



BS 5489 : Part 2 : 1987

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British Standard

Road lighting

Part 2. Code of practice for lighting for traffic routes

Eclairage routier

Partie 2. Eclairage des routes à grande circulation. Code de bonne pratique

Straßenbeleuchtung

Teil 2. Leitfaden zur Beleuchtung von Verkehrswegen

British Standards Institution

Foreword

This Part of BS 5489 has been prepared under the direction of the Electrical Illumination Standards Committee and is a revision of BS 5489 : Part 2 : 1974, which is withdrawn.

In this revision a new design procedure is formulated to calculate specific standards of uniformity and levels of luminance on the dry road surface. Disability and discomfort glare are controlled by limiting threshold increment rather than by limiting lantern intensities. These concepts are discussed in BS 5489 : Part 1, the reading of which is essential for the understanding of this Part 2. Furthermore, a new method is introduced for designing installations on bends.

Generally, the lighting levels and glare control achieved by this revision are similar to those of the 1974 edition to ensure continuity of practice.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

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Code of practice

1 Scope

This Part of BS 5489 gives recommendations for the lighting of all-purpose traffic routes up to 15 m in width for single carriageways and up to 2 x 11 m in width for dual carriageways. Motorways are not included.

A step by step illustration of the use of this code is given in appendix A.

NOTE. The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

NOTE. A checklist of abbreviations and symbols used in this Part of BS 5489 is given in table 7.

For the purposes of this Part of BS 5489 the definitions given in BS 5489 : Part 1, BS 6100 : Subsection 2.4.1, BS 5225 : Part 1 and BS 4727 : Part 4 : Group 03 apply, together with the following.

2.1 bracket projection. The horizontal distance from the point of entry to the lantern to a vertical line passing through the centre of the cross section of the column at the ground level.

NOTE. See figure 1.

2.2 lighting design lumens. The nominal light output from a lamp for lighting design purposes.

NOTE. The light output of a discharge lamp at 2000 h is normally taken as its lighting design lumens.

2.3 maintenance factor (MF). A factor which allows for the depreciation in the photometric performance of a lantern from its state when new to its worst acceptable state in service.

2.4 spacing index (SI). The product of the calculated average road luminance (in cd/m^2) produced by an installation of lanterns in their clean state and the spacing (in m) divided by the lamp flux (in klm).

2.5 veil factor (VF). The equivalent veiling luminance per kilolumen of lamp output, multiplied by 650.

2.6 width of carriageway (WK). The distance between kerb lines, measured at right angles to the length of the carriageway.

NOTE. See figure 1.

3 Mounting height

3.1 General

The mounting heights to be adopted should be 8 m, 10 m or 12 m, except in special situations, e.g. where the appearance of the installation is particularly important. In these circumstances consideration may be given to other systems and mounting heights but it is essential to ensure that the lighting performance is not inferior to that recommended in this standard.

3.2 8 m mounting height

8 m is the recommended mounting height for:

- (a) urban traffic routes where, owing to the multiplicity of road junctions, no reduction in the number of lighting points is to be gained by the use of a higher mounting height;
- (b) traffic routes where higher mounting heights would be out of scale with the adjacent buildings;
- (c) relatively narrow roads such as local distributor and access roads to residential areas in which a mounting height between 10 m or 12 m and 5 m or 6 m is desirable.

3.3 10 m mounting height

10 m is the recommended mounting height for lighting for:

- (a) the majority of urban traffic routes;
- (b) lighting for traffic routes in which a mounting height of 12 m would be of an undesirable appearance;
- (c) lighting for wide heavily used routes where a large number of intersections, bends, etc., could lead to a short spacing making the use of 12 m mounting height uneconomical.

3.4 12 m mounting height

12 m is the recommended mounting height for lighting for wide or heavily used routes where advantage can be taken of a longer spacing of lanterns.

4 Limitation of glare

4.1 Disability glare

Disability glare, defined and discussed in BS 5489 : Part 1, reduces the contrast between objects and their background, so that their visibility is decreased. An object that is just visible (that is at the threshold of visibility) when there is no disability glare will, in the presence of disability glare, merge into the background. The percentage by which the background luminance has to be increased to render the object just visible again is known as the threshold increment (TI). This provides a notional measure of disability glare from installations.

