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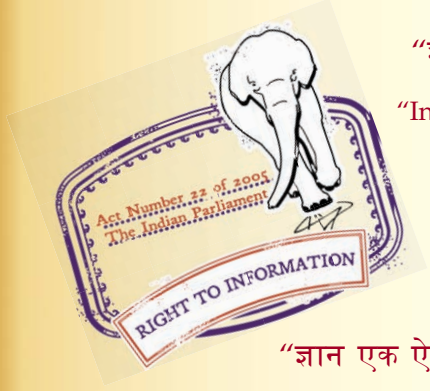

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"Knowledge is such a treasure which cannot be stolen"

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IS : 1944 (Parts I and II) - 1970

Indian Standard

(Reaffirmed 2003)

CODE OF PRACTICE FOR LIGHTING OF PUBLIC THOROUGHFARES

(*First Revision*)

Fourth Reprint APRIL 1991

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 8 *February* 1971

Indian Standard

CODE OF PRACTICE FOR LIGHTING OF PUBLIC THOROUGHFARES

(First Revision)

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Indian Standard

CODE OF PRACTICE FOR LIGHTING OF PUBLIC THOROUGHFARES

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 3 March 1970, after the draft finalized by the Illuminating Engineering Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard was first published in 1961. The number of motor vehicles plying on the streets in the towns and cities of India has increased considerably in these intervening years. Further, more efficient light sources are now available for use in street-lighting installations and levels of illumination which were considered too high then can be achieved economically. It was felt by the Sectional Committee that the values of illumination prescribed earlier are low in practice and need to be increased. Hence this revision has been undertaken.

0.3 In this revision apart from traffic routes, the lighting of residential streets, bridges and flyovers, town and city centres, etc, are being dealt with. The code lays down the principles governing the lighting of public thoroughfares and makes recommendations on the quantity and quality of lighting to be provided. The details of design entirely depend on local circumstances.

0.4 This standard is devided into Parts I and II. Part I includes the new classification and a statement of general principles for non-specialist users; Part II gives recommendations for the lighting of traffic routes (Groups A1, A2 and B). Recommendations for Groups C, D, E and F will be covered in other parts of this standard.

0.5 In preparing this revision, assistance has been derived from the CIE Publication No. 12 (E-33.1)-1965 'International Recommendations for the Lighting of Public Thoroughfares' and BS CP1004 : Parts 1 and 2: 1963 — 'Street lighting' issued by the British Standards Institution.

0.6 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS: 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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1. SCOPE

1.1 This code of practice provides guidance to public lighting authorities who are concerned with the preparation of public lighting schemes, their installation and maintenance. This code deals only with electric lighting sources and does not include gas or other types of lighting.

2. TERMINOLOGY

2.0 For the purpose of this code, the following terms and those provided in IS: 1885 (Part XVI/Sec 2)-1968† shall apply.

2.1 Terms Relating to Highways

2.1.1 *Highway* — A way for the passage of vehicular traffic over which such traffic may lawfully pass.

2.1.2 *Layout* — All those physical features of a highway other than the surfacing of the carriageway, which have to be taken into account in planning a lighting installation.

2.1.3 *Carriageway* — That portion of a highway intended primarily for vehicular traffic.

2.1.4 *Dual Carriageway* — A layout of two separated carriageways, each reserved for traffic in one direction only.

2.1.5 *Central Reserve* — A longitudinal space dividing a dual carriageway.

2.1.6 *Service Road* — A subsidiary road between a principal road and buildings or properties facing thereon and connected only at selected points with the principal road.

2.1.7 *Cycle Track* — A way or part of a highway for use by pedal cycles only.

2.1.8 *Footway* — That portion of a road reserved exclusively for pedestrians.

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*Rules for rounding off numerical values (*revised*).

†Electrotechnical vocabulary: Part XVI Lighting, Section 2 General illumination lighting fittings and lighting for traffic and signalling.

2.1.9 *Verge* — The unpaved area flanking a carriageway, forming part of the highway and substantially at the same level as the carriageway.

2.1.10 *Shoulder* — A strip of highway adjacent to and level with the main carriageway to provide an opportunity for vehicles to leave the carriageway in an emergency.

2.1.11 *Refuge* — A raised platform or a guarded area so sited in the carriageway as to divide the streams of traffic and to provide a safety area for pedestrians.

2.1.12 *Kerb* — A border of stone, concrete or other rigid material formed at the edge of a carriageway.

2.2 Terms Relating to the Lighting Installation

2.2.1 *Lighting Installation* — The whole of the equipment provided for lighting the highway comprising the lamps, luminaires, means of support and electrical and other auxiliaries.

2.2.2 *Lighting System* — An array of luminaires having a characteristic light distribution, sited in a manner concordant with this distribution. (Lighting systems are commonly designated by the name of the characteristic light distribution, for example, cut-off, semi-cut-off, etc).

2.2.3 *Luminaire* — A housing for one or more lamps, comprising a body and any refractor, reflector, diffuser or enclosure associated with the lamp(s).

2.2.4 *Outreach* — The distance measured horizontally between the centre of the column or wall face and the centre of a luminaire (p in Fig. 1).

2.2.5 *Overhang* — The distance measued horizontally between the centre of a luminaire mounted on a bracket and the adjacent edge of the carriageway (s in Fig. 1).

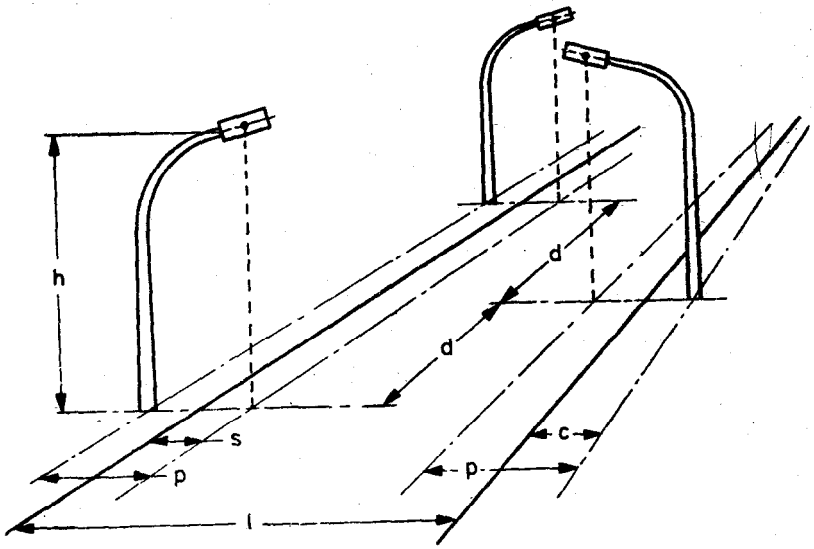
2.2.6 *Mounting Height* — The vertical distance between the centre of the luminaire and the surface of the carriageway (h in Fig. 1).

2.2.7 *Spacing* — The distance, measured along the centre line of the carriageway, between successive luminaires in an installation (d in Fig. 1).

NOTE — In a staggered arrangement, the distance is measured, along the centre line of the carriageway, between a luminaire on one side of the carriageway and the next luminaire, which is on the other side of the carriageway. It is not the distance measured on the diagonal joining them, nor the distance between successive luminaires on the same side of the carriageway.

2.2.8 *Span* — That part of the highway lying between successive luminaires in an installation.

2.2.9 *Width of Carriageway* — The distance between kerb lines measured at right angles to the length of the carriageway (l in Fig. 1).



h = mounting height of luminaires
d = spacing
l = width of the carriageway
p = outreach
s = overhang
c = clearance

FIG. 1 SITING OF LUMINAIRES: CHARACTERISTIC DIMENSIONS

2.2.10 *Arrangement* — The pattern according to which luminaires are sited on plan, for example, staggered, axial, opposite (*see* Fig. 2).

2.2.11 *Geometry (of a Lighting System)* — The inter-related linear dimensions and characteristics of the system, namely, the spacing, mounting height, width, overhand and arrangement.

2.3 Photometric Terms

2.3.1 *Luminous Flux* — The light given by a light cource or a luminaire or received by a surface irrespective of the directions in which it is distributed. The unit of the luminous flux is the lumen (lm).

2.3.2 *Lower Hemispherical Flux or Downward Flux* — The luminous flux emitted by a luminaire in all directions below the horizontal.

2.3.3 *Luminous Intensity* — The quantity which describes the light-giving power of a luminaire in any particular direction. The unit of luminous intensity is the candela (cd).

