BRITISH STANDARD

BS 5489-1:2003
Incorporating
Corrigendum No. 1

Code of practice for the design of road lighting —

Part 1: Lighting of roads and public amenity areas

ICS 93.080.40

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee CPL/34/8, Road lighting, upon which the following bodies were represented:

Chartered Institution of Building Services

Council for the Protection of Rural England

County Surveyors' Society

Department of Transport, Local Government and the Regions — Construction Directorate

Department of Transport, Local Government and the Regions — Highways Agency

General Aviation Awareness Council

Institution of Electrical Engineers

Institution of Lighting Engineers

Institution of Mechanical Engineers

Lighting Industry Federation Ltd

Scottish Office — Construction and Building

Co-opted members

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 11 December 2003

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 11 December 2003

The following BSI references relate to the work on this British Standard:
Committee reference CPL/34/8
Draft for comment DC 00/241997

ISBN 0 580 42711 0

Amendments issued since publication

Amd. No.	Date	Comments
15031 Corrigendum No. 1	10 March 2004	Two rows added to Table B.2

Contents

Foreword

This part of BS 5489 has been prepared by Technical Committee CPL/34/8. It supersedes BS 5489-1:1992, BS 5489-2:1992, BS 5489-3:1992, BS 5489-4:1992, BS 5489-5:1992, BS 5489-6:1992, BS 5489-8:1998, BS 5489-9:1996 and BS 5489-10:1992, which are withdrawn.

The revision and consolidation of BS 5489 has been carried out following the publication of BS EN 13201, which has resulted in a need to withdraw many clauses of the formerly separate parts of BS 5489, and to adapt many remaining clauses to the technical requirements and terminology of the European Standard.

This new edition of BS 5489 contains guidance and recommendations that are intended to support BS EN 13201 and to enable designers of lighting systems to comply with that standard. The new edition of BS 5489 consists of two parts only:

a) BS 5489-1, which gives guidance and recommendations for the lighting of roads and public amenity areas;

b) BS 5489-2, which gives guidance and recommendations for the lighting of tunnels.

This new edition of this part of BS 5489 has been introduced following a full review, and introduces many technical and editorial changes to align BS 5489 with BS EN 13201.

Attention is drawn to the statutory requirements listed in Annex A.

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 does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 75 and a back cover.

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1 Scope

This part of BS 5489 gives recommendations on the general principles of road lighting, gives recommendations on aesthetic and technical aspects, and advises on statutory provisions, operation and maintenance.

It gives recommendations for the design of lighting for all types of highways and public thoroughfares, including those specifically for pedestrians and cyclists, and for pedestrian subways and bridges, but it excludes the lighting of vehicular tunnels and underpasses, 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, harbours and navigable waterways, in order to minimize the possibility of the lighting interfering with these modes of transport.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 5266 (all parts), *Emergency lighting.*

BS 6100-2 (all sections), *Glossary of building and civil engineering terms — Part 2: Civil engineering.*

BS 6651:1999, *Code of practice for protection of structures against lightning.*

BS 7430, *Code of practice for earthing.*

BS 7671, *Requirements for electrical installations — IEE wiring regulations — Sixteenth edition.*

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 12464-1:2002, *Light and lighting — Lighting of workplaces — Part 1: Indoor 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 and test methods.*

BS EN 13201-2:2003, *Road lighting — Part 2: Performance requirements.*

BS EN 13201-3:2003, *Road lighting — Part 3: Calculation of performance.*

BS EN 13201-4, *Road lighting — Part 4: Methods of measuring the light performance of installations.*

BS EN 60598-1, *Luminaires — General requirements and tests.*

BS EN 60598 –2-18, *Luminaires — Particular requirements — Luminaires for swimming pools and similar applications.*

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 13201-2, BS EN 13201-3, BS EN 12665, 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
conservation area
statutory, designated geographical area of architectural merit needing special attention to preserve its character

3.1.3
design spacing
required distance between the geometric centres of adjacent road lighting luminaires, calculated as specified in BS EN 13201-2, for a straight and level section of the particular type of road

3.1.4
emergency lane
lane parallel to the traffic lane(s), not destined for normal traffic, but for emergency (police) vehicles and/or for broken-down vehicles

NOTE An emergency lane is commonly referred to as a "hard shoulder".

3.1.5
footbridge
bridge over an obstacle to pedestrians, provided for the passage of pedestrians only

NOTE Cyclists are sometimes permitted to use footbridges.

3.1.6
geometry
interrelated linear dimensions and characteristics of the road lighting system, i.e. spacing, mounting height, transverse position and arrangement

3.1.7
high-mast lighting
system of lighting for large areas using masts carrying clusters of luminaires

3.1.8
lower viewpoint
any location off the structure from where a side view of the bridge or elevated road can be seen in full or oblique elevation

3.1.9
mounting height
nominal vertical distance between the geometric centre of a road lighting luminaire and the surface of the road

3.1.10
residential road
road that carries little vehicular traffic, other than that generated by residents

3.1.11
road bridge
structure carrying the road under consideration over another road, railway, river, etc.

3.1.12
set back
shortest distance from the forward face of a lighting column to the edge of a carriageway

3.1.13
shared surface
surface of a road used in common by vehicles, cyclists and pedestrians, typically occurring in compact housing layouts

3.1.14
sparkle
subjective contribution by a luminaire to the enhancement of the visual scene made without causing visual discomfort or disabling glare

3.1.15
traffic flow
number of vehicles passing a specific point in a stated time in both directions

3.1.16
upper viewpoint
any location on the structure of a bridge or elevated road where a view along the structure can be seen

3.2 Symbols

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

$\overline{E}$	maintained average horizontal illuminance, in lux (lx)
E_{min}	maintained minimum horizontal illuminance at any point, in lux (lx)
F	initial luminous flux of lamp or lamps in luminaire, in lumens (lm)
H	mounting height, in metres (m)
MF	maintenance factor
R_A	colour rendering index factor
r	reduced luminance coefficient
S	design spacing, in metres (m)
TI	threshold increment, as a percentage (%)
W_L	width of driving lane, in metres (m)
W_r	width of relevant area of carriageway, in metres (m)
β	angle of deviation, in degrees (°)
γ	vertical photometric angle, in degrees (°)
θ_f	luminaire tilt in application, in degrees (°)

4 General principles

NOTE Attention is drawn to the statutory requirements listed in references [1] to [15]. Further information on the relevant regulations is given in Annex A.

4.1 Aims of road lighting

Road lighting encompasses the lighting of all types of highways and public thoroughfares, assisting traffic safety and ease of passage for all users. It also has a wider social role, 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.

Road lighting should reveal all the features of the road and traffic that are important to the different types of road user, including pedestrians and police.

NOTE 1 These can include the limits of the carriageway and the footway, obstructions and defects in the road, and the presence and characteristics of other road users.

It is not a primary function of lighting to indicate the routing of 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 drivers as to the route ahead (see **5.2.4.1**).

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 good conditions. Traditionally, footway lighting has often been considered little beyond functional lighting for the space alongside the carriageway. But lighting can offer more and consideration should be given to creating an environment that is pleasant and interesting as well as satisfying the basic functional objectives for lighting.

NOTE 2 The creation of such an environment can be affected by factors including the appearance of lighting columns and luminaires, the scale of equipment related to people and buildings, and the colour temperature and colour rendition of the light source.

4.2 Principles of road lighting for vehicular traffic

4.2.1 *The visual task*

The driver of a moving vehicle has to absorb sufficient visual information from the continually changing view in front of the vehicle in order to proceed safely at reasonable speed, see the route ahead, respond to signs and manoeuvre in good time.

As only a small part of the central field of vision of a driver is in sharp focus, most information is received peripherally and, therefore, not in detail. A driver is likely to focus directly on a significant object that appears in the field of vision, but for a driver 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 driver's ability to perceive contrast is considerably poorer at low lighting levels. Road lighting should, therefore, aim to provide the appropriate class of lighting in accordance with BS EN 13201-2, so as to provide adequate brightness of the general scene and to maximize the contrast between objects and their background.

NOTE 1 In some circumstances this contrast will be negative, with objects seen in dark outline against a bright background, and in others the contrast will be positive, with directly lighted objects brighter than the background.

NOTE 2 Information on the appropriate class of lighting for different situations is given in Annex B and in CEN/TR 13201-1.

Whereas in most lighting the aim is to light objects rather than backgrounds, in road lighting for vehicular traffic the converse is true in most situations, with the exception of subsidiary roads (see Clause **9**), some conflict areas (see Clause **11**), and pedestrian areas and car parks in urban centres (see Clause **10**). When lighting of the background is desired, the relatively small amount of light available should be used to maximum effect by lighting the road surface and the immediate surrounds against which the objects will generally appear in silhouette. 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 3 The relationship between the function of the luminaire and the road surface in traffic route lighting is described in Annex C.

4.2.2 *Visual guidance*

The lighting installation should give visual guidance by revealing the run of the road, particularly at T-junctions and bends. This visual guidance is the aspect of the lighting that complements 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 drivers have an unambiguous view of the road at the end of the lighting.

4.2.3 *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 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 This light is also of assistance to the pedestrian as it reveals the footway surface, obstructions and other pedestrians. Moreover, it is needed to reveal pedestrians about to step into the carriageway and vehicles emerging from side roads.

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 to the values given in BS EN 13201-2:2003, Table 1a) and Table 1b), calculated in accordance with BS EN 13201-3:2003, **8.5**.

For traffic routes with heavily trafficked adjacent footways and/or cycle tracks, an appropriate lighting class from BS EN 13201-2 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 considered as a separate area for the purpose of calculation.

NOTE 2 Information on the lighting class selection for emergency lanes is given in Annex B.

On motorways without an adjacent emergency lane, surround ratio should be applied to the adjacent verge.

4.3 Glare

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 to control disability glare, and maximum values of this parameter are set for each ME and MEW lighting class in BS EN 13201-2. At conflict areas on traffic routes, *TI* cannot always be applied and in these situations luminaire intensity limits should be used as recommended in **11.1.4**.

For residential and subsidiary roads, intensity limits should be used to control direct glare from luminaires as recommended in **9.1**.

5 Appearance, siting, environmental aspects and hours of operation

5.1 Appearance

5.1.1 *General*

This clause indicates some matters that should receive attention and gives recommendations, but it is recognized that in aesthetics subjective judgements can apply. Furthermore, considerations of safety 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.

5.1.2 *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.

NOTE It can be desirable for the equipment to be specially designed for this purpose.

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.

5.1.3 *Night-time appearance*

An aspect of planning any lighting scheme is the positive contribution it can make to the improvement of the night environment. Much can be done in basic design to ensure that the lighting directly helps to create a pleasant and attractive after-dark atmosphere, especially for areas of civic importance (see Clause **10**).

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 lighting urban and residential roads, amenity and environmental requirements should always be given full consideration and there should be an evaluation of the assistance lighting can afford to crime prevention. Careful consideration should be given to the colour rendering index of the lamp (R_a). For urban and residential roads the light source used on such roads should have an $R_a \geqslant 20$. 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 $R_a \geqslant 60$ should be used. Where street crime is a major problem and the police use CCTV for prosecution, the use of light sources with an $R_a \geqslant 80$ can be advantageous. The colour appearance of lamps should be quantified by the correlated colour temperature (T_{CP}), and should be in accordance with one of the categories in Table 1.

Table 1 — Lamp colour appearance groups

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

5.2 Siting

5.2.1 *Siting of lighting columns*

5.2.1.1 *General*

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.

Siting of lighting columns adjacent to bridges should be such that the light from the luminaire is not obstructed and does not cause problems of nuisance or glare to users on top of 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.

NOTE 1 If lighting columns are essential in front of scenic views they may sometimes be placed against groups of trees to mitigate the effects on the view.

Trees in streets and front gardens contribute greatly to the effectiveness of the street scene and deserve special consideration. Here, lighting columns when first installed should be sited so as not to require serious cutting back of trees.

NOTE 2 In an avenue, an alternative is to mount luminaires centrally. 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 first and the planting sites fixed afterwards.

NOTE 3 Trees of suitable habit for a street may be chosen and their effect when mature and in leaf may be considered in relation to potential interference with the lighting.

NOTE 4 It is not necessary for trees to be closely planted to give an attractive impression.

NOTE 5 Careful siting of trees and luminaires can help to minimize interference with the performance of the lighting by the foliage.

5.2.1.2 *Lighting columns as hazards*

Many accidents involve a motor vehicle leaving the carriageway, and if the vehicle collides with a lighting column the severity of the injuries to the occupants is likely to 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 desirable clearances according to the design speed of the road given in Table 2 should therefore be achieved wherever possible. The set-back of lighting columns should be sufficient to allow the free passage of blind and disabled people, and those with prams, on any footway.

NOTE 1 Where practicable, it can be preferable to support the luminaires on wall brackets on adjacent buildings.

NOTE 2 Attention is drawn to the Public Health Act 1985 [2] in respect of the fixing of public lights to buildings.

NOTE 3 In situations such as motorways, where lighting columns are often protected by safety barriers, the set-back is determined by the design requirements of the safety barrier.

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

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.

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. In that position they are less likely to suffer impact from passing vehicles. Also they 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, consideration should be given to siting the lighting columns in this verge, if adequate clearance from the carriageway can be maintained in accordance with Table 2.

In siting lighting columns in residential areas, consideration should also be given to the convenience of occupants with regard to windows, entrances, drives, etc.

5.2.1.3 *Breakaway or energy absorbing lighting columns*

As indicated in **5.2.1.2**, when vehicles collide with lighting columns the occupants can suffer severe injuries. On roads where traffic speeds are high and there are few pedestrians, or in situations where collisions with lighting columns are probable, the installation of breakaway or energy absorbing lighting columns as an alternative to rigid lighting columns should be considered to reduce the severity of injury. 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 breakaway or energy absorbing lighting columns are to be used.

5.2.2 *Mounting heights*

When choosing the mounting height, consideration should be given to both technical and economic constraints and daytime appearance.

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).

5.2.3 *Lighting unit assemblies*

5.2.3.1 *General*

The lighting unit should be considered 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.

5.2.3.2 *Size and type of luminaires*

The dimensions and profile of the luminaire should be considered against its background.

NOTE Long, deep luminaires can look oppressive against the open sky, but can be acceptable against a background of high buildings.

5.2.3.3 *Form of bracket*

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.

5.2.3.4 *Material of lighting column and bracket*

The material of the lighting column and bracket can affect both their finish and their shape in cross-section. For aesthetic reasons the lighting column and bracket should be as slender as possible.

5.2.3.5 *Colour of lighting equipment*

Colour and finish should be considered 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.

5.2.3.6 *Lighting arrangements*

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

NOTE 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 where brackets are turned in many directions, the effect can be very unpleasing, particularly with long luminaires or inclined luminaires. Where complex layouts involve both horizontal and vertical curves, and changes of radius, attempts should be made to avoid the use of equipment with complex outlines.

Where brackets are used at complex junctions, simple straight designs with a uniform uplift should be used to avoid the tangled web effect of curved brackets of varying projections and alignments. Using a fewer number of higher lighting columns each with multiple luminaires on short brackets, post-mounted luminaries, and high-mast installations, are all solutions that should be considered to alleviate this problem.

The following arrangements of lighting should be considered.

a) twin central: used on dual carriageways and motorways; provides clear visual guidance for the through route at T-junctions;

b) opposite: used on wide roads or dual carriageways where twin central are not suitable due to narrow central reserve width, ground conditions or maintenance access constraints;

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

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

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.

5.2.4 *Siting of luminaires*

5.2.4.1 *General*

The pattern of luminaires for special requirements such as intersections and bends should be laid out first. The pattern necessary for uninterrupted sections of road can then be added to the layout. An installation should both be cost-effective and meet appearance and environmental requirements.

NOTE 1 In rural areas, there are generally fewer physical constraints than in urban areas but the same principles apply.

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

NOTE 2 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 **4.2.3** for the lighting of adjacent areas such as footways and cycle tracks, using either surround ratio or a specific lighting class applied to the adjacent areas.

5.2.4.2 *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 lamp 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.

5.2.4.3 *Luminaire arrangements for dual carriageways*

Where dual carriageways are separated by a wide central reserve, the carriageways should be treated separately. Normally, when the distance between the outer carriageway edges is not excessive, dual carriageways can be lit as a single road.

NOTE With the use of appropriate mounting height and luminaire and lamp 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.

5.2.4.4 *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 that conform to installed intensity classes G4, G5 or G6 of BS EN 13201-2:2003, Table A.1 should be used.

Similar considerations apply to the lighting of some bridges (see **5.2.4.5**).

5.2.4.5 *Lighting on bridges*

Special problems of appearance arise where road lighting on bridges is concerned, related to various viewpoints, the relationship with the features and scale of the structure, and to bridges of particular historical and architectural interest. The recommendations in Clause **8** should be followed.

5.3 Minimizing light in directions where it is neither necessary nor desirable

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.

Light above the horizontal should be minimized in all road lighting installations by controlling the intensity of light from luminaires at high angles.

NOTE 1 The installed intensity classes from BS EN 13201-2:2003, Table A.1 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 can be beneficial in enhancing the appearance of the area and the protection of property.

NOTE 2 Further information is given in the ILE publication *Guidance notes for reduction of light pollution* [16].

Lighting schemes in, or adjacent to, environmentally sensitive areas, seen from within these and adjacent areas, should be given particular attention. Such areas include green belts, national 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 on adjoining areas, by selection of an appropriate installed intensity class from BS EN 13201-2:2003, Table A.1.

In the following situations, luminaires which when installed conform to classes G4, G5, or G6 of BS EN 13201-2:2003, Table A.1 should be used:

— traffic routes 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;

— motorways in open areas;

— remote isolated junctions.

NOTE 3 For information on lighting in the vicinity of astronomical observatories, refer to the joint IAU/CIE publication *Guidelines for minimising urban sky glow near astronomical observatories* [17] and the CIE publication *Guideline for minimising sky glow* [18].

5.4 Hours of operation

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 following matters should be considered on operation once the decision to light has been taken.

NOTE 1 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.

NOTE 2 Attention is drawn to the statutory requirements listed in **A.2** in respect of empowerment to light roads.

NOTE 3 In CEN/TR 13201-1, parameters relevant to lighting are used in the selection of lighting classes, and in CEN/TR 13201-1:2003, **6.1.3** it is explained that these parameters can vary during the night, and thus within the hours of operation the lighting class may be varied. This can be achieved by dimming or switching techniques.

NOTE 4 See also Annex B.

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. Nevertheless, in some limited situations a lighting installation may be completely extinguished during certain periods of the night when usage is very low. Where crime prevention is an important consideration, however, lighting should not be extinguished.

If individual luminaires are extinguished in order to reduce lighting levels to a lower class from BS EN 13201-2, the correct lighting parameters for that class should be maintained.

6 Equipment, maintenance and safe working clearances

6.1 Light sources

A wide range of light sources are available that are suitable for road lighting.

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 lamp efficacy in terms of lumens per watt (lm/w). Consideration should be given to the efficiency of the complete lighting installation, taking into account the effectiveness of the lamp and luminaire combination in providing the selected class of lighting on the road, with the desired degree of colour rendering.

b) *Colour rendering*. For advice on the colour rendering of light sources refer to **5.1.3**.

c) *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 **6.4.4**).

6.2 Luminaires

Luminaires should conform to BS EN 60598-1. The sealing of luminaires, and their resistance to the ingress of dirt and water, is indicated by their international protection code (IP) number.

NOTE See BS EN 60529 for further information.

Luminaires with an IP number in the range IP 2X 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. Consideration should be given to the IP number of both the optical compartment and the control gear compartment.

6.3 Lighting columns

Lighting columns should conform to BS EN 40. 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.

