Guidelines for the Provision of Road Lighting

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Jabatan Kerja Raya
Cawangan Jalan

NTJ 29/2015

GUIDELINES FOR THE PROVISION OF ROAD LIGHTING

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KERAJAAN MALAYSIA

GUIDELINES FOR THE PROVISION OF ROAD LIGHTING

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FOREWORD

The purpose of publishing this Nota Teknik Jalan 29/2015, hereinafter called NTJ 29/2015 – Guidelines for the Provision of Road Lighting is to provide some basic requirements and design considerations for the installation of lighting along the roads. The application of this guideline is to improve the decision making process through applications of selected criteria.

The preparation of this document was carried out through some research and discussions by a Technical Committee which has been formally formed for the purpose. This Committee consisted of members with experiences in planning and design of lighting facilities particularly those related to roads. Feedbacks and comments received from stakeholders are carefully considered and incorporated into the document wherever appropriate. This document has been presented and approved in the *Mesyuarat Jawatankuasa Pemandu Pengurusan JKR Bil. 13/2014* on 17th June 2014.

For continuous improvement, this NTJ will be reviewed and updated from time to time to incorporate changes in policies and current design requirements. Following which it will be upgraded as part of the Arahan Teknik Jalan (ATJ) series of documents. In this respect, any comments and feedbacks regarding this document are welcome and should be forwarded to *Unit Standard & Spesifikasi, Cawangan Jalan*, *JKR Malaysia.*

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ABBREVIATIONS

JKR	-	*Jabatan Kerja Raya Malaysia* (Public Works Department Malaysia)
ATJ	-	*Arahan Teknik (Jalan)*
NTJ	-	*Nota Teknik (Jalan)*
CKJG	-	*Cawangan Kejuruteraan Jalan & Geoteknik, JKR (2014)*
CKASJ	-	*Cawangan Kejuruteraan Awam, Struktur & Jambatan, JKR*
CKE	-	*Cawangan Kejuruteraan Elektrik, JKR*
CKBA	-	*Cawangan Kerja Bangunan Am, JKR*
CJ	-	*Cawangan Jalan, JKR*
CPUM	-	*Cawangan Pengkalan Udara dan Maritim, JKR*
BPJ	-	*Bahagian Perancang Jalan, KKR*
CKS	-	*Cawangan Kejuruteraan Senggara, JKR*

GUIDELINES FOR THE PROVISION OF ROAD LIGHTING

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1.0 INTRODUCTION

1.1 General

Basically, on all rural roads and some of the urban roads, vehicle headlight provides the only form of illumination for road users at night, and this is usually quite sufficient. However, on many urban roads, vehicle headlights are supplemented with fixed road lighting so that all road users including drivers of vehicles, pedestrians and bicyclists, can travel with safety and comfort. Road lighting in urban areas also results in significant community benefits such as improved security of property, deterrence of crime and enhancement of the local environment.

Many of the arguments for road lighting relate to a reduction in both the rate and severity of night-time accidents. Research has shown that road lighting can reduce injury accidents between 25 - 30 per cent. The cost savings relating to reduction in injury and death more than offset the capital cost of providing the road lighting.

Road lighting is an integral part of road infrastructure. The general concept in road infrastructural design is to make the road environment, in particular hazardous objects, sufficiently visible to road users. This would enhance traffic flow and create safer road environment.

This document outlines the guidelines for the provision of road lighting including its principles, basic lighting needs for roads and the appropriate design considerations. This document should also be read together with other relevant documents relating to the standards and specifications on road lighting.

1.2 Purpose Of Road Lighting

The general purpose of road lighting is to make the surrounding traffic and all features along the road visible in order to attain a certain level of visibility with distinctly significant details. Such visual standards are important to all road users including enforcement and road maintenance authorities. More importantly, it provides good visual guidance and should not mislead driver's vision. A lesser but equally significant is the communal roles in creating an interesting and pleasant environment both by day and night.

Good road lighting will create a visual environment that enables people to see clearly, thus allowing them to move around safely and perform visual tasks efficiently without causing undue visual fatigue and discomfort. Some of the functions of road lighting are described as below.

1.2.1 Illuminated Environment

The purpose of road lighting is to provide an illuminated environment, which is conducive to the safety and comfort of vehicular and pedestrian traffic movement at night. To fulfill this, the lighting system must sufficiently produce both quantitatively and qualitatively, the illumination required for accurate revelation and comfortable visibility at night.

1.2.2 Road Safety

The primary purpose of road lighting is to reduce the possibilities of accident occurrences on the roads at night. Road lighting can improve traffic flow at night by providing light beyond that provided by vehicle lights. It also aids the drivers in manoeuvring their vehicles, delineates the road alignment and highlight obstructions in the road environment as well as judging opportunities for overtaking.

1.2.3 Accident Countermeasures

The introduction of adequate road lighting can help to overcome frequent night time accidents at certain stretch of roads. It is particularly important where there are high proportions of pedestrians, cyclists or other poorly lit road users.

1.2.4 Lighting for Other Purposes

The other benefits of road lighting to the community accrue through improved security of property, lower crime rates and enhancement of commercial, business and social / recreational environments.

For all that being mentioned above, road authorities must be aware that the provision of road lighting may not be the most cost effective means of reducing night time accidents. Other carriageway improvements such as delineation of road alignments by reflective studs, improved traffic signages and road markings, and restoration of road furniture should be considered before installing road lighting.

1.3 Scope Of This Guideline

This guideline emphasises on road lighting design based on well-established principles and experiences including taking into account economic considerations. It stressed on the application of warrants for installation of road lighting where standards associated with it need to be applied with flexibility and judgement to account for the wide variation in site, traffic and environmental conditions. However, the term 'road lighting' used in this document only encompasses lighting specifically provided for public roads.

This document shall be referred to by road designers (civil engineers) and should be a useful reference for other engineering disciplines such as electrical and mechanical engineers. Any provision on the facility contained in other related documents (published by PWD Malaysia) that are contradictory to this guideline is hereby deem superceded.

1.4 Relevant Standards

This guideline should be read together with other relevant documents related to road lightings. The followings are locally and internationally published standard references covering some aspects of road lightings.

a. MS 825: Code of Practice for the Design of Road Lighting
b. L-S20 – *JKR Malaysia* - Specification for Road Lighting Installation
c. BS EN 13201: Road Lighting
d. *Panduan Teknik Cawangan Kejuruteraan Elektrik, JKR Malaysia*
e. Standard Specification for Road Works - Section 7: Road Lighting (JKR/SPJ/2011-S7)
f. REAM – GL 4/2002 – Guidelines for Works Related to Public Utility Installations within the Road Reserve

1.5 Terms And Definitions

This section covers a list of terms commonly used in this document. Each term is defined appropriately in the context of road lighting through the interpretation of civil engineering discipline.

