13201-2:2015, Table A.1.

E.2.2 Adjacent areas

The lighting of any areas adjacent to the carriageway, such as footways, cycle tracks and verges, is required to meet quality criteria using one of the following approaches.

a) Apply an appropriate illuminance class to the surrounding areas, defining the extent of such areas.

b) Apply R_{EI} to the adjacent strip, defining the width of the strip.

NOTE In most situations, the carriageway lighting can be used to light adjacent areas, whichever approach is taken, subject to confirmation that the requirements of the selected lighting class will be met.

E.2.3 Conflict areas

Any conflict areas are identified, and a decision made to use one of the following approaches.

a) Apply the luminance or illuminance class of the main route passing through the area.

b) Apply an appropriate illuminance class.

If option b) is taken, the relevant area for each conflict area is determined, a lighting class selected from BS EN 13201-2:2015, Table 2, and an installed intensity class selected from BS EN 13201-2:2015, Table A.1.

NOTE Environmental considerations can also influence the choice of installed intensity class.

E.2.4 Pedestrian crossings

Any pedestrian crossings are identified, and a decision made to light them using one of the following approaches.

a) Use the normal road lighting.

b) Use separate local lighting, with the criteria of horizontal or vertical illuminance.

c) Incorporate in the lighting design of an adjacent conflict area.

If option a) is taken, the lighting class is either the carriageway luminance class, or a higher class from the same table.

If option b) is taken, a lighting class is selected from BS EN 13201-2:2015, Table 2, for horizontal illuminance, or from BS EN 13201-2:2015, Table 6, for vertical illuminance.

NOTE Further guidance on lighting of pedestrian crossings is given in ILP TR12 [48].

E.2.5 Choice of lighting arrangement

The choice of lighting arrangement is normally made from those described in **6.3.3**. Separate consideration is given to main carriageway and slip or link roads.

NOTE The choice of lighting arrangement is influenced by a mixture of technical, operational, economical and environmental factors. In arriving at the choice, it might be necessary to carry out preliminary design calculations for a number of possible arrangements.

E.3 Preliminary data

E.3.1 Carriageway

Having selected the appropriate lighting class(es), and installed intensity class where necessary, the following preliminary data are ascertained before carriageway lighting design calculations are commenced:

a) mounting height (H);

b) luminaire type and optic setting (and installed intensity class where necessary);

c) light source type;

d) initial luminous flux of light source or light sources in luminaire (Φ);

e) IP rating of luminaire light source housing;

f) cleaning interval planned for luminaires;

g) pollution category at location;

h) luminaire maintenance factor (from Table C.1);

i) light source replacement interval;

j) light source luminous flux factor (f_{LF}) at replacement interval;

k) maintenance factor (f_M);

l) luminaire tilt in application (θ_f);

m) width of relevant area of carriageway (W_r);

n) width of driving lane (W_L);

o) width of areas to be lit adjacent to the carriageway; either width of strip for edge illuminance ratio (R_{EI}), or width of a separate relevant area (W_r) if a separate lighting class is applied;

p) luminaire transverse position relative to the calculation grid;

q) luminaire arrangement; and

r) road surface *r*-table.

E.3.2 Conflict areas

Conflict area calculations generally need similar preliminary data to that listed in **E.3.1**, but there are some differences.

a) The relevant area is likely to be an irregular shape.

b) The relevant area might include areas adjacent to the carriageway.

c) Individual luminaire angles in azimuth relative to the alignment of the calculation grid are needed.

d) The *r*-table is not relevant where illuminance is the criterion.

E.3.3 Pedestrian crossings

Where the normal road lighting is used to light the crossing, the information listed in **E.3.1** is sufficient.

Where local lighting is to be used, similar information is needed, related to the light sources and luminaires to be used and to the particular geometry of the crossing. The relevant areas for calculation are the crossing and a defined area of footway. As illuminance is the criterion, the *r*-table is not relevant.

NOTE Further guidance on pedestrian crossings is given in ILP TR12 [48].

E.4 Calculation of design spacing for straight roads

The procedure set out in BS EN 13201-3 is used to calculate the design spacing for straight roads, with the aim of achieving all the photometric requirements of the selected luminance class from BS EN 13201-2:2015. It is normally necessary to carry out an iterative process for a range of mounting heights, spacings, arrangements, luminaires, settings of optical control system in the luminaire and light source luminous fluxes, comparing the results with the photometric requirements until the optimum solution is reached.

