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FOREWORD

The Public Lighting Design Manual sets out standards and provides guidance for the design of lighting works on public roads in Hong Kong. The Manual was first published in March 1996 and has been widely used by the practitioners.

This second edition incorporates the designs for gantry and roadside directional sign lighting, noise enclosure lighting and public road lighting. To assist the practitioners in the preparation of specification for lighting installations, we have included model specifications in the Appendices of this Manual.

The Lighting Division of Highways Department will regularly review and improve on the content of this Manual to align with the most up-to-date practice. We welcome any comments on this Manual for further improvements.

(MAK Chai-kwong)
Director of Highways

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1. INTRODUCTION

1.1 SCOPE

This Manual intends to provide guidance for the designers in the preparation of lighting schemes, which are to be handed over to the Lighting Division of Highways Department for maintenance.

The Manual gives specific requirements in the design of lighting for covered pedestrian routes, covered public transport interchanges, tunnels, underpasses/underdecks, noise enclosures, gantry and roadside directional signs, high mast lighting, conventional and decorative road lighting.

Apart from stating the required lighting levels for various lighting installations, emphasis has also been placed on the other aspects of visual comfort including uniformity, energy conservation, avoidance of glare and light pollution.

Emergency lighting is a requirement for the building interiors, it has been included in the requirements for certain covered public transport interchanges, long and complex subways, tunnels and noise enclosures.

Unless otherwise stated in this Manual, current editions of the relevant technical publications together with any amendments made thereto shall be adopted.

It should be noted that the guidelines provided in this Manual are not intended to be exhaustive. The Lighting Division of Highways Department may review the requirements from time to time.

1.2 PROPOSED MATERIALS AND EQUIPMENT

Proposed materials and equipment together with recognized test certificates or reports as stipulated in the Code of Practice for the Electricity (Wiring) Regulations published by Electrical & Mechanical Services Department shall be submitted to the Lighting Division of Highways Department for approval and to the Maintenance Agent/Contractor for comment from maintenance viewpoint at early stage. The supplied products after approval shall conform to the approved submission of the test certificates or reports.

Good workmanship should be used in the construction and installation of every lighting electrical installation in accordance with the Code 4 therein.

1.3 STATUTORY STANDARDS

All the lighting installations shall comply with the following technical publications in order of preference:

1. This Public Lighting Design Manual;
2. Code of Practice for the Electricity (Wiring) Regulations issued by the Electrical

and Mechanical Services Department;
3. General Specification for Electrical Installation in Government Buildings of the Hong Kong Special Administrative Region issued by the Architectural Services Department;
4. The IEE Wiring Regulations issued by the BSI (BS 7671) and
5. Local Power Company's "Supply Rules" and other requirements.
6. Relevant BS, BS EN, EN, IEC and ISO.

1.4 ABBREVIATIONS

The following abbreviations are used throughout this Manual:

A. 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
EMSD	Electrical & Mechanical Services Department
HyD	Highways Department
IEE	Institution of Electrical Engineers (UK)
LD	Lighting Division of Highways Department
MOM	Management, Operation, Installation and Maintenance

B. Technical Terms Abbreviations

AC	Alternating Current
CDMTT	Ceramic Discharge Metal Halide Tubular
CMCS	Central Monitoring and Control System
DC	Direct Current
IP	Ingress Protection
MCB	Miniature Circuit Breaker
RCD	Residual Current Device
MCF	Mercury Fluorescent
PVC	Polyvinyl Chloride
SON	High Pressure Sodium
SON-T Plus	Tubular High Pressure Xenon High Pressure Sodium
TI	Threshold Increment
UPS	Uninterruptible Power Supply
UPVC	Unplasticized Polyvinyl Chloride
PLCC	Public Lighting Control Cubicle

C. 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. LIGHTING FOR COVERED PEDESTRIAN ROUTES

2.1 GUIDANCE NOTE

The covered pedestrian routes related to the highway structures in this Manual comprise subways, footbridges, elevated walkways, ground-level walkways and temporary ground-level walkways.

This guidance note intends to help the designers to realize the specific requirements on the lighting installations for the covered pedestrian routes and to ensure that the overall appearance of the structures is aesthetically pleasing.

All lighting designs including illumination calculations prepared by Project Offices or Consultants (for pedestrian routes to be taken over by HyD) must be submitted to Lighting Division, HyD for approval. The layout and schematic wiring diagram shall be forwarded to the Maintenance Agent/Contractor for comment concerning the electrical circuitry and maintenance aspects. The Maintenance Agent/Contractor shall be consulted regarding the quantity of spares to be incorporated in the Tender Documents.

The responsible Project Offices or Consultants shall co-ordinate the design (liaising with Bridges and Structures Division, HyD where necessary), installation, provision of electricity supply, and arrange for the Maintenance Agent/Contractor to carry out the final inspection in the presence of Lighting Division, HyD who shall witness the commissioning tests prior to handing-over the installation to the Maintenance Agent/Contractor for maintenance.

It should be noted that the Maintenance Agent/Contractor will not carry out inspections during the installation/contract period. Therefore, the Engineer or his representative shall carry out at frequent interval on-site inspections on the lighting installations for schemes not designed by Lighting Division, HyD. For schemes designed by Lighting Division, HyD, the same will undertake electrical inspections on site.

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

The design of the electricity pillar box including the size, materials, finish and its siting shall be submitted to the Engineer for approval.

2.1.1 Pillar Box

This is where the consumer supply main terminates and the particular power distribution system takes off. Its location is therefore determined on the one hand by the most convenient access to a supply main and on the other 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. It also includes the earthing pit which shall be built as close to

the pillar box as possible.

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

(a) 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 flows;

(ii) avoid obstruction to sight line of traffic and pedestrian flows;

(iii) avoid obtrusiveness in appearance; and

(iv) maintain free access.

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

(b) Typical Design. Details of a typical free standing all weather pillar box are as illustrated in HyD Standard Drawings numbered H2172 to H2174 inclusive and H2177.

It is important to note the bottom of the metal envelope should be at least 150 mm above average formation level as a precaution against flooding.

(c) Materials. Materials used must be durable and sufficiently rigid to protect the boxes from mechanical damage.

Plastics or fibre-glass is specifically excluded whereas galvanised mild steel or stainless steel shall be used.

Where mild steel is specified, the envelope or box shall be prefabricated complete with bolt holes drilled and barrel bolts fitted. The entire unit shall be hot dip galvanised to BS EN ISO 1461 before delivery to site. No subsequent drilling or welding on site is permitted and care must be taken to avoid damaging galvanized surfaces during transport, storage or installation.

Where stainless steel is specified, steel plate, sheet and strip shall comply with BS EN 10258 and BS EN 10259. All incidental items such as holding down bolts and fixing screws should be of same stainless quality.

Concrete or masonry for free-standing boxes should only be considered in special circumstances such as for the larger sized units.

(d) Dimensions. The overall size of pillar boxes is determined by the amount of equipment to be accommodated. Nevertheless, for free-standing units, their size 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 application:

(i) A small unit with overall dimensions 1200 mm wide x 1500 mm high x 500 mm deep, used for footbridges or small subways with up to 2 pumps and a bus-bar chamber. A typical design of such a unit is illustrated in the HyD Standard Drawings numbered H2171 to H2174 inclusive and H2177.

(ii) A larger unit with overall dimensions 1800 mm wide x 1500 mm high x 500 mm deep, used for medium to large subways with up to 3 pumps and a bus-bar chamber.

Each pillar box shall have 600 mm of its total width partitioned off to house equipment owned by the Power Company.

(2) Recessed Pillar Boxes. The box must be designed as an integral part of the structure by allowing a suitable recess in an external wall where easy access is possible. A typical design is as illustrated in the HyD Standard Drawings numbered H2174 to H2177 inclusive. However, there are circumstances which make it physically impossible to provide for the necessary space within the structure's envelope, such as for subways which are subject to flooding. In such cases, alternative locations in retaining walls or staircases should be considered and if found to be impractical or undesirable, a free standing pillar box may be used as an exceptional solution to the problem.

(3) Fixtures, Fittings and Finishes. Reference shall be made to the standard details and drawings covering the following items:

(a) Doors. Two swing doors, provided to one side only, 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. A perspex viewing window of 200 mm x 200 mm square shall be built into the door opposite the energy meter to allow meter readings to be taken without unlocking the door.

Door locks shall consist of two suitably sized padlocks.

(b) Equipment Panels. Each box shall contain two such panels, one in each compartment, made of selected hardwood with a finished thickness not less than 25 mm for mounting all equipment.

(c) Ventilation Louvers. Louvers may be pressed into the body as part of its manufacturing process or fitted in the form of independent, pressed steel panels. Openings must face downward and provide a 5-8 mm clear gap per slit.

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

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

(d) PVC Seals. A suitable waterproof seal of PVC or similar material shall be provided between the concrete plinth and steel cabinet for waterproofing and anti-vibration purposes.

(e) Cable Trenches. The cable trench inside the pillar box shall be backfilled with sand and sealed with a 50 mm 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 generally as illustrated on the HyD Standard Drawings numbered H 2174.

(g) Surface Finishes. All stainless steel surfaces shall need no surface treatment or painting. All galvanised surfaces shall receive an etching primer, undercoat and two finishing coats in full gloss enamel paint of approved manufacture and applied strictly in accordance with the manufacturer's 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 in addition relate to its immediate surround so as to avoid obtrusiveness as a principal objective. 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 should be submitted for approval by Landscape Unit, HyD.

(h) Electrical Equipment. All electrical equipment shall be as specified in the electrical specification of the contract document and their layout together with the location of the pillar box and earth pit must be acceptable to the Maintenance Agent/Contractor.

2.1.2 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 200 mm x 200 mm square shall be built into the external wall, facing the energy meter to allow meter readings to be taken outside the switch room.

The designer shall inform the relevant party of the required structural opening at an

early stage.

2.1.3 Power Distribution System

The power distribution system distributes the power from the pillar box or switch room to the luminaires or pumps. It comprises cables, conduits and junction boxes etc. The system shall be designed as an integral part of the structure. Concealed conduit system shall be adopted wherever possible.

Conduits shall not be used as earthing conductors. Separate circuit protective conductor in the form of an earthing cable shall be installed for each lighting circuit.

The layout shall be as simple as possible, featuring long, straight runs, avoiding unnecessary bends and changes of direction.

Junction boxes shall be inserted at every changes 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 Main Contractor no doubt as to all requirements in relation to this installation.

Where it is absolutely unavoidable to expose conduits and junction boxes, they shall be located in logical, unobtrusive positions throughout and be painted in with 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 IEE Wiring Regulations.

2.1.4 Luminaires Arrangement

Luminaires shall be longitudinally mounted in order to reduce glare to the pedestrians to an acceptable level. In case where luminaires approved by Lighting Division, HyD to be mounted transversely due to various reasons, it is always advantageous to have them partially recessed to avoid causing excessive glare to the users. By adopting this, care should be taken to ensure that the lighting level and uniformity are not impaired.

To avoid dark spots being created due to lamp failure, the spacing between adjacent fluorescent luminaires shall not exceed 5 metres.

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

2.1.5 Electricity Supply

Each installation shall be separately metered, except where 24 hours consumer supply is not available, street lighting supply can be used as an alternative.

The application for electricity shall be made by, and in the name of, the Developer or Contractor on standard application forms available from the Power Company.

In the case of using street lighting supply, Lighting Division, HyD will issue a works order to their Contractor for the connection of supply.

2.1.6 Application for Electricity Supply and Change of Consumership

The Developer/Project office/Contractor shall be required to prepare and submit, under his name, application for electricity supply in accordance with the time schedule of the project, and be responsible for the energy cost (including, for administrative convenience, the electrical pump systems where provided) before the lighting installation is tested and accepted by the Engineer and Lighting Division, HyD.

When the lighting installation is accepted, the Contractor shall submit an application for change of name to Chief Engineer/ Lighting, Highways Department, who will endorse and forward the application to the Power Company and assume the consumership thereafter.

2.1.7 Materials and Equipment

All materials and equipment to be used for the lighting installations must be approved by Lighting Division, HyD and the Maintenance Agent/Contractor at an early stage. Designers shall refer to the Model Electrical Specification for Lighting Installations Serving Highway Structures - such as Footbridges, Subways, Covered Walkways and Escalators as shown in Appendix A, for their requirements.

2.2 DESIGN RECOMMENDATIONS FOR SUBWAYS

2.2.1 Lighting Design Standard

A maintained average illuminance at floor level of 150 lux with a uniformity, minimum to mean illuminance, not less than 0.5 shall normally be provided in the subway main barrels for long and complex subways with the length of main barrels over 30m.

For subways with length of main barrels over 30m, which were connected to railway stations or other complexes with large pedestrian flow, a maintained average illuminance at floor level of 180-200 lux with a uniformity, minimum to mean illuminance, not less than 0.5 shall be provided in the main barrels.

A maintained average illuminance at floor level of 100 lux with a uniformity, minimum to mean illuminance, not less than 0.5 shall be provided in the subway main barrels

for subways at grade or short subways with the length of main barrels not more than 30m.

On covered ramps and stairs, the maintained average illuminance shall be 50 lux and 100 lux respectively.

On uncovered ramps and stairs, the maintained average illuminance shall be 25 lux and 50 lux respectively.

A maintenance factor of 0.75 and the initial lumen (100 hours) of the lamp output shall be used in all design calculations.

2.2.2 Emergency Lighting

For subways with the length of main barrels more 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 one to six but not fewer than one to eight. The systems shall last for at least one hour.

2.2.3 Luminaires

Luminaires with energy-saving tubular fluorescent lamps (18W-58W MCF) equipped with electronic ballast with colour temperature 4,000K shall be used. They shall be mounted on the ceiling wherever possible. However for exceptionally high ceilings (greater than 4 metres) 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 ceramic discharge metal halide tubular lamps and with colour temperature 3,000K or compact fluorescent lamps with colour temperature 4,000K can be used. Bulkhead luminaires shall not be mounted higher than 3 metres. Where covers are not provided and the height of the side walls is low, street lighting luminaires with metal halide lamps at 5 m mounting height may be used. Ceramic discharge metal halide tubular lamps are adopted in order to match with white colour source used in main barrel and achieve for better colour rendering.

To maximize the available light, the luminaires should be surface mounted or partially recessed. However, wall-mounted luminaires installed less than 2.0 metres from floor level shall preferably be fully recessed to avoid the risk of injury to pedestrians. To minimize glare, fluorescent luminaires shall be installed longitudinally on, or parallel to, the major axis of the subway.

2.2.4 Decorative Lighting Fittings

Where subways located in prestigious areas such as in commercial or tourist areas, decorative lighting fittings shall be adopted for those ceiling and wall/cornice mounted fluorescent lights, pass lights, down lights and up lights in order to enhance the harmony of the environment.

2.2.5 Lighting Control

Subways located at grade level such as just under the flyover with adequate daylight contribution from both ends of the subways, the lighting in the main barrels shall be controlled by a photoelectric controller calibrated to 100 lux with an on:off ratio of 1:1.5 and a time delay of 30 seconds. This controller shall be located on the wall just under the ceiling in the middle of the subway.

For other subways, the main barrel shall be permanently energized. Where daylight at the ends of subways including staircases and ramps can be a major contributing factor in providing illumination, the artificial lighting in these areas shall be controlled by a photo-electric controller calibrated to switch on at 100 lux with an on:off ratio of 1:1.5. The controller shall be connected in parallel with a back-up time switch and a bypass switch.

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

2.3 DESIGN RECOMMENDATIONS FOR FOOTBRIDGES, ELEVATED WALKWAYS AND ESCALATORS

2.3.1 Lighting Design Standard

A maintained average illuminance at floor level of 60-80 lux with a uniformity, minimum to mean illuminance, not less than 0.3 shall normally be the target value.

A maintained average illuminance at floor level of 80-100 lux with a uniformity, minimum to mean illuminance, not less than 0.3 shall normally be the target value where footbridges are located in areas with high district brightness and large pedestrian flow.

For the main spans and ramps of uncovered footbridges, the maintained average illuminance shall be 25 lux whereas the uncovered stairs, the maintained average illuminance shall be 50 lux.

A maintenance factor of 0.75 and the initial lumen (100 hours) of the lamp output shall be used in all design calculations.

2.3.2 Footbridge Lift Lobby

There is an increasing demand for the provision of lifts for footbridges, in particular the installation of disabled lifts. The maintained average illuminance for the covered lift lobbies at floor level of the deck and the ground floor shall be 100 lux and 50 lux respectively and the lighting fittings shall be arranged close to the lift doors.

For uncovered lift lobbies, at least one cut off lighting fitting with minimum lighting level of 25 lux, preferably of low glare recessed down light if recessed door opening is

provided, wall mounted atop the lift door shall be installed for illuminating the door openings.

Lift lobby area can be regarded as the equivalent internal lift car floor area projected at the lobby.

2.3.3 Luminaires

Wherever covers are provided on footbridges and elevated walkways, it is a standard practice to install lighting and this can best be achieved by installing luminaires with energy-saving tubular fluorescent lamps (18W-58W MCF) and be equipped with electronic ballast. In order to reduce glare to the pedestrians, luminaires shall be longitudinally mounted and shall be recessed as far as possible. In case the luminaires approved by Lighting Division, HyD to be mounted transversely due to various reasons, they have to be recessed to avoid excessive glare to the users.

The colour temperature of the fluorescent tubes shall normally be 4,000K. However, where footbridges or elevated walkways are located in prestigious areas or areas with low district brightness, the colour temperature of the fluorescent tubes shall be 3,000K to create a warm environment. At these locations, cut-off lanterns shall be used to reduce glare to the public.

2.3.4 Decorative Lighting Fittings

Where footbridges, elevated walkways and escalators located in prestigious areas such as in commercial or tourist areas, decorative lighting fittings shall be adopted for those ceiling and wall /cornice mounted fluorescent lights, pass lights, down lights and up lights in order to enhance the harmony of the environment.

2.3.5 Lighting Control

The lighting shall be controlled by means of a photo-electric controller calibrated to switch on at 70 lux with an on:off ratio of 1:1.5 and a time delay of 30 seconds. The controllers shall be connected in parallel with a back-up time switch and a bypass switch. The location of photo-electric controller shall be decided on site.

Additional photo-electric controllers shall be considered to be installed for those footbridges which are partially shaded by buildings or structures. The lighting for these shaded areas shall be switched on earlier by siting the controller at the shaded areas.