The value of the TI depends on the light distribution from the lantern between 70° and 90° in elevation in the vertical plane at which the lantern is observed, usually within 10° of azimuth of the transverse axis of the lantern. It also depends on the road luminance, the layout of the lanterns, the mounting height and the observer position.

4.2 Discomfort glare

Control of the TI within the limits recommended in 4.3 will generally ensure that discomfort glare, defined in BS 5489 : Part 1, will be adequately controlled.

4.3 Recommended threshold increment

Recommended limits on the TI are for the lantern operated in a clean state, as in this condition the lantern will produce its maximum disability glare.

A value of the TI not exceeding 15 % is recommended where it is necessary to minimize glare, e.g. on high speed roads. It is of particular advantage in rural areas, where the absence of a reflecting background, such as buildings bordering the road, may increase the effect of glare.

In all other installations the value of the TI should not exceed 30 %. The light distribution for this less stringent glare control generally permits more scope for the siting of individual columns and longer spacing between lanterns, leading to lower capital and running costs.

NOTE. Other special requirements may be imposed in the neighbourhood of aerodromes, where the luminous intensity above the horizontal may need to be limited (see BS 5489 : Part 8) and in environmentally sensitive areas, where spill light may be regarded as being visually intrusive (see BS 5489 : Part 1).

4.4 Selection of lanterns

As an aid to their selection according to the recommendations in 4.3, lanterns are divided into two classes: low threshold increment (LTI) and moderate threshold increment (MTI). An LTI lantern will generally be capable of meeting the recommendation for the TI being not more than 15 % and an MTI lantern will generally meet the recommendation for the TI being not more than 30 %.

On straight roads, the TI should be checked in the manner described in 8.2(g), when the lantern has been selected. This is necessary because in certain installations the TI may exceed the recommended limits, even though the lantern classification may indicate otherwise. In practice this will occur rarely. On bends it may be assumed that the limits hold according to the class of the lantern.

NOTE. The classification of a lantern will depend, to a small extent, on the luminous flux of the lamp used for calculating the TI. For increases (or decreases) of flux up to 50 %, the TI will increase (or decrease) by approximately 0.2 % for every 1 % increase (or decrease) in flux. For larger changes of flux the equation for the TI given in 8.2(g) may be used.

5 Choice of lamps

5.1 Preferred sources

The preferred sources, on grounds of efficacy and life, are low pressure sodium and high pressure sodium lamps. The low pressure sodium lamp has the greater efficacy and emits a monochromatic yellow light. The high pressure sodium lamp has a longer life and renders colours. The use of other sources may be considered for special applications.

5.2 Use of lamps giving light of different colour

A change of colour of the light of the installation, by the use of different types of lamps, may be advantageous if used with discretion, the change being intentional and consistent; haphazard changes are distracting. There may be an advantage (where, for example, low pressure sodium lamps are used on the approach roads) in using high pressure sodium lamps in shopping areas, civic centres and other areas where better colour rendering is desirable.

6 Lighting of surrounds

Adequate lighting of the surrounds to the carriageway is necessary to serve the needs of the driver and the pedestrian.

For the driver, it helps to reveal objects on the carriageway that are only partly seen against the background of the carriageway, as is often the case on bends, or where there are stationary vehicles or bicycles near the margin of the carriageway. Moreover, it is needed to reveal pedestrians about to step into the carriageway and vehicles emerging from side roads.

For the pedestrian, it reveals the footway surface, obstructions and other pedestrians.

The surround lighting is quantified by the surround ratio (SR), defined in BS 5489 : Part 1.

For the chosen arrangement, the lantern should give a value of the SR which is not less than 0.5; otherwise the surround lighting may be inadequate.

7 Lighting of road surface

To be visually satisfactory, the value and uniformity of road luminance should be in accordance with the recommendations given in table 1.

The recommended average luminance ensures that the road is sufficiently bright to reveal objects adequately. The recommended overall uniformity ratio (UO) ensures that no part of the road surface is so dark that it becomes ineffective as a background for revealing objects, whilst the recommended longitudinal uniformity ratio (UL) ensures that pronounced visual patchiness of the lighted road surface is avoided.

The geometry required to obtain these recommended values can be found by interrelating the light distribution from the lantern and the reflection properties of the road surface, as described in clause 8 for straight roads and in clause 9 for bends. The results are valid for the assumed photometric conditions, e.g. no atmospheric attenuation, road surface of the stated reflection properties, clean lanterns correctly mounted, etc. In practice there will be departures from these conditions and, therefore, it may be difficult to substantiate the values in the actual installation by measurement. Nevertheless, the mathematical procedures described will provide a good representation of the absolute installation performance, as well as enabling valid comparisons between lanterns to be made.

