BS 5489-1:2013

BSI Standards Publication

Code of practice for the design of road lighting

Part 1: Lighting of roads and public amenity areas

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Published by BSI Standards Limited 2012

ISBN 978 0 580 70690 5

ICS 93.080.40

The following BSI references relate to the work on this document:
Committee reference EL/1/2
Draft for comment 12/30217236 DC

Publication history

First published as CP 1004, January 1952
Second edition, October 1963
Third edition, September 1973 (later amended to become BS 5489-1)
Fourth edition as BS 5489-1, February 1987
Fifth edition, August 1992
Sixth edition, December 2003
Seventh (present) edition, December 2012

Amendments issued since publication

Date	Text affected

Contents

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 74, 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 December 2012. 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 this committee can be obtained on request to its secretary.

Supersession

This part of BS 5489 supersedes BS 5489-1:2003+A2:2008, which is withdrawn.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 BS EN 13201 [1)] and to assist designers of lighting systems in using that standard.

Where references are made to specific lighting classes in BS EN 13201-2:2003, the equivalent classes in CIE 115:2010 [N1] are also included. It is expected that the CIE 115 classes will be adopted in the new edition of BS EN 13201-2, currently in preparation.

The preferred approach is to use the BS EN 13201-2:2003 lighting classes. Whichever approach is adopted, it is essential that that approach is used consistently throughout a specific lighting project or area for all criteria, and that it is clearly specified to avoid confusion.

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 [1)].

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.

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 whose use it has been produced.

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1) At the time of publication of this part of BS 5489, the BS EN 13201 series is undergoing revision. A new part, prEN 13201-5, is in preparation.

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 this standard is read thoroughly to ensure that all relevant issues are taken into account.

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.

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 advises on operation and maintenance.

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, but it excludes the lighting of vehicular tunnels which is covered in BS 5489-2.

It gives recommendations for the design of lighting for urban centres and public amenity areas.

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, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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, *Glossary of building and civil engineering terms – Part 2: Vocabulary – Spaces, building types, environment and physical planning*

BS 8300, *Design of buildings and their approaches to meet the needs of disabled people – 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 12464-2:2007, *Lighting of work places – Part 2: Outdoor work places*

BS EN 12665, *Light and lighting – Basic terms and criteria for specifying lighting requirements*

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

BS EN 13201-2:2003, *Road lighting – Part 2: Performance requirements* [2)]

BS EN 13201-3, *Road lighting – Part 3: Calculation of performance* [2)]

BS EN 13201-4, *Road lighting – Part 4: Methods of measuring lighting performance* [2)]

BS EN 60598-1, *Luminaires – 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*

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

2) At the time of publication of this part of BS 5489, the BS EN 13201 series is undergoing revision.

Other publications

[N1] COMMISSION INTERNATIONALE DE L'ÉCLAIRAGE. *Lighting of roads for motor and pedestrian traffic*. CIE 115. Vienna: Commission Internationale de l'Éclairage, 2010.

[N2] INSTITUTION OF LIGHTING PROFESSIONALS. *Code of practice for electrical safety in highway electrical operations.* GP03. Rugby: Institution of Lighting Professionals, 2011. [3)]

[N3] INSTITUTION OF LIGHTING ENGINEERS. *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)]

[N4] 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.

[N5] INSTITUTION OF LIGHTING PROFESSIONALS. *Guidance notes for the reduction of obtrusive light*. GN01. Rugby: Institution of Lighting Professionals, 2011. [3)]

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 13201-2:2003, BS EN 13201-3, BS 6100-2 and the following apply.

3.1.1 arrangement

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

3.1.2 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 advise on the best means by which the recommendations of this British Standard may be implemented.

3.1.3 conservation area

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

3.1.4 cost

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

3.1.5 design spacing

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

3.1.6 edge illuminance ratio (EIR)

*see **3.1.20***

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

3.1.7 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, it is not considered, for the purposes of road lighting design, to be an emergency lane.

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

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

3.1.10 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.

3.1.11 lamp lumen maintenance factor (LLMF)
ratio of the luminous flux of a lamp at a given time in its life to the initial luminous flux

NOTE 1 Lamp manufacturers can provide this data either in tabular or in graphical form.

NOTE 2 For LEDs, refer to A guide to the specification of LED lighting products 2012 *[1].*

[SOURCE: BS EN 12665, modified – Notes 1 and 2 have been omitted and new notes added]

3.1.12 lamp survival factor (LSF)
fraction of the total number of lamps which continue to operate at a given time under defined conditions and switching frequency

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

3.1.13 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

3.1.14 lifetime
time from construction up to removal of a scheme

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

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

3.1.17 road bridge
structure carrying the road under consideration over another road, railway, river, etc.

3.1.18 set-back
shortest distance from the forward face of a lighting column to the edge of a carriageway

3.1.19 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, $V(\lambda)$

3.1.20 surround ratio (SR)

average illuminance on strips just outside the edges of the carriageway in proportion to the average illuminance on strips just inside the edges

NOTE This is expected to be replaced by "edge illuminance ratio (EIR)" upon publication of the revised edition of BS EN 13201-2. A definition of EIR will be given in that standard.

3.1.21 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.

$\bar{E}$	maintained average horizontal illuminance, in lux (lx)
E_{min}	maintained minimum horizontal illuminance at any point, in lux (lx)
F_y	LED failure fraction: percentage of LED modules at their rated life that have failed
H	mounting height, in metres (m)
$\bar{L}$	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
MF	maintenance factor
R_a	general colour rendering index as defined in CIE 13.3 [2]
r	reduced luminance coefficient
s	design spacing, in metres (m)
TI	threshold increment, as a percentage (%)
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
W_L	width of driving lane, in metres (m)
W_r	width of relevant area of carriageway, in metres (m)
v	speed limit, in miles per hour (mph) [4)]
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) 1 mph = 1.61 km/h.

4 General considerations

NOTE Attention is drawn to the statutory requirements listed in references [3] to [18]. 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

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.

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.

It is not a primary function of lighting to provide visual guidance for traffic; however, where possible, lighting should be arranged to assist such routing, and the components of the lighting installation should be arranged so as not to visually mislead motorists as to the route ahead (see **4.2.3** and **4.3.4.3**).

Transport and environment policy is increasingly emphasizing the need to improve conditions for walking and cycling. One factor that has been identified as possibly influencing 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.

When lighting is provided on a previously unlit road, it is important to obtain guidance on whether certain traffic signs will have to be illuminated. The provision of traffic calming measures might require particular lighting arrangements.

NOTE Further guidance relating to lighting for traffic calming features is given in ILP TR25 [19].

4.2 Lighting design

*COMMENTARY ON **4.2***

Lighting design is a complex task, and there are many parameters which need to be considered 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. It is recommended that anyone undertaking lighting design is adequately trained in the profession and competent to do so. Attention is drawn to the Construction (Design and Management) Regulations 2007 [18].

Information on the selection of lighting classes is given in Annex A and PD CEN/TR 13201-1:2004 (undergoing revision).

4.2.1 Visual tasks for motorists

*COMMENTARY ON **4.2.1***

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.

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 it 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. The uniformity of the road surface luminance also has a significant influence on object visibility.

Road lighting should achieve the class of lighting, in accordance with BS EN 13201-2:2003, 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.

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). The relatively small amount of light available should be used to maximum effect by lighting the road surface and the immediate surrounds to reveal objects in silhouette. Exceptions to this approach include 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.

4.2.2 Visual tasks for pedestrians – Recognition and personal safety

*COMMENTARY ON **4.2.2***

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, it is recommended that a lighting class from the ES series of lighting classes given in BS EN 13201-2:2003, Table 5 [5)], or from the E_{SC} lighting classes given in CIE 115:2010 [N1], Table 7, should be applied.

4.2.3 Visual guidance

The lighting installation should give visual guidance by revealing the run of the road, particularly at T-junctions and bends. This function of the lighting should be achieved by careful positioning of lighting equipment, complementing 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.

4.2.4 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, will be 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 surround ratio (SR) or edge illuminance ratio (EIR) 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 surround ratio (SR) or edge illuminance ratio (EIR) to the values given in BS EN 13201-2:2003, 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 13201-2:2003 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 ensure 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, surround ratio (SR) or edge illuminance ratio (EIR) should be applied to the adjacent verge.

5) These are expected to become SC classes in the new edition of BS EN 13201-2, currently in preparation.