The optimum solution normally takes account of capital cost, operating cost, electrical energy consumption, and environmental and aesthetic issues in addition to the technical issue of meeting the photometric performance requirements.

E.5 Plotting of luminaire positions

Plotting is carried out as follows.

a) The luminaire positions at conflict areas are plotted, following the principles set out in **7.5**. Once the draft layout is established, an area lighting calculation is carried out to verify that the design is in accordance with the requirements of the selected lighting class from BS EN 13201-2:2015. The layout, mounting height, luminaires/optic settings and light source luminous flux are modified as necessary to ensure conformity.

NOTE Where a separate lighting class has been selected for adjacent areas to a conflict area, separate calculations are necessary for those areas.

b) Where pedestrian crossings exist and are to be lit using the normal road lighting, the luminaire positions are plotted.

c) The luminaire positions on bends are plotted, using the procedure set out in 7.1.3.

d) Where the lighting column positions are dictated by the location of over-bridges or under-bridges, the resulting lighting column positions are plotted.

e) The layout of uninterrupted straight sections is fitted into that of the conflict areas, pedestrian crossings and bends. There is likely to be a need for compromise at the interfaces, but without exceeding the straight road design spacing.

E.6 Determination of lighting column positions

Luminaire positions are ultimately determined by the positions of lighting columns or other support systems (see 6.2). Individual lighting column positions are checked on site for existing roads, or against the road design for new roads, to verify that they are feasible, and for aesthetic acceptability.

The major issues that are encountered at this stage include:

a) overhead power lines or other obstruction;

b) underground power lines or other utility services;

c) trees, including potential growth and accounting for summer foliage;

d) dropped kerbs;

e) minimizing obtrusive light;

f) locations on property boundaries and away from windows; and

g) avoiding locations where lighting columns could be struck by a vehicle.

NOTE Minor adjustments might be necessary for practical or aesthetic reasons, with care taken to ensure that these do not significantly affect the photometric performance of the installation.

Annex F (informative) Outline of lighting design process for subsidiary roads and associated areas

F.1 General

The lighting design process for subsidiary roads and associated areas consists of the following five main stages:

a) selection of lighting class(es) and definition of relevant area(s) (see F.2);

b) gathering of preliminary data (see F.3);

c) calculation of design spacing (see F.4);

d) plotting of luminaire positions (see F.5);

e) determination of lighting column positions (see F.6).

F.2 Selection of lighting class(es) and definition of relevant area

Guidance on the selection of lighting class is given in Annex A. The class chosen might vary at different times due to different conditions such as (pedestrian) traffic flow.

The lighting class is normally selected from BS EN 13201-2:2015, Table 3, which specifies average and minimum illuminance. A different class may be selected for areas of traffic calming measures, as indicated in Annex A.

Where an additional lighting class is required using vertical illuminance and uniformity, this is selected from BS EN 13201-2:2015, Table 6.

In order to limit glare, a luminous intensity class is selected from BS EN 13201-2:2015, Table A.1.

When determining the relevant area for the application of lighting classes and calculation, the following factors are taken into account.

a) If a road has a carriageway with adjacent footway, cycle track or verges, the relevant area is the whole width of the road, from boundary to boundary.

b) If a road is a shared surface residential road, or a shared space where there is no priority to motorized traffic over pedestrians and cyclists, which might also have an adopted service strip, the relevant area is the shared surface only.

c) For a separate footpath or cycle track, the relevant area is the specific area on the carriageway defined by road markings. In addition, it includes the area defined by continuing the lines of the carriageway markings across the whole width of the footway, or to a distance equal to the width of the specific area, whichever is the smaller. The relevant area may be extended beyond the actual width of the path or track.

d) Where there are traffic calming measures, the relevant area is the locality of the particular measures, and the boundary is determined between this area and the approach road. Where there is a significant distance between particular traffic calming measures on a road, each may be regarded as a separate relevant area. In this case the area is only the immediate vicinity of the particular measure. Where particular measures are close to each other, the measures and the road between may be regarded as one relevant area to which the same lighting class is applied.

F.3 Preliminary data

Having selected the appropriate lighting class(es), and installed intensity class where necessary, the following preliminary data are ascertained before carriageway lighting design calculations are commenced:

a) mounting height (H);

b) luminaire type and optic setting;

c) light source type;

d) initial luminous flux of light source or light sources in luminaire (Φ);

e) IP rating of luminaire light source housing;

f) cleaning interval planned for luminaires;

g) pollution category at location;

h) luminaire maintenance factor (from Table C.1);

i) light source replacement interval;

j) light source luminous flux factor (f_{LF}) or at replacement interval;

k) maintenance factor (f_M);

l) luminaire tilt in application (θ_f);

m) width of relevant area (W_r);

n) luminaire transverse position relative to the calculation grid;

o) luminaire arrangement; and

p) luminaire intensity class of luminaire.