8 Design spacings

8.1 For day-to-day installation design, spacings are determined from design tables prepared from the photometric quantities determined in accordance with appendix B for each lantern, and normally available from the manufacturer.

An example is shown in table 2 for a mounting height of 10 m. If the lantern can be used at 8 m or 12 m, tables for these mounting heights can be produced as appropriate.

NOTE. On some computers it is not possible to print the second letter of a symbol as a subscript. In these cases it is recommended that the corresponding abbreviation is used, e.g. VF for V_F .

As well as enabling the user to determine the design spacing needed to achieve a desired average luminance, the design table enables the UO, UL and SR to be checked, and the TI to be calculated.

Data for four arrangements are tabulated:

- (a) staggered (see figure 2);
- (b) opposite (see figure 3);
- (c) single side (see figure 4);
- (d) twin central on dual carriageway (see figure 5).

These tables are calculated for zero overhang ($A = 0$) but they may be used to a good accuracy for a positive or negative overhang not exceeding 1 m by applying the following rules.

- (1) Find the WE by using the appropriate relationships in figures 2 to 5.
- (2) Find the SR, SI, UL, and VF corresponding to the WE.
- (3) Use the isoluminance templates described in clause 9 to check the UO and adjust the spacing as necessary.

Designs for geometries not included in the table can be calculated by following the methods given in appendix B.

The road surface for which the design tables are prepared is designated the 'representative British road surface', and is typical of the great majority of road surfaces used in Great Britain. The average luminance coefficient for this surface is 0.07 and the full reflection data are given in table 3 (see B.2).

8.2 The calculation procedure using the design tables is as follows.

- (a) Consult table 1 to establish photometric requirements.
- (b) Decide on mounting height and degree of glare limitation.
- (c) Consult design tables for the chosen lanterns at their design attitude and for the mounting height to be used.
- (d) For the lantern arrangement to be used, and the WE, check that the SR is equal to or greater than 0.5.
- (e) Calculate the design spacing, S (in m), required to give the desired average luminance. This is done by using the spacing index, S_I , obtained from the design table, in the following equation:

$$S = \frac{S_I \phi M_F}{\bar{L}}$$

where

ϕ is the lamp flux (in klm), which is the value for the 'lighting design lumens' as quoted by the manufacturer;

M_F is the maintenance factor (see table 4) as determined according to the degree of pollution at the site of the installation, the intervals

between cleaning, and the degree of protection afforded by the lamp housing of the lantern as indicated by its international protection (IP) classification;

$\bar{L}$ is the average road luminance (in cd/m^2) as selected from table 1.

- (f) Use the calculated value of S to enter the design table and check whether the UL and UO recommendations given in table 1 are satisfied. If they are not, select the maximum spacing at which they are satisfied and determine the new average road luminance, $\bar{L}$ (in cd/m^2) from the equation:

$$\bar{L} = \frac{S_I \phi M_F}{S}$$

where the symbols are as defined in 8.2(e).

- (g) Check that the design limit for the threshold increment T_1 (expressed as a percentage) is not exceeded. This is done by substituting the appropriate value of the veil factor, V_F from the design table into the equation:

$$T_1 = \frac{V_F \phi}{10(\bar{L}/M_F)^{0.8}}$$

where

ϕ is as defined in 8.2(e):

$10(\bar{L}/M_F)^{0.8}$ can be evaluated by using table 5.

If the design limit is exceeded it will be necessary to select a different lantern, or a different installation geometry.

9 Spacings for roads with bends

9.1 General

The method described in clause 8 should be used to determine the maximum spacings between lanterns as though the road were straight. This spacing, which is the design spacing and which is not to be exceeded, is then used to plan the installation around the bend.

Transferring the straight road spacing to a bend is unlikely to reduce the values of longitudinal uniformity of luminance and average luminance. However, it is necessary to check that the overall uniformity of luminance does not fall below the value of 0.4, recommended in table 1. This is done by means of isoluminance templates for the lantern concerned (see figure 6). There are three of these (A, B and C) for each mounting height. The use of these templates is described in 9.2.

