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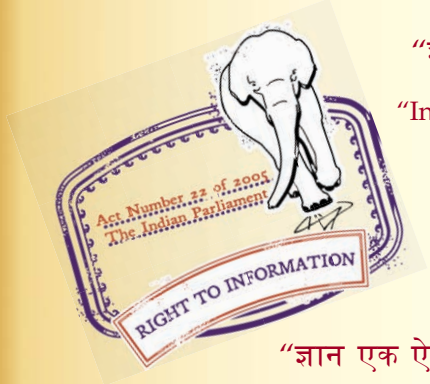
IS 1944-5 (1981): Code of practice for lighting of public thoroughfare, Part 5: Lighting for grade separated junctions, bridges and elevated roads (Group D) [ETD 24: Illumination Engineering and Luminaries]



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(Reaffirmed 2003)

Indian Standard

CODE OF PRACTICE FOR LIGHTING OF PUBLIC THOROUGHFARES

PART V LIGHTING FOR GRADE SEPARATED JUNCTIONS, BRIDGES AND ELEVATED ROAD (GROUP D)

(First Reprint JANUARY 1998)

UDC 628.971.6 : 625.739 + 624.21 : 006.76

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

Gr 6 *September* 1981

Indian Standard

CODE OF PRACTICE FOR LIGHTING OF PUBLIC THOROUGHFARES

PART V LIGHTING FOR GRADE SEPARATED JUNCTIONS, BRIDGES AND ELEVATED ROAD (GROUP D)

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CODE OF PRACTICE FOR LIGHTING OF PUBLIC THOROUGHFARES

PART V LIGHTING FOR GRADE SEPARATED JUNCTIONS, BRIDGES AND ELEVATED ROAD (GROUP D)

0. FOREWORD

0.1 This Indian Standard (Part V) was adopted by the Indian Standards Institution on 27 February 1981, after the draft finalized by the Illuminating Engineering Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 The purpose of this part (Part V) of the code is to draw attention to problems encountered in and considerations that should be given to the design of street lighting installations for grade separated junctions, bridges and elevated roads. The detailed lighting designs outlined in IS : 1944 (Parts I and II)-1970* should apply in general to these situations, but deviations may be necessary to meet special conditions imposed by structural design or traffic. It is essential that individual cases are considered on their merits, and for this reason, it is not possible for this part of the code to suggest optimum solutions or to make detailed recommendations.

The aim of this code is to bring together all technological details and processes of workmanship with which the objectives put forth in the code can be reached.

This code also takes into account the evolution of the techniques during the last 10 to 12 years (development of new and efficient light sources, use of high masts, etc).

0.3 This standard (Part V) has been prepared in pursuance of **0.4** of IS : 1944 (Parts I and II)-1970*. Revision of IS : 1944 (Parts I and II)-1970* is also under the consideration of the Committee and it is intended that Part I of the revised IS : 1944 should cover general principles and the subsequent parts should deal with the requirements for various groups of roads as per the standard classification. This standard,

*Code of practice for lighting of public thoroughfares (*first revision*).

therefore, when the revision of IS : 1944 (Parts I and II)-1970* is completed, will have the following parts:

Part I General principles

Part II Lighting for main roads (Group A)

Part III Lighting for secondary roads which do not require lighting up to Group A standard (Group B)

Part IV Lighting for residential and unclassified roads (Group C)

Part V Lighting for grade separated junctions, bridges and elevated roads (Group D)

Part VI Lighting for town and city centres and areas of civic importance (Group E)

Part VII Lighting for roads with special requirements (Group F)

Part VIII Lighting in tunnels (Group G)

0.4 In preparing this part of the standard, assistance has been derived from the following:

BS: CP 1004 — Street lighting, Part 5 Lighting for grade-separated junctions and Part 6 Lighting for bridges and elevated roads issued by British Standards Institution.

CIE No. 32 (TC-4·6) - 1976 Lighting in situations requiring special treatment issued by International Commission on Illumination.

0.5 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 or analysis, 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.

1. SCOPE

1.1 This part of the code examines special problems associated with the lighting of grade separated junctions, bridges and elevated roads (Group D). It deals with technical requirements and aesthetic considerations that shall be given when designing lighting installations for these situations and provides guidelines in regard to choice between conventional lighting arrangement and high mast lighting for grade separated junctions. It deals with fuction, appearance and design requirements of the lighting installation.

*Code of practice for lighting of public thoroughfares (*first revision*).

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

1.2 It is not envisaged that all grade separated junctions will require lighting either in full or in part. There are two main categories of junctions where lighting will be considered necessary:

a) Where some or all roads concerned are lit; and

b) Where the junction is so complicated that lighting is an essential safety feature.

1.3 This part of the code deals with electric lighting and does not include gas or other types of lighting.

2. TERMINOLOGY

2.0 For the purpose of this code, the following terms in addition to those provided in IS : 1944 (Parts I and II)-1970* and IS : 1885 (Part XVI/ Sec 2)-1968† shall apply.

2.1 Grade Separated Junctions — A crossing of two or more roads at different levels.

2.2 High Mast Lighting — A system of lighting in which the luminaires are mounted at a height of 20 m or more.

2.3 Slip Road — A road leaving or joining the spine road by tapering acceleration or deceleration lanes.

3. LIGHTING FOR GRADE SEPARATED JUNCTIONS

3.1 General

3.1.0 *Basis of Lighting Requirements* — The level and type of lighting adopted for street lighting are based on its traffic importance, both vehicular and pedestrian. Inadequately designed lighting installation may cause accidents which may be more grave than on normal roads. The lighting installation shall therefore fulfil the following requirements.

