

PUBLIC LIGHTING DESIGN MANUAL

Third Edition

HIGHWAYS DEPARTMENT

*The Government of the Hong Kong
Special Administrative Region*



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1. GENERAL INFORMATION

1.1 SCOPE OF MANUAL

This Manual provides guidelines on design of public lighting installations to be handed over to the Highways Department. The Manual covers the following public lighting installations:

- (a) road lighting;
- (b) gantry and directional sign lighting;
- (c) tunnel lighting;
- (d) noise enclosure lighting;
- (e) covered public transport interchange lighting;
- (f) covered pedestrian route lighting; and
- (g) traffic bollards.

This edition of Manual shall apply to all new public lighting designs prepared after its publication. Those installations or part of the installations complying with the second edition of this Manual are deemed to have met the requirement of the Highways Department provided that the design approval is obtained within 6 months from the publication date of this Manual. It should be noted that the guidelines provided in this Manual are not exhaustive. The Lighting Division of the Highways Department (hereafter referred to as “the Lighting Division”) may review the requirements from time to time.

1.2 DESIGN CONSIDERATIONS

The major functions of public lighting are to ensure road users’ safety and to enhance city security. The public lighting installations shall be designed to appropriate lighting levels in an energy efficient and environmental-friendly manner. In this Manual, there are requirements on lighting level, uniformity, reliability, durability, etc. for different types of roads and highway structures. Due consideration has been given to the international practices, traffic safety, operational needs, local conditions, energy efficiency and reduction of sky glow. Lighting designers shall prepare the lighting scheme strictly according to the specified limits or values in this Manual for approval by the Lighting Division.

In addition to this Manual, lighting designers shall also observe the latest edition of the following standards, specifications or requirements and, in case of any conflict, technical advice from the Lighting Division shall be obtained:

- (a) “Code of Practice for the Electricity (Wiring) Regulations” issued by EMSD (CoP);
- (b) “General Specification for Electrical Installation in Government Buildings of the Hong Kong Special Administrative Region” issued by ArchSD;
- (c) Local Power Companies’ “Supply Rules” and other requirements; and
- (d) Relevant international standards including BS, BS EN, IEC and ISO.

All materials and equipment supplied by the Contractor shall be in accordance with the relevant standard specifications and be approved by the Lighting Division.

1.3. SUBMISSIONS FOR APPROVAL

All lighting designs, computer simulations, shop drawings and proposed materials/equipment shall be submitted to the Lighting Division for approval before installation. The Lighting Division will not take over any completed lighting installations without prior approval.

1.4 HANDOVER OF LIGHTING SYSTEM

1.4.1 Handover Inspections

After the completion of installation work, the Project Office shall arrange the first inspection for staff of the Lighting Division to inspect the lighting installation. In general, a list of defects and outstanding items list shall be agreed by all relevant parties and the Lighting Division. The Lighting Division shall highlight those major defects. After the Contractor has rectified all the major defects, a handover inspection shall be arranged.

1.4.2 Electricity Account

The Developer/Contractor shall prepare and submit, under his name, an application for electricity supply in accordance with the project schedule, and be responsible for the electricity cost before the lighting installations are accepted and handed over to the Lighting Division as mentioned in Clause 1.4.1.

When the lighting installations including the rectification of all major defects, the submissions of as-fitted drawings and other required documents (see Clause 1.4.4), and the provision of spare parts, are fully completed to the satisfaction of the Lighting Division, the Contractor shall arrange a handover inspection. During the handover inspection, the Contractor shall take the initial reading on the electricity meter in presence of the Lighting Division staff and then submit an application for change of electricity account ownership to the Lighting Division for endorsement and forward submission of the application to the Power Company concerned. Thereafter the electricity consumption and responsibility for payment of electricity charges will be transferred to the Government of the Hong Kong Special Administrative Region.

1.4.3 Provision of Spare Parts

The exact quantities and types of spare parts for the road lighting installations shall be confirmed with the Lighting Division at design stage. Spare parts shall be provided and delivered to the Lighting Division before handing over the lighting installations for maintenance.

For tunnel lighting and noise enclosure lighting installations, in general, 10% of each type of the installed luminaires, 100% of the installed luminance meters and 1 set of controller shall be provided as spare parts. For more complicated installation, the Lighting Division shall be consulted at design stage.

For lighting installations at other types of structures such as covered public transport interchanges, covered pedestrian routes and high mast lights, 10% of each type of the installed luminaires shall be provided as spare parts if typical luminaires are used. The exact quantities of spare parts for non-typical luminaires shall be confirmed with the Lighting Division at design stage.

1.4.4 As-fitted Drawings and Other Required Documents

On completion of the lighting installations, the Contractor shall provide two hard copies of as-fitted drawings in A1 or A3 size to the Lighting Division to facilitate the handover inspection.

For the final handover, the Contractor shall provide the Lighting Division with 2 sets of CD ROMs each containing the following documents in PDF format:

- (a) As-fitted drawings including lighting layouts, schematic drawings, circuit diagrams and conduit routes layouts;
- (b) Lighting measurement results;
- (c) Electrical test reports;
- (d) Equipment database in required format; and
- (e) Operation and maintenance manual.

For as-fitted drawings, 1 more set of CD ROM containing the drawings in Microstation version 3D DGN format shall be provided. To save paper, it is not required to submit any hardcopy of the above documents (a) to (e) for final handover.

For lighting systems with software/electronic control, the design logic flow chart and associated software protocols of the controller shall be submitted to the Lighting Division after commissioning and testing.

1.5 ABBREVIATIONS

The following abbreviations are used throughout this Manual:

1.5.1 General Abbreviations

ACABAS	Advisory Committee on Appearances of Bridges and Associated Structures
Arch SD	Architectural Services Department
BSI	British Standards Institution (UK)
CIBSE	Chartered Institution of Building Services Engineers (UK)
CIE	International Commission on Illumination
CoP	Code of Practice for the Electricity (Wiring) Regulations” issued by EMSD
EMSD	Electrical and Mechanical Services Department
HyD	Highways Department
IET	Institution of Engineering and Technology

ILP	Institution of Lighting Professionals
TD	Transport Department

1.5.2 Technical Terms Abbreviations

AC	Alternating Current
CMCS	Central Monitoring and Control System
IP	Ingress Protection
GI	Galvanized Iron
MCB	Miniature Circuit Breaker
RCD	Residual Current Device
LED	Light Emitting Diode
SON	High Pressure Sodium
TI	Threshold Increment
UPS	Uninterruptible Power Supply
UPVC	Unplasticized Polyvinyl Chloride
PLCC	Public Lighting Control Cubicle

1.5.3 International Standards Abbreviations

BS	British Standards
BS EN	European Standards adopted as British Standards
EN	European Standards
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization

2. ROAD LIGHTING

2.1 GENERAL

The main function of road lighting is to provide visual conditions for safe and comfortable movement of road users during nighttime. Road lighting shall reveal all features of the road and traffic that are important to all users including pedestrians, cyclists and drivers. Apart from high efficiency, reliability and durability, road lighting equipment shall be of pleasant appearance by both day and night and in harmony with surrounding environment.

The general approach to the design of road lighting is based on the luminance concept in which the objective is to provide a bright road surface background against which objects are seen in silhouette. It therefore uses luminance level, uniformity of luminance on road surface and glare control as quality criteria. However, when it comes to visual tasks at a closer distance such as in conflict areas including car parks, bus terminus and cycle tracks, the objects may not be seen in silhouette but rather revealed by direct light. Furthermore, in areas with congested traffic conditions such as toll plazas and transport interchanges, much of the view of the road surface may have been obstructed by vehicles and thus a background for revealing objects cannot be provided. Under these circumstances, illuminance approach will be adopted. Nevertheless, the approach of providing a good level and uniformity of road luminance with adequate glare control has been widely adopted in international recommendations for all motorized traffic.

2.2 DESIGN STANDARDS

Road lighting levels are described in classes with different lighting parameters to suit local lighting requirements. These classes shall be selected according to the functions of the road, traffic density, traffic complexity, traffic segregation, pedestrian volume and ambient brightness. For road classification, the terminology promulgated in Chapter 3.2 Volume 2 of the Transport Planning and Design Manual (TPDM), published by TD is adopted and recapitulated in Table 2-1a and Table 2-1b.

Table 2-1a Definitions of Road Types for Rural Roads

Type	Description
Expressway	Roads under Expressway Legislation which connect main centres of population. They are designed to a dual carriageway standard and with no frontage access. Pedestrians, cyclists, learner drivers, hand carts and animals are prohibited and all pedestrian cross movements are fully segregated.
Trunk Road	Roads connecting main centres of population. High capacity roads with no frontage access or development, pedestrians segregated, widely spaced grade-separated junctions, and 24-hour stopping restrictions.
Rural Road	Roads connecting smaller centres of population or popular recreation areas with major road networks. Frontage access is limited. Junctions are of a high capacity standard.
Feeder Road	Roads connecting more remote settlements to rural roads.

Table 2-1b Definitions of Road Types for Urban Roads

Type	Description
Expressway	Same as Table 2-1a above
Trunk Road	Roads connecting main centres of population. High capacity roads with no frontage access or development, pedestrians segregated, widely spaced grade-separated junctions, and 24-hour stopping restrictions. These roads are in developed urban areas or sections of rural trunk roads passing through new towns.
Primary Distributor	Roads forming the major network of urban areas. These roads have high capacity junctions, segregated pedestrian facilities wherever possible, limited frontage access and 24-hour stopping restrictions.
District Distributor	Roads linking districts to primary distributor roads. These roads have high capacity at-grade junctions with peak hour stopping restrictions and parking restrictions throughout the day (including housing estate roads and residential major access roads).
Local Distributor	Roads within districts linking developments to district distributor roads.

2.2.1 Carriageways

There are 5 lighting classes (L1, L2, L3, L4 and L5), in 5 lighting levels as shown in Table 2-2, for different types of carriageways.

Table 2-2 Lighting Classes for Carriageways

Lighting Class	Maintained Average Luminance (L_{av}) (cd/m^2)	Overall Uniformity Ratio (U_o)	Longitudinal Uniformity Ratio (U_l)	Threshold Increment (TI) (%)
L1	$2.00 \leq L_{av} < 2.25$	0.40	0.70	≤ 10
L2	$1.50 \leq L_{av} < 1.75$	0.40	0.70	≤ 10
L3	$1.00 \leq L_{av} < 1.25$	0.40	0.60	≤ 15
L4	$0.75 \leq L_{av} < 1.00$	0.40	0.60	≤ 15
L5	$0.50 \leq L_{av} < 0.75$	0.35	0.40	≤ 15

The recommended maintained average luminance (L_{av}) ensures that the carriageway is sufficiently bright to reveal objects adequately whereas the recommended overall uniformity ratio (U_o), which is the ratio of the minimum to average luminance over a defined area, ensures that no part of the road surface is so dark that it becomes ineffective as a background for revealing objects. The recommended longitudinal uniformity ratio (U_l), which is the ratio of the minimum to maximum luminance along a longitudinal line through the observer position, ensures that pronounced visual patchiness of the lighted road surface is avoided. Disability glare, measured in threshold increment (TI), reducing the contrast between objects and their background. The recommended TI limit ensures the glare would not impair the vision of road users.

The properties of road surfaces directly affect the performance of lighting installations. For instance, increasing the roughness of macro-texture will improve the wet-weather performance whereas adding a certain proportion of white stones in the surface will improve luminance level and uniformity. It should be noted that road surface reflective properties change throughout its lifecycle. The standard C2 class of road surface with average luminance coefficient 0.07 is taken as the standard road surface for the design. The reason is simply that the characteristic of this class of road surface is close to that of newly resurfaced bituminous surface, which is relatively dark and smooth. In Hong Kong, assumptions based on this C2 class of road surface would render a good safety factor as well as avoid the need of different

design tables.

The carriageways are divided into two categories namely rural roads and urban roads that the definitions can be referred to Chapter 3.2 Volume 2 of TPDM. The required lighting classes for carriageways under these two categories are shown in Table 2-3 below. Roads in new towns of the New Territories shall be classified as urban roads. There are also roads designated as expressways under the Road Traffic (Expressway) Regulations.

Table 2-3 Lighting Classes for Different Types of Carriageways

Category	Carriageway Type	Lighting Class
Rural Roads	Expressways	L1
	Trunk Roads (speed \geq 70km/h)	L3
	Trunk Roads (speed < 70km/h)	L4
	Rural Roads	L4
	Feeder Roads	L5
Urban Roads	Expressways	L1
	Trunk Roads (speed \geq 70km/h)	L2
	Trunk Roads (speed < 70km/h)	L3
	Primary Distributors (speed \geq 70km/h)	L2
	Primary Distributors (speed < 70km/h)	L3
	District Distributors	L3
	Local Distributors	L4

Note : The luminance requirement for hard shoulders of all carriageway types is 0.5cd/m².

2.2.2 Conflict Areas

It is very common that a carriageway is adjoining or leading to an open facility area such as a bus terminus, a ferry concourse, a taxi stand, a toll plaza or a car park. Other areas of similar concern are road junctions, pedestrian crossings and

roundabouts, etc. These are often termed “conflict areas” and it is more appropriate to design the lighting at these areas in the illuminance approach.

Area lighting techniques are used for lighting open spaces such as conflict areas where there is either mixed traffic or merging and diverging of traffic. The main requirements are the provision of a specified illuminance level and uniformity ratio combined with adequate control of glare.

In conflict areas, due to changes of road layout or high patronage by pedestrians, cyclists or other road users, the visual task is usually more difficult than on straight roads. A higher lighting level should be provided as described in Table 2-4.

Table 2-4 Lighting Classes for Conflict Areas

Lighting Class	Locations	Maintained Average Illuminance (lux)	Uniformity Ratio*
CE1	Toll plazas, large roundabouts, large interchanges and grade separated intersections	30.0	0.4
CE2	Small roundabouts, carparks, bus terminuses and taxi stations	20.0	0.4
CE3	Road junctions of urban roads	15.0	0.4
CE4	Road junctions of rural roads	10.0	0.4
CE5	Cul-de-sacs and small parking lots	7.5	0.4

Remarks * : Uniformity Ratio is the ratio of the minimum illuminance to average illuminance.

2.2.2.1 Junctions

Lighting provision at a junction should reveal its configuration, positions of kerbs and road markings, directions of roads, presence of pedestrians or obstructions and movements of vehicles in the vicinity of the junction.

The provision should also meet the needs of drivers approaching the junction to see vehicles approaching from other directions. The lighting level on the carriageway throughout a junction shall not be lower than that provided on the main roads leading to the junction. Luminaires and column positions for typical single level junctions shall make reference to ILP lighting guide PLG02 “The Application of

Conflict Areas on the Highway”. Road lights shall not be placed at the curved corner of a road junction as this will reduce the effectiveness of the main beams from all on-coming traffic at different branches of the junction.

2.2.2.2 Roundabouts

The lighting provision at a roundabout should enable drivers to see clearly any traffic at the preceding entry and the traffic already in the roundabout. When in the roundabout, the lighting provision should also enable drivers to have adequate forward vision to see traffic entering from the left and to decide whether it is safe to proceed. It should reveal the form, direction and edges of the carriageway all the way round the roundabout.

Lighting columns shall not be installed on the central traffic islands as they would confuse the visual guidance required above and increase the possibility of vehicle collisions. They shall be placed behind the outer kerb at appropriate spacing.

The maintained average illuminance on the road surface of a roundabout shall be higher than that of approach roads. The lighting layout arrangement for roundabouts shall also refer to ILP lighting guide PLG02.

2.2.2.3 Pedestrian Crossings

Precaution shall be made to avoid placing road light columns at a pedestrian crossing, regardless of whether it is signalized or not, as it will block pedestrian flow. The lighting class of a pedestrian crossing shall generally follow the carriageway lighting class as shown in Table 2-3. Dimming or reduction of lighting level is not recommended for roads with non-signalized pedestrian crossing.

2.2.3 Footpaths and Cycle Tracks (without motorized traffic)

There are 5 lighting classes for footpaths and cycle tracks without motorized traffic as shown in Table 2-5. Different from users of carriageways for motorized traffic, pedestrians prefer a brighter environment for a sense of security. For prestigious areas and rear lanes where facial recognition is necessary, lamps of colour rendering index greater than 60 and post-top lanterns providing minimum vertical illumination at 1.5 lux shall be selected to enhance a sense of security and for crime prevention.