4.2.5 Glare

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

In traffic route lighting, the parameter threshold increment (*TI*) is used as a measure of disability glare, and maximum values of this parameter are set for each ME lighting class in BS EN 13201-2:2003 and M lighting class in CIE 115:2010 [N1]. At conflict areas on traffic routes, *TI* cannot always be calculated and in these situations luminaire intensity limits should be used as recommended in BS EN 13201-2:2003.

For residential and subsidiary roads, intensity limits should be used to control direct glare from luminaires as recommended in **7.2.1**.

4.2.6 Maintenance

4.2.6.1 General

The maintained levels of the relevant lighting classes should be in accordance with BS EN 13201-2:2003. In order to achieve this, and to ensure the provision of the selected class, it is essential that appropriate luminaire cleaning and light source replacement routines are 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, and screens or baffles, checking of alignment and monitoring of operation. It is desirable to minimize the frequency of maintenance visits.

NOTE 1 Monitoring for non-operable lighting is usually by means of night-time inspection. However, electronic monitoring systems can provide viable alternatives.

*NOTE 2 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, lamp changing and other maintenance requirements (see **4.2.6.2**) carried out to criteria used in the design can generally maintain the lighting within acceptable levels.*

NOTE 3 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.

The frequency of replacement of light sources is a matter of local policy, cost and light source type used. Decisions should not be made purely on economic grounds, but should take all the relevant factors into account, including:

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

b) the lamp lumen maintenance factor 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 frequency of need for 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 frequency of inspection for electrical safety;

k) the 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.

4.2.6.2 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 13201-2:2003. The calculation methods in BS EN 13201-3 should be used to determine luminance and illuminance levels and quality criteria.

These methods incorporate a maintenance factor (*MF*), which is the product of the lamp lumen maintenance factor and the luminaire maintenance factor.

NOTE 1 In some instances, such as pedestrian subways, an additional factor is taken into account, the lamp survival factor.

The lamp lumen maintenance factor should be obtained from the luminaire manufacturer's data, taking account of light source type, controller type, switching regime, operating environment and light source change policy.

NOTE 2 Typical values of luminaire maintenance factors are given in Annex B. Alternatively, luminaire maintenance factors established by local testing may be used.

NOTE 3 Maintenance factors for LEDs are discussed in Annex C.

4.2.6.3 Maintenance of high-mast lighting

High-mast lighting systems, and other specialized installations using more complex mechanical, hydraulic, or electrical equipment, generally require additional maintenance. They 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 Detailed inspection regimes are given in ILP TR07 [20].

4.2.6.4 Roads with limited maintenance access

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, and should be taken into account at the design stage. Factors that should be taken into account include:

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;

i) the implications and cost of traffic management.

4.2.6.5 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 recommendations contained within the following documents:

- ILP GP03 [N2];
- ILP GP10 [N3] (supplement to GP03);
- Electricity Association Engineering Recommendation G39/1 [N4].

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 [21].

4.3 Environment

4.3.1 General

Environmental issues associated with road lighting are prime considerations when designing a new or replacement lighting scheme. The issues that designers should address include:

- minimizing obtrusive light;

  NOTE 1 Guidance is given in ILP GN01 [N5].
- undertaking a visual impact assessment;

  NOTE 2 Guidance will be given in ILP PLG04 [22], currently in preparation.
- daytime and night-time appearance;
- effect on flora and fauna as well as human health;

  NOTE 3 Some species of flora and fauna are protected by legislation.
- specific environmental issues within local planning policies.

Subclause **4.3** indicates some matters that should receive attention and gives recommendations, but it is recognized that in aesthetics, subjective judgements can apply. Furthermore, 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.

*NOTE 4 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 **4.4.4**.*

4.3.2 Appearance

4.3.2.1 Daytime appearance

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. In such cases, the siting should be carefully related to the architectural or landscape setting.

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

4.3.2.2 Night-time appearance

An aspect of planning any lighting scheme is the positive contribution it can make to the improvement of the night environment. The basic design should 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**).

While efficient lighting for traffic and pedestrian safety is essential, consideration of the whole visual scene at night is highly desirable for many reasons. In designing lighting for urban and residential roads, efficient lighting for traffic and pedestrian safety is an essential factor. Other factors such as amenity and environmental requirements and the assistance in perception of a safe environment that lighting provides should also be taken into account.

The colour rendering index of the light source (R_a) should be suitable for the application or task and should be ≥20. In civic centres, shopping streets, boulevards, promenades and other places that are the hub of social activity and have a high night-time pedestrian use, light sources with an $R_a \geq 60$ should be used.

Where street crime is a major problem and the police use CCTV for prosecution, 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 and is quantified by the correlated colour temperature (T_{CP}). Values of T_{CP} are usually categorized into one of three groups (warm, intermediate or cool colour appearance) as shown in Table 1.

Table 1 **Light source colour appearance groups**

Colour appearance	Correlated colour temperature, T_{CP} K
Warm	<3 300
Intermediate	3 300 to 5 300
Cool	>5 300

4.3.3 Siting of lighting columns

4.3.3.1 General

*COMMENTARY ON **4.3.3.1***

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 ensure that the designed location is suitable. Factors that should be taken into account include, but are not limited to, the following:

- overhead power lines or other obstruction (see **4.2.6.5**);
- underground power lines or other utility services or obstruction;
- trees, including potential growth and accounting for summer foliage (see **4.3.3.2**);
- dropped kerbs;
- preference for alignment with property boundaries;
- need to minimize obtrusive light (see **4.3.5**), especially where it could affect residential property windows;
- views from residential properties;
- potential for vehicle impacts (see **4.3.3.3**);
- provision of road restraint systems or use of passively safe lighting columns (see **4.3.3.4**);
- accessibility for maintenance.

NOTE 1 Further guidance is given in HSE publication HSG 47 [23].

NOTE 2 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 3 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 so 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 so as not to interfere with the view of buildings or monuments of architectural interest, or with scenic views.

4.3.3.2 Effect of trees

Lighting columns when first installed should be sited so 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 so as to minimize issues such as:

- incorrect photocell operation;
- impaired maintenance access;
- 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.

4.3.3.3 Lighting columns as hazards

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 2 should therefore 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 will need additional space.

Table 2 **Recommended minimum clearances from edge of carriageway to face of lighting column**

Design speed km/h	**Horizontal clearance** m
≤50	0.8
80	1.0
100	1.5
120	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.

The lowest point of overhang of luminaires or bracket arms that overhang the carriageway, or are within the respective horizontal clearances given in Table 2, 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 2) 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 if possible be sited at the rear of the footway, i.e. away from the carriageway.

NOTE 3 In that position they 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 2.

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 4 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.

4.3.3.4 Passively safe lighting columns

*COMMENTARY ON **4.3.3.4***

On roads where traffic speeds are high and there are few pedestrians or cyclists, the installation of passively safe (also known as breakaway or energy-absorbing) lighting columns is an alternative to rigid lighting columns to reduce the severity of injury.

As indicated in **4.3.3.3**, when vehicles collide with lighting columns the occupants can suffer severe injuries. The design of lighting installations should aim 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, which provides a system of classification in passive safety terms for support structures for road equipment including lighting columns, should be specified when passively safe lighting columns are to be used.

NOTE 2 ILP TR30 [24] provides additional guidance.

4.3.4 Arrangements

4.3.4.1 Mounting heights

When choosing the mounting height, technical and economic 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).

4.3.4.2 Lighting unit assemblies

4.3.4.2.1 General

Lighting columns should conform to BS EN 40 and PD 6547. When specifying lighting columns, it should be ensured that 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), are taken into consideration.

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 so that the clearance of the luminaire from the edge of the carriageway is at least 450 mm.

4.3.4.2.2 Size and type of luminaires

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

4.3.4.2.3 Form of bracket

*COMMENTARY ON **4.3.4.2.3***

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 and it is recommended that it does not exceed one quarter of the mounting height.

4.3.4.2.4 Colour of lighting equipment

Colour and finish should be appropriate in the context of the environmental surroundings. Care should be taken to avoid the use of highly reflective finishes 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.

4.3.4.2.5 Overall appearance

*COMMENTARY ON **4.3.4.2.5***

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.

4.3.4.3 Luminaire arrangements

4.3.4.3.1 General

There are many variables to take into account when designing a lighting installation. With the choice of arrangement, designers should appraise ease of maintenance, traffic management costs and road worker safety.

NOTE 1 The following are typical lighting arrangements:

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.

*NOTE 2 For lighting on bridges, see **7.6**.*

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 can then be added to the layout.

The layout should be examined in perspective to ensure 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 3 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 conform to the recommendations given in **4.2.4** for the lighting of adjacent areas such as footways and cycle tracks, using either surround ratio (SR)/edge illuminance ratio (EIR) or a specific lighting class applied to the adjacent areas.