Figure 6 is in the preferred format, which has a scale of 1:500. For use with maps to other scales, it will be necessary to redraw the templates. The orientation of the lantern is as indicated. The observer is located at (0,0) and an observer circle with a radius equivalent to one quarter of a mounting height is drawn around this point. The circle facilitates spacing the observer one quarter of a mounting height from the kerb. A method of producing the templates is described in appendix C.

9.2 Use of isoluminance templates

9.2.1 Orientation of lantern. As indicated by the orientation of the lantern in figure 6, the template is drawn for columns positioned on the nearside. For columns on the offside, a mirror image of the template is required with the designation 'nearside' changed to 'offside'.

9.2.2 Positioning the template. The lantern position marked on the template is placed over the lantern on the scale plan, except in the case of the twin central arrangement, when it is placed over the columns. The observer circle is placed tangential to the nearside kerb edge and the template shape transferred onto the plan. The process is repeated for adjacent lanterns. If a gap occurs between two contours, as shown in figure 7, then the lantern spacing should be decreased until the road surface is fully covered by the outlines of the template as shown in figure 8. Alternatively, it may be necessary to use extra lanterns. The check should be carried out for both vehicle directions.

9.2.3 Staggered arrangement. Where the staggered arrangement is in use on straight sections of the road, a change to a row of lanterns on the outside of the curve may be required where the radius of curvature is less than 80 times the mounting height. The number of lanterns per unit length of curved road should be not less than that for the staggered installation, and the location of the lanterns in the single row is determined by isoluminance template A. For wide roads it may be necessary also to position lanterns on the inside of the bend to ensure adequate coverage (see figure 9). Some adjustment of the spacing may be necessary on the adjacent straight sections of road. This may be determined also by using the isoluminance template A.

9.2.4 Opposite arrangement. Where the opposite arrangement is in use on straight sections of the road, the spacing adopted for the straight section of the road may be preserved on the inside of the curve and the spacing on the outside of the curve determined by means of isoluminance template A.

9.2.5 Single side arrangement. Where the single side arrangement is in use on straight sections of the road, the lanterns should be sited on the outside of bends having a radius of less than 80 times the mounting height. The spacing is determined by means of isoluminance template A.

9.2.6 Twin central arrangement on dual carriageways. Where the twin central arrangement is in use on straight sections of the road on dual carriageways, one row of lanterns should 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 should be used to determine the coverage achieved (see figure 10). If this is not adequate, the spacing may have to be reduced.

Adequate coverage should be checked for both vehicle directions. This may reveal inadequate coverage on the outside of the bend which can be overcome by the addition of a single lantern. In this case isoluminance template C should be used for a single lantern as shown in figure 11.

Some adjustment may be necessary on the adjacent straight sections of road, which may be determined by using the isoluminance templates.

10 Planning

10.1 Bracket projection and overhang

Bracket projection should be as small as possible, and it is essential that it does not exceed one quarter of the mounting height, to limit vibration. Consult 5.4 of BS 5489 : Part 1 : 1987 for recommendations regarding the form of the bracket.

10.2 Design attitude

Lanterns should be mounted in the design attitude recommended by the manufacturer.

10.3 Choice of lantern arrangement

10.3.1 Single carriageways. For single carriageways there is a choice of three arrangements:

- (a) staggered (see figure 2), suitable for roads of medium width;
- (b) opposite (see figure 3), for the widest roads;
- (c) single side (see figure 4), for the narrowest roads.

For certain road widths, depending on lantern and lamp type, two or all of the three arrangements will be in accordance with the photometric recommendations of table 1. Choice may then be made on grounds of economy.

10.3.2 Dual carriageways. Where dual carriageways are separated by a wide reserve, the carriageways should be lighted separately. When the distance between outer kerbs is not excessive, dual carriageways can be lighted as a single wide road. For example, dual carriageways can be satisfactorily lighted by the use of lanterns on the nearsides only (see figures 2 and 3) or twin lanterns on the central reserve only (see figure 5), provided that little pedestrian traffic is expected.

10.3.3 Junctions and roundabouts. Junctions and roundabouts are dealt with in BS 5489 : Parts 4 and 5.

10.3.4 Gradients and crests of hills. On gradients, each lantern should be set with its plane of symmetry normal to the road surface.

At a dip there is no special lighting problem. At a crest, however, it is necessary to limit glare from lanterns beyond the crest; these can be viewed at angles where the intensity is high, and the more distant lanterns may appear low in the scene. At such situations there is an advantage in using LTI lanterns.