6.4 Maintenance

6.4.1 *General*

In BS EN 13201-2 the lighting classes are given in terms of maintained levels. In order to comply, and to ensure the provision of the selected class, it is essential that appropriate luminaire cleaning and lamp replacement routines are closely followed. Maintenance programmes should include lamp replacement, luminaire cleaning, renewal of failed parts, checking of gaskets and optical components, and monitoring of operation.

NOTE 1 Monitoring is usually by means of night-time inspection. However, recent technical advances in electronic systems can provide viable alternatives.

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 will depend on the quality of the original materials and the IP number of the luminaire, but eventually the restoration of photometric performance might necessitate replacement of the optical system or even of the whole luminaire. When site tests are carried out to establish that the performance of the system continues to be acceptable as materials and equipment degrade, the guidance given in BS EN 13201-4 should be followed.

The procedure for replacement of lamps is a matter of local policy, cost and lamp type used. The cost of replacing lamps on demand should be compared to that of group replacement. In making the comparison, the following factors should be considered as a minimum:

a) the shape of the lamp survival curve for its environment (from manufacturers' data);

b) the lamp luminous flux maintenance curve for the specific lamp control gear combination (from manufacturers' data);

c) system power consumption variation through life cycle;

d) interference with traffic, ease of access and extent of traffic management required;

e) the required frequency of night inspection monitoring;

f) the frequency of need for cleaning of luminaires, related to the local environment and the IP number of the lamp enclosure;

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

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

i) the frequency of inspection for electrical safety;

j) the frequency of inspection for structural safety of lighting columns and other supporting systems.

Maintenance inspection should include checks on luminaire aiming and screening.

NOTE 2 Aiming and screening can have particular safety implications when lighting is in the vicinity of aerodromes or other transport systems (see Clause **12**).

6.4.2 *High-mast lighting*

High-mast lighting systems and other specialized installations using more complex mechanical, hydraulic, or electrical equipment, might require additional maintenance. They should be inspected and maintained regularly in accordance with manufacturers' recommendations, and depending on local conditions.

NOTE Detailed inspection regimes are provided in ILE Technical Report No. 7 [19].

6.4.3 *Roads with limited maintenance access*

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

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 adequate protection, by appropriate traffic management measures, of lighting maintenance personnel and vehicles;

d) the minimizing of 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;

NOTE If the safe working zone overlaps into the left-hand traffic lane, diversion of traffic from that lane might be necessary.

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

6.4.4 *Maintenance factor*

The luminance or illuminance levels should not in service fall below the values specified for the lighting class selected from BS EN 13201-2, as these are maintained levels. The calculation method in BS EN 13201-3 should be used to determine luminance and illuminance levels and quality criteria.

NOTE 1 This method incorporates a maintenance factor (*MF*), which is a product of the lamp maintenance factor and the luminaire maintenance factor.

The lamp luminous flux maintenance factor should be obtained from the lamp manufacturer's data, taking account of lamp type, operating environment and lamp change policy.

NOTE 2 The luminaire maintenance factor is influenced by the quality of sealing of the lamp compartment (represented by the IP number), the local environmental pollution, and the frequency of cleaning. Typical values of luminaire maintenance factors that take into account these aspects are given in Annex D. Alternatively, luminaire maintenance factors established by local testing may be used.

6.4.5 *Safe working clearances near overhead electricity supply lines*

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

NOTE These clearances may be achieved by the adoption of such measures as lower mounting height or hinged lighting columns. Where axial median catenary lighting is used, it is sometimes necessary to interrupt the suspension system at an overhead line crossing. The operator of the line should be consulted regarded safe working clearances and to establish the accurate position and height of the line.

7 Lighting of traffic routes

7.1 General

NOTE 1 This clause 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 and an outline of the design process for motorways is given in Annex F.

NOTE 2 Attention is drawn to the statutory requirements listed in **A.3** and **A.4** in respect of lighting of previously unlit roads.

An appropriate lighting class should be selected from those given in BS EN 13201-2:2003, Table 1a) and Table 1b).

NOTE 3 Information on the selection of lighting classes is given in Annex B.

NOTE 4 Further information can be found in CEN/TR 13201-1.

For the lighting of conflict areas, including single level and grade-separated junctions, pedestrian crossings and crossovers, the recommendations in Clause **11** should be followed.

7.2 Calculation procedure

The calculation procedure for straight roads given in BS EN 13201-3:2003, Clause **7** 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, and the designer should use a table that is appropriate for the particular carriageway which is the subject of the design.

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 Annex C gives typical *r*-tables for the "representative British road surface" in Table C.2, and for a concrete road surface in Table C.3.

NOTE 3 For porous asphalt, the standard reflection table R2 given in the joint CIE/PIARC publication *Road surfaces and lighting* [20] may be used, but with a value of $Q_o = 0.05$.

An *r*-table will normally be used which represents a dry road surface. In BS EN 13201-2:2003 the option is given in Table 1b) 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.

7.3 Spacing for bends

The calculation procedure described in **7.2** 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.

Transferring the straight road spacing to a bend is unlikely to reduce the value of average luminance. Longitudinal uniformity is not a relevant criterion on bends, as the viewing distance is reduced, and the normal direction of view of the driver 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, Table 1.

NOTE The lighting design for bends on traffic routes may be checked by means of isoluminance templates for the luminaire concerned. An example of such a procedure is given in Annex G.

8 Lighting of bridges and elevated roads

8.1 General

NOTE 1 This clause gives recommendations for the technical and aesthetic considerations of designing lighting for road bridges, footbridges and elevated roads.

The lighting scheme should provide the selected class of lighting from BS EN 13201-2 for each area, including carriageways, footways and cycle tracks, giving a high priority to considerations of safety and maintenance.

NOTE 2 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 **5.2.1.1** and **5.2.1.2**).

The lighting equipment can be conspicuous and, therefore, special attention should be given to aesthetic considerations by day and by night, both from the viewpoint of the bridge/road itself and from the surrounding neighbourhood. Various systems of lighting such as conventional columns, high-mast lighting, floodlighting, catenary lighting, unidirectional lighting or low-level lighting should be considered, but whichever is used the lighting scheme should conform to the requirements specified in BS EN 13201-2 for the selected lighting class.

8.2 Lighting for bridges

8.2.1 *Bridge characteristics and associated landscape features*

The design of lighting for a bridge should take account of the character and structure of the bridge and the surrounding environment.

NOTE 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 driver. Drivers approaching the crest of a 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. An appropriate installed intensity class from BS EN 13201-2:2003, Table A.1 should be selected in order to mitigate such problems.

Further technical 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 Clause **11**.

8.2.2 *Structural considerations*

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.

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, should be such as to minimize the possibility of detrimental oscillations occurring.

On new bridges, the positions for lighting columns and the location of power supply cables should be decided at a sufficiently early stage in the design to ensure the provision of suitable space, fixings and protection for them.

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

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

8.2.3 *Appearance of bridge lighting installations*

8.2.3.1 *Viewpoints*

General advice on the daytime and night-time appearance of road lighting installations is given in Clause **5**. Some special problems can arise where bridges are concerned. These vary so much in individual cases that only broad guidelines can be suggested.

The upper and lower viewpoints should be considered in accordance with **8.2.3.2** and **8.2.3.3** respectively.

8.2.3.2 *Upper viewpoint*

Lighting columns and luminaires on bridges are often silhouetted against the sky and so are more conspicuous than those at the approaches; consequently equipment suitable for the approaches is not always suitable for the bridge. This is particularly so where the bridge has a strong character of its own or forms the gateway to a town.

Where a bridge has major structural elements above deck level, the lighting equipment should be related to these elements. The lighting columns and luminaires should either be combined with the structure or be so placed as to not conflict unduly with the structural forms. A lighting column seen against a structure is often less obtrusive than one seen against the sky. In its detailed design the equipment should be sympathetic to the structure, except on very large bridges where lighting columns will be no more than minor intrusions in a scene dominated by the structure.

Where the main structure of the bridge is wholly below deck level, the bridge parapet should be the main consideration. The detailed lighting design should be sympathetic to that of the parapet and, where there are important structural elements in the parapet, their spacing should be taken into account when siting the lighting columns. Some bridges, however, particularly older ones, have a heavy masonry parapet, perhaps originally designed to carry lighting equipment. Where the bridge is not too wide and the spacing as determined in BS EN 13201-3 is feasible, it can be preferable to site the new equipment on the parapet, but in this case the new equipment should be in proportion to the dimensions of the bridge.

NOTE 1 If this arrangement is impractical it is advisable to keep lighting columns well clear of the parapet and it can be visually preferable to site the lighting columns on a central reserve.

NOTE 2 Where a combination of side-mounted and centrally mounted luminaires is necessary, it is preferable to achieve overall consistency in the design of the equipment, co-ordinating it with the structure and parapets if possible, rather than to closely relate the side-mounted equipment to the structure and have different equipment on the central reserve.

8.2.3.3 *Lower viewpoint*

The lower viewpoint is aesthetically more important than the upper viewpoint in most cases and is often more difficult to consider. The installation is seen in relation to both substructure and superstructure above parapet level, and the height and spacing of lighting columns should be related to the design of the bridge. It is preferable, for example, to have a lighting column either wholly clear in silhouette or wholly hidden, than apparently cut in half by the upper flange of a girder or suspension cable.

On very large bridges, the scale of the superstructure above parapet level permits greater freedom in the design of the lighting installation. On smaller bridges it might be possible, e.g. with bow-string girders, to make the lighting equipment inconspicuous in daytime as seen from the side of the bridge. In other cases it can be practicable to attach the luminaires to the superstructure above parapet level. Where there is no superstructure above parapet level, the lighting installation is a very prominent feature of the side view and therefore extra aesthetic care should be taken. On very long bridges, the lighting columns are less dominant and the spacing and arrangements are likely to be more important than the height and detailed design. If there is a recurring feature in the structure, e.g. a series of heavy arches, the spacing should be related to this feature.

The arrangement of luminaires on the bridge should also be considered, with regard paid to its appearance in oblique where such viewpoints are important. Staggered arrangements of lighting columns can produce an irregular appearance when seen obliquely.

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

NOTE 2 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 3 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.

8.2.4 *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 following matters should be considered in relation to a specific bridge:

a) is the bridge an ancient monument?

b) is it possible to light the bridge from the road at either end, to avoid siting equipment on the bridge?

NOTE 1 For the medieval type of bridge, with embrasures above the cutwaters, relatively short lighting columns in some of the embrasures might be acceptable.

NOTE 2 Stock designs of columns are seldom appropriate for bridges of historical importance.

8.2.5 *Lighting for footbridges*

The lighting on a footbridge should follow the recommendations for structural considerations and appearance in **8.2.2** and **8.2.3**. Special care should be given to the illumination of stairs and ramps.

Where a footbridge is in a lit area or over a lit road, the illumination on the footbridge should be integrated with the surrounding area. 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.

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 considered. 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.

8.3 Lighting for elevated roads

8.3.1 *General*

Elevated roads differ from bridges in that they are usually longer, they are often sinuous, and they often have parallel roads alongside them at lower levels. They also often have slip roads that join the two levels, they usually carry very heavy traffic and have little room for maintenance. Maintenance can be very difficult, since the closing of lanes for a maintenance vehicle might not be acceptable and this can be a ruling factor in the lighting design. The recommendations on the lighting of elevated roads given in **8.3.2** and **8.3.3** should be followed.

8.3.2 *Configurations with special needs*

8.3.2.1 *General*

Elevated roads differ so much from each other that each requires individual consideration. The lighting installation should meet the requirements of the selected lighting class(es) from BS EN 13201-2 for both the elevated road, and any parallel ground-level road. Special lighting needs and solutions can be defined for:

a) elevated roads on an embankment with parallel ground-level roads (see **8.3.2.2**);

b) elevated roads on a viaduct with parallel ground-level roads (see **8.3.2.3**).

8.3.2.2 *Elevated road on embankment with parallel ground-level roads*

When an elevated road is on an embankment with a slope, the bank results in the lower road having a vertical and horizontal separation from the upper road. The following lighting arrangements should be considered.

a) *Each road lit individually*. This solution can generate a large number of units, related maintenance problems and conflicting arrays of lights.

b) *Masts mounted between the roads*. If the overall width of the combined area is suitable, both roads may be lit by luminaires mounted on masts that are high compared with the difference in level between the roads. This arrangement has the advantage of reducing the number of lighting points, can reduce glare, and simplifies maintenance.

c) *Masts mounted on the outside of the lower road*. Where there are steep embankments or retaining walls, the masts may be mounted on the outside of the lower road. This has the same advantages as b), but can result in inferior light utilization.

d) *Luminaires mounted on the upper road lighting columns*. The luminaires used to illuminate the upper road can sometimes suffice to light both roads. If this is not the case, separate luminaires should be mounted on the upper lighting columns at an appropriate height to illuminate the lower road.

8.3.2.3 *Elevated road on a viaduct with parallel ground-level roads*

8.3.2.3.1 *Parallel ground-level roads close to and/or partly beneath the viaduct*

If the upper road is lit by luminaires at its sides, their light might reach only part of the lower carriageway and they can cause an undesirable continuous shadow. Lights mounted on the underside of the viaduct can offset this problem, although the mounting height for such lights is often restricted, and care should be taken to minimize problems with shadows cast by beams or pillars.

8.3.2.3.2 *Parallel ground-level roads close to or crossing the elevated road*

Consideration should be given to lighting both the upper and lower roads from luminaires mounted on the outer sides of the lower roads. To achieve this, the mounting height should be such that the lighting requirements for the upper road are met, without shadows being cast by the viaduct on the inner sides of the lower road such that the lighting requirements for the lower road are not met. This solution avoids all lighting maintenance activity on the elevated road. It might be necessary to provide a special light distribution designed to control light beyond the limits of the road. If the lighting requirements for the elevated road cannot be met by the outer luminaires on the lower road, then luminaires should also be mounted on the elevated road.

8.3.3 ***Lighting for slip roads***

Where slip roads connect two levels of road, particular attention should be given to the following:

a) view of the rising slip road from both the upper and lower levels;

b) clear definition of routes and turn-off points;

c) clear revealing of merging traffic;

d) merging of different types of lighting installations;

e) clear definition of carriageway markings and protective barriers;

f) requirements for luminaires with special light distribution properties.

The recommendations on the lighting of grade-separated junctions in **8.4** should also be followed when determining the lighting of slip roads.

8.4 Grade-separated junctions

8.4.1 *General principles*

NOTE 1 This subclause gives recommendations for the lighting of grade-separated junctions and gives guidance on the factors that can influence a choice between, or a combination of, different types of lighting systems.

Recommendations for the lighting of roundabouts, bridges, pedestrian subways, subsidiary roads and footways, which can be associated with grade-separated junctions, are given in **11.1**, **11.3**, **8.2**, **10.6** and Clause **9**.

NOTE 2 Recommendations for the lighting of tunnels and vehicle underpasses, which might be associated with elevated roads, are given in BS 5489-2.

Account should be taken of the number of roads present and their relative dispositions, which might indicate the need for either lighting of individual roads or an integrated lighting system covering large areas.

Conflict areas can sometimes be lit using road surface luminance criteria (see **11.1.1**), and this can apply to the main route(s) passing through a grade-separated junction where the main route is straight. If there are sharp bends, junctions, roundabouts or changes in gradient the design should be based on horizontal luminance and uniformity, using the appropriate CE lighting class from BS EN 13201-2:2003, Table 2.

NOTE 3 In some cases the two approaches may be combined for different parts of the junction.

Whilst lighting can show the various routes available, it does not normally provide the information necessary to assist in the choice of route.

NOTE 4 Such information is normally furnished by traffic signs.

NOTE 5 The road lighting design may be considered in consultation with the traffic sign designer so that a co-ordinated layout is achieved which does not impair daytime sight lines.

8.4.2 *Lighting using conventional systems*

NOTE Conventional lighting systems are here taken to be those using lighting columns of up to 15 m height in a regular array for each carriageway or combination of carriageways.

8.4.2.1 *General*

Where a site involves a single grade-separated junction (e.g. of two-level, four ways with a roundabout layout above or below the major road), the junction should be lit as recommended in Clause **7** and Clause **11**.

Design of layouts should avoid a confusion of light sources at the different levels and angles of approach. An appropriate installed intensity class should be selected from BS EN 13201-2:2003, Table A.1, in order to limit glare (see **11.1.4** for further information).

8.4.2.2 *Design considerations*

Priority should be given to the needs of any major roads within the junction. In many cases, this will be a dual carriageway road and can most easily be defined throughout by lighting from lighting columns mounted in the central reserve. If centrally mounted safety fences are being provided as a safety measure, these can give protection to the lighting columns. If safety fences are not being provided, the need for local protection and suitable siting of the lighting columns should be taken into account.

Slip roads usually join the main carriageway by tapering acceleration or deceleration lanes. Where the main carriageway is lit, single-sided lighting should commence from a point on the taper along the length of each slip road to give delineation of the slip roads and to reinforce the lighting in the areas where the road widens.

8.4.2.3 *Engineering considerations*

Consideration should be given to the lighting at an early stage in the design of the junction so that fixings for lighting columns and cable ducting can be allowed for and incorporated into the structures. Longitudinal and transverse ducting and draw-in chambers should be provided for any future lighting.

For lighting on viaducts and bridges in complex grade-separated junctions, the recommendations given in **8.2** should be followed. It can be difficult to relate lighting columns to structural elements, such as supports, and the initial spacing arrived at by lighting design calculations might have to be modified to suit constructional features, such as the spacing and width of transverse beam sections of the structure. However, the lighting in all cases should conform to BS EN 13201-2.

8.4.3 *Lighting by high-mast techniques*

8.4.3.1 *General*

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.

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°.

8.4.3.2 *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 lamp or luminaire.

NOTE Multiple lamps or luminaries will minimize the extent of carriageway left in darkness in the event of failure of a single lamp.

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, as indicated in **11.1.3**.

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. If this occurs, some form of supplementary lighting at a lower level should be provided.

8.4.3.3 *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 in a potentially vulnerable position, i.e. where it could be struck by a vehicle leaving the carriageway, a safety fence should be provided.

8.4.3.4 *Lightning protection*

The need for lightning protection should be evaluated in accordance with BS 6651.

Where a structure is a continuous metal frame, it requires no air termination or down conductor. However, it should be ensured that the connecting path is electrically and mechanically continuous and the recommendations given in BS 6651:1999, Clauses **16**, **17** and **18** should be met.

The resistance to earth of the earth termination network and of each earth electrode should be tested in accordance with BS 7430.

9 Lighting of subsidiary roads and associated areas, footpaths and cycle tracks

9.1 General

NOTE 1 This clause 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 Clause **10**. An outline of the design process is given in Annex H.

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 drivers, but is unlikely to be sufficient for revealing objects on the road without the use of headlights.

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 detect the presence of other cyclists and pedestrians and other hazards, and to discourage crime against people and property.

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

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

NOTE 3 Further information can be found in CEN/TR 13201-1.

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 may 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 4 CEN/TR 13201-1:2003, **5.3** gives information on definition of the relevant area.

There are two possible technical solutions to general lighting for pedestrians and cyclists in BS EN 13201-2:

a) average and minimum horizontal illuminance (see BS EN 13201-2:2003, Table 3);

b) average hemispherical illuminance and uniformity (see BS EN 13201-2:2003, Table 4).

The technical solution using horizontal illuminance classes should be used.

NOTE 5 The provision of lighting designed to meet the requirements of the appropriate horizontal illuminance class normally provides adequate vertical illuminance at the height of the human face, ensuring a high possibility of recognition.

In respect of the S series lighting classes, BS EN 13201-2:2003, Table 3 requires that the average illuminance $\overline{E}$ does not exceed more than 1.5 times the minimum value of $\overline{E}$ indicated for the specified lighting class. For any lighting system, this requirement 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.