Table 2-5 Lighting Classes for Footpaths and Cycle Tracks

Lighting Class	Locations	Maintained Average Illuminance (lux)	Maintained Minimum Illuminance (lux)
S1	Footpaths at prestigious and crowded pedestrian areas	15.0	3.0
S2	Footpaths/cycle tracks at amenity areas where nighttime public utilization is moderate to high, e.g. places associated with amenities such as shopping precincts, footpaths/cycle tracks near train stations or town centres	10.0	2.0
S3	Footpaths/cycle tracks at amenity areas where nighttime public utilization is moderate	7.5	1.5
S4	Footpaths where nighttime public utilization is low	5.0	1.0
S5	Footpaths where nighttime public utilization is very low	3.0	0.6

2.2.4 Variable Lighting Levels

The lighting level for a carriageway shall be reduced during off-peak period when the traffic flow is lower. For primary and district distributors, the lighting level shall be reduced by one lighting class after 12:00 am by applying dimmable ballasts or advanced lighting control. Variable lighting is not recommended for other types of roads and roads with non-signalized pedestrian crossings.

2.3 DESIGN LAYOUT

2.3.1 Luminaire Arrangement

2.3.1.1 Single-sided

Single-sided arrangement is used when the width of the road is not more than the mounting height of the luminaires. Luminaires for this type of arrangement are located on one side of the road. The luminance of road surface on the far side is

inevitably lower than that on the near side of the luminaires. The advantage of this arrangement is to provide a good visual guidance of the road and good longitudinal uniformity to drivers. This arrangement is also recommended for slip roads.

2.3.1.2 Staggered

Staggered arrangement is mainly used when the width of the road is between 1 and 1.5 times the mounting height of the luminaires. Luminaires for this type of arrangement are located on both sides of the road in a staggered or zigzag fashion. Attention shall be paid to the uniformity of luminance on the road surface. Alternate bright and dark patches can produce an unpleasant zigzag effect. This arrangement is not recommended for expressways because of the difficulty in achieving an acceptable longitudinal uniformity.

2.3.1.3 Opposite

Opposite arrangement is mainly used when the width of the road is greater than 1.5 times the mounting height of the luminaires. Luminaires for this type of arrangement are located opposite to each other. It is recommended for wide carriageways or expressways.

2.3.1.4 Twin-central

Twin-central arrangement is mainly used in dual carriageways. Lighting columns are located on the central reserve. Each lighting column normally accommodates two luminaires in a back-to-back orientation on each side of the carriageways. This type of arrangement can reduce the capital and maintenance costs, but consideration should be given to its potential hazards during mobile operations or lane closures for lighting maintenance on fast lanes.

2.3.1.5 Combined Twin-central and Opposite

In combined twin-central and opposite arrangement, twin luminaires located on the central reserve are combined with the opposite arrangement. Where hard shoulders are provided on expressways, lighting columns shall be placed on the side of the hard shoulder, i.e. opposite arrangement is preferred to twin-central arrangement in such road layout. This type of arrangement is recommended for expressways with exceptionally wide carriageways.

2.3.2 Lighting Columns

Five major types of lighting columns commonly used in road lighting design ranging from 5m to 15m are shown in Table 2-6. The columns used shall be two-section circular columns (5m to 12m), round conical columns (5m to 12m) or octagonal column (15m). Design of lighting columns shall be in accordance with the requirements of BS EN 40, together with all current amendments.

Table 2-6 Recommended Installation Locations for Columns of Different Heights

Column Height	Recommended Locations	Suitable Lighting Classes
5m	Footpaths, cycle tracks and feeder roads	L4, L5 and S
8m	Local distributors, and narrow and meandering roads	L3, L4, CE3, CE4, CE5 and S
10m	Local distributors, primary distributors, district distributors, trunk roads (low speed) and rural roads	L2, L3, L4, CE2, CE3, CE4 and CE5
12m	Primary distributors, district distributors and trunk roads	L1, L2, L3, CE1 and CE2
15m	Expressways and trunk roads	L1, L2 and CE1

2.3.3 Appearance and Siting of Columns and Lanterns

2.3.3.1 General Requirements

The lighting installations shall give visual guidance to road users by revealing the run of the road. To prevent misleading patterns of luminaires, the alignment of the siting of columns shall be along the road layout as far as possible and any sudden changes in set-back distance or column height should be avoided. In general, for locations with special lighting requirements such as at crests, junctions, pedestrian crossings, bends and adjacent to flyovers, the pattern of lanterns should be laid out first. Remaining lanterns are then carefully added to the layout to ensure that the pattern is visually acceptable.

Columns sited directly in front of any shops, windows, stairways, premises doorways, middle of pedestrian ways, fire emergency access or monuments of architectural interest etc. shall be avoided. It is preferable to place the column between two shops or buildings or in front of a service lane but not blocking the lane. For footpaths with width less than 2m, columns shall be sited at their back whenever practicable, i.e. away from the road, so as to minimize obstruction to pedestrians. Columns shall also be sited away from kerbs or carriageways in accordance with Clause 2.3.5 below.

2.3.3.2 Appearance

For daytime appearance, the design and siting of road lighting and other road equipment can make a great difference to the overall street scene. At locations such as a processional way, monumental bridge and roads abutting onto heritage buildings, the design and placing of lighting columns shall match with the architectural setting, in order to make a positive-contribution to the street scene.

For the selection of luminaire, in urban and rural town centres, shopping streets, boulevards, promenades and other places that are the hubs of social activities, decorative road lights are highly desirable. In general, proposals using decorative road lights should be agreed by the Lighting Division and all relevant parties such as the ACABAS, the Landscape Unit of the Highways Department and relevant Project Offices.

Lighting designers should also consider whether the lighting scheme could make a positive contribution to the night environment, especially for areas of civic importance. A higher colour rendering index ($Ra \geq 60$) of the light source is paramount to the nighttime appearance of the street scene and can enhance the sense of nighttime security.

2.3.3.3 Trees and Planters

Where trees are to be planted on new roads, the lighting layout shall be designed before the trees are fixed. Trees and lighting columns shall be sited in such a way that the trees do not block off light onto the carriageways or cast confusing shadows. In general, the trees shall be planted at least 10m away from the road lighting columns and 15m away from high mast lighting columns. To avoid obstruction to maintenance access, no planting of bushes shall be allowed in an area of at least 1m radius from the lamp post.

For planters located next to the carriageways, a recess shall be provided in the planter to accommodate the lighting columns for easy maintenance. If the width of the planter is less than 1.6m, lighting columns can be located just behind the planter and lighting cables should preferably not be laid inside the planter areas.

2.3.3.4 Fire Hydrants

Lighting columns shall be sited at least 1.5m away from fire hydrants in order not to block its operation.

2.3.3.5 Soffit Lanterns

In road lighting design, an elevated structure such as a footbridge or flyover spanning across a road may require soffit lanterns to light the road underneath the structure. However, for narrow elevated structures of covered roads less than 10m in length along traffic direction and there is adequate clearance for installation of road light columns nearby, soffit lanterns are not required and lighting shall be provided by two adjacent road lights installed at equal spacing from the structure.

Soffit lanterns shall be carefully planned so that minimum traffic disruption shall be achieved during maintenance. For example, a row of soffit lanterns shall be placed along only one traffic lane as far as practicable, preferably over the hard shoulder or the slow lane or the lane with maximum sightline clearance. Anchor plates and bolts shall be securely embedded to the structure for safe fixing of lanterns.

2.3.3.6 Gantry/Directional Signs

Lighting columns shall preferably be sited at least 10m away from gantry/directional signs so that the main beams of road lights will not be blocked by them.

2.3.3.7 Noise Barriers

If noise barriers are located along the central divider, lighting columns shall be sited on the opposite sides of the roads. In advising the designer of noise barriers, consideration shall be given to allowing sufficient space for the installation of road lights and to avoiding obstruction to its maintenance or shading of the light falling on the carriageways or hard shoulders.

2.3.4 Bracket Projection

Columns with long bracket projection shall be carefully designed. The bracket projection shall be determined and be consistent so as to provide a good optical guidance and uniformity of luminance on the carriageway. For low mounting heights in particular, post-mounted luminaires without brackets can be aesthetically advantageous. However, when brackets are to be used for decorative luminaires, large arc or quadrant brackets are usually more conspicuous than straight line brackets, because they contrast more with the surrounding lines of roofs.

Bracket projection shall not exceed one quarter of the mounting height in general, to avoid excessive amplitude of vibration.

2.3.5 Set-back and Clearance

The number of vehicles colliding with lighting columns is likely to decrease with increasing clearance of the lighting columns from the edge of the carriageway. The recommended minimum horizontal clearances according to the design speeds of road shall refer to Table 3.5.2.1 of Chapter 3.5 in TPDM Volume 2 – “Highway Design Characteristics”. The set-back of lighting columns shall also be sufficient to allow free passage of blind and disabled people on any footpath.

The minimum safe vertical clearance to overhead electricity supply lines during erection, installation, commissioning and maintenance operations on all road lightings shall refer to the relevant statutory requirements of EMSD.

2.4 DESIGN METHOD

2.4.1 Lighting Computer Simulation

Computer simulation software acceptable to the Lighting Division can be used for the calculation of road lighting luminance, illuminance, uniformity and glare. The software programs shall be based on BS EN 13201-3 in which the driving convention is identical to our local environment. Photometric data in TM-14 format and IESNA LM-63 format shall be used as part of the input data for calculation.

2.4.2 Field of Calculation for Luminance

According to BS EN 13201-3, transversely there are 3 grid points for each lane whereas longitudinally there are at least 10 grid points at maximum spacing of 3m. The average luminance, overall uniformity and longitudinal uniformity are calculated from an observer located at the centre of each lane. The lowest calculated value of L_{av} , U_o and U_l and highest calculated value of TI shall be used.

2.4.3 Calculation for Illuminance

For locations where the illuminance concept is adopted, such as conflict areas, road curves and footpaths, grid points used for the calculation shall be chosen from the points lying within the boundary of the relevant area. The spacing of the grid points in either direction shall not exceed 1.5m.

For road curves, the spacing of road lighting columns shall be reduced. The illuminance method and lighting classes for conflict areas (CE) shall be adopted. The applicable CE lighting classes corresponding to different L lighting classes of carriageways are shown in Table 2-7.

Table 2-7 Applicable CE Lighting Classes for Road Curves

Lighting Class of Carriageway	Applicable CE Lighting Class for Road Curves
L1	CE1
L2	CE2
L3	CE3
L4	CE4
L5	CE5

The positions of lighting columns at road curves shall generally follow the original carriageway to maintain visual guidance. Lighting designers shall consider to put the columns at the outer bend as far as practicable. For curves with radius of curvature less than 300m on dual carriageways, the columns with single-sided luminaire shall be placed at the outer bend of each carriageway.

2.4.4 Maintenance Factor

The recommended maintenance factors for luminaires with rating not less than IP66 in urban and rural areas are shown in Table 2-8. For decorative lanterns

with IP65 and lanterns with LED lamps, the maintenance factor shall be reduced by 0.05.

Table 2-8 Maintenance Factors for Luminaires in Urban and Rural Locations

Location	Maintenance Factor
Urban Areas	0.85
Rural Areas	0.90

2.5 HIGH MAST LIGHTING

High mast lighting is defined as a lighting system in which each mast supports a group of luminaires at a height between 20m and 40m. In Hong Kong, 30m to 40m masts are normally used for better utilization. This form of lighting is more expensive to install and operate than conventional lighting. However, it is easier to maintain without causing too much disruption to heavy traffic.

2.5.1 Application

To avoid excessive road lights, the use of high mast lighting system is recommended at the following locations:

- (a) Large Concourses: Such as toll plazas and tunnel portal areas where conventional lighting in the peripheral is impracticable to uniformly illuminate the huge area.
- (b) Complexes: Such as large interchanges, grade-separated junctions or roundabouts where a higher than normal level of illuminance is considered desirable, or a large number of conventional road light columns would confuse the motorists with patterns of lanterns at different levels or impair the aesthetics.

The required lighting levels for the above locations shall refer to Clause 2.2.2. The use of high mast lighting system shall observe the obtrusive light limits as stipulated in Clause 2.6 and shall be avoided with residential areas nearby. All high mast lighting systems must be separately metered. The lanterns for high mast lighting shall comply with BS EN 60598 and shall have an IP rating not less than 65 in accordance with BS EN 60529. General specification for high mast lighting is given in Appendix B. Prior consultation with the Lighting Division is essential at the preliminary design stage.

2.6 CONTROL OF GLARE AND OBTRUSIVE LIGHT

Disability glare, reducing the contrast between objects and their background, can impair one's vision. An object that is just visible when there is no disability glare will in the presence of disability glare, merge into the background. The percentage by which the background luminance has to be increased to make the object just visible again is known as TI. The presence of disability glare can be reduced by the use of curved temper glass (CTG) or flat glass (FG) lanterns, either with moderate or low threshold increment (MTI/LTI), instead of bowl type lanterns. A CTG or FG luminaire generally meets the recommendation of TI being not more than 10%, and more pronouncedly limits its glaring effect at a low mounting height close to the road.

On slopes with a gradient in excess of 10%, lanterns shall be rotated at the spigot entry to match with the slope profile for glare control. It is also beneficial to do this on the straight long section of a sloped road in order to maintain the longitudinal uniformity. It would be too glaring when driving up and too patchy when driving down a slope if the lanterns are not rotated accordingly. In addition, despite there is no special lighting problem at a dip, it is necessary to limit the glare from luminaires beyond a crest by siting the lighting columns at appropriate locations.

To reduce obtrusive light and sky glow, light above the horizontal should be properly controlled by careful design. The limits as shown in Table 2-9 shall be applied for all road lights.

Table 2-9 Limitations for Obtrusive Light

	Max. Sky Glow ULR (%)	Max. Light Intrusion Into Windows (lux)
Obtrusive Light Limitations	15	25

2.7 MODE OF OPERATION

Road lighting, where provided, is normally required to be in operation during all the hours of darkness. Astronomical time switches shall be adopted so that the operation of road lighting can be based on sunset and sunrise times. An adjustable digital photoelectric controller shall be operated in parallel under abnormal ambient condition such as heavy rainstorm so that the road lights can be turned on when the ambient light level drops below a pre-set value. The setting of the switches

will be confirmed by staff of the Lighting Division on site according to different ambient conditions.

For road lights or soffit lights located in a shaded area such as under-bridge or under-flyover, their operation shall follow other road lights along the same carriageway. Therefore, the power supply for the soffit lights should be obtained from the road lights of that carriageway instead of from the bridge or flyover.

2.8 CHOICE OF EQUIPMENT

2.8.1 Luminaires

Lanterns shall be of sound and robust construction to BS EN 60598-2-3. The IP rating for decorative and conventional lanterns shall not be less than 65 and 66 for decorative and conventional lanterns respectively. They shall be for use on 220V, 50Hz single phase mains supply. To ensure high energy efficiency of public lighting system, the overall efficacy of the whole lantern for new road projects shall not be less than 100lm/W.

In addition to above, LED luminaires shall comply with IEC 62471 hazard class Group 1 or Exempt Group and shall have a correlated colour temperature at 3000K. The luminaire shall be in modular type so that replacement of parts such as drivers, LED circuit boards and other components can be carried out as necessary. The supplier shall guarantee supply of compatible spare parts for a period of 10-year after the product guarantee period. For luminaire that replacement of spare parts is not allowed, approval shall be obtained from the Lighting Division for its use. LED luminaires shall have a minimum of 50,000 hours of lifetime at 70% lumen maintenance.

Luminaires installed on a bridge deck shall be capable of withstanding the effects of vibration from structures, passing vehicles and prevailing winds. Vibration studies/analyses and tests shall be carried out on the proposed luminaires beforehand in order to illustrate that no premature failure of lamps would occur under the structural vibration of the bridge. Studies/analyses/test reports and any proposed vibration reduction measures on the luminaires shall be submitted to the Lighting Division for approval.

2.8.2 Light Sources

The choice of light source depends on the number of lumen per watt, life time, flux maintenance, colour rendering, initial costs and lamp replacement costs. The luminous efficacy of a light source has a dominating influence on the energy consumption and consequent running costs of a road lighting installation. The requirement on minimum luminous efficacy for different types of light sources is shown in Table 2-10. In addition, the light sources shall also comply with the following standards:

High pressure sodium vapour lamp (SON):	BS EN 62035
Ceramic metal halide lamp (CDM):	BS EN 62035
Light emitting diode lamp (LED):	IEC 62471
T5 fluorescent lamp (T5):	BS EN 60081
Compact fluorescent lamp (CFL):	BS EN 60901

Table 2-10 Minimum Luminous Efficacy for Different Light Sources

	SON			CDM		LED	T5
Wattage (W)	<100	100-150	>150	<100	≥100	All	All
Min. Luminous Efficacy (lm/W)	85	105	125	90	100	100	90

2.8.3 Ballasts/Drivers

In general, electronic ballasts shall be used for road lighting for higher energy efficiency. The use of conventional magnetic ballasts shall be agreed by the Lighting Division. An electronic ballast shall be a solid-state converter capable of converting single phase mains supply of 220V ± 6% and 50Hz ± 2% to a high frequency voltage output at its rated power to suit the lamps connected. Electronic ballasts shall conform to IEC 61000-3-2, IEC 61000-3-3, BS EN 55015 and IEC 61547. Electronic ballasts used in tubular fluorescent lamps shall be manufactured and tested in compliance with IEC 61347-2-3 and IEC 60929.