3.1.1 The aim in lighting a grade separated junction is the same as that for lighting any other road in so far as vehicular traffic is concerned. The same quality of lighting shall be maintained, so that the drivers are

*Code of practice for lighting of public thoroughfares (*first revision*).

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

given clear information with regard to their course and the presence and movement of other road users. It is desirable to achieve a higher standard of lighting without causing glare and avoiding a multiplicity and confusing array of luminaires, since in the absence of fulfilment of these requirements, the consequences of accidents might be more grave.

3.1.2 The basic requirement is that drivers must be able to pick up their route very clearly and unmistakably in heavy traffic and bad weather conditions. Lighting must ensure, when the traffic is heavy, good visual guidance indicating without error the line of path to be followed on one hand when the driver arrives at a point 200-300 metres from the interchange and on the other when he is within the interchange. Any mistake in finding the correct turnout may result in waste of time and may be hazardous. The lighting must, therefore, be of a high standard to produce sufficient level of illumination without producing unacceptable glare and arrangement of luminaires shall be such as not to produce confusing array of sources, which would make defining the alignment of the road difficult and may be at times misleading.

3.1.3 Coventional lighting relying on silhouette vision, as recommended in IS : 1944 (Parts I and II)-1970*, may be used to light each individual road in the junction. Alternatively, light sources on very high columns (high-mast lighting) may be used.

3.1.4 It will be considerably advantageous to produce alternative designs of coventional and high-mast lighting or combination of the two and select the best design taking into consideration the economic aspect in so far as installation and running charges are concerned *vis-a-vis* other factors concerning technical merit, safety features, daylight appearance, etc. The economic aspect shall make allowance for cost of control units, structural fixtures, cable ducts, switching, etc in conventional column system, whereas in high-mast installations for foundation, access to bases, cable trenching, control units, etc, shall be ensured.

3.1.5 It shall, however, be borne in mind that while lighting can show the various routes available, it does not usually provide the information necessary to determine the choice of route. Such information has to be furnished by road signs. Schemes of road signs shall be considered in conjunction with road lights, so that a coordinated layout is achieved.

3.2 Aesthetics — The aesthetics of lighting installation are principally judged by day. General principles on the day-time appearance of street lighting installations are laid down in **4.6** of IS : 1944 (Parts I and II)-1970*. Other parts of the code give guidance on problems in particular situations.

*Code of practice for lighting of public thoroughfares (*first revision*).

Both the general principles and guidelines with regard to a particular situation as is relevant must be borne in mind while designing the complex junction, but the more important points to remember are enumerated below:

a) The column, bracket and luminaire shall be of good integrated design (that is, it should appear to have been designed as one unit).

b) The installation as a whole, comprising single unit, when seen at a time in the field of vision, particularly on sinuous road or complex junction, shall be compatible with its setting. Arrays of curved brackets and columns appear to interlace and form confusing and ugly patterns in daylight. For this reason, when employing conventional schemes, it is better to use simple straight brackets with standard upward rake (say 5°) to avoid the tangle web effect of curved brackets of varying outreach and alignment.

NOTE — If a model of a grade separated junction is available this may be used, perhaps with a suitable periscope to gain an impression of a lighting installation from the drivers' point of view.

3.3 Lighting by Conventional Street Lighting Technique

3.3.1 *General* — A complex grade separated junction is essentially a configuration of linear roads linked with a main road forming a spine. These linking roads can be widely spaced laterally from one another and from the main roadway and may, in some cases, reach heights of 25 m above ground level. Such situations make high-mast lighting uneconomical and difficult for installation and maintenance and favour adoption of lighting by means of conventional luminaires installed on columns of 10 to 12 m height.

For a simple grade-separated junction (say of two level, four ways with 'roundabout' above or below the major road), it may be preferable to light the junction to conform to the conventional lighting system, on both the major and minor roads. If the major road is not to be provided with lighting, the minor road should have cut-off lighting on columns of normal height to avoid distracting spillage of light into the carriageway of the main road.

3.3.2 *Design Characteristics*

3.3.2.1 *Principles* — The principles affecting the application of street lighting by conventional means to grade-separated junctions are in general those applicable to the use of conventional methods in other road situations (*see* other parts of IS : 1944). Special care shall be exercised in the design of the layout to avoid confusion of arrays of light sources at different levels and angles of approach.

3.3.2.2 *Siting of columns* — Preference shall be given to the treatment of the major 'Spine' road within the junction which is invariably a dual carriageway. It can be most easily defined by adopting a lighting system with columns muonted in the central reserve. Alternatively, consideration may be given to the use of a longitudinal catenary system with columns in the central reserve. If centrally mounted fences are provided as a safety measure, these, as a secondary function, can give protection to the columns against accidental damage. Otherwise, suitable measures on protection to the columns shall be carefully considered.

3.3.2.3 On slip roads, luminaires with lower output and installed with a lower-mounting height on single-sided columns and extending from an appropriate point on a taper along the length of the slip road will give delineation of slip roads. Additional reinforcement of lighting at the points where the road widens, may perhaps be necessary. Where the slip roads leave the roundabout portion of a junction, siting of a few columns on the right-hand side of the turnout road usually may be necessary. However, on the entry points of slip road to the 'round-about', columns on the right-hand side tend to be vulnerable and it may be found preferable to continue the columns on the left-hand side of the slip road and to provide an artificial background on the right (outer side of the bend) which will be illuminated by lighting on the inner side of the bend. The background could take the form of markers or an upstand, but care shall be taken to ensure that these do not seriously obstruct the lines of sight. Frequent cleaning of the artificial background may be necessary according to the situation so as to maintain its reflection efficiency.