F.4 Calculation of design spacing

The procedure set out in BS EN 13201-3 is used to calculate the design spacing for subsidiary roads, with the aim of achieving all the photometric requirements of the selected illuminance class. Where the relevant area is a nominally straight road, footpath or cycle track, the field of calculation given in BS EN 13201-3 is used, with a regular array of luminaires. Where the relevant area is irregular, or includes severe bends, the advice given in BS EN 13201-3 is followed. In this case a trial layout is plotted to establish individual luminaire angles in azimuth relative to the calculation grid, before carrying out the calculation.

It is sometimes necessary to carry out an iterative process for a range of mounting heights, spacings, arrangements, luminaires/optic settings and light source luminous fluxes, comparing the results with the photometric requirements until the optimum solution is reached.

The optimum solution normally takes account of capital cost, operating cost, electrical energy consumption, and environmental and aesthetic issues in addition to the technical issue of meeting the photometric performance requirements.

F.5 Plotting of luminaire positions

Plotting is carried out as follows.

a) The luminaire positions at T-junctions are plotted.

b) Where traffic-calming measures exist, the relevant luminaire positions are plotted.

c) The luminaire positions for any irregular areas or severe bends are plotted.

d) The layout of uninterrupted nominally straight sections is fitted into that of junctions, traffic calming measures and irregular areas. There is likely to be a need for compromise at the interfaces, but without exceeding the straight road design spacing.

F.6 Determination of lighting column positions

Luminaire positions are ultimately determined by the positions of lighting columns or other support systems. Individual lighting column positions are checked on site for existing roads, or against the road design for new roads, to verify that they are feasible, and for aesthetic acceptability.

The major issues that are encountered at this stage include:

a) overhead power lines or other obstruction;

b) underground power lines or other utility services;

c) trees, including potential growth and accounting for summer foliage;

d) dropped kerbs;

e) minimizing obtrusive light;

f) locations on property boundaries and away from windows; and

g) avoiding locations where lighting columns could be struck by a vehicle.

NOTE Particularly on residential roads, minor adjustments might be necessary for practical or aesthetic reasons, and to avoid inconvenience to the occupiers of adjacent buildings, with care taken to ensure that these do not significantly affect the photometric performance of the installation.

Annex G (informative) Outline of lighting design process for lighting urban centres and public amenity areas

G.1 General

The lighting design process for urban centres and public amenity areas consists of the following five main stages:

a) gathering of preliminary data (see **G.2**);

b) determining of the lighting needs and how best they can be met (see **G.3**);

c) choice of appropriate equipment, desirable mounting height(s), and possible methods of support best suited to the area concerned (see **G.4**);

d) calculation of the design geometry which ensures conformity to the requirements of the selected lighting class(es) (see **G.5**);

e) plotting of luminaire positions, taking into account both the individual features of the area and its future maintenance (see **G.6**).

G.2 Preliminary data

The following preliminary data are ascertained before lighting design calculations are commenced:

a) type of area:

   1) city or town centre;

   2) suburban shopping street;

   3) village centre;

b) size of area;

c) average building height;

d) shape of area;

e) traffic category:

   1) primarily vehicular;

   2) mixed vehicular and pedestrian;

   3) wholly pedestrian;

f) architectural style:

g) special aspects:

    1) community needs;

    2) conservation area;

    3) other;

h) pollution category at location;

i) access for maintenance;

j) preferred location for luminaires; and

k) planning and/or listed building consent required.

G.3 Determination of lighting needs

The following items are assessed before determining the lighting needs and how best to meet them:

a) traffic category;

b) selected lighting class(es) for the area, normally selected from BS EN 13201-2:2015;

c) photometric data for the light source/luminaire:

    1) colour appearance;

    2) colour rendering;

    3) restraints on light distribution, normally applying an appropriate installed luminous intensity class from BS EN 13201-2:2015; and

    4) cleaning interval.