Similar considerations apply to some bridges and for the lighting of these, and other bridges, BS 5489 : Part 6 should be consulted.

10.3.5 Pedestrian crossings. Although this Part of BS 5489 is not concerned with any special lighting provided for pedestrian crossings, it is necessary to make some reference to the siting of columns in their vicinity.

It is desirable to ensure that the normal road lighting installation gives the optimum visibility in these situations, and that the footway and kerb are revealed.

At crossings in the immediate vicinity of junctions, the arrangement should be on the principles shown in figures 12 and 13, although individual junction dimensions will vary widely.

Lighting is most effective in revealing pedestrians using the crossings when it is symmetrical from both directions along the road. The lighting, therefore, should be so arranged that the crossing is at the mid-point of a span. This may involve the use of one span of shorter spacing than that calculated. Particularly, a column should not be placed adjacent to a pedestrian crossing.

In a staggered arrangement, the optimum is to provide two columns at equal distances of not more than 10 m from the centre of the crossing. The column on the left-hand side of the road should be beyond the crossing as seen by an approaching driver (see figure 14(a)).

In an opposite arrangement, there should be two pairs of columns at equal distances of not more than 15 m from the centre of the crossing. These distances should be measured parallel to the centre line of the road in the usual way and for very wide roads they may need to be reduced (see figure 14(b)).

10.4 Siting of columns

Intersections, pedestrian crossings, bends, gradients, and crests of hills occur frequently and their particular lighting requirements may require compromise. Also there are constraints on the siting of columns caused by over-ground and underground obstructions as well as the effects on the occupation and maintenance of properties. Siting of columns adjacent to overbridges should be such that the main beam from any of the lanterns is not obstructed.

As a general rule, the pattern of lanterns for special requirements such as the intersections and bends should be laid out first. The pattern necessary for uninterrupted sections of road can then be added to the layout. Care is needed to effect the compromises which are necessary for an installation to be both cost effective and visually acceptable.

In rural areas, there are fewer constraints but the same principles apply.

The layout should be examined in perspective to ensure that the array of lanterns forms a pattern giving guidance to traffic, and that misleading patterns are avoided.

The guidance is significant particularly on winding roads and at complex junctions, and in fog is one of the most useful contributions of a lighting system.

The appearance of the layout by day also should be considered, particularly on winding roads, where certain types of bracket and luminaire may combine to form an unpleasing interlaced pattern. See BS 5489 : Part 1 for further guidance on appearance and the siting of columns.

10.5 Set back of columns

The required set back of columns should be indicated on the working drawings, with the bracket projection. Particular attention should be paid to the presence of adjacent street furniture, so that an adequate footway width is maintained to meet the needs of blind persons, perambulators and wheelchairs.

Very often on footways up to 3 m wide, columns are best sited at the back of the footway to minimize the likelihood of collision and provide the maximum usable width.

BS 5489 : Part 1 should be consulted for the clearances from the edge of the carriageway to the face of a column, which are the minima recommended in all cases.

11 Maintenance and operation

In the design of a lighting system to the principles of this Part of BS 5489 the spacing between lanterns is directly related to the MF as in the equation in 8.2(e). The values of MF given in table 4 are typical and take into account the quality of the sealing (IP number) of the lamp housing of the lantern, the environmental pollution and the frequency of cleaning. MFs established by local testing may be used. The fall-off in lamp output with age is allowed for by the use of the lighting design lumens in the same equation.

Further guidance both on maintenance and hours of operation is given in BS 5489 : Part 1.

Appendices

Appendix A. Step by step illustration of the use of this code

A.1 General

The purpose of this example is to provide a step by step illustration of the use of this Part of BS 5489 in designing a lighting installation for the situation described in A.2.

A.2 Description of the road

The road is a single carriageway with a distance between kerbs of 10 m. On either side there are footways, which vary in width between 1.5 m and 2.0 m. Low voltage electricity cables are available on both sides of the road.

The road, which is a traffic route, passes through a shopping area on the outskirts of an industrial town and is not in an environmentally sensitive area. The existing installation is considered inadequate for present needs and is nearing the end of its economic life. A 30 miles/h speed limit is in force on the length of road concerned.