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

2.4 DESIGN RECOMMENDATIONS FOR COVERED GROUND-LEVEL WALKWAYS

When a permanent cover is provided over a ground level walkway, there may be a

need to install a system of lighting. Only those with less than 5 metre headroom are worthy of consideration, and the decision to provide lighting is to be based on the location, usage and the effectiveness of any extraneous road lighting.

Luminaires with energy-saving tubular fluorescent lamps (18W-58W MCF) and be equipped with electronic ballast shall be used. Because of the absence of stairs and to minimise distraction to vehicle drivers, the average maintained illuminance shall be within the range of 35 to 50 lux with the luminaires mounted longitudinally to the walkways in order to reduce glare to the pedestrians.

The colour temperature of the fluorescent tubes shall normally be 4,000K. However, where the covered ground-level walkways are located in prestigious areas or areas with low district brightness, the colour temperature of the fluorescent tubes shall be 3,000K to create a warm environment. At these locations, cut-off lanterns shall be used to reduce glare to the public.

A maintenance factor of 0.75 and the initial lumen (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, walkways, architectural light fittings shall be considered to enhance the harmony of the environment.

2.5 DESIGN RECOMMENDATIONS FOR TEMPORARY COVERED GROUND-LEVEL WALKWAYS

These are usually associated with building development work and the lighting design is the responsibility of the Building Authority/Contractor.

A system of temporary lighting shall be provided for all covered walkways of building sites and shall be maintained in good order by the developers. The average illuminance on the floor level of the covered walkway shall be within the range of 35 lux to 50 lux.

A recommended lighting layout for a typical 2 m wide walkway with 2.5 m high cover is the installation of luminaires complete with 18W 600mm long tubular fluorescent lamps at 3 m spacing.

2.6 AS-FITTED DRAWINGS, ILLUMINANCE READINGS & TEST REPORTS

On completion of the installation, the Contractor shall submit two sets each including hard copy and soft copy/computer file at Microstation version 3D DGN format of "As-fitted" drawings comprising the lighting layouts, circuit diagrams, schematic wiring diagrams, conduit routes, cable routes and two sets each of illuminance and uniformity readings, certified electrical test reports, database in LD's required format and Operation & Maintenance Manual to Lighting Division, HyD and the Maintenance Agent/Contractor.

2.7 MODEL ELECTRICAL SPECIFICATION

A model electrical specification is given in Appendix A.

3. LIGHTING FOR COVERED PUBLIC TRANSPORT INTERCHANGES

3.1 CONSULTATION

Consultation between the Developer/Project Office/Consultant and Lighting Division, HyD is essential at all stages of design to ensure the most appropriate luminaires are used having regard to the headroom available and restrictions of ceiling space.

Normally the lighting design is the responsibility of the Developer/Project Office/Consultant. They shall also consult the Maintenance Agent/Contractor of Lighting Division, HyD on the maintenance aspects of the installation and to ascertain the quantity of spare equipment to be included in the Tender Documents. Lighting proposals with illuminance calculations, proposed luminaires, mounting details and switching arrangements prepared by the Developer/Project Office/Consultant shall be submitted to Lighting Division, HyD for approval before tenders are sought.

3.2 DESIGN STANDARDS

A maintained average illuminance at floor level of 150-170 lux with a uniformity, minimum to mean illuminance, not less than 0.2 between 0600 hour and 0100 hour the next day shall normally be the design values.

For those covered public transport interchanges connected to railway stations or complexes with large pedestrian flow, a maintained average illuminance at floor lever of 180-200 lux with a uniformity, minimum to mean illuminance, not less than 0.3 between 0600 hour and 0100 hour the next day shall be provided.

A maintenance factor of 0.75 and the initial lumen (100 hours) of the lamp output shall be used in all design calculations.

Between 0100 hour and 0600 hour, the illuminance shall be reduced to 1/3 of the above level by means of a dimmer or time-switch having a spring or battery reserve of not less than 24 hours.

The above operation times specified may be altered to suit operational need for serving the public in special circumstances.

Perimeter lights on the sides of a terminus largely exposed to daylight shall be switched off during daytime by means of photo-electric controller(s) with a switch-on value of 200 lux and an on:off ratio of 1:1.5.

The lighting design shall take into effect the provision of any light-wells. In such case, a photo-electric controller shall be incorporated to switch off the lights underneath it during a bright clear day.

3.3 LIGHTING SYSTEM

The lighting system for covered transport interchanges shall include, but not be limited to, light fittings, electrical cables connecting from the MCB boards to lighting fittings and their associated trunking and concealed conduits, MCB boards and UPS.

3.4 EMERGENCY LIGHTING

Emergency lighting complying with BS 5266 shall be installed for the covered public transport interchanges to achieve satisfactory emergency exit during normal power failure. The emergency lighting requirements and specification of the uninterruptible power supply system are given in Appendix C and Appendix D respectively.

3.5 LUMINAIRES

Depending on the mounting height, highbay or lowbay luminaires shall be used. Luminaires shall incorporate tubular high pressure xenon high pressure sodium (SON-T plus) lamps or tubular ceramic discharge metal halide lamps and be equipped with integral control gear. However, the latter lamp with white colour shall only be adopted for crowdy and prestigious public transport interchanges. For wall mounted luminaires, if required for illuminating the footway, shall be of low glare pass light or bulkhead light complying with clause A.7.3 in Appendix A of this Manual. In this case high pressure sodium, ceramic discharge and compact fluorescent lamps could also be used to match the environment.

All luminaires shall comply with BS EN 60598 and have an ingress protection (IP) rating not less than 65. High frequency electronic gear together with energy saving tubes shall be used for fluorescent luminaires for energy saving. It also gives instant starting and longer lamp life.

To reduce lighting being blocked by the vehicles, luminaires should not be mounted right above the parking areas. Each luminaire shall be rigidly fixed to the ceiling by means of a stainless steel rod and be attached with two endless stainless steel chain of diameter not less than 4 mm. Alternative mounting methods to meet special site conditions shall be submitted to Lighting Division, HyD for approval prior to installation. Wiring conduits should not be used as proper support for the luminaires.

Luminaires shall be labeled with a number plate for identification. The numbers will be assigned by the Maintenance Agent/Contractor of Lighting Division, HyD.

3.6 ELECTRICITY SUPPLY

The lighting installation shall be separately metered in order to clearly define the maintenance responsibilities.

The electricity meter and associated equipment for the installation shall preferably be housed in a switch room. Subject to the approval by the Power Company, the meter and equipment may be installed in the main switch room provided they are physically separated

from the main switchboard to facilitate maintenance.

3.7 INSTALLATION

The installation of the lighting shall be carried out in conjunction with the development and shall contractually be the responsibility of the Developer/Project Office.

All wiring shall be laid in a continuous trunking system or concealed conduit system.

The Maintenance Agent/Contractor as well as Lighting Division, HyD shall be invited to inspect and be satisfied with the installation before the same is handed over to the Maintenance Agent/Contractor for maintenance.

3.8 APPLICATION FOR ELECTRICITY SUPPLY AND CHANGE OF CONSUMERSHIP

The Developer/Project Office/Contractor shall be required to prepare and submit, under his name, application for electricity supply in accordance with the time schedule of the project, and be responsible for the energy cost before the lighting installation is tested and accepted by the Engineer and Lighting Division, HyD.

When the lighting installation is accepted, the Contractor shall submit an application for change of name to Chief Engineer/ Lighting, Highways Department, who will endorse and forward the application to the Power Company and assume the consumership thereafter.

In order to avoid abuse of the PTI lighting by private Developer/Project Office, the initial reading on the electricity meter will be taken on a day as close to the official opening date of the PTI as practicable. Thereafter the consumership and responsibility for payment of energy charges will be transferred to Lighting Division, HyD. Upon expiry of the defects liability period, Lighting Division, HyD will delegate the maintenance responsibilities to the Maintenance Agent/Contractor.

3.9 AS-FITTED DRAWINGS, ILLUMINANCE READINGS & TEST REPORTS

On completion of the installation, the Contractor shall submit two sets each including hard copy and soft copy/computer file at Microstation version in 3D DGN format of "As-fitted drawings comprising the lighting layouts, circuit diagrams, schematic wiring diagrams, conduit/trunking routes, cable routes and two sets each of illuminance and uniformity readings, certified electrical test reports, database in LD's required format and Operation & Maintenance Manual to Lighting Division, HyD and the Maintenance Agent/Contractor.

3.10 MODEL ELECTRICAL SPECIFICATION

A model electrical specification for covered public transport interchanges lighting installation is given in Appendix B. Any materials and equipment to be used for the lighting

installation shall be subject to the approval of Lighting Division, HyD at an early stage.

4. HIGH MAST LIGHTING

4.1 GENERAL

High mast lighting is defined as a system in which each mast supports a group of luminaires at a height between 20m and 40m inclusive. 30m to 40m masts are normally used for standardisation and better utilization. This form of lighting is more expensive to install and to operate than conventional lighting. However, it can be easier to maintain without causing disruption to the traffic if it is carefully designed.

4.2 APPLICATION

The use of high mast lighting system is confined to the following areas:

(1) Large Concourses. Such as toll plazas or tunnel portal areas where conventional lighting is impracticable.

(2) Complexes. Usually grade separated interchanges or roundabouts where a higher than normal level of illuminance is considered desirable or the large number of conventional lighting columns would confuse the motorists with patterns of lanterns at different levels and impair the aesthetics.

4.3 DESIGN RECOMMENDATIONS FOR HIGH MAST LIGHTING

All high mast lighting systems must be separately metered. The lanterns for high mast lighting shall comply with BS EN 60598. They shall have an ingress protection rating (IP) not less than 65 to BS EN 60529 and be equipped with tubular high pressure xenon high pressure sodium (SON-T Plus) lamps. A maintenance factor of 0.75 and the initial lumen (100 hours) of the lamp output shall be adopted in the design calculations. Prior consultation between Consultants and Lighting Division, HyD is essential at the preliminary design stage.

An isocandela diagram of the proposed lantern, a statement of its light output ratio and isolux diagrams must be submitted to Lighting Division for approval. All data shall be based on initial lamp lumens (100 hours) at the specified voltage. An isolux diagram covering the whole scheme (preferable to a scale 1:500) must be submitted to Lighting Division for approval.

Before installation, three copies of certificates of all equipment, lighting fittings, lamps and lanterns must be submitted to Lighting Division. Equipment catalogues and manufacturers' specification relating to the proposed equipment shall be specific and shall include all information necessary for Lighting Division to help ascertain that the equipment complies with the relevant specification.

4.3.1 Large Concourses

For toll plazas and tunnel portal areas, a minimum maintained average illuminance of 50 lux with a uniformity, minimum to mean illuminance, not less than 0.4 shall be achieved.

4.3.2 Complexes

A minimum maintained average illuminance of 30 lux with a uniformity, minimum to mean illuminance, not less than 0.5 shall be provided for the main carriageways of the interchanges and roundabouts.

For slip roads, the minimum maintained average illuminance and uniformity over any 60m length of road shall be 25 lux and 0.4 respectively.

4.4 APPLICATION FOR ELECTRICITY SUPPLY AND CHANGE OF CONSUMERSHIP

The Developer/Project Office/Contractor shall be required to prepare and submit, under his name, application for electricity supply in accordance with the time schedule of the project, and be responsible for the energy cost before the lighting installation is tested and accepted by the Engineer and Lighting Division, HyD.

When the lighting installation is accepted, the Contractor shall submit an application for change of name to Chief Engineer/ Lighting, Highways Department, who will endorse and forward the application to the Power Company and assume the consumership thereafter.

4.5 AS-FITTED DRAWINGS, ILLUMINANCE READINGS & TEST REPORTS

On completion of the installation, the Contractor shall submit two sets each including hard copy and soft copy/computer file at Microstation version 3D DGN format of "As-fitted drawings comprising the lighting layouts, circuit diagrams, schematic wiring diagrams, conduit /trunking routes, cable routes and two sets each of illuminance and uniformity readings, certified electrical test reports, database in LD's required format and Operation & Maintenance Manual to Lighting Division, HyD and the Maintenance Agent/Contractor.

4.6 MODEL SPECIFICATION FOR HIGH MAST LIGHTING

A model specification for high mast lighting is given in Appendix E. Any materials and equipment to be used for the high mast lighting installation shall seek approval from Lighting Division, HyD and the Maintenance Agent at an early stage.

5. TUNNEL LIGHTIING

5.1 GENERAL

Tunnel lighting systems are frequently required to be installed for vehicular covered structures such as road tunnels, underpasses and underdecks.

The objectives of installing such lighting systems are to enable the motorists to drive at the same speed and enjoy the same degree of safety and visual comfort as on the approach roads.

The main features of tunnel lighting are the need of lighting during daytime and the lighting level within the tunnel interior can be reduced to a constant level if the tunnel is of sufficient length.

5.2 LIGHTING SYSTEM

The tunnel lighting system shall include, but not be limited to, light fittings, electrical cables connecting from the MCB boards to fittings and their associated trunking and concealed conduits, lighting fitting suspension/fixing system, MCB boards, UPS and lighting control system.

5.3 CONSIDERATION FOR SHORT TUNNEL LIGHTING

A tunnel or covered road section less than 100m in length is considered as short. One less than 25m long does not require daytime lighting to illuminate its interior. Nighttime lighting shall be switched on when the ambient lighting level falls below 1,000 lux.

If the length of a tunnel is between 25m and 100m, there are three scenarios for providing lighting to its interior in accordance with the chart as shown in table 4, (i) no daytime lighting for the most favourable situation, (ii) limited daytime lighting for the medium favourable situation, and (iii) 50% normal threshold zone lighting requirement for the least favourable situation.

The limited daytime lighting shall be 15cd/m^2 in the threshold zone and be switched on when the ambient is below 5,000 lux and switched off when the nighttime lighting is turned on.

For the more stringent situation with such a short tunnel, a 50% of the threshold zone daytime lighting shall be installed to eliminate the black hole effect. The control of the boost lighting shall be set at stages no more than 5 times the previous lighting level to ensure smooth transition. Typical ambient settings are at below 5,000 lux, 5,000-25,000 lux, 25,000 or above in case photoelectric controller is used, with 15 cd/m^2 being maintained at below 5,000 lux until the nighttime lighting is turned on.

5.4 DESIGN STANDARDS

The design of tunnel lighting systems shall be generally in compliance with the following standards/publications stipulated in order of preference:

(1) This Public Lighting Design Manual.

(2) CIE 88:2004 – Technical Report : Guide for the lighting of Road Tunnels and Underpasses (Hereinafter referred to as CIE 88:2004).

(3) BS 5489-2 : 2003 - Part 2 : Lighting of Tunnels.

(4) Transport Planning & Design Manual, Volume 11, Chapter 6 – Lighting, published by Transport Department, Hong Kong.

In cases of conflict among these technical documents, the one with higher preference shall take precedence over the lower.

5.5 STOPPING SIGHT DISTANCE

The stopping sight distance 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 stopping sight distance is a function of design speed as shown in Table 1. These values of stopping sight distance shall be adopted unless there are extra demands being 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;

(b) There is a mixture of slow and fast vehicles;

Under these circumstance, the stopping sight distance corresponds to the next higher design speed in the Table shall be adopted.

5.6 DAYTIME LIGHTING

Tunnel lighting is most critical during daytime. Adequate lighting must be provided in the interior to enable the users passing through the passage comfortably and safely, and to effect smooth flow of traffic.

In designing tunnel lighting systems, it is necessary to consider lighting requirements for the five lighting zones:

(1) Access Zone. The access zone is that part of the road leading to the tunnel entrance, from where a driver should be able to see clearly into the tunnel.

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 stopping sight distance and with the expression :

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

or

$$L_{20} = \frac{aLs + bL_R + cL_E}{1 - dk}$$

Where Ls = sky luminance; a = % of sky

L_R = road luminance; b = % of road

L_E = surrounding luminance; c = % of surroundings

L_{th} = first 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 year.

(2) Threshold Zone. The threshold zone is the first stretch of the tunnel interior. Its length must be at least equal to the stopping sight distance corresponding to the design 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 stopping sight distance from the portal are capable of seeing clearly into the tunnel.

The required maintained average road surface luminance over the first half of the threshold zone $L_{th} = kL_{20}$. The values of k for symmetrical lighting system and for various design speeds are given in Table 2. The lighting level for the other half of the threshold zone may gradually and linearly decrease to 0.4 L_{th} at the end of the threshold zone.

The reduction of lighting level over the last half of the threshold zone can be effected in steps. The luminance ratio between successive steps shall not exceed 3:1 and the lighting level shall not fall below the curve.

(3) Transition Zone. Having passed through the threshold zone, the motorists become adapted to the lower luminance environment. The lighting level can be gradually reduced towards the interior zone. The luminance ratio between successive steps shall not exceed 3:1 and the lighting level shall not fall below the curve illustrated in Fig. 6.6 of CIE 88:2004.

The end of the transition zone is determined by the lighting level that has been dropped to three times the lighting level in the interior zone.

(4) Interior Zone. The lighting level in the interior zone is constant. The recommended lighting levels in the interior zone for various design speeds are given in Table 3.

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.

(5) 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 over the last 60m of the tunnel shall be 5 times the level of the interior zone.

5.7 NIGHTTIME LIGHTING

Nighttime lighting is usually achieved by the operation of continuous row(s) of fluorescent lamps over the whole length of the tunnel. Consideration may be given for the use of electronic control gear to dim the tubes to the required lighting levels.

The recommended daytime and nighttime lighting requirements for various design speeds for long tunnel, underdeck without sidewalls, underpass and noise enclosure as well as the emergency lighting requirements for long tunnel and noise enclosure exceeding 200m long are given in Table 3.

Where daylight screens are installed, the nighttime lighting system shall be extended to the area covered by the daylight screens.

5.8 LUMINANCE OF THE WALLS

The walls in a tunnel form an important background in revealing objects. Walls lined with higher reflectance materials would give more inter-reflected light.

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

5.9 UNIFORMITY

Uniformity shall be considered as it would affect visual comfort and road safety.

An overall uniformity, minimum to average luminance, 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, minimum to maximum luminance, of 0.6 on the road

surface along the centre of each lane for all zones and all lighting stages shall be achieved.

5.10 GLARE CONTROL AND AVOIDANCE OF FLICKER

5.10.1 Glare Control

Glare must be minimized as it reduces visibility. Threshold increment (T.I.) is used as a measure of disability glare. The threshold increment shall not exceed 15% for all zones and lighting stages except the exit zone during daytime. Threshold increment is calculated by the expression:

$$T.I. = 65\ Lv / (L/MF)^{0.8} \quad \text{for } L \leqq 5\ cd/m^2$$

or $$T.I. = 95\ Lv/(L/MF)^{1.05} \quad \text{for } L > 5\ cd/m^2$$

Where Lv = veiling luminance created by all luminaires,

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

MF = maintenance factor.