G.4 Choice of equipment and installation

The choice of appropriate equipment, desired mounting height(s) and the possible methods of support best suited to the area concerned is determined, taking into account the following criteria:

a) desired mounting height;

b) luminaire type:

    1) road lighting luminaire;

    2) floodlight;

    3) other;

c) light source type:

d) luminaire style:

    1) contemporary;

    2) period;

    3) other;

e) lighting column or wall bracket style:

    1) contemporary;

    2) period;

    3) other;

f) IP rating of luminaires; and

g) whether planning and/or listed building consent is required.

G.5 Calculation of design geometry

The procedures set out in BS EN 13201-2:2015 are used to calculate the design geometry, with the aim of achieving all the photometric requirements of the selected lighting class(es). For primarily vehicular traffic the calculation is of luminance, but for mixed areas and pedestrian areas the calculation is normally of horizontal illuminance.

Where the relevant area for illuminance is a nominally straight road, and the array of luminaires is to be regular, the field of calculation given in BS EN 13201-3 is used. Where the relevant area is irregular, or the array of luminaires is to be irregular, the advice given in BS EN 13201-3 is followed. In this case, it is necessary to plot a trial layout and establish individual luminaire angles in the vertical, and in azimuth relative to the calculation grid, before carrying out the calculation.

G.6 Plotting of luminaire positions

At this stage the details are finalized to ascertain whether the luminaire positions are physically achievable and aesthetically acceptable. If they are not, it is necessary to re-examine and repeat the whole design procedure thus far.

The major issues that are encountered at this stage include:

a) overhead power lines or other obstruction;

b) underground power lines or other utility services;

c) trees, including potential growth and accounting for summer foliage;

d) dropped kerbs;

e) minimizing obtrusive light;

f) locations on property boundaries and away from windows; and

g) avoiding locations where lighting columns could be struck by a vehicle.

Bibliography

Standards publications

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 1376, *Specification for colours of light signals*

BS 5489-2, *Code of practice for the design of road lighting – Part 2: Lighting of tunnels*

BS 5837, *Trees in relation to design, demolition and construction – Recommendations*

BS EN 60529, *Degrees of protection provided by enclosures (IP code)*

BS ISO 37100, *Sustainable cities and communities – Vocabulary*

BS ISO 37105, *Sustainable cities and communities – Descriptive framework for cities and communities*

BS ISO 37106, *Sustainable cities and communities – Guidance on establishing smart city operating models for sustainable communities*

BS ISO 37122:2019, *Sustainable cities and communities – Indicators for smart cities*

PD CEN/TR 13201-1:2014, *Road lighting – Part 1: Guidelines on selection of lighting classes*

PD ISO/CIE TS 22012:2019, *Light and lighting – Maintenance factor determination – Way of working*

Other publications

[1] GREAT BRITAIN. Highways Act 1980. London: The Stationery Office.

[2] GREAT BRITAIN. Parish Councils Act 1957. London: The Stationery Office.

[3] GREAT BRITAIN. Local Government Act 1996, Section 29. London: The Stationery Office.

[4] GREAT BRITAIN. Roads (Northern Ireland) Order 1993, Article 44. London: The Stationery Office.

[5] GREAT BRITAIN. Roads (Scotland) Act 1984, Section 35. London: The Stationery Office.

[6] GREAT BRITAIN. Traffic Signs Regulations and General Directions 2002. London: The Stationery Office.

[7] GREAT BRITAIN. Traffic Signs Regulations (Northern Ireland) 1997. London: The Stationery Office.

[8] GREAT BRITAIN. Road Traffic Regulation Act 1984. London: The Stationery Office.

[9] GREAT BRITAIN. Road Traffic Regulation (Northern Ireland) Order 1997. London: The Stationery Office.

[10] GREAT BRITAIN. Highways (Road Hump) Regulations 1999. London: The Stationery Office.

[11] GREAT BRITAIN. Road Hump Regulations (Northern Ireland) 1999. London: The Stationery Office.

[12] GREAT BRITAIN. Road Hump (Scotland) Regulations 1998. London: The Stationery Office.

[13] GREAT BRITAIN. Roads (Northern Ireland) Order 1993, Article 113. London: The Stationery Office.

[14] GREAT BRITAIN. Roads (Scotland) Act 1984. London: The Stationery Office.

[15] GREAT BRITAIN. Construction (Design and Management) Regulations 2015. London: The Stationery Office.

[16] INSTITUTION OF LIGHTING PROFESSIONALS. *Lighting for traffic calming features*. Technical Report TR25. Rugby, Institution of Lighting Professionals, 2009.[4)]

[17] THE HIGHWAYS AGENCY, THE SCOTTISH OFFICE DEVELOPMENT DEPARTMENT, THE WELSH OFFICE and THE DEPARTMENT OF THE ENVIRONMENT FOR NORTHERN IRELAND. *Design manual for roads and bridges – Road lighting design*. TD501. London: Department for Transport (in preparation).