4.3.4.3.2 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) staggered;

b) opposite;

c) single-sided.

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.

4.3.4.3.3 Luminaire arrangements for dual carriageways

Where dual carriageways are separated by a wide central reserve, the carriageways should be treated separately.

NOTE 1 Normally, when the distance between the outer carriageway edges is not excessive, dual carriageways can be lit as a single road.

NOTE 2 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.

4.3.4.3.4 Luminaire arrangements for dips and crests of hills

At a dip, there is no special 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 such situations, luminaires should be used that conform to installed intensity classes G4, G5 or G6 as specified in BS EN 13201-2:2003.

*NOTE Similar considerations apply to the lighting of some bridges (see Commentary on **7.6.2**).*

4.3.5 Obtrusive light

*COMMENTARY ON **4.3.5***

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 above the horizontal.

NOTE 1 The installed intensity classes from BS EN 13201-2:2003 can be used for this purpose.

Precautions should be taken to avoid unnecessary light intrusion into adjacent properties. However, 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 2 Further information is given in ILP GN01 [N5].

Lighting schemes in, or adjacent to, environmentally sensitive areas should be given particular attention. Such areas include green belts, national parks, dark sky parks and areas of outstanding natural beauty. Similarly, schemes close to the edge of residential areas should also receive special attention. In these cases the light distribution should be controlled to minimize light spill onto adjoining areas by selection of an appropriate installed intensity class from BS EN 13201-2:2003.

NOTE 3 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 Bats and lighting in the UK *[25] 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 G4, G5, or G6 as specified in BS EN 13201-2:2003:

- traffic routes and motorways in environmentally sensitive and open areas;
- roundabouts and mini-roundabouts, particularly in environmentally sensitive areas and/or with unlit approach roads;
- elevated roads and bridges;
- remote isolated junctions.

NOTE 4 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 *[26] and the CIE publication* Guideline for minimising sky glow *[27].*

4.3.6 Sustainability

*COMMENTARY ON **4.3.6***

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. Guidance on energy-efficient design is given in **4.4**.*

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

NOTE Guidance is given in Annex D.

4.4 Electrical energy

*COMMENTARY ON **4.4***

*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 **4.3.6**) is also relevant.*

4.4.1 General

Designers should develop appropriate energy-efficient designs in accordance with the recommendations in **4.4.2** to **4.4.5**.

NOTE 1 Energy efficiency measures will be covered in BS EN 13201-5 [6].

NOTE 2 Attention is drawn to Directive 2009/125/EC (the Ecodesign Directive) [28].

NOTE 3 Useful information can be found in the EU Green public procurement publication on street lighting [29].

4.4.2 Measures to minimize electrical energy use

NOTE 1 Energy efficiency measures will be covered in BS EN 13201-5 [6], which will define 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 13201-2:2003.

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 carefully assessed. These strategies include the following.

- **Variable 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 providing the equipment is suitable, the lighting levels can be reduced through dimming. See **4.4.4** 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 should be 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 should switch lights on and off in a contiguous order, as a random approach will temporarily compromise longitudinal uniformity.
- **Switch off**. Lighting is switched off and removed.

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

[6] In preparation as prEN 13201-5 at the time of publication of this part of BS 5489.

NOTE 2 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 (midnight to 0530hrs) 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.

4.4.3 Hours of operation

*COMMENTARY ON **4.4.3***

The question of whether or not 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 **4.4.2** for guidance on trimming).*

See also Annex 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. The level of lighting may vary during the night, dependent upon usage and other factors (see **4.4.4**). 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. A risk assessment should be undertaken prior to making a decision for part-night lighting.

4.4.4 Variable lighting levels

*COMMENTARY ON **4.4.4***

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 over-riding 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.

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 and PD CEN/TR 13201-1:2004 (undergoing revision). ILP TR27 [30] provides additional guidance on variable lighting.

If individual luminaires are extinguished in order to reduce lighting levels, the recommendations given in this subclause should be followed. If switching light sources off is the method used to vary the lighting level, it should be ensured that the uniformity requirements are still met. When varying the lighting, each lighting level should meet the requirements of a distinct lighting class from BS EN 13201-2:2003 or CIE 115:2010 [N1].

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.

NOTE Annex A gives details of the lighting classes set out in BS EN 13201-2:2003 and CIE 115:2010 [N1], 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.

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

4.4.5 Controls

*COMMENTARY ON **4.4.5***

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 designer should take into account all the requirements of the lighting system, and the solution chosen will often be a compromise between flexibility and cost. Designers should use the guidance given in **6.4**.

NOTE Guidance will also be given in ILP PLG01 [31], currently in preparation.

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

5 Design recommendations

5.1 Design strategy and road classification – Risk assessment

*COMMENTARY ON **5.1***

There are a number of recognized guidance documents providing different methods of designating a road classification or lighting class for a particular road. Generally these methods aim to determine the lighting class based upon the type of user, the usage, the complexity of the task and other site-specific criteria.

Designers should check whether a client has a specific lighting strategy, lighting policy or specification which relates to the area they are considering. 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 and PD CEN/TR 13201-1:2004 (undergoing revision).

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 [32].

The lighting class chosen should be as a result of a risk assessment, which should assess the particular risks associated with the road.

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.

5.2 Lighting criteria

*COMMENTARY ON **5.2***

*This subclause provides information on the lighting criteria used for road lighting design and can be categorized as relevant for traffic routes (**5.2.1**) or for subsidiary roads including pedestrian areas, footpaths and cycle tracks (**5.2.2**).*

5.2.1 Traffic routes

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

*COMMENTARY ON **5.2.1.1***

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 13201-2:2003 or CIE 115:2010 [N1], and be calculated according to the method in BS EN 13201-3.

Calculated values should take into account the luminaire and lamp lumen maintenance factors.

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 B gives indicative values. Their values may alternatively be established by field measurements.

NOTE 2 Lamp lumen maintenance factors vary according to light source type and power. Values are usually available from light source manufacturers.

5.2.1.2 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.

5.2.1.3 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.

5.2.1.4 Threshold increment (*TI*)

COMMENTARY ON ***5.2.1.4***

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.

Lighting designs for traffic routes should meet the *TI* requirements of the selected class as defined in BS EN 13201-2:2003 or CIE 115:2010 [N1], and be calculated according to the method in BS EN 13201-3.

5.2.1.5 Surround ratio (SR) or edge illuminance ratio (EIR)

In situations where an alternative lighting system is already provided on the surrounds, the use of surround ratio (SR) or edge illuminance ratio (EIR) is unnecessary; however, the lighting class on the surrounds should be checked to ensure that it fully conforms to the requirements of BS EN 13201-2.

Lighting designs for traffic routes should meet the surround ratio (SR) or edge illuminance ratio (EIR) requirements of the selected class as defined in BS EN 13201-2:2003 and calculated according to the method in BS EN 13201-3.

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

5.2.2.1 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. For this, the lighting on horizontal surfaces, as well as the control of glare and the colour rendering, is important. Environmental issues should 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 ***4.2.2****.*

5.2.2.2 Lighting of horizontal surfaces

To ensure that pedestrians can move over the road and footpath surfaces in safety, the horizontal illuminance should meet the appropriate class in BS EN 13201-2:2003 or CIE 115:2010 [N1].

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****.*

5.2.2.3 Lighting of vertical surfaces

COMMENTARY ON ***5.2.2.3***

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 13201-2:2003 defines lighting classes for vertical illuminance and semi-cylindrical illuminance.

In cases where additional visual recognition is required, a lighting class for semi-cylindrical illuminance should be selected from BS EN 13201-2:2003 or CIE 115:2010 [N1] and calculated in accordance with BS EN 13201-3.

5.2.2.4 Control of glare

*COMMENTARY ON **5.2.2.4***

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.

Direct glare from luminaires should be controlled. Where luminaires have clear bowls or refractors, these should conform to class G1 as specified in BS EN 13201-2:2003, Table A.1, or a higher class, to provide adequate control of glare.

5.3 Electrical energy targets

Many authorities have targets to reduce electrical energy use, and consequently electrical energy targets often form part of the requirements for a lighting design. The specific guidance in **4.4** should be followed.

5.4 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 will often highlight 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.

6 Technologies

6.1 Light sources

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

NOTE 2 Attention is drawn to EC Regulation No. 245/2009 [33].

There is a wide range of available light sources that are suitable for lighting roads and public amenity areas. The following factors, which will influence the choice of light source for a particular application, or type of application, 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 will be dealt with more comprehensively in BS EN 13201-5 [7)].