For junctions where the 'roundabout' is below the major road, care must be exercised to avoid glare from light sources on the lower carriageway which might affect the users of the upper road. Careful siting of columns and the use of columns of reduced height in the immediate vicinity of viaduct section of the upper road coupled with luminaires of the cut-off type afford the means of controlling this problem.

In complex grade-separated junctions from day-time appearance point of view it may be found difficult to relate the lighting columns to structural elements such as supports and the basic spacings dictated by pure lighting considerations may have to be modified to suit constructional units, for example, the spacing and width of transverse beam sections of the carriageway.

It is of particular importance that consideration be given to the lighting of a junction at an early stage in its design, so that fixing arrangement for columns and cable ducting may be incorporated in the structures.

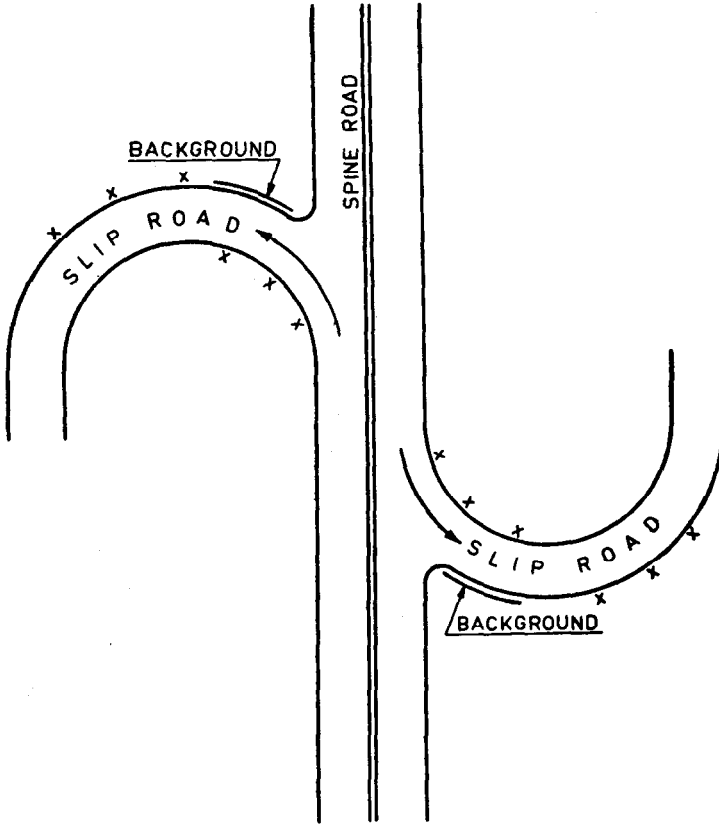

FIG. 1 SITING OF COLUMNS AT THE ENTRY POINT OF SLIP ROAD

3.3.2.4 *Choice of type of luminaire* — Glare may arise due to the absence of bright background, variation of gradient and appearance of array of several luminaires in the field of view. Use of luminaires with cut-off light distribution is therefore strongly recommended.

3.3.2.5 *Light sources* — The light sources used generally are high pressure mercury vapour lamps and low and high pressure sodium vapour lamps. The choice of light source is governed by functional, economic and aesthetic considerations. For some complex junctions, where, for example, a local road system crosses an urban arterial and the contiguous sections of the local roads are lighted by a different type of light source

from that of the urban arterial road, there may be some advantage in lighting the section of the local road within the junction with the same type of light source as that used on its contiguous sections to assist in its demarcation.

3.4 Lighting by High-Mast Techniques

3.4.1 *General* — Where junctions involve a compact and complex system of roads at different levels, lighting by conventional technique leads to confusing array of columns which would impair or suppress the optical guidance. Lighting by powerful sources on high masts (20 to 40 metres) offers the opportunity of providing adequate lighting with reduced number of columns at a reasonable cost and with improved daylight appearance. The mast used for high-mast lighting usually incorporates means of lowering the luminaire to the ground level for maintenance purposes. Maintenance of such installations must be considered seriously as early as the conception.

3.4.2 *Design Characteristics*

3.4.2.1 *Principles* — The principal use of high-mast lighting at present is to light a complex junction of roads as a whole rather than individual roads in the junction. The ratio of the width of the area to be lighted to the height of the mast is, therefore, often large compared with the width to height ratio generally adopted in conventional lighting installations. Preferential reflection from the surface of the road, therefore, becomes of less utility and also the level of road surface luminance may be lower than those achieved in conventional lighting installations giving the same levels of illumination. There is a greater reliance on direct vision and somewhat less reliance on silhouette vision, than that in conventional lighting design. Use of light distribution which will ensure adequate uniformity of the road surface luminance and absence of glare is necessary.

Although in practice designs of high mast lighting will be based on horizontal surface illuminance, care shall be taken to site masts to promote the best possible surface luminance. This is of particular importance in those areas where by necessity the normal level of illuminance is near the minimum service level value (30 lux). Uniformity of road surface luminance to the extent possible, shall be aimed at Recommended values for uniformity ratio are $\frac{E_{min}}{E_{avg}} = 0{\cdot}4$

and $\frac{E_{min}}{E_{max}} = 0{\cdot}25$.