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

NOTE 6 BS EN 13201-2:2003, note to Clause **6**, states that limitation of glare can be achieved by the selection of luminaires according to the classes of Table A.2 of that standard. In practice, this solution is only suitable for luminaires with completely diffusing or frosted bowls.

9.2 Roads with traffic calming measures

Traffic calming measures are often provided on subsidiary roads, particularly in residential areas, and can include speed restriction humps, constructed according to the regulations identified in **A.5** (see Note 2). An appropriate lighting class should be selected from BS EN 13201-2 for the area of traffic calming measures.

NOTE 1 The information on selection of lighting class in Annex B and in CEN/TR 13201-1 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 Attention is drawn to the statutory requirements listed in **A.5** in respect of the lighting of road humps.

9.3 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.

NOTE 1 Attention is drawn to the Crime and Disorder Act 1998 [21], 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 2 A lighting class using semi-cylindrical illuminance, BS EN 13201-2:2003, Table 5, can be specified in addition to the general lighting class when there are particular problems of 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).

9.4 Conflict areas

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. No particular recommendations apply to junctions on subsidiary roads, but it should be ensured that the requirements of the selected lighting class from BS EN 13201-2 are met by the lighting design at any junction.

At roundabouts on subsidiary roads, the design should conform to the appropriate recommendations in **11.1** and **11.3**.

9.5 Calculation procedure

The calculation procedure defined in BS EN 13201-3:2003, Clause **7** 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.

10 Lighting of urban centres and public amenity areas

10.1 General

NOTE This clause 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 drivers, cyclists and pedestrians within urban centres, recommendations are also given for the illuminating 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 being considered, no uniform method of lighting provision is suggested, and an individualized approach should be taken for each site. For this reason, basic recommendations are made only with regard to the overall lighting provisions related to each area.

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

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 considered 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.

10.2 Objectives of lighting

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 master plan should be drawn up which contains all the relevant objectives in order of their perceived importance and emphasis. These can include some or all of the following:

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 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 light pollution;

j) protection of installations from accidental or deliberate damage;

k) maintenance of installations.

NOTE 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.

10.3 Lighting to meet traffic needs

10.3.1 *Categories of traffic*

The relative balance of the lighting needs listed in **10.2** 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 should be selected from BS EN 13201-2.

NOTE 1 Further information on the selection of lighting classes is given in Annex B.

NOTE 2 Further information can be found in CEN/TR 13201-1.

10.3.2 *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).

The lighting of footways, other pedestrian areas and cycle tracks adjacent to the carriageway might need to be considered 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 2.

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. One way to mark this change of use is to alter the appearance of the lighting equipment to a more decorative type, height and/or change the colour of the light source.

10.3.3 *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 2. 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 1 Further information on the selection of lighting classes is given in Annex B.

NOTE 2 Further information can be found in CEN/TR 13201-1.

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 totally 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.

10.3.4 *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 attempt to 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 **5.1.3** and adequate facial illuminance as recommended in **10.4.1** should be provided.

NOTE 1 Pedestrian areas whilst excluding motor 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 2.

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

NOTE 3 Further information can be found in CEN/TR 13201-1.

10.4 Lighting for other purposes

10.4.1 *Security and safety*

The general lighting needs of traffic referred to in **10.3** 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. However, when the selected lighting class provides high lighting levels related to the periods of major traffic movements, a reduction to a lower class should be considered at other times. This can be achieved by the "variable lighting" approach discussed in **10.13**, by switching lamps in multi-lamp luminaires or by dimming.

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 1 The provision of lighting designed to meet the horizontal illuminance requirements of the appropriate class normally provides adequate vertical illuminance, using mounting heights of between 4 m and 12 m.

NOTE 2 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 problems of 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).

10.4.2 *Visual appreciation*

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.

NOTE Information on the lighting of buildings, monuments and fountains can be found in the ILE publication *The outdoor lighting guide* [22].

10.5 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 of $R_a \geqslant 60$ 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
Totally enclosed arcade or canopied area	250	150	150	75

10.6 Lighting of subways, footbridges, stairways and ramps

10.6.1 *General*

Subways, footbridges, stairways and ramps should be lit to the appropriate level given in Table 4. 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 1 It is also advantageous that all surfaces are as light coloured as is practicable.

Lamp colour temperature and colour rendering are important factors that should also be considered.

Lighting should be considered at the design stage to determine the location of the chosen luminaires relative to their performance, so that the electrical intake cabinets and wiring conduits 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 2 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 with due consideration given to future maintenance.

Table 4 — 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 should be considered. 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.

10.6.2 *Emergency lighting*

On longer, complex subways, emergency lighting in accordance with BS 5266-1 to BS 5266-7 should be considered.

NOTE Self-maintained units are recommended.

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.

10.7 Lighting of car parks

10.7.1 *General*

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

The variation in character of car parks in terms of size, structure, location and access means that different lighting techniques should be considered 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 considered. The lighting of ticket offices should be in accordance with BS EN 12464-1:2002, **5.7.5**.

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

10.7.2 *Enclosed car parks*

NOTE 1 For lighting purposes, both surface car parks and the open roof level of multi-storey car parks are to be regarded as outdoor car parks rather than enclosed ones.

The average illuminance level in enclosed car parks is not as important as the illuminance uniformity ratio (minimum illuminance to average illuminance). Good uniformity produces easy viewing conditions and gives the impression of a space with a much higher illuminance. To achieve good uniformity, consideration should be given to the spacing of luminaires and reflectance factors. The lighting levels recommended in BS EN 12464-1:2002, **5.7** should be provided and maintained throughout all hours of use. Uniformity of illuminance is important to provide easy viewing conditions and avoid the impression of relatively dark areas. Illuminance uniformity ratio (E_{min} to $\overline{E}$) should be as high as possible but no lower than 0.4.

NOTE 2 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 lamps with warm colour appearance (as defined in Table 2).

NOTE 3 The protrusion of luminaires below the ceiling surface can make the ceiling appear dark.

NOTE 4 Floor surfaces with a light finish will reflect light onto the ceiling.

The design, orientation and location of luminaires in the driver's line of sight should be arranged to ensure that glare is minimized and conforms to BS EN 12464-1:2002, **4.4**.

NOTE 5 Linear light sources mounted crossways to the driver's line of sight can be a glare source unless baffles are used.

10.7.3 *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 some lighting into the car parking area but, as this lighting cannot be assured in terms of quality and duration, car parks should have independent lighting provisions.

Luminaires should be selected and mounted so as to avoid obtrusive lighting.

NOTE 1 Recommendations for the control of obtrusive light are given in prEN 12464-2:2003, **4.5**.

The design, orientation and location of luminaires in the driver's line of sight should be arranged to ensure that glare is minimized.

NOTE 2 Recommendations for the control of glare are given in prEN 12464-2:2003, **4.4** and **5.9**.

The lighting classes should be selected to take into account the type and location of the car park, and should be provided and maintained through all the hours of use.

NOTE 3 Recommendations for lighting classes are given in prEN 12464-2:2003, **5.9.**

Careful consideration should be given to lighting for open roof level car parks 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 4 For further information, refer to the ILE publication *Guidance notes for reduction of light pollution* [16].

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.

10.7.4 *Emergency lighting*

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 Attention is drawn to the Building Regulations 1991, Fire Safety Approved Document B (2000 edition), Section B1 [23].

10.7.5 *Calculation procedure*

The calculation procedure for car parks should be in accordance with BS EN 13201-3:2003, Clause **7**, 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.

The lighting levels should be calculated using a grid spacing of no more than 1.0 m (for enclosed car parks) or 5.0 m (for outdoor car parks) over the area under consideration.

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.

10.8 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 appropriate lighting class should be selected from BS EN 13201-2:2003, Table 2.

Service areas have varying needs and this can cause conflicts between types of vehicles and pedestrians. 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.

Where suitable luminaire positions on surrounding buildings can be utilized, the use of lighting columns can be avoided. In such circumstances, the use of suitable floodlighting luminaires should be considered as 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.

NOTE The main usage of each area usually indicates the form of lighting that should be provided.

10.9 Lighting of conservation areas

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.

A lighting class should be selected from BS EN 13201-2 that relates to the needs of vehicular and pedestrian traffic, and should be selected in accordance with Clause **7**, Clause **9** or **10.3** as appropriate.

The daytime appearance of any installation in a conservation area should relate to the surroundings and 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 should all be considered.

NOTE The best lighting effect may 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 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.

10.10 Lighting of parks and landscaped areas

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.

NOTE 1 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.

NOTE 2 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.

NOTE 3 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.

NOTE 4 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.

NOTE 5 Attention is drawn to the Public Health Act 1985 [2] in respect of the fixing of public lights to buildings.

The recommendations given in Clause **9** should be followed when lighting footpaths and cycle tracks.

10.11 Installation design

10.11.1 *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 I.

Lighting is a vital part of the environment and should be complementary to the surroundings. Multidisciplinary teamwork by planners, architects and engineers 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 lamp life and replacement costs, luminaire cleaning cycles, and energy costs.

10.11.2 *Site appraisal*

Site appraisals should be carried out before, during and soon after installation, by day and night, to ensure that all 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.

During installation, site visits should be made in order to attempt to avoid unforeseen problems and ensure compliance with design objectives.

10.12 Light sources and luminaires

10.12.1 *Basic needs*

Lighting equipment used 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 **5.2.3**). 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 **5.1.3** 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 lamp are equally important.

Luminaires and their supports should be regarded as a unit, and should be chosen to harmonize with the area in which they are to be used. Where older style luminaires are adopted for re-use, due regard should be given to their optical performance and appearance. If ancillary control gear boxes are necessary, these should be made as inconspicuous as possible.

10.12.2 *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 Consultation with the Local Planning Authority is recommended.

If a higher level of lighting is required than can be obtained without detracting from the visual appearance, a variable lighting system as described in **10.13** should be considered.

10.13 Variable lighting systems

In some areas where user demands can vary during the course of the night, lighting provisions can be varied by arranging multiple luminaires, lamp switching sequences, or dimming. This should be considered where traffic usage varies, for security and energy saving purposes, and where a higher level of lighting is required than can be obtained without detracting from the visual appearance.

Where an architectural objective could result in the use of a relatively inefficient luminaire at pedestrian level, a further luminaire or luminaires, mounted remotely at a higher location, should be considered to provide the necessary ambient lighting level.

Where footways are parallel to carriageways but are screened by intervening trees, consideration should be given to the use of luminaires mounted at lower mounting heights on the rear of road lighting columns or to using a separate lighting system.

11 Lighting of conflict areas

11.1 General principles

11.1.1 *Lighting class and luminaire positions*

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. Such situations can sometimes be lit using the road surface luminance criteria of the main route passing through the area, but where there is more than one viewing direction the illuminance classes in BS EN 13201-2:2003, Table 2 should be used.

NOTE 1 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.

NOTE 2 Information on the selection of the appropriate class of lighting, related to the class on the approach roads, is given in Annex B.

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. Once a draft layout of luminaires has been established, the design should be checked for conformity to the photometric requirements of the selected lighting class from BS EN 13201-2, and adjusted as necessary.

Solutions using multiple positions of lighting columns of 10 m or 12 m height, a fewer number of higher lighting columns each with multiple luminaires, or high-mast installations, are all equally valid and should be considered.

NOTE 3 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.

NOTE 4 In the case of roundabouts, such other solutions can be particularly appropriate in the case of the following:

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.

NOTE 5 The use of high-mast lighting is discussed in **8.4.3** in relation to grade-separated junctions, but this type of lighting can also be appropriate for large single level junctions.

NOTE 6 Information on luminaire and column positions for typical single level junctions and roundabouts using 10 m and 12 m columns is given in Annex J.

NOTE 7 Roundabouts can often be effectively lit from the perimeter, with typically 10 m or 12 m lighting columns, and the lights thus forming a ring around the perimeter, as illustrated in Annex J (see **11.1.2.2**).

NOTE 8 Recommendations for the lighting of surrounds to conflict areas and determining the extent of conflict areas are given in **11.1.3**.

11.1.2 *Functions of lighting at conflict areas*

11.1.2.1 *Junctions*

The lighting at a junction should reveal the positions of kerbs and road markings, the directions of roads, the presence of any pedestrians or obstructions, and the movement of any vehicles in the vicinity of the junction. The choice of position of lighting columns and luminaires should be made after consideration of the lines of traffic flow, the sight lines for merging flow and the areas of possible collisions.

The lighting at a junction should be related to the need of drivers approaching the junction to see vehicles approaching from other directions.

11.1.2.2 *Roundabouts*

The lighting provided at a roundabout should enable the driver to see clearly any traffic to the right at the preceding entry or entries and traffic already on the gyratory system of the roundabout. The lighting should also enable the driver to have adequate forward vision, when on the roundabout, to see traffic entering from the left and to decide whether it is safe to proceed.

A roundabout presents a diversion to the direct flow of traffic and should be revealed as such. Lighting should assist in making drivers aware of the roundabout ahead and enable them to recognize it in ample time. The arrangement and character of the lighting may be distinctive, and thus assist the warning signs in providing reliable warning of the roundabout. The lighting should reveal the form, direction and edges of the carriageway all the way round the roundabout, with special emphasis on the central and other traffic islands.

Mini-roundabouts, particularly those of the ghost island type, or those that have been located relatively remote from approach road give way lines, can be difficult to see. Luminaires should where possible be sited to reveal the island.

NOTE Dome-type islands do not present great difficulties, but illumination of flush-painted islands without profiles is more difficult, and probably impossible in wet conditions.

11.1.3 *Lighting of surrounds and extent of conflict area*

As explained in **4.2.3**, lighting of the surrounds is necessary to serve the needs of the driver and the pedestrian. In the case of conflict areas, this can be achieved by applying an appropriate class of lighting to the footway or other relevant areas adjacent to the carriageway, or by including such adjacent areas within the relevant area of the conflict area.

NOTE 1 CEN/TR 13201-1:2003, Annex F gives information on the definition of the relevant area.

The method of lighting the surrounds should be considered as follows.

a) Where there are no adjacent footways or cycle tracks, no special measures should be taken to light the surrounds.

b) Where there are very lightly trafficked adjacent footways, no special measures should be taken to light the surrounds.

c) Where there are more heavily trafficked adjacent footways, either an appropriate lighting class should be selected for the footways, or the footways should be included in the relevant area of the conflict area.

d) Where there are adjacent cycle tracks, including those with joint pedestrian use, an appropriate lighting class should be selected for the cycle tracks, or the cycle tracks should be included in the relevant area of the conflict area.

NOTE 2 In a) and b) it is assumed that a degree of spill light will provide some unquantified lighting of the surrounds.

For complex junctions, including those with ghost islands or traffic islands, it can be important for drivers to assess the whole scene when making decisions about navigation through the junction. For this reason, the area of ghost islands and of splitter islands or refuges should always form part of the conflict area for calculation. Similarly, the central islands of mini-roundabouts should always be included in the conflict area, whether defined only with road markings, domed, or kerbed.

The longitudinal extent of the conflict area along the approach roads should also be determined.

For roundabouts, the mouth of each exit road should be included in the conflict area to which the selected lighting class is applied, to assist vehicles turning out of the roundabout, and to reveal the tail of a traffic island if there is one. Consideration should be given to including small splitter islands and pedestrian refuges completely within the conflict area.

NOTE 3 Issues such as traffic speed, visibility distance, lane changing before a junction, and the presence of splitter islands and pedestrian routes and refuges will influence the decision on the extent of the conflict area.

NOTE 4 Where conflict areas to be lit have unlit approach roads, determination of the extent of the conflict area will also determine the extent of any lighting on the approach roads.

11.1.4 *Limitation of glare*

In any conflict area, glare should be at least as well controlled as on the approach roads, as the conflict area situation increases the visual demands on the driver.

NOTE 1 Disability glare, discussed in **5.2.3**, reduces the contrast between objects and their background so that their visibility is decreased.

Where the luminance design approach of the main through-route can be applied to simple conflict areas as indicated in BS EN 13201-2, the threshold increment (*TI*) of the lighting is determined by the selected lighting class. For glare control, it is normally sufficient to use the same luminaires within the conflict area, but if different luminaires are to be used, an appropriate installed intensity class should be selected from BS EN 13201-2:2003, Table A.1.

Where luminance design is not appropriate, as indicated in BS EN 13201-2, and an illuminance class has been selected from BS EN 13201-2:2003, Table 2, it is likely that there will be multiple viewing directions of luminaires at varying angles of azimuth, and thus *TI* cannot be calculated. In order to limit glare, an appropriate installed intensity class should be selected from BS EN 13201-2:2003, Table A.1.

NOTE 2 Classes G4, G5 or G6 are normally appropriate.

11.2 Conflict areas with ghost or traffic islands

To minimize delays and reduce the risk of accidents, the layout of junctions can include traffic islands or their equivalent in roadway markings. These ghost islands are often associated with diverging traffic lane markings with suitable directional arrows or other instructions. To ensure efficient working, markings, as well as other features of the junction, should be clearly visible to approaching drivers.

NOTE The texture and colour of the paint used for road markings can influence the visibility of the markings when viewed under road lighting.

Where junctions include increased carriageway width to accommodate additional lanes, the mounting height of luminaires might have to be greater than that used on the connecting roads, especially if ghost islands defined by road markings are used instead of solid islands with raised kerbs. If the latter exist, they may be used to site lighting columns, but care should be taken to ensure that the clearances to the carriageway edge are not less than the minimum values recommended in Table 2, and that columns are not sited in positions where vehicles are likely to overrun the kerb. If there is such a risk of collision, lighting columns should ideally not be sited on traffic islands.

11.3 Siting of lighting columns at roundabouts

11.3.1 *Approach and exit roads*

Lighting columns should not be placed on the central traffic island opposite to any entry road, as in this location they increase the possibility of vehicle collisions.

NOTE They may be placed behind the outer kerb at a spacing necessary to conform to the selected lighting class from BS EN 13201-2.

Care should also be taken to ensure that the clearances to the carriageway edge are not less than the minimum values recommended in Table 2, and that columns are not sited in positions where vehicles are likely to overrun the kerb.

11.3.2 *Central traffic island roundabouts*

For gyratory carriageways, over 15 m wide, it is sometimes necessary to supplement the peripheral lighting, by providing lighting columns in the central traffic island. This should only be done where approach speeds are low, unless other measures are taken to mitigate the effect of vehicle collisions, such as protective barriers or the use of breakaway or energy-absorbing lighting columns.

For small roundabouts with kerbed central traffic islands, a centrally placed lighting column can provide an acceptable solution. In this case, exit roads, islands and refuges should be carefully considered in relation to the extent of the relevant conflict area, as recommended in **11.1.3**.

11.3.3 *Set-back of lighting columns*

The clearance between the lighting columns and the carriageway should be not less than the minimum distance recommended in Table 2 for the appropriate design speed.

NOTE The position of the luminaires around the periphery of a roundabout is not so critical in relation to the line of the kerb as it is on straight roads, so the luminaires themselves may be set back provided the requirements of the selected lighting class from BS EN 13201-2 are met within the defined conflict area.

11.4 Mounting height

Mounting height should generally be uniform throughout a conflict area. It should not normally be less than that on any approach road, but may be increased if the number of lighting columns is thereby reduced.

11.5 Pedestrian crossings

NOTE "Pedestrian crossings" is intended to include both zebra crossings and signal-controlled crossings.

11.5.1 *Pedestrian crossings apart from junctions*

11.5.1.1 *Criteria for choice of lighting method*

Two possibilities for the lighting of pedestrian crossings apart from junctions are described in BS EN 13201-2:2003, Annex B:

a) position the normal road lighting so as to provide good negative contrast;

b) provide additional local lighting of the crossing so as to positively illuminate the crossing area and pedestrians waiting at and using the crossing.