5.10.2 Avoidance of Flicker

Flicker effects may be created by discontinuous rows of luminaires or by daylight screens, causing visual discomfort to the motorists.

Critical flicker frequencies between 2.5 and 15 Hz should be avoided as they disturb the tunnel users.

Flicker effect is negligible if the distance between the flashed areas of adjacent luminaires is less than the length of each flashed area.

Flicker frequency (Hz) is calculated by dividing the speed (m/s) by the luminaire spacing (m).

5.11 EMERGENCY LIGHTING

Emergency lighting is required for long tunnels to allow for evacuation during normal power failure. The essential power shall be fed by uninterruptible power supply (UPS) system(s) connected to a generator installed for the tunnel. A minimum maintained road surface luminance as shown in Table 3 shall be provided for at least 30 minutes for the whole tunnel during daytime or nighttime.

5.12 BI-DIRECTIONAL TRAFFIC

For manned tunnels, sometimes they are operated in bi-directional mode. Under this condition, the driving speed of both traffic directions within the same tube is normally reduced. Accordingly, tunnel lighting shall be designed at the reduced speed for both traffic directions taking into account of the lighting contribution from the opposite traffic direction.

5.13 POWER SUPPLIES AND DISTRIBUTION CABLES

All tunnels shall be separately metered. The power supply for long tunnels shall be taken from two independent power sources, each one feeds about half of the lighting load. In the event of one supply fails, the remaining one shall be able to feed the whole lighting load through switching. Manual and automatic switching modes shall be provided.

All distribution cables shall be protected from fire and mechanical damage and shall be of copper conductor, low smoke halogen free type.

5.14 DESIGN PARAMETERS & CRITERIA

The recommended design parameters and criteria are given in Table 5.

5.15 LIGHTING CONTROL SYSTEM

5.15.1 General

The access zone luminance varies with outdoor lighting conditions. For effective energy management, it is necessary to control automatically the lighting level inside the tunnel in accordance with the variation with the access zone luminance. The switching of lighting can be implemented in stages. At least 6 lighting stages shall be provided for long tunnels. The preferred reduction of luminance between successive stages should not be 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 controller and associated control and indicating accessories. For manned tunnels, additional facilities shall be provided as detailed in Transport Planning and Design Manual, Volume 11, Chapter 6 – Lighting.

In general, the use of photo-electric controllers in lieu of luminance meters may be accepted for short tunnels.

5.15.2 Luminance Meters

Luminance meters shall normally be used to sense the variation in access zone luminance. The measurements are made by the meters admitting 20^{o} angular field of view. They should be placed at the stopped sight distance from the tunnel portal and mounted at not less than 5.1 metre clear height to avoid vandalism and pollution.

The housing of the measuring device shall be adjustable to give suitable aiming angles at the entrance and be made of extruded aluminium or stainless steel with ingress protection rating not less than 55. The meters shall be equipped with a heating control system to ensure absence of moisture to obtain accurate measurement results. They shall be able to operate at a temperature range between $-5^{o}C$ to $50^{o}C$.

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

5.15.3 Tunnel Lighting Control Console

A tunnel lighting control console shall be installed inside a room, normally the control room, for the operation of the tunnel lighting system. The power supply for the control console shall be fed by the UPS with at least 60 minutes battery back up.

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

(a) key operated selector switches for selecting remote manual operation or automatic operation mode;

(b) push-buttons for the manual operation of each lighting stage; and

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

5.15.4 Control and Indication Units

A microprocessor-based dual controller shall be installed for controlling the lighting level in accordance with the signals sensed 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 :

(1) Control Function

(i) Under the automatic operation mode, the appropriate lighting stages are automatically selected in accordance with the signals detected by the luminance meters. The selection is performed by switching selected groups of luminaires, giving the required lighting level for each zone.

(ii) Under remote manual operation mode, it overrides the stage selection made by the controller. The lighting stage can be changed sequentially by pressing the manual push-button.

(iii) Under local manual operation mode, the individual lighting stages can

be controlled through their respective local control panels to facilitate maintenance. Each panel shall be equipped with a control overrides the remote control and vice versa. The panels shall only be accessible by the authorised maintenance staff.

(iv) Prior to changing from remote manual operation to automatic operation mode, the manually selected lighting stage must be changed to coincide with the stage selected by the controller.

(v) Provision of delay on adjustable from 0.5 to 5 minutes and delay off adjustable from 10 to 20 minutes for each lighting stage.

(vi) Upon detection of faulty luminance readings, the readings from the adjacent luminance meter shall be adopted for controlling the lighting.

(vii) Where no adjacent luminance meter is installed or the luminance meter system is completely failed, it will automatically switch over to a preset lighting level.

(viii) For fluorescent luminaires without light regulating ballasts, facility shall be provided to exchange the operation of the tubes every 24 hours in order to equalize lamp life.

(2) Indication Function

(i) Digital indication of real time access zone and first threshold zone luminance measured by the luminance meters.

(ii) Lamp indicators with lamp test facilities to indicate the activated stage and the status of all lighting circuits.

(iii) Lamp indicators with lamp test facilities to indicate the selected control mode (remote manual, local manual or automatic), traffic operation mode (uni-directional or bi-directional).

(iv) Alarm indications for faulty luminance meters and mismatch of activated contactors against the selected lighting stage.

(3) Data Storage and Retrieval

Facilities shall be provided for data storage at regular intervals and subsequent on line retrieval and report generation of the following information for at least two months:

(i) lighting stages at each tunnel portal

(ii) luminance readings at each tunnel portal and at each first threshold zone.

(iii) alarms with date and time.

(4) Additional Facilities for Manned Tunnels
For manned tunnels, the status of all lighting circuits shall be displayed on a mimic 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 the Central Monitoring and Control system (CMCS). Additional facilities shall be provided as detailed in Transport Planning and Design Manual, Volume 11, Chapter 6 – Lighting.

5.16 LAMPS

5.16.1 Low Pressure Sodium Lamps

Due to poor colour rendering, low pressure sodium lamps shall not be used for illuminating tunnels.

5.16.2 High Pressure Sodium Lamps

Tubular high pressure xenon high pressure sodium (SON-T Plus) lamps shall normally be used for the threshold, transition and exit zones which demand for relative high lighting levels.

5.16.3 Fluorescent Lamps

Fluorescent lamps give very uniform light distribution. Energy-saving fluorescent lamps shall be used for the interior zone and nighttime lighting. As the lumen output is low, the formation of appropriate continuous lines of luminaires would aid visual guidance and alleviate the flicker problem.

5.16.4 Minimum Initial Lumens

The minimum initial lumens (100 hours) for the SON-T Plus and fluorescent lamps are given in Table 12.

5.17 LUMINAIRES

5.17.1 General

(a) Generally, fluorescent luminaires in continuous row shall be used for interior zone and nighttime lighting whereas high pressure sodium luminaires shall be used for reinforcement lighting in threshold, transition and exit zones.

(b) Luminaires shall have symmetrical lighting distribution in the axial plane. Provided approval has been given by Lighting Division, HyD for a particular

lighting scheme, counterbeam lighting system shall not be adopted.

(c) Luminaires shall be specifically designed for use in vehicular tunnels. They shall comply with BS EN 60598 with an ingress protection (IP) rating not less than 65 as stated in BS EN 60529.

(d) Luminaire bodies shall be made from extruded aluminium alloy of 2.5 mm minimum thickness. They shall be fitted with anodised high purity aluminium reflectors.

(e) The front panels shall be glazed with high thermal resistant toughened glass of 5mm minimum thickness. They shall be capable of being opened without using any tools and be suspended from the luminaires in open position to facilitate maintenance.

(f) Control gear shall be mounted on removable gear trays made from heavy aluminium alloy, which are fitted with a plug and socket. It shall be suitable for continuous operation.

(g) The internal wiring of the luminaires shall be of heat resisting cables sheathed with low smoke halogen free material.

(h) Luminaires shall be provided with radio interference suppression and shall comply with BS EN 55015.

(i) No external power factor correction shall be required to bring the power factor to satisfy with Power Companies' requirements.

(j) Luminaires shall be connected to alternate electrical circuits to maintain partial lighting in an area in the event of failure occurring on one circuit.

(k) A fuse or miniature circuit breaker unit shall be fitted in the gear tray for each lamp.

5.17.2 High Pressure Sodium Luminaires

High pressure sodium luminaires shall be fitted with superimposed pulse ignitors mounted within the gear trays.

5.17.3 Fluorescent Luminaires

High frequency electronic gear shall be used for fluorescent luminaires for energy saving and to facilitate dimming of fluorescent lamps, if required. It also gives instant starting and longer lamp life.

5.18 ENERGY CONSIDERATIONS

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 charges:

(1) Daylight contribution. For tunnels installed with glazed panels or their geometry admit large amount of daylight, consideration should be given to take into account the daylight contribution into the tunnels.

(2) 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 facade such as hydro-seeding and grassing.

(3) Lighting Control Stages. The access zone luminance varies during the day and the year. Ideally, the first threshold zone luminance L_{th} should be a constant percentage of the access zone luminance. This demands for many lighting stages for controlling the first threshold zone lighting. A minimum of 6 lighting stages shall be provided for long tunnels.

(4) Dimming of Fluorescent Tubes. Dimming of fluorescent tubes should be considered for the interior zone and nighttime lighting for long tunnels. Energy-saving high frequency electronic control gear is normally used to perform the dimming function but attention shall be paid for radio interference suppression.

(5) Daylight Screens. Daylight screens may be considered to be constructed at the tunnel entrances to create an artificial access zone in order to save energy. The screens, erected immediately outside the entrances to the tunnel, 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, if provided, are considered as part of the tunnel.

5.19 LIGHTING DESIGN SUBMISSION

All lighting designs must be submitted to Lighting Division, HyD and the Maintenance Agent/Contractor 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 of :

(i) Length of each lighting zone;

(ii) Access zone luminance using perspective drawings/sketches taking into account of site conditions;

(iii) Maintained average luminance on the road surface and tunnel walls up to 2m high for all zones and all lighting stages;

(iv) Overall uniformity and longitudinal uniformity on the road surface for all zones and all lighting stages;

(v) Glare control for all zones and all lighting stages, except exit zone during daytime;

(vi) Avoidance of flicker for all zones and all lighting stages;

(vii) Luminance settings of each lighting stage;

(viii) Emergency lighting;

(f) Luminance diagrams showing the highest lighting levels in each lighting zone; and

(g) Lighting schedule summarizing the luminance level, overall uniformity, longitudinal uniformity and glare for all zones and all lighting stages.

Computer printouts shall be provided for items (iii) to (v) and (viii) listed above.

5.20 STATUTORY STANDARDS

All materials and equipment supplied by the Contractor shall be in accordance with the appropriate Standard Specifications and be approved by Lighting Division, HyD and the Maintenance Agent/Contractor at an early stage. The whole installation works shall comply with the current editions of the "Code of Practice for the Electricity (Wiring) Regulations" issued by the Electrical & Mechanical Services Department, the "General Specification for Electrical Installation in Government Buildings of the Hong Kong Special Administrative Region" issued by Architectural Services Department, the IEE Wiring Regulations issued by the BSI and the local Power Company's "Supply Rules".

5.21 SPARE EQUIPMENT

For ease of maintenance, 10% each of the installed luminaires, 100% of the installed luminance meter and 1 programmable logic controller and other spare parts shall be provided and delivered to the respective Maintenance Agent/Contractor by the Contractor as spares before handing over lighting installation to Lighting Division for maintenance.

The exact quantities of spares will be advised by the Maintenance Agent /Contractor.

5.22 APPLICATION FOR ELECTRICITY SUPPLY AND CHANGE OF CONSUMERSHIP

The Developer/Project Office/Contractor shall be required to prepare and submit, under his name, application for electricity supply in accordance with the time schedule of the project, and be responsible for the energy cost before the lighting installation is tested and accepted by the Engineer and Lighting Division, HyD.

When the lighting installation is accepted, the Contractor shall submit an application for change of name to Chief Engineer/ Lighting, Highways Department, who will endorse and forward the application to the Power Company and assume the consumership thereafter.

5.23 AS-FITTED DRAWINGS, TEST REPORTS AND SOFTWARE PROTOCOLS

On completion of the installation, the Contractor shall submit two sets each including hard copy and soft copy/computer file at Microstation version in 3D DGN format of "As-fitted" drawings comprising the lighting layouts, circuit diagrams, schematic wiring diagrams, conduit/trunking routes, cable routes and two sets each of luminance/illuminance readings, uniformity, certified electrical test reports, database in LD’s required format and Operation & Maintenance Manual to Lighting Division, HyD and the Maintenance Agent/Contractor.

The design logic flow chart and associate software protocols of the programmable logic controller shall also be submitted to Lighting Division, HyD and the Maintenance Agent/Contractor after commissioning and testing.

6. LIGHTING FOR NOISE ENCLOSURES

6.1 GENERAL

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

Lighting Designer should work closely with the enclosure designer at early stage to establish the form of structure with due consideration of daylight contribution into the enclosure with a view to eliminating daytime lighting requirement. Consideration should also be taken on the selection of glazing materials, spacing, sizing and location of glazing, etc. Explanations and detailed justifications have to be provided to Lighting Division, HyD in case artificial daytime lighting is unavoidable.

6.2 DESIGN STANDARDS

The design of noise enclosure lighting systems, where applicable, shall be generally in compliance with the following standards/publications stipulated in order of preference:

(1) This Public Lighting Design Manual

(2) CIE 88:2004 – Technical Report : Guide for the lighting of Road Tunnels and Underpasses (Hereinafter referred to as CIE 88:2004).

(3) BS 5489-2: 2003 Part 2 : Lighting of Tunnels.

(4) Transport Planning & Design Manual, Volume 11, Chapter 6 – Lighting, published by Transport Department, Hong Kong.

In cases of conflict among these technical documents, the one with higher preference shall take precedence over the lower.

6.3 UNIFORMITY, GLARE AND FLICKER EFFECTS OF DAYLIGHT PENETRATION

Adequate uniformity of lighting should be striven for to avoid glare and flicker effects, which reduce the ability of motorists to observe the road conditions in a noise enclosure.

Skylights are best to be uniformly distributed in more or less horizontally and longitudinally 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 will never offer the necessary uniformity and illumination for the central lanes as compared to skylights. Hence, skylights are the best type of openings for daylight.

The use of diffuse glazing materials will ensure a uniform illumination on road surface and will avoid hard shadows of opaque elements from the enclosure structure especially during periods with the sun in a clear sky. Diffused translucent glazing panel for skylight opening should be adopted for daylight design of noise enclosure to avoid shadows.

Hard shadows caused by sunlight through windows have to be softened by diffusing skylights, in particular at the center length of the enclosure. The same can be made effective by using translucent windows for the upper part above the visual field of drivers. In case of existence of substantial length of opaque element which can be a source of flicker, use of translucent windows at both upper and lower parts shall be required. Coloured glazing materials should be avoided as far as possible.

6.4 DETAILD DESIGN FOR NOISE ENCLOSURE LIGHTING

The first step in the design is to identify the need of skylight or window according to the principles of tunnel lighting for a particular noise enclosure. If the section of enclosure is less than 25 metres in length, tunnel lighting approach will not be necessary for the daytime. Daylight penetrating from both ends of the enclosure or from the side windows will provide sufficient lighting level for safe operation but normal provision of lighting at night will still be necessary.

For noise enclosure between 25m and 100m in length, it is still unlikely that daytime lighting is necessary. But a double checking has to be performed to ensure either (i) the daylight factor is greater or equal to the k value in Table 2, or (ii) if the daylight factor is below the requirement, the same approach for provision of daytime lighting in accordance with Table 4 shall be applied.

If the enclosure in question is a full enclosure, glazing areas shall be considered at the roof and on the sidewalls. Having included the provision of roof glazing and windows on the sidewalls, checking on the level and distribution of illuminance together with the effect of flickering due to structural elements and position of glazing panels shall be carried out.

The basic criteria is to ascertain that the daylight factor of the noise enclosure is equal to or greater than the k value required by the tunnel lighting as stipulated in Table 2, which is to avoid provision of boost lighting during daytime.

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

$$Sf \times \frac{As}{Ar} \times Ts \times MFs + \frac{Apw}{Aen} \times Tpw \times MFw \times D \quad \ldots\ldots (1)$$

where
- Sf = Sky Factor (see Table 7)
- As = Area of skylights)
- Apw = Area of sidewall noise panels) Both including frame factor
- Ar = Area of roof
- Aen = Area of noise enclosure (roof + sidewalls)
- Ts = Skylight transmittance
- Tpw = Wall panel transmittance

D = Shade factor for side window

MFs and MFw are maintenance factors of skylight and wall panel respectively as per Table 9.

D is shade factor which is normally assumed to be 0.5 for side window where there is no obstruction whereas the values as shown on Table 8 shall be applied for a continuous row of high rise building in close proximity to the side panels/ opening of the noise enclosure. Caution should be taken to add two shade factors on both sides of the enclosure before applying to formula (1) above.

The above formula works well when the noise enclosure configuration is up to width to height ratio of 3. For width to height ratio greater than 3, the factor 2/3 can safely be used as the sky factor in the formula (1).

where γ is the angle of elevation of the obstruction (see illustration on Fig. 1)
ρ is the average reflectance of the obstruction

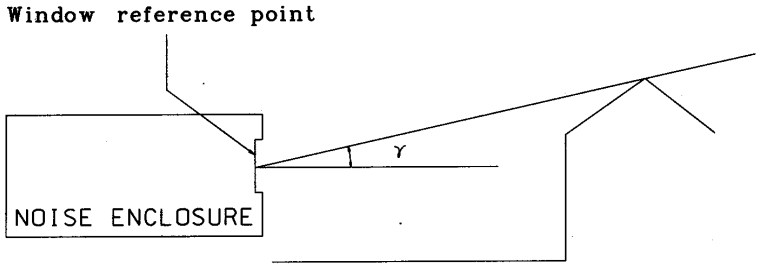

Figure 1. Angle of obstruction to noise enclosure

In case the calculated daylight factor greater than k value is established, a lighting system which only caters for the nighttime as well as during dusk, dawn and inclement weather conditions, to be switched on at 1,000 lux with on:off ratio 1:1.5 and an inherent delay of approximately 30 seconds shall be provided. The lighting level shall be in accordance with Table 3 of this Manual for nighttime lighting. In the event that there are shadows cast onto the noise enclosure by external structures, photo-electric controllers shall be installed at these locations to ensure adequate switching of the lighting system.