1.5.1 Terminology on General Road Lighting

a. Luminaire

A complete lighting unit consisting of a lamp or lamps together with the parts designed to distribute the light, to position and protect the lamps and to connect the lamps to the power supply.

b. Silhouette Vision

When object is viewed against a brighter background, the object will appear as a dark profile in contrast to its lit background.

c. Disability Glare

Disability Glare from road lighting luminaire causes loss of visibility due to the reduction in contrast between objects and their background.

d. Discomfort Glare Control Mark (G)

A measure of the discomfort glare evaluates in a specified way on a scale of 1 to 9; the higher numbers corresponding to greater glare control.

e. Visual Acuity

Visual acuity is defined as the clarity or sharpness of vision, which is the ability of the eye to see and distinguish fine details. This is an important factor for a variety of everyday tasks, including reading text, recognizing symbols, and performing assembly work. Good visual acuity is very important when driving, because it helps people recognize landmarks, avoid obstacles, and read road signs.

f. Visual Performance

One of the components which determine the visual reliability of a motorist that deals with the ability to detect subtle change in his view.

g. Visual Stimulus

Visual stimulus is basically the light (or electromagnetic waves) entering the eye. The human eye is capable of seeing only a small portion of the electromagnetic wave spectrum, called the visible light spectrum. Visual experience occurs when light entering the eye is transduced into neuronal signals and processed by the brain.

h. High Mast

An unstayed steel mast supporting a cluster of luminaries with height of 18 m or more. The height of the mast is defined as the vertical distance between the base flange and the plane in which the lamps lie when in their operating position.

i. Expressway

A divided highway for through traffic with full control of access and always with grade separations at all intersection.

j. Highway

They constitute the interstate national network for intermediate traffic volumes and complement the expressway network usually linking up directly or indirectly the Federal Capital, State Capitals, large urban centres and points of entry/exit to the country.

k. Single Carriageway

A single carriageway is a road without a central reservation to separate opposing flows of traffic regardless of the number of lanes. For instance, two-lane road are single carriageway with one lane for each direction.

l. Dual Carriageway

A dual-carriageway is a class of road with two carriageways for traffic travelling in opposite directions separated by a central reservation.

m. Annual Average Daily Traffic (AADT)

It is the total volume of vehicle traffic of a highway or road for a year divided by 365 days.

n. Clear Zone

The roadside area clear of obstacles, starting at the edge of the traveled way, available for safe use by errant vehicles. This area may consist of a shoulder, a recoverable slope and/or a clear run-out area. The desired width depends on traffic volumes and speed, and on roadside geometry.

o. Verge

This is that part of a road located on the immediate outside of the road shoulder. The verge (about 1.0 m) typically terminates before the roadside drain adjacent to the road if one exists.

p. Road Shoulder

An area of pavement, gravel or hard surface placed adjacent to through or auxiliary lanes. Intended for emergency stopping and travel by emergency vehicles only, it also provides structural support for the pavement.

q. Feeder Pillar

A feeder pillar (UK) or power box (USA) is a cabinet for electrical equipment, mounted on the roadside. It is designed to control and monitor the electrical supply of road lighting in a neighbourhood. A feeder pillar is simply a layman's term for a transformer, cutout

enclosure, or other enclosure used in conjunction with underground electrical distribution.

1.5.2 Terminology on Lighting Hardware and Geometrical Features
(Refer to Figure 1 for illustration)

a. Lighting Column
Support intended to hold one or more lantern, consisting of one or more parts; a post possibly an extension piece and, if necessary, a bracket.

b. Nominal Height
The distance between the centre line of the point of entry of the lantern and the intended ground level, for a column planted in the ground, or the bottom of the flange plate, for a column with a flange plate.

c. Setback
Horizontal distance between the edge of the carriageway and the centre line of the lighting pole, measured normal to the direction of the traffic.

d. Bracket Projection
Horizontal distance from the point of entry to the lantern to a vertical line passing through the centre of the cross section of the column at the ground level.

e. Upcast Angle
Angle between the axis of the lantern fixing and the horizontal.

f. Planting Depth
The length of the column below the intended ground level.

g. Base Plate
Plate below ground level fixed to a planted column to prevent the column from sinking into the ground and to help prevent the column from overturning.

h. Flange Plate
A plate, with an opening for cable entry, attached rigidly to a column which is surface-mounted, to allow it to be secured to a concrete foundation or to other structures.

i. Deflection
Horizontal displacement of the point of entry of the lantern as a result of exterior loadings on the column, bracket and lantern and the

vertical displacement of the point of entry of a lantern as a result of the mass of the lantern and the bracket.

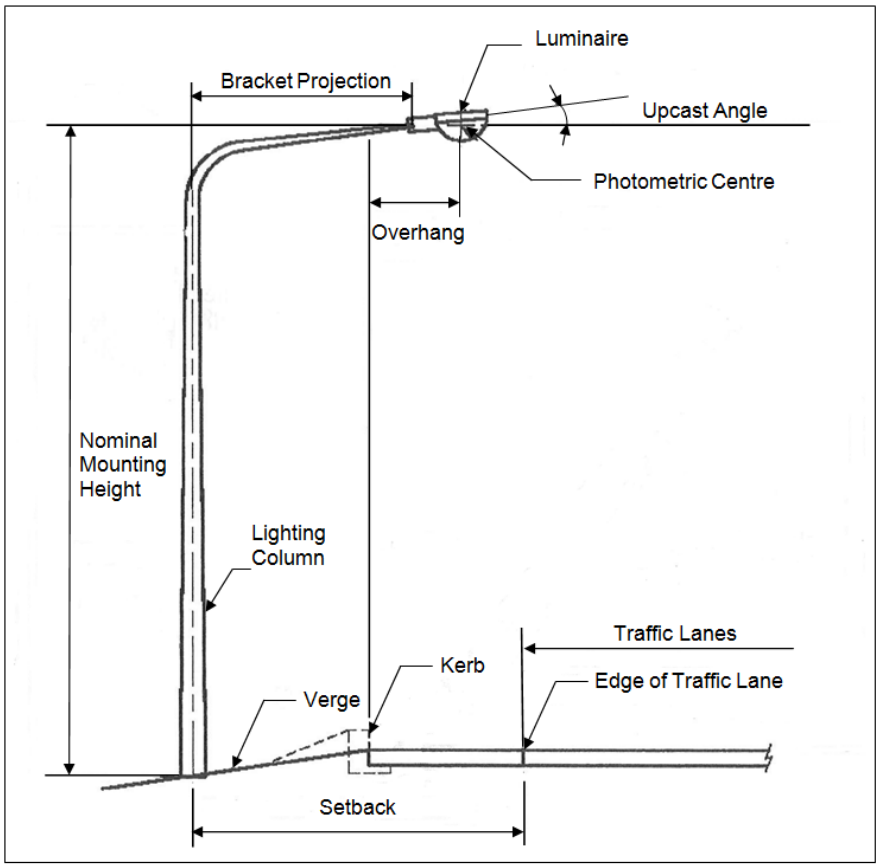

Figure 1: Lighting Hardware and Geometrical Features

2.0 PRINCIPLES OF ROAD LIGHTING

Road lightings are intended to expose signs, objects and hazards along the driving route. They must provide sufficient amount of lighting to reveal visual information for road users, assist traffic flow and provide comfort to road user.

2.1 Visual Perception

An object on a road may be seen in one of the following ways:

a. By silhouette vision, which occurs when the brightness of the background is greater than that of the object. This type of vision enables the size, shape and location of the object to be determined, even though all details of its surface are not visible. It is widely accepted as being satisfactory for good road lighting visibility.

Figure 2: Example of silhouette vision

b. By reverse silhouette vision, which occurs when the object is slightly brighter than its background, but not bright enough to indicate surface detail. Traffic islands may often be seen by reverse silhouette.