[18] INSTITUTION OF LIGHTING PROFESSIONALS. *Guidance on visual impact assessments*. PLG04. Rugby: Institution of Lighting Professionals.[5)]

[19] BAT CONSERVATION TRUST/INSTITUTION OF LIGHTING PROFESSIONALS. *Bats and artificial lighting in the UK*. Guidance Note GN08. Rugby: Institution of Lighting Professionals, 2018.[5)]

[20] DEFRA. “MAGIC” website (magic.defra.gov.uk/magicmap.aspx).

[21] CAYREL, R., SMITH, F.G., FISHER, A.J. and DE BOER, J.B. *Guidelines for minimising urban sky glow near astronomical observatories.* CIE 01-1980. Vienna: Commission Internationale de l’Éclairage/International Astronomical Union, 1980.[6)]

[22] COMMISSION INTERNATIONALE DE L’ÉCLAIRAGE. *Guideline for minimising sky glow.* CIE 126-1997. Vienna: Commission Internationale de l’Éclairage, 1997.[6)]

[23] BRUCE-WHITE, Charlotte and SHARDLOW, Matt. *A review of the impact of artificial light on invertebrates.* Peterborough: Buglife – The Invertebrate Conservation Trust, 2011.

[24] THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION. Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products. (Ecodesign Directive.) Brussels: European Commission, 2009.

[25] EUROPEAN COMMISSION. *Green public procurement – Street lighting and traffic lights – Technical background report.* Brussels: European Commission, 2011.

[26] INSTITUTION OF LIGHTING PROFESSIONALS. *Guidance on the application of adaptive lighting within the public realm*. Professional Lighting Guide PLG08. Rugby: Institution of Lighting Professionals, 2016.[5)]

[27] INSTITUTION OF LIGHTING PROFESSIONALS. *Central management systems*. Professional Lighting Guide PLG01. Rugby: Institution of Lighting Professionals, 2017.[5)]

[28] PUBLIC HEALTH ENGLAND. *Human responses to lighting based on LED lighting solutions*. CRCE-RDD 01:2016. Crown Copyright 2016.

[29] INSTITUTION OF LIGHTING PROFESSIONALS. *Maintenance factor determination and its impacts on the performance and overall efficiency of LED luminaires*. ILP Guidance Note GN11/19. Rugby: Institution of Lighting Professionals, 2019.[5)]

[30] IES LM 63-02 IESNA. *Standard File Format for Electronic Transfer of Photometric Data and Related Information.* Illuminating Engineering Society of North America: 2002.

[31] INSTITUTION OF LIGHTING PROFESSIONALS. *Practical guide to the development of a public lighting policy for local authorities*. Technical Report TR24. Rugby: Institution of Lighting Professionals, 2009.[5)]

[32] HEALTH AND SAFETY EXECUTIVE. *Avoiding danger from underground services.* HSG 47. London: HSE Books, 2000.

4) Obtainable from the Institution of Lighting Professionals, Regent House, Regent Place, Rugby, CV21 2PN.
5) Obtainable from the Institution of Lighting Professionals, Regent House, Regent Place, Rugby, CV21 2PN.
6) Obtainable in the UK from CIE-UK, Delta House, 22 Balham High Road, London, SW12 9BS.

[33] INSTITUTION OF LIGHTING PROFESSIONALS. *Passive safety – Guidance on the implementation of passively safe lighting columns and signposts*. Technical Report TR30. Rugby: Institution of Lighting Professionals, 2011.[5)]

[34] INSTITUTION OF LIGHTING PROFESSIONALS. *High masts for lighting and CCTV*. Professional Lighting Guide PLG07. Rugby: Institution of Lighting Professionals, 2013.[7)]

[35] GREAT BRITAIN. Lifting Operations and Lifting Equipment Regulations 1998. London: The Stationery Office.

[36] GREAT BRITAIN. Provision and Use of Work Equipment Regulations 1992. London: The Stationery Office.

[37] GREAT BRITAIN. Electricity Safety Quality and Continuity Regulations 2002. London: The Stationery Office.

[38] EUROPEAN COMMUNITIES. Commission Regulation (EC) No 245/2009 of 18 March 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for fluorescent lamps without integrated ballast, for high intensity discharge lamps, and for ballasts and luminaires able to operate such lamps, and repealing Directive 2000/55/EC of the European Parliament and of the Council. Brussels: European Commission, 2009.