The whole electronic ballast shall be housed in a single front-access enclosure with appropriate terminal blocks for easy connection of wires. Electronic ballasts shall be suitable to operate at an ambient temperature range of 0°C to 50°C and at maximum relative humidity of 95%. The electronic ballast shall go into a shutdown or lower power stand-by state when the connected lamp is failed or when overload occurs in the lamp circuit.

LED drivers shall comply with IEC 61347-1 and IEC 61347-2-13. For drivers with dimming function, they shall be capable of providing continuous dimming range of 10% to 100%. An external surge protection device capable of withstanding surges of 10kV shall be provided to the driver. The driver and the surge protector shall be housed in a separated front-access enclosure to be installed at the column door level of the lighting column.

2.8.4 Power Cables

Cables shall be of 600/1,000V grade with cross-linked polyethylene (XLPE) insulation, galvanized steel wire armored and PVC outer sheath. 2-cored cable with stranded copper conductor of 35mm² and full size neutral is generally adopted in Hong Kong Island whereas 2-cored and 4-cored cables with stranded copper conductor of 25mm² and full size neutral are generally adopted in Kowloon and New Territories. In general, the cables shall conform to BS 5467.

2.8.5 Astronomical Time Switches and Digital Photoelectric Controllers

The on/off control of lighting circuits shall be by means of an astronomical time switch and a digital photoelectric controller as a backup. The astronomical time switch shall comply with IEC 60730-1. It shall have 2-channel, an accuracy of ± 0.5 sec/day and a battery reserve for at least 5 years. The digital photoelectric controller shall be of electronic fail-safe type, and have a LCD display showing the local time, on/off settings and measured illuminance level. It shall also have a plug-in and replaceable photo sensor, and an on/off adjustable setting from 1 to 2,000lux with adjustable time delay of 0-60 seconds. Both the switch and the controller shall be suitable for use in exposed weather conditions and shall function correctly at a temperature range of -5°C to +50°C at the local supply voltage and frequency.

2.9 ELECTRICITY SUPPLY

2.9.1 Road Lighting Circuits

Road lighting shall be fed from PLCCs. For the security of road lighting circuit systems, 100% backfeed capability is mandatory for road lighting along trunk roads or above including slip roads. The same arrangement shall be adopted for other roads as far as possible. Backfeed will be needed when the power supply for a series of lights fed from one PLCC is suspended, faulted or affected and could not be

immediately restored.

2.9.2 Cable Circuits

All road lights fed from the same circuit shall be looped together by turning in and out the lighting cables and terminating them with cable glands at the base section of lighting columns. Alternative connection means, such as teeing underground lighting cables in the proximity, are unacceptable.

To maximize the number of road lights that can be supplied by one circuit, the whole length of lighting cables shall be of the same size. Reducing the cable size or the number of cable cores at any section of the circuit shall not be allowed for consistent circuit design and for circuit backfeed. The maximum number of lights to be connected to an outgoing circuit shall be determined by wattage of the lamps and voltage drop of the cables. For circuits with back-feed, a two-stage approach shall be adopted: (i) Care must be taken to ensure that the voltage of the last light during the most critical backfeed condition shall be maintained at no less than 198V, i.e. a total voltage drop of the entire circuit be no more than 22V, assuming the supply voltage is 220V. (ii) During normal operation, the minimum voltage of the last light up to the normal open (N/O) point, shall be no less than 198V by taking into account the $\pm 6\%$ voltage fluctuation as specified by the respective Power Company.

A full ducting system for protecting road lighting cables is required. For all road projects including reconstruction of carriageways/footpaths, a full ducting system comprising either UPVC ducts or GI pipes and draw pits shall be specified to facilitate future maintenance of the cables.

Whenever possible, ducts/pipes shall be laid under footpaths instead of carriageways. On footpaths or carriageways where a minimum cover of 450mm from the finished surface of the footpath and 900mm from the finished surface of the carriageway could be provided, UPVC ducts shall be used. In locations where provision of the minimum cover is not possible due to obstructions and the agreement of the respective HyD Office has been sought to waive the minimum cover requirement, GI pipes of appropriate size shall be used. The GI pipes shall comply with BS EN 10255 and be of medium grade. The UPVC ducts shall comply with BS3506 Class B, have 100mm diameter and be in purple colour of colour code number 3050-R50B of the Natural Colour System of the Swedish Standard. For ease of identification, the ducts shall be imprinted with the following bilingual cautionary wordings at regular 1m intervals of dimensions about 240mm x 50mm.

注意路燈電纜
CAUTION : ROAD LIGHTING CABLE

The Lighting Division shall be consulted at the design stage on details of the ducting system including the draw pits requirement. For a new road project, the ducting system shall be provided and installed by the Contractor. For further details of the imprinting work on the UPVC ducts, the Contractor shall contact the Lighting Division.

As regards the protection of existing road lighting cables in roads where lots of existing utilities have occupied the space underneath the pavement, the use of split UPVC cable ducts may be appropriate in these areas. Such split UPVC ducts shall also be imprinted with the above cautionary wordings for ease of recognition.

For road lights to be installed in the concrete profile barrier of carriageways, cable ducts and draw pits shall be laid and constructed in accordance with the latest version of HyD Standard Drawing No. H2106A or its latest version. For footpaths adjoining carriageways, cables shall be laid longitudinally within 1m from the road kerbs.

2.9.3 PLCCs

There are two different types of PLCCs, i.e. pole-mounted and ground-mounted PLCCs. Detailed construction of these PLCCs shall comply with the requirements as specified by the Lighting Division.

The locations of PLCCs and earth pits shall be chosen at places where they are practically accessible for maintenance and less obstructive to pedestrian flow. For the accurate operation of the photoelectric controller, the PLCCs shall not be sited in shaded areas, such as under trees and structures, in order to avoid mis-operation of the road lighting system. Wherever possible, especially at new developments, the respective Power Company shall be consulted at the early design stage for the availability of power supply.

2.9.4 Fuse and MCB

Incoming and outgoing circuits at a PLCC shall be protected by high rupturing capacity (HRC) fuses of an appropriate rating to BS EN 60269-2 and BS

88-2. Each lighting point shall be separately protected by an MCB unit to BS EN 60898-1. For double arm road lights, each lamp shall be supplied from a different circuit to avoid total loss of light in the event of fault. The rating of fuses and MCBs shall be properly designed according to circuit cable size and loading.

2.9.5 Earthing

The complete road lighting installations, including PLCCs, lighting columns, lanterns, control gear, conduits, cables fittings and other exposed conductive parts, shall be effectively earthed to the ground by means of copper conductors of appropriate sizes and shall comply with the recommendations contained in the CoP. The results of the earth fault loop impedance test for each road light and PLCC shall be submitted to the Lighting Division for acceptance.

A separate earthing system shall be provided at each PLCC. Earth electrodes of 16mm diameter copper bonded steel core rods shall be used. The electrode shall be driven into the ground and connected to a sufficiently sized copper earth terminal inside the PLCC. It may require more earth electrodes connected in parallel to achieve the required earth fault loop impedance value. The earthing of each outgoing circuit shall be bonded to the main earth terminal of the PLCC. The main earth terminal shall then be bonded to the exposed conductive parts of the electricity supplier's incoming cable such as metallic cable endbox, metallic cable glands, cable armour or metallic sheath according to Code 12B of the CoP.

In locations such as villages or remote areas where pole-mounted PLCCs are installed, the earth fault loop impedance for these PLCCs shall have a value less than 1.76Ω for a current of 32A as specified in Table 11(11) of the CoP. The use of RCD to achieve earth fault protection for lighting circuits shall be avoided as far as possible as its mis-operation will result in total shut down of road lighting and affects road safety. Lighting designers shall consider using other methods of earthing such as additional earth rods or earth mesh. If the use of RCD is inevitable, special approval shall be obtained from the Lighting Division.

3. GANTRY AND DIRECTIONAL SIGN LIGHTING

3.1 GENERAL

TPDM Volume 3 Clause 3.2.5.4 stipulates that all gantry signs, and all roadside advance and final advance directional signs on trunk roads, expressways, primary distributor roads and rural roads must be directly illuminated by their own source of illumination.

3.2 DESIGN STANDARDS

The lighting for gantry and directional signs adopts the illuminance concept as described in BS EN 12899-1. Lighting designers shall follow the lighting level and uniformity (minimum to maximum illuminance) requirements for sign faces as shown in Table 3-1 and Table 3-2 respectively:

Table 3-1 Lighting Level for Gantry and Directional Sign

Sign Location	Required Mean Illuminance of Sign Face (lux)
Rural Areas	$100 \leq E < 200$
Urban Areas	$250 \leq E < 400$

Table 3-2 Uniformity for Gantry and Directional Signs of Different Dimensions

Sign Size	Min. Uniformity of Illuminance*
For signs with an area not exceeding 1.5m^2	0.35
For signs with an area exceeding 1.5m^2 and with a height to width ratio not exceeding 2:5	0.15
For signs with an area exceeding 1.5m^2 and with a height to width ratio greater than 2:5	0.10

Remarks * : Uniformity Ratio is the ratio of the minimum illuminance to maximum illuminance

The lighting level for a sign face is related to the ambient brightness. If the ambient environment is bright, a higher lighting level within the range limits shall be adopted. Computer simulation shall be carried out for selection and arrangement of luminaires. Lighting designer shall submit the simulation results to the Lighting Division for approval before selection of luminaires.

3.3 LANTERN ARRANGEMENT

3.3.1 Luminaires

LED linear washers at a correlated colour temperature of 4,000K shall be for gantry and directional sign lighting. Lanterns shall be of sound and robust construction to the current edition of BS EN 60598. Lanterns and the integral control gear shall have a minimum environmental protection class not less than IP65 in accordance with BS EN 60529.

The gantry and directional sign lanterns shall be protected by a MCB and an external 10kV surge protector housed inside a stainless steel enclosure to IP55 rating. Separate circuit protective conductors shall be installed in accordance with the CoP. The lanterns should be adjusted on site in respect of the tilting angles, position etc. in order to provide optimum illuminance and uniformity for the gantry and directional signs.

3.3.2 Lantern Arrangement for Directional Signs

Lantern arrangements shall take into account the long-term operation, maintenance, energy consumption, feasibility for installation, and the practical needs of motorists and pedestrians and shall not induce glare effect to road users.

Lanterns for directional signs are usually top-mounted with normally 1.5m bracket arm projection. For signs with height higher than 4m, additional bottom-mounted lanterns may be required to illuminate the lower part of these signs subject to computer simulation results. However, to avoid collision by pedestrians or cyclists, care shall be taken to allow adequate clearance when they are installed over a footpath. In such case, the sign plate, the bracket arm and all parts of the lighting installations shall have a minimum vertical clearance of 2.5m above the footpath. In the event that the combination of top and bottom-mounted arrangement is not feasible, single top-mounting shall be adopted.

3.3.3 Lantern Arrangement for Gantry Signs

If catwalk is available, the linear washer lights shall be bottom-mounted evenly along the catwalk. For gantry signs with supplementary sign faces or total height higher than 4m, the designer may consider to provide additional top-mounted lanterns. For those without catwalk, top-mounted approach shall be adopted similar to the arrangement of directional signs.

3.4 MODE OF OPERATION

Gantry and directional sign lighting shall be connected to a nearby road lighting circuit. However, if a gantry sign or directional sign is located inside a tunnel or underpass where the ambient lighting cannot cope with the lighting requirements, the lighting shall be switched on round-the-clock.

3.5 MOUNTING DETAILS

The mounting details of the directional sign lights and gantry sign lights shall be in accordance with the Lighting Division's Standard Drawings, and relevant HyD Standard Drawings together with all current amendments. The Contractor shall prepare working drawings and schematic wiring diagrams indicating the size of the conduit, cable run, layout/arrangement of the installation, circuitry, earthing, bonding/supplementary bonding arrangement etc., and submit to the Lighting Division for approval before commencing works.

All wiring shall be laid in a continuous trunking system or conduit system. Wiring conduits shall not be used as supports for luminaires. The Lighting Division shall be invited to inspect and be satisfied with the installation before the system is handed over for maintenance.

Conduits shall not be used as circuit protective conductors and separate cables shall be provided for all circuits. The cable route shall be as simple as possible, e.g. in straight runs and avoids unnecessary bends and changes of direction. Junction boxes shall be inserted at every change of direction to facilitate access to all sections of the system.

4. TUNNEL LIGHTING

4.1 GENERAL

Tunnel lighting systems are installed for covered vehicular structures such as road tunnels, underpasses and underdecks. Their objectives are to enable motorists to drive at the same speed and enjoy the same degree of safety and visual comfort as on the approach roads.

The main feature of a tunnel lighting system is the provision of multiple-stage lighting at the entrance and exit of the tunnel during daytime to enhance motorists' adaptation. Provided that the tunnel is of sufficient length, the lighting level within the tunnel interior zone can be kept at a constant level after the adaptation through the threshold zone and transition zone.

With the advancement of lighting control and dimming technology, it is recommended that a single group of lighting installations shall be used to provide multiple stages of lighting level.

4.2 SHORT TUNNEL LIGHTING

A tunnel, underpass or underdeck less than 200m in length is considered as short. Those less than 25m long do not require daytime lighting. Nighttime lighting shall be switched on when the ambient lighting level falls below 1,000lux. The nighttime lighting level requirement is shown in Table 4-2.

If the length of a tunnel is between 25m and 200m, there are three scenarios for providing lighting to its interior as depicted in Chart 4-1, (i) no daytime lighting for the simplest situation, (ii) limited daytime lighting for the medium situation, and (iii) 50% normal threshold zone lighting requirement for most stringent situation. The lighting requirements are shown in Table 4-2.

The above daytime lighting shall be switched to nighttime lighting when the ambient lighting level drops below 1,000lux. The nighttime lighting level requirement is shown in Table 4-2.

Chart 4-1 Daytime Lighting Arrangement for Short Tunnels/Underpasses/Underdecks

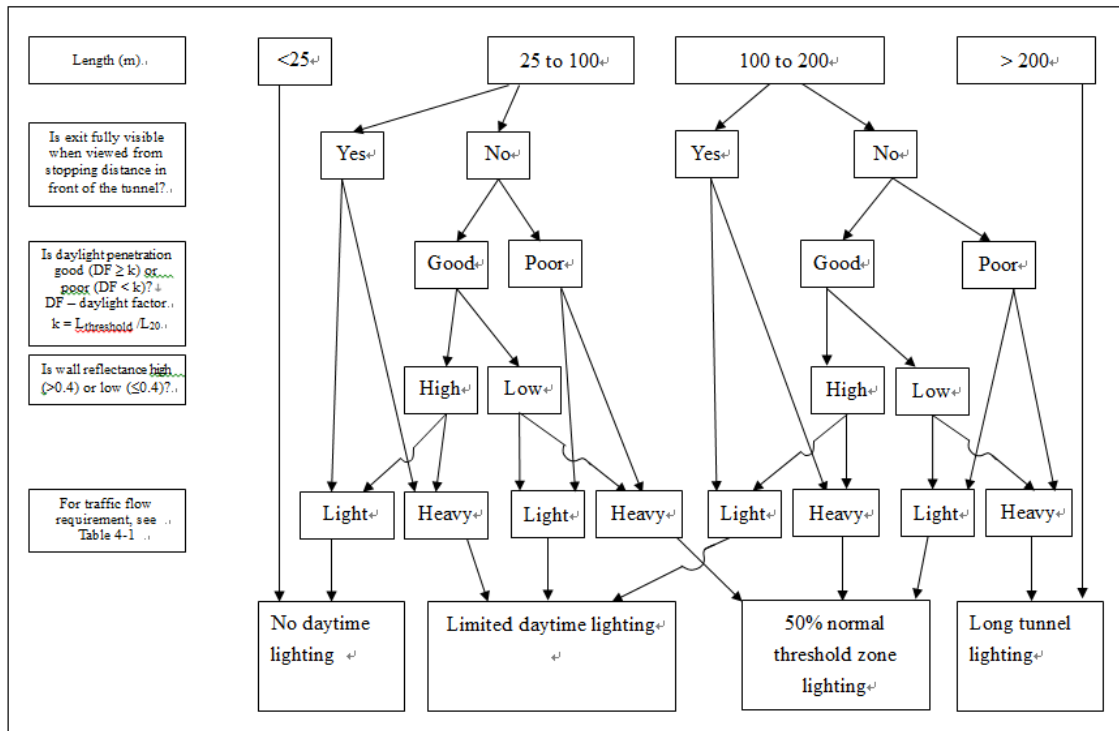


Table 4-1 Traffic Flow Requirement

Traffic Flow	One-way*	Two-way*
Heavy	> 1,500	> 400
Light	≤ 1,500	≤ 400

* No. of vehicles per hour per lane during peak hour

Table 4-2 Lighting Requirements for Short Tunnels/Underpasses/Underdecks

Lighting Requirement	Maintained Average Luminance (L_{av}) for Daytime (cd/m^2)
Limited daytime lighting	$L_{av} = 15$
50% normal threshold zone lighting	$L_{av} = 0.5 \times \text{normal threshold zone lighting}$ where normal threshold zone lighting = k value \times access zone luminance L_{20} (details refer to Clause 4.3.2)
Nighttime lighting	$L_{av} = 2 \text{ to } 3$

For 50% normal threshold zone lighting, as the access zone luminance is changing throughout the day, electronic lighting control shall be applied to adjust the L_{av} continuously according to the access zone luminance until the nighttime lighting is on. If the reduction of daytime lighting level is effected in stages using traditional circuit control, the luminance ratio between each successive stage shall not exceed 5:1 and the maximum number of stages is 4.