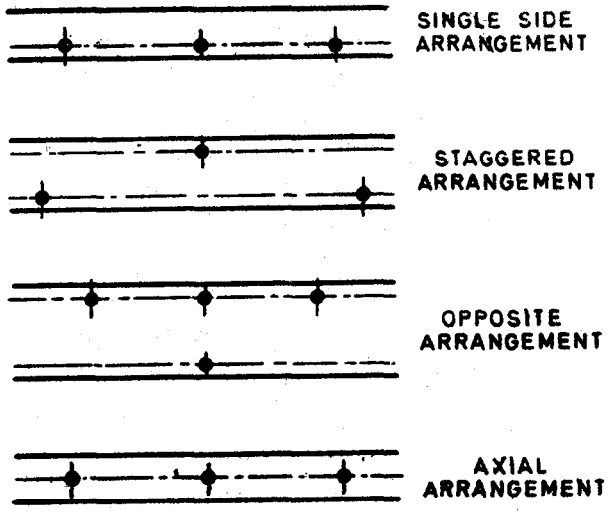


FIG. 2 BASIC ARRANGEMENTS IN PUBLIC LIGHTING

2.3.4 *Illumination* — The luminous flux incident on a surface per unit area. The unit of illumination is the lumen per square metre (lux).

2.3.5 *Luminance (at a Point of a Surface and in a Given Direction)* — The luminous intensity per unit projected area of a surface. If a very small portion of a surface has an intensity I candelas in a particular direction and its orthogonal projection (that is, its projection on a plane perpendicular to the given direction) has an area D, the luminance in this direction is I/D candelas per unit area. The usual unit is the candela per square metre (cd/m^2).

2.3.6 *Luminosity* — The attribute of visual sensation according to which an area appears to emit more or less light. It is sometime called brightness.

NOTE — Luminosity is the visual sensation which correlates approximately with the photometric quantity 'luminance'.

2.3.7 *Light Output* — The luminous flux emitted by a luminaire.

2.3.8 *Light Distribution* — The distribution of luminous intensity from a luminaire in various directions in space.

2.3.9 *Symmetrical (Converse Asymmetrical) Distribution* — A distribution of luminous intensity which is substantially symmetrical (conversely asymmetrical) about the vertical axis of the luminaire.

2.3.10 *Axial (Converse Non-axial) Distribution* — An asymmetrical distribution in which the directions of maximum luminous intensity lie (do not lie) in vertical planes substantially parallel to the axis of the carriageway.

2.3.11 *Peak Intensity Ratio* — The ratio of the maximum intensity to the mean hemispherical intensity of the light emitted below the horizontal.

2.3.12 *Mean Hemispherical Intensity* — The downward flux divided by 6·28 (2π). (This is the average intensity in the lower hemisphere).

2.3.13 *Intensity Ratio (in a Particular Direction)* — The ratio of an actual intensity from the luminaire (in a particular direction) to the mean hemispherical intensity.

2.3.14 *Beam* — The portion of the light output of the luminaire contained by the solid angle subtended at the effective centre of the luminaire containing the maximum intensity, but no intensity less than 90 percent of the maximum intensity.

2.3.15 *Beam Centre* — A direction midway between the directions for which the intensity is 90 percent of the maximum in a vertical plane through the maximum and on a conical surface through the maximum.

2.3.16 *Isocandela Curve* — A curve traced on an imaginary sphere with a source at its centre and joining all the points corresponding to those directions in which the luminous intensity is the same or a plane projection of this curve.

2.3.17 *Isocandela Diagram* — An array of isocandela curves.

2.3.18 *Polar Curve* — Curve of light distribution using polar co-ordinates.

PART I GENERAL PRINCIPLES

3. CLASSIFICATION OF INSTALLATIONS

3.1 Basis of Lighting Requirements — The level and type of lighting adopted for a street is based mainly on its traffic importance, both vehicular and pedestrian. However, the system of lighting to be provided should take into account all the relevant factors, such as the presence of factories, or places of public resort, the character of the street (whether a shopping area or a ring road in non-built-up area), aesthetic considerations, the properties of the carriageway surface, the existance of humps, bends or long straight stretches and overhanging trees.

3.2 Classification of Lighting — The classification is one of lighting and not of roads but is linked with traffic density. It is left to the local

engineer to decide upon the category of the lighting for the given road. Lighting for streets is classified into the following groups:

Group A — For main roads. This is sub-divided into two categories:

Group A1 — For very important routes with rapid and dense traffic where the only considerations are the safety and speed of the traffic and the comfort of the drivers.

Group A2 — For other main roads with considerable mixed traffic like main city streets, arterial roads and thoroughfares.

Group B — For secondary roads which do not require lighting up to Group A standard. This is also divided into two categories:

Group B1 — For secondary roads with considerable traffic, such as principal local traffic routes, shopping streets, etc.

Group B2 — For secondary roads with light traffic.

Group C — Lighting for residential and unclassified roads not included in the previous groups.

Group D — Lighting for bridges and flyovers.

Group E — Lighting for town and city centres.

Group F — Lighting for roads with special requirements, such as roads near airfields, railways and docks.

4. PUBLIC LIGHTING

4.1 Aims of Public Lighting — Public lighting should permit users of the road at night to move about with the greatest possible safety and comfort so that the traffic capacity of the road at night is as much equal to that planned for the daytime as possible.

The driver should be able to see distinctly without the use of dipped or driving headlights and locate with certainty and in time all significant details notably the alignment of the road (its direction and its surrounds), any traffic signs and possible obstacles; moreover, he should be made aware of any dangerous situation without the use of his headlight beams, either driving or passing.

The pedestrian should be able to see distinctly the edges of the footways, vehicles and obstacles; dark patches should not occur.

The above aim should be achieved with due respect to the aesthetic appearance of the lighted road within acceptable limits of cost of installation and maintenance. The economy and aesthetics of the installations are a function of the character of the road, taking into account its situation as well as the nature and the intensity of traffic.

4.2 Principles of Vision in Public Lighting — Though public lighting has to satisfy both drivers and pedestrians, it is in practice the requirements of the drivers which are the more stringent.

4.2.1 *Requirements for Drivers*

4.2.1.1 At any moment, the whole of the road and its details should be clearly visible. Among the details the perception of which is particularly necessary are the surrounds of the carriageway and the footway, the entry of side roads and traffic signs, whether at the side or painted on the carriageway surface.

4.2.1.2 The clearest possible visual guidance should be provided on the alignment of the road. Perception of details of the road gives some indication of its alignment; but this should be reinforced by other means, for example, the pattern formed by the luminaires as seen by the driver, and by their colour (the beacon effect).

4.2.1.3 Any object which is or which may be dangerous should be seen and recognized clearly and in time. Such an obstacle should be seen at a distance great enough to give the driver time to make, without danger to himself or others, any manoeuvre which the presence of the obstacle may demand. This time should be sufficient for the perception of the obstacle, its identification, the appraisal of its direction of movement, its distance, its speed and the taking of the decision as to the manoeuvres to be effected, to carry them out, taking into account the speed of the vehicle, the reaction time of the driver and the braking time. This perception should obviously be provided over the whole of the visual field of the driver, that is, in the zone of both foveal and peripheral vision.

In the absence of obstacles, the presentation of the road should be such that the driver is certain that the road is clear. This condition involves affording to the driver visual comfort, such that he is not subjected to nervous fatique, which may be dangerous.

4.2.1.4 One of the criteria of street lighting should be to attain good seeing condition by silhouette vision. An object is discerned by silhouette when the brightness of the substantial part of the object is lower than the brightness of its background. This method of discernment predominates in the observation of distant objects on lighted streets.

4.2.1.5 The lighting of the street should appear continuous and uniform. Special lighting, which does not alter the appearance of continuity of the lighting of the road as a whole, should be provided at critical points and areas, such as bends, crossroads, bridges, tunnels, underpasses, level crossings, etc.

4.2.1.6 Direction signs and such features as islands and guard posts should be made conspicuous at night, though without involving glare; they may be lighted either by the general installation or by special equipment.

4.2.2 *Visual Field of the Driver* — The usual visual field of the driver comprises, in order of decreasing importance,

a) the carriageway;

b) the surrounds to the road, including signs; and

c) the sky, including the bright luminaires.