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. For further advice on the colour rendering of light sources, refer to **4.3.2.2**.

7) In preparation as prEN 13201-5 at the time of publication of this part of BS 5489.

c) **Colour appearance**. Light sources can be of a warm, intermediate or cool colour appearance (see **4.3.2.2)**.

d) **Lamp life and luminous flux depreciation**. Data on lamp life and luminous flux depreciation should be obtained from manufacturers, and will affect the maintenance factor (see **4.2.6.2**).

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 a large number of 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.

NOTE 4 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 [34] provides further information.

6.2 Control gear

The control gear used to power and control the light source should conform to the requirements of BS EN 60598-1 and 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. Additional flexibility and future-proofing is achieved by the use of variable output control gear. 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 Attention is drawn to the Directive 2009/125/EC (the Ecodesign Directive) [28], which gives minimum requirements for control gear, and to EC Regulation 245/2009 [33] in respect of requirements for energy efficiency of control gear.

6.3 Luminaires

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

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

Luminaires with an IP rating in the range IP 5X to IP 6X should be used, but the higher numbers in this range are recommended for optical compartments as these will reduce light output depreciation, reduce degradation of internal components and minimize the need for internal cleaning. If the optical compartment and the control gear compartment are separate they might have separate IP ratings for each compartment.

6.4 Lighting controls

*COMMENTARY ON **6.4***

*The purpose of lighting controls is described in the commentary on **4.4.5**. 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 dimming 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.

7 Applications

7.1 Lighting traffic routes

*COMMENTARY ON **7.1***

This subclause gives guidance on the lighting of traffic routes, including motorways and all-purpose traffic routes. 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 viewing distance is greater than 60 m.

7.1.1 General

The lighting requirements for traffic routes are strongly dependent on traffic density and composition. An appropriate lighting class should be selected from those given in BS EN 13201-2:2003 or CIE 115:2010 [N1].

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 and PD CEN/TR 13201-1:2004 (undergoing revision).

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

Care should be taken to ensure that the *r*-table used does in fact represent the road surface that exists or is to be provided.

NOTE 1 There can be significant variations in reflection when different aggregates are used in standard asphalt; with porous asphalt; and with concrete surfaces.

NOTE 2 CIE 144 [35] gives standard r-tables for road surfaces.

NOTE 3 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.

An *r*-table representing a dry road surface is normally used.
In BS EN 13201-2:2003, 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 should 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.

7.1.3 Calculation procedure for bends

7.1.3.1 General

The calculation procedure described in **7.1.2** determines the maximum spacing between luminaires 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 CE class from BS EN 13201-2:2003, Table 2, or C class from CIE 115:2010 [N1], Table 5.

Transferring the 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, as 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 and should not fall below the recommended value for the selected lighting class in BS EN 13201-2:2003 or CIE 115:2010 [N1].

7.1.3.2 Lighting column location on bends

When locating lighting columns on a bend, it is essential that lighting columns are not 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. 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 Additional guidance is given in **4.3.3.3** and **4.3.3.4**.*

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, and to discourage crime against people and property. 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 **4.2.2**.*

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 will be given in PLG02 [36], currently in preparation.

*For roundabouts on subsidiary roads, refer to **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 13201-2:2003 or CIE 115:2010 [N1] need to be met by the lighting design at any junction.

7.2.1 General

The appropriate lighting class should be selected from BS EN 13201-2:2003 or CIE 115:2010 [N1].

NOTE 1 Information on the selection of lighting classes is given in Annex A and PD CEN/TR 13201-1:2004 (undergoing revision).

When considering 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, it is recommended that 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 considering 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 2 PD CEN/TR 13201-1:2004 (undergoing revision) gives information on definition of the relevant area.

The technical solution for the general lighting for pedestrians and cyclists using average and minimum horizontal illuminance classes should be used. The design should ensure that the road edge and immediate surrounds are illuminated.

NOTE 3 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.

In respect of the S series lighting classes as given in BS EN 13201-2:2003, Table 3, and the P series lighting classes as given in CIE 115:2010 [N1], Table 7, it is recommended that the average illuminance $\bar{E}$ does 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 provide confirmation of a compliant design.

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 G1 as specified in BS EN 13201-2:2003, Table A.1, or a higher class, to provide adequate control of glare.

NOTE 4 BS EN 13201-2:2003 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 recent scientific research that there is a correlation between the spectral power distribution of a lamp or light source and the visual performance under low lighting levels associated with mesopic vision.

For the lighting levels associated with lighting residential and minor roads in accordance with the S classes from BS EN 13201-2:2003, Table 3, and the P classes from CIE 115:2010 [N1], 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 and may be used to amend the lighting class selected. The adjustment factor varies with S/P ratio and also with illuminance.

NOTE 1 Guidance is given in ILP PLG03 [34].

NOTE 2 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

Traffic calming measures are often provided on subsidiary roads, particularly in residential areas, and can include speed restriction humps. An appropriate lighting class should be selected from BS EN 13201-2:2003 or CIE 115:2010 [N1] for the area of traffic calming measures.

NOTE 1 The information on selection of lighting class in Annex A and in PD CEN/TR 13201-1:2004 (undergoing revision) 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 2 Further guidance relating to lighting for traffic calming features is given in ILP TR25 [19].

7.2.5 Crime prevention and detection, and pedestrian safety

In areas where there is a high crime risk, care should be taken to ensure that any potentially dark areas, which could provide cover for a criminal, are included within the relevant area to which the selected lighting class will be applied.

It is recommended in such areas that the lighting levels are not reduced at any time of the night.

*NOTE 1 Guidance on recognition, visual tasks and personal safety is given in **4.2.2**.*

NOTE 2 Attention is drawn to the Crime and Disorder Act 1998 [37], Section 17.

Colour rendering can help in crime detection by permitting better identification of objects and people, and this should be taken into account in choosing a light source.

NOTE 3 A lighting class using semi-cylindrical illuminance, from BS EN 13201-2:2003, Table 5, 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 S-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 S-series of lighting classes in BS EN 13201-2:2003.

The overall uniformity of illuminance, U_o, should be not less than that derived from the ratio of the minimum illuminance level to the maximum maintained average horizontal illuminance level recommended in BS EN 13201-2:2003. 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. However, 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.

NOTE The most economical lighting scheme will be obtained by ensuring that the lighting levels provided are as close as possible to those specified in BS EN 13201-2:2003 for the specific S-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 they 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, a suitable lighting class should be obtained.

NOTE 1 Information on the selection of lighting classes is given in Annex A and PD CEN/TR 13201-1:2004 (undergoing revision).

When locating lighting columns, it should be ensured that there is an adequate set-back of the lighting column to avoid the potential for cyclists colliding or coming into contact with the lighting column.

NOTE 2 Further guidance is given in ILP TR23 [38].

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 the horizontal to assist in the identification of pedestrians.

In areas of high crime or where CCTV is present, lighting designs should be based upon semi-cylindrical illuminance or 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, it is important to remember that 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;

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:*

a) primarily vehicular;

b) mixed vehicular and pedestrian;

c) pedestrians and cyclists only.

The appropriate lighting class for each category of traffic should be selected from BS EN 13201-2:2003 or CIE 115:2010 [N1].

NOTE Further information on the selection of lighting classes is given in Annex A and PD CEN/TR 13201-1:2004 (undergoing revision).

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 13201-2:2003, Table 1a or CIE 115:2010 [N1], Table 2.

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 13201-2:2003, Table 3 or CIE 115:2010 [N1], Table 7.

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 13201-2:2003, Table A.1 or CIE 115:2010 [N1], Table 7.

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 and PD CEN/TR 13201-1:2004 (undergoing revision).

Luminaire intensities should be carefully controlled in order to prevent glare, using an installed intensity class selected from BS EN 13201-2:2003, 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 promote easy movement of pedestrians, attempt to 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 **4.3.2.2**, and adequate visual recognition as recommended in **4.2.2** 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 13201-2:2003, Table 3 or CIE 115:2010 [N1], Table 7.

NOTE 2 Further information on the selection of lighting classes is given in Annex A and PD CEN/TR 13201-1:2004 (undergoing revision).

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. This can be achieved by the "variable lighting" approach detailed in **4.4.4**, by switching light sources in multi-light source luminaires, or by varying the lighting level. When considering switching on or off light sources to vary the lighting level, it should be ensured that the uniformity requirement is still 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 A lighting class using semi-cylindrical illuminance, from BS EN 13201-2:2003, Table 5, can be specified in addition to the general 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).

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 *[39] and CIBSE LG06 [40].*

Lighting designers should consult with 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 3, and should match that of the adjacent shop windows. Light sources with colour rendering $R_a \geq 60$ should be used.