In case every effort has been made that the arrangement of glazing panels still cannot provide sufficient daylight exceeding the k value to the enclosure at the entrance, artificial boost lighting should be provided to cover the shortfall.

6.5 DAYTIME LIGHTING

Daytime lighting is only required when the need for tunnel lighting is identified as referred to clause 5.3 of this Manual and where the provision of glazing panels cannot

provide sufficient daylight exceeding the k value as stated in clause 6.4.

The lighting design shall follow the same principles of tunnel lighting as stated in clause 5.6 taking into account the daylight contribution into the structures. The amount of daytime lighting shall be the deficiency of that provided by skylight.

6.6 NIGHTTIME LIGHTING

As far as possible, tubular high pressure xenon high pressure sodium (SON-T Plus) lamps shall be used for nighttime lighting for economic reason. Continuous fluorescent lamps may be used where the available mounting height is exceptionally low that it is difficult to obtain the required uniformity by using SON-T Plus lamps. In this case, the fluorescent luminaries shall be equipped with dimmable electronic ballast to dim the tubes to the required lighting level.

The recommended nighttime lighting requirements for various stopping sight distances are given in Table 3.

6.7. UNIFORMITY AND GLARE CONTROL

The requirements for uniformity and glare control shall be same as those for tunnel lighting as stipulated in clauses 5.9 and 5.10.

6.8 AVOIDANCE OF FLICKER

Flicker effects may be created by discontinuous rows of glazing area in the sidewalls or roof of noise enclosures. Critical frequencies between 2.5 and 15 Hz should be avoided because they disturb motorists passing the enclosures. Flicker frequency (Hz) is calculated by dividing the speed in metres/second by the spacing of the light transmitting glazing area. The use of diffused translucent glazing panels will greatly eliminate shadows on the road surface.

6.9 EMERGENCY LIGHTING

Emergency lighting might be required subject to agreement with Lighting Division, HyD for enclosures to allow for evacuation during power failure. Where required, the essential power shall be fed by uninterruptible power supply (UPS) systems. A minimum maintained road surface luminance as shown in Table 3 shall be provided for at least 30 minutes. Emergency lighting is not required if the length of enclosure is less than 200 metres and the exit can be seen at the stopping sight distance.

6.10 BI-DIRECTIONAL TRAFFIC

When noise enclosures are operated in bi-directional mode, lighting contribution from the opposite traffic direction may be taken into account if the lighting is not blocked by the

vehicles.

6.11 POWER SUPPLIES AND DISTRIBUTION CABLES

The provision shall follow the guidelines recommended for tunnel lighting design as referred to Clause 5.13.

6.12 DESIGN PARAMETERS AND CRITERIA

The recommended design parameters and criteria are given in Table 6.

6.13 LIGHTING CONTROL SYSTEM

For effective energy management, it is necessary to control automatically the lighting inside the enclosure. Nighttime lighting systems should be controlled by the photo-electric controllers to be switched on at 1,000 lux with on:off ratio 1:1.5 and an inherent delay of 30 seconds. If there are shadows cast onto the noise enclosure by external structures, photo-electric controllers shall be installed at these locations to ensure adequate switching of the lighting system.

Daytime lighting systems, if provided, should be controlled in accordance with the tunnel lighting control system as detailed in clause 5.15.

6.13.1 Lighting Control Panel

A lighting control panel made of stainless steel shall be installed inside a pillar box or in a room off the enclosure for the operation of the nighttime lighting system. In case emergency lighting is required, the power supply for the control panel should be fed by the UPS system with at least 30 minutes battery back up time.

6.14 LAMPS AND LUMINAIRES

The requirements for the lamps and luminaries shall be as specified for the tunnel lighting as referred to clauses 5.16 and 5.17.

6.15 LIGHTING DESIGN SUBMISSION

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

The submission shall include the following technical information:

(1) Technical information, where applicable, required for tunnel lighting design submission as referred to clause 5.19. 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;

(2) Calculation for eliminating the need for daytime lighting;

(3) Drawings showing sizes and positions of the glazing on walls and ceilings taking into account of the avoidance of flicker; and

(4) Calculations for avoidance of flicker effect.

6.16 STATUTORY STANDARDS

All materials and equipment supplied by the Contractor shall be in accordance with the appropriate Standard Specifications and be approved by Lighting Division, HyD and the Maintenance Agent/Contractor at an early stage. The whole installation works shall comply with the current editions of the "Code of Practice for the Electricity (Wiring) Regulations" issued by the Electrical & Mechanical Services Department, the "General Specification for Electrical Installation in Government Buildings of the Hong Kong Special Administrative Region" issued by Architectural Services Department, the IEE Wiring Regulations issued by the BSI and the local Power Company's "Supply Rules".

6.17 SPARE EQUIPMENT

For ease of maintenance, 10% each of the installed luminaries, 100% of the installed luminance meter and 1 programmable logic controller and other spare parts shall be provided and delivered to the respective Maintenance Agent/Contractor by the Contractor as spares when handing over the lighting installation, not withstanding the fact that the installation may still be within the contractual maintenance liability period.

The exact quantities of spares will be advised by the Maintenance Agent /Contractor.

6.18 APPLICATION FOR ELECTRICITY SUPPLY AND CHANGE OF CONSUMERSHIP

The Developer/Project Office/Contractor shall be required to prepare and submit, under his name, application for electricity supply in accordance with the time schedule of the project, and be responsible for the energy cost before the lighting installation is tested and accepted by the Engineer and Lighting Division, HyD.

When the lighting installation is accepted, the Contractor shall submit an application for change of name to Chief Engineer/ Lighting, Highways Department, who will endorse and forward the application to the Power Company and assume the consumership thereafter.

6.19 AS-FITTED DRAWINGS, TEST REPORTS AND SOFTWARE PROTOCOLS

On completion of the installation, the Project Office shall submit two sets each including hard copy and soft copy/computer file in Microstation version 3D DGN format of “As-fitted" drawings comprising the lighting layouts, circuit diagrams, schematic wiring diagrams, conduit routes, cable routes etc. and one set each of luminance/illuminance readings, uniformity, certified electrical test reports, database in LD’s required format and Operation and Maintenance Manual to Lighting Division, HyD and the Maintenance Agent/Contractor.

The design logic flow chart and associated software protocols of the programmable logic controller shall also be submitted to Lighting Division, HyD and the Maintenance Agent/Contractor after commissioning and testing.

7. GANTRY AND DIRECTIONAL SIGN LIGHTING

7.1 GENERAL

The Transport Planning and Design Manual (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 A must be directly illuminated by their own source of illumination. Clause 3.2.5.5 also states that for external lighting of signs, illumination shall be to BS 873: Part 5 (latest version). In particular, the mean luminance of the white portion of a new sign shall be between 45 and 75 cd/m^2.

7.2 DESIGN STANDARDS

Following Clause 7.1, the low side of the above luminance standard shall be adopted in normal cases, especially for those signs situated at low ambient lighting level locations. The high side of the above standard shall only be required at locations where the ambient lighting level is very high.

The design and installation of the lighting system shall generally be in compliance with the current edition of the following standards/publications:

1. Code of Practice for the Electricity (Wiring) Regulations.
2. General Specification for Electrical Installation in Government Buildings of the Hong Kong Special Administrative Region.
3. IEE Wiring Regulations.
4. Transport Planning and Design Manual- Published by Transport Department.
5. BS 873- Road Traffic Signs and Internally Illuminated Bollards.
6. BS EN61167: 1995 - for Metal Halide Lamps.
7. BS 559 –Specification for Design, Construction and Installation of Signs.

7.3 DESIGN CALCULATIONS

A. Recipe Method

The calculation of average luminance on the sign plate is complicated. To simplify the design task, a recipe method as shown on the attached Table 21 can be adopted.

B. Computer Calculation

Alternatively, design using supplier's software is also acceptable.

The general conversion formula: $Lav = \frac{0.3 \times Eav}{\pi}$ can be used as a design method, where:

Lav = Average luminance (cd/m^2) of the white portion of the class 1 retroreflective sign plate.

Eav = Average illuminance (Lux) of the corresponding white portion of the sign plate.

And 0.3 is the reflective factor of the white portion of the class 1 retroreflective sign plate under the specific mounting configuration as described in Clauses 7.4.1 and 7.4.2.

7.4 LANTERN ARRANGEMENT

7.4.1 Lantern Arrangement for Roadside Directional Signs

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

Lanterns for roadside directional signs are usually top mounted with normally 1.5m bracket arm projection. For signs with height higher than 4m, additional bottom mounted lanterns as shown in Table 21 are required to illuminate the lower part of these signs. However, to avoid collision by the pedestrians or cyclists, care should be taken to allow adequate clearance when they are installed over a footpath. In such case, both the sign plate and the bracket arm or any part of the lighting installation shall provide a minimum vertical clearance of 2.5m to the footpath. In the event that the combination of top and bottom mounted arrangement is not feasible, single top mounting shall be adopted. The number of fittings can be determined by the computer calculation method as detailed in clause 7.3 (B) with the selection of suitable lanterns.

7.4.2 Lantern Arrangement for Gantry Signs

Lanterns for gantry signs are usually bottom mounted evenly along the catwalk. They shall be mounted far away from the sign plate to achieve better uniformity. For gantry signs with supplementary sign faces and total height higher than 4m, additional bottom mounted lanterns or higher rating of lamps shall be provided for both the upper and bottom sign plates. The arrangement of lantern and the wattage of lamp used is shown in Table 21.

7.5 MODE OF OPERATION

Gantry sign and roadside directional sign lighting shall be controlled by means of a photo-electric controller calibrated to switch on at 55 lux with an on:off ratio of 1:1.5. This can usually be achieved by connection to the street lighting circuit. However, if a gantry sign or roadside 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.

7.6 LUMINAIRES

Lanterns shall be of sound and robust construction to the current edition of BS EN 60598-2-3. They shall be equipped with colour temperature 3,000K tubular ceramic discharge metal halide lamps, or equivalent lamps approved by Lighting Division, of 70W, 100W (if available), 150W and shall be suitable for 220V, 50 Hertz single phase supply. The power density of the luminaire used shall not be more than $4W/m^2/100$ lux.

Lanterns and the integral control gear shall have a minimum environmental protection class not less than IP65 in accordance with BS EN 60529.

The minimum initial lumens (100 hours) for the Ceramic MBI lamps are given in Table 12.

Each gantry and directional sign lantern shall be protected by an individual miniature circuit breaker (MCB). The MCB board and switch-fuse shall be housed inside a stainless steel enclosure to IP55. Separate earth continuity conductors shall be installed in accordance with the Code of Practice for the Electricity (Wiring) Regulation or the IEE Wiring Regulations.

Each gantry and directional sign lantern should be adjusted on site in respect of the tilting angles, position etc. in order to provide optimum luminance and uniformity for the gantry and directional signs.

7.7 MOUNTING DETAILS

The mounting details of the roadside directional sign lights and gantry sign lights shall be in accordance with Lighting Division's Standard Drawings, and relevant HyD Standard Drawings together with current amendments.

7.8 ELECTRICITY SUPPLY

For gantry and directional signs lighting to be switched on round the clock, the Consultants/Project Offices are required to arrange the 24 hour supply as appropriate.

For other sign lighting operated by photo-electric controller, they shall be connected to the street lighting supply.

7.9 INSPECTION

Lighting Division, HyD and the Lighting Division's Contractor shall be invited to inspect the lighting installation and be satisfied with the installation before the same is handed over to Lighting Division, HyD for maintenance.

7.10 SPARE PARTS

For ease of maintenance, 10% each (Minimum one No.) of the installed luminaires

and MCB units, and other spares shall be delivered to the Lighting Division's Contractor by the Project Office before handing over the lighting installation to Lighting Division, HyD for maintenance.

7.11 AS-FITTED DRAWINGS & LUMINANCE/ ILLUMINANCE READINGS

On completion of the installation, the Project Office shall submit two sets each including hard copy and soft copy in Microstation version 3D DGN format of "As-fitted " drawings comprising the lighting layouts, circuit diagrams, conduit routes, and one set of luminance/illuminance readings, certified electrical test reports, database in LD's required format and Operation and Maintenance Manual to Lighting Division, HyD and the Lighting Division's Contractor.

8. ROAD LIGHTING

8.1 GENERAL

The main function of a road lighting installation is to provide visual conditions for the speedy, yet safe and comfortable movement of road users during nighttime. Road lighting shall reveal all the features of the road and traffic that are important to all users including pedestrians, cyclists and drivers. Lighting installation shall be of pleasing appearance by both day and night and their effect on environment shall also be considered.

The general approach to the design of lighting for roads is based on the luminance concept. In the application of luminance concept, the objective is to provide a bright road surface background against which objects are seen in silhouette. It therefore uses luminance level, uniformity of road surface and glare control as quality criteria. However, when it comes to visual tasks at close distance such as in conflict areas, pedestrian and cyclist traffic, they may not be seen in silhouette but rather by directly reflected light. Furthermore, in congested traffic conditions, much of the view of the road surface may have been obstructed by vehicles and thus cannot provide a background for revealing objects. 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.

The basic principles and lighting classes for road lighting in Hong Kong are referencing to the British version of the European Standards, i.e. BS EN 13201:2003, (Road Lighting—Part 2 : Performance Requirements). The latest standard has introduced a greater range of lighting classes and has a flexible approach to the selection of them and make the specific point that the parameters used are that the lighting classes determined can vary during the night.

As awareness of intrusive light and light pollution has become a topic of the general mass, measures to alleviate the undesirable effect of light source are incorporated here for compliance as far as possible, making reference to the ILE publication -- Guidance Notes for the Reduction of Light Pollution.

Apart from the requirements as stated in this Manual, the design guidelines and specifications for road lighting installation as specified by Lighting Division of Highways Department shall also be complied with.

8.2 ROAD CLASSIFICATION

The lighting recommendations are in classes which are selected according to the function of the road, traffic density, traffic complexity, traffic segregation, pedestrian volume and ambient brightness. In road classification, it would be easier to adopt the terminology which is promulgated in Transport Planning and Design Manual, published by Transport Department.

Summaries of rural and urban road types are given in Tables 14 and 15 respectively and these tables show such classification together with some other factors which would influence the design as well as the requirements for the corresponding lighting class. New roads in the new town of the New Territories should be classified as urban roads.

There are also roads designated as expressways under the Road Traffic (Expressway) Regulations. The design standards for these roads are also given in this standard.

8.3 DESIGN STANDARDS

8.3.1 Design Considerations

This design guide generally works close to the BS EN 13201:2003. Nevertheless, in the wake of the provision in the above BS EN code for possible reduction in the class of lighting requirement with respect to average daily traffic (ADT), and the fact that traffic volume falls substantially after mid-night, there is a strong case for reducing the class of lighting required at these off peak hours as compared to that of the normal duty requirement. However, in view of the rapid change in the traffic conditions, the ADT flow concept in BS 5489-1:2003 to determine the lighting class for motorways and traffic routes is inappropriate for specifying here.

The lighting standards for wet road surface conditions and the special approaches for semi-cylindrical, vertical and hemispherical illuminance in BS EN 13201-2:2003 will also not be followed.

The lighting installation shall give visual guidance by positioning the columns and lanterns to reveal the run of the road, particularly at junctions, round-abouts and bends. This visual guidance supplements the lighting effect and other means for road delineation and alignment.

8.3.2 Design Standards for Public Roads including Expressways

Six lighting classes (L0, L1, L2, L3 , L4 & L5) of 5 levels shown in Table 13 in this Manual are recommended to suit the local lighting requirements for motorized traffic routes.

The recommended maintained average luminance ensures that the road is sufficiently bright to reveal objects adequately whereas the recommended overall uniformity ratio Uo, which is the ratio of the minimum to the 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 the maximum luminance along a longitudinal line through the observer position, ensures that pronounced visual patchiness of the lighted road surface is avoided.

Disability glare reduces the contrast between objects and their background, impairing the vision. Usually the maximum threshold increment (TI) given by a lighting installation is restricted to 15%.

The property of the road surface directly affects the performance of the lighting installation. Increasing the roughness of the macro-texture will improve the wet-weather performance. Some 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 simply because this road surface is close to the characteristic of newly resurfaced bituminous surface which is quite dark and smooth. Assumption based on this C2007 class of road surface would render a good safety factor as well as avoiding the need of different design tables.

8.3.3 Design Standard for Footpaths, Cycle Tracks, Feeder Roads and Village Access

The 5 lighting standards for footpaths, cycle tracks, feeder roads and village access shown in Table 10 shall be adopted:

(i) Category S1, where the maintained minimum point and average illuminance are 5 lux and 15 lux respectively, applicable to prestigious and crowded pedestrian areas or areas of mixed pedestrian and vehicular traffic.

(ii) Category S2, where the maintained minimum point and average illuminance are 2.5 lux and 10 lux respectively, applicable to feeder roads or footways of amenity areas where night-time public utilization is moderate to high, e.g. places associated with amenities such as shopping precinct, clubs, footpath/cycle track near train stations, town centres; or near subways/footbridges etc.

(iii) Category S3, where the maintained minimum point and average illuminance are 1.5 lux and 7.5 lux respectively, applicable to feeder roads or footways of amenity areas where night-time public utilization is moderate.

(iv) Category S4, where the maintained minimum point and average illuminance are 1 lux and 5 lux respectively, applicable to footpaths, village access, etc where nighttime utilization is low.

(v) Category S5, where the maintained minimum point and average illuminance are 0.5 lux and 3 lux respectively, applicable to footways at village where night-time public utilization is very low.

Since improving the colour rendering of lamp source can enhance the security in the vicinity, lighting levels for a scheme may be relaxed by 1 class if the lamp chosen has a colour rendering index equal or greater than 80.

8.3.4 Design Standards for City and Town Centres

It is very common that a road is adjoining or leading to an open facility area such as a bus terminus, a ferry concourse, a taxi/ maxicab 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 in illuminance approach.

Area lighting techniques are used for lighting open spaces such as the above where there are either mixed traffic or involving merging and diverging of traffic. The main

requirements are the provision of a specified illuminance and uniformity ratio combined with adequate control of glare. The outdoor areas are those with vehicular traffic and are illuminated by conventional or decorative road lighting fittings and the 5 illuminance standards are described in Clause 8.3.5.

8.3.5 Lighting Standards for Conflict Areas

Conflict areas occur when vehicle streams intersect with each other or with other road users as cyclists or pedestrians, or when the existing roads are connected to a stretch of road with different road layouts. Typical examples of conflict areas are junctions, roundabouts and pedestrian crossings.