Any obstruction or circumstance liable to lead to an obstruction, should be clearly displayed in this visual field. Since the perception and the speed of perception are directly related to the luminances and the contracts in the visual field, it is necessary to understand the mechanism by which the relevant luminances are produced.

4.2.2.1 The luminance of the carriageway results from the distribution of luminous intensity of the luminaires, from the geometry of the installation, that is, the siting with respect to the plan of the carriageway and the reflection characteristics of the surface of the carriageway. Calculations are fairly complex; nevertheless it is possible to obtain a good idea of the influence of the light distribution and of the reflection characteristics of the carriageway by examining the visual field of the driver (that is, in perspective) and the shape of the bright patch formed on the ground by a single luminair (*see* Fig. 3).

This patch has the form of the letter *T*, the tail of which is shorter as the road surface is more diffusing and as the distribution of luminous intensity is more cut-off. The head of the *T* is wider as the surface is more diffusing and as the distribution of the luminaire is wider in the direction of width of the road.

The pattern of luminance on the carriageway is produced by the juxtaposition of these patches with results from the siting of the luminaires and the geometry of the road. The interdependence refferred to above is obvious. The siting of the luminaires should, therefore, be carefully set out and studied in a perspective view of the road.

It should be noticed here that the ratio of the spacing to the mounting height is a predominant factor, as is also the ratio of the width of the carriageway to the mounting height.

NOTE — It should also be stated here that the physical properties of the road surface have a controlling influence on the effectiveness of the lighting since they determine the form and luminance of the individual bright patches. In this context the road surface means the exposed surface of the wearing course of the carriageway.

The properties are:

a) the macroscopic surface texture which determines whether the appearance of surface would be judged by a driver as 'rough-looking', 'medium-textured' or 'smooth-looking' (for example, the texture imparted by large aggregate, surface chippings or crimping or tamping respectively;

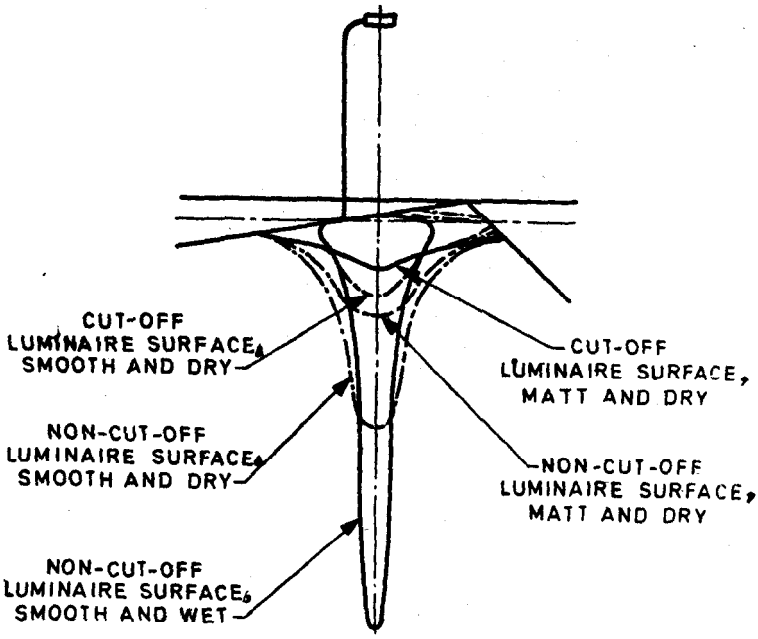


FIG. 3 FORMS OF THE BRIGHT PATCH SHOWN IN CONTOURS OF EQUAL LUMINANCE FORMED ON THE CARRIAGEWAY BY A SINGLE LUMINAIRE, ACCORDING TO THE TYPE OF ITS LIGHT DISTRIBUTION CURVE AND THE NATURE OF THE ROAD SURFACE

b) the microscopic surface texture on the materials visible in the surface (for example, on individual stones and on the matrix of the rolled asphalt); and

c) the colour of the surface.

The effect of the various properties is as follows:

a) The surface texture, both the macroscopic and the microscopic texture, determines the length and the brightness of the tails and the width and the brightness of the heads of the patches in dry weather. Improvement in the skidding resistance of roads have resulted in more matt surfaces, which means that the tails of the patches will be shorter.

b) The macroscopic texture alone determines whether a water film will form in wet weather, causing the patches to degenerate into narrow streaks. To avoid this a surface with a medium-textured appearance is to be preferred, though this involves some shortening of the tails of the patches in dry weather.

c) The lightness of the colour of the surface affects the size and brightness of the heads of the patches without having much effect on tails. In general, a light-coloured surface is markedly better than a dark-coloured one. The colour of bituminous surfaces which have received some wear by traffic depends on the colour of the aggregate which is exposed and, therefore, surfaces containing light-coloured aggregates are more easily lighted than surfaces containing dark-coloured aggregates.

4.2.2.2 The luminance of the surrounds to the road depends on their nature and the distribution of luminous intensity of the luminaire. It is not usually calculated, but it enters into evaluation of the degree of glare, and in the estimation of the contrast presented by objects seen against the surrounds of the carriageway.

4.2.2.3 The luminance of the luminaires themselves depends on the distribution of luminous intensity and on their projected area. Its order of magnitude is very much greater than that of the luminances of the carriageway and of the facades. It may result in an effect of glare which reduces the visual faculties of the eye or gives rise to a sense of discomfort which, eventually, brings about fatigue.

4.2.3 *Visibility* — The phenomenon of visibility is directly related to contrast. It follows from the visual requirements of the driver that good contrast should always be produced:

a) between the carriageway and all objects which indicate its boundaries; and

b) between any obstacle which may be present and the background against which it appears; since the characteristics of the obstacle may vary over a very wide range, any factor which tends to increase contrast should be exploited.

In the first place, the luminances of the surfaces which form a background should be sufficiently high and uniform. In open country or if the surrounds are insufficiently bright, only the luminance of the carriageway is involved; but in built-up areas, the luminances of facades or of trees at the side of the road are also important. Secondly, the discomfort due to glare should be reduced as far as possible within the limits of practical considerations.

The contrast of an obstacle depends on both its own luminance and on that of its background; but in most installations luminances vary in

such a way that low contracts are transient. It is, however, important to avoid situations in which low contrasts can persist over long distances.

4.2.4 *Glare and Visual Comfort*—Glare in public lighting is generally caused by the luminaires. There are two forms of glare: disability glare, which depresses the visual capacity of the eye and hence the visibility of objects; and discomfort glare which diminishes visual comfort and which may eventually lead to irritability and fatigue.

However, it should not be forgotten that other factors can lead to glare, such as in particular, the presence of undesirable large surface of high reflection factor, specular surfaces, excessively bright shop windows, advertisement signs or road direction signs.

Glare depends mainly on the illumination produced by the luminaires on the eyes of the observer. For this reason, limits have to be set to the luminous intensity emitted by luminaires in directions near the horizontal. Moreover, for a luminance of given luminous intensity:

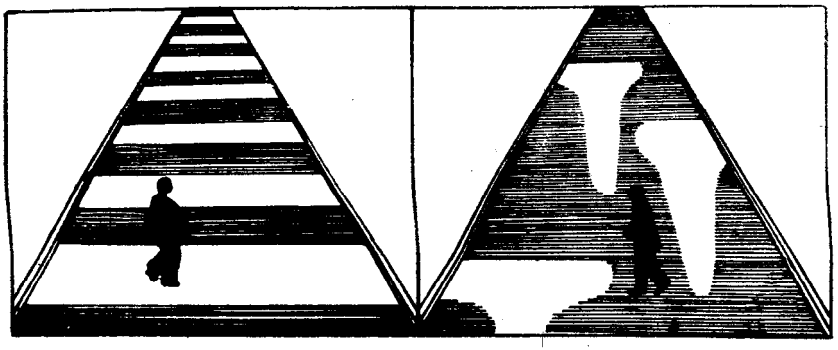
a) the glare decreases as the projected area of the luminaire increases and as it is seen further from the direction of vision; and

b) the glare diminishes as the background against which the luminaire seen is brighter. This background comprises not only its immediate surround, but also the totality of the visual field, in particular the road surface, its surrounds and any facades. The limits set for the luminous intensity may be relaxed when the level of luminance of the carriageway is increased, or when there are lighted facades which form a background to the luminaire.

If several luminaires are present in the visual field, the glare effect which results increases by an additive process.