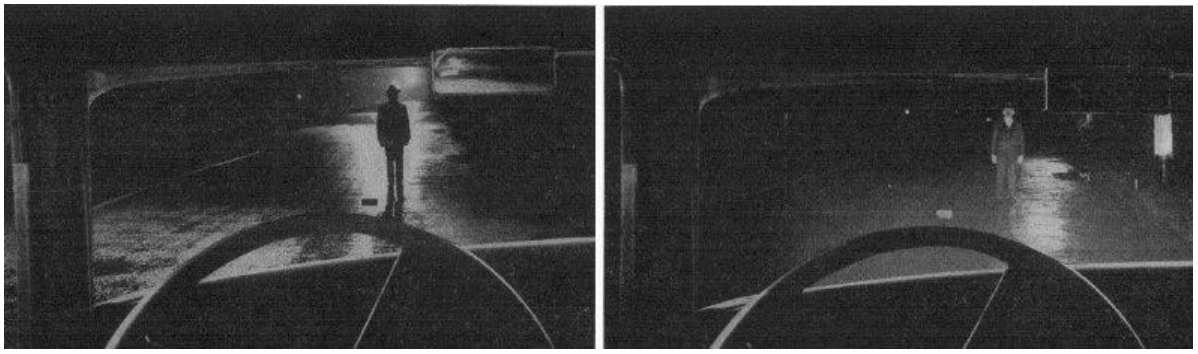

Figure 3: Comparison of silhouette vision (left) and reverse silhouette vision (right)

c. By direct vision, which occurs when the level of illumination is sufficient to enable surface detail to be seen. Traffic signs must be seen by direct vision.

Figure 4: Example of direct vision

Road lighting need to be adequate and systematically arranged in order to assist driving and avoid visually misleading drivers. Driver's visual ability to perceive contrast is poorer at low lighting level.

Figure 5: Comparison of a road with good (left) and poor (right) lighting level

2.2 Basic Requirements

When planning for the provision of road lighting, the following requirements shall be taken into consideration:

2.2.1 Driver's Requirements

All objects are seen by contrast, either dark against a light or light against dark. Our ability to see objects depends upon this contrast, and we need more of it at lower lighting levels and when we need to see smaller detail. Thus, a driver needs more light at higher speeds as his safe stopping distance increases, and he has less time to see the edges and even the state of the road surface itself.

Silhouette vision technique is used whereby the object appears dark against a bright road surface. At the same time, light coming directly into the eyes (glare) has to be kept to a minimum, as it reduces the sensation of contrast.

2.2.2 Vulnerable Road User's Requirements

Special considerations need to be given to vulnerable groups such as pedestrians, cyclists, elderly, disabled and children to increase their safety while traveling along the roads. They need to see other people and objects along the road but do not have to react so quickly to distant objects as do the drivers and therefore, overall lighting levels can be lower. The light has to be directed towards vertical, rather than horizontal surfaces, particularly for viewing other pedestrians.

2.2.3 Lighting for Surrounding

This is important for all road users. For the driver, lighting provides a background against which stationary objects at the side of the carriageway can be seen. For the pedestrian, it helps create a pleasant visual scene by night, revealing the buildings and surroundings. It also helps to identify landmarks by which strangers can recognise areas.

Lighting up roadside residential areas also act as a deterrent of vandalism and reduce the fear of crime which helps to increase personal safety and security to properties.

2.2.4 Environmental Considerations

Artificial light does not merely counteract darkness but can also degrade the perception of natural light at night and interrupt the night life of animals. Migrating birds can, in the worst instances, collide with structures due to disorientation, and amphibians can change reproduction patterns due to increased light intensity in the immediate area. Apart from this, an imbalance in the competition for food may occur because species that have a high capacity to adapt will alter their strategies when it comes to seeking food. This phenomenon is known as the "night light

niche" referring to the way bats, spiders and certain species of bird seek food among the insects that gather around artificial light sources.

Hence, planning of road projects with road lighting through forest reserves or jungles shall include measures to limit light pollution to the greatest extent possible in order to control any environmental impacts from artificial lighting on animals.

2.3 Fundamentals On Road Lighting

Any surface is made visible by light being reflected from it and entering the eye of the observer. The source of the lighting can be either vehicle or road lighting. However, detailed discussion on vehicle lighting is beyond the scope of this document.

The procedures used for road lighting are based on making the carriageway bright by beaming light against pavement. Reflection from this beamed light helps the road user to have better visual during night time. Dark objects are thus seen as a contrast against a bright background. This is done for the following reasons:

a. Road surface reflection characteristics permit relatively high luminance.
b. Object reflection characteristics can be poor.
c. The eye functions better at high ambient luminance.
d. The illuminated carriageway is a key piece of information for the driver.

Vehicle lighting, on the other hand, illuminates objects against a dark background. In both cases the lighting provides the illumination and the lit surfaces of pavements and objects provide the luminance. These technical terms and others derived from them are defined in detail in sub-section 1.5 above.

The visibility of an object depends on the object shape, size and contrast. The contrast factor is the one which can be influenced by lighting and is therefore a common visibility measure. Contrast begins at the threshold at which an object can just be detected separately from its background. Lighting needs to raise objects to some threshold level because:

a. the presence of glare from on-coming vehicles will cause the viewer's threshold detection ability to be degraded,
b. in the driving task, it is necessary to detect relative motion between objects as well as to detect the objects themselves, and
c. in night-time conditions, discrimination of colour and detail will be impaired and objects will be seen mainly by contrast, i.e. as silhouettes or reversed silhouettes.

2.4 Vision And Visibility

With the aid of a pair of eyes, humans rely primarily on visual information to interact with their environment. The human eye functions in roughly the same way as a traditional camera with a lens that projects an inverted image of a scene onto a light sensitive inner back surface. This surface, called the retina, consists of more than a hundred million light-sensitive nerve endings. These transmit signals to the brain that it interprets as visual information.

2.4.1 Anatomy of the Eye

The process of vision begins with the eye, the sensory organ responsible for detection of light. The photoreceptors within the eye are located in the *retina*, a thin covering on the back, inner surface of the eye. There are two types of photoreceptors, rods (approx. 120 million rod receptor cells) and cones (approx. 6.5 million cone receptor cells), which form the basis of two-receptor systems.

Detection of a visual stimulus is evaluated over the entire receptor system, including the receptors and the neural network that processes, encodes, and transmits signals to the brain.

The rod receptor system is more sensitive at very low light levels, but generally provides poor visual acuity and no colour discrimination. The cone system is comprised of three different cone receptor cells (commonly called blue, green, and red cones), with different sensitivity functions, and is responsible for colour vision. The cone system also provides relatively high visual acuity, but requires significantly higher light levels to function.

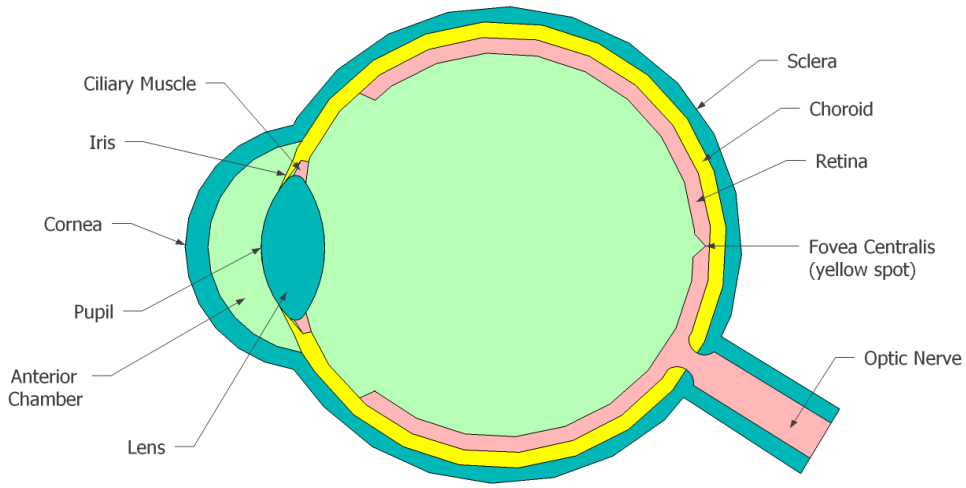

Figure 6: A horizontal cross-section of the human eye.