3.4.2.2 *Siting of masts* — In high mast lighting, although relatively more emphasis is placed on direct vision rather than on silhouette vision,

nevertheless, it is desirable to site the masts according to the principles of silhouette vision, as adopted in the conventional lighting technique, that is ensuring, as far as possible, that the unit to light each section of this road is beyond that section of road as seen by the observer for whom the lighting is intended.

3.4.2.3 *Masts* — Various types of masts are used differing mainly with respect to the material of which they are constructed, the finish applied and their cost. Whatever may be the construction, these masts have to comply with tight specifications. In some installations, shafts are of prestressed concrete mainly because of corrosion problem. Their weight and handling problems are considered to be severe handicaps. Steel masts are considerably lighter and they can be easily transported and assembled at site.

3.4.2.4 *Height of the mast* — The height of the mast is normal determined by the size and the extent of the area to be lit and by the difference in road levels of the junction complex. The minimum effective mounting height, that is the actual height of the luminaire above the carriageway should preferably be not less than 20 m.

3.4.2.5 *Choice of type of luminaire* — Individual luminaires may provide a symmetric, asymmetric or double asymmetrical distribution and may be so grouped as to produce an overall symmetrical, axial asymmetrical or non-axial asymmetrical distribution from each mast (*see* Fig. 2). They shall provide a distribution with negligible light at the horizontal and at angles just below the horizontal. Beam elevation in the region 55° from the downward vertical gives satisfactory result, but higher angles may prove to be acceptable. For all types of distributions, whether symmetrical, asymmetrical or double asymmetrical, glare shall be controlled by ensuring that the intensities at specific angles of elevation higher than the angle of maximum intensities, shall not exceed the limits defined in **5.3.1** of IS: 2149-1970*, for conventional cut-off luminaire of C. O. type. If flood light luminaires are used, suitable anti-glare devices may be provided on the luminaires and adequate care should be taken while aiming luminaires.

3.4.2.6 *Light distribution of installation* — Since the area illuminated by a single high mast may be large, it may be necessary that each mast carries more than one lamp or luminaire and the overall light distribution of the luminaires shall be so arranged that no large section of the carriageway would be left in darkness in the event of failure of a single lamp or a luminaire. The number of luminaires and lamps shall be such as to meet the illumination requirement of the scheme as a whole.

*Luminaires for street lighting (*first revision*).

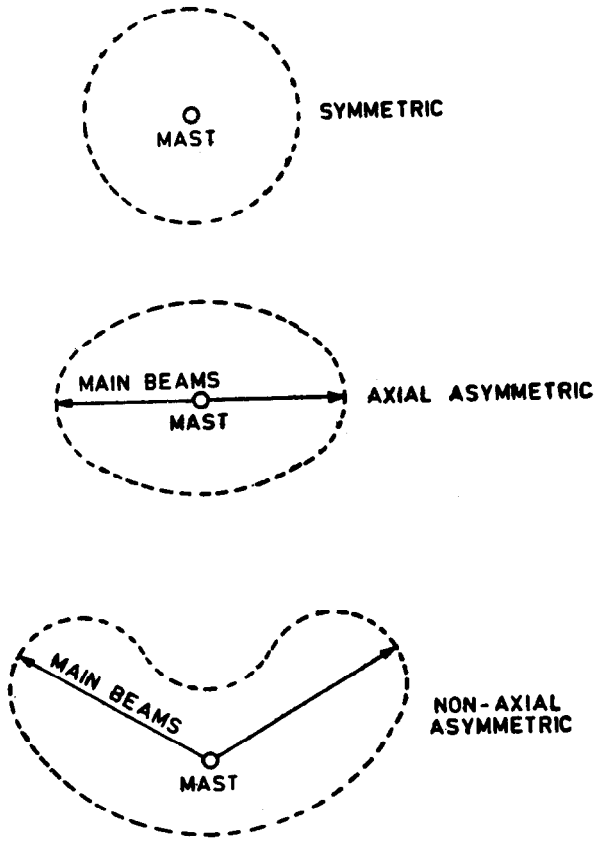

FIG. 2 HIGH MAST DISTRIBUTIONS

It is impracticable to provide and maintain a distribution of light from a particular mast tailored to boundaries and not beyond the area it is supposed to cover. It is inevitable that there would be overspill of light in adjacent areas. Unless this has a nuisance value, it is not considered a drawback and may in fact help to define the visual scheme by lighting the background of the road system or may even in some cases provide amenity lighting in the adjacent areas which may otherwise require separate consideration.

In a grade-separated junction, one road passing over another will cast shadow on the lower road. The size and density of the shadow will

depend on the location of the mast in relation to the crossing of the roads at different levels. In the planning stage itself this aspect shall be considered and it shall be decided whether such a shadow will present a traffic hazard. In case it is decided that it does, then some form of supplementary lighting at a lower level may be provided. However, on account of high illuminance levels provided by high mast lighting, schemes for provision of additional lighting with adequate illuminance beneath the structures may be perhaps costly.

3.4.2.7 *Light source* — On account of adoption of reversed silhouette conditions and somewhat higher levels of illuminance, and also because the surroundings of the roads, perhaps consisting of more coloured surfaces, floral and landscape features, which would be lighted along with the roads, the benefits from using a light source with good colour rendering properties may be somewhat greater than those in conventional lighting installation. However, this would need close scrutiny, depending on the local conditions.

3.4.2.8 *Luminaire mounting* — Luminaires can be fixed on either a platform or a rack mounted on the top of the mast, but constructions are also possible in which the luminaires are distributed over a certain length of the mast.