4.3 DESIGN STANDARDS FOR LONG TUNNEL LIGHTING

The design principle for long tunnel lighting basically follows BS 5489 Part 2 and CIE 88 with some adjustments to suit local situations. The below paragraphs describe the requirements for local tunnel lighting design.

4.3.1 Stopping Sight Distance

The stopping sight distance (SSD) is the forward distance required by a driver, driving at a designated speed, to bring a vehicle to a complete standstill safely. It covers the distance for perception, reaction and breaking.

The SSD is relative to the designated speed of the tunnel as shown in Table 4-3. There are circumstances where extra demands are placed upon the motorists' perception as they drive near the tunnel entrance, such as:

- (a) There are road junctions near or within the access or threshold zones, giving rise to lane merging or speed changing; and
- (b) The traffic is mixed.

Under these circumstances, the k value corresponding to the next higher SSD and designated speed, as specified in Table 4-3, shall be adopted to increase the tunnel lighting level.

Table 4-3 Stopping Sight Distances for Various Designated Speeds

Designated Speed (km/h)	50	60	70	80	100	120
Stopping Sight Distance (m)	50	70	90	120	160	215

4.3.2 Daytime Lighting

Adequate daytime lighting is essential to enable motorists passing through the passage comfortably and safely, and to ensure a smooth flow of traffic. In designing tunnel lighting systems, it is necessary to consider the lighting requirements for the following five lighting zones:

(a) Access Zone

The access zone is the part of the road leading to the tunnel entrance, covering the distance over which a driver should be able to see clearly into the tunnel. It begins at the SSD ahead of the entrance. The access zone luminance L_{20} shall be evaluated with the aid of perspective drawings/sketches of the tunnel entrance surroundings as seen at the SSD and by the expression:

$$L_{20} = aL_s + bL_R + cL_E + dL_{th}$$

or
$$L_{20} = (aL_s + bL_R + cL_E) / (1 - dk)$$

where L_s = sky luminance , a = % of sky

L_R = road luminance , b = % of road

L_E = surrounding luminance , c = % of surroundings

L_{th} = first half of threshold zone luminance , d = % of tunnel entrance

$$k = L_{th}/L_{20}$$

with $a + b + c + d = 1$

Site investigations have to be conducted to obtain the highest values of L_s , L_R and L_E occurring with sufficient frequency during the design stage.

(b) Threshold Zone

The threshold zone is the first stretch of the tunnel. Its length is equal to the SSD corresponding to the designated speed.

To enable the tunnel entrance not to appear as a dark hole, the lighting level in the threshold zone must be boosted to an extent that the motorists being at the SSD from the portal can see clearly into the tunnel.

The required maintained average road surface luminance over the first half of the threshold zone is denoted as L_{th} and $L_{th} = kL_{20}$. For symmetrical lighting systems, the values of k for various designated speeds are given in Table 4-4. The lighting level for the other half of the threshold zone may gradually and linearly decrease to $0.4L_{th}$ at the end of the threshold zone by means of electronic dimming controls. If the reduction is effected in steps, the luminance ratio between successive steps shall not exceed 3:1 and the lighting level shall not fall below the luminance reduction curve as illustrated in Figure 2 of BS 5489-2.

Table 4-4 k Values for Different Designated Speed

Designated Speed, V (km/h)	k Value
$V \leq 60$	0.04
$60 < V \leq 80$	0.05
$80 < V \leq 100$	0.07
$V > 100$	0.10

(c) Transition Zone

Having passed through the threshold zone, the motorists become adapted to a lower luminance environment. The lighting level can be gradually reduced towards the interior zone. Similar to the above, linear reduction of lighting level is recommended. If the lighting level is reduced in steps, the luminance ratio between successive steps shall not exceed 3:1 and the lighting level shall not fall below the same luminance reduction curve. The end of the transition zone is designed to have a lighting level equal to 3 times that of the interior zone.

(d) Interior Zone

The lighting level in the interior zone shall be constant. The recommended lighting levels in this zone for various designated speeds are given in Table 4-5.

Table 4-5 Lighting Level for Interior Zone of Long Tunnels

Designated Speed, V (km/h)	Maintained Average Luminance (during daytime) (cd/m²)	Maintained Average Luminance (during nighttime) (cd/m²)	Emergency Lighting Maintained Average Illuminance (lux)
V ≤ 60	4-5	2-3	10
60 < V ≤ 80	5-6	3-4	10
V > 80	8-10	4-5	10

The length of the interior zone is determined by the length of the tunnel subtracting the total length of the other zones covered by the tunnel.

(e) Exit Zone

Exit zone lighting shall be provided to assist egress adaptation and enable motorists to view the following traffic by rear view mirrors. The lighting level in this zone increases linearly over a length equal to the SSD (before the exit portal), from the level of the interior zone to a level equal to 5 times that of the interior zone at a distance of 60m before the exit portal.

4.3.3 Nighttime Lighting

Nighttime lighting is usually achieved by the operation of continuous rows of fluorescent/LED lamps over the whole length of the tunnel. Consideration may be given to the use of electronic control gear to dim the tubes to the required lighting levels. The recommended nighttime lighting requirements for various designated speeds for long tunnels, as well as the emergency lighting requirements for long tunnels are given in Table 4-5.

Where daylight screens are installed, the nighttime lighting system shall be extended to the area covered by the daylight screens, while the threshold zone length can be reduced by this length as daylight is sufficient as replacement of artificial lighting.

4.3.4 Luminance of Walls

The walls in a tunnel form an important background in revealing objects. Walls lined with high reflectance materials give more inter-reflected lights. The average luminance of the tunnel walls up to a height of 2m plus the road surface shall be treated as the background so that reduced lighting and energy can be achieved by using light-coloured wall panels.

In all circumstances, the average luminance of the tunnel walls up to a height of 2m shall not be less than that of the road surface for all zones and all lighting stages.

4.3.5 Uniformity

Uniformity shall be considered as it affects visual comfort and road safety. An overall uniformity, which is the ratio of minimum to average luminance over a defined area, of 0.4 on the road surface and on the walls up to a height of 2m in clean conditions for all zones and all lighting stages shall be achieved. A longitudinal uniformity, which is the ratio of minimum to maximum luminance along a longitudinal line through the observer position, of 0.6 on the road surface along the centre of each lane for all zones and all lighting stages shall be achieved.

4.3.6 Glare Control and Avoidance of Flicker

4.3.6.1 Glare Control

Glare must be minimized as it reduces visibility. TI is used as a measure of disability glare and it shall be less than 15% for all zones and all lighting stages except the exit zone during daytime. TI is calculated by the following expression:

$$TI = 65 L_v / (L/MF)^{0.8} \quad \text{for } L \leq 5 \text{ cd/m}^2$$

or
$$TI = 95 L_v / (L/MF)^{1.05} \quad \text{for } L > 5 \text{ cd/m}^2$$

where L_v = veiling luminance created by all luminaires

L = maintained average luminance of the road surface and walls forming the background

MF = maintenance factor

4.3.6.2 Avoidance of Flicker

Flicker effects may be created by discontinuous rows of luminaires or by daylight screens, causing visual discomfort to motorists. Critical flicker frequencies between 2.5Hz and 15Hz shall be avoided as they may disturb the tunnel users.

The flicker effect is negligible if the distance between two adjacent luminaires in a luminaire row is less than half of the flashed length of the luminaire. Flicker frequency (Hz) is calculated by dividing the speed (m/s) by the luminaire spacing (m).

4.4 EMERGENCY LIGHTING

Emergency lighting is required in long tunnels to allow for evacuation during power failure. The essential power shall be fed by UPS system(s) which shall be best connected to generator if possible. A minimum maintained road surface luminance as shown in Table 4-5 shall be provided for at least 30 minutes for the whole tunnel during daytime and nighttime.

4.5 BI-DIRECTIONAL TRAFFIC

For maintenance purpose, sometimes tunnels are operated in a bi-directional mode. Under this circumstance, the driving speed of vehicles in both traffic directions within the same tube is normally reduced. However, tunnel lighting shall not be lowered at the reduced speed for both traffic directions taking into account the disability glare of vehicles' headlights as well as the collision hazard from oncoming traffic.

4.6 POWER SUPPLIES AND DISTRIBUTION CABLES

Electricity consumption for each tunnel shall be separately metered. The power supply for long tunnels shall be taken from two independent power sources, each of them feeds about half of the lighting load. In the event of failure of one of the power sources, the remaining one shall be able to feed the whole lighting load through switching. Both manual and automatic switching modes shall be provided.

All distribution cables shall be of low smoke halogen-free type with copper conductors, and properly protected against fire and mechanical damage.

4.7 OTHER DESIGN PARAMETERS AND CRITERIA

Other design parameters and criteria are given in Table 4-6.

Table 4-6 Tunnel Lighting Design Parameters and Criteria

Item Description	Parameters and Criteria
Maintenance factor	0.85 (0.8 for LED luminaire)
Average luminance coefficient of standard class C2 asphalt road surface (Qo)	0.07
Overall uniformity on road surface and walls up to 2m height	0.4 minimum
Longitudinal uniformity along centre of each lane	0.6 minimum
Glare (TI)	less than 15%
Maximum reduction of luminance between successive steps in lighting zones	3:1

4.8 LIGHTING CONTROL SYSTEM

4.8.1 General

The access zone luminance varies with outdoor lighting conditions. For effective energy management, it is necessary to adjust automatically the lighting level inside the tunnel in accordance with the variation of the access zone luminance. Electronic dimming control is recommended for linear control of the threshold zone lighting. If the switching of lighting is controlled in stages by means of circuit control, at least 6 lighting stages shall be provided for long tunnels. The preferred reduction of luminance between successive stages is not more than 3:1 albeit 5:1 is also acceptable.

Tunnel lighting systems shall be controlled by means of a system comprising luminance meters, microprocessor-based dual controllers, and associated control and indicating accessories. For manned tunnels, additional facilities shall be provided as detailed in TPDM, Volume 11, Chapter 6 – “Lighting”. In general, the use of adjustable digital photoelectric controllers in lieu of luminance meters is accepted for short tunnels less than 200m long. The adjustable digital photoelectric controller shall be of electronic fail-safe type, with an on/off adjustable setting from 1 to 30,000lux and a time delay of 0-59 minutes.

4.8.2 Luminance Meters

The variation of access zone luminance should normally be measured by luminance meters having an angular field of view of 20°. The meters shall be placed at the SSD from the tunnel portal and mounted at a clear height of not less than 5m to avoid vandalism and pollution.

The housing of the measuring device shall be adjustable to give the required angular field of view and be made of extruded aluminum or stainless steel with an IP rating not less than 55. For more accurate measurement results, the meters shall be equipped with a heating control system to ensure absence of moisture. They shall be able to operate at a temperature range from –5°C to 50°C.

A luminance meter shall also be installed inside a manned tunnel to monitor the road surface luminance in each of the first half of the threshold zone, for both unidirectional and bi-directional traffic.

4.8.3 Tunnel Lighting Control Panel

A tunnel lighting control panel shall normally be installed inside a control room, for the operation of the tunnel lighting system. The power supply for the control console shall be fed by a UPS system with at least 60 minutes battery backup. The UPS system shall be connected to a generator if it is available in the tunnel.

The console shall be made of stainless steel and be equipped with:

- (a) key-operated selector switches for selecting remote manual operation mode or automatic operation mode;
- (b) push-buttons for the manual operation of each lighting stage; and

- (c) key-operated selector switches for unidirectional or bi-directional traffic operation.

4.8.4 Control and Indication Units

A microprocessor-based dual controller shall be installed for controlling the lighting level based on the signals detected by the luminance meters. The dual controller shall be configured in hot-standby mode. In case one controller fails, the other shall be able to take up the entire functions of the former immediately without affecting the operation of the lighting system. In association with other control and indication units, the controller shall be able to perform the functions stipulated below:

(a) Control Function

- (1) Under the automatic operation mode, the appropriate lighting stages are automatically selected based on the signals detected by the luminance meters.
- (2) Under the remote manual operation mode, the lighting stage selection made by the controller will be overridden by pressing the manual push-button.
- (3) Under the local manual operation mode, the individual lighting stages can be controlled through their respective local control panels to facilitate maintenance. Each local panel shall be equipped with a control to override the remote control in main panel, and vice versa. The local panels shall only be activated by means of key-operated selector switches.
- (4) Prior to changing from remote/local manual operation mode to automatic operation mode, the manually selected lighting stage must be changed to coincide with the stage selected by the controller.
- (5) Provision of a delay timer adjustable from 0 to 30 minutes for switching of lighting stages.
- (6) In case of failure of the duty luminance meter, the readings from the standby luminance meter shall automatically be used for taking over the lighting level control.
- (7) Where no standby luminance meter is installed or the luminance meter system is completely failed, the controller will automatically switch over to a preset lighting level.

- (8) For fluorescent luminaires without light regulating ballasts, suitable facilities shall be provided to exchange the operation of the tubes every 24 hours in order to balance the lamp life.

(b) Indication Function

- (1) Digital indication of real time access zone luminance and first threshold zone luminance measured by the luminance meters.
- (2) Lamp indicators with lamp test facilities to indicate the activated stages and the statuses of all lighting circuits.
- (3) Lamp indicators with lamp test facilities to indicate the selected control mode (remote manual, local manual or automatic) and traffic operation mode (unidirectional or bi-directional).
- (4) Alarm indications for faulty luminance meters and mismatch of activated contactors against the selected lighting stage.

(c) Data Storage and Retrieval

Suitable facilities shall be provided for data storage at regular intervals and subsequent online retrieval and report generation of the following information for a period of at least two months:

- (1) lighting stages at each tunnel portal.
- (2) luminance readings at each tunnel portal and at each first threshold zone.
- (3) alarms with date and time stamps.

(d) Additional Facilities for Manned Tunnels

For manned tunnels, the status of all lighting circuits shall be showed on a display panel which is normally shared with other services for remote manual control and indications. All the field status signals including luminance meter readings, lighting stages, control mode, traffic mode shall be monitored by CMCS. Other additional facilities be provided shall refer to TPDM, Volume 11, Chapter 6 – “Lighting”.

4.9 LUMINAIRES

4.9.1 General

- (a) Generally, LED or fluorescent luminaires of a correlated colour temperature of 4,000K in a continuous row shall be used for interior zone and nighttime lighting whereas SON or high power LED luminaires shall be used for reinforcement lighting in threshold, transition and exit zones.
- (b) Luminaires shall have symmetrical lighting distribution in the axial plane. Unless approval has been given by the Lighting Division for a particular lighting scheme, counter-beam lighting systems shall not be adopted.
- (c) Luminaires shall be specifically designed for use in vehicular tunnels. They shall comply with BS EN 60598-1 with an IP rating not less than 65 as stated in BS EN 60529. LED luminaires shall also comply with IEC 62471 hazard class Group 1 or Exempt Group.
- (d) LED luminaires shall be designed to operate at an ambient temperature of at least 50°C. They shall have a minimum of 50,000 hours of lifetime at 70% lumen maintenance.
- (e) Luminaire bodies shall be made of extruded aluminum alloy with a minimum thickness of 2.5mm. They shall be fitted with anodized high purity aluminum reflectors.
- (f) The front panels shall be glazed with high thermal resistant toughened glass with a minimum thickness of 5mm. They shall be capable of being opened without using any tools and being suspended from the luminaires in an open position to facilitate maintenance.
- (g) Control gear shall be of electronic type and shall be mounted on removable gear trays, which are made of heavy aluminum alloy and fitted with a plug and socket. It shall be suitable for continuous operation.