Table 3 **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 4.

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. The decision on whether to light a rural subway will also depend on the following:

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

It is recommended to undertake a risk assessment to assist with the decision-making process of whether and when to light.

NOTE 1 Table 4 applies to lighting in urban or suburban areas. The levels in Table 4 are not appropriate when the approaches are unlit or when there is little ambient lighting in the vicinity.

Table 4 **Maintained lighting levels for subways, footbridges, stairways and ramps**

Values in lux

Type	Day		Night	
	$\bar{E}$	E_{min}	$\bar{E}$	E_{min}
Subways				
• open A)	—	—	50	25
• enclosed B)	350	150	100	50
Footbridges				
• open A)	—	—	30	15
• enclosed B)	350	150	100	50
Stairways/ramps				
• open A)	—	—	30	15
• enclosed B)	350	150	100	50

A) “Open” equates to major daylight penetration.

B) 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.

Lighting on stairways and ramps giving exterior access for disabled people to buildings should be in accordance with BS 8300. In subways, vertical surfaces should be well illuminated.

NOTE 2 It is also advantageous that all surfaces are as light coloured as is practicable.

Light source colour appearance and colour rendering are important factors that should also 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 3 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 entry area of such subways should be provided with extra threshold lighting so that the threshold zone has illuminance values of twice the general daytime illuminance level in the subway. At night, the threshold zone values should be reduced, with exterior approaches to the subway provided with good levels of light.

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, care should be taken to install the lighting units in such a manner as to complement the structure but ensure future ease of maintenance.

*NOTE 4 For additional guidance for the lighting of footbridges refer to **7.6.2.3**.*

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.

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 (as defined in Table 1).

The protrusion of luminaires below the ceiling surface can make the ceiling appear dark. Floor surfaces with a light finish will 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 conform to **7.4.8.3**.

The spacing of luminaires and reflectance factors in enclosed car parks should be carefully chosen to achieve a uniformity which 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 to ensure 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. See 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 so as to avoid obtrusive lighting, following the guidance in **4.3.5**.

The design, orientation and location of luminaires in the motorist's line of sight should be arranged to ensure that glare is minimized. In order to limit glare, an appropriate intensity class should be selected from BS EN 13201-2:2003, Table A.1.

The appropriate lighting level should be selected from Table 5, 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 5 is extrapolated from BS EN 12464-2:2007, Table 5.9.

Table 5 **Maintained lighting levels for outdoor car parks**

Type of area and usage	$\bar{E}$ lx	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 schools, churches, major sports and multipurpose sports and building complexes	20	0.25

Lighting for open roof level car parks should be carefully 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 [N5].

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, access for maintenance should be taken into account.

7.4.8.4 Calculation procedure

The calculation procedure for 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.

Some obstructions can affect the illuminance level and uniformity, and extra care should therefore be taken when obstructions are present.

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. A minimum of 36 points per grid should be used.

7.4.9 Lighting of service areas

Service areas and important parts of central areas can be shared or can be in such close proximity that the service area lighting has a visual effect on the more important central area. The lighting class should be selected from BS EN 13201-2:2003 or BS EN 12464-2:2007, as appropriate for the relevant tasks.

Service areas have varying needs and this can cause conflicts between types of vehicles and pedestrians. For example, tall delivery vehicles can create shadows when parked, and where possible the lighting should be designed to minimize this. The design should also take into account the effect of manoeuvring of large vehicles, which might be contrary to normal traffic flow.

NOTE Where suitable luminaire positions on surrounding buildings can be utilized, the use of lighting columns can be avoided. In such circumstances, the use of floodlighting luminaires can be an alternative to road lighting luminaires.

If pedestrian areas are divided or crossed by service roads, there is likely to be fragmentation of both areas by physical features designed to separate the conflicting needs of vehicles and pedestrians. The lighting engineer should examine the area or areas both individually and as a complete unit, to determine whether separate or combined lighting provisions can be made. The main usage of each area usually indicates the form of lighting that should be provided.

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 pre-requisite for period-style lighting. Modern equipment of good functional design is often suitable. Conventional lighting forms often prove most economic, both in terms of 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 1985 [4] in respect of the fixing of public lights to buildings.

A lighting class should be selected from BS EN 13201-2:2003 or CIE 115:2010 [N1] that relates to the needs of vehicular and pedestrian traffic, in accordance with **7.1**, **7.2** or **7.4.3** 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 at an early stage.

For night-time appearance, the quality of lighting, observed effect, light source colour temperature and colour rendering properties are all important criteria that should 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.

Utmost care should be taken with the design and execution of all installation work, with particular attention being given to the routing of all wiring and cables, and location of electricity service equipment, to ensure the minimum visual intrusion.

When it becomes necessary to replace equipment following damage or other causes, equipment should be replaced with identical or similar 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 an additional effect to the overall scene.

The presence of fauna also needs to be taken into account. Some specific guidance is given in Bats and lighting in the UK *[25] and* A review of the impact of artificial light on invertebrates *[41].*

General guidance on outdoor environments is given in the ILP publication The outdoor lighting guide *[39] and CIBSE LG06 [40].*

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

Lighting design should be in accordance with ILP GN01 [N5].

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

7.4.12 Installation design

7.4.12.1 General

In environmentally sensitive areas, the relevant planning authority should be consulted along with the relevant planning architect, to ensure that historical styling and/or location of equipment is correct.

The lighting needs of all users should be identified. The area concerned should be subjected to detailed daytime and night-time site appraisal prior to detailed design work.

NOTE 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 by planners, architects and lighting designers can achieve good effective and economic 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 night, to ensure 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

The lighting performance of new lighting installations should be measured to ensure that the design requirements have been met.

The measurements should be undertaken in accordance with BS EN 13201-4.

NOTE Further guidance is given in ILP TR28 [42].

7.4.13 Light sources and luminaires

7.4.13.1 Basic needs

Lighting equipment should be suitable for fulfilling the lighting needs. 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. It should be aesthetically pleasing in itself as well as being in harmony with its surroundings (see **4.3.4.2**). At all times, and especially at night, it should add to the attraction of the urban scene rather than detracting from it.

*NOTE 1 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. See **4.3.2.2** for recommendations on the colour rendering index of light sources.*

NOTE 2 The different colour appearances of light sources can be exploited by the lighting engineer to bring planned variety to the night-time urban scene. While long life and high efficacy are important economic 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, care should be taken to match historical periods.

NOTE 1 Consultation with the local planning authority is recommended.

*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 **4.4.4** can be used.*

7.4.14 Vehicular charging points

Electricity charging points for electric vehicles are becoming a feature on some urban streets. Vehicular electricity charging points should be lit to the same lighting class as the adjacent road.

Task lighting should be provided for specific local areas such as meter and instruction reading. Other service areas and trailing cables should be adequately illuminated such that their visibility reduces the trip hazard.

NOTE BS EN 12464-2:2007, Table 5.6, reference 5.6.5 provides lighting levels for meter reading areas at fuel filling stations, which can be adopted for vehicular charging points.

Illuminance should be horizontal or vertical as appropriate to the task.

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 economic 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;

d) roundabouts with unlit approach roads.

Roundabouts can often be effectively lit from the perimeter, with typically 10 m or 12 m lighting columns, 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.

Solutions using 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 will be given in ILP PLG02 [36], currently in preparation. Guidance on lighting of pedestrian crossings is given in ILP TR12 [43].

Conflict areas should be lit to a CE series lighting class chosen from BS EN 13201-2:2003, Table 2, or a C series lighting class chosen from CIE 115:2010 [N1], Table 5.

*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 will need 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) [44].*

7.6.1 General

The lighting scheme should provide the selected class of lighting from BS EN 13201-2:2003 or CIE 115:2010 [N1] for each area, including carriageways, footways and cycle tracks, giving due consideration to road-user and maintainer safety.

NOTE The lighting on roads approaching bridges and elevated roads will normally be lit using road surface luminance criteria, and often this approach can be continued on the bridge or elevated road.

There is a risk to traffic both on and off the structure as a result of a possible collision with lighting columns. Consideration should be given to the siting of lighting columns, their method of fixing and their protection with safety fences or parapets (see **4.3.3.3** and **4.3.3.4**).

7.6.2 Lighting for bridges

*COMMENTARY ON **7.6.2***

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 directly above rail lines.*

7.6.2.1 Structural considerations

*COMMENTARY ON **7.6.2.1***

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 Air and/or water navigation lights might be 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.

7.6.2.2 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.