2.4.2 Visibility

Visibility is the quality or state of being perceptible to the eye. Factors that directly influence visibility for drivers include:

- the luminance of objects on or near the road,
- the luminance of the road and other backgrounds against which objects are viewed,
- the size of an object and the identifying details of the object,
- the contrast between an object, or the road, and its surroundings,
- the time available for detection and recognition of objects,
- the presence of glare from on- and off-road light sources (including other vehicular lighting),
- the driver's physical and mental condition (including visual ability),
- the condition and cleanliness of a vehicle's windshield.

2.4.3 Adaptation

Adaptation is the mechanism by which the eye changes its sensitivity to light. The eye can adapt readily to a wide range of lighting levels from moonlight to a bright sunny day. This is done in three ways: adjustment of the iris to alter the pupil size, adjustment of the sensitivity of the nerve endings in the retina, and adjustment of the chemical composition of the photosensitive pigments in the rods and cones. Adaptation from dark to light takes less than a minute but adaptation from light to dark takes somewhere between 10 and 30 minutes.

2.4.4 Contrast

Contrast expresses the difference in luminance between closely spaced areas of a scene. Contrast takes two forms which mostly occur together: colour contrast and luminance contrast, the latter usually being expressed in terms of the contrast ratio which is the ratio of the higher to the lower luminance in the scene. The ability of the eye to detect luminance contrast depends on the state of adaptation of the eye, which is governed by the overall luminance of a scene.

2.4.5 Glare

Glare is the sensation produced by luminance levels within the field of view that are considerably higher than the brightness to which the eyes are adapted. This can lead to discomfort and in extreme cases to eyestrain and headaches.

Glare can be controlled by specifying the light distribution characteristics of the luminaire as specified in Clause 4.3 of MS 825 Part 1:2007.

2.5 Factors For Consideration

Provision of road lighting will depend on many factors. In establishing a warranting system, designers must understand the road users' information needs which include emphasis on geometric, operational, environmental and accident factors. The following section presents some of the issues of each of these factors and their effects on the need for lighting.

2.5.1 Geometric Factors

a. Number of Lanes and lane widths:
The more lanes, the wider the road, the more light needed.

b. Median Openings and Driveways:
The more openings, the greater the visibility need in those areas.

c. Curves and Grades:
Sharper curves and steeper grades require more lighting.

d. Left Turns:
If the road has left turn lanes in both directions, it has a greater visibility requirement than others.

e. Median Widths:
The greater the median width the less the need for lighting because of the separation of opposing traffic.

2.5.2 Operational Factors

a. Road Classification:
An arterial road needs more lighting than a neighborhood minor road by virtue of the amount of traffic it carries.

b. Parking:
Parking on one side, both sides and loading zones will only affect the need for the lighting in those areas where parked vehicles are present.

c. Operating Speed:
The greater the speed, the greater the need for lighting.

d. Road Intersections:
If road intersections (or accesses) are present on the road, road lightings are necessary.

e. Pedestrians:
The more pedestrian traffic that is present, the greater the need for improved lighting.

2.5.3 Environment and Security Factors

a. Crime Rate:
The higher the crime rate, the greater the need for lighting.

b. Rural road:
Road crossing forest reserve requires controlled lighting as to minimize light pollution.

c. Scale of Linear Settlement:
The greater the abutting built-up area, the greater the need for additional lighting.

d. Type of Land Use:
Single family developments require less lighting than commercial areas.

2.5.4 Accident Factors

a. Night-time Accidents:
As night traffic accidents approaches 1.3 times that of daytime accidents, there is an increased need for more lighting.

b. Accident Blackspots:
Locations where the number of accidents exceeds a certain limit (blackspots' categorisation), lighting may need to be installed.

A quantitative measure of all the characteristics above can be achieved by using a rating system based on the extent to which these factors influence driver informational needs. This guideline does not intend to establish any form of assessment based on priority evaluation technique. However, it recommends the consideration of few selected factors that are critically important as the main criteria for the warrants on road lighting which is presented in the following chapter.

3.0 LIGHTING NEED ANALYSIS

Road lighting shall be designed to control glare, promote effective safety and security, provide safe operation of motor vehicles, enhance safety for all modes of travel and minimize direct upward light emission. The minimum intensity needed for the intended purpose should be used.

In general, road lighting shall be designed in accordance to the latest prevailing edition of **MS 825: Code of Practice for the Design of Road Lighting** in conjunction with the applicable Specifications, Regulations and normal practice of the relevant Authorities having jurisdiction over the works.

In determining the levels of illumination, lighting positions and styles, the design shall take into account of an area's unique characteristics and needs in terms of vehicular or pedestrian activities and location of local amenities. However, the requirement of the MS 825 standard is expected to be met.

The extent and level of road lighting in any particular case depends on the following factors:

1. The classification of the road and its geometric standards.
2. The nature and extent of abutting development and of direct access from it.
3. The volume of traffic during hours of darkness.
4. The numbers of pedestrians and bicycles, and the extent of parking and their interaction with motor traffic.

3.1 General Classification Of Roads

The hierarchy of roads categorizes roads according to their functions and capacities. Each function class is based on the type of service the road provides to the motoring public and has its own design standards. Each class has a range of allowable lane widths, shoulder widths, curve radii, etc.

The classification is divided into group of roads in the urban and rural areas as follows:

3.1.1 Roads in Rural Area

a. Expressway

An expressway is a divided highway for through traffic with full control of access and always with grade separations at all intersections. Examples of expressway include North-South Expressway and North Klang Valley Expressway (NKVE).

b. Highway

They constitute the interstate national network for intermediate traffic volume and complement the expressway network. Example of highway includes major federal roads (F0001, F0003 and F0005).

c. Primary Roads

They constitute the major roads forming the basic network of the road transportation system within a state. Examples of primary road include minor federal roads and major state roads.

d. Secondary Roads

They constitute the major roads forming the basic network of the road transportation system within a district or regional development areas. The example of secondary road includes minor state road, municipal road and industrial road.

e. Minor Roads

They apply to all roads other than those described above in the rural areas.

3.1.2 Roads in Urban Area

a. Expressway

This is also a divided highway that forms the basic framework of urban transportation for through traffic with full access control, serving relatively long trips and complements the Rural Expressway.

b. Arterial Roads

An arterial road is a continuous road with partial access control for through traffic within urban areas. However this category of road can be subdivided further into the following:

1. Protocol Roads

   Protocol roads are routes commonly travelled by dignitaries and key leaders of the country. These roads are also gateway for overseas leaders who are arriving to this country on official visits and, therefore, should portray good image of the country. For the same reasons, high level of attention is given where immediate maintenance is undertaken should there be any damage occurs.

2. Major Roads

   Major roads consist of roads connecting the districts or areas in the city centre. These roads could also be major collector roads linking with many other roads, ring roads and elevated roads. Examples of major roads include Federal Highway, Jalan Pudu, Jalan Cheras, Jalan Ampang, Jalan Damansara, Jalan Pahang / Jalan Genting Klang, Jalan Bangsar and many more. There are three ring roads encircling Wilayah Persekutuan Kuala Lumpur

which are Jalan Lingkaran Dalam, Jalan Lingkaran Tengah 1 (MRR1) and Jalan Lingkaran Tengah 2 (MRR2) while there is one elevated road which connects Ampang to the City Centre.