The normal road lighting can be satisfactory, subject to location of lighting columns and luminaires, where the road is relatively straight and level, and where the road surface luminance is high.

However, the use of local lighting should be considered where the road surface luminance is lower than BS EN 13201-2:2003, Table 1, class ME3; on bends; on the brow of hills; and in situations where for practical or economic reasons the positions of the crossing and normal road lighting luminaires cannot be co-ordinated.

NOTE The latter problem can occur where a pedestrian crossing on a main road is situated next to a junction with a minor side road.

11.5.1.2 *Normal road lighting*

Road lighting is most effective in revealing pedestrians using crossings when it is symmetrical from both directions along the road on a two-way road. The lighting should therefore be arranged so that the crossing is at the mid-point of a span.

NOTE This may involve the use of one span in the lighting scheme shorter than the normal calculated design spacing for the road.

In particular, a lighting column should not be placed adjacent to a pedestrian crossing.

In a staggered arrangement, the optimum scenario is to provide two lighting columns at equal distances from the centre of the crossing. The lighting column on the left-hand side of the road should be beyond the crossing as seen by an approaching driver. In an opposite arrangement, there should be two pairs of lighting columns at equal distances from the centre of the crossing. These distances should be measured parallel to the centre line of the road.

If the luminance class of the road on which the crossing is sited is to be applied to the crossing, the design spacing for the road should be equalized about the crossing. If a higher class is selected for the crossing, the spacing and/or the light output of the luminaires adjacent to the crossing should be amended as necessary.

11.5.1.3 *Local lighting*

Local lighting is additional lighting to the normal road lighting, to provide positive illumination of the crossing area and the pedestrians using the crossing.

The local lighting should illuminate the crossing carpet to a horizontal illuminance of a higher level than provided by the normal road lighting on the approach to the crossing, to emphasize the presence of the crossing to approaching drivers. A suitable class should be selected from BS EN 13201-2:2003, Table 2. The local lighting should also have a strong vertical component, to ensure that pedestrians are positively illuminated and are thus visible to approaching drivers.

Pedestrians can be regarded as approximating to a vertical cylinder in shape; thus the vertical component may be provided either by luminaires in advance of the crossing, orientated towards the crossing, or luminaires at each end of the crossing, orientated across the road. In either case, care should be taken to control glare to drivers.

BS EN 13201-2:2003, Table 6, gives classes of minimum values of vertical plane illuminance, but if these are used the designer should consider the height and position of the vertical calculation area. (An area 1.5 m high at the leading edge of the crossing is recommended.)

NOTE CEN/TR 13201-1:2003, **5.3** gives information on the definition of the relevant area when carrying out the design of lighting on pedestrian crossings.

11.5.2 *Pedestrian crossings T-junctions and roundabouts*

Pedestrian crossings are sometimes sited next to junctions and roundabouts, and in such locations the use of road surface luminance design is not practicable.

In this case the area of the pedestrian crossing should be included in the relevant conflict area of the junction or roundabout, to which the selected horizontal illuminance lighting class is applied in design calculations.

11.6 Motorway crossovers

Long crossovers are installed in order to provide a temporary facility for traffic management during extensive road works, such as contra-flow traffic on one carriageway. They comprise one or two lanes specially delineated, with appropriate speed limits advised or imposed.

Arrangements for appropriate non-permanent lighting for the duration of the works only, should be as follows.

a) On lit lengths, the lighting arrangement should conform as far as practicable to the contiguous lighting, and provide the appropriate lighting class related to the class on the approaching motorway, as indicated in Clause **7**.

b) On unlit lengths, lighting should provide the appropriate lighting class selected by the Highway Authority from BS EN 13201-2:2003, Table 2, taking into account the following:

1) requirements for traffic management measures;

2) availability of mains electricity supplies;

3) provision of local generators;

4) provision of a permanent power cable network with its associated feeder pillar;

5) difficulties of ensuring glare control and sufficient uniformity from portable floodlights, unless adequate mounting height, sturdy mounting and accurate aiming are provided.

12 Lighting of areas around aerodromes, railways, harbours, and navigable inland waterways

12.1 General

NOTE 1 This clause 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.

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

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

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

NOTE 2 Interference can be caused by:

— disability glare from luminaires or installations;

— variations in contrast and reflected light;

— lighting of the same colour and pattern as signal lights.

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.

12.2 Lighting in the vicinity of aerodromes

12.2.1 *General*

NOTE 1 The Civil Aviation Act 1982 [24], 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 The Air Navigation Order 2000 [25], Article 110 provides that a person shall not exhibit in the UK any light which is liable to endanger aircraft taking off or landing or which is liable to be mistaken for an aeronautical light. 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.

12.2.2 *Safeguarded obstacle limitation surfaces*

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).

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

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

NOTE 2 Full details of the OLS are contained in the Civil Aviation Authority publication CAP 168:2001, Chapter 4 [26].

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 (Safeguarding, Defence Estates).

12.2.3 *Design considerations*

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.

NOTE 1 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 reference should be made to the Ministry of Defence.

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 [26]. Attention is particularly drawn to the areas described in Chapter 6, paragraph 1.3 of this document.

It is therefore essential to eliminate interference with the pilot's visual picture and with RV 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, Table A.1, class G4, or a higher class.

NOTE 3 Attention is also drawn to the provisions regarding road lighting of the Air Navigation Order 2000 [25].

12.3 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.

If a road lighting scheme is planned within an area that could affect the safe use of a railway, the railway track authority should be consulted.

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* [27].

It is essential that any lighting scheme does not affect track visibility for railway operatives.

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.

12.4 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 seamen, the local Marine Office of the Marine Safety Agency and the General Lighthouse Authority should be consulted.

12.5 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. Particular consideration should be given to installation and maintenance of high-mast lighting for dock roads, terminals and other facilities.

12.6 Lighting in the vicinity of navigable inland waterways

If a road lighting scheme is planned adjacent to navigable inland waterways, the following authorities should be consulted:

— British Waterways;
— Environment Agency;
— local navigation authority.

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)
Summary of statutory requirements for the provision of lighting

A.1 General

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, the statutes referred to in **A.2** empower authorities to light roads.

The provision of road lighting on a previously unlit road might involve statutory requirements.

The relevant regulations for certain aspects of lighting are described in **A.3**, **A.4** and **A.5**.

Statutes dealing with the fixing of lighting to or on private property are described in **A.6**.

A.2 Empowerment to light roads

In England and Wales, the Highways Act 1980 [1], Section 97 empowers a Highway Authority to provide lighting for any highway or proposed highway for which they are or will be the Highway Authority. District Councils and many Parish or Town Councils also have the power to provide lighting as local lighting authorities. This power is given by the Public Health Act 1985 [2], or the Parish Councils Act 1957 [3]. Where such Councils wish to provide lighting on a highway, the consent of the Highway Authority is required, under the Local Government Act 1996, Section 29 [4].

In Northern Ireland, the Roads (Northern Ireland) Order 1993, Article 44 [5] grants the Department of the Environment the power to provide road lighting, where the Department considers that any road should be illuminated.

In Scotland, the Roads (Scotland) Act 1984, Section 35 [6], empowers a local roads authority to provide lighting for roads, or proposed roads, which are, or will be, maintainable by them and which in their opinion ought to be lit.

A.3 Traffic signs

When lighting is provided on a previously unlit road, it is likely that certain traffic signs will have to be illuminated. The following regulations are relevant:

— in England, Wales and Scotland, the Traffic Signs Regulations and General Directions 2002 [7];

— in Northern Ireland, the Traffic Signs Regulations (Northern Ireland) 1997 [8].

A.4 Speed limits

The provision of road lighting on a previously unlit road can cause the imposition of speed limits. The following regulations deal with the link between speed limits and a “system of street lighting”:

— in England, Wales and Scotland, the Road Traffic Regulation Act 1984 [9];

— in Northern Ireland, the Road Traffic Regulation (Northern Ireland) Order 1997 [10].

A.5 Road humps

The provision of road humps might require particular lighting arrangements. The following regulations are relevant:

— in England and Wales, the Highways (Road Hump) Regulations 1999 [11];

— in Northern Ireland, the Road Hump Regulations (Northern Ireland) 1999 [12];

— in Scotland, the Road Hump (Scotland) Regulations 1998 [13].

A.6 Public lights on private buildings or land

In some circumstances, public lights and associated equipment can be fixed to private buildings or sited on private land. The following statutes are relevant:

— in England and Wales, the Public Health Act 1985 [2] deals with the fixing of public lights to buildings;

— in Northern Ireland, the Roads (Northern Ireland) Order 1993, Article 113 [14] gives the power to install on, under or over any land various items of lighting equipment, but there is no statutory right to fix to buildings;

— in Scotland, the Roads (Scotland) Act 1984 [15] gives the power to fix lamps and related structures to rails, walls or buildings fronting or abutting the road.

Annex B (informative)
Selection of lighting classes

B.1 General

This annex gives information on the selection of lighting classes, using the ME, CE and S series of lighting classes defined in BS EN 13201-2. Their use is adapted to UK conditions and the particular applications described in this part of BS 5489.

NOTE 1 Table B.1 to Table B.5 do not list MEW classes for wet roads, but the same class number as the listed ME class can be used. Further information can be found in BS EN 13201-2 and CEN/TR 13201-1.

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

NOTE 2 For subsidiary roads, it is indicated in Table B.4 that the lighting class can be varied when a light source with a higher R_a value is used.

Table B.1 to Table B.5, giving information on the selection of lighting classes, make use of the following parameters:

— type of road or area;
— traffic flow of vehicles per day (ADT);
— traffic flow of pedestrians and cyclists;
— presence of conflict areas;
— presence of traffic calming measures;
— crime risk;
— ambient luminance levels.

B.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 B.1 shows lighting classes from BS EN 13201-2 and indicates those of comparable level, whether using luminance or illuminance criteria.

Table B.1 — Lighting classes of comparable level

ME class	CE class	S class
—	CE0	—
ME1	CE1	—
ME2	CE2	—
ME3	CE3	S1
ME4	CE4	S2
ME5	CE5	S3
ME6	—	S4
—	—	S5
—	—	S6
NOTE The data in this table is extrapolated from CEN/TR 13201-1.		

B.3 Specific situations

B.3.1 *Traffic routes*

Table B.2 gives lighting classes for motorways and traffic routes in terms of the lighting classes in BS EN 13201-2:2003, Table 1a).

Table B.2 — Lighting classes for motorways and traffic routes

Hierarchy description	Type of road/general description	Detailed description	Traffic flow (ADT)[a]	Lighting class
Motorway[b]	Limited access	Routes for fast moving long distance traffic. Fully grade-separated and restrictions on use.		
		Main carriageway in complex interchange areas	⩽40 000 >40 000	ME1 ME1
		Main carriageway with interchanges <3 km	⩽40 000 >40 000	ME2 ME1
		Main carriageway with interchanges ⩾3 km	⩽40 000 >40 000	ME2 ME2
		Emergency lanes	—	ME4a
Strategic route[c]	Trunk and some principal "A" roads between primary destinations	Routes for fast moving long distance traffic with little frontage access or pedestrian traffic. Speed limits are usually in excess of 40 mph and there are few junctions. Pedestrian crossings are either segregated or controlled and parked vehicles are usually prohibited.		
		Single carriageways	<15 000 >15 000	ME3a ME2
		Dual carriageways	<15 000 >15 000	ME3a ME2
Main distributor[c]	Major urban network and inter-primary links Short- to medium-distance traffic	Routes between strategic routes and linking urban centres to the strategic network with limited frontage access. In urban areas speed limits are usually 40 mph or less, parking is restricted at peak times and there are positive measures for pedestrian safety reasons.		
		Single carriageways	⩽15 000 >15 000	ME3a ME2
		Dual carriageways	⩽15 000 >15 000	ME3a ME2
Secondary distributor	Classified road (B and C class) and unclassified urban bus route, carrying local traffic with frontage access and frequent junctions	Rural areas (Zone E1/2[d]) These roads link the larger villages and HGV generators to the strategic and main distributor network.	⩽7 000 >7 000, ⩽15 000 >15 000	ME4a ME3b ME3a
		Urban areas (Zone E3[d]) These roads have 30 mph speed limits and very high levels of pedestrian activity with some crossing facilities including zebra crossings. On-street parking is generally unrestricted except for safety reasons.	⩽7 000 >7 000, ⩽15 000 >15 000	ME3c ME3b ME2
Link road	Road linking between the main and secondary distribution network with frontage access and frequent junctions	Rural areas (Zone E1/2[d]) These roads link the smaller villages to the distributor network. They are of varying width and not always capable of carrying two-way traffic.	Any	ME5
		Urban areas (Zone E3[d]) These are residential or industrial inter-connecting roads with 30 mph speed limits, random pedestrian movements and uncontrolled parking.	Any Any (with high pedestrian or cyclist traffic)	ME4b or S2 S1

NOTE 1 See Table B.3 for conflict areas.

NOTE 2 Traffic flow can vary significantly during the night, and the use of different lighting levels at some periods may be considered. For this purpose, a detailed analysis of traffic flow is carried out, considering hourly flow through the night.

NOTE 3 Where lighting levels are reduced at certain periods, any lower levels selected can use the $\bar{L}$ values from appropriate lower ME classes, but retain the U_O and U_L values of the ME class selected for the peak period.

[a] The guidance on lighting class application for motorways and traffic routes is based on average daily traffic flow (ADT). It can be assumed that there is a reasonably consistent relationship between ADT and peak daily traffic, and that the lighting classes suggested are thus suitable for peak daily traffic flow.

[b] Free flow link roads connecting motorways may be lit to the same standard as the main carriageway of the motorways they are connecting. Motorway slip roads may be lit to one class lower than the main carriageway. In the case where the main carriageway class is ME2, the slip road class is ME3a. Slip road lighting may be extended to cover the full length of the slip road to provide additional lighting at the conflict point.

[c] In urban areas consideration may be given to the use of ME3b or ME3c in place of ME3a, in view of the lower traffic speeds and shorter viewing distances

[d] Environmental zone, as given in the ILE publication *Guidance notes for reduction of light pollution* [16].

B.3.2 *Conflict areas*

Table B.3 gives lighting classes for conflict areas on traffic routes, using the CE lighting classes in BS EN 13201-2:2003, Table 2, related to the lighting class on the roads approaching the conflict area.

Where traffic routes meet to which different classes have been applied, the higher class normally determines the class at the conflict area.

Where all the approach roads to a roundabout are unlit, but a decision has been made to light the roundabout, the CE lighting class chosen can be related to the traffic demands and general environment of the roundabout.

Table B.3 — Lighting classes for conflict areas

Traffic route lighting class	Conflict area lighting class
ME1	CE0
ME2	CE1
ME3	CE2
ME4	CE3
ME5	CE4

B.3.3 *Subsidiary roads including pedestrian areas, footpaths and cycle tracks*

Table B.4 gives lighting classes for subsidiary roads in terms of lighting classes in BS EN 13201-2:2003, Table 3. These are related to pedestrian and cyclist traffic flow, as the needs of such users normally have priority on such roads.

Table B.4 — Lighting classes for subsidiary roads (pedestrians and cyclists)

Crime rate	R_a value	Lighting class					
		Low traffic flow[a]		Normal traffic flow[b]		High traffic flow[c]	
		E1/E2[d]	E3/E4[d]	E1/E2[d]	E3/E4[d]	E1/E2[d]	E3/E4[d]
Low	$R_a < 60$	S5	S4	S4	S3	S3	S2
	$R_a \geqslant 60$	S6	S5	S5	S4	S4	S3
Moderate	$R_a < 60$	S4	S3	S3	S2	—	S1
	$R_a \geqslant 60$	S5	S4	S4	S3	—	S2
High	$R_a < 60$	S2	S2	S2	S1	—	S1
	$R_a \geqslant 60$	S3	S3	S3	S2	—	S2

NOTE 1 Crime rates are relative to the local area, not national. Assistance can be obtained from the local crime prevention officer.

NOTE 2 The lighting levels shown in this table may be increased by one lighting class in the vicinity of traffic calming measures.

[a] Low traffic flow refers to areas where the traffic usage is of a level equivalent to a residential road and solely associated with the adjacent properties.

[b] Normal traffic flow refers to areas where the traffic usage is of a level equivalent to a housing estate access road and can be associated with local amenities such as clubs, shopping facilities, public houses, etc.

[c] High 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.

[d] Environmental zone, as given in the ILE publication *Guidance notes for reduction of light pollution* [16].

B.3.4 *City and town centres*

Table B.5 gives lighting classes for pedestrian areas and mixed vehicle and pedestrian areas in city and town centres in terms of the lighting classes in BS EN 13201-2:2003, Table 2.

NOTE For roads within city and town centres that carry primarily vehicular traffic, refer to Table B.2.

Table B.5 — 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 only	CE3	CE2	CE2	CE1
Mixed vehicle and pedestrian with separate footways	CE2	CE1	CE1	CE1
Mixed vehicle and pedestrian on same surface	CE2	CE1	CE1	CE1

[a] Environmental zone, as given in the ILE publication *Guidance notes for reduction of light pollution* [16].

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 B.5, 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.

Annex C (informative)
Relationship between the luminaire and road surfaces for traffic route lighting

C.1 The function of the luminaire

An individual luminaire mounted over an empty carriageway makes a portion of the road and footway bright and also lights and models other parts of the surroundings. To a driver approaching this luminaire, the patch of light on the road generally assumes a "T" shape (see Figure C.1), having a discernible head and tail orientated towards the observer. The head of the patch does not usually extend much beyond the point on the road surface below the luminaire. The shape and luminance of this patch depend upon the light distribution of the luminaire (in terms of both shape and quantity) and on the properties of the road surface as described in **C.4**.

C.2 Superimposition of bright patches

The appearance of the lit roadway results from the superimposition of the bright patches formed by the luminaires. The design of the lighting installation involves positioning the luminaires so that the bright patches coalesce to give the road surface an average luminance with overall and longitudinal uniformities that are satisfactory for use of the road.

C.3 Lighting of objects

The aim of road lighting for vehicular traffic is generally to reveal objects in silhouette, and this is maximized when the illuminance of vertical and near vertical surfaces is as low as possible. This is achieved at most positions on the road as a result of the inter-relation of the spacing of the luminaires, their mounting height and their light distribution. A light coloured object can appear in reversed silhouette and there might be a certain reflectance of the object which will give it the same luminance as that of the road forming the background, making it disappear. In practice, this is unlikely to occur, firstly because objects are viewed against a considerable stretch of road or road surrounds, which will show some unevenness of luminance, and secondly because objects are rarely of uniform reflectance. In addition, as the driver moves position, the background against which the object is viewed changes, thereby helping to reveal the object.