At conflict areas, due to the change of road layout or the areas are frequented by pedestrians, cyclists or other road users, the visual task is usually more difficult than on straight roads. A higher lighting standard than the S classes of lighting standard in Clause 8.3.3 should be provided in Table 11.

8.3.5.1 Junctions

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

The provision should also be related to the need of drivers approaching the junction to see vehicles approaching from other directions. The lighting level on the carriageway throughout a junction shall not be less than that provided on the main roads leading to the junction. Luminaires and column positions for appropriate typical single level junctions shall make reference to Annex J in BS 5489-1:2003.

8.3.5.2 Roundabouts

The lighting provision at a roundabout should enable the drivers to see clearly any traffic at the preceding entry or entries and traffic already on the roundabout. When on the roundabout, it should also enable the drivers to have adequate forward vision to see traffic entering from the left and to decide whether it is safe to proceed. The lighting provision should reveal the form, direction and the 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 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 on the approach roads. The lighting layout arrangement for roundabouts shall make reference to Annex J in BS 5489-1:2003.

8.3.5.3 Pedestrian Crossings

In Hong Kong, almost all road crossings are signalised so that it is not as critical as

other non-signalised crossings for a pronounced need to pre-alert drivers of these conflict areas.

Road lights should preferably be so arranged that the crossing is at the mid-point of a span which is comparatively shorter than the normal calculated design spacing of the road as recommended in Clause 11.5 in BS 5489-1:2003. Additional local lighting for the crossing does not need to be considered.

8.4 DESIGN LAYOUT

8.4.1 Arrangement

8.4.1.1 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 the road surface at 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 road to the drivers as well as good longitudinal uniformity. This arrangement is also recommended for slip roads.

8.4.1.2 Staggered

It 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 staggered or zigzag. Attention shall be paid to the uniformity of the luminance on the road surface. Alternate bright and dark patches can produce unpleasant zigzag effect. This arrangement is not recommended for expressways because of the difficulty in achieving an acceptable longitudinal uniformity.

8.4.1.3 Opposite

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

8.4.1.4 Twin-central

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

8.4.1.5 Combined Twin-central and Opposite

This type of arrangement with twin luminaires located on the central reserve are combined with the opposite arrangement. Where hard shoulders are provided in

expressways, lighting columns shall be placed at the side of the hard shoulder, i.e. opposite arrangement is preferred to twin-central arrangement in such road layout. Combined twin-central and opposite is recommended for expressways with exceptionally wide carriageway.

8.4.2 Lighting Columns

Four major types of lighting column are used in road lighting design ranging from 5m to 15m. The columns used shall be of two-sections circular columns (from 5m to 12m), round conical columns (5m to 12m), octagonal column (15m) and hinged octagonal columns (8m and 10m).

Design of lighting column shall be generally in accordance with the requirements of BS EN 40, together with all current amendments. The mounting height of the lighting columns ranges from 5.1m to 15m.

8.4.2.1 5.1 m Mounting Height

5.1m is recommended to be used for footpaths, cycle tracks, feeder roads and village access with class of lighting to L3, L4, L5 and the S classes.

8.4.2.2 8 m Mounting Height

8m is recommended to be adopted in narrow and meandering roads designed with class of lighting L2, L3 & L4. It is also suitable for lighting CE class up to 20 lux.

8.4.2.3 10m Mounting Height

10m is recommended to be sited in major roads pertaining to high speed and traffic volume designed with class of lighting L1, L2 and L3. It is also suitable for lighting to CE class up to 30 lux.

8.4.2.4 12m Mounting Height

12m is recommended to be located in trunk roads and rural roads (A) designed with class of lighting L0, L1 and L2. It is also suitable for lighting CE class up to the highest 50 lux.

8.4.2.5 15m Mounting Height

15m is recommended to be mounted in trunk roads and expressways designed with class of lighting L0 and CE0 and CE1.

8.4.2.6 8m & 10m Hinged Columns

8m and 10m hinged columns are recommended to be used in a very narrow slip road/ flyovers in order to avoid lane closure during maintenance, or areas cannot be reached by maintenance vehicles.

8.4.3 Siting of Columns and Lanterns

8.4.3.1 General Requirement

Wherever possible, columns shall not be sited directly in front of any shops, windows, stairways, premises doorways, middle of pedestrian ways, fire emergency access or monuments of architectural interest etc., and they are better placed between two shops or buildings or in front of a scavenger lane but not blocking the lane.

For width of footpath less than 2m, columns are best sited at the back of the footpath, i.e. away from the road. In that position they are less obtrusive, and less liable to block the pedestrian flow. In all other cases, columns shall be sited away from the kerb or the carriageway in accordance with Transport Planning and Design Manual Vol. 2 Table 3.5.2.1, which is shown in Table 19 for easy reference.

In very narrow slip roads or on flyovers, e.g. with only one lane, consideration should be given to the use of hinged columns with post-top mounting lanterns to be mounted on the outer bend, e.g. 8m column without a bracket instead of the standard column with 1.5m bracket projection. This would help to avoid lane closure for maintenance.

In general, the pattern of lanterns for special requirements such as at crests, intersections, pedestrian crossings, bends, adjacent to overbridge, etc. should be laid out first. Others are then carefully added to the layout to effect compromises which are necessary for an installation to be both practical, cost effective and visually acceptable.

8.4.3.2 Appearance

For daytime appearance, the design and siting of road lighting and other road equipment can make a great difference to the street scene. In situation such as a processional way or monumental bridge, the design and placing of lighting columns can make a positive formal contribution to the overall street scene. In such case, the siting shall be carefully related to the architectural setting.

For nigh-time appearance, an aspect of planning any lighting scheme is the positive contribution it can make to the improvement of the night environment, especially for areas of civic importance. Colour and colour rendition of the light source is paramount to the night-time appearance of the street scene and have proven evidence in boosting the sense of night-time security.

8.4.3.3 Tree Planting

Where trees are to be planted on new roads, the lighting layout shall be designed before trees are fixed. Trees and the lighting columns shall be sited in such a way that trees do not block off light onto the carriageways or cast confusing shadows. In general, trees shall be planted 5m away from the lighting columns.

8.4.3.4 Planter

For planters located next to the carriageways, a recess shall be provided in the planter to accommodate the lighting column for easy maintenance. If the width of the

planter is less than 1.6m, lighting columns can be located just behind the planter and the lighting cables should preferably not be laid inside the planter areas.

8.4.3.4 Fire Hydrant

Lighting column shall be sited at least 1.5m away from the fire hydrant in order not to block its operation.

8.4.3.5 Soffit Lantern

In road lighting design, an elevated structure such as a footbridge or flyover spanning across a road may require soffit lanterns to light up the road underneath the structure. However, soffit lanterns may not be necessary for some structures by careful design and planning. This can be achieved by placing two adjacent road lights at equal spacing from the structure such that the main beams of these lights fall onto the road surface underneath the structures.

Soffit lanterns shall be carefully planned so that minimum traffic disruption could 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.

8.4.3.6 Siting Clearance from Gantry Sign

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

8.4.3.7 Noise Barriers

Noise barriers are often proposed to mitigate traffic noise impact on expressways or roads located near the sensitive areas. If the 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 allow sufficient space for the installation of road lights and to avoid obstructing its maintenance or shading of the light falling on the carriageways and hard shoulders.

8.4.4 Bracket Projection

Columns with long bracket projection shall be carefully designed. The bracket projection shall be determined so as to provide 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 lines, 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.

8.4.5 Clearance of Lighting Columns

The number of vehicles colliding with lighting columns is likely to decrease with increased clearance of the lighting columns from the edge of the carriageway; the recommended minimum desirable horizontal clearances according to the design speed of road are given in Table 19. The set-back of lighting columns shall be sufficient to allow the free passage of the blind and disabled people on any footway.

Minimum safe vertical clearance to overhead electricity power supply lines during erection, installation, commissioning and maintenance operations on all road lighting shall refer to requirements outlined by the respective power company.

8.5 DESIGN METHOD

8.5.1 Computer Aided Design

Computer programmes acceptable to Lighting Division can be used for calculation of road lighting luminance, illuminance, uniformity and glare. The programmes should be based on BS EN 13201-3:2003 in which the driving convention is identical to local environment.

Photometric data in TM-14 format shall be used as part of the input data for calculation.

8.5.2 Field of Calculation for Luminance

Based on BS EN 13201-3:2003, transversely there are 3 grid points for each lane whereas longitudinally the maximum spacing between grid points is 3m with a minimum number of 10 points. The average luminance, overall uniformity and longitudinal uniformity are calculated from an observer located at the centre of each lane. It is noted that the lowest calculated value of Lav, Uo and U_l and highest calculated value of TI would be used.

8.5.3 Reduction Ratio at Road Bends

The spacing of road lighting at road curves shall be reduced in accordance with Table 16 or Table 17.

As these reduction ratios are deduced with a view to maintaining the luminance values of the lighting installation in the straight section of the road, the following precaution shall be taken to ascertain the spacing at road curves:

For schemes of straight road sections with spacing S_o which fulfills the Lav requirement but has been designed with a reduced spacing S_1 taking into other considerations such as uniformities, glare control etc., then at a curve, the reduced spacing should be

obtained by multiplying S_o instead of S_1 by the corresponding reduction ratio. Of course, the final spacing should not be greater than S_1.

For staggered arrangement in the straight section of the road, provided that the effective width of the road does not exceed 1.2 times the mounting height, it can be changed to a row of lanterns at the outer bend with reduced spacing as determined for single side arrangement.

For opposite arrangement, the spacing at the outer bend has to be reduced by adopting the reduction ratio for single side arrangement while the corresponding number of lanterns are to be placed at the inner bend.

In the case of dual carriageway roads lit by a twin-central arrangement, an alternative design approach at bends is to change to a row of lanterns on the outside of the curve of each carriageway, the spacing being determined by reduction ratio and spacing in the straight section for single side arrangement, i.e. independently lit by two single side arrangements, for radius of curvature of the road bend less than 300m. Reduction ratio could be applied for mild curves where the radius of curvature exceeds 300m.

8.5.4 Maintenance Factor

Table 18 shows the recommended maintenance factors based on the lantern cleaning frequencies and the degree of pollution. For luminaire with higher IP rating, higher maintenance factor may be used.

8.6 OTHER CONSIDERATIONS

8.6.1 Glare Control and Avoidance of Light Pollution

Disability glare reduces the contrast between objects and their background, impairing the 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 the threshold increment (TI).

The presence of disability glare can be reduced by the use of curved temper glass (CTG) or flat glass (FG) lanterns instead of bowl type lanterns, either of moderate or low threshold increment (MTI/LTI) lanterns. A CTG or FG luminaire generally meets the recommendation for the TI being not more than 10%, and more pronouncedly limits the glaring effect at low mounting height close to the road.

In slopes with a gradient in excess of 10%, lanterns shall be rotated at the spigot entry to suit the slope so as to control the glare. It is also beneficial to do this on 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, there is no special lighting problem at a dip but it is necessary to limit glare from luminaires beyond a crest by siting the lights to appropriate locations.

Light pollution, whether it keeps someone awake through bedroom window or impedes his view of the night sky, is a form of pollution. Sky glow is another form of pollution. Glare, the uncomfortable brightness of a light source when viewed against a dark background, light trespass and the spilling of light beyond the boundary of the property on which the source is located are other forms of light pollution.

In order to reduce light pollution, light above the horizontal should be minimized because it is wasteful, it may cause a nuisance by shining through bedroom windows and it contributes to sky glow.

8.6.2 Mode of Operation

Road lighting where provided is normally required during all the hours of darkness in operation. In practice, they are normally switched on at ambient light level 55 lux and off around 1.5 times this value by photo-electric controller (PEC). This in reality triggers the operation within 15 minutes after sunset and 15 minutes before sunrise. In certain deck-over road sections like short tunnel, the operation will be controlled by PEC set at 1,000 – 5,000 lux or by timer control to suit the local condition.

For road lights/ soffit lights located in a shaded area, separate PEC may be placed under the same area so that the switch-on value at 55 lux ambient can be maintained. Consideration shall be given to provide a control circuit for soffit lights separated from that for those on flyover.

8.6.3 Cost and Energy Conservation

Many factors play a role in determining the costs and energy effectiveness of a road lighting installation. There are factors such as lamp and luminaire type, type of control gear employed, mode of operation, the column type and arrangement, luminaire mounting height, the reflection properties of the road surface, the location of the electricity supply cables and, last but not the least, the maintenance programmme.

The luminous efficacy of a lamp has a dominating influence on the energy consumption and consequent recurrent costs of a road lighting installation using that lamp. As such, high luminous efficacy lamps such as tubular high xenon pressure high pressure sodium (SON-T Plus) and tubular ceramic discharge metal halide lamps shall be adopted as far as possible.

The type of luminaires adopted has a considerable influence on both cost and energy consumption. An important consideration with respect to light distribution is the luminaire's downward light output ratio (DLOR). However, use of a luminaire having a high DLOR but a poor light distribution necessitates closer column spacing in order to meet luminance and uniformity requirement. As such, in road lighting design, luminaires with high IP and better light distribution are important factors in keeping costs and energy consumption to a minimum. Also, the ability of luminaires to maintain the high lighting performance very much depends on its construction as well as the IP rating, hence its maintenance factor.

8.7 CHOICE OF EQUIPMENT

8.7.1 Luminaires

Lanterns shall be of sound and robust construction to BS EN 60598-2-3. They shall have an ingress protection (IP) rating not less than 65 and 66 for decorative and conventional lantern respectively. They shall be for use on 220V, 50 hertz single phase supply and be suitable for 50W to 600W SON-T and 70W to 250W tubular ceramic discharge metal halide lamps.

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

8.7.2 Lamps

The choice of lamps source depends on number of lumen per watt, life rate, flux maintenance, colour rendering, initial costs and lamp replacement costs.

The luminous efficacy of a lamp has a dominating influence on the energy consumption and consequent running costs of a road lighting installation using that lamp.

Comparisons of road lighting installations made on the basis of different local circumstances show that total annual maintenance costs and energy consumption are lower for installations using high pressure sodium lamps. As such, it is desirable to install tubular high xenon pressure high pressure sodium (SON-T Plus) lamps of rating 50W, 70W, 100W, 150W, 250W, 400W and 600W for road lighting application.

The use of other lamp sources such as tubular ceramic discharge metal halide and compact or conventional fluorescent lamps may be considered for illuminating footpath, pedestrianization schemes and open areas where good colour rendering is a major concern.

Different types of lamps shall comply with the following international standards:

High pressure sodium vapour lamps:	BS EN 60662.
Metal halide lamps:	EN 62035 :2000.
Fluorescent lamps:	BS EN 60081.
Compact fluorescent lamps:	BS EN 60901.

The minimum initial lumens (100 hours) for the SON-T Plus, metal halide and fluorescent lamps are given in Table 12.

8.7.3 Control Gear

Control gear shall be of the solid filled, metal-clad type and with shrouded terminal.

It must be suitable for nominal voltage 220V ± 6 % , 50 hertz supply and shall meet with the requirement of BS EN 61048, BS EN 61049, BS EN 60922 and BS EN 60923 together with all current amendments.

The ballast shall be of a straight tapped type with three tapings at voltages ranging from 200V to 220V at 10V interval (i.e. No autotransformers are to be used in conjunction with chokes or leakage transformers).

The capacitor shall be totally enclosed, condensation proof, internal safety leaks and fitted with an internal discharge resistor.

The external ignitor shall be of electronic superimposed type without the built-in time cutout and be suitable for SON-T Plus lamps. It shall be capable of igniting these lamps at 198 V minimum.

The electronic ballast shall be used for fluorescent and compact fluorescent tubes. It shall be manufactured and tested in compliance with BS EN 60928 and BS EN 60929 respectively.

8.7.4 Power Cable

Cables shall be 600/1,000V grade with cross-linked polyethylene (XLPE) insulation, galvanized steel wire armoured and PVC outer sheath. 2-cored cable with stranded copper conductor of 35 mm^2 with full size neutral are generally adopted in Hong Kong Island whereas 2-cored and 4-cored cable with stranded copper conductor of 25 mm^2 with full size neutral are generally adopted in Kowloon and N.T. In general, the cables shall conform to BS 5467 and BS6724.

8.7.5 Photo-electric Controller

The on/off control of the lighting circuits shall be by means of photo-electric controller. The controller shall be of electronic fail-safe type with an adjustable switch-on value of 30 - 200 lux or specifically for controlling short tunnel lighting etc. can be adjustable from 1,000 to 25,000 lux with on:off ratio 1:1 is sufficient where a time delay is in place. They shall be suitable for use in exposed weather conditions and shall function correctly within the temperature of -5° C to +50°C at local supply voltage and frequency. They shall comply with BS5972. It will be installed inside the public lighting control cubicle via an aperture for detecting the ambient illumination level.

8.8 DESIGN RECOMMENDATION FOR DECORATIVE ROAD LIGHTING

Nowadays, luminaires are no longer simply providing illumination at night but more than that, it creates image. Tourist areas, town centers and pedestrian walking area are being transformed by lighting schemes that blend harmoniously with their environments by adopting decorative lighting.

The choice of decorative road lighting must take into account the different zones of the city district. For commercial zone, luminaires in this very active and generally modern area will adopt a modern character.

For cultural zone, luminaires in this zone will also be multifunctional and help to light up the surroundings. Luminaires shall be more decorative in this area and shall distribute a warm white, yellowish light.

In urban and rural town centers, shopping streets, boulevards, promenades and other places that are the hub of social activities, decorative road lighting is highly desirable.

The lighting design standard for decorative road lighting is the same as Clause 8.3 but the decorative lighting shall be chosen in liaison with all relevant parties such as ACABAS, Landscape Unit of HyD and project offices.

8.9 ELECTRICITY SUPPLY

8.9.1 Public Lighting Circuit

For public lighting circuit system security, 100% backfeed capability is mandatory for road lighting along expressways including slip roads. The same design philosophy 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 public lighting control cubicle is suspended, faulted or affected and could not be immediately restored. These lights could be temporarily taken up by feeding from an adjacent public lighting control cubicle (PLCC).

In the case of trunk routes, double alternate circuits are to be deployed for a series of lights to improve availability.

8.9.2 Cable Circuits

All road lights to be fed from the same circuits shall be looped together by turn in and out the lighting cables and terminate them with cable glands at the base section of lighting columns. Alternative connection means by teeing underground lighting cable in the proximity shall not be acceptable.

To maximize the number of road lights that can be supplied by any lighting circuits, the whole lengths shall be of the same size. Reducing cable size or cable cores at any section of lighting circuits shall not be allowed for consistent sake of circuit design and for the purpose of circuit back feed.