3. Strategic Roads
   Strategic roads are roads connecting places which are vital for the economic and national security such as airports and seaports. For instance, Jalan Pulau Indah (Klang) and Jalan Pekeliling (KLIA).

c. Collector Roads
   A collector road is a road with partial access control designed to serve as a collector or distributor of traffic between the arterial and the local road systems. Examples of collector road include commercial areas and subways. Subways are roads located below ground level and examples of these subways are the ones located at the intersection of Jalan Loke Yew / Jalan Hang Tuah / Jalan Lapangan Terbang Lama (also known as Bulatan Dewan Bahasa) and also the intersection of Jalan Pahang / Jalan Gombak / Jalan Genting Klang.

d. Local Roads
   The local road system is a basic road network within a neighbourhood and serves primarily to offer direct access to abutting land. Examples of local road include service road and residential road.

   Service roads are roads that form boundaries of residential areas or roads located at the roadside that run parallel to existing main roads with limited but strategically located accesses / junctions.

Understanding the functions and capacities of each category of road should form the basis in determining the lighting need and level of lighting necessary particularly when dealing with midblock sections of a road. Installation of lighting for some roads shall be automatically approved due to their economic role and imperative national strategy. Others may have to go through the criteria evaluation process before any decision is made on the installation of road lighting. The criteria for the warrant of road lighting are presented in the following section.

3.2 Warrants For Road Lighting

Providing lighting for all roads is neither practical nor cost effective. Lighting should be provided where justified, based on sound engineering judgment on certain acceptable criteria or warrants. Apart from complying with these criteria, the provision of road lighting shall also be subjected to the local conditions or requirements set by the local authorities.

As mentioned in Clause 2.5 above, there are many issues (pedestrians, accesses, parking, intersections etc.) which contribute to night-time accident problems. Some of the issues on normal urban roads may not be present on expressways and highways.

However, it is generally accepted that benefits may be obtained from lighting the roads in particular situations and areas.

Warrants for the provision of road lighting are presented based on specific road features. These features are mainly the major components of road (i.e. intersections and midblock sections) and common road facilities usually provided during construction stage or at some point when the need arises. The applications of these warrants are, when specific conditions are fulfilled or particular criteria are complied depending on these road features.

3.2.1 Intersection Lighting

Some level of lighting is always desirable when dealing with intersections or roundabout regardless of the traffic volume. Intersections are locations where two roads intersect each other and each may be of different hierarchy. Installation of road lighting at intersections shall be determined by the categories of the intersecting roads. These conditions shall be applicable for both new and existing roads.

a. Intersecting roads in rural areas

Table 1: Road Lighting Requirements for Intersections in Rural Areas

Expressway	Highway	Primary	Secondary	Local	
IC (Y)	IC (Y)	IC (Y)	-	-	Expressway
	IC (Y)	IC / SI (Y)	SI / SC (Y)	SC (Optional)	Highway
		SI (Y)	SI / SC (Y)	SC (Optional)	Primary
			SC (Optional)	SC (Optional)	Secondary
				SC (optional)	Local

b. Intersecting roads in urban areas

Table 2: Road Lighting Requirements for Intersection in Urban Areas

Expressway	Arterial	Collector	Local Street	
IC (Y)	IC (Y)	-	-	Expressway
	IC / SI (Y)	SI (Y)	SI / SC (Y)	Arterial
		SI (Y)	SC (Optional)	Collector
			SC (Optional)	Local Street

Notes:
IC – Interchange; SI – Signalised Intersection; SC – Stop Control
(Y) – Yes for Lighting; (N) – No for Lighting; (Optional)

The term 'optional' means that lighting of the intersections to appropriate standards can be justified at relatively low traffic volume. AADT of more than 1000 vehicle/day (vpd) can be used as the limit for the warrant of road lighting for the intersections.

Alternatively, accident can also be used as a criterion for the installation of road lighting. High night-time accident at and within the vicinity of the intersection may justify the need for lighting. Night-to-day accident rate ratio greater than 1.3 can be used as the warrant for the installation.

3.2.2 Midblock Lighting

Another major road component that may need to be lit is the midblock sections or links between intersections. The warrants for the installation of road lighting along these sections shall be based on the following criteria depending on whether it is an existing or new road section:

a. Existing Link Road
Unlike that for intersections, warrants for the installation of road lighting along midblock sections may be evaluated in two (2) parts. The first part is the Primary Analysis and the second part is the Secondary Analysis. However, the Secondary Analysis shall only be performed if the Primary Analysis does not warrant the installation of road lighting. The Primary Analysis requires the evaluation of the following criteria:

i. Category of Road
The following category of road shall be provided with road lighting irrespective of the results obtained from the other criteria hereafter.

1. Protocol road (route heading to main government office or palace),
2. Strategic road (roads connecting airports or seaports),
3. Industrial roads (main roads to industrial areas).

ii. Night-time accident

Road lighting shall be provided if the night-to-day accident rate ratio within the midblock section of the road is greater than 1.3 (with a minimum of 4 night-time accidents per year). This criterion shall be applicable for both roads in the urban and rural areas.

If any of the above criteria does not warrant the installation of road lighting, then the following Secondary Analysis is necessary. Secondary Analysis requires the evaluation of the following criteria:

iii. Traffic Volume

Road lighting shall be provided if the current AADT exceeds the value based on the road type:

1. Dual carriageway (greater or equal to 4 lanes) - AADT is about 40,000 vpd or greater;
2. Single Carriageway - AADT is about 20,000 vpd or greater.

These criteria are more applicable for high category roads in urban areas (e.g. expressway, arterial and collector roads). However, lighting may not be necessary for rural expressway and highways, even if the above criteria are fulfilled, unless there are unusual conditions likely to be corrected by lighting.

iv. Multilane carriageway

Roads with more than one lane per direction may require the installation of road lighting.

v. Scale of Linear Settlement

Roadside development and linear settlement beckon plenty of human activities and movement of vehicles. To provide comfort and safety during night-time driving along federal roads with high intensity of linear settlement and abutting roadside development, the roadway must be complemented with adequate lighting facility.

vi. Pedestrians, Bicycles and Motorcycles

These are vulnerable road users and their safety must be given due consideration especially when their combined volume is high during night-time travel.

vii. Operating Speed

Lighting may be needed if operating speed (85^{th} percentile speed) of vehicles exceeds 70 km/h.

Collectively, road lighting is warranted only if any 3 or more of the criteria specified under the Secondary Analysis demonstrate that lighting is required.

If warranted, lighting shall be installed all along the midblock section. However, except for item (a) (i) above, it may not be economically practical to install lighting throughout the whole length of the midblock. Installation can be optimised to focus at least on a reasonably populated area or accident-prone locations. The remaining sections can be enhanced with improved delineation features.

b. New Link Roads

Considering their importance to the nation's interests the following roads shall be provided with road lighting:

i. Protocol roads,
ii. Major roads,
iii. Strategic roads,
iv. Industrial roads (main roads to industrial areas),

See Section 3.1.2 (b) on the descriptions of item i, ii and iii above. However, provision of lighting for other new roads shall be based on the projected traffic volume with a design period of 10 years (minimum). The traffic volume stipulated in Clause 3.2.2 (a) (i) shall be used as the limiting criterion that warrants the provision of road lighting.

3.2.3 Road Facility Lighting

a. Pedestrian Crossings

Pedestrian crossings are potential conflict areas involving pedestrians and traffic even though they are provided as a means to give safer access and easier movements to pedestrians wishing to cross the road.

As the pedestrian is more vulnerable in an accident involving a vehicle, the visibility of all road users is of paramount importance. During the day, this is generally not a problem. A lighting system must be provided to enable pedestrians to clearly judge traffic conditions and allow incoming drivers to correctly interpret the visual scene and view pedestrians.