From these considerations it is possible for a given effect of glare to relate the form of the permitted light distribution of the luminaire to the class of lighting which is envisaged. The realization of all the conditions necessary to obtain good visibility is not sufficient. It is necessary to provide for the driver a certain degree of visual comfort to reduce nervous tension and fatigue which may result after some time. The higher the level of lighting and the less the glare, the greater will this comfort be; but there must also be continuity in the luminous impression, both statically and dynamically. The road surface is a uniform surface, it should appear uniform. The uniformity of the luminance of the road surface should be such that, first, the driver's eyes do not undergo undue changes of adaptation according to the point of vision; secondly, they do not, while driving, experience repetitive impressions of light and dark which are more rapid and irritating as his speed increases. Moreover, a patchy effect on the roadway may camouflage any obstacle present. Although at first sight the need for continuity would seem to be greater along the

normal direction of vision of the driver, that is to say, greater in the direction of the traffic than along axes at right angles to it, good transverse uniformity is also necessary to assist in the visibility of obstacles. (This is illustrated in Fig. 4 by exaggerated luminance patterns).



4A Traverse Uniformity 4B Longitudinal Uniformity

FIG. 4 UNIFORMITY OF LUMINANCE

4.3 Criteria of Quality — From these considerations, it follows that the following four factors contribute to the fundamental criteria of quality of public lighting:

a) The level of luminance,

b) The uniformity of luminance,

c) The limitation of glare, and

d) The optical guidance.

4.3.1 *Level of Luminance* — The level of luminance should be adequate to provide visibility which will guarantee for the user a maximum of safety and sufficient visual comfort. It is obvious that it is the road surface luminance rather than the illumination level which provides the more accurate measure of the effective light in a street lighting installation. However, in the present state of the technique and the knowledge of reflection properties of road surfaces, the calculation and measurement of luminance are likely to present difficulties. This code, therefore, recommends illumination values to be provided on the road surfaces. These recommendations will usually provide good results on surfaces which give bright patches of moderate length and which are not unduly dark in colour.

4.3.2 *Uniformity of Luminance* — Uniformity of luminance is required to provide visual comfort for the driver. It should be noted that the requirements are more stringent than those which are demanded merely by

questions of visibility. For the reasons stated above, this code recommends desirable variations in levels of illumination.

4.3.3 *Limitation of Glare* — The glare due to luminaires should be controlled at a value which keeps the visual discomfort to which the driver is subjected below an acceptable level. Luminaires have been classified, according to the form of their light distribution, into three categories and limits have been set to their employment from the point of view of glare (*see also* **4.5**).

4.3.4 *Visual Guidance* — A good visual guidance is required especially on long stretches of lighted roads and even more on complicated intersections, roundabouts, etc. Most of the long range guidance is offered by the luminaires.

4.4 Electric Light Sources — The choice of source for public lighting is guided by the following considerations:

a) Luminous flux,
b) Economy (determined by lumens/watt and life),
c) Dimensions of the light sources, and
d) Colour characteristics.

The sources normally used in public lighting are:

a) incandescent lamps,
b) mixed incandescent and high pressure mercury vapour lamps,
c) high pressure mercury vapour lamps with clear or fluorescent bulbs,
d) tubular fluorescent lamps,
e) sodium vapour lamps,
f) mercury-halide lamps, and
g) high pressure sodium vapour lamps.

4.4.1 *Incandescent Lamps* — For new installations the employment of incandescent lamps is very limited in practice. They are sometimes used for residential streets when initial cost is to be kept low. They are not usually employed in traffic routes.

4.4.2 *Mixed Incandescent and Mercury Lamps* — These lamps may sometimes be employed in modernizing an installation to obtain higher levels without the need for ballasts required for discharge lamps.

4.4.3 *High Pressure Mercury Vapour Lamps* (*HPMV*) — These lamps have higher luminous efficiency and longer life than mixed incandescent and mercury lamps. These are suitable for installations where colour rendering is less important and where high powers are needed. High pressure

mercury vapour lamps with fluorescent bulbs are suitable for installations where colour appearance and colour rendering are important.

4.4.4 *Tubular Fluorescent Lamps*—These lamps have high luminous efficiency and long life. They are suitable for installations where colour appearance and colour rendering are important and where large multiple-lamp luminaires are acceptable. The choice between high pressure mercury vapour fluorescent lamps and fluorescent tubes is in general determined by local considerations of aesthetics and cost of installation.

4.4.5 *Sodium Vapour Lamps*—The use of sodium lamps is convenient when colour rendering is not important and when a high luminous efficiency is desired. Their colour is sometimes useful to provide the visual guidance. It is also particularly suitable under foggy conditions.

4.4.6 *Mercury-Halide Lamps*—These lamps are improved versions of HPMV lamps (**4.4.3**) and having very much higher efficiencies in the order of 80 lm/W combined with good colour characteristics.

4.4.7 *High Pressure Sodium Vapour Lamps*—These lamps are improved versions of sodium vapour (**4.4.5**) with efficiency approximating to 100 lm/W with colour rendering satisfactory and of dimensions suited to fittings of small size and accurate light control.

4.5 Luminaires—The luminaire has a double role of protecting the light source from the weather and redistributing its luminous flux.

In the choice of the luminaire the following points should be considered:

a) Nature and power of the source or sources;
b) Nature of the optical arrangements and the light distribution which they provide;
c) Light output ratio;
d) Whether the luminaire is open or closed type;
e) Resistance to heat, soiling and corrosion;
f) Protection against collection of dust and insects;
g) Resistance to atmospheric conditions;
h) Ease of installation and maintenance;
j) Presence or absence of auxiliaries; and
k) Fixing arrangements, the weight and area exposed to wind pressure.

The influence of all these factors varies according to local circumstances, and it is difficult to recommend one solution rather than another, but the attention of designers may be drawn to the fact that the most economical installation can be achieved only by the choice of the most suitable

luminaire, selected according to the relative importance of the above mentioned factors. There is, however, one essential characteristic of luminaires the choice of which directly influences the quality of the lighting, that is, the general form of its distribution curves of luminous intensity particularly in directions near the usual directions of vision.

Three fundamental forms of light distribution are considered according to the degree of glare which is acceptable:

a) Cut-off luminaires,

b) Semi-cut-off luminaires, and

c) Non-cut-off luminaires.

4.5.1 *Cut-Off Luminaire* — A luminaire whose light distribution is characterized by a rapid reduction of luminous intensity in the region between about 80° and the horizontal. The intensity at the horizontal should not exceed 10 cd per 1 000 lm of flux from the light sources* and the intensity at 80° is of the order of 30 cd per 1 000 lm. The direction of the maximum intensity may vary but should be below 65°.

The principal advantage of the cut-off system is the reduction of glare and its use is favoured under the following conditions:

a) Matt carriageway surfaces,

b) Absence of buildings,

c) Presence of large trees,

d) Long straight sections,

e) Slight humps, bridges, and

f) Few intersections and obstructions.

4.5.2 *Semi-Cut-Off Luminaire* — A luminaire whose light distribution is characterized by a less severe reduction in the intensity in the region 80° to 90°. The intensity at the horizontal should not exceed 50 cd per 1 000 lm of flux from the light sources* and the intensity at 80° is of the order of 100 cd per 1 000 lm. The direction of the maximum intensity may vary but should be below 75°. The principal advantage of the semi-cut-off system is a greater flexibility in siting, and its use is favoured under the following conditions:

a) Smooth carriageway surfaces;

b) Buildings close to carriageway, especially those of architectural interest; and

c) Many intersections and obstructions.

*Subject to a maximum value of 1 000 cd whatever is the luminous flux emitted.

4.5.3 *Non-Cut-Off Luminaire* — A luminaire whose luminous intensity in directions making an angle equal to or greater than 80° from the downward vertical is not reduced materially and the intensity of which at the horizontal may exceed the values specified for the semi-cut-off distribution, but should not nevertheless exceed 1 000 cd. Non-cut-off luminaires are permissible only when a certain amount of glare may be accepted and when the luminaires are of large size and of reduced brightness. In certain cases they have some advantages in increasing the illumination on facades.

4.5.4 *Inclination* — Attention should be given to the inclination of luminaires. An upward inclination which is generally called for reasons of aesthetics, should be employed with care. Too great an inclination of the luminaire may modify, particularly in certain directions, the cut-off qualities of the luminaires and in certain situations (for example, when there are roads at several levels, bends, roundabouts, etc) this inclination may lead to unexpected glare.