7.6.2.3 Lighting for footbridges

Special care should be given to the illumination of stairs and ramps.

Where a footbridge crosses a lit road, the lighting of the road can suffice for the footbridge and its ramps, especially if the parapets are not solid, but in this case calculations should be carried out to ensure that the road lighting will provide on the footbridge the appropriate lighting class from BS EN 13201-2:2003 or CIE 115:2010 [N1].

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

7.6.3 Lighting for elevated roads

*COMMENTARY ON **7.6.3***

*Maintenance of the lighting asset can be made very difficult if not adequately considered during the design phase. Parking for maintenance vehicles, higher wind speeds and access to and opening of maintenance access doors are particular problems. The commentary on **7.6.2.1** is 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 will provider easier and safer access to the maintenance access door and simplify structural considerations and design detail. If this is not possible 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;*
- *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 lamps with a lifetime well in excess of the anticipated lamp change interval should be used where appropriate to avoid the need for unplanned maintenance.

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

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.

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

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 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.

7.7.1 General

Individual luminaires can provide a symmetric or an asymmetric light distribution tailored to match the area to be lit from each mast. They 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°.

7.7.2 Design considerations

Some of the aspects that should be taken into account in the design using high-mast techniques are as follows.

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

b) 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.

c) 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.

d) In grade-separated junctions, shadows will occur where one road passes over another. The size and density of the shadow will depend upon the siting of the masts. It should be determined at the design stage if 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 13201-2:2003 or CIE 115:2010 [N1]. If this occurs, some form of supplementary lighting at a lower level should be provided.

7.7.3 Engineering considerations

The planned position of the mast and mast foundations will depend upon 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.

7.7.4 Lightning protection

The need for lightning protection should be evaluated in accordance with BS EN 62305.

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

*COMMENTARY ON **7.8***

This subclause gives additional guidance on road lighting within areas around aerodromes, railways, harbours and navigable waterways, as such lighting can affect the safe use of these areas. The recommendations given in this clause may also be applied to lighting other than road lighting.

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.

Lighting should be located to minimize interference with clear vision or with the ability of transport operators to recognize signals.

NOTE Interference can be caused by:

- *disability glare from luminaires or installations;*
- *variations in contrast and reflected light;*
- *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

7.8.2.1 General

NOTE 1 The Civil Aviation Act 1982 [45], Section 105 specifically 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 2000 [46], Article 110 in respect of lights that might affect aircraft. A light can endanger aircraft when:

a) the intensity causes glare in the direction of an approaching aircraft;

b) the colour (e.g. advertising signs) causes it to be mistaken for an aeronautical light;

c) viewed from the air, lights make a pattern (e.g. a row of street lights) similar to an approach or runway lighting pattern;

d) 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.

Road lighting can present a hazard due to the effect of lighting upon the pilot's visual picture or due to the creation of physical obstacles within the airspace manoeuvring area around the aerodrome. A road lighting scheme could prejudice the safe movement of aircraft on either or both grounds. Each issue should be addressed separately and appropriate measures taken to minimize any hazards identified.

7.8.2.2 Safeguarded obstacle limitation surfaces

NOTE 1 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 [47].

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

NOTE 3 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.

Lighting installations in the vicinity of a military site should be referred to the Ministry of Defence.

7.8.2.3 Design considerations

NOTE 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.

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, and the Ministry of Defence should be consulted.

Aerodromes with instrument landing systems (ILS) also need to determine runway visual range (RVR) during operating hours. Where an aerodrome has ILS facilities, account should be taken of RVR sensor equipment when designing lighting installations.

NOTE 2 Further details regarding dangerous and confusing lights are contained in the Civil Aviation Authority publication CAP 168:2001, Chapter 6 [47]. Attention is particularly drawn to the areas described in Chapter 6, paragraph 1.3 of that document.

It is essential to eliminate interference with the pilot's visual picture and with RVR equipment, and road lighting in the vicinity of aerodromes should be designed to achieve this.

On those roads 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 13201-2:2003, class G4, or a higher class.

NOTE 3 Attention is also drawn to the provisions regarding road lighting of the Air Navigation Order 2000 [46].

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 carefully designed to avoid compromising the visibility of signals. In particular:

- light spill should be minimized in the vicinity of a railway bridge crossing/passing above a road;
- columns should be placed as far away as practicable from a rail bridge or the fence line of railway track;
- unwanted glare should be minimized for the train driver by the use of luminaires conforming to an appropriate G class selected from BS EN 13201-2:2003, Table A.1 or 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.

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 *[48].*

It is essential that any lighting scheme does not affect track visibility for railway operatives. It is also essential, when designing the location of lighting columns adjacent to railways, that any likely foreseeable collision with a lighting column by road traffic does not then lead to a hazard on the railway 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. 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, Scottish Canals in Scotland, and Waterways Ireland in Northern Ireland.

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 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 ME, CE and P series of lighting classes defined in BS EN 13201-2:2003, and the M, C and S series of lighting classes defined in CIE 115:2010 [N1]. 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 13201-1:2004 (undergoing revision) and CIE 115:2010 [N1], 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) **Step 1**: select the lighting class from the relevant table:

- Table A.2: very high speed traffic route ($v \geq 60$ mph), motorized users only;
- Table A.2: high speed traffic route (40 mph < v < 60 mph), mixed users;
- Table A.3: moderate speed traffic route (30 mph > $v \leq$ 40 mph), mixed users;
- Table A.4: conflict areas;
- Table A.5: subsidiary roads, low speed ($v \leq$ 30 mph);
- Table A.6: subsidiary roads, very low speed (walking pace), pedestrians and cyclists;
- Table A.8: city and town centres.

b) **Step 2**: carry out a risk assessment to identify specific lighting needs for the road, as defined in the relevant subclause below.

c) **Step 3**: if necessary, adjust the lighting class up or down based on the assessed risks. The adjustment would normally not be more than 1 class up or down.

d) **Step 4**: adjust the lighting level according to the S/P ratio of the light source when choosing an S class as defined in BS EN 13201:2003, Table 3, or P class as defined in CIE 115:2010 [N1], Table 7, and when the light source has an $R_a \geq 60$. Use Table A.7, which is derived from ILP PLG03 [34].

e) **Step 5**: 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 **4.4.4** and ILP TR27 [30] provide more guidance on this.

Table A.1 to Table A.8, 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, then the visual needs of each have to be considered.

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 the night-time activity and make an appropriate judgement on the lighting class.

A.1.3 Variable 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.

Guidance on variable lighting is given in **4.4.4** and ILP TR27 [30].

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 13201-2:2003 and CIE 115:2010 [N1] and indicates those of comparable level, whether using luminance or illuminance criteria.

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

ME or M class	CE or C class	S or P class
—	CE0 or C0	—
ME1 or M1	CE1 or C1	—
ME2 or M2	CE2 or C2	–
ME3 or M3	CE3 or C3	S1 or P1
ME4 or M4	CE4 or C4	S2 or P2
ME5 or M5	CE5 or C5	S3 or P3
ME6 or M6	—	S4 or P4
—	—	S5 or P5
—	—	S6 or P6

NOTE The data in this table is extrapolated from PD CEN/TR 13201-1:2004 (undergoing revision).

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 ME class, which is detailed in BS EN 13201-2:2003, or the M class, which is detailed in CIE 115:2010 [N1]. 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 ME or 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 ME or 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 13201-2:2003, Table 1a, and CIE 115:2010 [N1], Table 2, 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)]	ME2 or M2	ME3b or M3	ME2 or M2
Low to moderate [B)]	ME3b or M3	ME4a or M4	ME3b or M3
Very low [C)]	ME4a or M4	ME5 or M5	ME4a or 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 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 13201-2:2003, Table 1a, and CIE 115:2010 [N1], Table 2, to be used for the following situations:

- speed: $v \leq 40$;
- users: motorized traffic, slow-moving vehicles, cyclists and pedestrians.

Table A.3 **Lighting classes for traffic routes ($v \leq 40$ mph)**

Traffic flow	**Lighting class**		
	Dual carriageway		**Single carriageway**
	Junction density: high	**Junction density: low**	
High to very high A)	ME3b or M3	ME4a or M4	ME3b or M3
Low to moderate B)	ME4a or M4	ME5 or M5	ME4a or M4
Very low C)	ME5 or M5	ME6 or M6	ME5 or 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 > 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

Step 2 of the selection process is to undertake a risk assessment for the road which will evaluate 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 high percentage 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) [49] 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 [N5], 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.

Step 3 of the selection process would take the assessment of the above parameters and make a judgement on whether the lighting class needs to be adjusted by 1 class higher or lower.