Nevertheless, the road lighting may be required at some pedestrian crossings, such as in these typical examples:

1. At crossings at or near crests,
2. At crossings on curves,
3. At locations where experience indicates that drivers may have special difficulty in seeing pedestrians on the crossings.

In addition, road lighting can be beneficial at most pedestrian crossings in rainy weather, where the road surface is wet.

b. Bridges and Elevated Structures

Special problems of appearance arise where road lighting on bridges and elevated structures is concerned. There is a risk of collision with lighting columns and structures to traffic both on and off the structure. Consideration should be given to the sitting of lighting poles, their method of fixing and their protection with safety fences or parapets.

As and when required, the installation of road lighting shall be considered for the following cases:

1. Approach to bridges,
2. For curved bridges less than 100 m span,
3. Bridges with more than 100 m span.

Where lights are to be provided on a bridge, the desirable locations for the lighting units are at abutments and at pier locations, or at distance from an abutment or pier not to exceed 25 percent of the length of the span. This placement of the lighting units reduces the effects of vibration. The light poles should utilize davit type mast arms and shorter mast arm lengths so that there are no joints to be weakened by vibration.

c. Tunnels / Underpasses

Warrant for road lighting for tunnel/underpass shall comply with MS 825 Part 2.

Other locations that may be considered for road lighting installation shall be subjected to engineering judgment. Such locations are certain midblock areas, sharp curves, gore areas and where changes in road cross-section exist.

3.3 Recommended Class Of Lighting

Road links, intersections and other road facilities that comply with the warrants mentioned in the previous sections are therefore justifiable to be provided with lighting system. However, the selection of the type of lighting must be based on those shown in Table 3.

Table 3 below is an extract from BS EN 13201-2 showing the classes of lighting and their comparable lighting level, whether using luminance or illuminance criteria. The classes are related to the type of areas to be lighted up.

Table 3: Lighting Classes of Comparable Levels (BS EN 13201-2)

ME Class (for traffic routes)	CE Class (for conflict areas)	S Class (for footways, cycleways, emergency lanes)
-	CE0	-
ME1	CE1	-
ME2	CE2	-
ME3	CE3	S1
ME4	CE4	S2
ME5	CE5	S3
ME6	-	S4
-	-	S5
-	-	S6

The level of lighting requirements also differs for different hierarchy of road. Generally, road of the higher order needs better lighting level than that below it due to the high speed environment and higher volume of traffic. This applies to both roads in the urban and rural areas. The recommended class of lighting for various roads in rural and urban areas are shown in Table 4 below:

Table 4: Recommended Lighting Classes for Rural and Urban roads

Rural	Lighting Class	Urban
Expressway	ME1	Expressway
Highway	ME1	Arterial
Primary Road	ME2	Collector
Secondary Road	ME3a / 2	Local
Minor	ME5 / 4b	Local

MS 825 presented different terminology for the various categories of road within the road network which is not in line with the terms used in other technical documents. This has created some confusion among the practitioners and the misconception has contractually affected the installation of appropriate road lighting requirements for certain category of road.

It is therefore necessary to provide clear definition of each road category in synonym with the current road design guidelines published by JKR. Comparisons are made based on the characteristics of each road category as defined by MS 825 and that by REAM/ATJ documents (see Appendix II). Table 5 presents the

road hierarchy as stated in MS 825 with an equivalent to that of REAM/ATJ including the recommended lighting classes.

Table 5: Road Hierarchy Equivalent including the Recommended Lighting Classes.

MS825	Lighting Class	REAM / ATJ
Highway	ME 1	Expressway
Strategic route	ME 1	Highway
Main distributor	ME 2	Primary road
Secondary Distributor	ME 3a / 2	Secondary road
Link road	ME 5 / 4b	minor road

3.3.1 Flow Chart

The following diagram is a flow chart of the process in determining the need of road lighting. It is divided in two parts consisting of Primary Analysis and Secondary Analysis. Each part evaluates specific criteria on warrant for road lighting. Secondary Analysis shall only be performed if the Primary Analysis indicates that lighting may not be applicable.