- (h) The internal wiring of the luminaires shall be of heat resistant cables sheathed with low smoke halogen-free materials.
- (i) Luminaires shall be provided with radio interference suppression complying with BS EN 55015.
- (j) External power factor correction and harmonic filter shall not be required to bring the power factor and harmonic current distortion respectively, in order to satisfy with Power Companies' requirements.
- (k) Luminaires shall be connected to alternate electrical circuits to maintain partial lighting in an area in the event of failure occurring on one circuit.
- (l) Electronic ballasts shall conform to IEC 61000-3-2, BS EN 55015 and IEC 61547. Electronic ballasts used for tubular fluorescent lamps shall be manufactured and tested in compliance with IEC 61347-2-3 and IEC 60929.
- (m) The LED driver shall comply with IEC 61347-1, IEC 61347-2-13, IEC 62384, IEC 61000-3-2, IEC 61547 and BS EN 55015 together with all current amendments.
- (n) A fuse or MCB unit shall be fitted in the gear tray for each lamp.

4.10 ENERGY MANAGEMENT

Apart from achieving the required lighting levels for the tunnel interior, it is also important that the lighting efficiency is optimized and running costs are minimized. The following points need to be considered in order to reduce energy consumption:

- (a) **Daylight Contribution**
If a tunnel is installed with glazed panels or its geometry admits large amount of daylight, the daylight contribution shall be taken into account.

(b) Reduction of Access Zone Luminance

The required threshold zone luminance could be reduced by minimizing the access zone luminance. This can be achieved by constructing a darker tunnel entry portal facade such as hydro-seeding or grassing. If there is a noise enclosure or landscape deck at the access zone, an appropriate level of daylight penetration (i.e. daylight factor is equal to the k value and the length is equal to 0.5SSD) can help to reduce the threshold zone lighting. Daylight screens may be constructed at the tunnel entrances to create an artificial access zone in order to save energy. The screens, erected immediately outside the entrances, reduce the amount of daylight reaching the road according to the daylight incident upon them. However, they must be carefully designed to avoid flicker problems. Daylight screens, noise enclosures or landscape decks, if properly designed with a suitable daylight factor, are considered as part of the tunnel.

(c) Lighting Control Stages

The access zone luminance varies throughout the day and the year. Ideally, the first half of threshold zone luminance L_{th} should be a constant percentage of the access zone luminance. With the advancement of lighting control technology, continuous monitoring of access zone luminance for linear control of transition zone luminance is recommended.

4.11 LIGHTING DESIGN SUBMISSION

All lighting designs must be submitted to the Lighting Division and the Maintenance Agent who will comment on the maintenance aspects, for approval at an early stage. The submission shall include the following technical information:

- (a) Lighting layout together with relevant cross-sectional drawings;
- (b) Circuit diagrams and electrical schematic wiring diagrams;
- (c) Particular specification and description on the lighting scheme;
- (d) Design parameters and criteria; and
- (e) Calculations/preparations of:
 - (1) Length of each lighting zone;
 - (2) Access zone luminance using perspective drawings/sketches

- taking into account the site conditions;
- (3) Maintained average luminance on the road surface and tunnel walls up to 2m high for all zones and all lighting stages;
 - (4) Overall uniformity and longitudinal uniformity on the road surface for all zones and all lighting stages;
 - (5) Glare control for all zones and all lighting stages, except exit zone during daytime;
 - (6) Avoidance of flicker for all zones and all lighting stages;
 - (7) Luminance settings of each lighting stage;
 - (8) Emergency lighting;
 - (9) Luminance diagrams showing the highest lighting levels in each lighting zone; and
 - (10) Lighting schedule summarizing the luminance level, overall uniformity, longitudinal uniformity and glare for all zones and all lighting stages.

Computer simulations shall also be provided for items (e)(3) to (e)(5) and (e)(8) listed above.

5. NOISE ENCLOSURE LIGHTING

5.1 GENERAL

Lighting for noise enclosures has a close resemblance to tunnel lighting. Their approaches to lighting design are very similar but the design procedures are different. The difference mainly attributes to the roof and sidewall glazing which admit skylight eliminating the requirement of artificial lighting during daytime.

Lighting designers should work closely with noise enclosure designers at an early stage to establish the form of structure with due consideration to the daylight contribution into the enclosure with a view to eliminating daytime lighting requirement. Consideration shall also be given to the selection of glazing materials, spacing, sizing and location of glazing, etc. Consent from the Lighting Division shall be obtained to the design of the noise enclosure if artificial daytime lighting cannot be avoided.

5.2 UNIFORMITY, GLARE AND FLICKER EFFECTS OF DAYLIGHT PENETRATION

Skylights are best to be uniformly distributed in a more or less horizontally and longitudinally way on the roof or ceiling of a noise enclosure. They collect light from the whole sky vault, whereas vertical wall openings, which are also referred to as “windows”, can use only up to 50% of light from the sky. This means that windows need to be at least twice the area of skylights to provide a comparable level of lighting to the inside of the enclosure. Windows can never offer the necessary uniformity and illumination for the central lanes as compared to skylights. Hence, skylights are the best type of openings for admitting daylight. Adequate uniformity of lighting should be striven for to avoid glare and flicker effects, which reduce the ability of motorists to observe road conditions in a noise enclosure.

The use of diffuse glazing materials ensures a uniform illumination on road surfaces and avoids hard shadows of opaque elements from the enclosure structure especially during bright clear days. Diffused translucent glazing panels for skylight openings shall be adopted for the daylight design of noise enclosures to avoid shadows. Coloured glazing materials should be avoided as far as possible.

5.3 DETAILED DESIGN FOR NOISE ENCLOSURE LIGHTING

The first step in the design is to evaluate whether a noise enclosure receives sufficient daylight. If daylight penetrating from both ends or side windows of the enclosure can provide sufficient lighting level for safe operation, the lighting design shall follow general road lighting as stipulated in Chapter 2 of this Manual.

The evaluation is based on the value of the daylight factor. If the daylight factor is greater than or equal to the k value in Table 4-4, the noise enclosure has sufficient daylight and general road lighting design shall be applied. However, if the daylight factor is below the k value, the lighting design of the noise enclosure shall follow tunnel lighting requirements as stipulated in Chapter 4 of this Manual.

Daylight factor can be obtained by either computer calculations using software pre-approved by the Lighting Division or the following formula:

$$\left(S_f \times \frac{A_s}{A_r} \times T_s \times MF_s \right) + \left\{ (A_{pWL} \times D_L + A_{pWR} \times D_R) \times (A_{en})^{-1} \times T_{pw} \times MF_w \right\}$$

- where
- Sf = Sky factor (see Table 5-1)
 - As = Area of skylights
 - Ap_{WL} = Area of left sidewall noise panels
 - Ap_{WR} = Area of right sidewall noise panels
 - Ar = Area of roof
 - A_{en} = Area of noise enclosure (roof + sidewalls)
 - T_s = Skylight transmittance
 - T_{pw} = Wall panel transmittance
 - D_L = Shade factor for left side window
 - D_R = Shade factor for right side window
 - MF_s = Maintenance factors of skylight (see Table 5-2)
 - MF_w = Maintenance factors of wall panel (see Table 5-2)
- } including frame factor

Table 5-1 Sky Factor (Sf) for Noise Enclosure Lighting

width(m) height(m)	1 skylight						2 skylights					3 skylights		
	7	8	9	10	11	12	13	14	15	16	18	20	22	24
6	0.48	0.52	0.56	0.60	0.62	0.65	0.60	0.62	0.64	0.65	0.68	0.68	0.70	0.71
7	0.44	0.48	0.52	0.56	0.59	0.61	0.57	0.59	0.61	0.63	0.66	0.66	0.68	0.69
8	0.40	0.44	0.48	0.52	0.55	0.58	0.54	0.56	0.58	0.60	0.63	0.64	0.66	0.67

Table 5-2 Maintenance Factor for Dirt on Glazing of Noise Enclosure

Scenario	Vertical Glazing	Sloping Glazing	Horizontal Glazing
Noise Enclosures Located in Rural Areas	0.9	0.8	0.7
Noise Enclosures Located in Urban Areas	0.7	0.6	0.5
Very Dirty Noise Enclosures (Assuming No Cleaning Operation)	0.6	0.5	0.4

Shade factor (D) which is normally assumed to be 0.5 for side window where there is no obstruction. When there is a continuous row of high rise buildings in close proximity to the side panels/openings of the noise enclosure, values in Table 5-3 shall be applied. Caution should be taken to add two shade factors on both sides of the enclosure when applying the formula above.

Table 5-3 Shade Factor (D) for Noise Enclosure Lighting

D ρ	γ										
	10°	20°	30°	35°	40°	45°	50°	60°	70°	80°	
0.0	0.49	0.46	0.41	0.38	0.34	0.29	0.25	0.15	0.07	0.02	
0.2	0.49	0.46	0.42	0.39	0.36	0.32	0.28	0.21	0.14	0.09	
0.4	0.495	0.46	0.44	0.41	0.39	0.35	0.32	0.26	0.20	0.16	

The above formula works well when the width to height ratio of the noise enclosure configuration is up to 3. For width to height ratio greater than 3, the factor 2/3 can safely be used as the sky factor (Sf) in the formula above.

Where γ is the angle of elevation of the obstruction (see illustration on Figure 1)
 ρ is the average reflectance of the obstruction

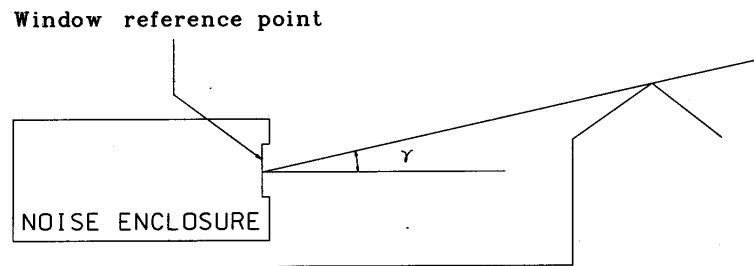


Figure 1. Angle of obstruction to noise enclosure

In case the calculated daylight factor greater than the k value is established, a general road lighting system shall be adopted.

5.4 DAYTIME LIGHTING

Daytime lighting is only required when the need for tunnel lighting is identified as referred to Clause 4.2 and where the provision of glazing panels cannot provide sufficient daylight equal to or exceeding the k value as stated in Clause 5.3.

The lighting design shall follow the same principles of tunnel lighting as stated in Chapter 4 taking into account the daylight contribution into the structures. The amount of daytime lighting shall be the deficiency of that provided by skylights.

5.5 EMERGENCY LIGHTING

Emergency lighting is not required if the daylight factor is greater than the k value or the enclosure length is less than 200m. Provision of emergency lighting for noise enclosures shall be subject to the agreement of the Lighting Division. Where required, the essential power shall be fed by UPS systems. A minimum maintained road surface luminance as shown in Table 4-5 shall be provided for at least 30 minutes.

5.6 LIGHTING DESIGN SUBMISSION

All lighting designs shall be submitted to the Lighting Division and the Maintenance Agent who will comment on the maintenance aspects, for approval at an early stage.

The submission shall include the following technical information:

- (a) Technical information, where applicable, required for tunnel lighting design submission as mentioned in Chapter 4. Calculations for luminance and uniformity on walls up to 2m are not required if the lower parts of the walls do not act as a background for traffic;
- (b) Calculations for eliminating the need for daytime lighting;
- (c) Drawings showing the sizes and positions of the glazing on walls and ceilings; and
- (d) Calculations for avoidance of flicker effect.

6. LIGHTING FOR COVERED PUBLIC TRANSPORT INTERCHANGES

6.1 GENERAL

Covered public transport interchanges (PTIs) are one of the conflict areas as there is a high mixture of pedestrians and motorized traffic. Proper lighting is essential to ensure the safety of all users. As the layout of a covered PTI is usually complex, area lighting concept is normally adopted.

For lighting installations at covered PTIs to be handed over to HyD, Developer/Project Office/Consultant shall, before inviting tenders for the construction works, ensure that approval from the Lighting Division on the lighting design, power circuitry and proposed material, etc., has been obtained.

6.2 DESIGN STANDARDS

The lighting requirements for covered PTIs are as follows:-

Table 6-1 Lighting Requirements for Covered PTIs

Location of Covered PTI	Maintained Average Illuminance (lux)	Uniformity (Min. to Average)
Connected to railway stations or complexes with high pedestrian flow	150	0.4
Others	120	0.4

A maintenance factor of 0.85 (0.8 for LED) and an initial lumen of 100 hours of the lamp output shall be used in all design calculations.

For those covered PTIs where the operation is suspended after midnight, the lighting installations shall be able to be switched to a “rest mode”. Under this mode, the number of operating luminaires can be reduced to 1/3 of the normal level between 0100 hours and 0600 hours by means of circuitry control with timer switches or bypass switches. The operation time of the “rest mode” may be altered to suit operational needs of different PTIs.

Luminaires at the perimeter of the PTI where daylight is available shall be switched off during daytime by means of adjustable digital photoelectric controllers, which shall be of electronic fail-safe type, with an on/off adjustable setting from 10 to 1000lux and a time delay of 0-60 seconds.

The lighting design shall also take into account the effect of light wells, if any. In such case, an adjustable digital photoelectric controller shall be provided to switch off the lights underneath the light wells during a bright clear day.

6.3 EMERGENCY LIGHTING

The provision of the above public lighting installations is for normal operation of a covered PTI. If essential power supply is available, it is recommended that all luminaires to be operated under the “rest mode” shall be connected to the essential circuit so that the operation of the lighting system can be maintained during power supply failure.

For covered PTIs where a lighting system for emergency evacuation is required by relevant authorities, a separated and non-maintained type lighting system shall be provided according to the requirements of the Fire Services Department. The power supply for this type of lighting system shall be connected to a separate power supply circuit serving the fire service installations (FSI).

6.4 LUMINAIRES

Highbay luminaires shall normally be applied for covered PTIs with headroom more than 5.5m. For better colour rendering, luminaires shall have a correlated colour temperature of 4,000K. Wall-mounted luminaires, if required for illuminating the footpath, shall be of low glare pass lights or bulkhead lights.

All luminaires shall comply with BS EN 60598-1 and have an IP rating not less than 65. High frequency electronic gear together with energy saving tubes shall be used for fluorescent luminaires for energy saving. The gear also gives instant lamp starting and a longer lamp life. In addition, LED luminaires shall comply with IEC 62471 hazard class Group 1 or Exempt Group, and shall be rated suitable for continuous service at an ambient temperature of 50°C. The LED luminaires shall have minimum of 50,000 hours of lifetime at 70% lumen maintenance.

To avoid blockage of lighting by tall vehicles, luminaires shall not be mounted right above carriageways. Each luminaire shall be rigidly fixed to the ceiling by means of a stainless steel rod and be attached with two endless stainless steel chains of diameter not less than 4mm. Alternative mounting methods to meet special site conditions, such as windy conditions, shall be submitted to the Lighting

Division for approval prior to installation. Wiring conduits shall not be used as supports for luminaires.

Luminaires shall be labeled with a number plate for easy identification. The numbers shall be assigned by the Lighting Division.

6.5 INSTALLATION

All wiring shall be laid in a continuous trunking system or a concealed conduit system. The Lighting Division shall be invited to inspect and be satisfied with the installation before the system is handed over for maintenance.

7. LIGHTING FOR COVERED PEDESTRIAN ROUTES

7.1 GENERAL

The main purpose of lighting for covered pedestrian routes is to provide a safe walking environment and to enhance the sense of security in an energy efficient and environmentally friendly manner. The covered pedestrian routes related to the highway structures in this Manual include subways, footbridges, elevated walkways, ground-level walkways and temporary ground-level walkways.

For pedestrian routes to be taken over by HyD, all lighting designs including illumination calculations, layouts and schematic diagrams, and material submissions shall be submitted to the Lighting Division for approval. Project Office/Consultant shall co-ordinate the design (liaising with the Bridges and Structures Division of HyD where necessary), installation and provision of electricity supply. They shall also arrange to carry out the final inspection in the presence of the Lighting Division, who shall witness the commissioning tests prior to handing-over the installation to the HyD's Maintenance Agent for maintenance.