4.6 Aesthetics — The aesthetics of a lighting installation are principally judged by day. Half of the time, the lighting installation serves no useful purpose; an attractive or at least a non-disturbing daytime appearance which harmonizes well with the surroundings is, therefore, of great importance. Aesthetic considerations should relate to the unit formed by the luminaire and its support and the situation in which it is placed.

Firstly, the unit formed by the luminaire and its support should be considered. Secondly, the siting of the luminaires in the scene may lead to unpleasant effects even if the luminaires themselves considered in isolation, are aesthetic.

There are no simple or universal rules for aesthetically satisfactory design and layout since every city, town and village has its own character and what may look well in one place may be incongrous in another. There are, however, some points of general application which are dealt with here.

4.6.1 *Design and Siting* — The design and siting of street lighting installations can make a great difference to the street picture, even though this may not be consciously appreciated. In situations such as a processional way or monumental bridge, the design and placing of lamp columns can make a positive formal contribution to the scene.

Wherever possible columns should not be sited directly in front of buildings or monuments of architectural interest and they are better placed at the junction of two buildings. They should not interfere with important oblique view of an outstanding building, such as a church tower. Nor should they interfere with scenic views; if columns are essential in such cases they can sometimes be placed against clumps of trees and so have little effect on the view. Trees in streets and front gardens contribute

greatly to the effectiveness of the street picture and columns should be so sited as not to require serious cutting back of the trees. In an avenue, it may be preferable to mount the luminaires centrally.

In new streets where trees are to be planted it is best to design the lighting first and to fix the planting sites afterwards, choosing trees of suitable habit and considering their effects when mature and in leaf. It is not necessary for trees to be closely planted to give an attractive impression. The trees and the luminaires should be so sited relatively that shadows of trees do not fall across the carriageway or footway.

4.6.2 *Columns and Surroundings* — It is advantageous visually if the height of the column and luminaire does not exceed that of nearby objects. If mounting heights are reduced consequential adjustments to other parameters may have to be made.

If in a narrow road columns can be avoided altogether and wall brackets substituted, it is generally aesthetically better.

A lamp column silhouetted against the sky is far more noticeable by day than one seen against a solid background.

Backgrounds change with viewpoint; if it is unavoidable for columns to stand out conspicuously against the sky, it may be worthwhile to increase the mounting height and spacing in order to decrease the number of columns in view. It is sometimes possible to avoid siting columns on a short bridge by having extra high columns at the ends.

4.6.3 *Size and Type of Luminaire* — Long horizontal luminaires are apt to look oppressive against the sky, although they may be acceptable against a background of high buildings. For luminaires which are not circular on plan, side entry is usually better than top entry.

4.6.4 *Form of Bracket* — Large arcs or quadrants are usually more conspicuous than straight lines, because they contrast more violently with the surrounding lines of roofs. A straight horizontal bracket gives the illusion of sagging; a straight raking bracket is better, but with a side entry luminaire a segmented bracket may provide a smoother junction with the luminaire. It is better to preserve a constant outreach, if possible, where a row of luminaires is seen in line.

4.6.5 *Assembly of Column, Bracket and Luminaire* — The lighting unit is the complete assembly of the column, the bracket and the luminaire and should be considered as a complete whole; a luminaire which agrees with one column may be quite incongruous with another. It is recognized that luminaires and columns are often made by different manufacturers; nevertheless great care should be exercised in the choice of equipment which will match satisfactorily.

4.6.6 *Arrays of Luminaires*—A combination of luminaire, bracket and column which is satisfactory as a single unit may not look well when a number are seen together, especially in long stright or slightly sinuous roads and at complex junctions. In a long straight road, an array of curved brackets may make a tunnel; in a slightly sinuous road such brackets appear to interlace and form a confusing and ugly pattern. At complex juctions where brackets are turned in many directions the effect can be very unpleasing, particularly with long luminaires.

4.6.7 *Material of Column and Bracket*—The material of the column and bracket may affect both their finish and their shape in cross section. It is visually preferable if the column and bracket are as slender as possible; they are less noticeable in sunlight if they are cylindrical rather than composed of flat surfaces and if they have (and retain) a glossy rather than a matt finish. These features are rather more readily obtained in some metal constructions than in concrete; nevertheless there are situations, such as among some modern buildings, in which concrete may be more appropriate than metal.

4.6.8 *Colour*—Sober and subdued colours are to be preferred for all lighting equipment. Generally speaking, 'cool' colours (that is, silver, blue and lilac) are preferable to 'warm' (that is, yellow, gold, brown and red). There are many subtle shades of grey which can be used.

4.7 Lighting Columns as Hazards—A motor vehicle involved in an accident frequently leaves the carriageway and the probability of this happening increases with the speed of the vehicle. If the vehicle collides with a lighting coloumn the severity of injuries to the occupants is likely to be increased. There is evidence to suggest that the number of such collisions decreases with the increase of distance of the column from the edge of the carriageway. The following recommendations are given for siting the columns:

Normally the clearance (*see* Fig. 1) between column and carriageway edge should be at least 1·5 m. Where there is a footway close to the carriageway, the column should be sited behind the footway. In exceptional cases a smaller clearance may have to be used.

4.8 Maintenance—It is essential to the proper functioning of a public lighting installation that it should be properly maintained. Certain maintenance activities, aimed at keeping the effectiveness of the installation at the highest possible level are economically justified, (a) so that the heavy investment in public lighting installations should continue to provide a good return, and (b) because of the far from negligible power consumption that in a poorly maintained installation, is to a large extent wasted.

Maintenance of a lighting installation should embrace:

a) replacement of defective and missing lamps and accessories;

b) systematic replacement of lamps having a reduced efficiency, that is, those lamps that have come to the end of their useful service life;

c) cleaning of luminaires and lamps;

d) maintenance of cables and columns; and

e) inspection of the mains, earthing arrangements, gaskets, the tracing of defects and broken lamps, and control of the switching equipment.

4.8.1 *Breakdown Maintenance* — For the tracing of defective lamps systematic supervision by a specialized mobile agent is preferable. This agent switches on the lights during daytime and replaces defective lamps immediately or makes a note of them and replaces them afterwards with a latter truck or the more modern hydraulic platform truck. Intermediate solutions still used are the tracing and even replacement of defective lamps in the evening hours but these methods are becoming more and more obsolete.

4.8.2 *Preventive Maintenance* — The procedure according to which lamps are replaced is a matter of local convenience and cost; it should be such as to ensure that lamps will not be left extinguished for more than one night and, that lamps, especially discharge lamps, are not left in luminaires indefinitely or until they fail to light. Such lamps have lives which are indeterminate and may burn for a very long time but efficiency may be very low beyond the normal life indicated in the relevant Indian Standard.

Cleaning of dirty luminaires and lamps at regular interval is important to prevent the decline in the quantity and quality of lighting. The soiling of the luminaires depends very much on local conditions, the presence of industries in the area and the prevailing direction of the winds and for the same reasons the intervals at which maintenance should be performed depends on local conditions. A good guide to maintenance is visual inspection; lighting equipment will appear soiled to the eye before its lighting efficiency is seriously impaired by dirt.

PART 2 LIGHTING FOR TRAFFIC ROUTES

(Groups A1, A2, B1 and B2)

5. RECOMMENDED VALUES OF ILLUMINATION

5.1 Taking into account considerations of principles of vision, criteria of quality, and characteristics of sources and luminaires, set out in Part 1, Table 1 gives for each classification of installation the desirable level of illumination, the degree of uniformity, and the luminaires which are recommended or permitted.

TABLE 1 CLASSIFICATION OF LIGHTING INSTALLATION AND LEVELS OF ILLUMINATION

(*Clauses* 5.1 *and* 5.7)

Classification of Lighting Installation	Type of Road	Average Level of Illumination on Road Surface	Ratio Minimum/ Average Illumination	Transverse Variation of Illumination	Type of Luminaire	
					Preferred	Permitted
(1)	(2)	(3)	(4)	(5)	(6)	(7)
		lux		percent		
Group A1	Important traffic routes carrying fast traffic	30	0·4	33	cut-off	semi-cut-off
Group A2	Other main roads carrying mixed traffic, like main city streets, arterial roads, throughways, etc	15	0·4	33	cut-off	semi-cut-off
Group B1	Secondary roads with considerable traffic like principal local traffic routes, shopping streets, etc	8	0·3	20	cut-off or semi-cut-off	non-cut-off
Group B2	Secondary roads with light traffic	4	0·3	20	cut-off or semi-cut-off	non-cut-off

5.2 For Group A lighting, the level and uniformity of illumination should be as high as possible and the glare strictly reduced.