Construction of these 'luminaire carriers' or 'headframe' depends very much on the number of luminaires required to be mounted. They vary from huge constructions to comparatively light-weight constructions. The luminaire rack can either be fixed to the top of the mast or could be lowered to the ground. For the first type, mobile elevation platforms may be employed for the transport of maintenance technicians to the top for relamping or maintenance. An alternative choice is to climb the mast, a rather tedious job for mast heights above 20 metres, apart from safety hazards.

Maintenance is much easier by lowering the rack of headframe to the ground by means of winch mechanism.

3.4.3 *Engineering Consideration* — When designing a high-mast lighting scheme, the planned position of the mast and mast foundations will depend on the layout of the complete junction complex. Neither the mast nor its headframe supporting the luminaires, in the lowered position shall present traffic hazards. The area around the foot of the mast shall be adequate for the operator to have full facilities to carry out maintenance in safety. If it is inevitable to place a mast in a position which is vulnerable, where it could be struck by a vehicle leaving the carriageway, a safety fence shall be provided around this mast.

3.4.4 *Lighting Protection* — It is essential that such a mast shall be permanently and effectively earthed separately. The earthing arrangement

shall be of adequate capacity to safely conduct and disperse any lightning discharge liable to strike the mast. The earthing system shall be tested in accordance with the recommendation of IS : 3043-1966*.

3.5 Maintenance

3.5.1 *General Maintenance* — An installation shall continue to give the desired standard of lighting throughout its life. All equipment and accessories shall be periodically inspected and reports maintained on their performance. There shall be a planned and regular preventive maintenance system and adequate records, particularly of the frequency and necessity of replacements of any kind, shall be kept.

3.5.2 *High Mast Installation* — High mast installations require more complex maintenance than is normally required for the conventional lighting installations because of the additional mechanised gear involved for lowering the headframe supporting the luminaires, for maintenance purpose. This factor shall, therefore, be given particular consideration in estimating the running cost of high mast lighting.

Depending on the local conditions such as air pollution, etc, it is recommended that the high mast installation shall be inspected every 3 to 4 months. During these inspections, particular attention shall be given to the lowering gear with associated winches, compensating pulleys, wire ropes and electrical equipment attached to the gear. Besides, maintenance of mast luminaires shall receive regular attention.

4. LIGHTING FOR BRIDGES

4.1 General

4.1.1 *Short Bridges* — In short length bridges, that is, those whose length does not exceed 60 m; the normal street lighting system adopted along the approach roads can usually continue across them. A few special problems could be overcome through minor adjustments. Care has to be taken to ensure that the entrance to and the exit from the structure and the edge of the footpath are clearly visible, especially when the bridge has narrower carriageway than that of the approach roads. An attempt shall be made to have a light source at each entrance to the bridge (if the lighting arrangement is single-sided or staggered) or two light sources opposite each other (if the arrangement is symmetrical opposite).

4.1.2 *Long Bridges* — For bridges having length more than 60 m, however, certain problems arise out of geometrical characteristics and nature of surroundings. At the hump, with the absence of buildings, it

*Code of practice for earthing.

often results in absence of background against which objects can be seen, except those which are fairly close to the observer. More distant objects are seen either near the crown of the hump or partly in dead ground beyond it, against the background, which is usually illuminated haze or sometimes medley lighted buildings at a considerable distance. Thus, to make the carriageway bright, which is an aim of the conventional mode of lighting is of an avail for the more distant obstacles, because they are not seen against it.

The first requirement on a long bridge, therefore, is the use of cut-off type of luminaires to avoid glare, and confusing background. Secondly, where objects cannot be reliably silhouetted, the only practical means of revealing them is to illuminate them directly.

Uniformity is important as specified in IS : 1944 (Parts I and II)-1970*, but mounting height, arrangement, spacing, etc, may be modified and the illumination level shall be generous.

Further technical problems may arise from the features such as railways, navigational waterways, etc, which the bridge spans over. This would necessitate consultation with the respective authorities in the design stage itself.

4.2 Aesthetics — Given the progress achieved in the art of designing long bridges, it is desirable not to spoil the appearance by installing too many columns.

As regards day-light appearance of street lighting installations along bridges and elevated roads, some special problems arise. These problems are so diverse, that only broadest guidlines can be suggested.

In most cases, two viewpoints are to be considered:

a) That of the person on the bridge, who is presented normally with a vista of structures along its length (upper viewpoint).

b) That of the person not on the bridge, who sees the bridge obliquely or in elevation (lower viewpoint).

Siting of columns, therefore, needs careful consideration.

4.3 Design Characteristics

4.3.1 *Principles* — In so far as traffic is concerned, the aim of lighting a bridge is the same as that in lighting any other road. The same quality of lighting shall be maintained in that the drivers are given clear information as to their course and the presence and the movement of all road users. It may be desirable to achieve a higher standard on the bridge in as much as the consequence of the seriousness of an accident.

*Code of practice for lighting of public thoroughfare (*first revision*).

4.3.2 *Siting of Columns* — When viewed from the location on the bridge (upper view point), columns and luminaires will appear more conspicuous against the sky. Consequently, the type of equipment acceptable for the approach roads may not be suitable, particularly if the bridge has a strong character of its own.

4.3.2.1 A column seen against the structure is less obtrusive than one seen against the sky.

4.3.2.2 Columns and luminaires shall, therefore, either be combined neatly with the structure itself or so placed as not to conflict unduly with the structural forms. Where the bridge has major structural elements above deck level, for example, in suspension bridge or bow-string girder bridge, lighting columns and equipment shall be carefully related to such elements. In the case of large bridges with heavy structure which dominates the scene, lighting columns may not be conspicuous and, therefore, siting may not present much difficulty. Columns and equipment in its detailed design shall be sympathetic to the structure.