Relevant parties responsible for structural design and maintenance should be advised that light-coloured surface finishes could greatly contribute to a pleasing and efficient lighting effect.

7.2 DESIGN STANDARDS

7.2.1 Subways

7.2.1.1 Lighting Level

The lighting requirements for subways of different barrel lengths are shown in Table 7-1:

Table 7-1 Lighting Requirements for Subways

Length of Main Barrels	Maintained Average Illumination (lux)	Uniformity (Min. to Average)
< 30m	100	0.4
≥ 30m (Not connected to public transport utilities)	150	0.4
≥ 30m (Connected to public transport utilities)	180	0.4

On covered ramps and stairs, the maintained average illuminance shall be 50lux and 100lux respectively. On uncovered ramps and stairs, the maintained average illuminance shall be 25lux and 50lux respectively. A maintenance factor of 0.85 (0.8 for LED) and an initial lumen of 100 hours of the lamp output shall be used in all design calculations.

7.2.1.2 Emergency Lighting

For subways with main barrels longer than 30m, emergency lighting systems complying with BS 5266 shall be installed. The ratio of emergency lighting fittings to the total number of lighting fittings shall be about 1:6 but must not be less than 1:8. The systems shall last for at least one hour.

7.2.1.3 Luminaires

Luminaires with LED lamps or T5 energy-saving tubular fluorescent lamps equipped with electronic ballasts with a correlated colour temperature of 4,000K shall be used. They shall be mounted on the ceiling wherever possible. However for exceptionally high ceilings (greater than 4m high) and sections of ramps/stairs which are uncovered or have ceiling configurations that may create structural problems in installing fluorescent luminaires, wall-mounted fluorescent luminaires or bulkhead luminaires with vandal-resistant prismatic polycarbonate covers and equipped with LED or compact fluorescent lamps with a correlated colour temperature of 4,000K can be used. Bulkhead luminaires shall be mounted between 2m and 3m from the floor level. Where covers are not provided and the height of the side walls is low, road lighting luminaires of 4,000K at 5 m mounting height shall be used. To prevent glare to pedestrians, wall-mounted lighting at or below eye level shall be avoided.

To maximize the lamp efficiency, luminaires should be surface-mounted or partially recessed. However, wall-mounted luminaires installed less than 2m from the floor level shall be fully recessed to avoid injury to pedestrians. To minimize glare, fluorescent luminaires shall be installed longitudinally on, or parallel to, the major axis of the subway.

7.2.1.4 Lighting Control

For subways located at grade level (e.g. under flyover) with adequate daylight contribution from both ends, the lighting in the main barrels shall be controlled by an adjustable digital photoelectric controller with an on/off adjustable setting from 10 to 1000lux and a time delay of 0-60 seconds. The photocell shall be installed at either opening of the subway.

For other subways, the main barrels shall be lit up round-the-clock. At the entrances of main barrels where daylight is adequate, consideration shall be given to the use of a digital photoelectric controller to switch off the first two luminaires during daytime and to switch them on when the ambient lighting level falls below 200lux. The controller shall be connected in parallel with an astronomical time switch as a backup and a bypass switch.

Luminaires shall be connected to alternate circuits so that partial lighting will be available in the event of a fault or fuse/MCB failure on one circuit.

7.2.2 Footbridges, Elevated Walkways and Escalators

7.2.2.1 Lighting Level

The lighting requirements for footbridges, elevated walkways and escalators at different locations are shown in Table 7-2:

Table 7-2 Lighting Requirements for Footbridges, Elevated Walkways and Escalators

Location	Maintained Average Illuminance (lux)	Uniformity (Min. to Average)
Rural Areas	30 – 50	0.4
Urban Areas	60 – 80	0.4

For structures with expected high pedestrian flow, the design illuminance level should approach the upper limit while lower limit shall be generally adopted under normal conditions. For lift lobbies and stairs, same lighting level shall be adopted along their main spans. For staircase of lift tower, lighting level shall be at 30lux. For long footbridges in urban areas which will have more than 100 nos. of lighting points being idle during off-peak hours, it is recommended to install a detection and dimming system to reduce the lighting level for energy saving.

For uncovered footbridges, in view of their relatively low patronage and/or environmental concerns, artificial illumination solely for the footbridge is normally not needed. In special cases where artificial illumination is warranted, the maintained average illuminance of 15lux at floor level and a minimum illuminance of 5lux for the main spans as well as its connecting ramps or stairs shall be provided. For footbridges with high lift tower (>15m), the lighting level for non-enclosed or semi-enclosed staircase shall be at 30lux.

A maintenance factor of 0.85 (0.8 for LED) and an initial lumen of 100

hours of the lamp output shall be used in all design calculations.

7.2.2.2 Luminaires

Luminaires with LED lamps or T5 energy-saving tubular fluorescent lamps equipped with electronic ballasts with a correlated colour temperature of 4,000K shall be used. In order to reduce glare to pedestrians, luminaires shall be longitudinally mounted and shall be recessed as far as possible. In special cases where the approval from the Lighting Division has been sought to mount the luminaires transversely, they have to be recessed to avoid excessive glare to the users.

Where footbridges or elevated walkways are located in prestigious areas or areas with low district brightness, luminaires with a correlated colour temperature of the luminaires 3,000K shall be used to create a warm environment. At these locations, cut-off lanterns shall be used to reduce glare to the public.

7.2.2.3 Lighting Control

The lighting shall be controlled by means of an adjustable digital photoelectric controller with an on/off adjustable setting from 10 to 1,000lux and a time delay of 0-60 seconds. The controller shall be connected in parallel with an astronomical time switch as a backup and a bypass switch. The location of the photoelectric controller shall be decided on site to prevent shading by nearby trees or structures.

Luminaires shall be connected to alternate circuits so that partial lighting will be available in the event of a fault or fuse/MCB failure on one circuit.

7.2.3 Covered Ground-Level Walkways

When a permanent cover is provided over a ground-level walkway, there may be a need to install a lighting system. Only walkways with less than 5m headroom are worthy of consideration, and the decision to provide lighting shall be based on the location, usage and the effectiveness of any extraneous road lighting. Lighting may not be required for walkways with glass/transparent rooftop and road lights nearby.

The average maintained illuminance shall be within the range of 35 to 50lux with luminaires mounted longitudinally to the walkways in order to reduce glare to pedestrians. The correlated colour temperature of the lamps shall normally be 4,000K. However, where the covered ground-level walkways are located in

prestigious areas or areas with low district brightness, fluorescent tubes with a correlated colour temperature of 3,000K shall be used to create a warm environment. At these locations, cut-off lanterns shall be used to reduce glare to the public.

A maintenance factor of 0.85 (0.8 for LED) and an initial lumen of 100 hours of the lamp output shall be used in all design calculations. The lighting control shall be the same as those for footbridge lighting.

In prestigious covered concourses and walkways, architectural light fittings shall be considered to enhance the harmony of the environment.

For temporary covered walkways associated with building development works, the lighting design is the responsibility of the Building Authority/Contractor. A temporary lighting system shall be provided for all covered walkways of the building sites and shall be maintained in good order by the developers. The average illuminance at floor level of the covered walkway shall be within the range of 35 to 50 lux.

7.3 OTHER REQUIREMENTS

7.3.1 Pillar Box

A pillar box is where the consumer supply mains and the Power Company's Supply mains terminate. Its location is therefore determined on the one hand by the most convenient access to the supply mains and, on the other hand, the most desirable position from which the system layout extends.

The pillar box houses the metering equipment, fuses, circuit breakers, power socket outlets and switchgear, etc. Earthing pit shall be built as close to the pillar box as possible.

There are two types of pillar boxes, 'Recessed Pillar Box' & 'Free Standing Pillar Box'.

(a) Recessed Pillar Boxes: This type of pillar box must be designed as an integral part of the structure and a suitable recess in an external wall shall be provided for easy access. However, there are circumstances which make it physically impossible to provide the necessary space within the structure's envelope, such as subways subject to flooding. In such cases, recessing the pillar box in alternative

locations, such as retaining walls or staircases, should be considered. If all alternative locations have been explored and are found to be impractical or undesirable, a free standing pillar box may be used as an exceptional solution to the problem.

(b) Free Standing Pillar Boxes: This type of pillar box is commonly used. Attention should be paid to the following:

- (1) Location: Once it has been decided that a free standing pillar box is the only practical way to accommodate the necessary equipment, its location must be selected so as to:
 - (i) avoid obstruction to pedestrian flow;
 - (ii) avoid obstruction to sight line of drivers and pedestrians;
 - (iii) avoid obtrusiveness in appearance; and
 - (iv) maintain free access to the pillar box.

The Power Company concerned must be consulted on the exact location of the pillar box to ensure that cable entry requirements are met and to avoid subsequent changes.

- (2) Typical Design: Details of a typical free standing weather-proof pillar box are as illustrated in HyD Standard Drawings Nos. CL1001 to CL1007. It is important to note that the bottom of the metal envelope shall be at least 150mm above the mean formation level in order to protect against flooding.
- (3) Materials: Materials used must be durable and sufficiently rigid to protect the boxes from mechanical damage. Where stainless steel is specified, the steel sheet and strip shall comply with BS EN ISO 9445-1. All incidental items such as holding down bolts and fixing screws shall be of the same stainless quality. Concrete or masonry for free-standing pillar boxes should only be considered in special circumstances such as for large-sized units.
- (4) Dimensions: The overall size of a pillar box is determined by the number of equipment items to be accommodated. Nevertheless, for free-standing units, their sizes must be kept to an absolute minimum. Reference shall always be made to HyD Standard Drawings when developing special designs.

Basically there are two sizes that suit most common applications: (i) a small unit with internal dimensions of 1200mm wide x 1500mm high x 500mm deep, used for footbridges or small subways with up to 2 pumps and a bus-bar chamber; (ii) a large unit with internal dimensions of 1800mm wide x 1500mm high x 500mm deep, used for large footbridges or medium to large subways with up to 3 pumps and a bus-bar chamber.

Each pillar box shall have half of its total internal width partitioned off for housing equipment owned by the Power Company.

As to the fixtures, fittings and finishes of the above two types of pillar boxes, reference shall be made to the standard details and drawings covering the following items:

- (a) Doors: Two swing doors shall be with opening outward from the centre of the box. Each must be capable of being operated and locked independently so as to allow separate access to the two compartments. The left hand side compartment is to house the cutouts and energy meter provided by the Power Company concerned. A perspex viewing window of 200mm x 200mm square shall be built into the door facing the energy meter to allow meter readings to be taken without unlocking the door. Each door shall consist of two suitably sized padlocks.
- (b) Equipment Panels: Each pillar box shall contain two equipment panels, one in each compartment, made of selected hardwood. For mounting necessary equipment, the finished panel thickness shall not be less than 25mm.
- (c) Ventilation Louvers: Louvers may be pressed into the body of pillar box as part of its manufacturing process or fitted in the form of independent and pressed steel panels. Openings must face downward and provide a 5-8mm clear gap per slit.

For free standing pillar boxes, two louvered panels shall be provided at the top and bottom of each end wall with overall dimensions of 200mm wide x 100mm high. For recessed pillar

boxes, two such louvers shall be provided at the centre of each door.

- (d) Seals: Suitable waterproof seals of PVC or similar material shall be provided between the concrete plinth and the steel cabinet for waterproof and anti-vibration purposes.
- (e) Cable Trenches: Cable trenches inside the pillar box shall be backfilled with sand and sealed with a 50mm layer of 3:1 Sand/Cement grout once cables are in position.
- (f) Earth Pits: Earth pits shall be located as close to the pillar box as possible and constructed in accordance with HyD Standard Drawings Nos. CL0034 to CL0036.
- (g) Surface Finishes: All stainless steel surfaces shall have no surface treatment or painting. All galvanized surfaces shall receive an etching primer, undercoat and two finishing coats in full gloss enamel paint from approved manufacturers. The paints shall be applied strictly in accordance with the manufacturers' instructions.

For recessed boxes, finished colour selection shall be considered as part of the colour scheme for the structure. For free-standing boxes, the finished colour shall blend in with their immediate surrounds so as to avoid obtrusiveness. Where concrete or masonry is used for the external envelope, consideration shall be given to applying more durable finishes capable of resisting graffiti and bill-posting.

Except where applied finishes have been evaluated by the ACABAS as part of the structure's colour scheme, proposals shall be submitted to the Landscape Unit of HyD for approval.

- (h) Electrical Equipment: All electrical equipment shall be as specified in the electrical specification of the contract documents. Their layouts together with the locations of the pillar box and earth pits must be acceptable to the Lighting Division.

7.3.2 Switch Room

Where a switch room is provided, all the metering equipment, fuses, circuit breakers, power socket outlets and switchgear, etc., shall be housed therein.

A perspex viewing window of 200mm x 200mm square shall be provided at the entrance door, facing the energy meter to allow meter readings to be taken outside the switch room. Warning notices should be provided on the outside of the door of the room according to the CoP.

Designers shall inform the relevant parties of the required structural openings at an early stage.

7.3.3 Power Distribution System

The power distribution system distributes the power from a pillar box or switch room to luminaires or pumps. A concealed conduit system shall be adopted wherever possible. Conduits shall not be used as circuit protective conductors and separate cables shall be provided for all circuits. The cable route shall be as simple as possible, featuring long and straight runs, to avoid unnecessary bends and changes of direction. Junction boxes shall be inserted at every change of direction to facilitate access to all sections of the system. Boxes shall be set flush with adjoining finished surfaces wherever possible and be readily accessible for maintenance.

Working drawings shall contain adequate and unambiguous details showing where conduits are to be placed in relation to structural members so as to leave the Contractor no doubt about the installation requirements.

Where it is absolutely unavoidable to expose conduits and junction boxes, they shall be located in logical and unobtrusive positions, and be painted in the colour of the surface to which they have been mounted unless otherwise directed. Where a conduit crosses an expansion joint, special arrangement shall be made to allow relative movement to occur on either side of the expansion joint. A separate circuit protective conductor shall be installed to maintain an effective electrical continuity across the expansion joint. The circuit protective conductor shall have a cross-sectional area rated to suit the largest live conductor drawn into the conduits in accordance with the CoP.

7.3.4 Luminaires Arrangement

Luminaires shall be longitudinally mounted in order to reduce glare to an acceptable level. In special cases where the approval from the Lighting Division has been sought to mount the luminaires transversely, it is always advantageous to have them partially recessed to avoid excessive glare to pedestrians. In doing so, care shall be taken to ensure that the lighting level and uniformity are not impaired.

To avoid dark spots caused by lamp failure, the spacing between adjacent fluorescent luminaires shall not exceed 5m.

7.3.5 Decorative Lighting Fittings

Where subways, footbridges, elevated walkways and escalators are located in prestigious areas such as in commercial or tourist areas, subject to the approval of the Lighting Division, decorative lighting fittings may be adopted to enhance the harmony of the environment.

7.3.6 Materials and Equipment

Lighting designers shall refer to Appendix A – “Electrical Specification for Lighting Installations Serving Highway Structures – Footbridges, Subways, Covered Walkways and Escalators” for the related requirements.

7.4 ELECTRICITY SUPPLY

Each installation shall be separately metered and power supply from nearby road lighting can be used as an alternative except where 24 hours power supply is not available.

The Developer/Contractor shall prepare and submit, under his name, an application for electricity supply to the Power Company concerned.

8. TRAFFIC BOLLARDS

8.1 GENERAL

Traffic bollards are traffic aids equipment for transport planning and design. Designers shall refer to TPDM for the transport design and propose traffic bollard locations with associated signage types under the authority of TD.

8.2 DESIGN STANDARDS

The design and installation of traffic bollards shall generally be in compliance with BS EN 12899. The requirements of signage shall refer to the latest edition of TD's Working Drawings.

To enhance the bollard reliability and to eliminate the need for power supply, non-illuminated retro-reflective traffic bollards (NRTBs) instead of conventional illuminated traffic bollards (ITBs) shall be installed if situation warrants. NRTBs shall comply with BS 8442.

8.3 ILLUMINATED TRAFFIC BOLLARDS

Each ITB shall consist of a bollard body shell housing a light source, cable connectors/fuse holders, cables, supports and an earthing system. The bollard shell shall be removable for ease of maintenance. The shell body and its base shall be made of ultra-violet stabilized plastic material.

The light source shall be of 2 x 11W compact fluorescent lamps (4,000K minimum) or equivalent, such as LED light, and connected with electronic ballasts for operation under a A.C. power supply of 220V, 50Hz.