5.3 For Group B lighting, greater tolerances on uniformity and glare may be admitted which may be justified by the character of the roads and by the presence of facades.

5.4 The reflection characteristics of the carriageway surface affect both the level and distribution of luminance resulting from the illumination incident on it. Classification of road surfaces which would permit a precise predetermination of the results to be expected, is not available. At a first approximation it is nevertheless possible to distinguish between:

a) light coloured surfaces (total reflection factor lying over 0·15) and dark coloured surfaces (total reflection factor less than 0·15); and

b) polished surface whose reflection properties are sharply preferential (this is the case in all surfaces which are smooth either by construction or by heavy wear) and matt surfaces whose reflection properties are approximately diffusing (which is the case with most modern nonskid surfaces, at least when they are new).

5.5 This classification applies to dry surfaces; with all the above surfaces their reflection characteristics approach those of a very polished surface as they become damper.

5.6 The recommendation of this code will usually provide good results on 'average' surfaces, that is, surfaces which give bright patches of moderate length and which are not unduly dark in colour.

5.7 The values given in Table 1 are service mean value taking into account the depreciation of the installation. The effect of ageing of the sources and soiling should be considered. The mean service value, with reasonable maintenance, usually fall to 75 percent of the initial values; consequently the installation should be designed to give initial value 1·33 times those specified in **4.5** to **4.5.3**.

6. REALIZATION OF RECOMMENDED VALUES

6.1 The realization of the above recommendations requires detailed calculations of the level and uniformity of illumination on the road surface and of the glare. Such calculations are possible when photometric data of the luminaires and the geometry of the installation are known. For the determination of the glare limits, it is recommended to apply the limits specified in the classification of luminaires in **4.5**.

6.2 It is already seen that the level and uniformity of luminance of the road surface is important but the characteristics of the surface are not known in such terms that they can be applied in calculations. To get some idea of the extent to which this criteria will be satisfied, it may be

preferable to make a temporary trial installation of a few luminaires on a stretch of the road to be lighted.

7. CHOICE OF LUMINAIRES

7.1 The choice of luminaires is decided by the level of illumination to be provided and the limits of glare to be ensured within the limitation of spacing and height permitted in the installations. The following considerations may be kept in view while making the choice.

7.1.1 In open roads outside built-up areas, such as ring roads around cities, high speeds are encountered. In general the road picture there includes no surfaces above eye-level which can serve as background and below eyelevel the road surface and its immediate surroundings from a bright background. The field of vision above the horizon is dark. The luminaires are, therefore, seen against a background which is as unfavourable as possible from the point of view of glare. For open roads, cut-off luminaires are, therefore, indicated.

7.1.2 On the other hand, in built-up areas, the visual field includes facades and the use of semi-cut-off fittings creates light coloured background against which the bright fitting does not give rise to too much contrast.

7.1.3 In a shopping street where the illumination of the surroundings is high due to shops and show-window lighting, even non-cut-off luminaire may not cause disturbing glare because of the high luminance of the background. However, care should be taken to ensure that after the shoplighting is switched off the glare from the streetlighting luminaires is within permissible limit.

8. SITING OF LUMINAIRES

8.1 Types of Arrangement — Four fundamental types of arrangement are recognized (Fig. 2):

a) The single side arrangement, where all the luminaires are on one side of the carriageway, is recommended only when the width of the carriageway is equal to or less than the mounting height. The illumination on the road surface on the side remote from the luminaires is inevitably lower than that on the same side as the luminaires.

b) The staggered arrangement, where the luminaires are situated on either side of the carriageway and in a zig-zag formation, may be employed when the width of the carriageway is greater than the value recommended for single side lighting but not exceed 1·5 times the mounting height. It is superior to the single side arrangement in that it provides more nearly uniform illumination and better visibility of the two sides of the road.

c) Opposite mounting in which the luminaires situated on either side of the carriageway opposite to one another is advisable when the width of the carriageway is more than 1·5 times the mounting height.

d) Axial mounting, in which the luminaires are placed along the axis of the carriageway, is admissible for narrow roads the width of which does not exceed the mounting height. In some tree-lined roads axial mounting may be the only acceptable device. It has in wide roads the undesirable effect of drawing the attention of the driver towards the centre of the carriageway and of reducing the illumination at its edges, which are just the points where obstacles may appear.

Other arrangements exist, but they result from the combination of the four preceding fundamental types.

A road with dual carrigeway can be regarded as a combination of two separate roads.

8.2 Mounting Height — The minimum mounting height should be chosen taking into account the power of the sources, the light distribution of the luminaires and the geometry of the installation. The mounting height should be greater as the lamps are more powerful to avoid excessive glare; and also greater as the roadway is wider to obtain adequate transverse uniformity. As a general rule heights of 9 to 10 metres are suitable for Group A roads and 7·5 to 9 metres for Group B roads. Heights of less than 7·5 metres are undesirable except in certain special cases, such as the lighting of residential roads or roads bordered by trees.

8.3 Spacing — To preserve longitudinal uniformity the spacing should generally be not greater than the values given below:

Type of Luminaire	*Maximum Spacing/Height Ratio*
Cut-off	3
Semi-cut-off	3·5
Non-cut-of	4

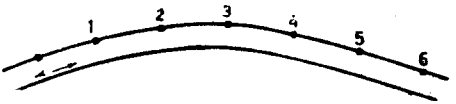
8.4 Outreach and Overhang of Luminaire — The outreach is usually determined by architectural or aesthetic considerations. The overhang should not in general exceed one-fourth of the mounting height; excessive overhang leads to reduced visibility of kerps, obstacles and footways (*see* Fig. 1).

9. SITING OF LUMINAIRES AT SPECIAL FEATURES

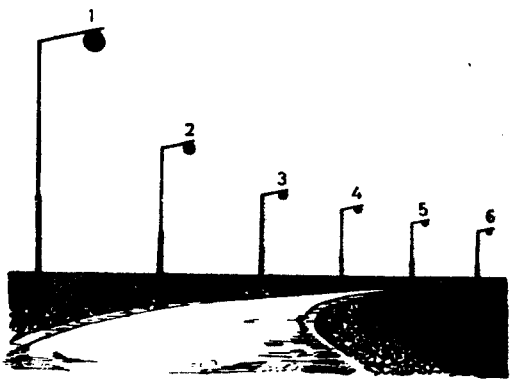
9.1 As in the straight parts of the road, it is the judicious siting of the bright patches formed by the individual luminaires which determines the

siting at special features of the road which is the best for providing good visibility and for making them conspicuous.

9.2 Curves — Curves of large radius of the order of 1 000 m can be treated as straight. For curves of smaller radius, a study of the respective shows that it is mainly the luminaires which are placed at the outside of a bend which contribute to the brightness of the carriageway, and that in order to bring about the same degree of juxtaposition of the patches the spacing should be progressively reduced as the bend is more pronounced (*see* Fig. 5). For similar reasons the overhang should not be excessive.



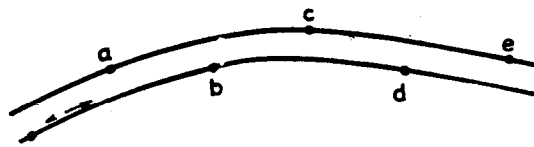
5A Single Side Arrangement of Luminaires on a Bend



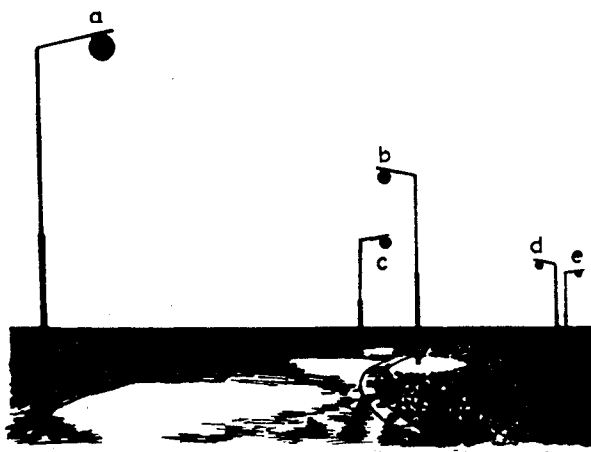
5B Night Perspective View of the Arrangement

FIG. 5 SITING OF LUMINAIRES AT CURVES (RECOMMENDED)

9.2.1 In this case, single side arrangement is obviously indicated because it gives in addition effective beaconing of the curve. Staggered arrangement is to be avoided here as far as possible, because not only does the beaconing effect usually disappear, but the driver may even be deceived into thinking that there is a side road (*see* Fig. 6).