A.3 The design process

A.3.1 General

The design process consists of five main parts:

- (a) the gathering of preliminary data (see A.3.2);
- (b) the calculation of design spacing (see A.3.3);
- (c) the plotting of lantern positions taking into account the individual features of the road (see A.3.4);
- (d) the determination of column positions taking into account the individual features of the environment (see A.3.5);
- (e) the finalization of the installation specification (see A.3.6).

A.3.2 Preliminary data

The following steps give an example of the preliminary data to be acquired.

Step no.	Data required	Reference clause, figure or table no.	Example
1	Is the road within the scope of this code?	1	Yes
2	Mounting height (H)	3	10 m
3	Glare limitation	4	MTI
4	Lamp type	5	High pressure sodium (SON)
5	Surround ratio (S_R)	6	0.5
6	Width of carriageway (W_K)	8.1, figure 1	10 m
7	Overhang (A)	10.1	Zero
8	Effective width (W_E)	8	10 m
9	Lantern arrangement	10.3	Staggered
10	Cleaning interval	8.2(e), table 4	12 months
11	Pollution category	Table 4	Medium
12	Photometric requirements for the road	Table 1	
	Category		2
	Average luminance level ($\bar{L}$)		1.0 cd/m ²
	Overall uniformity ratio (U_O)		0.4
	Longitudinal uniformity ratio (U_L)		0.5
13	Choice of lantern from manufacturer's literature		Fullight, 150 W SON/T, MTI
14	Lamp flux of 150 W SON/T	See 8.2 and manufacturer's data	15.5 klm
15	International protection code of lamp housing for Fullight 150 W SON/T		IP54
16	Design attitude of Fullight 150 W SON/T	10.2	Spigot entry elevated 5°

A.3.3 Calculation of design spacing

A.3.3.1 Consult the lantern manufacturer's design tables for the chosen lantern (see table 2: Example: FULLIGHT 150 W SON/T).

A.3.3.2 Select tables for chosen mounting height ($H = 10$ m).

A.3.3.3 Select table for chosen lantern arrangement (staggered).

A.3.3.4 Select column for chosen effective width

A.3.3.5 Check that the surround ratio is equal to or greater than 0.5 ($S_R = 0.86$).

A.3.3.6 Read the spacing index from head of column ($S_I = 3.02$).

A.3.3.7 From a knowledge of reference cleaning interval (12 months), IP rating (IP54), and pollution category (medium) use table 4 to obtain the maintenance factor ($M_F = 0.88$).

A.3.3.8 Calculate the design spacing, S , (in m) required to give the desired average luminance (see 8.2(e)) using the equation:

$$S = \frac{S_I \phi M_F}{\bar{L}}$$

where

S_I is the spacing index;

ϕ is the lamp flux (in klm);

M_F is the maintenance factor;

$\bar{L}$ is the average road luminance (in cd/m^2).

$$\text{Then } S = \frac{3.02 \times 15.5 \times 0.88}{1.0} = 41 \text{ approx.}$$

A.3.3.9 Consult design table for the chosen lantern and select appropriate column as in A.3.3.1 to A.3.3.6.

A.3.3.10 In the design table read values U_O , U_L and V_F set against calculated design spacing(s).

$$(U_O = 0.47 \quad U_L = 0.49 \quad V_F = 16)$$

A.3.3.11 Check that U_O , and U_L values are not less than those given by table 1 for the category of road (see step no. 12), and T_I is not greater than 30 % (see step no. 3).

Recommended values $U_O : 0.4$ $U_L : 0.5$ $T_I : 30 \%$

Calculated values $U_O = 0.47$ $U_L = 0.49$ $T_I =$
Defer calculation

U_L is below the recommended limits, and reference to the design table shows that the design spacing has to be decreased to 40 m. It is now necessary to recalculate the road luminance, $\bar{L}$ (in cd/m^2).

From 8.2 (f),

$$\begin{aligned} \bar{L} &= \frac{S_I \phi M_F}{S} \\ &= \frac{3.02 \times 15.5 \times 0.88}{40} \\ &= 1.03 \end{aligned}$$

where the symbols are as defined in A.3.3.8.

The threshold increment, T_I (expressed as a percentage) is checked by using the equation in 8.2(g), where V_F is the veil factor, as follows:

$$\begin{aligned} T_I &= \frac{V_F \phi}{10 (\bar{L}/M_F)^{0.8}} \\ &= \frac{16 \times 15.5}{10 \times (1.03/0.88)^{0.8}} \\ &= 22 \end{aligned}$$

where the symbols are as defined in 8.2(g).