The electronic ballasts shall be manufactured and tested in compliance with BS EN 61347 and BS EN 60929 respectively. The ballast shall maintain a constant light output under a single phase A.C. power supply of $220V \pm 6\%$, $50Hz \pm 2\%$. The percentage of light emitted from a reference fluorescent tube with this ballasts (Ballast Lumen Factor) shall not be less than 95%.

Each lamp shall be operated on an independent and separately-fused circuit so that at least one lamp continues to function in the event of the failure of other lamps or control gear. All auxiliaries shall comply with relevant BS or equivalent. Each bollard shall be fitted with a double pole isolator and be installed within the supply position.

The traffic bollard shall be suitable for installation on a pre-casted concrete plinth without any modification work being necessary on the plinth or the bollard itself.

8.4 NON-ILLUMINATED RETRO-REFLECTIVE TRAFFIC BOLLARDS

The sign face of a NRTB shall be directed to the oncoming traffic and its body shall be securely attached to a flexible support post. It shall be conspicuously visible to motorists and other road users at all times. The body shall be made of flexible plastic material and formed with four-sided retro-reflective strips in order for the sign face and conspicuity panels to be visible. NRTBs shall comply with BS 8442.

The retro-reflective material shall be of high intensity micro-prismatic type and comply with relevant European Technical Approval guidelines. It shall also comply with BS EN 12899-1 and in the performance class of R3B-UK or above. For the minimum coefficient of retro-reflection, the values for fluorescent yellow are the same as those given for yellow, unless specified in relevant standards or European Technical Approval guidelines. The area of the circle on the retro-reflective sign shall be of about 700cm² with a diameter of about 30cm.

NRTBs shall comply with the requirements for testing of vehicle impacts with the permanent road equipment support structures, and be classified under performance type (100, NE, 4) as described in BS EN 12767:2007. NRTBs shall return to their upright position after a vehicle impact from any direction.

NRTBs shall be suitable for installation on an existing pre-casted concrete plinth without any modification work being necessary on the plinth. NRTBs are installed using an anchor kit or concrete-in base or equivalent. The recommended mounting method by NRTB manufacturers shall be referred and submitted to the Lighting Division for approval.

8.5 RECOMMENDATIONS FOR INSTALLATION OF NRTBS

NRTBs rely on the light beams of vehicle headlights directly reflected from the sign face back to the driver and, therefore, there are limitations for the installation locations of NRTBs. It is unsuitable for locations where the vehicle headlights cannot light the signage in a straight ahead direction, e.g. when turning at a road junction. Based on this limitation, the recommended locations for ITBs and NRTBs are depicted in Figure 2 below, in which NRTBs shall not be installed at locations “TB” and “CB”. The proposed locations for installing NRTBs, colour of NRTBs and their retroreflective sheets shall be submitted to the Lighting Division for approval.

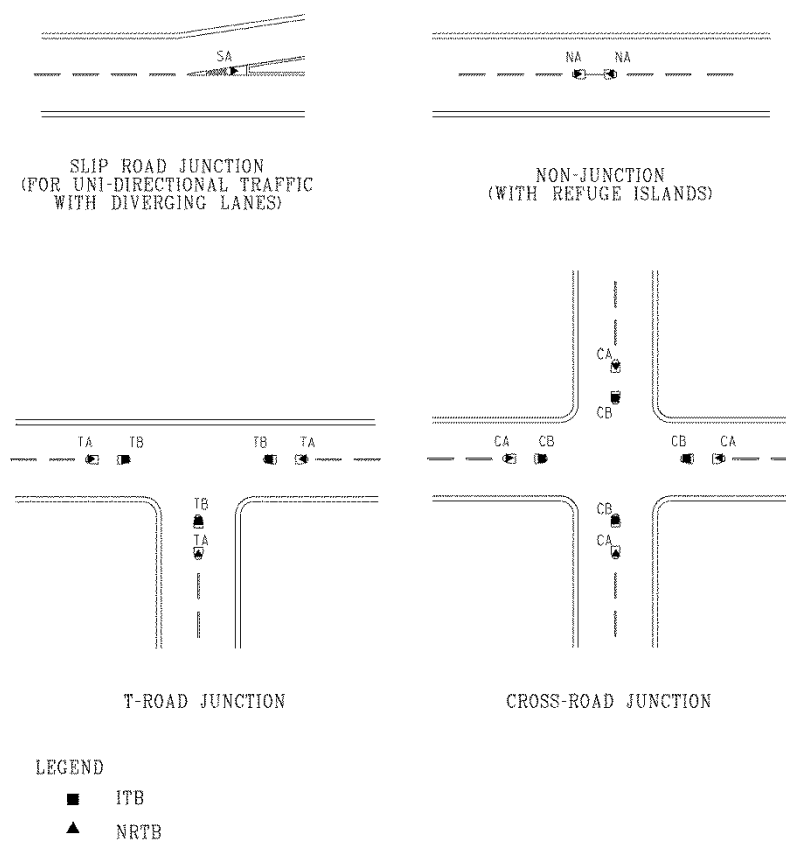


Figure 2 Recommended Locations for ITBs and NRTBs

8.6 ELECTRICITY SUPPLY

ITBs shall be connected to nearby road lighting circuits for operation.

8.7 MOUNTING DETAILS

The mounting details of the traffic bollards shall be in accordance with the Lighting Division's Standard Drawings and relevant HyD Standard Drawings together with all current amendments.

APPENDIX A

ELECTRICAL SPECIFICATION FOR LIGHTING INSTALLATIONS SERVING HIGHWAY STRUCTURES - FOOTBRIDGES, SUBWAYS, COVERED WALKWAYS AND ESCALATORS

A.1 GENERAL

A.1.1 Statutory Standards

All materials and equipment supplied by the Contractor shall be in accordance with the appropriate BS Specifications. The installation works shall comply with the current editions of the CoP, the “General Specification for Electrical Installation in Government Buildings of the Hong Kong Special Administrative Region”, the IET Wiring Regulations issued by the BSI and the local Power Companies’ “Supply Rules”.

A.1.2 Supply Voltage

Unless otherwise specified, all apparatus and wiring shall be suitable for operation on low voltage supply system, i.e. 220V/380V, 50Hz.

A.2 DRAWING BY THE CONTRACTOR

A.2.1 Size of Drawing

Drawings submitted by the Contractor shall be of a standard size from A0 to A4 in accordance with BS EN ISO 5457. “As-fitted” drawings shall be A1 or A3 size. The soft copies of drawings shall be in Microstation version 3D DGN format.

A.2.2 Working Drawings and Schematic Wiring Diagram

The Contractor shall prepare working drawings and schematic wiring diagram indicating the size of the conduit, cable run, layout/arrangement of the installation, circuitry, earthing, bonding/supplementary bonding arrangement, etc., and submit to the Lighting Division for approval before commencing works.

A.2.3 “As-installed” Drawing

“As-installed” drawings shall show the positions of all conduits, trunkings, cable routes, switchgear, distribution boards, luminaires, photoelectric controllers, timers, pillar boxes and earthing, and all other items which have been installed. Such drawings shall be suitable for reproduction of prints.

A.3 PILLAR BOX

A.3.1 Design and Construction of Pillar Box

The pillar box consisting of the meter and equipment compartments shall be constructed and designed in accordance with Clause 7.3.1 of this Manual.

Apart from the two sizes of pillar box recommended in Clause 7.3.1, the Contractor may propose alternative design if deemed necessary, prior to installation, to the Lighting Division for approval. The control gear shall be installed and connected in the equipment compartment by the Contractor. The incoming electricity supply and the energy meter shall be installed in the meter compartment by the Power Company concerned, while all other outgoing connections shall be installed by the Contractor.

Every piece of equipment installed by the Contractor inside the pillar box shall be labeled both in English and in Chinese characters.

A.4 LIGHTING CIRCUIT

A.4.1 Conduit System

Unless otherwise specified in the Specification or on the Contract Drawings, concealed conduit system shall be adopted. Surface conduits may be installed inside switch rooms, meter/pillar boxes or where there is site constraint that conduits cannot be concealed.

A.4.2 Underground Cable

PVC insulated and PVC sheathed armoured cables complying with IEC 60502-1 or XLPE insulated, PVC sheathed armoured cables complying with BS 5467 and BS 6724 shall be used for the main sub-circuits which are laid underground. UPVC ducts to BS 3506 Class B shall be used to draw the cables laid underground. The medium grade, GI ducts shall be used to draw the cable laid underground at carriageway or loading area and be in purple colour of colour code number 3050-R50B of the Natural Colour System of the Swedish Standard.

A.5 EARTHING

A.5.1 General

All metal works associated with the lighting installations but not forming part of a live conductor, including exposed conductive parts and extraneous conductive parts, shall be solidly and effectively earthed.

A.5.2 Earth Pit

An earth pit shall be constructed in accordance with HyD Standard Drawings Nos. CL0034 to CL0036. The earth pit shall be sited as close as possible to the pillar box.

A.5.3 Earth Electrode

A copper or copper-clad steel rod of a diameter not less than 15mm shall be used as the earth electrode. The earth fault loop impedance and earth electrode resistance shall be measured and additional electrodes shall be provided by the Contractor to bring the earth fault loop impedance to the acceptable value as stipulated in the CoP, if necessary.

A.5.4 Main Earthing Terminal and Earthing Conductor

A solid copper main earthing terminal of ample size shall be provided for the lighting installations at a position near the main incoming switch for the connection of the circuit protective conductors, the main equipotential bonding conductors and the earthing conductors to create the equipotential zone. Conduits or trunkings shall not be used as a circuit protective conductor. Independent circuit protective conductor shall be provided for each circuit. The main earthing terminal shall be connected to the earth electrode via a 25mm x 3mm PVC sheathed earthing conductor. This earthing tape shall be labeled as 'SAFETY EARTH CONNECTION – DO NOT REMOVE' and '安全接地終端 ----- 切勿移去' in legible letters and characters each not less than 5mm high to be permanently fixed at or near the point of connection of every earthing conductor to an earth electrode, and at or near each main bonding connection.

A.6 INSPECTION AND TESTING

A.6.1 Routine Inspection

The Contractor shall closely liaise with the Lighting Division during the course of the works to conduct routine electrical inspections on site.

A.6.2 Commissioning Trial

When the works are finally completed, the whole system must be demonstrated to be working satisfactorily during commissioning trials in the presence of the Lighting Division. The Contractor shall liaise with the Lighting Division to witness the final commissioning trials, which shall include both visual inspection and relevant tests as stipulated in the Lighting Division's inspections forms and the CoP.

A.7 MATERIAL AND EQUIPMENT

A.7.1 Luminaire

Luminaires shall comply with BS EN 60598-1 and have an IP and IK rating not less than 65 and 09 respectively. They shall be equipped with vandal resistant diffusers, control gear and fluorescent tubes for use on local supply voltage and frequency. The diffuser shall be externally smooth to facilitate cleaning. LED luminaires shall also comply with IEC 62471 hazard class Group 1 or Exempt Group.

A.7.2 Electronic Ballast

Electronic ballasts shall conform to IEC 61000-3-2, BS EN 55015 and IEC 61547. The electronic ballast shall be manufactured and tested in compliance with BS EN 61347 and BS EN 60929 respectively.

The ballast shall maintain a constant light output under a single phase A.C. power supply of $220V \pm 6\%$, $50Hz \pm 2\%$. The Ballast Lumen Factor of the electronic ballast shall not be lower than 0.95 or high than 1.05 with reference to a standard conventional ballast.

The electronic ballast shall be suitable to operate at an ambient temperature range of $0^{\circ}C$ to $50^{\circ}C$ and at a maximum relative humidity of 95%.

The overall power factor of the electronic ballast shall not be less than 0.95

lagging. The service life of the electronic ballast shall not be less than 50,000 hours at the test point of 70°C, whereas the failure rate shall be less than 1% per 4,000 operating hours at its maximum case temperature.

The electronic ballast shall have a total harmonic distortion of less than 15% when tested on a pure sinusoidal mains supply.

Where one electronic ballast is used for operating two lamps in one luminaire, the failure of one lamp shall not affect the operation of another lamp.

A.7.3 LED driver

The LED driver shall comply with IEC 61347-1, IEC 61347-2-13, IEC 62384, IEC 61000-3-2, IEC 61547 and BS EN 55015 together with all current amendments.

A.7.4 Pass Light and Bulkhead Light

Luminaires shall be of low glare complying with BS EN 60598 and have an IP rating not less than 65. Each luminaire body shall be made of die-cast aluminum with a reflector and vandal-resistant polycarbonate cover. The luminaires shall accommodate compact fluorescent lamps or ceramic discharge metal halide tubular lamps of wattage not more than 50 Watt together with control gear suitable for use on local supply voltage and frequency.

A.7.5 Adjustable Digital Photoelectric Controller

Adjustable digital photoelectric controllers shall be of electronic fail-safe type, and with an on/off adjustable setting from 10 to 1000lux and a time delay of 0-60 seconds. They shall be suitable for use in exposed weather conditions and shall function correctly within the temperature range of -5°C to +50°C at local supply voltage and frequency.

A.7.6 Astronomical Time Switch

Astronomical time switches used for the backup of the photoelectric controller shall comply with IEC 60730-1. It shall have 2-channel, accuracy of ± 0.5 sec/day and battery reserve for at least 5 years.

A.7.7 Contactor

Contactors shall be of air-break type, with contactor coil rated at local supply

voltage and frequency, complying with BS EN 60947-4-1 and with utilization category AC-5a.

A.7.8 Main Switch

For a single-phase power supply, the main switch at meter position shall be of double pole type, whereas for a three-phase power supply, triple pole type shall be used. Main switches shall comply with BS EN 60947-3.

A.7.9 MCB and Distribution Board

MCB shall be of thermal magnetic type calibrated at 30°C and shall comply with BS EN 60898-1.

All MCB distribution boards shall be fabricated of galvanized steel not less than 1.2mm thick. The design and construction of MCB distribution boards shall comply with and be tested to IEC 60439-3.

A.7.10 PVC Cable

All cables shall have copper conductors. Except those mentioned below, all cables enclosed in conduits or trunking shall be single core, 450/750V grade, PVC insulated, complying with BS EN 50525-2-31.

Cables with size up to 35mm² and for voltages up to 300/500V within the pillar box, if not concealed in conduit or trunking, shall be PVC insulated and PVC sheathed type complying with BS 6004.

A.7.11 Conduit and Accessories

Steel conduits shall be heavy gauge, screwed, longitudinally welded and shall comply with IEC 61386-21. Conduit fittings shall comply with IEC 61386-1. Metal boxes for enclosure of electrical accessories in conduit installation shall comply with BS 4662/IEC 60670-1.

All conduit entries to adaptor boxes shall be connected by means of couplings and hexagonal male bushes. All conduit entries to luminaires shall be sealed by silicone rubber after wirings are drawn in order to guard against the ingress of water, insects, etc., into the luminaires.

Conduits shall not be used as circuit protective conductors. Independent

circuit protective conductor shall be provided for each lighting circuit.

A.8 MISCELLANEOUS

A.8.1 Proposed Materials and Equipment

Any materials and equipment to be used for the lighting installations shall be submitted to the Lighting Division for approval before commencing works.

APPENDIX B

GENERAL SPECIFICATION FOR HIGH MAST LIGHTING

B.1 GENERAL

The specification described below includes the design, installation and commissioning of high mast lighting.

B.1.1 Materials, Equipment and Works

- (a) Supply and delivery of steel flanged-base high mast lighting columns to give lantern mounting heights between 20m and 40m inclusive together with power-operated raising and lowering gear. Holding down bolts, template for positioning these bolts and anchor plate for casting into the foundation (by others) shall also be supplied;
- (b) Supply and delivery of lanterns, head frames, earthing and lightning protection facilities, ballasts, capacitors, switchboard control equipment, other electrical gear and fittings, internal wiring and accessories;
- (c) Installation of (a) and (b) above; and
- (d) Maintenance of the installation during the defect liability period.

Construction of foundations of high masts and concrete pillars for the power supply will be carried out separately by others. Where a mast is to be erected on sloping ground, the foundation shall include an area of 3m x 3m flat working platform.

B.1.2 Defective Works

Where in the opinion of the Lighting Division materials or workmanship in any part of the finished works do not comply with the relevant requirements of this specification, that part of the works shall be classified as defective works. They shall be removed from site and be replaced to the satisfaction of the Lighting Division. All removal and replacement of defective works and all costs arising thereof shall be at the Contractor's expense.

B.1.3 Compliance with Relevant Standards

All materials and equipment shall comply with relevant BS and the current editions of the CoP, the "General Specification for Electrical Installation in Government Buildings of the Hong Kong Special Administrative Region" issued by Arch SD, and the local Power Companies' "Supply Rules".