The maximum number of lights to be connected to an outgoing circuit shall be determined by the wattage of lamps and voltage drop of the cable. For circuits with backfeed, 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 back feed condition must be maintained at no less than 198V, i.e. a total voltage drop of the entire circuit be no more than 22V, assuming supply voltage is at 220V. (ii) During normal operation, the minimum voltage at the last light, i.e. up to the normal open (N/O) point, shall be no less than 198V by taking into

account the ± 6 % voltage fluctuation as specified by the power company.

Full ducting system for protecting public lighting cables is required in accordance with the Highways Department Technical Circular - Requirement to Provide Full Ducting System for Public Lighting Installation. For road lights to be installed in the central divider of carriageways, cable ducts and draw pits shall be laid and constructed in accordance with HyD Standard Drawing No. H2106. For footpaths adjoining carriageways, cables shall be laid longitudinally within 1m from the road kerb.

8.9.3 Public Lighting Control Cubicle (PLCC)

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

The location of PLCC and earth pit shall be chosen at places where they are practically accessible for maintenance and unobtrusive to pedestrian flow. As the photo-electric controller is installed inside the PLCC, it shall be located in an open area and not be sited under shaded areas such as trees, structures etc. in order to avoid early switch-on of road lighting system.

Wherever possible, especially at new developments, the power company must be consulted at the early stage of design for the availability of power supply.

8.9.4 Fuse and Miniature Circuit Breaker (MCB)

Incoming and outgoing circuits at the PLCC shall be protected by high rupturing capacity (HRC) fuses of appropriate rating to BS EN 60269 and BS 88. Each lighting point shall be separately protected by a MCB unit to BS EN 60898, which shall be rated as shown in Table 20.

For double or triple arm road lights, each lamp shall be supplied from different phase of the power cable to avoid total loss of light in the event of fault in one phase.

8.9.5 Earthing

The whole public lighting installation including PLCC, lighting columns, lanterns, control gear, conduits, cables fittings and other exposed conductive parts shall be effectively earthed to the ground by means of appropriate size copper conductors and comply with the recommendations contained in EMSD’s Code of Practice for Electricity (Wiring) Regulations. The results of the earth fault loop impedance test for each road light and PLCC shall be submitted to the Engineer of Lighting Division for acceptance.

Separate earthing system shall be provided at each PLCC. Earth electrode(s) of size 16mm diameter copper bonded steel cored rod(s) shall be used. The electrode shall be driven into the ground and connected to a sufficient sized copper earth terminal inside the PLCC. It may require two or more earth electrodes driven into the ground and 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.

In location such as in villages or remote areas where pole-mounted PLCCs are installed, the earth fault loop impedance for these PLCCs shall have a value less than 1.8Ω for 30A mains or other values in compliance with the requirements specified in Table 11 of (11) of the Code of Practice for the Electricity (Wiring) Regulations of EMSD.

When the earth fault loop impedance cannot be reduced to the required value as specified in Table 11 (11) of the Code of Practice despite the measure of installing additional earth rods to cover a larger distance span has been taken and as agreed by the Engineer of Lighting Division, residual current device (RCD) shall be installed as recommended in Section 11J of the Code of Practice. The operating current of the RCD and the maximum allowable earth fault loop impedance shall meet the requirement as specified in Table 11(14) of the Code of Practice.

8.9.6 Additional Items

The following items are applicable to the road lighting installations which are not carried out by Lighting Division's Contractors:

8.9.6.1 Inspection

Lighting Division and its Contractor shall be invited to inspect the lighting installation and be satisfied with the installation before the same is handed over to Lighting Division for maintenance.

8.9.6.2 Spare Parts

For ease of maintenance, 10% each of the installed luminaires (For decorative luminaires, the quantity shall be as required by Lighting Division) and MCB units (Minimum one number), and other spares shall be delivered to Lighting Division's Contractor before handing over the lighting installation to Lighting Division for maintenance.

8.9.6.3 As-Fitted Drawings and Luminance/ Illuminance Readings

On completion of the installation, the Project Office shall submit four sets each including hard copy and soft copy in Microstation version 3D DGN format of "As-fitted " drawings comprising the lighting layouts, circuit diagrams, conduit routes, including luminance/ illuminance readings, certified electrical test reports, database in Lighting Division's required format and Operation and Maintenance Manual to Lighting Division before handing-over the completed work.

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TABLES

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Table 1 -- Stopping Sight Distances for Various Design Speeds

Design Speed (km/h)	50	60	70	85	100
Stopping Sight Distance (m)	50	70	90	120	160

Table 2 -- k Values for Symmetrical Lighting System : $k = L_{th}/L_{20}$

Design Speed (km/h)	**k Value**
50	0.04
60	0.04
70	0.05
85	0.05
100	0.07

Table 3 -- Lighting Level on Road Surface for Long Tunnels, Underdeck without Sidewalls, Underpass and Noise Enclosure with Glazing

Design Speed (km/h)	**Daytime Interior Zone Maintained Average Luminance for Long Tunnel (cd/m^2)**	**Nighttime Lighting Maintained Average Luminance (cd/m^2)**		**Emergency Lighting Maintained Average Luminance for Long Tunnel and Noise Enclosure Exceeding 200m long (cd/m^2)**
		Long Tunnel	**Underdeck, Underpass and Noise Enclosure**	
50	4-5	3-4	2-3	1
60	4-5	3-4	2-3	1
70	5-6	4-5	3-4	1
85	5-6	4-5	3-4	1
100	8-10	5-6	4-5	1

Table 4: Daytime lighting of short tunnels /deck-overs

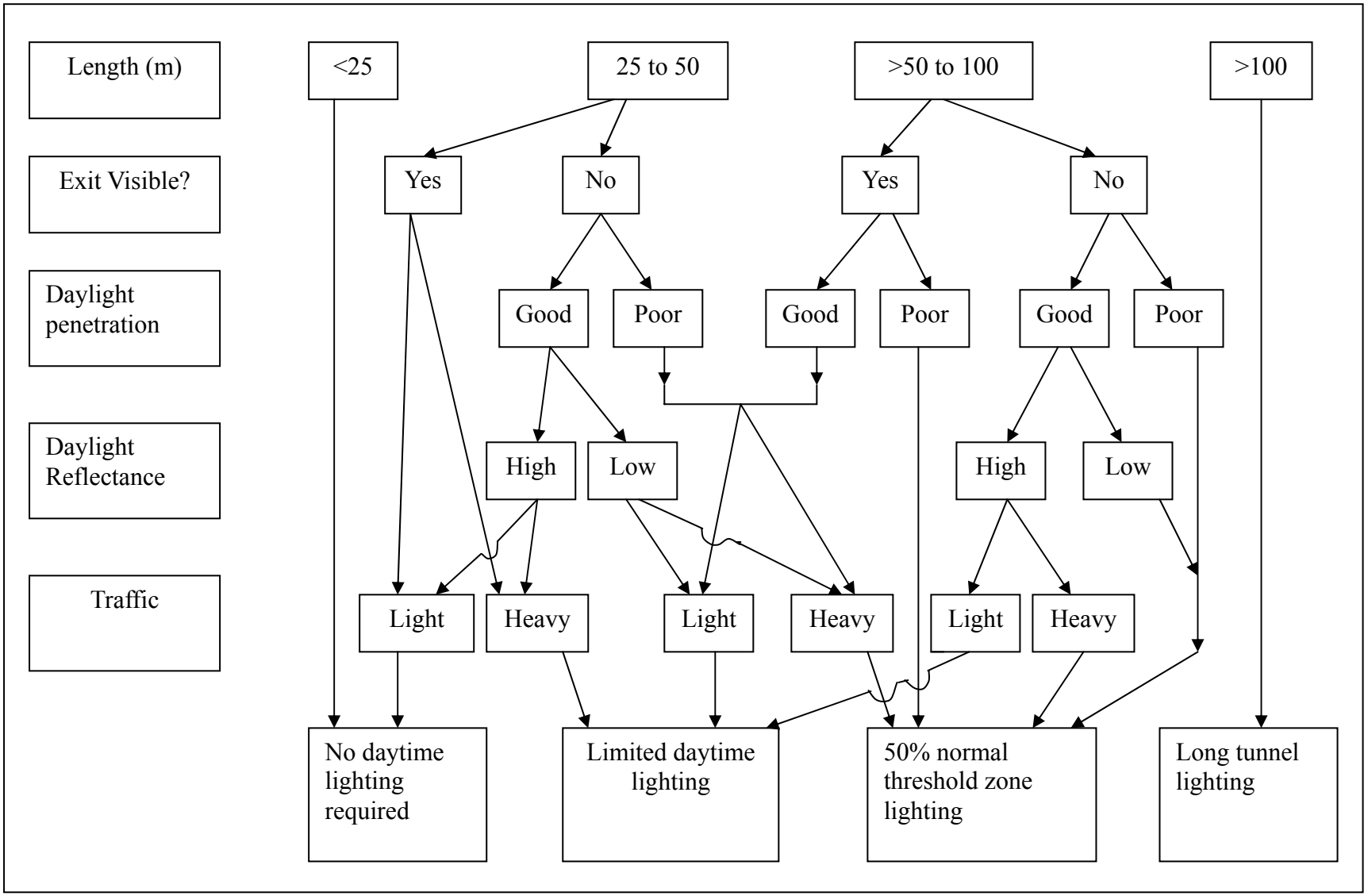

Table 5 -- Tunnel Lighting Design Parameters and Criteria

Item Description	**Parameters and Criteria**
Maintenance factor	0.7
Stopping sight distance	Table 1
Average luminance coefficient of standard class C2 asphalt Road surface (Qo)	0.07
k value (Ratio of first threshold zone luminance to access zone luminance)	Table 2
Daytime interior zone lighting	Table 3
Daytime exit zone lighting	5 times interior zone lighting level
Nighttime lighting	Table 3
Overall uniformity on road surface and walls up to 2 m height	0.4 minimum
Longitudinal uniformity along centre of each lane	0.6 minimum
Glare (Threshold increment)	less than 15%
Critical flicker frequency	2.5 to 15 Hz
Emergency lighting (Daytime and nighttime)	Table 3
Maximum reduction of luminance between successive steps	3:1
Maximum reduction of luminance between successive stages	5:1 (Preferably 3:1)

Table 6 -- Noise Enclosure Lighting Design Parameters and Criteria

Item Description	Parameters and Criteria
Maintenance Factor – Natural cleaning is assumed	0.7
Average luminance coefficient of standard class C2 asphalt road surface (Q_0)	0.07
k value (ratio of first threshold zone luminance to access zone luminance)	Table 2
Lighting level	Table 3
Overall uniformity on road surface	0.4 minimum
Longitudinal uniformity	0.6 minimum

Table 7 – Sky Factor (Sf) for Noise Enclosure Lighting

	1 skylight						**2 skylights**					**3 skylights**		
width(m) / height(m)	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 8 – Shade Factor (D) for Noise Enclosure Lighting

γ / D	10°	20°	30°	35°	40°	45°	50°	60°	70°	80°
ρ										
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

Table 9 – Maintenance Factor for Dirt on Glazing of Noise Enclosure

Type of Location	**Vertical Glazing**	**Sloping Glazing**	**Horizontal Glazing**
Rural	0.9	0.8	0.7
Urban	0.7	0.6	0.5
Very Dirty Assuming No Cleaning Operation	0.6	0.5	0.4

Table 10 -- Design Standard for Footpaths, Cycle Tracks, Feeder Roads and Village Access

Category	**Maintained average illuminance (E_{av}lux)**	**Maintained minimum illuminance (E_{min}lux)**
S1	15	5
S2	10	2.5
S3	7.5	1.5
S4	5	1
S5	3	0.5

Table 11 -- Design Standards for Open Area with Vehicular Traffic

Lighting Class	**Area of Consideration**	**Traffic Flow**	**Minimum Average Illuminance**	**Minimum Illuminance**
CE0	Toll Plaza	High	50 lux	20 lux
CE1	Mixed Vehicle and Pedestrian e.g. Carpark, Bus Terminus, Taxi/Maxicab Station; and Road Junction, Roundabout	High	30 lux	10 lux
CE2		Medium	20 lux	7.5 lux
CE2	Pedestrian and Cycle Underpass	Low or Medium	20 lux	7.5 lux
CE3	Road Junction, Roundabout	Low	15 lux	5 lux
CE4	Cul-de-sac, Small Parking Lot Access road junction	Low	10 lux	2.5 lux

Table 12 -- Minimum Initial Lumens (100 hours) of High Pressure Sodium (SON-T Plus), Ceramic Metal Halide (MBI) and Fluorescent Lamps

Lamp Types	**SON-T Plus**							**Ceramic MBI**			**Fluorescent (T5)**	
Wattage (Watt)	50	70	100	150	250	400	600	70	150	250	28	35
Initial Lumen (klm)	4.4	6.5	10.0	17.0	33.0	55.0	90.0	6.5	14.0	25.8	2.9	3.65

Table 13 -- Design Standards for Motorized Traffic Routes including Expressways

Class of Lighting	**Maintained Average Luminance (Lav) (cd/m^2)**	**Overall Uniformity Ratio (Uo)**	**Longitudinal Uniformity Ratio (Ul)**	**Threshold Increment T.I. (%)***
L0	≧2.0 Hard Shoulder of Expressways ≧0.5	≧0.4	≧0.7 for each lane	≦10
L1	≧2.0	≧0.4	≧0.7, or ≧0.5 for speed limit less than 70 km/h	≦15
L2	≧1.5	≧0.4	≧0.7, or ≧0.5 for speed limit less than 70 km/h	≦15
L3	≧1.0	≧0.4	≧0.5	≦15
L4	≧0.75	≧0.4	≧0.5	≦15
L5	≧0.5	≧0.35	≧0.4	≦20

Table 14 -- Summary of Road Types and Lighting Classes For Rural Roads

	Types	Description	Ambient Brightness	Pedestrian Volume	Class of Lighting
1	Expressways	Roads under Expressways Legislation are connecting the main centres of population within the territory. They must be to dual carriageway standard with no frontage access. Pedestrians, cyclists, learner drivers, hand carts and animals will be prohibited and all pedestrian cross movements must be fully segregated.	Dark	None	L0
2	Trunk Roads	Roads connecting the main centers of population. High capacity roads with no frontage access or development, pedestrians segregated, widely spaced grade-separated junctions, and 24 hour stopping restrictions.	Dark	None	L2
3	Rural Roads (A)	Roads connecting the smaller centers of population or popular recreation areas with major road networks. Frontage access should be limited wherever possible and junction design whilst not necessarily grade separated should be of a high capacity standard.	Dark	Low	L3
4	Rural Roads (B)	Roads which connect villages to Rural Roads (A). Medium to low capacity roads, with priority junctions and frontage development with direct access.	Dark	Low	L4
5	Feeder Roads	Roads connecting more remote settlements to Rural Roads (B).	Dark	Low	L5

Table 15 -- Summary of Road Types and Lighting Classes for Urban Roads

	Type	Description	Ambient Brightness	Pedestrian Volume	Class of Lighting
1	Expressways	Roads under Expressways Legislation are connecting the main centres of population within the territory. They must be to dual carriageway standard with no frontage access. Pedestrians, cyclists, learner drivers, hand carts and animals will be prohibited and all pedestrian cross movements must be fully segregated.	Dark	None	L0
2	Trunk Roads	Roads connecting the main centers 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 Area or sections of Rural Trunk Roads passing through New Towns: a) The road layout is complicated or of wider width, e.g. dual 3-lane, flyover, underpass, etc. b) The road layout is less complicated or narrower.	Bright to Medium Bright Medium Bright	None None	L1 L2
3	Primary Distributors	Roads forming the major network of the urban area. Roads having high capacity junctions, though may be at-grade, segregated pedestrian facilities wherever possible and frontage access limited if not entirely restricted, and 24 hour stopping restrictions.	Bright Medium Bright	High Medium	L1 L2
4	District Distributors	Roads linking Districts to the Primary Distributor Roads. High capacity at-grade junction with peak hour stopping restrictions and parking restrictions throughout the day.(Including Housing Estate Road and residential major access road)	Bright to Medium Bright Medium Bright	Medium Few	L2 L3
5	Local Distributors	Road within Districts linking developments to the District Distributor Roads	Medium Bright Dark	Few Few	L3 L4

Table 16 -- Reduction Ratios for 8m/10m Mounting Height Installation

Radius of Curvature of Road Bends	**Reduction Ratios**		
	Single Side Arrangement		**Twin-central Arrangement**
	Outer Bend	**Inner Bend**	
75 m	0.70	0.50	(N.A.) Place all luminaires to outer bend
100 m	0.78	0.53	(N.A.) Place all luminaires to outer bend
150 m	0.89	0.62	(N.A.) Place all luminaires to outer bend
200 m	0.98	0.63	(N.A.) Place all luminaires to outer bend
300 m	1.00	0.69	0.72
400 m	1.00	0.76	0.76

N.A. - Not Applicable

Table 17 -- Reduction Ratios for 12m/15m Mounting Height Installation

Radius of Curvature of Road Bends	Reduction Ratios		
	Single Side Arrangement		Twin-central Arrangement
	Outer Bend	Inner Bend	
75 m	0.72	0.53	(N.A.) Place all luminaires to outer bend
100 m	0.74	0.56	(N.A.) Place all luminaires to outer bend
150 m	0.79	0.61	(N.A.) Place all luminaires to outer bend
200 m	0.95	0.66	(N.A.) Place all luminaires to outer bend
300 m	1.00	0.74	0.73
400 m	1.00	0.79	0.79

N.A. - Not Applicable

Table 18 -- Maintenance Factor for IP 66 Luminaire

Cleaning Interval	Pollution Category		
	High	Medium	Low
6 months	0.75	0.80	0.85
12 months	N.A.	0.75	0.80

N.A.- Not Applicable

Table 19 –Horizontal Clearances from the Carriageway to Obstructions

	Design Speed (km/h)	Height of Object	Minimum Clearance where carriageway cross fall is:-		
			Away or towards object but not steeper than 2.5% (mm)	Towards object but not steeper than 4% (mm)	Towards object and steeper than 4% (mm)
1	50 or less	(i) Less than 3 m	500	600	600
		(ii) 3 m and above	500	600	800
2	Above 50 less than 80	(i) Less than 3 m	600	600	600
		(ii) 3 m and above	1,000	1,000	1,000
3	80 and above	Any Height	1,000	1,000	1,000

Table 20 – MCB Rating for Road Lighting Control

Lamp Wattage	MCB Rating (Amp)
50W	6
70W	6
100W	6
150W	6
250W	10
400W	10
600W	16

Table 21 -- Arrangement of Sign Lighting for Roadside Directional Sign and Gantry Sign (GS)

Width(W) / Height (H)		W≤ 2 m		2m < W≤ 3 m		3m<W≤ 4m		4m< W≤ 5m		5m<W≤ 6m	
		No. of Fittings	Watt.	No. of Fittings	Watt.	No. of Fittings	Watt.	No. of Fittings	Watt.	No. of Fittings	Watt.
H≤ 1m		1	70W	2	70W	2	70W	3	70W	4	70W
1m<H≤ 2m		2	70W	2	70W	3	70W	3	70W	2	150W
2m<H≤ 3m		1	150W	2	150W	2	150W	2	150W	2	150W
3m<H≤ 4m		2	150W	2	150W	2	150W	2	150W	3	150W
4m<H≤ 5m	Top	1	150W	1	150W	2	150W	2	150W	2	150W
	Bottom	1	70W	2	70W	2	70W	2	70W	2	70W
5m<H≤ 6m	Top	1	150W	2	150W	2	150W	2	150W	3	150W
	Bottom	1	70W	2	70W	2	70W	2	70W	3	70W

Note: 1.Tubular ceramic discharge metal halide lamps, or equivalent lamps approved by Lighting Division, HyD, of 70W, 100W (if available) and 150W with colour temperature 3,000K shall be adopted for all sign lighting.