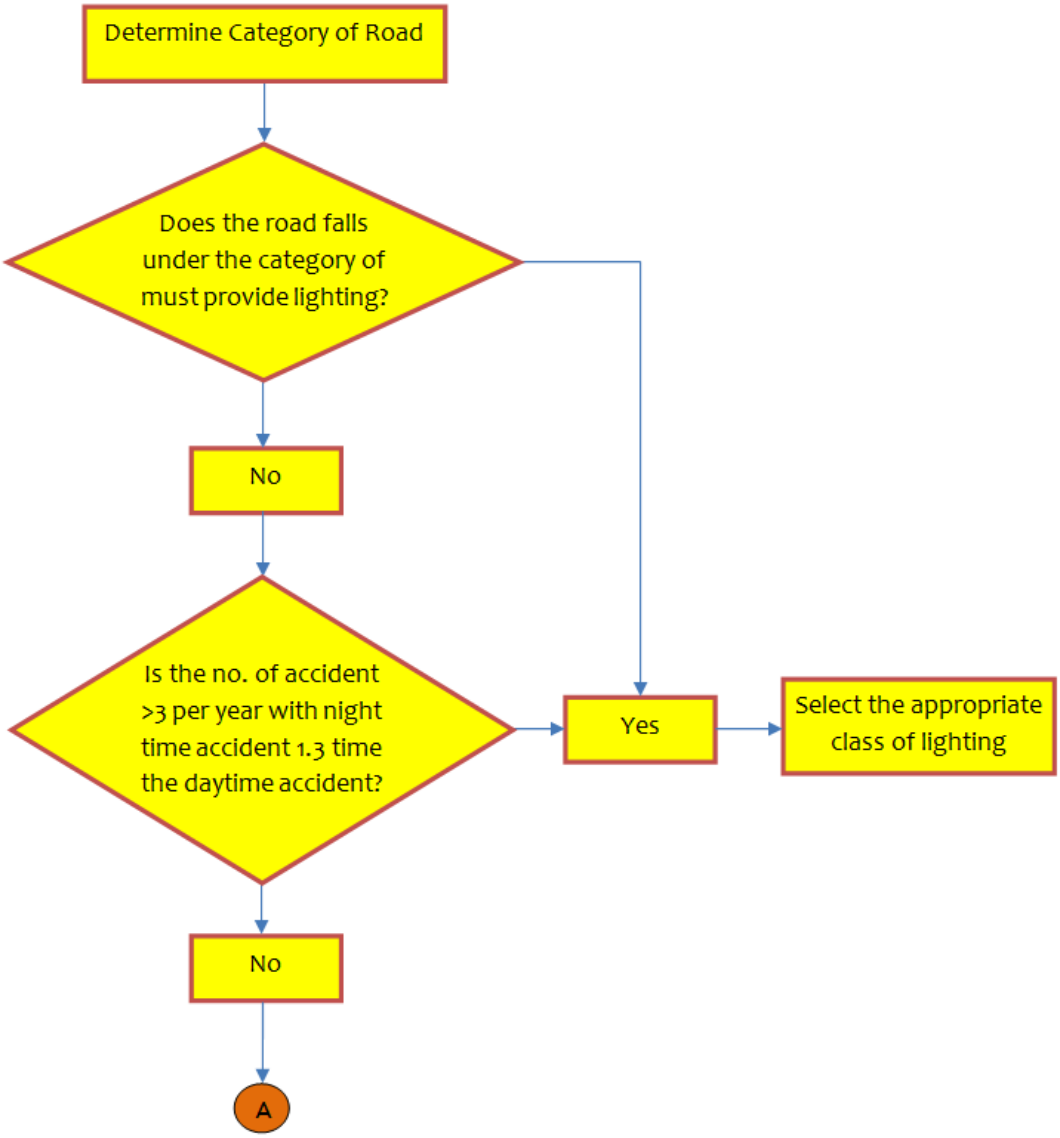

Figure 7a: Flow Chart of Primary Analysis for Road lighting

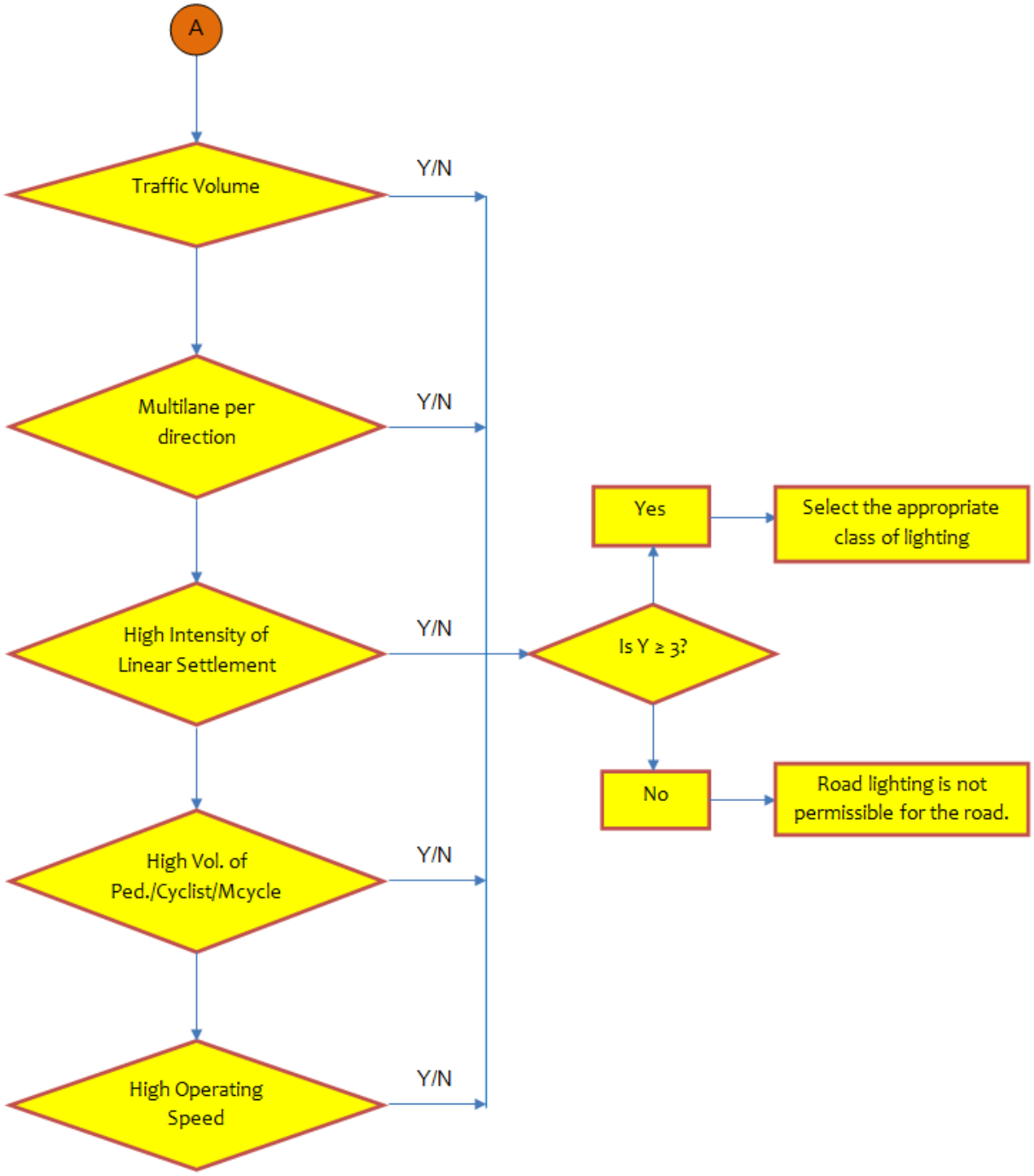

Figure 7b: Flow Chart of Secondary Analysis for Road lighting

4.0 DESIGN CONSIDERATIONS

The main objective of installing road lighting is to enhance traffic safety. It is therefore essential to ensure that it benefits in reducing night time accident without imposing unnecessary hazards with the installation of lighting poles.

The design shall also take into consideration aspects of anti-vandalism, maintainability, serviceability, availability, sustainability and energy efficiency. However, some of the concerns above are beyond the scope of this guideline.

4.1 Road Design In Connection With Electrical Works

In designing roads, the designer shall consider the following requirements:

- For dual carriageway roads, it is preferable to mount lighting poles within the median because it reduces the number of lighting poles and cabling as compared to installation along both sides of the road. The width of median should be sufficient to cater for the lighting poles without causing negative impact on road safety.

- For installation along both sides of the roads, the setback, which is the horizontal distance between the edge of the carriageway and the centre line of the lighting poles, should not be more than 3.5 metres. This is to ensure the required luminance is achieved according to the lighting standards.

- Verge of 1.5 metres width shall be levelled to allow for the installation of lighting poles.

- Corbels complete with anchoring accessories shall be provided at parapet walls of bridges and elevated structures for installation of lighting poles.

- Utility corridor if required, shall be provided (minimum 2.0 m wide on both sides) beyond the drain at appropriate platform level.

4.2 Lighting Design In Connection With Road Works

In designing road lighting, the designer shall consider the following requirements:

- Ideally, location of the lighting poles should not be within the ‘clear zone’. Practically, this requirement is not achievable and hence, frangible lighting poles should be introduced. Avoid placing lighting poles in positions where vehicles are known to or are likely to run off the road.

- Frangible type poles are those specially designed to breakaway or otherwise yield in a controlled way when impacted during a crash to the extent that the deceleration forces on the vehicle occupants during a collision are generally low enough to avoid serious injury. Two types of frangible poles available are slip-based type poles and impact absorbent type poles.

- Rigid lighting poles should preferably be limited to locations where they are either sufficiently offset from the traffic lanes to reduce the possibility of being hit by errant vehicles (desirable clearance 3.0 m) or be protected by existing safety barriers.

- Sufficient lighting level shall be provided at places within conflict areas where the risk of collision is greatest. Conflict areas shall include:
  1. intersections,
  2. at merge and diverge areas,
  3. on the approach noses of traffic islands such as entry and exit ramp 'gore' areas,
  4. ramp intersections on expressways,
  5. complex channelised intersections, and
  6. roundabouts.

- Pedestrians crossing and bus stops/lay by shall also be lighted up.

- Avoid sections of lighting with short gaps of unlit road in between.

- Where there are guardrails, the poles set back shall be at least equal to barrier's deflection distance (600 - 1000 mm) in the direction away from the road.

- Fire hydrant conflicts – When locating proposed lighting, avoid possible conflicts with fire hydrants. Install at least 2 m away from the fire hydrant.

4.3 Support Structure Maintenance

Important considerations in facilitating maintenance activities are the safety and ease of access to the lighting installation. A poorly maintained and unsightly appearing lighting installation can become a source of embarrassment to the agency responsible, and tends to reflect unfavourably on the agency's overall public service. The daytime appearance of a lighting installation can be nearly as important in the view of the public as its night time performance.

Lighting poles and feeder pillars should be installed where it can be quickly serviced with minimum risks to the maintenance crews and minimum inconvenience to the motorist.