6A Staggered Arrangement on a Curve



6B Night Perspective View of the Arrangement Showing the Absence of Beaconing Effect Which Results

FIG. 6 SITING OF LUMINAIRES AT CURVES (NOT RECOMMENDED)

9.2.2 At curves on roads where the width exceeds 1·5 times the mounting height additional luminaires should be mounted on the inside of the curve. In those cases there is less risk of misreading the pattern of lights.

9.3 Crossroads and Pedestrian Crossings — The basic principle of the arrangement of luminaires at crossroads can be illustrated by the mode by which a pedestrian traversing a pedestrian crossing is seen.

9.3.1 Lighting by a single luminaire whose position has been chosen so that the bright patch which it produces covers the greater part of the pedestrian crossing, nevertheless leaves a dark background against which the pedestrian is difficult to see (*see* Fig. 7). It is desirable, therefore, to provide a supplementary luminaire placed further away than the first and on the other side of the road (*see* Fig. 8).

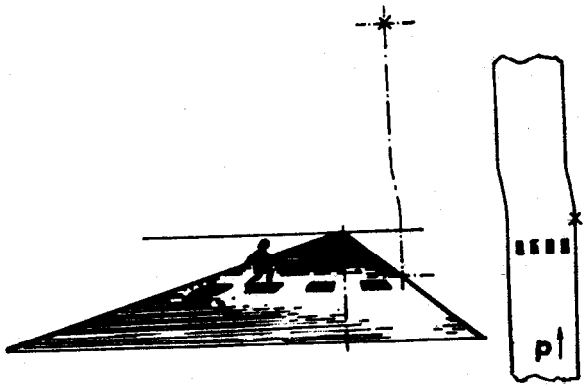


FIG. 7 LIGHTING OF A PEDESTRIAN CROSSING BY A SINGLE LUMINAIRE (NOT RECOMMENDED)

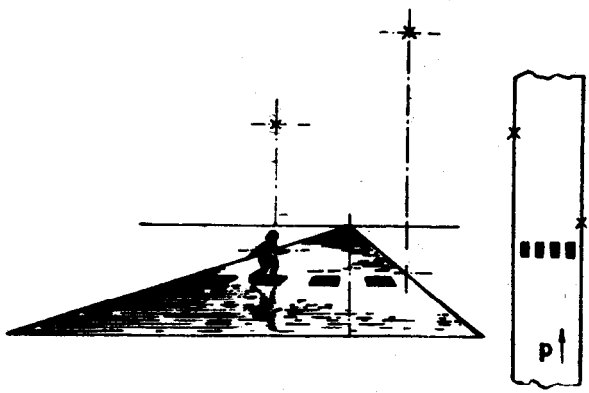


FIG. 8 WIDENING OF THE BRIGHT BACKGROUND BEHIND PEDESTRIAN CROSSING AS A RESULT OF A SECOND LUMINAIRE (RECOMMENDED)

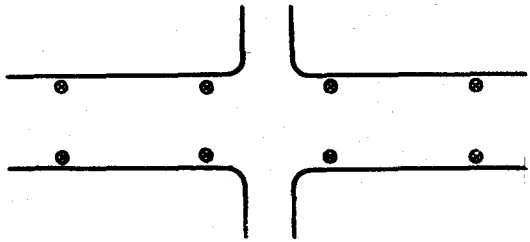
9.3.2 If this reasoning is applied to traffic in both directions, it indicates that the crossing should always occur mid-way between two consecutive luminaires situated on either side of the carriageway. Moreover, to draw attention to the discontinuity of the carriageway without altering the continuity of the lighting, it is recommended that the spacing of these

situations should be reduced so as to increase the level of illumination, and to use materials, for marking the crossing on the carriageway, which will provide and maintain good contrast under the conditions of illumination and view which will occur. Luminaires should never be sited just before the crossing and on the near side.

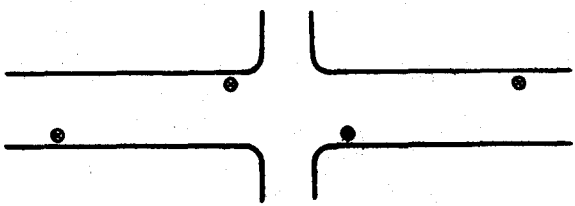
9.3.3 On these principles, a few typical cases of siting at intersections by way of illustration, are shown as follows:

a) The intersection of a lighted road and an unlighted road (*see* Fig. 9A for opposite arrangement, and Fig. 9B for staggered arrangement).

b) The intersection of two lighted roads of equal importance (*see* Fig. 10).



9A Siting Recommended for the Intersection of a Lighted Road with Opposite Arrangement and an Unlighted Road



9B Siting Recommended at the Intersection of a Lighted Road with Staggered Arrangement and an Unlighted Road

FIG. 9 SITING RECOMMENDED AT THE INTERSECTION

In such a case a luminaire should never be placed at the centre of the crossing because its presence will lead to a light band on the intersection which may mask what is happening on the farther side, for instance on a pedestrian crossing located there.

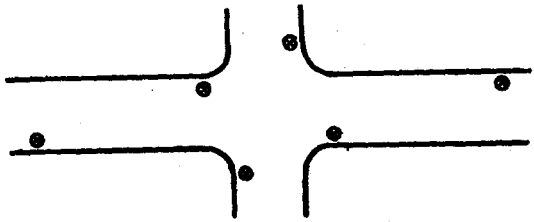


FIG. 10 SITING RECOMMENDED AT THE INTERSECTION OF TWO ROADS LIGHTED WITH STAGGERED ARRANGEMENT

c) A 'T' junction (*see* Fig. 11).

The same principles as before are applied, but, in this case, it is essential that there should be a bright background opposite the side road, lighted by the luminaire sited there or by other public lighting. If there are no suitable facades, appropriate artificial backgrounds may be provided, such as hedges or fences.

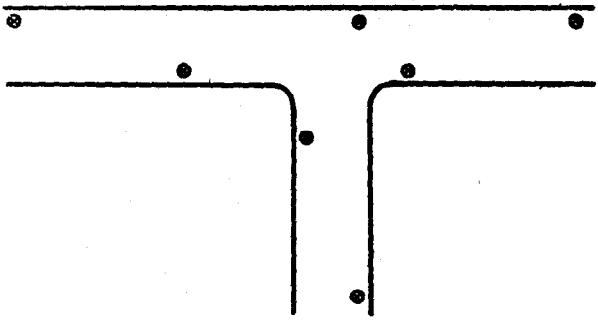


FIG. 11 SITING RECOMMENDED AT A T-JUNCTION

Usually, if the road feature is set out both in plan and in perspective and the bright patches which result from the individual luminaires are drawn, the best positions for the luminaires can be determined. Moreover, it is possible to check on the perspective drawing of the night view that the beacon effect will not be ambiguous. Multiplication or irregular siting of the luminaires may deceive the driver. Some examples of siting at intersections of important roads with guard islands are given.

d) The intersection of a principal road and a secondary road with guard island (*see* Fig. 12).

It is in general wise to avoid a luminaire placed on the island if the latter is of small dimensions. On the principal road a staggered arrangement on both sides has been adopted, whereas on the secondary road a single side arrangement is used. The lighting may be reinforced at the crossing itself; the power of the lamps may be reduced on the secondary road.

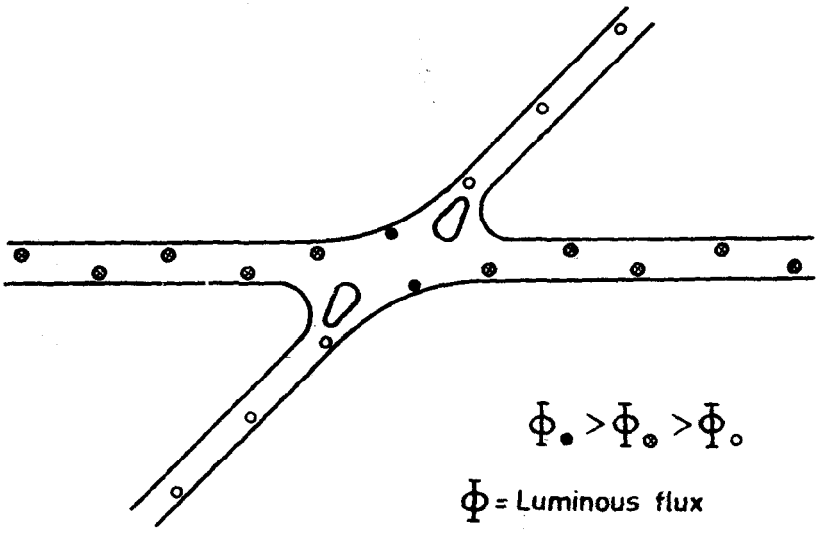


FIG. 12 SITING RECOMMENDED AT ROAD WITH GUARD ISLAND

e) The oblique intersection of two principal routes (*see* Fig. 13).