C.4 Road surfaces

C.4.1 *General*

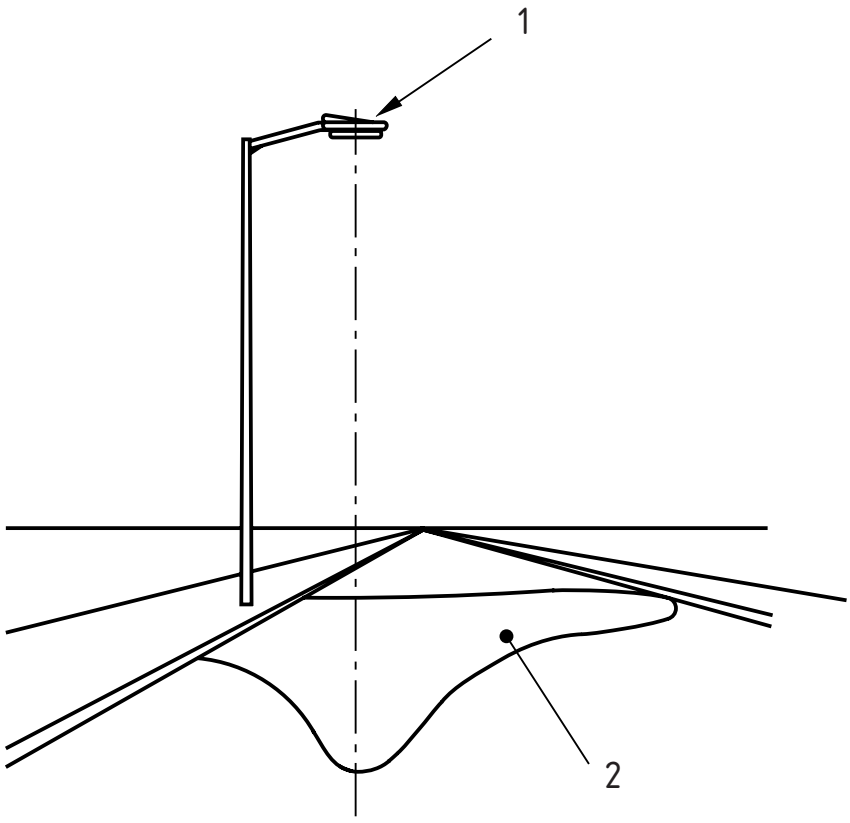
The main types of wearing courses used in the UK for road construction are asphalts, surface dressings and concrete, the individual lives and properties of which vary considerably. The important property for road lighting of traffic routes, where road surface luminance is the design criteria, is the light reflection. For calculation purposes this can be represented by an *r*-table, the format of which is set out in BS EN 13201-3.

Consultation with the authority responsible for maintenance of the carriageway can provide information on the type of surface which exists or is to be provided, the expected life of the surface, the type of wearing course with which it is expected to be renewed, and the kind of aggregate likely to be used. Similarly, such consultation can make the authority aware of installations where systems that depend upon specific surface properties are being considered, so that these properties can be maintained throughout the life of the installation.

Where luminance is the design criterion, the lighting and the road surface are essentially one system and the surface is likely to be replaced during the life of the installation.

C.4.2 *Physical properties of the road surface*

The typical shape of the bright area produced by a single luminaire is shown in Figure C.1.



Key

1 Luminaire

2 Bright area

Figure C.1 — "T" shaped bright area produced by a single luminaire

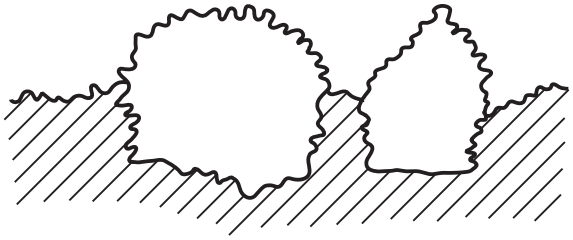
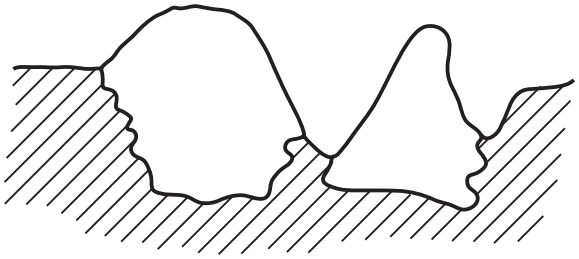
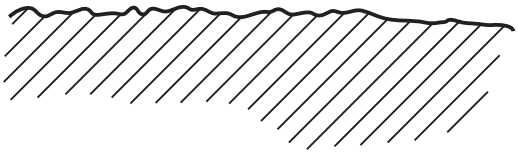
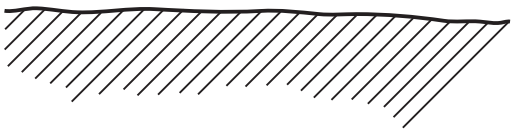
The physical properties of the road surface that influence the reflective properties of the road surface are as follows and as shown in Table C.1:

a) macroscopic surface texture (or macro-texture), which is determined by the size and angularity of the exposed aggregate, or surface treatments, such as crimping and tamping. The visual appearance of macro-texture leads to descriptions such as rough and smooth;

b) microscopic surface texture (or micro-texture), which is determined by the state of polish of the individual components of the surface. Micro-texture of dry surfaces can be experienced by touch, leading to such descriptions as harsh or polished;

c) lightness of the surface, which is usually determined by the colour of the stones at the top of the texture.

Table C.1 — Illustration of terms used to describe road surface textures

Surface type	Scale of texture	
	Macro (large)	Micro (fine)
	Rough	Harsh
	Rough	Polished
	Smooth	Harsh
	Smooth	Polished

The effect of these properties on the luminance of the road surface is as follows.

1) For dry surfaces, all three properties together influence the breadth, length and luminance of the patch.

At one extreme, a dark coloured, polished stone reduces the luminance of the head of the "T" and produces a long bright tail. The overall pattern then consists of longitudinal streaks of light. The average luminance is not low, however, as the loss of brightness in the head of each "T" is slightly more than compensated for by the bright streak of the tail.

At the other extreme, a rough textured harsh surface made with white stones produces a broad, bright head to the "T" and a very small tail. The average luminance is high with a reasonable overall uniformity, but the longitudinal uniformity is poor if the luminance patches do not join together along the road.

Most road surfaces in use today lie between these extremes.

2) On wet surfaces, the lightness of the surface is of less importance.

The macro-texture determines the extent to which the visible water-film will be affected by the amount of rainfall. A visible water-film acts in the same way as a polished micro-texture to lengthen and strengthen the tail of the luminance patch and decrease the width of its head. The effect is to produce longitudinal streaks separated by dark areas of road surface. A rougher micro-texture limits the occurrence of the effect to more extreme weather conditions. Porous asphalt is likely to almost remove this effect, however severe the conditions.

The type of road surface used directly affects the performance of the lighting installation. Increasing the roughness of the micro-texture will increase the wet-weather performance. Avoiding non-polishable aggregates in the wearing course of the road surface can prevent a streaky appearance and maintain skid resistance. Some proportion of white stones in the surface improves luminance level and uniformity.

C.4.3 *Reflection properties of particular road surfaces*

Data is provided in the *r*-tables indicated for the following road surfaces:

a) the "representative British road surface" (see Table C.2);

b) the concrete road surface (see Table C.3).

Table C.2 — *r*-table for representative British road surface CIE type C2

tan γ	*r*-value for different values of β																			
	β = 0°	β = 2°	β = 5°	β = 10°	β = 15°	β = 20°	β = 25°	β = 30°	β = 35°	β = 40°	β = 45°	β = 60°	β = 75°	β = 90°	β = 105°	β = 120°	β = 135°	β = 150°	β = 165°	β = 180°
0	329	329	329	329	329	329	329	329	329	329	329	329	329	329	329	329	329	329	329	329
0.25	362	358	371	364	371	369	362	357	351	349	348	340	328	312	299	294	298	288	292	281
0.5	379	368	375	373	367	359	350	340	328	317	306	280	266	249	237	237	231	231	227	235
0.75	380	375	378	365	351	334	315	295	275	256	239	218	198	178	175	176	176	169	175	176
1	372	375	372	354	315	277	243	221	205	192	181	152	134	130	125	124	125	129	128	128
1.25	375	373	352	318	265	221	189	166	150	136	125	107	91	93	91	91	88	94	97	97
1.5	354	352	336	271	213	170	140	121	109	97	87	76	67	65	66	66	67	68	71	71
1.75	333	327	302	222	166	129	104	90	75	68	63	53	51	49	49	47	52	51	53	54
2	318	310	266	180	121	90	75	62	54	50	48	40	40	38	38	38	41	41	43	45
2.5	268	262	205	119	72	50	41	36	33	29	26	25	23	24	25	24	26	27	29	28
3	227	217	147	74	42	29	25	23	21	19	18	16	16	17	18	17	19	21	21	23
3.5	194	168	106	47	30	22	17	14	13	12	12	11	10	11	12	13	15	14	15	14
4	168	136	76	34	19	14	13	11	10	10	10	8	8	9	10	9	11	12	11	13
4.5	141	111	54	21	14	11	9	8	8	8	8	7	7	8	8	8	8	10	10	11
5	126	90	43	17	10	8	8	7	6	6	7	6	7	6	6	7	8	8	8	9
5.5	107	79	32	12	8	7	7	7	6	5	—	—	—	—	—	—	—	—	—	—
6	94	65	26	10	7	6	6	6	5	—	—	—	—	—	—	—	—	—	—	—
6.5	86	56	21	8	7	6	5	5	—	—	—	—	—	—	—	—	—	—	—	—
7	78	50	17	7	5	5	5	5	—	—	—	—	—	—	—	—	—	—	—	—
7.5	70	41	14	7	4	3	4	—	—	—	—	—	—	—	—	—	—	—	—	—
8	63	37	11	5	4	4	4	—	—	—	—	—	—	—	—	—	—	—	—	—
8.5	60	37	10	5	4	4	4	—	—	—	—	—	—	—	—	—	—	—	—	—
9	56	32	9	5	4	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9.5	53	28	9	4	4	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10	52	27	7	5	4	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10.5	45	23	7	4	3	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
11	43	22	7	3	3	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
11.5	44	22	7	3	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12	42	20	7	4	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

NOTE 1 All the figures in this table relate to a road surface having an average luminance coefficient of $Q_0 = 0.07$.
See BS EN 13201-3.

NOTE 2 This table is taken from the joint CIE/PIARC publication *Road surfaces and lighting* [20].

Table C.3 — *r*-table for concrete road surface

tan γ	*r*-value for different values of β																			
	β = 0°	β = 2°	β = 5°	β = 10°	β = 15°	β = 20°	β = 25°	β = 30°	β = 35°	β = 40°	β = 45°	β = 60°	β = 75°	β = 90°	β = 105°	β = 120°	β = 135°	β = 150°	β = 165°	β = 180°
0	470	470	470	470	470	470	470	470	470	470	470	470	470	470	470	470	470	470	470	470
0.25	517	511	530	520	530	527	517	510	501	499	497	486	469	446	427	420	426	411	417	401
0.5	541	526	536	533	524	513	500	486	469	453	437	400	380	356	339	339	330	330	324	336
0.75	543	536	540	521	501	477	450	421	393	366	341	311	283	254	250	251	251	241	250	251
1	531	536	531	506	450	396	347	316	293	274	259	217	191	186	179	177	179	184	183	183
1.25	536	533	503	454	379	316	270	237	214	194	179	153	130	133	130	130	126	134	139	139
1.5	506	503	480	387	304	243	200	173	156	139	124	109	96	93	94	94	96	97	101	101
1.75	476	467	421	317	237	184	149	129	107	97	90	76	73	70	70	67	74	73	76	77
2	454	443	380	257	173	129	107	89	77	71	69	57	57	54	54	54	59	59	61	64
2.5	383	374	293	170	103	71	59	51	47	41	37	36	33	34	36	34	37	39	41	40
3	324	310	210	106	60	41	36	33	30	27	26	23	23	24	26	24	27	30	30	33
3.5	277	240	151	67	43	31	24	20	19	17	17	16	14	16	17	19	21	20	21	20
4	240	194	109	49	27	20	19	16	14	14	14	11	11	13	14	13	16	17	16	19
4.5	201	159	77	30	20	16	13	11	11	11	11	10	10	11	11	11	11	14	14	16
5	180	129	61	24	14	11	11	10	9	9	10	9	10	9	9	10	11	11	11	13
5.5	153	113	46	17	11	10	10	10	9	7	—	—	—	—	—	—	—	—	—	—
6	134	93	37	14	10	9	9	9	7	—	—	—	—	—	—	—	—	—	—	—
6.5	123	80	30	11	10	9	7	7	—	—	—	—	—	—	—	—	—	—	—	—
7	111	71	24	10	7	7	7	7	—	—	—	—	—	—	—	—	—	—	—	—
7.5	100	59	20	10	6	4	6	—	—	—	—	—	—	—	—	—	—	—	—	—
8	90	53	16	7	6	6	6	—	—	—	—	—	—	—	—	—	—	—	—	—
8.5	86	53	14	7	6	6	6	—	—	—	—	—	—	—	—	—	—	—	—	—
9	80	46	13	7	6	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9.5	76	40	13	6	6	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10	74	39	10	7	6	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10.5	64	33	10	6	4	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
11	61	31	10	4	4	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
11.5	76	31	10	4	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12	60	29	10	6	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

NOTE This table is derived from the joint CIE/PIARC publication *Road surfaces and lighting* [20] and is based on standard reflection table C.2 class CII scaled for $Q_0 = 0.10$.

Annex D (informative)
Typical luminaire maintenance factors

Table D.1 shows typical luminaire maintenance factors, which may be used in design calculations. It takes into account luminaire IP rating, pollution category and cleaning interval.

Table D.1 — Luminaire maintenance factors

Cleaning interval	Luminaire maintenance factor								
	IP2X minimum[a]			IP5X minimum[a]			IP6X minimum[a]		
months	High pollution[b]	Medium pollution[c]	Low pollution[d]	High pollution[b]	Medium pollution[c]	Low pollution[d]	High pollution[b]	Medium pollution[c]	Low pollution[d]
12	0.53	0.62	0.82	0.89	0.90	0.92	0.91	0.92	0.93
18	0.48	0.58	0.80	0.87	0.88	0.91	0.90	0.91	0.92
24	0.45	0.56	0.79	0.84	0.86	0.90	0.88	0.89	0.91
36	0.42	0.53	0.78	0.76	0.82	0.88	0.83	0.87	0.90

[a] Ingress protection code number of lamp housing; see BS EN 60529.
[b] High pollution generally occurs in the centre of large urban areas and heavy industrial areas.
[c] Medium pollution generally occurs in semi-urban, residential and light industrial areas.
[d] Low pollution generally occurs in rural areas.

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 five main stages

a) selection of lighting class(es) and definition of relevant area(s) (see **E.2**);

b) gathering of preliminary data (see **E.3**);

c) calculation of design spacings for straight roads (see **E.4**);

d) plotting of luminaire positions (see **E.5**);

e) 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 Table 1b) if the Highway Authority considers that the road surface will be wet for a significant proportion of the hours of darkness.

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.

E.2.2 *Adjacent areas*

The lighting of any areas adjacent to the carriageway is considered, such as footways, cycle tracks and verges, and a decision made to use 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 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 and an installed intensity class selected from BS EN 13201-2:2003, Table A.1.

NOTE Environmental considerations can also influence the choice of installed intensity class.

E.2.4 *Pedestrian crossings*

Any pedestrian crossings are identified, and a decision made to light them using one of the following approaches.

a) Use the normal road lighting.

b) Use separate local lighting, with the criteria 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, for horizontal illuminance, or Table 6 for vertical illuminance.

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) lamp type;

d) initial luminous flux of lamp or lamps in luminaire (F);

e) IP rating of luminaire lamp housing;

f) cleaning interval planned for luminaries;

g) pollution category at location;

h) luminaire maintenance factor (from Table 2);

i) lamp 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, 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 may 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, as 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 lamps 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.

E.4 Calculation of design spacing for straight roads

The procedure set out in BS EN 13201-3:2003, **7.1** 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. 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 lamp 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, 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

E.5.1 The luminaire positions at conflict areas are plotted, following the principles set out in Clause **11**. 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, Table 1. The layout, mounting height, luminaires/optic settings and lamp 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.

E.5.2 Where pedestrian crossings exist and are to be lit using the normal road lighting, the luminaire positions are plotted.

E.5.3 The luminaire positions on bends are plotted, using the procedure set out in **7.3**.

E.5.4 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.

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 motorways

F.1 General

The design lighting design process for motorways consists of the following six main stages:

a) selection of lighting class(es) and definition of relevant area(s) (see **F.2**);

b) choice of lighting arrangement (see **F.3**);

c) gathering of preliminary data (see **F.4**);

d) calculation of design spacings (see **F.5**);

e) plotting of luminaire positions (see **F.6**);

f) determination of lighting column positions (see **F.7**).

F.2 Selection of lighting class and definition of relevant area

F.2.1 *Carriageway*

The lighting class for the carriageway is selected from BS EN 13201-2:2003, Table 1a), or Table 1b) if the Highway Authority considers that the road surface will be wet for a significant proportion of the hours of darkness.

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.

F.2.2 *Adjacent areas*

The lighting of any emergency lanes or verges adjacent to the carriageway is considered, and a decision made to use one of the following approaches.

a) Apply surround ratio to the emergency lane.

b) Apply an appropriate luminance class to the emergency lane.

c) Apply surround ratio to the verge where there is no emergency lane, 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.

F.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, and an installed intensity class selected from BS EN 13201-2:2003, Table A.1.

NOTE Environmental considerations can also influence the choice of installed intensity class.

F.3 Choice of lighting arrangement

The choice of lighting arrangement is normally made from those described in **5.2.3.6**. 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.

F.4 Preliminary data

F.4.1 *Carriageway*

Having selected the appropriate lighting class(es), and an installed intensity class where necessary, the following preliminary data has to be ascertained before carriageway lighting design calculations are commenced. Separate calculations are carried out for main carriageways and slip or link roads.

a) mounting height (H);

b) luminaire type and optic setting (and installed intensity class where necessary);

c) lamp type;

d) initial luminous flux of lamp or lamps in luminaire (F);

e) IP rating of luminaire lamp housing;

f) cleaning interval planned for luminaires;

g) pollution category at location;

h) luminaire maintenance factor (from Table 2);

i) lamp 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 (or emergency lane) for surround ratio, or width of emergency lane as 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.

F.4.2 *Conflict areas*

Conflict area calculations generally need similar preliminary data to that listed in **F.4.1**, but there are some differences.

a) The relevant area is likely to be an irregular shape.

b) The relevant area may 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, as illuminance is the criterion.

F.5 Calculation of design spacing for straight roads

The procedure set out in BS EN 13201-3:2003, **7.1** 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. It is normally necessary to carry out an iterative process for a range of mounting heights, spacings, arrangements, luminaires/optic settings and lamp 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, energy consumption, and environmental and aesthetic issues in addition to the technical issue of meeting the photometric performance requirements.

F.6 Plotting of luminaire positions

F.6.1 The luminaire positions at conflict areas are plotted, following the principles set out in Clause **11**. 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, Table 1. The layout, mounting height, luminaires/optic settings and lamp 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.

F.6.2 Where the lighting column positions are dictated by the location of over-bridges or under-bridges the resulting lighting column positions are plotted.

F.6.3 The luminaire positions on bends are plotted, using the procedure set out in **7.3**.

NOTE This step does not normally apply to main carriageways due to the large radius of any bends.

F.6.4 The layout of uninterrupted straight sections is fitted into that of the conflict areas, bridges and bends. There is likely to be a need for compromise at the interfaces, but without exceeding the straight road design spacing.

F.7 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.

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 G (informative)
Example of a procedure for checking the lighting design of bends on traffic routes

G.1 Construction of isoluminance templates

NOTE 1 If luminaires with variable optics have been chosen for the project design, a different optic setting can be advantageous on the bend compared with the straight section of road.

To construct templates for use on bends, isoluminance contours are produced at 12.5 % and 25 % of the maximum luminance from a single luminaire at mounting heights, H, of 8 m, 10 m and 12 m. A third contour is produced at 12.5 % of the maximum luminance from an intensity table that is the average of two tables, one of which is rotated in azimuth by 180°.

NOTE 2 This contour represents the combined distribution of two luminaires in a twin central arrangement.