Prior to the selection of poles, brackets, and other equipment which will be exposed to the weather, it is essential that consideration be given to both the initial cost and to the long term cost of maintenance and operation.

Regular maintenance requirements for vegetation should be mentioned under design report. Vegetation in the vicinity of lighting is to be removed/pruned so as the required lighting levels are maintained.

4.4 External Factors

4.4.1 Vibration

Excessive vibration of luminaires and their support may occasionally be experienced, particularly on bridge structures where a combination of wind and the mechanical structure movement due to vehicles can damage the lighting units. The use of vibration dampers or auxiliary supports has been effective in reducing these forces to tolerable limits.

4.4.2 Environment

Corrosive atmospheres may dictate the selection of poles, brackets, etc. which can resist these influences.

4.4.3 Obstructions to Avoid.

There are many possible obstructions that exist along the roadside where lighting poles are to be installed. Generally, all poles must be located away from the obstructions but still within the Right of Way of the road. However, specific requirements must be observed for the following issues:

a. Existing Trees
   Trees, both large and small are a common problem when it comes to installing lighting poles. Low hanging trees located closed to luminaires can disrupt light distribution on the roadway, rendering the system ineffective and possibly causing confusing shadows for motorist. Existing trees in the vicinity of lighting is to be removed/pruned so as proposed lighting levels are maintained. Regular maintenance requirements should also be scheduled accordingly.

   For new installation of road lighting along existing roads the following observations must be considered:

   1. Lighting poles can be sited mid-way between trees even if the design criteria are exceeded.
   2. Where there are alternative locations away from the tree, the poles placement shall be reconfigure accordingly.

3. Lighting poles can be installed underneath the tree canopy provided there is at least 1 m clearance above the luminaire.
4. When locating poles amongst trees, lanterns must be clearly visible when standing at the mid-point between poles (See Figure 4)

b. Planting of Trees on New Roads
Where possible, trees shall be planted beyond the drain.

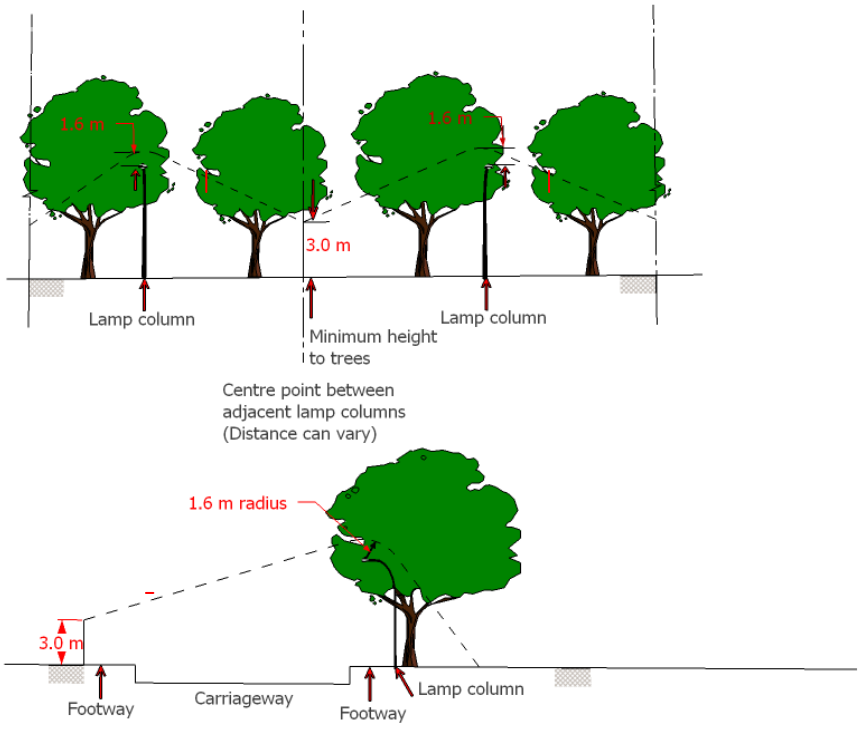

Figure 8: Tree Trimming Details.

c. Bushes/Hedges
Whilst bushes would unlikely obstruct the lantern, they will prevent future maintenance by blocking the access door. Trimming needs to be carried out on a regular basis so it is best to move the column away from existing locations where possible.

d. Overhead Lines
Lighting poles must not be positioned too close to the overhead lines. However, where closer positioning is required, the designer must consult Tenaga Nasional Berhad (TNB) and obtain written consent as regards to the appropriate location. Warning signs should be fitted to the poles located underneath any high voltage cables. The height of the poles near

LV or HV overhead lines must comply with the minimum clearance height specified by TNB.

e. Vehicular accesses / gateways
Lighting poles must never be positioned in a manner that blocks access, gateways or any other form of access to properties. Normally (but not always) locating poles on property boundaries will avoid this. However, in any case, poles must not obstruct site lines for vehicles entering onto the highway.

f. Bedroom windows
Light intrusion into properties may not be favourable to some people. Hence, it should be avoided if necessary. Consideration must be given to such problems in all cases and, if necessary, the affected residents should be consulted. The appropriate positioning of lighting poles should be identified prior to the installation stage.

g. Footpaths
Where poles are being located on footpaths, the choice of pole position will depend on the width of the footpath and any verge area available. Poles should not obstruct the free movement of pedestrian.

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APPENDIX I – ROAD DESIGN INFORMATION FOR LIGHTING DESIGNER

The followings are list of information regarding roads to be designed generally necessary in the evaluation and design of road lighting:

a. Category of roads
b. Road design standard
c. Speed environment
d. Cross section of roads
e. What is the topography (slopes, grades, etc.)
f. Existing utilities
    i. Overhead electrical power lines
    ii. Telecommunication lines
    iii. Gas pipeline
    iv. Water supply
g. Retaining walls
h. Guardrail
i. Type of Median Barrier
j. Width and type of shoulders
    i. Paved
    ii. Unpaved
    iii. Median
k. Space for feeder pillar
l. Sidewalks/paths
m. Intersections
n. Verge
o. Bridges
    i. Cross section
    ii. Length
    iii. Quantity
    iv. Corbels

APPENDIX II – CHARACTERISTICS OF EACH ROAD CATEGORY

The following tables are list of characteristics as defined by MS 825 and REAM/ATJ.

Standard	Classification	Access	Speed	Volume	Trip length	Network	Geometric	Parking	Pedestrians
MS825	Highway	fully grade separated	fast moving		long distance				
	Strategic route	few junction	> 60 km/j		long distance		single / dual	no	segregated
	Main distributor	limited frontage access	< 60 km/j		short to medium	linking urban centre	single / dual	restricted	some positive measure
	Secondary Dis (R)	frontage access, frequent junction				Link larger village to strategic and main			
	Secondary Dis (U)		50 km/j			industrial / residential		uncontrol led	random movement
	Link road (R)	frontage access, frequent junction				smaller village to dist. , linking main and sec. dst	varying width, not capable carry to way		
	Link road (U)		50 km/j			industrial / residential		uncontrol led	random movement

Standard	Classification	Access	Speed	Volume	Trip length	Network	Geometric	Parking	Pedestrians
REAM/ATJ	Expressway	fully control	high speed	high - medium	long trip	National	-	-	-
	Highway	partial control	high to medium	intermed iate	long / intermedi ate	interstate national network	-	-	-
	Primary road	partial control	medium	-	intermedi ate / medium	within state	-	-	-
	Secondary road	partial control	-	-	intermedi ate	link up the major town	-	-	-
	minor road	no control	-	-	short	-	-	-	-