In the vicinity of the crossing, the two directions of traffic are separated by large islands. The arrangement of luminaires is single side, adjacent to the islands, whereas beyond the crossing it is on both sides, staggered or opposite, according to the width of the road and the mounting height.

f) *Roundabouts* — Roundabouts present special lighting problems owing to the continuous movement of traffic and usually higher approach speed. In general the siting of luminaires should be such that corners are shown up, and the kerb lines tend to run in the brightness areas created on the road surface.

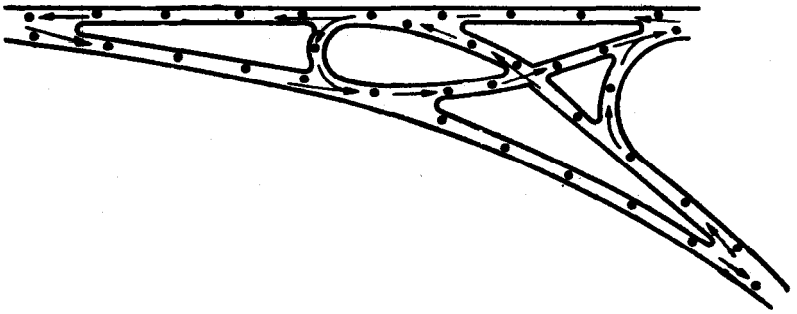


FIG. 13 EXAMPLE OF SITING AT THE OBLIQUE INTERSECTION OF TWO PRINCIPAL ROUTES

It is possible only to generalize and give typical examples of the more common types of layout but in practice many varied problems will be met and should be studied together with the traffic and site conditions.

Where the approach roads are unlighted it is essential to create suitable visual conditions for drivers who have been driving for sometime with their eyesight accommodated to conditions of no street lighting. To avoid glare, it might be essential under these circumstances to use cut-off luminaires. It is not essential, however, to use cut-off luminaires when the approach roads are adequately lighted as in many cases non-cut-off luminaires will provide perfectly satisfactory lighting.

9.3.4 *General Layout for Roundabouts* — On small islands of 18 metres or less diameter a single cut-off luminaire giving a symmetric distribution can be mounted centrally at a height of 7·5 metres or more and will give satisfactory results provided that the cut-off is so adjusted that it covers the outer edge of the surround roadway. For larger roundabouts a typical layout is shown in Fig. 14 which illustrates the following four general guiding principles to be observed:

a) To provide luminaires in position *A* above the kerb of the central island in line with each approach lane of traffic.

b) To provide luminaires at position *B* above each section of the outer kerb. These may be dispensed with if the central island does not exceed 31 metres in diameter but are of particular value where there are no vertical backgrounds.

c) To provide luminaires at position *C*, particularly when there is pedestrian traffic crossing at the guide islands.

d) Where non-cut-off luminaires are used, it may be necessary to screen some of them, generally those in position *A*, in order not to mislead approaching drivers as to their route. It is not normally correct to site luminaires on the guide islands nor should high angle-beam luminaires be used on roundabouts.

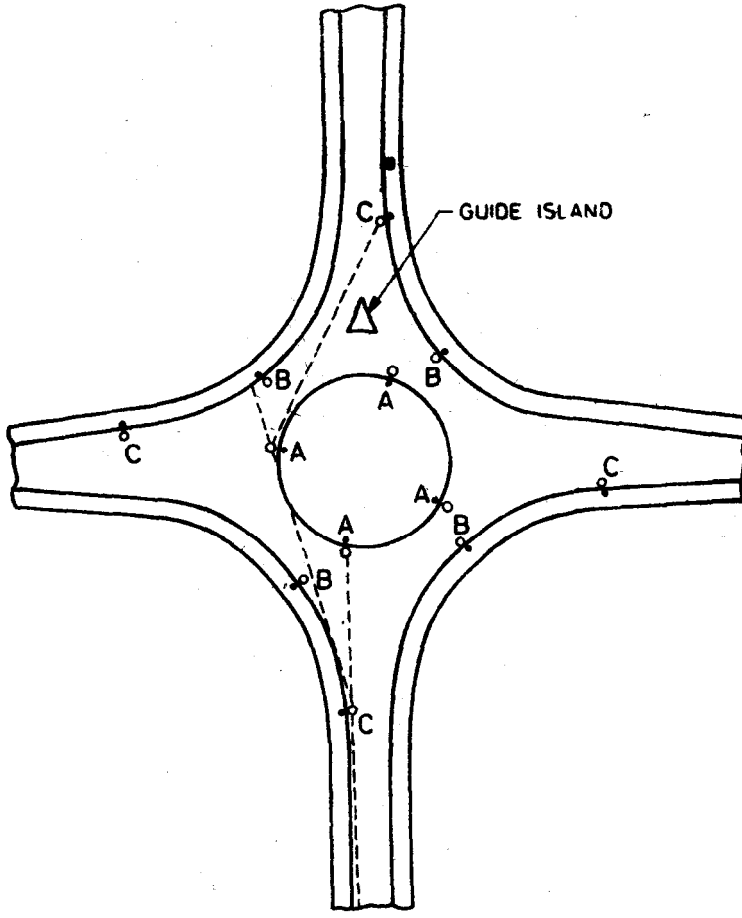


FIG. 14 TYPICAL LAYOUT AT A ROUNDABOUT

9.4. Transition Zone — It often happens that only certain sections of a rural highway are lighted; for example, a dangerous cross road or access

road to a motor way. In such a situation the driver passes from a dark to a lighted zone and *vice-versa* in a brief interval of time.

9.4.1 Adaptation takes place smoothly on entering the lighted zone, but it does not do so at the exit unless provision is made to facilitate it.

9.4.2 To accustom the driver to the visibility conditions in the unlighted zone, a transition zone should be provided in which the level of lighting is progressively reduced. This should be provided by preserving the spacing and using lamps of the same type but of reduced power.

9.4.3 This design allows the installation to be extended subsequently at a low cost.

9.4.4 In no case should the transition zone be shorter than 100 m at a cross road or 200 m at an access road to a motorway.

9.5 Treatment of Gradients — If luminaires having the same (non-cut-off) distribution are employed on a flat road and on a relatively steep gradient at the same spacing, conditions on the gradient will tend to be unsatisfactory when compared with the conditions on a flat road. There may be the effect of patchiness when looking down hill due to the apparent depression of the angle of maximum intensity, while increased glare will be evident when looking up-hill. Some improvement can be gained by one of the three following arrangements:

a) Cut-off lighting at its proper spacing,

b) The use of diffusing screens on the lights to reduce glare, and

c) Rotation of the luminaires about their horizontal axis (*see* Fig. 7).

It is not recommended that arrangement (a) be adopted unless cut-off luminaires are to be used on the installation as a whole; (b) is more off a compromise and it may be difficult to obtain a satisfactory distribution. The most practicable scheme is frequently (c) in which case side entry luminaires are recommended.

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IS : 1944 (Parts I and II)-1970 CODE OF PRACTICE FOR LIGHTING OF PUBLIC THOROUGHFARES

(First Revision)

Alteration

(*Page* 18, *clause* **4.5.1**, *line* 3) — Delete the word ' about '.

(ETDC 45)

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IS : 1944 (Parts I and II) - 1970 CODE OF PRACTICE FOR LIGHTING OF PUBLIC THOROUGHFARES

(First Revision)

Alteration

(*Page* 23, *Table* 1, *col* 5, *heading*) — Substitute the following for the existing column heading:

'TRANSVERSE UNIFORMITY RATIO $= \frac{Min \text{ ILLUMINATION}}{Max \text{ ILLUMINATION}}$',

(ETDC 45)

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