The positions of the contours are determined by linear interpolation from a grid of luminance values, obtained in accordance with BS EN 13201-3:2003, **7.1**.

The observer is positioned at (0,0), 90 m from the luminaire and in line with it within an observer circle of diameter 0.5H. The circle facilitates spacing the observer one quarter of a mounting height from the edge of the carriageway. The luminaire position is marked at (0,90).

Luminance values are calculated over a large enough area to allow each contour to be drawn completely.

NOTE 3 In most instances an area of 40 m by 135 m is sufficient.

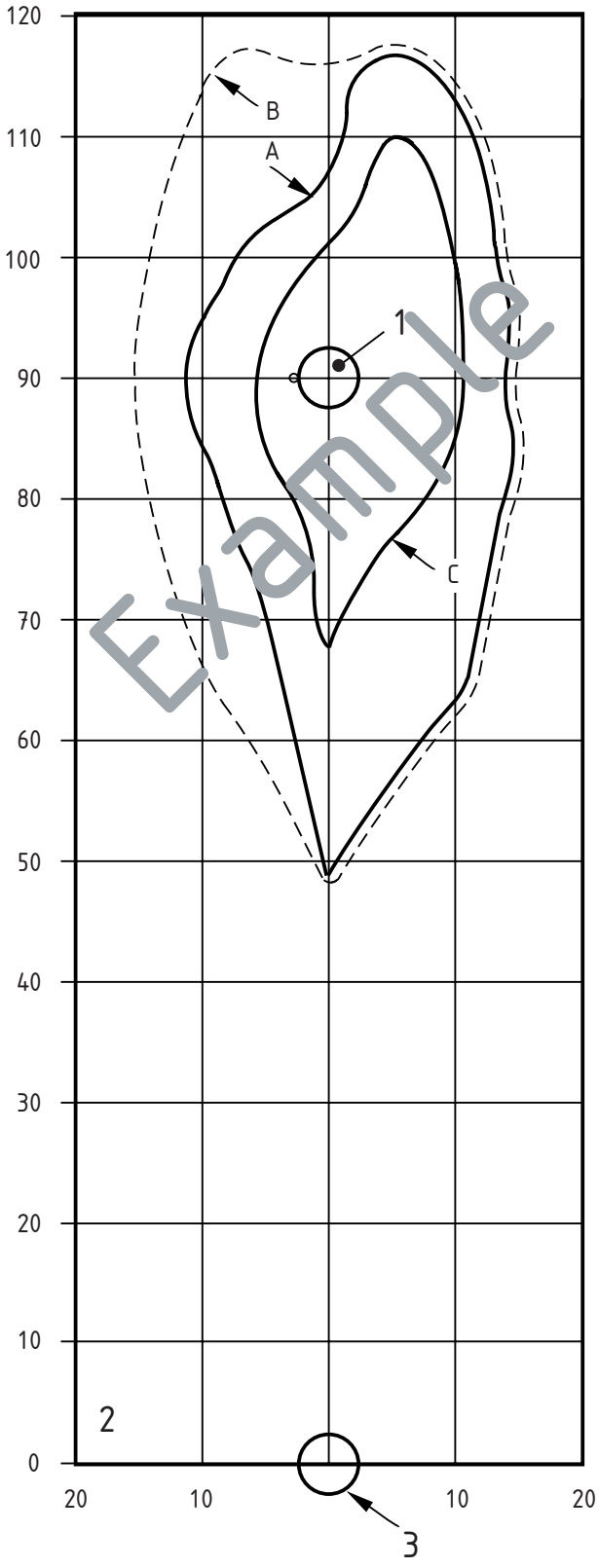
NOTE 4 In determining the position of the contours, linear interpolation in two directions will generally be required.

When all the points have been determined, two smooth curves are drawn through them to create the contours required for the template.

Figure G.1 shows the preferred format for a template, with a scale of 1:500 (i.e. 10 m is represented by 20 mm on the drawing). The three isoluminance contours, one for each mounting height, are shown in Figure G.1 as A, B and C.

NOTE 5 For plans to other scales, it is necessary to redraw the template.

Dimensions in metres



Key

1 Luminaire

2 Nearside

3 Observer circle with radius one quarter of mounting height

A Isoluminance contour at 12.5 % for a single luminaire

B Isoluminance contour at 12.5 % for back to back luminaires

C Isoluminance contour at 25 % for a single luminaire

NOTE The details in this example are as follows:

— tilt in application: 5°;

— lamp: 150 W SON/T;

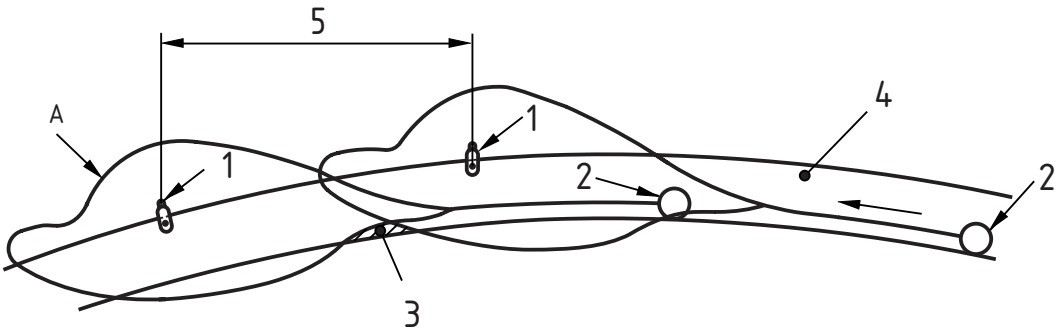
— mounting height: 10 m.

Figure G.1 — Isoluminance template

G.2 Use of templates

As indicated by the orientation of the luminaire in Figure G.1, the template is drawn for lighting columns positioned on the nearside. For lighting columns on the offside, a mirror image of the template is required with the designation “nearside” changed to “offside”.

The luminaire position marked on the template is placed over the luminaire on the scale plan, except in the case of the twin central arrangement, when it is placed over the lighting column. The observer circle is placed tangential to the nearside carriageway edge and the template shape transferred onto the plan. The process is repeated for adjacent luminaires. If a gap appears between two contours indicating a part of the road with inadequate coverage, as shown in Figure G.2, then the luminaire spacing is decreased or additional luminaires are used until the carriageway surface is fully covered by the outlines of the template. The check is carried out for both vehicle directions.



Key

1 Luminaires
2 Observer positions
3 Part of road with inadequate coverage
4 Road
5 Straight road spacing
A Isoluminance contour at 12.5 % for a single luminaire

Figure G.2 — Inadequate coverage of road

Various luminaire arrangements are considered as follows.

a) Where the staggered arrangement is in use on straight sections of the road, a change to a row of luminaires on the outside of the bend might be necessary where the radius of curvature is less than 80 times the mounting height. The number of luminaires per unit length of curved road may not be less than that for the staggered installation, and the location of the luminaires in the single row is determined by isoluminance template A in Figure G.1.

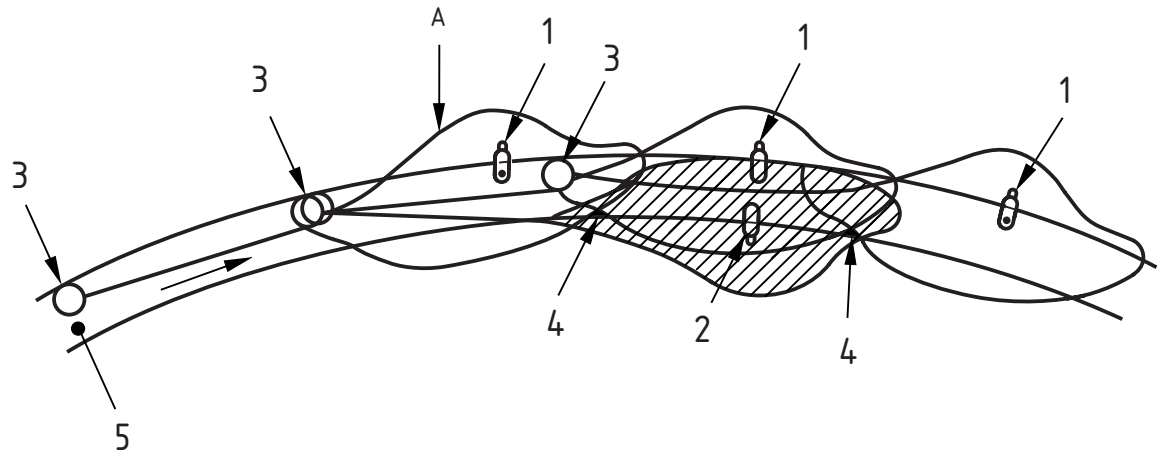
For wide roads, it might also be necessary to position luminaires on the inside of the bend to ensure adequate coverage (see Figure G.3).

b) Where the opposite arrangement is in use on straight sections of the road, the spacing adopted for the straight sections of the road may be preserved on the inside of the bend and the spacing on the outside of the bend determined by the means of isoluminance template A in Figure G.1.

c) Where the single-sided arrangement is in use on straight sections of the road, the luminaires may be sited on the outside of bends having a radius of less than 80 times the mounting height. The spacing may be determined by means of isoluminance template A in Figure G.1.

d) Where the twin central arrangement is in use on straight sections of the road on dual carriageways, one row of luminaires may be moved to the outside of bends on which the radius of curvature is less than 80 times the mounting height. Where the twin central arrangement is arranged around a bend, isoluminance template B in Figure G.1 is used as shown in Figure G.4 to ensure that coverage is adequate on the inside carriageway.

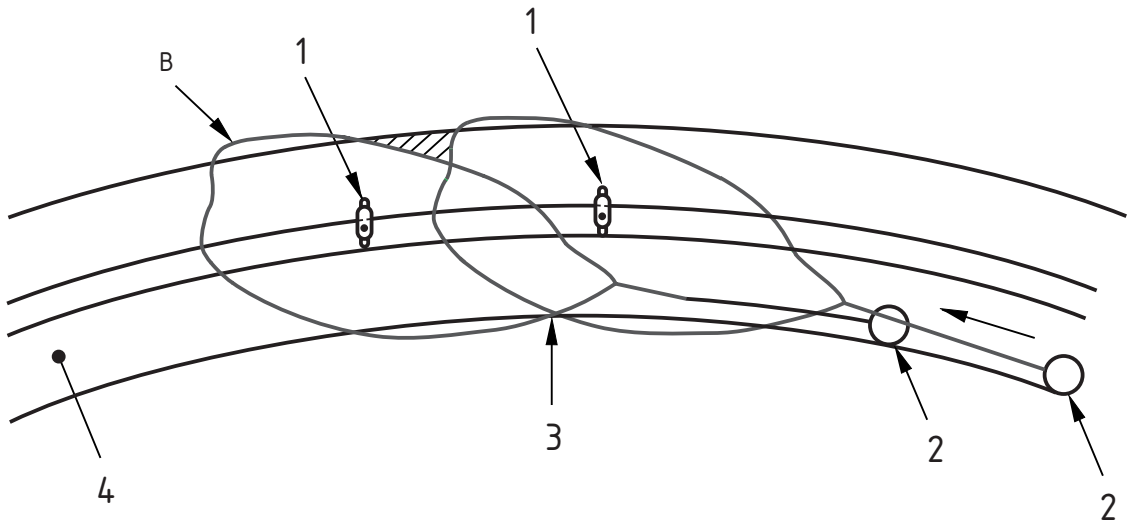
Coverage is checked for both vehicle directions. With the spacing set for the inside carriageway, a check as shown in Figure G.5 could indicate inadequate coverage of the outside carriageway. In this case isoluminance template C in Figure G.1 may be used to site a single luminaire as shown in Figure G.5 to cover the dark area.



Key

1 Luminaires on outside of bend
2 Additional luminaire
3 Observer positions
4 Dark areas of road covered by additional luminaire
5 Road
A Isoluminance contour at 12.5 % for a single luminaire

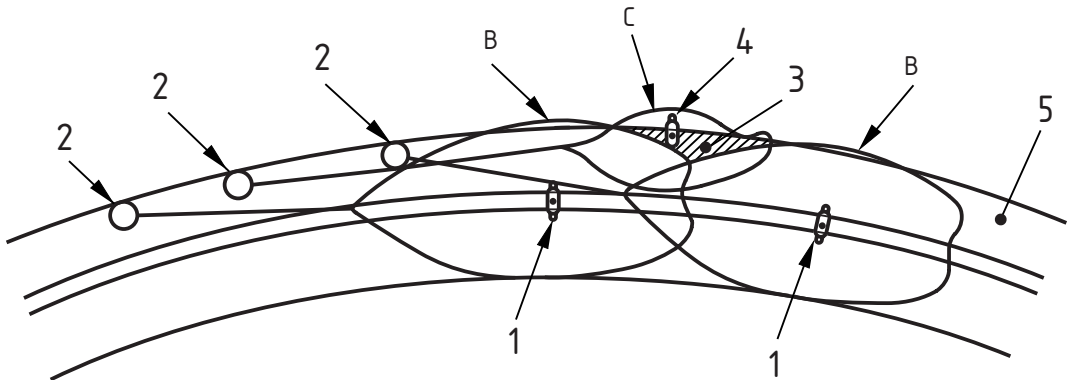
Figure G.3 — Additional luminaire covering two dark areas



Key

1 Luminaires
2 Observer positions on inside carriageway
3 No inadequate coverage on inside carriageway
4 Road
B Isoluminance contour at 12.5 % for back to back luminaires

Figure G.4 — Spacing set for inside carriageway



Key

1 Luminaires centrally mounted
2 Observer positions on outside carriageway
3 Inadequate coverage of outside carriageway with centrally mounted luminaires
4 Additional luminaire covering dark area on outside carriageway
5 Road
B Isoluminance contour at 12.5 % for a single luminaire
C Isoluminance contour at 25 % for a single luminaire

Figure G.5 — Additional luminaire covering dark area on outside carriageway

Annex H (informative)
Outline of lighting design process for subsidiary roads and associated areas

H.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 **H.2**);

b) gathering of preliminary data (see **H.3**);

c) calculation of design spacing (see **H.4**);

d) plotting of luminaire positions (see **H.5**);

e) determination of lighting column positions (see **H.6**).

H.2 Selection of lighting class and definition of relevant area

The lighting class is normally selected from BS EN 13201-2:2003, Table 3, which specifies average and minimum illuminance. A different class may be selected for areas of traffic calming measures, as indicated in **9.2**.

Where an additional lighting class is required using semi-cylindrical illuminance and uniformity, this is selected from BS EN 13201-2:2003, Table 5.

In order to limit glare, a glare index class is selected from BS EN 13201-2:2003, Table A.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, 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 CEN/TR 13201-1:2003, Annex F.

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 CEN/TR 13201-1:2003, Annex F.

H.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) lamp type;

d) initial luminous flux of lamp or lamps in luminaire (F);

e) IP rating of luminaire lamp housing;

f) cleaning interval planned for luminaires;

g) pollution category at location;

h) luminaire maintenance factor (from Table 2);

i) lamp replacement interval;

j) lamp flux maintenance factor at replacement interval;

k) maintenance factor (MF);

l) luminaire tilt in application (θ_t);

m) width of relevant area (W_r);

n) luminaire transverse position relative to the calculation grid;

o) luminaire arrangement;

p) glare index class of luminaire.

H.4 Calculation of design spacing

The procedure set out in BS EN 13201-3:2003, **7.2** 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 13201-3:2003, Figure 17, is used, with a regular array of luminaires. Where the relevant area is irregular, or includes severe bends, the advice given in BS EN 13201-3:2003, **7.2.9**, 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 lamp 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, energy consumption, and environmental and aesthetic issues in addition to the technical issue of meeting the photometric performance requirements.

H.5 Plotting of luminaire positions

H.5.1 The luminaire positions at T-junctions are plotted.

H.5.2 Where traffic-calming measures exist, the relevant luminaire positions are plotted.

H.5.3 The luminaire positions for any irregular areas or severe bends are plotted.

H.5.4 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.

NOTE At this stage it might be necessary to abandon positions opposite T-junctions, if they cannot be incorporated into an economic layout.

H.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.

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 I (informative)
Outline of lighting design process for lighting urban centres and public amenity areas

I.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 **I.2**);

b) determining of the lighting needs and how best they can be met (see **I.3**);

c) choice of appropriate equipment, desirable mounting height(s), and possible methods of support best suited to the area concerned (see **I.4**);

d) calculation of the design geometry which ensures conformity to the requirements of the selected lighting class(es) (see **I.5**);

e) plotting of luminaire positions, taking into account both the individual features of the area and its future maintenance (see **I.6**).

NOTE A worksheet for the installation design is shown in Figure I.1.

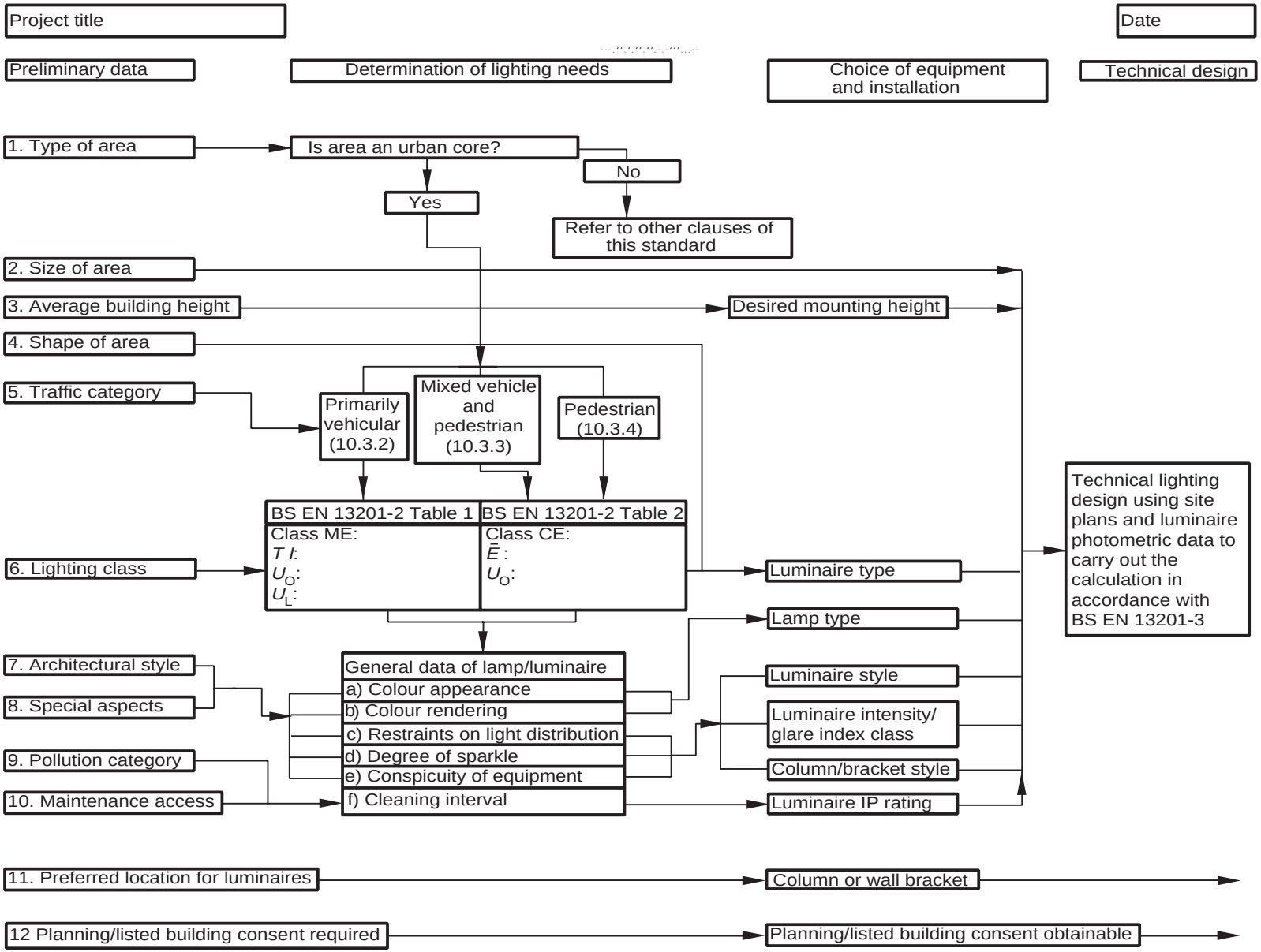


Figure I.1 — Worksheet for the installation design process

I.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:
   1) 18th century;
   2) 19th century;
   3) early 20th century;
   4) interwar;
   5) post-war;
   6) modern;
   7) other;

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.