2. Bracket projection of sign lantern for roadside directional sign shall normally be 1.5m.

3. For gantry signs with supplementary sign faces and total height higher than 4m, additional bottom mounted lanterns on the GS platform or higher rating of lamps shall be provided for both the upper and bottom sign plates except those GSs mounted on flyover/ footbridge.

4. For small sign plates, the following criteria shall be applied to determine if lighting is required:

Width (W)	Sign Content	Proposed Installation
Less than 1.6m	1 Destination	No lighting
	2 Destinations	1 lantern as referred to above
Between 1.6m and 2m	1 Destination	No lighting
	2 Destinations	1 or 2 lanterns as referred to above

APPENDICES

APPENDIX A

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

CONTENTS

A.1 GENERAL

A.1.1 Statutory Standards

All materials and equipment shall be supplied by the Contractor and shall be in accordance with the appropriate British Standard Specifications. The installation works shall comply with the current editions of the "Code of Practice for the Electricity (Wiring) Regulations" issued by the Electrical and Mechanical Services Department, the "General Specification for Electrical Installation in Government Buildings of the Hong Kong Special Administrative Region", the IEE Wiring Regulations issued by the BSI and the Power Company's "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.1.3 Case of Conflict

In case of conflict among the technical requirements, the following order of preference shall apply:

(1) Public Lighting Design Manual;

(2) The Code of Practice for the Electricity (Wiring) Regulations;

(3) The "General Specification for Electrical Installation in Government Buildings of the Hong Kong Special Administrative Region";

(4) The IEE Wiring Regulations; and

(5) The local Power Company's "Supply Rules".

A.2 DRAWING BY THE CONTRACTOR

A.2.1 Size of Drawing

Drawings submitted by the Contractor shall be of a standard size from AO to A4 in accordance with BS EN ISO 5457. "As-fitted" drawings shall be of AO to A1 size only. The soft copies of drawings shall be in Microstation 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 Works

Agent/Contractor for approval before commencing work.

A.2.3 "As-installed" Drawing

"As-installed" drawings shall show the positions of all conduits, trunkings, cable routes, switchgear, distribution boards, luminaires, photo-electric controller, timer, pillar box 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 2.1.1 of the Public Lighting Design Manual.

Apart from the two sizes of pillar box recommended in the Guidance Note, the Contractor may propose alternative design if deemed necessary, prior to installation, to the Engineer for approval, as appropriate. 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, 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 BS 6346 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 heavy 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 national colour system of the Swedish Standard.

A.5 EARTHING

A.5.1 General

All metal works associated with the lighting installation 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 as shown on the HyD Standard Drawings No. H2174. 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 shall be used as the earth electrode. The electrode shall be of minimum diameter 15mm. The thickness of the copper sleeve shall be 0.25mm minimum. The earth loop impedance and earth electrode resistance shall be measured and additional electrodes shall need to be provided by the Contractor to bring the earth loop impedance to the acceptable value as stipulated in the IEE Wiring Regulations, 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 installation at a position near the main incoming switch for the connection of the circuit protective conductors, the main equipotential bonding conductors and the earthing conductor to create the equipotential zone. Conduits or trunkings shall not be used as an earthing 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 shown on HyD Standard Drawings No. H2174.

A.6 INSPECTION AND TESTING

A.6.1 Routine Inspection

Inspections by the Engineer or his representative shall be carried out at frequent intervals during the course of the work. For schemes designed by Lighting Division, HyD, the Contractor shall liaise with Lighting Division, HyD so that routine electrical inspections can be carried out by Lighting Division, HyD on site.

A.6.2 Commissioning Trial

When the work is finally completed, the whole system must be demonstrated to be working satisfactorily during commissioning trials in the presence of the Engineer. The

Contractor shall liaise with Lighting Division, HyD and the Works Agent/Contractor to witness the final commissioning trials. The commissioning trials shall include both visual inspection and relevant tests as stipulated in Lighting Division's inspections forms, the Code of Practice for the Electricity (Wiring) Regulations and the IEE Wiring Regulations.

A.7 MATERIAL AND EQUIPMENT

A.7.1 Fluorescent Luminaire

Luminaires shall comply with BS EN 60598 and have an ingress protection (IP) rating not less than 65. They shall be equipped with vandal – resistant polycarbonate diffusers, control gear and fluorescent tube(s) for use on local supply voltage and frequency. The polycarbonate diffuser shall be externally smooth to facilitate cleaning.

A.7.2 Electronic Ballast

The electronic ballast shall be manufactured and tested in compliance with BS EN 60928 and BS EN 60929 respectively. They should be designed and manufactured in accordance with ISO 9001.

The ballast shall maintain constant light output in the voltage range 220V±6%, 50Hz single phase A.C. supply. The percentage of light emitted from a reference fluorescent tube with these ballast (Ballast Lumen Factor) shall be less than 95%.

The ballast's case temperature use shall not exceed 25^{o}C over 40^{o}C ambient.

The overall power factor of the lamp shall not be less than 0.95 lagging. The service life of the electronic ballast shall not be less than 50,000 hours at maximum case temperature, whereas the failure rate shall be less than 1% per 4,000 hours at maximum case temperature.

The electronic ballast shall have a total harmonic distortion of less than 15%.

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

A.7.3 Pass Light and Bulkhead Light

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

A.7.4 Photo-electric Controller

Photo-electric controllers shall be of electronic fail-safe type with a switch on value of

70 lux, an on:off ratio of 1:1.5, and shall have an inherent time delay of 30 seconds to prevent operation by extraneous light. They shall be suitable for use in exposed weather conditions and shall function correctly within the temperature range of -5^0 C to $+50^0$ C at local supply voltage and frequency. They shall also comply with BS 5972.

A.7.5 Time Switch

Time switches used for the back-up of the photo-electric controller shall be equipped with a spring or battery reserve of at least 24 hours. They shall be of self-starting type driven by synchronous motor.

A.7.6 Contactor

Contactors shall be an 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.7.7 Main Switch

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

A.7.8 Miniature Circuit Breaker and Distribution Board

Miniature circuit breakers (MCB) shall be of thermal magnetic type calibrated at 40^0 C and shall comply with BS EN60898.

All MCB distribution boards shall be fabricated of galvanised steel sheet not less than 1 mm thick. They shall be finished with high grade enamel paint and shall comply with BS EN 60439.

A.7.9 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 6004.

Cables up to $35mm^2$ within the pillar box, if not concealed in conduit or trunking, shall be PVC insulated and PVC sheathed, 300/500V grade to BS 6004 or PVC insulated and PVC sheathed greater than $50mm^2$ complying with BS 6346 with voltage grade 600/1,000V.

A.7.10 Conduit and Accessories

Steel conduits shall be of heavy guage, screwed, longitudinally welded and shall comply with IEC 60614-2-1.

Conduit fittings shall comply with IEC 61035. Metal boxes for enclosure of electrical accessories in conduit installation shall comply with BS 4662/IEC 60670.

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 an earthing conductor. 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 seek approval from Lighting Division, HyD and the Maintenance Agent/Contractor at an early stage.

A.8.2 Spare Equipment

10% each of the installed luminaires and MCB units, and other spare parts shall be provided by the Contractor and be delivered to the Maintenance Agent/Contractor for the future maintenance needs. At least two luminaires for each type shall be provided.

A.8.3 Application for Electricity Supply

The Contractor shall be required to prepare and submit, under his name, application for electricity supply in accordance with the time schedule of the project, and be responsible for the energy cost before the lighting installation is tested and accepted by the Engineer in respect of a Government Project, or by Lighting Division, HyD and the Maintenance Agent/ Contractor in respect of a private development.

A.8.4 Application for Change of Consumership

When the lighting installation is accepted, the Contractor shall submit an application for change of name to Chief Engineer/Lighting, HyD, who will endorse and forward the application to the Power Company and assume the consumership thereafter.

APPENDIX B

MODEL ELECTRICAL SPECIFICATION FOR COVERED PUBLIC TRANSPORT INTERCHANGE LIGHTING INSTALLATIONS

CONTENTS

B.1 GENERAL

All material and equipment shall be supplied by the Contractor and shall be in accordance with the appropriate British Standard Specifications. The electrical works shall comply with the current editions of the “Code of Practice for the Electricity (Wiring) Regulations” issued by the Electrical and Mechanical Services Department, the "General Specification for Electrical Installation in Government Buildings of the Hong Kong Special Administrative Region" issued by the Architectural Services Department, the IEE Wiring Regulations issued by BSI, and the local Power Company's "Supply Rules".

The Contractor shall submit, under his name, application for electricity supply in accordance with the time schedule of the project, and be responsible for the energy cost before the lighting installation is tested and accepted by Lighting Division, HyD.

B.2 CONNECTION TO MAINS SUPPLY

The control gear shall be installed and connected in the switch room by the Contractor. The incoming electricity supply and the energy meter shall be installed by the Power Company, while all other outgoing connections shall be installed by the Contractor.

The Contractor shall also be responsible to liaise and arrange with the Power Company for testing, provision and connection of the mains supply and meter.

B.3 LIGHTING CIRCUIT

Unless otherwise specified in the Specification or on the Contract Drawings, concealed conduit system shall be adopted. Surface conduits may be installed inside the switch room or where there are site constraints that conduits cannot be concealed.

Conduits and accessories, cables, control gear and luminaires shall be as specified. Conductor sizes shall be as stated on the schematic wiring diagram.

B.4 EARTHING

The whole system of control gear, MCB boards, contactors, photoelectric controllers, conduits and luminaires shall be effectively earthed to the ground by means of appropriate sized copper conductors.

The earth loop impedance and earth electrode resistance shall be measured and additional means should be provided by the Contractor to bring the earth loop impedance to the acceptable values. Conduits or trunkings shall not be used as an earthing conductor. Independent circuit protective conductor should be provided for each circuit.

B.5 ROUTINE AND FINAL INSPECTION

Inspections by the Engineer or his representative shall be carried out at frequent intervals during the course of work. When the work is finally completed, the whole system must be demonstrated to be working satisfactorily during commissioning trials supervised by the Engineer. Lighting Divisions, HyD shall be invited to witness the final commissioning trials.

B.6 MATERIAL AND EQUIPMENT

The equipment offered shall be as specified below or their equivalent approved by the Lighting Division, HyD :

(1) Highbay Luminaire. Highbay luminaires shall be cut-off type without any lighting distribution above horizontal. They shall comply with BS EN 60598 and have an IP rating not less than 65. They shall be equipped with optical reflectors, integral gear and lamps. The front protector panel shall be made from clear, high mechanical and high thermal resistant glass and free from changing colour on prolonged use.

(2) Lowbay Luminaire. Lowbay luminaires shall be cut-off type without any lighting distribution above horizontal. They shall only be used where the mounting height is less than 5.1m. They shall comply with BS EN 60598 and have an IP rating not less than 65. They shall be equipped with optical reflectors, integral gear and lamps. The front protector panel shall be made from clear, high mechanical and high thermal resistant glass and free from changing colour on prolonged use.

(3) Fluorescent Luminaire. Fluorescent luminaires shall comply with BS EN 60598 and have an ingress protection (IP) rating not less than 65. They shall be equipped with vandal-resistant polycarbonate diffuser, electronic ballast control gear and fluorescent tube(s) for use on local supply voltage and frequency. The polycarbonate diffuser shall be externally smooth to facilitate cleaning.

(4) Electronic Ballast. The electronic ballast for fluorescent lamps shall be manufactured and tested in compliance with BS EN 60928 and BS EN 60929 respectively. They should be designed and manufactured in accordance with ISO 9001.

The ballast shall maintain constant light output in the voltage range 220V±6%, 50Hz single phase AC supply. The percentage of light emitted from a reference fluorescent tube with these ballast (Ballast Lumen Factor) shall not be less than 95%.

The ballast's case temperature shall not exceed 25°C over 40°C ambient.

The overall power factor of the lamp shall not be less than 0.95 lagging. The service life of the electronic ballast shall not be less than 50,000 hours at maximum case temperature, whereas the failure rate shall be less than 1% per 4,000 hours at maximum case temperature.

The electronic ballast shall have a total harmonic distortion of less than 15%.

Where one electronic ballast is used for operating two lamps in one luminaire, the

failure of one lamp shall not affect the operation of the other lamp.

(5) Photo-electric Controller. Photo-electric Controllers shall comply with BS5972. They shall be of electronic fail-safe type with a switch on value of 200 lux, an on:off ratio of 1:1.5, and shall have an inherent time delay of 30 seconds to prevent operation by extraneous light. They shall also be suitable for use in exposed weather conditions and shall function correctly within the temperature range of -5^0C to + 45^0C at local supply voltage and freqency.

(6) Time Switch. Time switches are used for controlling those lights switched at fixed times. They shall be equipped with a spring or battery reserve of at lease 24 hours and shall be self-starting type driven by synchronous motor.

(7) Contactor. Contactors shall be 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.

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

(9) Miniature Circuit Breaker and Distribution Board. Miniature circuit breakers (MCB) shall be of thermal magnetic type calibrated at 40^0 C and shall comply with BS EN 60898.

All MCB distribution boards shall be fabricated of galvanised steel sheet not less than 1 mm thick. They shall be fiinished with high grade enamel paint and shall comply with BS EN 60439.

(10) PVC Cable. All cables shall have copper conductors. Except those mentioned below, all cables enclosed in conduit shall be single core, 450/750V grade, PVC insulated, complying with BS 6004.

Cables up to 35mm^2 within the pillar box, if not concealed in conduit or trunking, shall be PVC insulated and PVC sheathed, 300/500V grade to BS 6004 or PVC insulated and PVC sheathed greater than 50mm^2 complying with BS 6346 with voltage grade 600/1,000V.

(11) Conduit and Accessories. Steel conduits shall be of heavy guage, screwed, longitudinally welded and shall comply with IEC 60614-2-1.

Conduit fittings shall comply with IEC 61035. Metal boxes for enclosure of electrical accessories in conduit installation shall comply with BS 4662/IEC 60670.

All conduit entries to adaptor boxes shall be connection by means of couplings and hexagonal male bushes.

All conduit entries to luminaries shall be sealed by silicone rubber after wirings are drawn in order to safeguard against the ingress of water, insects etc into the luminaires.

Conduits shall not be used as an earthing conductor. Independent circuit protective

conductor shall be provided for each of the lighting circuit.

B.7 PROPOSED MATERIAL AND EQUIPMENT

Any materials and equipment to be used for the lighting installation shall seek approval from Lighting Division, HyD and the Maintenance Agent/Contractor at an early stage.

B.8 SPARE EQUIPMENT

For ease of maintenance, 10% each of the installed luminaires and other spare parts shall be delivered to the respective Maintenance Agent/Contractor by the Contractor as spares before handing over the lighting installation to Lighting Division for Maintenance.

The exact quantity of such spares will be advised by the Maintenance Agent/Contractor.

B.9 AS-FITTED DRAWINGS , ILLUMINANCE READINGS & TEST REPORTS

Two sets each including hard copy and soft copy/computer file in Microstation version 3D DGN format each of "As-fitted" drawings comprising the lighting layouts, circuit diagrams, schematic wiring diagrams, conduit/trunking routes, cable routes and two sets each of illuminance readings, certified electrical test reports and O & M Manual shall be submitted to Lighting Division, HyD and the Maintenance Agent/Contractor.

APPENDIX C

EMERGENCY LIGHTING REQUIREMENTS FOR COVERED PUBLIC TRANSPORT INTERCHANGE LIGHTING INSTALLATIONS

CONTENTS

C.1 OBJECTIVE

Emergency lighting is required for covered public transport interchanges for satisfactory emergency exit by the public during normal power failure.

C.2 GENERAL REQUIREMENT

Where a standby generator is to be installed for the building, at least 12% of the total luminaires shall be connected to the standby circuit (Alternatively, to simplify the lighting design, 1/3 of the total luminaires as assigned for the night-time lighting may be connected to the standby circuit). The highbay lighting fittings selected for operation under emergency shall be equipped with a tungsten halogen auxiliary lamp not less than 150 watt and with standby relay circuit. In the event of normal electricity supply failure, the auxiliary lamp shall be lit up until the SON or ceramic discharge metal halide lamp restrikes. The Developer shall be responsible for the maintenance and fuel costs of the generator.

C.3 UNINTERRUPTIBLE POWER SUPPLY SYSTEM

In case an emergency generator will not be provided for the building or it is impracticable to provide essential supply due to the generator being installed in a separate building, at least 12% of the total luminaires shall be connected to an uninterruptible power supply (UPS) system with a minimum one hour back-up time. The specification of UPS system is given in Appendix D.

C.4 UNIFORMITY

The selected positions of the emergency luminaire shall give a reasonable uniformity for lighting distribution. In addition, priority shall be given to the luminaires at the exits.

C.5 VENTILATION

Natural or forced ventilation shall be provided for the room housing the UPS system.

APPENDIX D

SPECIFICATION OF UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM FOR COVERED PUBLIC TRANSPORT INTERCHANGE LIGHTING INSTALLATIONS

CONTENTS

D.1 GENERAL

D.1.1 The UPS system shall only be installed when the standby emergency generator will not be provided for the building or it is impracticable to provide essential supply due to the generator being installed in a separate building.