(Table 5 can be used in the evaluation of this expression.)

As 22 % is below the recommended limit of 30 %, all the photometric requirements are now met, and 40 m is confirmed as the design spacing.

A.3.4 Plotting of lantern positions

A.3.4.1 First, the lantern patterns to meet the requirements of the special features of the road such as junctions and pedestrian crossings are established and then the lantern layout is developed (see clause 10).

A.3.4.2 Next, the layout of the uninterrupted straights and bends is fitted into that of the special features with an element of compromise (see clause 9 and 10.4).

A.3.4.3 Last, the whole layout is viewed in perspective to reveal misleading night time arrays and a check made on its daytime appearance (see 10.4).

A.3.5 Determination of column positions

A.3.5.1 Individual lantern positions are checked on site to ensure that it is possible to erect columns in accordance with clause 10 when underground and overground obstructions (see 10.4 and 10.5) are taken into account.

A.3.5.2 Minor adjustments may have to be made to a number of positions to ensure visual acceptability (see 10.4).

A.3.6 Installation specification

A.3.6.1 The maintenance plan to be applied to the installation is determined (see clause 11 of this Part of BS 5489 and 11.1 of BS 5489 : Part 1 : 1987).

A.3.6.2 The hours of operation required for the installation are established ('all night' in this example).

A.3.6.3 Values of set back and bracket projection are calculated and noted for individual columns on the scheme working drawings as is the design attitude of the lantern (see clause 10).

Appendix B. Determination of photometric quantities and lantern classification

B.1 General

The procedures for calculating road luminance, spacing indices, and surround ratios given in this appendix should be followed to ensure the results are consistent.

B.2 Reflection properties of the road surface

In general, the reflection properties of a point on the road surface (shown as P in figure 15) depend on the three angles, α , β and γ marked in figure 15.

The near and far limits of the part of the road on which the luminance pattern is determined are 60 m and 160 m ahead of the observer. For this area the reflection properties of the road are substantially independent of α , and, therefore, are tabulated in terms of β and γ only.

The luminance coefficient, q , at a point on the road surface is given by:

$$q = \frac{L}{E}$$

where

L is the luminance at that point (in cd/m^2);

E is the illuminance at the same point (in lux).

The reduced luminance coefficient, r , at a point on the road surface is given by the equation:

$$r = q \cos^3 \gamma$$

$$\text{Since } E = \frac{I_C \gamma}{H^2} \cos^3 \gamma$$

where

$I_C \gamma$ is the intensity of the lantern I , at the angle of azimuth C and elevation γ (see figure 15), and

H is the mounting height of the lantern,

then

$$L = \frac{I_C \gamma}{H^2} q \cos^3 \gamma$$

The first term in this equation is dependent on the light distribution from the lantern and its mounting height. The second term, which is the reduced luminance coefficient, r , is dependent on the reflection characteristics of the road. It is more convenient to use this than the luminance coefficient because it incorporates the $\cos^3 \gamma$ term.

The expression for luminance thus becomes:

$$L = \frac{I_C \gamma}{H^2} r$$

Values of r for the representative British road surface are given in table 3. This table should be used unless measurements on site indicate that another table of values would be suitable.

B.3 Intensity table

The recommended format for an intensity table is shown in table 6. This should be derived in accordance with BS 5225 : Part 1 and the values expressed in candelas per 1000 lamp lumens for a range of azimuth and elevation angles C and γ respectively (see figure 15).

B.4 Luminance at a point

The luminance at a point is calculated by applying the equation in B.2 to each lantern in turn and summing the results. In each instance it will generally be necessary to interpolate both for luminous intensity, I , and the reduced luminance coefficient, r .

A linear interpolation procedure is adequate for the calculation so long as the point densities of the r -table (see table 3) and the I -table (see table 6) are no less than those recommended.

B.5 Field of calculation for luminance

The field of calculation should be contained within the area bounded by the transverse lines 60 m and 160 m ahead of the observer as this is the area over which the r -table applies. Within this the field of calculation should cover a section between two lanterns in the same row.

Transversely, the field of calculation should cover the area enclosed by the lines demarcating the road width indicated in figures 2 to 5. It should be noted that for the purpose of generating design tables the effective width W_E , is equal to the width of carriageway W_K , that is the overhang, A , is taken to be zero.