I.3 Determination of lighting needs

The following items are considered 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, Table 1 or Table 2;

c) photometric data for the lamp/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, Table A.1;
   4) cleaning interval;

d) other data, e.g. sparkle.

I.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) lamp type:

1) high pressure sodium;

2) high pressure mercury;

3) tubular or compact fluorescent;

4) metal halide;

5) ceramic metal halide;

6) low pressure sodium;

7) other;

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) use of lighting column or wall bracket;

h) whether planning and/or listed building consent is obtainable.

I.5 Calculation of design geometry

The procedures set out in BS EN 13201-2:2003, **7.1** or **7.2** as appropriate 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 luminance.

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 13201-3:2003, Figure 17, is used. Where the relevant area is irregular, or the array of luminaires is to be irregular, the advice given in BS EN 13201-3:2003, **7.2.9** 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.

I.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.

Annex J (informative)
Luminaire and column positions for typical single level junctions and roundabouts using 10 m or 12 m columns

J.1 T-junctions

J.1.1 *T-junctions on straight roads*

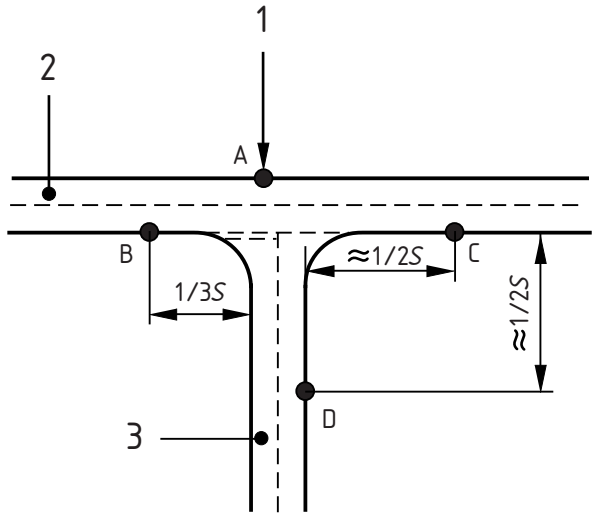
Typical luminaire positions for T-junctions are shown in Figure J.1. Four luminaires are directly associated with the junction.

a) Luminaire A reveals the end of the minor road to traffic approaching along it and pedestrians crossing its mouth.

b) Luminaire B reveals both the junction with the minor road to traffic in the major road (approaching from the right in Figure J.1) and a vehicle waiting in the mouth of the minor road.

c) Luminaire C reveals turning movements to traffic in the major road (approaching from the left in Figure J.1).

d) Luminaire D reveals the traffic conditions in the mouth of the minor road to traffic entering from the major road.



Key

1 Luminaire positions

2 Major road

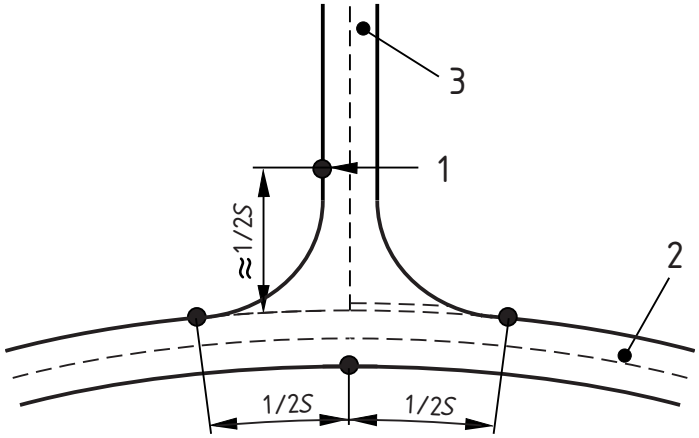
3 Minor road

NOTE The design spacing *S* relates to the major road.

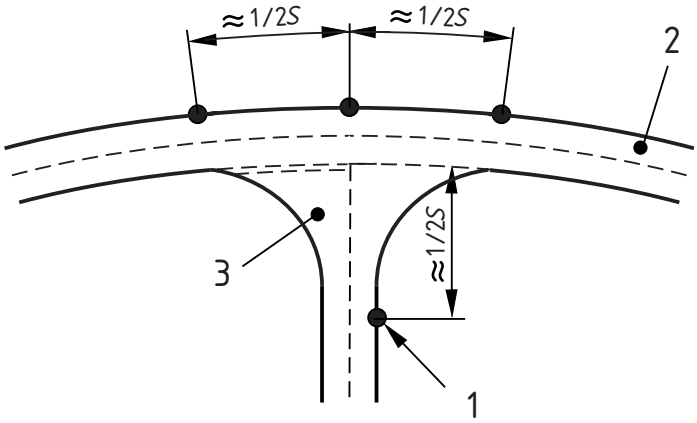
Figure J.1 — T-junctions on straight roads

J.2 T-junctions on bends

The design solution for a T-junction with a curved major road can differ from that for junctions illustrated in Figure J.1. Typical luminaire positions for a T-junction on a bend are shown in Figure J.2.



a) T-junction with minor road on outside of bend



b) T-junction with minor road on inside of bend

Key

1 Luminaire positions

2 Major road

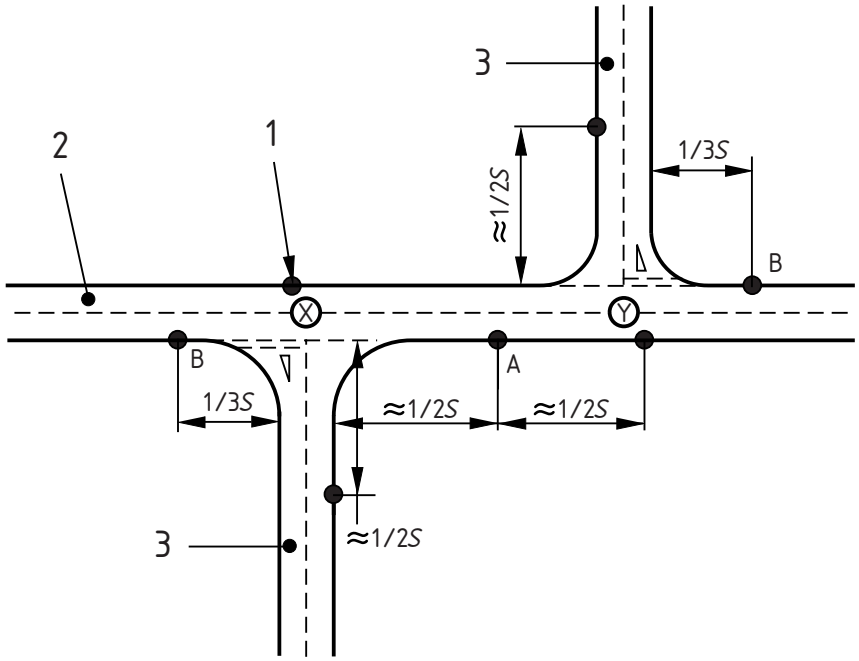
3 Minor road

NOTE The design spacing *S* relates to the major road.

Figure J.2 — T-junctions on bends

J.3 Staggered junctions

Two T-junctions (X) and (Y) on opposite sides of the main road, as shown in Figure J.3, may be considered independently in the first instance as separate conflict areas. If they are closer together, and considered as one area, compromise positions may be chosen for luminaires A or B.



Key

1 Luminaire positions

2 Major road

3 Minor road

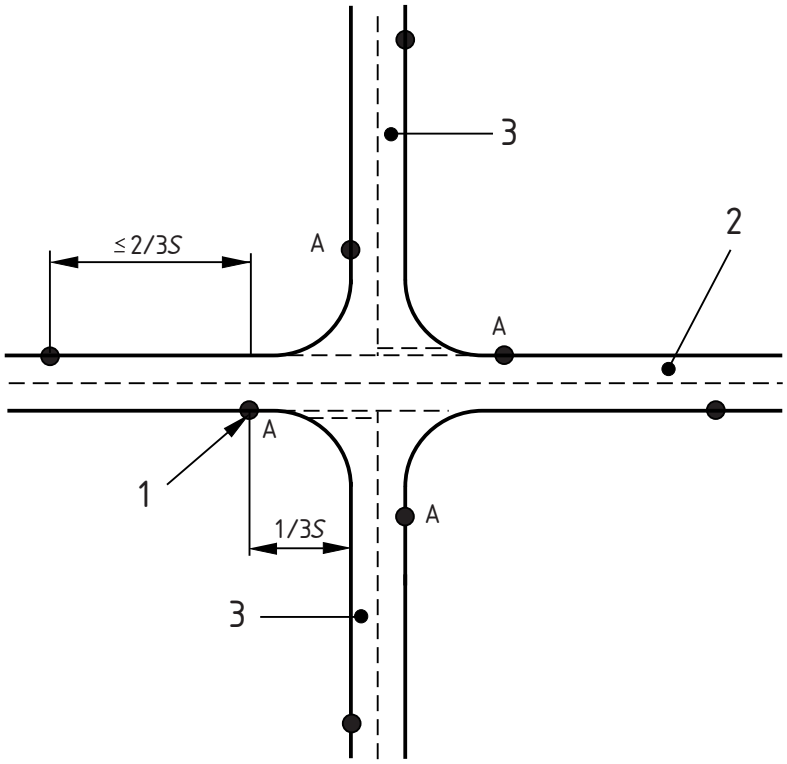
NOTE The design spacing *S* relates to the major road.

Figure J.3 — Staggered junctions

J.4 Crossroads

Typical luminaire positions for a crossroads are shown in Figure J.4.

Luminaires A serve to reveal crossing and turning traffic.



Key

1 Luminaire positions

2 Major road

3 Minor road

NOTE The design spacing *S* relates to the major road.

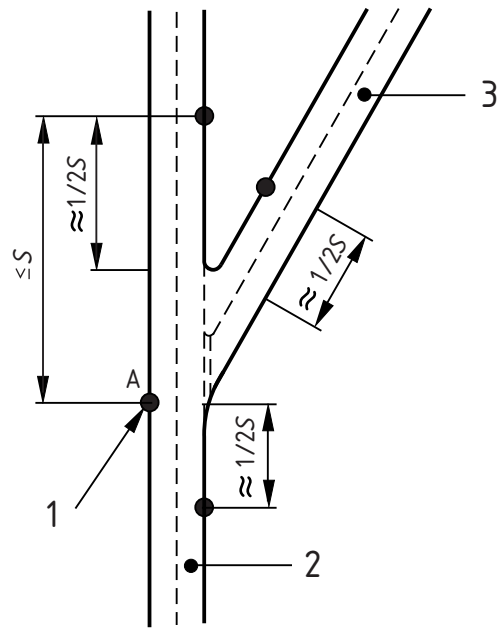
Figure J.4 — Crossroads

J.5 Y-junctions and fork-junctions

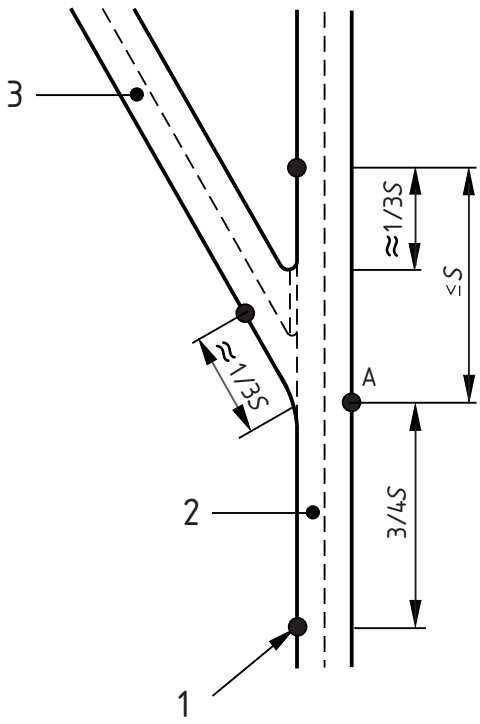
J.5.1 *Y-junctions*

Typical luminaire positions for a staggered arrangement at Y-junctions are shown in Figure J.5. These luminaires serve to reveal the junction in much the same way as for T-junctions. Luminaire A reveals road layout and traffic movement along the minor road.

NOTE At a Y-junction on a wide road a lighting column on a refuge or traffic island in the mouth of a wide entry road might be necessary in order to avoid excessive luminaire spacing.



a) Y-junction with minor road on the right



b) Y-junction with minor road on the left

Key

1 Luminaire positions

2 Major road

3 Minor road

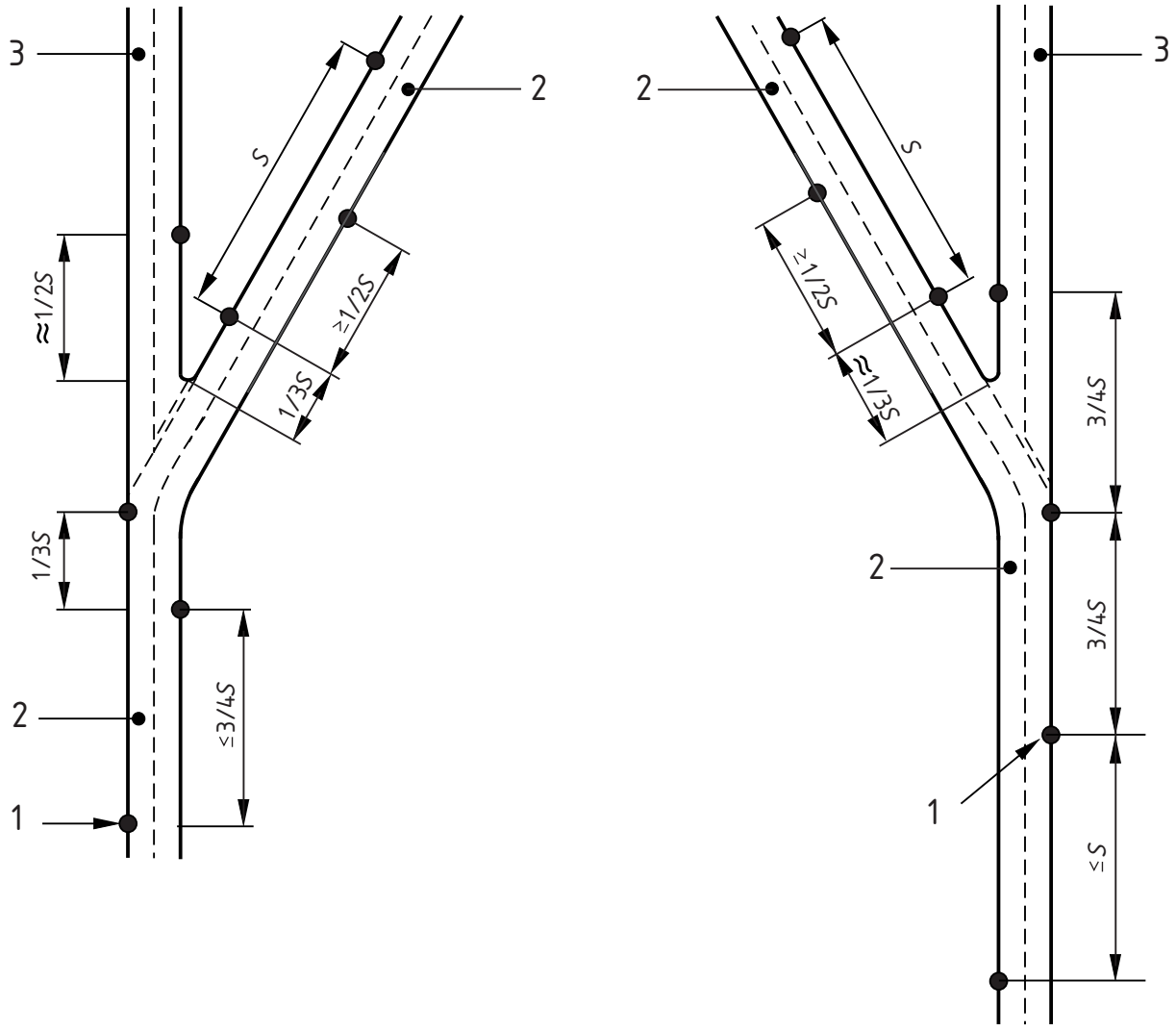
NOTE The design spacing *S* relates to the major road.

Figure J.5 — Y-junctions

J.5.2 *Fork-junctions*

A fork-junction may be lit as a bend with luminaires in the major road along the outer kerb and at appropriately reduced major road design spacings. Typical luminaire positions for a staggered arrangement are shown in Figure J.6.

NOTE In order to span the minor road without exceeding this design spacing, there might be situations where one luminaire has to be mounted on a longer bracket arm or on a lighting column situated on a refuge or traffic island in the mouth of the minor road.



a) Fork-junction with minor road on the right

b) Fork-junction with minor road on the left

Key

1 Luminaire positions

2 Major road

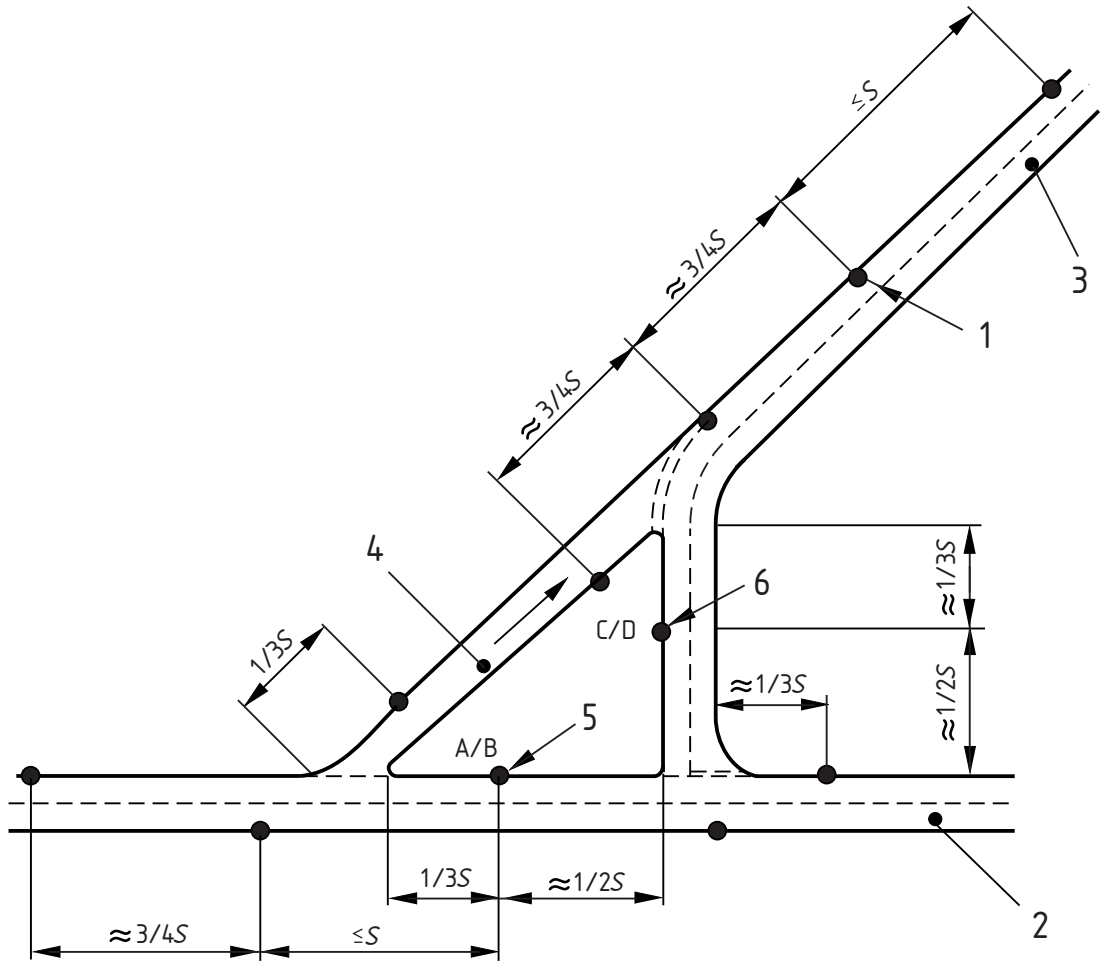
3 Minor road

NOTE The design spacing *S* relates to the major road.