4.3.2.3 In the case of bridges where the main structure is wholly below the deck level with a modern parapet, aesthetically, the columns shall be near the kerb. This would also avoid excessive and unsightly outreaches. The detailed design shall take into consideration important structural elements in the parapet and their spacing, while siting the columns, so that the design becomes sympathetic to that of the parapet.

4.3.2.4 Some old bridges have heavy masonry parapet. In such cases where the bridge is not too wide, and proper spacing is feasible, it would be best to site the columns on the parapet, however, care shall be taken to see that the detailed design is sympathetic to the parapet and the mounting height is not excessive. If this is not possible, it would be advisable to keep clear of the parapet wall and if feasible, it would be preferable to site the columns in the centre reserve.

4.3.2.5 If because of exceptionable width and height limitations, columns are provided both centrally and on sides, it would be preferable to retain a reasonable consistency in the design of the equipment rather than to relate the lateral lighting closely to the parapet design with a simpler functional treatment for the central installation.

4.3.2.6 From the lower viewpoint, the whole side view of the bridge is usually seen in elevation or obliquely. Aesthetics of the lighting installation become more difficult.

4.3.2.7 In smaller bridges, for example, bow-string girder type, it may be possible to make lighting equipment less conspicuous in daytime, as seen from the side of the bridge. Very large bridges with heavy

super-structures above parapet level permit greater freedom to design the lighting installation. In other situations, the installation will be seen in relation to both sub-structure and super-structure above parapet level. In such locations, height and spacing of columns, shall be properly related to the design of the bridge. It would be preferable, for example, to have a column either wholly clear in silhouette or wholly hidden, rather than apparently cut partly by upper flanges of a girder or a suspension cable.

4.3.2.8 In the absence of the super-structure above parapet, the lighting installation will become more conspicuous in daylight in the side view. In the case of very long bridges, columns will be less conspicuous, in which case, primary consideration shall be given to spacing and arrangement rather than height and detailed design. If there is a strong rhythm in the structure, for example, a series of heavy arches, the spacing shall be related to the rhythm. The height of the column shall be compatible with the height established by the sub-structure and parapet.

4.3.2.9 If the columns are to be sited on the parapet, it would be preferable to adopt a lower mounting height and opposite arrangement rather than staggered arrangement. Staggered arrangement, when seen obliquely, can produce irregular appearance of luminaires. Opposite arrangement is preferred when such view is important.

4.3.2.10 During the design of the bridge, arrangement could be made for mounting short columns on the solid parapet centrally over arches. Alternatively, it is usually better to mount them over piers and abutments where greater height may be more readily acceptable. With long spans, it may be necessary to have additional columns between the piers; in such an arrangement, mounting uniform height is important. It is desirable that the spacing between columns is submultiple of the dimensions of the arches. When the arches have a large span (such as 50 metres or over), a good solution consists in siting columns at $\frac{1}{4}$ and $\frac{3}{4}$ of the span rather than at the piers and the middle of the arch.

4.3.2.11 On very short bridges, it may be possible and indeed desirable not to have columns on the bridge proper, even if this means a greater mounting height for the luminaires at either end.

4.4 Bridges of Historical Importance — In the case of bridges, which are scheduled as monuments, and are required to be lighted, lighting proposals on the appearance of the bridges by day as well as by night, and of course of their superstructure, become of particular importance.

4.4.1 In the case of short bridges, consideration shall be given to having no lighting on the bridge at all. If the bridge is too long to be lit from both ends, even with substantial increase in mounting height, a

special design may be called for. Conventional lighting, if adopted, would need a careful design. Specially designed columns and luminaires with a style which harmonises with the bridge may be desirable and their choice shall be made in consultation with the appropriate authority. Perhaps short columns with post-top mounting may prove most acceptable, particularly in the case of narrow carriageway.

4.4.2 In the case of bridges with solid semicircular or elliptical arches and open masonry balustrades, greater refinement of details makes it more difficult in some ways to relate lighting installation satisfactorily to the lighting character of the structure, design of the parapet and the bridge generally. If there are solid dies between the runs of balusters, columns can sometimes be mounted on the parapet; a special design will almost certainly be required to blend with the historical importance of the bridge.

4.5 Parapet Lighting

4.5.1 *General*

4.5.1.1 When there are restrictions on the provision of conventional lighting above deck level on columns installed at the sides, equipment fixed to the inner side of the parapet 1 metre (generally) above the plane of the carriageway on either side, is sometimes provided. Such an installation has an aesthetic advantage and provides good optical guidance, however, it suffers from disadvantages of glare and flicker if not properly designed. Initial and maintenance costs are very high and the installation needs frequent cleaning.

4.5.2 *Design Characteristics*

4.5.2.1 *Principles* — In this type of installation, light is intended to be directed transversely across the carriageway. At the angles involved in low mounting height, even dry road surfaces do not reflect light strongly from the area near the axis of the carriageway and when wet, tend to reflect very little light. This poses difficulty in making the centre of the carriageway adequately bright, unless the road is curved in plan. This difficulty increases with the width of the carriageway and so also with the chamber. This kind of lighting is acceptable only for roads of not more than two traffic lines.

In order that light is reflected adequately in the direction of the traffic, it is important that the carriageway surface is light coloured and matt in texture, and unlikely to flood in rain and remain so throughout the life of the installation.