[39] INSTITUTION OF LIGHTING PROFESSIONALS. *Lighting for subsidiary roads – Using white light sources to balance energy efficiency and visual amenity*. PLG03. Rugby: Institution of Lighting Professionals, 2012.[7)]

[40] COMMISSION INTERNATIONALE DE L'ÉCLAIRAGE. *Road surface and road marking reflection characteristics*. CIE 144. Vienna: Commission Internationale de l'Éclairage, 2001.[8)]

[41] INSTITUTION OF LIGHTING PROFESSIONALS. *Conflict areas*. PLG02. Rugby: Institution of Lighting Professionals, 2010.[7)]

[42] GREAT BRITAIN. Crime and Disorder Act 1998. London: The Stationery Office.

[43] INSTITUTION OF LIGHTING ENGINEERS. *Lighting of cycle tracks*. Technical Report TR23. Rugby: Institution of Lighting Professionals, 1998.[7)]

[44] INSTITUTION OF LIGHTING ENGINEERS. *The outdoor lighting guide*. Rugby: Institution of Lighting Professionals, 2003.[7)]

[45] CHARTERED INSTITUTION OF BUILDING SERVICES ENGINEERS. *The outdoor environment. Lighting Guide* LG06 (Society of Light and Lighting SLL LG6). London: Chartered Institution of Building Services Engineers, 1992.

[46] GREAT BRITAIN. Public Health Act 1961. London: The Stationery Office.

[47] INSTITUTION OF LIGHTING PROFESSIONALS. *Measurement of road lighting performance on site*. Technical Report TR28. Rugby: Institution of Lighting Professionals, 2007.[7)]

[48] INSTITUTION OF LIGHTING PROFESSIONALS. *Lighting of pedestrian crossings*. Technical Report TR12. Rugby: Institution of Lighting Professionals, 2007.[7)]

[49] THE HIGHWAYS AGENCY, THE SCOTTISH OFFICE DEVELOPMENT DEPARTMENT, THE WELSH OFFICE and THE DEPARTMENT OF THE ENVIRONMENT FOR NORTHERN IRELAND. *Design manual for roads and bridges – Volume 1: Highway structures: approval procedures and general design – Section 3: General design – Part 11: The design and appearance of bridges*. BA 41/98. London: Department for Transport, 1998.

[7)] Obtainable from the Institution of Lighting Professionals, Regent House, Regent Place, Rugby, CV21 2PN.

[8)] Obtainable in the UK from CIE-UK, Delta House, 22 Balham High Road, London, SW12 9BS.

[50] GREAT BRITAIN. Civil Aviation Act 1982. London: The Stationery Office.

[51] GREAT BRITAIN. Air Navigation Order 2016. London: The Stationery Office.

[52] CIVIL AVIATION AUTHORITY. *Licensing of aerodromes.* CAP 168. London: Civil Aviation Authority, 2001.[9)]

[53] HEALTH AND SAFETY EXECUTIVE. *Railway safety principles and guidance – Part 2, Section E: Guidance on level crossings*. London: Health and Safety Executive, 1996.

[54] COMMISSION INTERNATIONALE DE L'ÉCLAIRAGE. *Lighting of roads for motor and pedestrian traffic.* CIE 115. Vienna: Commission Internationale de l'Éclairage, 2010.[10)]

[55] THE HIGHWAYS AGENCY, THE SCOTTISH OFFICE DEVELOPMENT DEPARTMENT, THE WELSH OFFICE and THE DEPARTMENT OF THE ENVIRONMENT FOR NORTHERN IRELAND. *Design manual for roads and bridges – Volume 5: Assessment and preparation of road schemes – Section 1: Preparation and implementation – Part 3: Traffic capacity of urban roads*. TA 79/99 incorporating Amendment No. 1. London: Department for Transport, 1999.

[56] COMMISSION INTERNATIONALE DE L'ÉCLAIRAGE. *Recommended system for visual performance based mesopic photometry.* CIE 191. Vienna: Commission Internationale de l'Éclairage, 2010.[10)]

[57] SANDERS, A and SCOTT, A. *Review of luminaire maintenance factors.* SL3. Wokingham: TRL, 2009.

9) This document can be downloaded from the CAA website at http://www.caa.co.uk.

10) Obtainable in the UK from CIE-UK, Delta House, 22 Balham High Road, London, SW12 9BS.

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