D.1.2 The UPS shall comprise a rectifier and charger unit, battery bank, inverter, static by-pass switch unit, controls, protection & indication equipment and accessories to perform the required functions.

D.1.3 The UPS shall comply with the functional requirements as stated in paragraph D.2 below and be suitable for unattended and maintenance free operation.

D.1.4 The materials and equipment offered, where applicable, shall comply with the relevant British Standards or IEC equivalent. The battery cells shall be of maintenance free sealed nickel cadmium or sealed lead type.

D.1.5 All electrical installation shall comply with the latest edition of the following documents:

(a) Code of Practice for the Electricity (Wiring) Regulations;
(b) General Specification for Electrical Installation in Government Buildings of the Hong Kong Special Administrative Region;
(c) The IEE Wiring Regulation issued by the BSI; and
(d) Local Power Company's "Supply Rules".

D.1.6 All electronics installation shall comply with the latest edition of the following documents:-

(a) General Requirement for Electronic Contracts, ESG 01, EMSD;
(b) General Technical Specification for Uninterruptible Power Supply System, ESG 15, EMSD; and
(c) IEE Wiring Regulations.

D.1.7 A lockable switch shall be provided to isolate the load and the UPS system for the mechanical maintenance of the luminaires.

D.2 FUNCTIONAL REQUIREMENT

D.2.1 Under normal operating condition, the mains AC power is fed to the rectifier and charger unit which converts the AC power to DC power charging the battery bank and providing power to the inverter. The inverter converts the DC power to AC power to supply the emergency lighting luminaires through the static bypass switch.

D.2.2 In the event of overload or breakdown of the UPS, the static by-pass switch shall enable the load to be supplied directly from the mains without interruption.

D.2.3 Upon failure of the mains supply, the input power for the inverter is automatically fed from the battery bank without interruption.

D.2.4 When the mains power is restored, the UPS will automatically switch to its normal operating mode as described in paragraph D.2.1 without interruption.

D.2.5 To facilitate maintenance service, the UPS shall include a manually operated mechanical bypass system to transfer its load to be fed from the mains without interruption.

D.3 PARTICULAR REQUIREMENTS FOR UPS SYSTEM

D.3.1 The inverter unit, rectifier unit and charger unit shall be designed in one compact module type and in the form of rack for easy maintenance. 1 set of spare module including inverter, rectifier and charger units shall be submitted to the Maintenance Agent/Contractor after commissioning and testing. The protection rating for the enclosure or housing of the UPS which is located outdoor shall be to IP65.

D.3.2 Battery type shall comply with BS 6290:Part 4 and shall have a life expectancy of at least ten years under normal condition. Each cell unit of battery bank shall not be in open-circuit state during faulty condition. All battery shall comply with ISO 14001 environmental requirements.

D.3.3 Battery bank shall be installed in the way that each battery cell could be easily accessed, with reasonable clearance and headroom, by personnel for daily maintenance/ measurement purpose.

D.3.4 Each electrical terminal shall be covered by insulated material and protected by suitable terminal grease.

D.3.5 Separate terminal for dummy load with key-lock switch shall be provided.

D.4 METER, LAMP INDICATOR AND FAULT INDICATOR

D.4.1 Meter

The following meters shall be installed :

(a) DC voltmeter - measuring power module DC volts;

(b) DC ammeter - measuring battery charging/discharging current;

(c) AC voltmeter - measuring power module input and output phase voltages and line voltages;

(d) AC ammeter - measuring current in each input and output phases; and

(e) Frequency meter - measuring UPS input and output frequency.

D.4.2. Lamp Indicator

Light emitting diodes shall indicate the status of each component unit of the UPS.

D.4.3 Fault Indicator

All fault indicators shall be electrically latched to indicate transient and continuous faults. The following light emitting diode fault indicators shall be installed:

(a) Mains failure;
(b) Fuse failure;
(c) Overload;
(d) Load on battery;
(e) Load on bypass; and
(f) Low battery

D.4.4 Remote Fault Indicator

To facilitate routine lighting inspection, a separate red indicating lamp with a diameter not less than 30 mm shall be installed inside the Bus Regulator's Office (or at a remarkable location if the Bus Regulator's Office is not available). The lamp shall be operated when one or more faults as listed in paragraph D.4.3 are detected. It shall be electrically latched to indicate the transient and continuous faults.

D.4.5 Lamp Test Facility

Lamp test facilities shall be provided for all the fault indicators as stated in paragraph D.4.3 and D.4.4.

D.5 ENCLOSURE

D.5.1 The casing of the UPS equipment shall be rodent proof and made of painted galvanized sheet steel complete with locks. Its design shall be easy to install. The enclosure shall be securely fixed onto the floor to guard against theft.

D.5.2 The UPS shall be provided with ventilation fans.

D.5.3 A minimum clearance space at least 450 mm shall be provided behind or by the side of the UPS and battery cabinet where access from behind or the side is required for connection or maintenance purpose.

D.6 AS-FITTED DRAWINGS & TEST REPORTS

Two sets each including hard copy and soft copy/computer file in Microstation version 2D DGN format each of "As-fitted" drawings comprising the lighting layouts, circuit diagrams, schematic wiring diagrams, conduit/trunking routes, cable routes and certified electrical test reports and O & M Manual shall be submitted to Lighting Division, HyD and the Maintenance Agent/Contractor.

APPENDIX E

MODEL SPECIFICATION FOR HIGH MAST LIGHTING

CONTENTS

E.1 GENERAL

The specification described in this document includes the design, installation and commissioning of high mast lighting in the positions shown on drawing Nos._____.

E.1.1 Extent of Works

The works included in the Contract comprise the following :

(a) Supply and delivery of steel flanged-base high mast lighting columns to give lantern mounting heights between 30 and 40 metres 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 frame, earthing and lightning protection facilities, ballast, 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 under the main Contract. Where a mast is to be erected on sloping ground, the foundation shall include an area of 3m x 3m flat working platform. Safety detachable railings shall be provided at the platform edges with sufficient working space near the mast to allow for the setting up of the maintenance cage without the requirement of any lane closure.

E.1.2 Defective Works

Where in the opinion of the Engineer any of the finished works, or the materials or workmanship in any part of the works, do not comply with the relevant requirements of the 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 Engineer. All removal and replacement of defective works and all costs arising thereof shall be at the Contractor’s expense.

E.1.3 Compliance with Relevant Standards

All materials and equipment shall comply with relevant British Standards and the current editions of the “Codes of Practice for the Electricity (Wiring) Regulations issued by the Electrical & Mechanical Services Department, the "General Specification for Electrical Installation in Government Buildings of the Hong Kong Special Administrative Region" issued by the Architectural Services Department, the IEE Wiring Regulations issued by BSI, and the local Power Company's "Supply Rules".

The design of high mast lighting system shall comply with Technical Report No. 7: High Mast Lighting, published by the Institution of Lighting Engineers (U.K.).

E.1.4 Associated Documents

This Particular Specification shall be read in conjunction with the Contract Drawings and the current editions of the following documents:

(a) The main contract documents;

(b) Code of Practice for the Electricity (Wiring) Regulations.

(c) The General Specification for Electrical Installation in Government Buildings of the Hong Kong Special Administrative Region; and

(d) Technical Report No.7: High Mast Lighting, published by the Institution of Lighting Engineers (UK).

E.2 MAST

E.2.1 General

The mast shall provide a lantern mounting height between 30 and 40 metres. It shall be of welded steel construction, unstayed and of continuously tapered form.

Details of the high mast design shall comply with Technical Report No. 7 published by the Institution of Lighting Engineers (U.K.).

The mast shall cater for a 3 second gust wind speed, with a return period of 50 years, of 70 m/s measured at a height of 10m above ground level, giving a reference pressure of 3 kN/m^2.

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

The maximum horizontal deflection at the top of the mast under a horizontal loading of 0.75 kN/m^2 (wind speed 35 m/s measured at a height of 10 m 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 10 m/s and 70 m/s. If the natural frequency of the structure falls within this range, the amplitude of the oscillation must be restrained by adequate structural damping.

Separate check for Seismic effects shall be made by means of the formula:

$$V = CW$$

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

E.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 3 m 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 design load.

E.2.3 Steel Base-plate

Each mast shall have a uniform steel base-plate for bolting to the foundations together with a set of high tensile stainless steel foundation bolts, a lower steel anchor plate and timber spacing jig. Stainless steel foundation bolts and nuts shall conform to BS 6105, steel grade A4 and property class 80 as per section 18 “Steelwork” in the General Specification for Civil Engineering Works. Where used, high strength friction grip bolts, nuts and washers shall conform to BS 4395 and BS 4604 part I. Other bolts, nuts and washers shall conform to BS 1769 and BS 3410.

Two copies of the method statements for the installation and relevant drawings shall be supplied to the Engineer.

The Contractor shall be responsible for leveling the steel anchor plate on the prepared foundations 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.

E.2.4 Mast Construction

Structural steel to be used for construction of the mast shall be Grade S355J0H to BS EN 10210 for thickness up to and including 38 mm. If a greater steel thickness is required, the contractor shall submit his construction proposals to the Engineer for approval.

Other steel may be considered 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 for the approval of the Engineer. 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. Keyholes shall be provided with weather-proof cover plates. A 16 mm 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.

E.2.5 Protection of Steelwork against Corrosion

Section 18 “Steelwork” in the General Specification for Civil Engineering Works must be followed. Protection of the mast surfaces shall be hot dip galvanized to BS EN ISO 1461 for both internal and external surfaces. Painting of the mast is required according to Section 18 “Painting Steelwork” in the General Specification for Civil Engineering Works. The colour for painting of the mast shall comply with BS 4800 (BS 18C35).

E.2.6 Winching Mechanism

E2.6.1 General

The lantern ring shall be raised and lowered by a self-sustaining worm-geared winch suitable for both manual and power driven operation and located at the foot of the mast. The winch shall be designed in 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 calculation for lanterns, headframe, steel wires and accessories shall be endorsed by 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 10 metres. Arrangement 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 designed life span,

replacement criteria, checklist for preventive maintenance and the recommended lubrication oil with renewal interval for the winch system.

E.2.6.2 Safe Working Load

The winch and all hoisting equipment must be adequate to allow for attaching to the lantern hoist ropes a maintenance cage or cradle which will sustain a working load of 350 kg. 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.

E2.6.3 Design

The hoisting ropes shall be 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 rope. 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 1 metre 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 hosting operation and the last 2 metres 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.

When the winch is used in conjunction with the maintenance cage, it 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 or cage 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.

E.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 ensure automatic correct location and locking in position when the assembly is in the raised position.

The Project Office shall provide, as required by the maintenance agent, the provision of counter weight on the head-frame for balancing on which the lanterns are not evenly installed.

E.3 LANTERN

E.3.1 General

The lanterns shall be of sound and robust construction to BS EN 60598. They shall be for use on 220V, 50 hertz single phase supply and be suitable for 400W, 600W or 1000W SON-T Plus lamps.

The lanterns shall have an ingress protection (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 particular case. Nevertheless, the lanterns shall not cause any spill lights above the horizontal.

Labels shall be securely affixed inside the lantern body. These shall include the mark of origin, model number, rated voltage, rated wattage of 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 column.

Lantern Wattage	Lantern Weight	Lantern Windage Area
400/600W	15 kg	0.30 m^2
1,000W	25 kg	0.34 m^2

E.3.2 Construction

The lanterns shall be of sound and robust construction to withstand the movement and vibration expected, totally enclosed, and shall be 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 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 resisting 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 it is of Class II insulation.

The Contractor shall supply a drawing of the lantern together with the photometric data stored in a floppy diskette in the TM-14 CIBSE format or other formats approved by Lighting Division, HyD.

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°).

(c) Axial Asymmetric.

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

E.4 ELECTRICAL AND MECHANICAL ACCESSORIES

E.4.1 Lamp

Lamps shall be 400W, 600W, 1,000W tubular high pressure xenon high pressure sodium (SON-T Plus) suitable for 220 volt, 50Hz operation, with design lumen output of 55, 90, 135 klm respectively. Details of lamp life and light output shall be supplied to the Engineer.

E.4.2 Ballast and Ignitor

Ballast shall have voltage tappings of 10 Volt steps from 200 Volts to 240 Volts and be

of the enclosed solid filled type. All tappings must be brought to suitably marked terminals to which lamp and supply connections must be made. The ballast shall be reasonably silent in operation. To obviate interference with radio and television, they shall be suitably wound so that the radio interference field strength shall lie within the limits specified by BS EN 55015.

Superimposed pulse ignitor featuring bilateral multipulse for high pressure discharge lamps up to 12A running current shall be mounted in the lantern or within 2 meters of the lamps. The ignitor should be compatible with any standard ballast.

E.4.3 Capacitor

Capacitors for the lamps shall be totally enclosed and proof against condensation, fitted with internal safety leaks and seal-in P.V.C. cable tails conforming to BS EN 61048 and BS EN 61049. The power factor of the load shall not be less than 0.85.

E.4.4 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 galvanised weather-proof junction box housing terminal blocks of suitable rating. One core in the cable shall be an earth continuity 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 galvanised steel enclosure shall protect the cable pulleys, winch rope pulleys and the top of the mast from the ingress of rain.

E.4.5 Interconnecting Cable

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

Cables shall enter 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 on the earth terminal of the ring distribution boxes.

E.4.6 Lightning Protection

East mast shall be effectively earthed for lightning protection by separate earth rod(s) 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 rod(s) 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 70 mm^2.

Means shall be provided to disconnect the mast from the rod(s) for testing.

The whole of the lightning protection system shall be in accordance with the recommendations of BS 6651. The down conductor and inter-connectors shall be buried at a depth at least 450 mm below final ground level.

It will 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.

E.4.7 Earthing

The whole of the equipment shall be effectively earthed by the Contractor in accordance with the current editions of the IEE Wiring Regulations, BS 7430, and the General Specification for Electrical Installation in Government Buildings of the Hong Kong Special Administrative Region.

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 masts by means of minimum 4 mm^2 cables to BS 6231. The earth terminals 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 and determine the necessary length and number of earthing rods. The earthing electrodes shall be housed in suitable earth pits.

E.4.8 Maintenance Cage

A maintenance cage of sufficient size and strength shall be provided to raise two men together with maintenance equipment, at a total weight of 350kg, to the top of the mast. The maintenance cage shall be raised and lowered by the mast winch and wire ropes. Suitable arrangements shall be provided to prevent damage to the protective systems of the mast during raising and lowering. The case shall be hot dip galvanised after manufacture. The safe working load in English and Chinese shall be prominently displayed in a permanent position on the maintenance cage.

The cage shall also incorporate a safety device which supports the loaded cage in the event of a failure of the hoist ropes or any part of the hoisting gear. The safety device shall comprise a suitably designed block stop mechanism and auxiliary suspension ropes, which allow the cage to ascend freely but will only allow the cradle to descend while a lever on the block stop is manually held open. Attachment points for operator's safety belts shall be provided on the cage. A swinging frame shall be fitted to the cage and engages a chain device to the mast head. The suspension wires shall be secured to the ends of the chain and pass through the block stops attached to the cage.

The cage shall comply with the Factories and Industrial Undertakings (Lifting Appliances and Lifting Gear) Regulations. A certificate to this effect (which shall appear on a label permanently fixed to the cage) shall be supplied with the cage.

The Project Office is required to provide at least one maintenance cage for one project for use by the maintenance agent.

E.5 ELECTRICAL SUPPLY AND CONTROL SYSTEM

E.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 British Standard Specifications. All electrical works shall comply with the current editions of the "Code of Practice for Electricity (Wiring) Regulation", "General Specification for the Electrical Installation in Government Buildings of the Hong Kong Special Administrative Region", the IEE Wiring Regulations, Electricity Supply Ordinance, "Supply Rules" of the respective Power Companies, Safety Regulations by the local Labour Department and Fire Services Department's Requirements.

E.5.2 Connection to Mains Supply

The switchfuses, 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 will be installed by the Power Company up to and including the meter.

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

E.5.3 Photo-electric Controller

The photo-electric controller to be supplied shall incorporate the design features and meet the details of performance set out below:

(a) Type: shall be of 2 part type with sensor;

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

(c) Differential: shall have an on:off ratio 1:1.5;

(d) Switch on On level: 55 lux;

(e) Temperature Range: shall be suitable to operate within a temperature range of -5^0 C to + 50^0 C;

(f) Operation:
(i) shall be designed so that in the event of a fault occurring in the photo-electric controller, the unit shall be fail-safe and in the 'on' position;

(ii) shall include a delay devise so that switch 'on' does not occur due to transient change in illuminance; and

(g) Humidity Range: shall be suitable to operate up to 100% relative humidity.

E.6 COMMISSIONING AND TESTING

Inspection by the Engineer, 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 Engineer

Commissioning of the system shall include :

(a) Insulation resistance measurements of individual circuit;

(b) Resistance measurement of the earthing system, earth continuity of the electricity installation and lightning protection system;

(c) Raising and lowering gear operation;

(d) Maintenance cage operation;

(e) Operation of automatic control system;

(f) Illuminance measurements;

(g) Reflectors setting of luminaires; and

(h) Testing of winching mechanism, maintenance cage auxiliary suspension ropes and safety devices, including requirements of Lifts and Escalators (Safety) Ordinance. Operating test shall be conducted from the fully lowered to the fully raised positions.

Test shall be carried out on each mast. Test reports and test certificates shall be submitted by the Contractor to LD, HyD.

E.7 SPARES AND MAINTENANCE

The Contractor shall provide and deliver the following spare parts to the Maintenance Agent/Contractor for future maintenance:

(a) 1 lantern for each mast supplied;

(b) 1 lamp for each mast supplied;

(c) 1 No. photo-electric controller;

(d) 1 No. winch with ancillary hoisting equipment and associated hoisting ropes;

(e) 1 No. power-driven unit; and

(f) Other spare parts as recommended by Lighting Division or the Maintenance Agent/Contractor.

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

At the expiry of the defect liability period, the Contractor shall perform all the tests to the Maintenance Agent/Contractor that the whole lighting installation is working satisfactorily.

E.8 AS-FITTED DRAWINGS, ILLUMINANCE READINGS & TEST REPORTS

On completion of the installation, the Contractor shall submit two sets each including hard copy and soft copy/computer file at Microstation version 3D DGN format of "As-fitted" drawings comprising the lighting layouts, circuit diagrams, schematic wiring diagrams, conduit routes, cable routes and two sets each of illuminance readings, certified electrical test reports and O & M Manual to Lighting Division, HyD and the Maintenance Agent/Contractor.