The design of high mast lighting system shall comply with PLG07 High Masts for Lighting and CCTV, published by ILP.

B.2 MAST

B.2.1 General

The mast shall provide a lantern mounting height between 20m and 40m inclusive. It shall be of welded steel construction, unstayed and of continuously tapered form.

Details of the high mast design shall comply with PLG07 High Masts for Lighting and CCTV published by ILP.

The mast shall cater for a 3-second gust wind speed of 70m/s measured at a height of 10m above ground level for a return period of 50 years (giving a reference pressure of 3kN/m²).

The design of foundation and holding down bolts shall comply with Structures Design Manual of HyD and shall be submitted to the Bridges and Structures Division of HyD for comment. The foundation shall cater for a maximum gust velocity of 79m/s measured at a height of 10m above ground level for a return period of 120 years at an exposed location.

The maximum horizontal deflection at the top of the mast under a horizontal loading of 0.75kN/m² (wind speed of 35m/s measured at a height of 10m above ground level), shall not exceed 1/40 of its length above the ground.

The eddy shedding frequency for the masts shall be determined for the range of wind speeds between 10m/s and 70m/s. If the natural frequency of the structure falls within this range, the amplitude of the oscillation must be restrained by adequate structural damping.

A separate check for seismic effects shall be carried out by means of the following formula:

	V	=	CW
Where	V	=	nominal seismic force
	C	=	seismic coefficient assumed to be 0.05 and
	W	=	total vertical load

B.2.2 Limit State Requirements

For Limit State Design, the nominal seismic force shall be multiplied by partial load factors of 1.00 for the serviceability limit state and 1.40 for the ultimate limit state to obtain the design seismic forces. The design seismic force shall be applied successively, longitudinally and transversely at the base-plate level.

The lighting mast shall be designed to resist a nominal collision load of 50kN acting in the worst direction and at the worst height up to 3m above the adjacent carriageway. For Limit State Design, partial load factors of 1.00 for the serviceability limit state and 1.25 for the ultimate limit state shall be applied to nominal loads to obtain the design load.

B.2.3 Steel Base-plate

Each mast shall have a uniform steel base-plate for bolting to the foundation together with a set of high tensile stainless steel foundation bolts, a lower steel anchor plate and a timber spacing jig. Stainless steel foundation bolts and nuts shall conform to BS EN ISO 3506-1 and BS EN ISO 3506-2 respectively, steel grade A4 and property class 80 as per Section 18 - "Steelwork" in the "General Specification for Civil Engineering Works" (GS) issued by the Civil Engineering and Development Department. Where used, high strength friction grip bolts, nuts and washers shall conform to BS EN 14399 and BS EN 1993-1-8. Other bolts, nuts and washers shall conform to BS 1769 and BS 3410.

Method statements for the installation and relevant drawings shall be supplied to the Bridges and Structures Division of HyD.

The Contractor shall be responsible for leveling the steel anchor plate on the prepared foundation and correctly aligning the mast. When measured in still air and even temperature conditions, the axis of the mast when erected shall not deviate:

- (a) From the vertical by more than 0.3% of the height above the base flange.
- (b) From straightness by more than 0.3% of any length measured at the centre of that length.

B.2.4 Mast Construction

Structural steel to be used for construction of the mast shall be of Grade

S355J0H with thickness up to and including 38mm, conforming to BS EN 10210. If a greater steel thickness is required, the Contractor shall submit his construction proposals to the Project Office for approval.

Other steel may be acceptable provided that full details of its chemical composition, mechanical properties and specification are supplied with the tender documents. Welding shall conform to BS 499 and BS EN 1011.

A copy of the calculations for the design of the masts showing clearly the grade of steel to be used shall be submitted to the Bridges and Structures Division of HyD for approval. The calculations shall take into account the weakening effect of the doorways.

A base compartment of adequate size shall be provided at the mast base for housing the necessary winching mechanism equipment and accessories. The compartment shall have a vandal-resistant, weatherproof access door with heavy duty vandal-resistant locks, suitable for identical pattern keys. Six such keys shall be provided for each mast. Keyholes shall be provided with weather-proof cover plates. A 16mm diameter corrosion resistant earth stud shall be fitted within the base compartment. Adequate working space should be available for operating the hoisting equipment at the foot of the mast.

B.2.5 Protection of Steelwork against Corrosion

Section 18 “Steelwork” in the GS must be followed. Both internal and external mast surfaces shall be hot dip galvanized to BS EN ISO 1461 for protection purpose. Painting of the mast is required according to the subsection – “Painting Steelwork” of Section 18 in the GS. The paint colour shall comply with BS 4800.

B.2.6 Winching Mechanism

B.2.6.1 General

The lantern ring shall be raised and lowered by a self-sustaining worm-gear winch suitable for both manual and power driven operations and located at the foot of the mast. The winch shall be of double drum and double gear type. Two separate and identical suspension systems and independently anchored ropes shall be provided. The gear ratio for the winch shall be marked on the winch. The loading calculations for lanterns, headframe, steel wires and accessories shall be endorsed by a Registered Structural Engineer.

The operating handle shall be removable for storage within the mast. The power tool shall be a multi-speed reversible tool incorporating a torque-limiting device which can be readily adjusted and locked. A remote control switch shall be incorporated to allow the equipment to be operated from a distance of 10m. Arrangements shall be provided to support the power tool accurately and securely during operation.

A danger plate shall also be affixed and shall bear the following warning statement with Chinese translation:

“Standing under the mobile ring during the raising and lowering operations is forbidden”.

The Contractor shall provide technical information on the design life span, replacement criteria, checklists for preventive maintenance and the recommended lubrication oil with renewal interval for the winch system.

B.2.6.2 Safe Working Load

The winch and all hoisting equipment must be adequate to allow for attaching to the lantern hoisting ropes. The hoisting mechanism, where relevant, shall comply with the Factories and Industrial Undertakings (Lifting Appliances and Lifting Gear) Regulations and a certificate to this effect shall also be provided.

B.2.6.3 Design

The hoisting ropes shall be made of stainless steel wire, running from the winch to the lantern ring over pulleys made of non-corrodible metal at the top of the mast. The pulley grooves shall be suitably protected against moisture, dirt, rust and fitted with guards to prevent derailment of the wire ropes. Self-lubricating pulley bearing shall be used.

All vital parts of the hoisting mechanism shall be of stainless steel or other non-corrodible material. Particular care shall be taken to ensure that the wire rope and electric cable cannot abrade against any component. In addition, the electric cables shall not share any weight load from the hoisting wire ropes.

When the lantern ring is in the fully lowered position, at least to within 1m of the base line, a sufficient number of turns of the hoisting rope shall be left on the winch drum to ensure that the securing arrangements on the winch drum do not take the full load when hoisting.

The rope shall be as clearly visible as practicable during the hoisting operation and the last 2m of the rope above the winch shall be clearly and indelibly marked. There shall be a clear indicating near the winch to show that the lantern ring has reached the designed operating height.

The winch shall be capable of being positively locked at any point in the full travel of the rope. A safety device shall be incorporated to automatically stop the lantern ring during raising or lowering operations if pressure is released at the winch. The safe working load shall be plainly marked on the winch.

Details relating to lubrication, both of winch drive and hoisting rope, indicating type and frequency of application shall be given on an engraved label fixed to and adjacent to the winch in a visible position.

B.2.7 Lantern Carriage

The lantern carriage shall be of durable steel construction fitted with lantern and lamp gear fixings and distribution box mounting plates. It shall be in two halves jointed by bolted flanges to permit removal from the erected mast.

The lantern carriage or ring should be anchored to at least two suspension wires and shall not rotate about or chafe the mast when being raised or lowered, and shall be fitted with guides or rollers to prevent damage to either the lantern ring assembly or the mast in the raising or lowering process.

The lantern carriage shall be so constructed as to enable automatic location correction and to ensure locking in position when the assembly is in the raised position.

The Project Office shall provide the provision of counter weight for balancing on the head-frame on which the lanterns are not evenly installed.

B.3 LANTERN

B.3.1 General

The lanterns shall be of sound and robust construction to BS EN 60598. They shall be for use on 220V, 50Hz single phase power supply. The lanterns shall have an IP rating not less than 65. However, if the lanterns are of open ventilated

design with self-cleaning effect and with rating less than IP 65, they may be accepted in exceptional cases. Nevertheless, the lanterns shall not cause any spill lights above the horizontal.

Labels shall be securely affixed inside the lantern body. They shall include the mark of origin, model number, rated voltage, rated wattage of the lamp, IP rating and terminal markings etc.

The following maximum lantern weight and lantern windage area shall be met in order to match the wind loading of the corresponding high mast lighting columns.

<u>Lantern Wattage</u>	<u>Max. Lantern Weight</u>	<u>Max. Lantern Windage Area</u>
400/600W	15kg	0.30m ²
1,000W	25kg	0.34m ²

B.3.2 Construction

The lanterns shall be of sound and robust construction to withstand the movement and vibration expected, be totally enclosed, and capable of being easily dismantled for maintenance and repair purposes. The means of fixing the lantern to the bracket shall include a substantial locking device so that the lantern remains in the designed position under all conditions.

The bowl or other part giving access to the interior of the lantern, when in the enclosed position, shall be firmly attached to the fixed part of the lantern. In the open position, it shall be attached so that it may not become accidentally detached or blown against the fixed part of the lantern assembly and the mast.

The hinges, toggle catches, captive screws, and captive nuts shall be made of non-corrodible material.

The lantern bowl shall have a smooth exterior surface to prevent the accumulation of dirt and to facilitate cleaning.

The lanterns shall be designed for easy wiring and shall be supplied with suitable lamp holders readily wired to a connector block with tinned copper wire suitably insulated with non-hygroscopic heat-resistant material. The lamp support, if provided, shall ensure that the position of the lamp in the lantern relative to the optical equipment remains substantially the same under all conditions throughout the life of

the lantern. An earthing terminal shall be provided in the lantern, unless the lantern is of Class II insulation.

The Contractor shall supply a drawing of the lantern together with the photometric data stored in a CD-ROM in the TM-14 CIBSE format and IESNA LM-63 or other formats approved by the Lighting Division.

The light distribution from the combined lantern assembly shall be variable by adjustment of the optical system of each individual lantern to give the following distribution:

- (a) Symmetric;
- (b) Non-axial Asymmetric (Principal Axis 120°, 140° and 160°); and
- (c) Axial Asymmetric.

The overall design of the lighting system shall limit the disability glare to TI = 15% observed at significant and critical positions of the road system, including its approaches, on which the system is lit.

B.4 Electrical Accessories

B.4.1 Cable and Cable Connection

A multi-core flexible cable of suitable conductor size, winching duty grade to BS EN 50214, shall run over suitably self-lubricate pulleys and be terminated in a galvanized weather-proof junction box housing terminal blocks of suitable rating. One core in the cable shall be a circuit protective conductor terminating in a crimped lug bolted to the lantern ring. The cable shall terminate in the base compartment with a metal cased plug and socket coupler fitted with a guard ring and locking device.

Pulleys shall be of non-ferrous metal and have a diameter not less than that recommended by the cable manufacturer. A galvanized steel enclosure shall protect the cable pulleys, winch rope pulleys and the top of the mast from the ingress of rain.

B.4.2 Interconnecting Cable

Interconnections on the lantern ring between the distribution box, control gear

and lantern shall be by means of 600/1,000V grade, multi-core PVC insulated and PVC sheathed cables which shall be secured to the ring by means of positive locking type plastic cable ties. Lanterns, cases of ballasts, capacitors and the distribution box shall be connected to the earth cores of the cables around the lantern ring.

Cables shall enter the distribution boxes and control gear boxes by means of glands of rustless materials to BS 6121. Cables entering lantern spigots shall pass through neoprene bushes. An extension lead of multicore cable equal to that within the mast and fitted with a suitable plug and socket shall be provided to enable the lantern to be tested in the lowered positions.

The earth cores in the traveling cables shall be terminated at the earth terminal of the ring distribution boxes.

B.4.3 Lightning Protection

Each mast shall be effectively earthed for lightning protection by separate earth rods buried in the ground immediately adjacent to the mast. The lightning protection earth systems shall be kept separate from the mast “circuit” earth system. The earth rods shall be housed in suitable earth pits.

The lightning protection system shall comprise a suitable earthing terminal at the base of the mast, conductors and earth rods. The conductors connecting the earth rods and the earthing terminal shall be of copper tapes with cross-sectional area not less than 70mm².

Means shall be provided to disconnect the mast from the rods for testing.

The whole of the lightning protection system shall be in accordance with the recommendations of BS EN 62305. The down conductors and inter-connectors shall be buried at a depth at least 450mm below the final ground level.

It shall be the Contractor’s responsibility to ascertain the soil resistivity under dry conditions and determine the necessary length and number of earthing rods. The resulting earth resistance shall not be greater than 10 ohms.

B.4.4 Earthing

The whole equipment shall be effectively earthed by the Contractor in accordance with the current edition of the CoP.

The earth pins in the multi-pin sockets and all non-current carrying metalwork shall be bonded to the earth terminal provided at the base of the mast by means of cables with minimum size of 4mm² to BS 6231. The earth terminal shall in turn be connected through the incoming cable sheaths to the mast circuit earthing electrodes. The mast circuit earthing electrodes shall be located near the control pillar box. The actual number of earthing electrodes shall depend on the resistivity under dry conditions. The earthing electrodes shall be housed in suitable earth pits.

B.5 ELECTRICAL SUPPLY AND CONTROL SYSTEM

B.5.1 General

All materials and equipment except otherwise stated shall be supplied by the Contractor as specified and shall be in accordance with the appropriate BS standards. All electrical works shall comply with the current editions of the CoP, “General Specification for the Electrical Installation in Government Buildings of the Hong Kong Special Administrative Region”, the Electricity Supply Ordinance, “Supply Rules” of the respective Power Companies, Safety Regulations by the Labour Department and the Fire Services Department’s requirements.

B.5.2 Connection to Mains Supply

The switch fuses, MCB, contactors and photo-electric controllers shall be installed and connected to the energy meter in the pillar box or switch room.

The electricity supply system up to and including the meter will be installed by the Power Company concerned.

The power cable route from the pillar box to the mast shall be provided by the Contractor.

B.5.3 Adjustable Digital Photoelectric Controller

The photoelectric controller to be supplied shall have an LCD display to show the local time, on/off settings and measured illuminance levels. The on/off setting shall be adjustable from 1 to 2,000 lux. The controller shall incorporate the design features and meet the performance details set out below:

- (a) Loading: shall be capable of controlling the connected load;

- (b) Temperature Range: shall be suitable to operate within a temperature range of -5°C to $+ 50^{\circ}\text{C}$ at the local supply voltage and frequency;
- (c) Operation:
 - (i) in the event of a fault occurring in the photoelectric controller, the unit shall be fail-safe and in the 'on' position; and
 - (ii) a delay device of 0-60 seconds shall be included so that the controller will not switch 'on' the system due to transient change in illuminance.

B.6 COMMISSIONING AND TESTING

Inspection by the Contractor, or his representative will be carried out during the course of the work. When the work is finally completed, the whole system must be demonstrated to be working satisfactorily during commissioning trials supervised by the Contractor. The Lighting Division shall be invited to witness the final commissioning trials.

Commissioning of the system shall include:

- (a) Insulation resistance measurements of individual circuits;
- (b) Resistance measurement of the earthing system, earth continuity of the electricity installation and lightning protection system;
- (c) Raising and lowering gear operation;
- (d) Operation of automatic control system;
- (e) Illuminance measurements;
- (f) Reflectors setting of luminaires; and
- (g) Testing of winching mechanism, lantern hoist ropes and safety devices, including requirements of the Lifts and Escalators (Safety) Ordinance.

Tests shall be carried out on each mast. Test reports and test certificates shall be submitted by the Contractor to the Lighting Division.

B.7 SPARES AND MAINTENANCE

The Contractor shall provide and deliver the following spare parts to the

Lighting Division for future maintenance:

- (a) 1 lantern for each mast supplied;
- (b) 1 lamp for each mast supplied;
- (c) 1 no. of adjustable digital photoelectric controller;
- (d) 1 no. of winch with ancillary hoisting equipment and associated hoisting ropes;
- (e) 1 no. of power-driven unit; and
- (f) Other spare parts as recommended by the Lighting Division or the Maintenance Agent

The Contractor shall maintain the lighting installations during the defect liability period in accordance with the manufacturer's recommendations and to the satisfaction of the Lighting Division and the Maintenance Agent.

On the expiry of the defect liability period, the Contractor shall perform all the tests to the Lighting Division to demonstrate that all lighting installations are working satisfactorily.