4.5.2.2 *Mechanism of the system* — Objects are lit fairly strongly from the side by this system up to the height at which cut off occurs. On hump curves where the road surface does not form a background, objects of suitable shape and reflection properties are revealed by reversed silhouette and modelling. The presence of vertical surfaces of a light colour (for example, kerb stones, crash barriers, balustrading, etc) will be strongly revealed in the cross-light and provide a very useful background and guidance to the motorists.

4.5.2.3 *Mounting height* — The luminaires shall be installed as high as possible, but not above the eye level of the driver so as to cause flicker and glare. The mounting height is usually not greater than 1 m above the carriageway.

4.5.2.4 *Continuity* — The luminaires shall be installed in a reasonably continuous row so as not to cause patchy appearance on the footway and the adjacent carriageway. Dark patches may hide a portion of the kerb and may cause disconcerting flicker.

4.5.2.5 *Width between the rows* — Separation between rows of lighting on either side shall normally not exceed beyond 12 m unless there is a central reserve with light coloured kerbs and paving. Wide separation does not produce satisfactory results even in dry weather. Lighting a carriageway from one side is not recommended. If footways are provided on a cantilever, the luminaires may be installed at the kerbs; however, footways will have to be lighted separately. In order to provide cut off to avoid glare, luminaires shall be provided with louvres.

4.5.2.6 *Photometric requirement* — In order that light may reach the centre of the carriageway, luminaires shall have light distribution with a strong peak just below the horizontal. This will also avoid overlighting footways or causing glare. Tubular fluorescent lamps, low or high pressure sodium vapour lamps or any other linear source of luminance are the obvious choice because of low mounting.

4.5.2.7 *Mechanical design* — Luminaires shall be weather-proof dust-proof, vermin-proof, robust and rigidly mounted and designed to reasonably resist interference and malicious damage. Glazing shall be smooth from outside with louvres inside, so that it could easily be wiped and cleaned. The direction of the luminaire shall be initially adjustable and capable of being permanently set.

4.5.3 *Comparative Cost*

4.5.3.1 On account of the large number of luminaires involved in this type of system, the initial and recurring expenditures are more than in the conventional system of lighting. Electrical load and the consequential cost of energy are also more.

4.5.4 *Maintenance*

4.5.4.1 On account of low mounting, the whole installation is exposed to dust and dirt, which calls for frequent cleaning to minimize loss of light and maintain aesthetic value to a reasonably high level. Dirt not only causes loss of light but also diffuses light adding to the glare.

Low mounting height provides ease of maintenance and makes it less hazardous than working at heights in the conventional system, but requires adequate precaution for safety from vehicular traffic.

4.6 Lighting for Footbridges — The illumination on a footbridge shall be not less than 6 lux and special care shall be devoted to the steps. Where a footbridge is in a lighted area or over a lighted road, the illumination on the bridge shall be commensurate with that in the surrounding area. Where the footbridge crosses a road lit to Group A lighting, with a mounting height of 9 m or more, the lighting of the road may suffice for the bridge and its access ramps or stairs, especially if the parapets are not solid. Where the bridge crosses an unlit main road, or a highway, lighting on the bridge shall, if possible, not be visible from the road below. Luminaires on the parapets have aesthetic advantages, but may cause glare and a very patchy effect.

4.6.1 In all cases, the lighting equipment shall be kept as inconspicuous as possible in the daytime, and shall be considered both in its design and siting in relation to the bridge structure. In new bridges it shall be incorporated as an integral part of the design, and not added as an afterthought. Provision shall also be made for the inconspicuous placing of supply cables and switchgear. Special precautions against damage or theft may be necessary.

5. LIGHTING FOR ELEVATED ROADS

5.1 General — Elevated roads differ from bridges in being usually longer, often sinuous, and in often having parallel roads along them at a lower level. They often have slip roads which join the two levels. Elevated roads usually carry heavy traffic and maintenance of the lighting installations may present difficulties, since such roads are usually narrow and closure of the traffic lanes for parking maintenance vehicles may not be possible. These factors are, therefore, required to be taken into consideration.

5.2 Aesthetics — While considerations of safety and maintenance shall have priority, attention is also required to be given to the aesthetics in respect of both the appearance of the road itself and its surroundings and appearance of the lighting installation by day and by night, particularly

in view of the fact that the lighting equipment appears conspicuous against the background of the sky on account of elevation of the road.

Many recommendations given in **4.2** and **4.3** if carefully applied will offer solutions to such problems.

5.3 Design Characteristics

a) The lighting of elevated roads shall be in accordance with the requirement for heavy traffic roads.

b) The visual guidance shall be excellent and the method of siting the light sources shall be the same throughout the length of the road. Lighting from both sides and the centre simultaneously is deprecated.

c) The lighting hardware (columns and luminaires) shall be satisfactory from aesthetic point of view.

d) The difficulties of maintenance of these installations thus exert an influence on their design and on the choice of material.

Lastly, particular situations impose other conditions.

5.3.1 *Siting of Columns* — It is essential that careful consideration is given to the siting of the columns, their design and method of fixing, having regard to the risk to traffic both on and off the structure, following collisions with columns.

The lighting shall aim at providing clear vision and information in the field of view in the direction of the traffic and also clearly indicate the presence of the slip road junctions. To achieve this aim, luminaires may be sited either at the sides of the road or on the central reserve. Siting of columns on central reserve, although desirable from lighting point of view, presents hazards, especially during the maintenance operation.