Figure J.6 — Fork-junctions

J.6 Junctions with triangular islands

In some junctions, traffic from the minor road might be separated from that on the major road by a triangular island. Figure J.7 indicates the possible arrangements of luminaires where the minor road approaches the major road at an obtuse angle of 135°, and Figure J.8 where the minor road joins the major road at an acute angle of 45°.



Key

1 Luminaire positions

2 Major road

3 Minor road

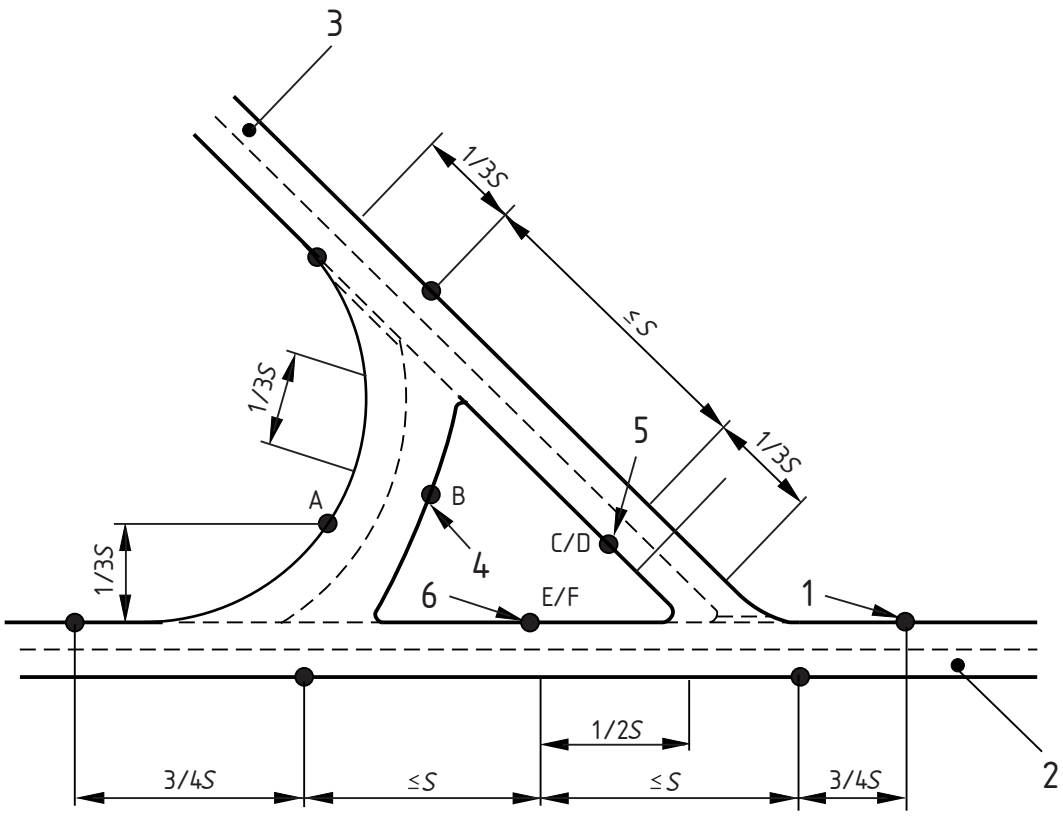
4 One-way link road

5 A and B can be separate or combined positions, depending on the size of the island

6 C and D can be separate or combined positions, depending on the size of the island

NOTE The design spacing *S* relates to the major road.

Figure J.7 — Junctions with triangular islands (minor road at obtuse angle)



Key

1 Luminaire positions

2 Major road

3 Minor road

4 A and B can be alternative positions, but B is preferred

5 C and D can be separate or combined positions, depending on the size of the island

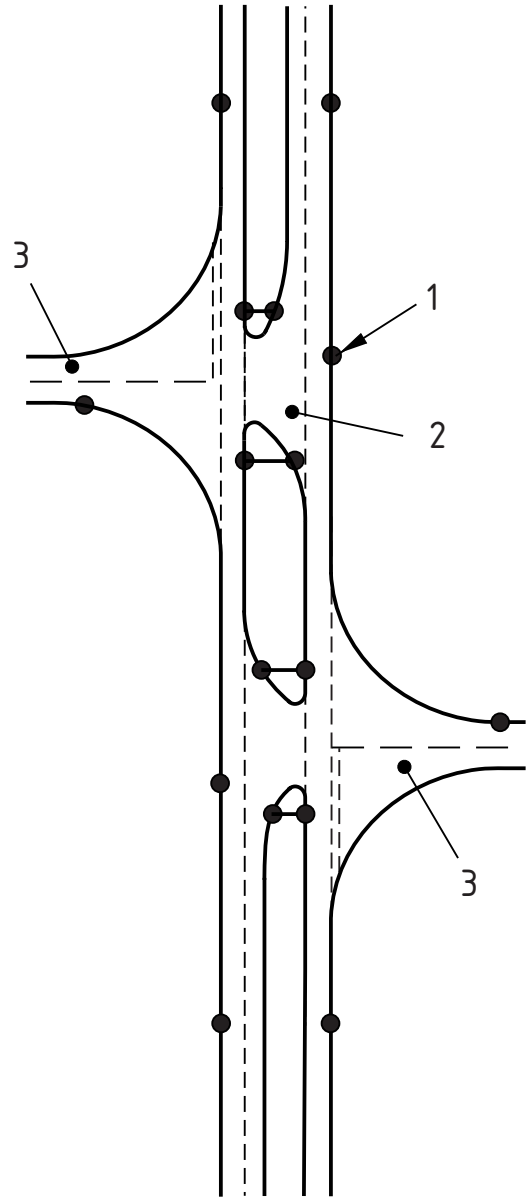
6 E and F can be separate or combined positions, depending on the size of the island

NOTE The design spacing *S* relates to the major road.

Figure J.8 — Junctions with triangular islands (minor road at acute angle)

J.7 Junctions with ghost or traffic islands

Typical luminaire positions for a junction with ghost or traffic islands and right-turn lanes are shown in Figure J.9.



Key

1 Luminaire positions

2 Major road

3 Minor road

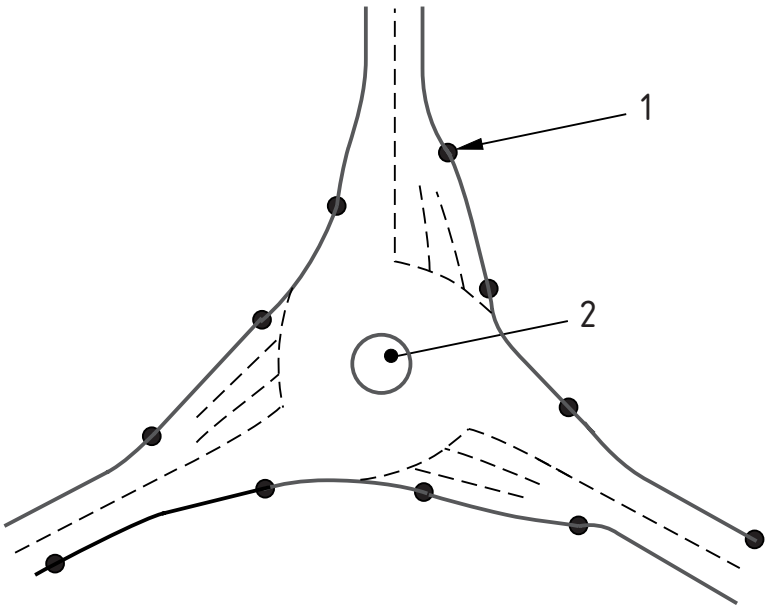
NOTE The design spacing *S* relates to the major road.

Figure J.9 — Junctions with ghost or traffic islands and right-turn lanes on the major road

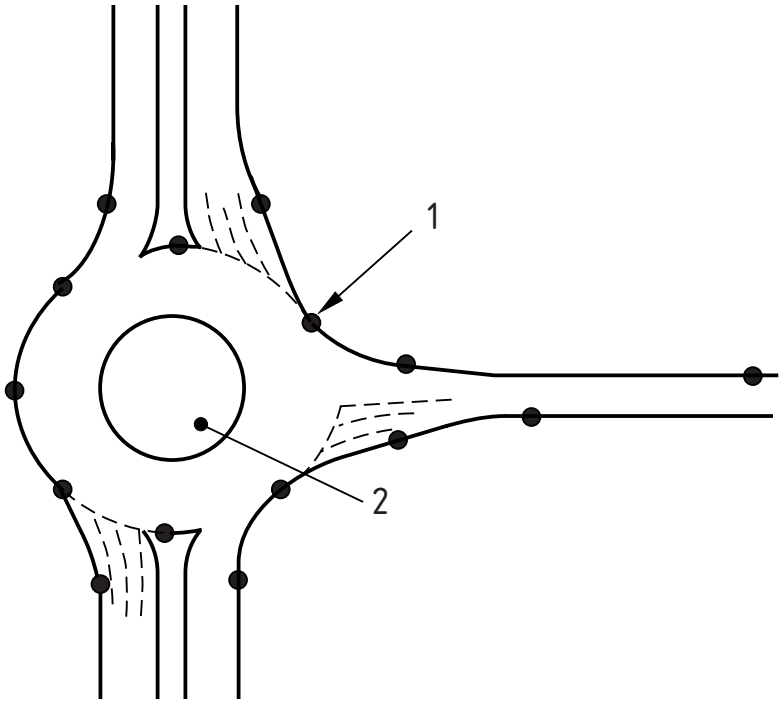
J.8 Roundabouts

J.8.1 *Central traffic island roundabouts*

Figure J.10 and Figure J.11 give examples of typical luminaire positions for central traffic island roundabouts with different numbers of access roads.



a) Single approach roads



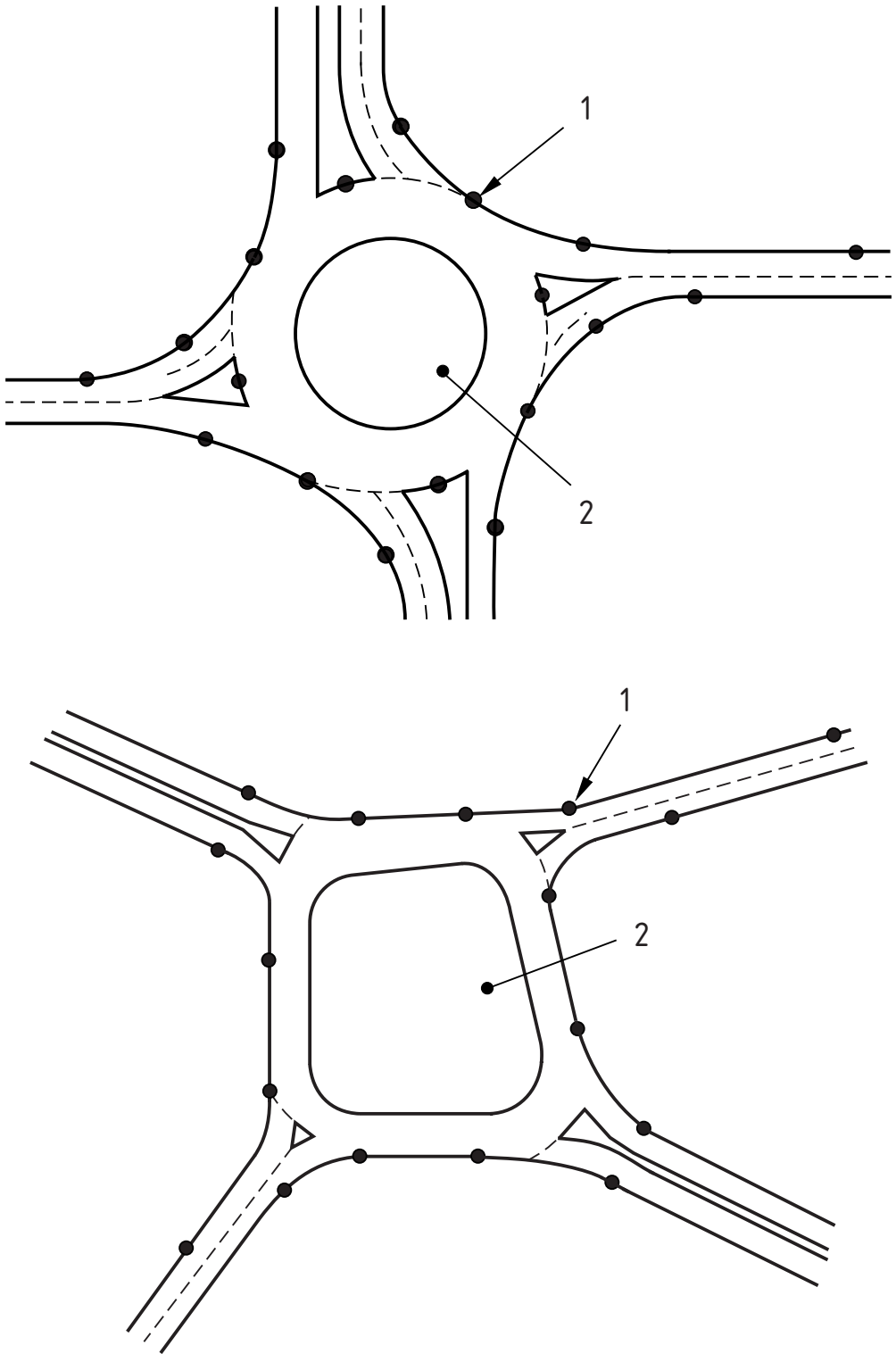
b) Dual and single approach roads

Key

1 Luminaire positions

2 Central island

Figure J.10 — Roundabouts at three-way junctions

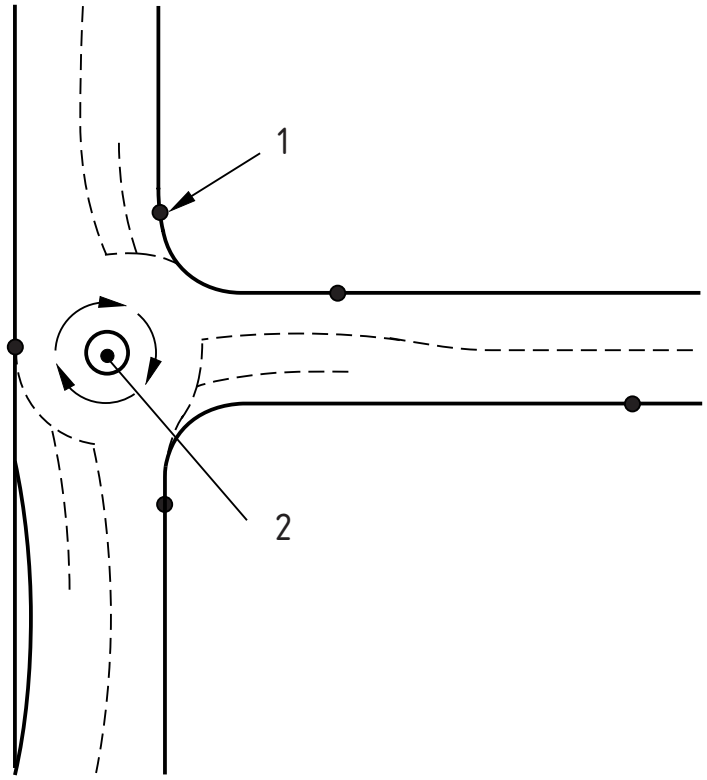


Key
1 Luminaire positions
2 Central island

Figure J.11 — Roundabouts at four-way junctions

J.8.2 *Mini-roundabouts*

Figure J.12 and Figure J.13 give examples of typical luminaire positions for mini-roundabouts of different configurations.

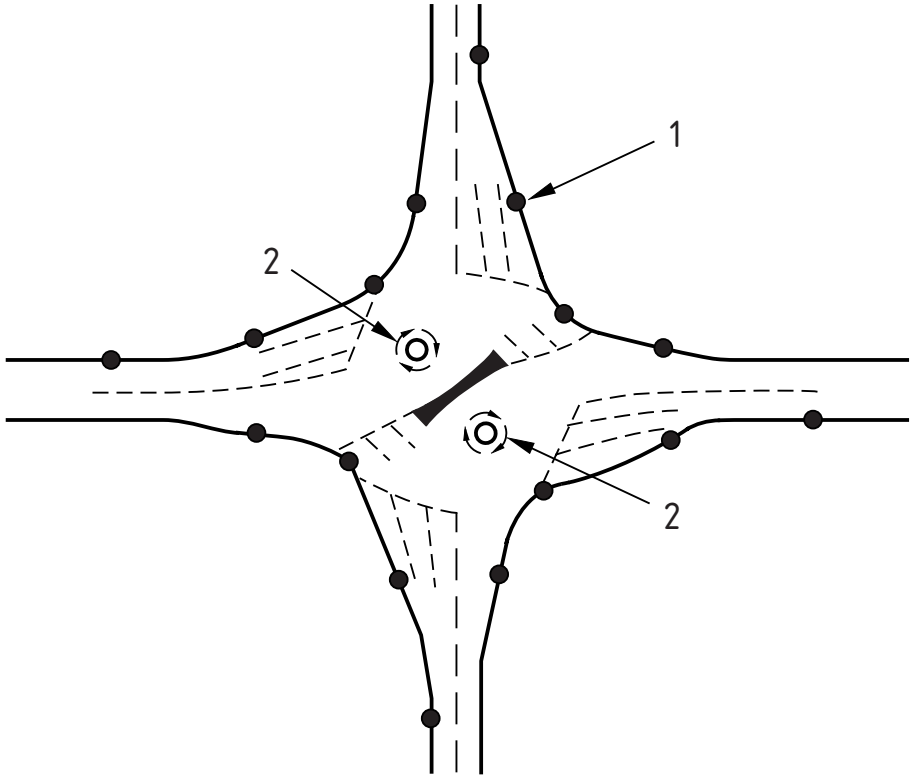


Key

1 Luminaire positions

2 Central island

Figure J.12 — Mini-roundabouts at T-junctions



Key

1 Luminaire positions

2 Central islands

Figure J.13 — Double mini-roundabouts (with large right-turning flows)

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