A.3.1.4 White light (mesopic vision)

ILP PLG03 [34] 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 yet 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

Assess the lighting requirements 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, create a lighting profile for the scheme by varying the lighting level at different times during the night or year. Subclause **4.4.4** and ILP TR27 [30] provide more guidance on this.

A.3.2 Conflict areas

The CE or 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 CE lighting classes in BS EN 13201-2:2003, Table 2, and the C classes in CIE 115:2010 [N1], Table 5, 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 will be given in ILP PLG02 [36], currently in preparation.

Table A.4 **Lighting classes for conflict areas**

Traffic route lighting class	Conflict area lighting class
ME1 or M1	CE0 or C0
ME2 or M2	CE1 or C1
ME3 or M3	CE2 or C2
ME4 or M4	CE3 or C3
ME5 or M5	CE4 or C4
ME6 or M6	CE5 or 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 S or P lighting class for a given pedestrian or low speed traffic area are summarized in Table A.5 and Table A.6. The lighting classes S1 to S6 are defined by the lighting criteria given for each class in BS EN 13201-2:2003, Table 3, and lighting classes P1 to P6 are defined in CIE 115:2010 [N1], Table 7. 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, parking places, etc.

For guidance on glare control, see **5.2.2.4**.

Table A.5 **Lighting classes for subsidiary roads with a typical speed of main user $v \leq 30$ mph**

Traffic flow	Lighting class			
	Ambient luminance: very low (E1)	**Ambient luminance: low (E2)**	**Ambient luminance: moderate (E3)**	**Ambient luminance: high (E4)**
Busy [A)]	S3 or P3	S3 or P3	S2 or P2	S2 or P2
Normal [B)]	S4 or P4	S4 or P4	S3 or P3	S3 or P3
Quiet [C)]	S5 or P5	S5 or P5	S4 or P4	S4 or P4

NOTE 1 Table A.5 assumes no parked vehicles – see risk assessment in ***A.3.3.2****.*

NOTE 2 If facial recognition is important then an ES lighting class from BS EN 13201-2:2003, Table 5, or an E_{SC} lighting class from CIE 115:2010 [N1], Table 7, can be selected as an additional criterion. Good colour rendering contributes to better facial recognition. (The ES lighting class in BS EN 13201-2:2003 is expected to be replaced by SC upon publication of the revised edition.)

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 It is recommended that the actual overall uniformity of illuminance U_o be as high as reasonably practicable.

NOTE 5 Grey highlighting indicates situations that would not usually occur in the UK.

NOTE 6 The ambient luminance descriptions E1 to E4 refer to the environmental zone as defined in ILP GN01 [N5].

A) 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.

B) Normal traffic flow refers to areas where the traffic usage is of a level equivalent to a housing estate access road.

C) Quiet traffic flow refers to areas where the traffic usage is of a level equivalent to a residential road and mainly associated with the adjacent properties or properties on other equivalent roads accessed from this road.

Table A.6 **Lighting classes for subsidiary roads with mainly slow-moving vehicles, cyclists and pedestrians**

Traffic flow	Lighting class	
	Ambient luminance: very low (E1) or low (E2)	**Ambient luminance: moderate (E3) or high (E4)**
Busy [A)]	S4 or P4	S4 or P4
Normal [B)]	S5 or P5	S5 or P5
Quiet [C)]	S6 or P6	S6 or P6

NOTE 1 If facial recognition is important then an ES lighting class from BS EN 13201-2:2003, Table 5, or an E_{SC} lighting class from CIE 115:2010 [N1], Table 7, can be selected as an additional criterion. Good colour rendering contributes to a better facial recognition. (The ES lighting class in BS EN 13201-2:2003 is expected to be replaced by SC upon publication of the revised edition.)

NOTE 2 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 3 It is recommended that the actual overall uniformity of illuminance U_o be as high as reasonably practicable.

NOTE 4 Grey highlighting indicates situations that would not usually occur in the UK.

NOTE 5 The ambient luminance descriptions E1 to E4 refer to the environmental zone as defined in ILP GN01 [N5].

A) 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.

B) Normal traffic flow refers to areas where the traffic usage is of a level equivalent to a housing estate access road.

C) Quiet traffic flow refers to areas where the traffic usage is of a level equivalent to a residential road and mainly associated with the adjacent properties or properties on other equivalent roads accessed from this road.

A.3.3.2 Risk assessment

Step 2 of the selection process is to undertake a risk assessment for the road which will evaluate 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 would include parked cars, school entrances, 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 facial recognition**: where there is a need for better facial recognition, an additional semi-cylindrical illuminance class (ES) from BS EN 13201-2:2003, Table 5 [8)], or an E_{SC} lighting class from CIE 115:2010 [N1], Table 7, might be chosen.

Step 3 of the selection process would take the assessment of the above parameters and make a judgement on whether the lighting needs to be adjusted by 1 class higher or lower.

A.3.3.3 White light and the adjustment of lighting class due to the light source (mesopic vision)

Step 4 of the selection process is to make adjustments for the light source with reference to ILP PLG03 [34] and Table A.7, as described below.

ILP PLG03 [34] provides details of the use of different light sources. The report concludes that for the visual tasks associated with lighting pedestrian associated roads, there is benefit to using a light source with a higher S/P ratio.

Table A.7 can be used to make an adjustment to the selected class. It is anticipated that lighting design software programmes will input the S/P ratio of the lamp and calculate to the revised levels.

NOTE Table A.7 is derived from ILP PLG03 [34], and gives S/P ratios for three typical cases. A more complete table giving S/P ratios for different lamps can be found in ILP PLG03, or the manufacturer can be consulted.

[8)] These are expected to become SC classes in the new edition of BS EN 13201-2, currently in preparation.

Table A.7 **Variation of maintained lighting level with S/P ratio of light source**

Values in lux

Lighting class	Benchmark (e.g. R_a < 60 or when S/P ratio of light source is not known or specified)		S/P ratio = 1.2 and $R_a \geq 60$ (e.g. some types of warm white lamp such as metal halide)		S/P ratio = 2 and $R_a \geq 60$ (e.g. some types of cool white compact fluorescent or LED)	
	$\bar{E}$	E_{min}	$\bar{E}$	E_{min}	$\bar{E}$	E_{min}
P1 or S1	15.0	3.0	13.4	2.7	12.3	2.5
P2 or S2	10.0	2.0	8.6	1.7	7.7	1.5
P3 or S3	7.5	1.5	6.3	1.3	5.5	1.1
P4 or S4	5.0	1.0	4.0	0.8	3.4	0.7
P5 or S5	3.0	0.6	2.2	0.4	1.8	0.4
P6 or S6	2.0	0.4	1.4	0.4	1.1	0.4

A.3.3.4 Variable lighting

Assess the lighting requirements 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, create a lighting profile for the scheme by varying the lighting class at different times during the night or year. Subclause **4.4.4** and ILP TR27 [30] provide more guidance on this.

A.3.4 City and town centres

A.3.4.1 General

Table A.8 gives lighting classes for city and town centres having a combination of pedestrians, cyclists and/or motorized traffic, in terms of either the S classes from BS EN 13201-2:2003, Table 3, and the P classes from CIE 115:2010 [N1], Table 7, or the CE lighting classes in BS EN 13201-2:2003, Table 2, and the C lighting classes in CIE 115:2010 [N1], Table 5.

To provide adequate control of glare, an installed luminous intensity class (G class) from BS EN 13201-2:2003, Table A.1 or CIE 115:2010 [N1], Table D.2 would be appropriate.

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 an S or P class rather than a CE or C class. Examples might be where the area is a thoroughfare from one area to another area.

Table A.8 **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	S2 or P2	S1 or P1	S2 or P2	S1 or P1
Pedestrian only	CE4 or C4	CE3 or C3	CE3 or C3	CE2 or C2
Mixed vehicle and pedestrian with separate footways	CE3 or C3	CE2 or C2	CE2 or C2	CE1 or C1
Mixed vehicle and pedestrian on same surface	CE2 or C2	CE1 or C1	CE1 or C1	CE1 or C1

[A)] Environmental zone, as given in ILP GN01 [N5].

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.8, taking account of:

- vehicular traffic use;
- pedestrian and cyclist use;
- on-street parking;
- amenities such as shops, public houses etc.;
- level of crime;
- CCTV requirements;
- competition from shop front and other off-road lighting.

A.3.4.3 Variable lighting

Assess the lighting requirements 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, create a lighting profile for the scheme by varying the lighting class at different times during the night or year. Subclause **4.4.4** and ILP TR27 [30] provide more guidance on this.