5.3.2 *Choice of Type of Luminaire* — There is an unusually great tendency to glare arising from the absence of a background of continuous buildings and from the large array of luminaires visible in the field of view at a time. Cut-off type of light distribution is strongly recommended. Furthermore, the problems at the ends of the elevated roads and slip roads also call for cut-off distribution. In case, requirements of geometry for cut-off installations cannot be met on account of limitations imposed on the spacing and mounting height by structural limitations, semi-cut-off distribution with suitable geometry would be preferable to a cut-off distribution with unsuitable geometry.

5.4 Special Requirements — It is possible to classify elevated roads into the following categories which require special lighting requirements.

5.4.1 *Elevated Roads Without Parallel Ground Level Roads* — If the elevated road is a viaduct, lighting installation shall be related structurally and visually to the design and rhythm of the supporting structure. On account of lack of space available on the outside of the carriageway in some cases, special arrangements would perhaps be necessary for mounting of columns in the design of the structure. In the case of elevated roads with embankment, these restrictions may not be encountered.

5.4.2 *Elevated Roads with Parallel Ground Level Roads* — In case, light from the upper installation reaches the lower road only over a part of its surface, it calls for a decision whether to light the two roads independently or whether to light them wholly or partly by a combined installation. The effect on the field of view of the driver on one road of the lighting on the other roads decides the criteria of the lighting design from the glare point of view. Where the slip roads connect the two levels, further problems are encountered, for example, the view of the rising slip road from both the lower and the upper level, the clear revealing of the routes and of points of turn-off, the clear revealing of merging traffic, and the avoidance of a confusing array of lights, and marrying of two installations of different types and quality. Design of the lighting installations, therefore, calls for careful consideration of all these aspects and evolving a suitable solution in specific cases.

5.4.3 *Elevated Road on Embankment with Parallel Ground Level Roads* — When the elevated road is provided with a wide embankment, the ground level roads are much separated in plan from the elevated road. One of the ways could be to light them individually. However, such an installation becomes costlier for both initial cost and the recurring cost of maintenance; besides, it produces a confusing installation of lights. It would, therefore, be preferable to provide luminaires on mast at suitable locations between the roads. The height of the mast would depend on the difference in levels of roads.

In the case of elevated roads with steep embankments, or retaining walls, there could be a similar solution, by providing luminaires with high mounting height, located on the outside of the ground level road. For this type of installation the maintenance costs depend on circumstances, avoidance of glare and ease of maintenance. The cost, however, in some cases will be more than that in conventional methods.

If these methods are impracticable, the ground level roads may be lighted by luminaires carried by columns on the upper road. Either the same luminaire would suffice, or alternatively separate luminaires may be fixed on the same column at a suitable mounting height or using light source of higher lumen output or using multiple light source and/or luminaires, depending on the difference in levels in roads. Care shall be

taken to ensure that the ground level roads are adequately lit, especially in wet weather and the luminaires at a lower height do not produce glare to the traffic on the elevated road.

5.4.4 *Elevated Viaduct with Parallel Ground Level Roads* — When the elevated road is on a viaduct, the ground level roads are generally close to it and may be partly underneath the elevated roads. In such situations, the lights installed on the sides of the elevated roads may cast objectionable continuous shadows on the portion of the ground level road. This may be offset by providing lights carried on the lower side of the elevated road. However, mounting height in such situations is restricted and might create glare problem, besides casting further shadows of beams and often structural features behind the elevated roads.

When all roads are close together or overlap, it may possible to light roads at both the levels from luminaires on the outer sides of the ground level road, provided the mounting height can be so chosen that the elevated road is lit to its centre without shadows being cast by the viaduct on the inner side of the ground level roads. This type of solution avoids all maintenance problems on the elevated road and gives better results on bends. The distribution of light shall be so designed as to avoid wastage of light beyond the confines of the road system. If in this type of installation the elevated road is inadequately lit, it calls for providing lighting on the elevated road also.

5.5 Lighting for Slip Roads — The descending line of lights along the slip road gives an indication of the presence of the slip road and provides useful visual guidance, provided the constellation of lights does not result in confusion. Due consideration has to be given to the possibility of glare from these units to the driver on the elevated road, because they appear strongly in the field of his vision, being at a lower height. Special distribution may be necessary below the horizontal and full cut-off above the horizontal.

Junction of the slip road with the elevated roads needs a special lighting treatment by careful siting of the columns, marking of the carriageway, installation of barriers carefully designed to make the point of turn-off and nose of the dividing barrier very clear to the driver. Where the slip road joins the elevated road, luminaire shall be installed on the outer side of the slip road to reveal clearly the joining traffic to the driver on the elevated road and care shall also be taken to reveal clearly the main traffic to drivers joining it, by appropriately locating the lights on the elevated road at the junction.

Provision of light on high mast located on the outer side of the slip road may provide better solution and would also avoid multiplicity of lights at different levels. However, care is needed to avoid dense shadows

cast by the elevated and slip roads outer to the lower carriageways. Complementary lighting will perhaps be necessary to eliminate the zones of shadow.

5.6 Maintenance — Bridges and elevated roads are expensive. Economic designs do not leave sufficient space for parking maintenance vehicle for access to the lighting equipment during heavy traffic hours. Maintenance work is required to be restricted during periods when traffic flow is sufficiently high. Besides, absence of hard shoulders on the carriageway of the elevated road presents a certain amount of risk to the traffic and maintenance crew.

To minimize both these, maintenance aspect shall be given careful consideration during the planning stage itself, so that specifications of components could be drafted with emphasis on reliability and sufficient standard of performance and best possible arrangement of lighting which will provide economic and easy maintenance with less hazards and minimum number of maintenance visits.

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Printed at Simco Printing Press, Delhi