Annex B (informative) Typical luminaire maintenance factors

Table B.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 B.1 is only valid for luminaires with a minimum IP rating of IP65.

NOTE 2 Table B.1 is derived from Review of luminaire maintenance factors *[50] 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 B.1 **Luminaire maintenance factors**

Environ-mental zone	Mounting height	Maintenance factor					
		Cleaning frequency 12 months	Cleaning frequency 24 months	Cleaning frequency 36 months	Cleaning frequency 48 months	Cleaning frequency 60 months	Cleaning frequency 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

Annex C (informative) Maintenance factors for LED luminaires

For lighting design, the overall maintenance factor for LED luminaires takes into account the following factors:

- the lumen maintenance of the LEDs at the end of their rated life – this is equivalent to lamp lumen maintenance factor (LLMF);
- the failure fraction of the LEDs at the end of their rated life – this is equivalent to lamp survival factor (LSF);
- the reduction in light output owing to the accumulation of dirt on the light-emitting parts of the luminaire (luminaire maintenance factor, LMF) – typical values are shown in Table B.1.

The life of LEDs (L_x) is defined as the length of time during which the LEDs will provide more than a claimed percentage (*x*) of the initial light output. A manufacturer will declare values for life and lumen maintenance, usually at a specified ambient temperature. For example, L_{70} (50 000 h) at 25 °C indicates that after an operating time of 50 000 h, 70% of the initial luminous flux will be emitted for a luminaire operating in an ambient of 25 °C. Using this example, the LED lumen maintenance factor is 0.7 at 50 000 h.

The factor L_x takes into account the general decline of light output over life. In addition to this there is likely to be a failure of LEDs, comprising both catastrophic (total) failure and a steep decline in light output to a value considered to be below acceptable operation. The failure rate over the rated life is defined as the failure fraction (F_y) where *y* is the percentage of LEDs that will have failed at the end of rated life. For example, F_{10} (50 000 h) indicates that 10% of the LEDs will no longer be considered operational at 50 000 h. For lighting design the failure fraction F_y needs to be taken into account. Using the example, if 10% of the LEDs have failed then 90% will be operational; this is equivalent to a survival factor of 0.9.

For LED luminaires the overall maintenance factor for lighting design, based on the rated life of the LEDs, is:

$$\left(\frac{\text{percentage of initial light output } (x)}{100}\right) \times \left(\frac{100 - y}{100}\right) \times \text{LMF (from Table B.1)}$$

For example, for the following parameters:

- IP66 luminaire installed at 8 m in environmental zone E3;
- cleaning frequency 72 months;
- LED rated life 50 000 h;
- using the values of *x* and *y* given above;

the overall maintenance factor would be:

$$\left(\frac{70}{100}\right) \times \left(\frac{100 - 10}{100}\right) \times 0.92 = 0.58$$

Further information about the factors L_x and F_y is given in *A guide to the specification of LED lighting products* [1].

Annex D (informative) Sustainability

COMMENTARY ON ANNEX D

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 publication on street lighting [29] gives general principles for street lighting. These include due consideration of a whole life costing approach, good design and energy-efficient equipment under EC Regulation No. 245/2009 [33].

D.1 General framework

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 works on site prior to operation, including confirmation that the installed scheme is in accordance with the design and programming of controls;
- operation – the life-time between installation and decommissioning;
- maintenance – planned and unplanned activities to ensure that the scheme continues to function as designed;
- decommissioning – the removal and disposal of some or all of the lighting infrastructure from the site at the end of life.

The following need to be considered for each stage of the scheme lifecycle.

- **Economic sustainability**: ensuring that the lighting scheme is cost effective over its anticipated life-time. 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 of crime and economic considerations.

The lifecycle stages and their associated sustainability criteria are outlined in Table D.1.

Table D.1 **Lifecycle stages and associated sustainability criteria**

Lifecycle stage	**Sustainability criteria**		
	Economic	**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 • Consider variable lighting or other control policies	• Minimize environmental impact – factors include obtrusive light and effects on wildlife	• Optimize the visual impact • Consider the benefit of lighting as an amenity
Design	• Ensure that intended benefits will be realized • 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 effects • Minimize obtrusive light	• Consider the benefits including safety (actual and perceived) and commercial (e.g. increased footfall) • Minimize potential adverse effects (e.g. delays) during 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 (re-use 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 variable lighting and/or trimming to minimize obtrusive light and CO_2 emissions	• Ensure that the amenity benefits identified at the policy stage are realized
Maintenance	• Adhere to the maintenance policy established at the design stage • Review the maintenance policy to take account of changing circumstances (e.g. technology and legislation)	• Re-use or recycle replaced components • Use energy-saving components wherever possible	• Minimize adverse effects on nearby residents and on road users • Consider the safety of road users and the workforce
Decommissioning and disposal	• Consider re-use 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 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 13201-2:2003, Table 1a or CIE 115:2010 [N1], Table 2.

If additional light control is required to further limit glare, or for environmental reasons, an installed intensity class is selected from BS EN 13201-2:2003, Table A.1 or CIE 115:2010 [N1], Table D.2.

E.2.2 Adjacent areas

The lighting of any areas adjacent to the carriageway, such as footways, cycle tracks and verges, are 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 surround ratio (SR) or edge illuminance ratio (EIR) 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 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 13201-2:2003, Table 2 or CIE 115:2010 [N1], Table 5, and an installed intensity class selected from BS EN 13201-2:2003, Table A.1 or CIE 115:2010 [N1], Table D.2.

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 13201-2:2003, Table 2 or CIE 115:2010 [N1], Table 5 for horizontal illuminance, or from BS EN 13201-2:2003, Table 6 or CIE 115:2010 [N1], Table 7 for vertical illuminance.

NOTE Further guidance on lighting of pedestrian crossings is given in ILP TR12 [43].

E.2.5 Choice of lighting arrangement

The choice of lighting arrangement is normally made from those described in **4.3.4.3**. 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, economic 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 has to be 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 B.1);

i) light source replacement interval;

j) lamp flux maintenance factor at replacement interval;

k) maintenance factor (MF);

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 surround ratio (SR)/edge illuminance ratio (EIR), 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;

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 [43].

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 13201-2:2003. 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 necessary to ensure that the design is in accordance with the requirements of the selected lighting class from BS EN 13201-2:2003 or CIE 115:2010 [N1]. 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. Individual lighting column positions are checked on site for existing roads, or against the road design for new roads, to ensure that they are feasible, and for aesthetic acceptability.

The major issues that are encountered at this stage include:

- overhead power lines or other obstruction;
- underground power lines or other utility services;
- trees, including potential growth and accounting for summer foliage;
- dropped kerbs;
- minimizing obtrusive light;
- locations on property boundaries and away from windows;
- 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 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 13201-2:2003, Table 3, or CIE 115:2010 [N1], Table 7 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 semi-cylindrical illuminance and uniformity, this is selected from BS EN 13201-2:2003, Table 5, or CIE 115:2010 [N1], Table 7.

In order to limit glare, a luminous intensity class is selected from BS EN 13201-2:2003, Table A.1, or CIE 115:2010 [N1], Table D.2.

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) The relevant area of traffic calming measures may be determined in accordance with the information in PD CEN/TR 13201-1:2004, **5.3.8** (undergoing revision).

d) For a separate footpath or cycle track, the relevant area may be extended beyond the actual width of the path or track, in accordance with the information in PD CEN/TR 13201-1:2004, **5.3.8** (undergoing revision).

F.3 Preliminary data

Having selected the appropriate lighting class(es), and installed intensity class where necessary, the following preliminary data has to be 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 B.1);

i) light source replacement interval;

j) light source flux maintenance factor at replacement interval;

k) maintenance factor (MF);

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;

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 ensure that they are feasible, and for aesthetic acceptability.

The major issues that are encountered at this stage include:

- overhead power lines or other obstruction;
- underground power lines or other utility services;
- trees, including potential growth and accounting for summer foliage;
- dropped kerbs;
- minimizing obtrusive light;
- locations on property boundaries and away from windows;
- 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 has to be 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;

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 13201-2:2003 or CIE 115:2010 [N1];

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 13201-2:2003;

  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;

g) whether planning and/or listed building consent is required.

G.5 Calculation of design geometry

The procedures set out in BS EN 13201-2:2003 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 that 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:

- overhead power lines or other obstruction;
- underground power lines or other utility services;
- trees, including potential growth and accounting for summer foliage;
- dropped kerbs;
- minimizing obtrusive light;
- locations on property boundaries and away from windows;
- avoiding locations where lighting columns could be struck by a vehicle.

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