METHODOLOGY OF GRADE SEPARATED STRUCTURES FOR NATIONAL HIGHWAY & STUDIES ON ENERGY EFFICIENT ILLUMINATION DESIGN

A dissertation submitted in
Partial fulfillment of the requirements for the degree of

Master of Engineering
in

Illumination Engineering

Submitted by

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SEPTEMBER 2023

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RECOMMENDATION CERTIFICATE

This is to certify that the thesis entitled **" METHODOLGY OF GRADE SEPARATED STRUCTURES OF NATIONAL HIGHWAY & STUDIES ON ENERGY EFFICIENT ILLUMINATION DESIGN "** submitted by **Kushal Roy**, (*Exam Roll no. M4ILN23005*–& *Registration No.–1610192 of 2021–2022*) of this university in partial fulfillment of requirements for the award degree of Master of Engineering in Illumination Engineering, Department of Electrical Engineering, is a bonafide record of the work carried out by him under my guidance and supervision.

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This foregoing thesis is hereby approved as a creditable study in the area of Illumination Engineering, carried out and presented by **KUSHAL ROY**, in a manner of satisfactory warrant its acceptance as a pre-requisite to the degree for which it has been submitted. It is notified to be understood that by this approval, the undersigned do not necessarily endorse or approved the thesis only for the purpose for which it has been submitted.

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DECLARATION OF ORIGINALITY AND COMPLIANCE OF ACADEMIC ETHICS

I hereby declare that this thesis contains literature survey and originalresearch work by the undersigned candidate, as part of my Master of Engineering in Illumination Engineering studies.

All information in this document have been obtained and presented inaccordance with academic rules and ethical conduct.

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ACKNOWLEDGEMENT

First and foremost ,with immense gratitude, I acknowledge the support and help extended by my supervisor, **Prof. (Dr.) Saswati Majumdar** , ElectricalEngineering Department, Jadavpur University whose encouragement and phenomenal supervision and impeccable guidance from the preliminary to the concluding level enabled me to complete this project work.

I would like to acknowledge my sincere thanks to **Prof. (Dr.) Biswanath Roy**, Head of Department of Electrical Engineering Department, Jadavpur University**,** for providing me the opportunity to carry out my project work in Illumination Engineering Laboratory of Jadavpur University.

I am very grateful to my teachers **Prof. (Dr.) Saswati Majumdar** ; **Asso. Prof. (Dr.) Suddhasatwa Chakraborty** and **Asst. Prof. Mrs. Sangita Sahana** ; associated with Electrical Engineering Department, Jadavpur University for the encouragement and suggestions they provided me during study and carrying out this project work.

A lot of inputs from various sources have gone into the making of this project work and the analysis that has been carried out. I take this opportunity to thank **Ms. Uma Lanka**, Associate Vice President, Lighting Division at Crompton Greaves Consumer Electricals Limited for her guidance.

I would also like to express my deep regards to **Mr. Sumit Kar** (DGM– Design),

Mr. Manash Bhattacharya (Sr. Manager – Design), **Mr. Sagar Bose** (Sr. Manager – Design), **Ujwala Prajapati** (Sr. Manager – Design) and **Mr. Prasenjit Roy** (Asso. Manager-Design) of Crompton Greaves Consumer Electricals Limited for their valuable inputs and unconditional support for carrying out my project in Crompton Greaves Consumer Electricals Limited, Lighting Division, Mumbai.

Last but not the least, I wish to convey my immense gratitude to my parents, whose love, teachings and support have brought me this far.

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This is to certify that Mr Kushal Roy, a student of M.E. in Illumination Engineering, Electrical Engineering Department, Jadavpur University, has worked as an Intern in the Lighting Advisory Bureau of Crompton Greaves Consumer Electricals Limited from 20th July, 2022 to 5th May, 2023.

The title of his thesis was "Studies on Energy Efficient Illumination Design & Methodology of Grade Separated Structures for National Highway" which was carried out under the guidance of Mr. Sumit Kar, DGM – Design. During the tenure of his internship with us, he has been sincere, hardworking and diligent in carrying out the assignment entrusted to him.

We wish him all success in his future endeavour.

For **Crompton Greaves Consumer Electricals Limited**

Falguni Sharma
Manager Human Resources

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CHAPTER1

INTRODUCTIONTO PROJECT

Introduction

Highway lighting is a critical service provided by governments to ensure the safety of all road users, including motor vehicle and motorbike operators, as well as to assist pedestrians to spot hazards, orient themselves, recognize other pedestrians, and feel secure. However, rising energy costs, constricted municipal and federal budgets, and a large increase in overall electricity use need a reassessment of how to deliver illumination in the most cost-effective manner.

Lighting accounts for around 19% of global *[The climate group, 2012]* electricity consumption. The use of renewable energy sources is essential to meet the expected increase in energy demand in an environmentally-sustainable manner. Light emitting diodes (LEDs) are proven to be the most efficient option for Highway lighting today and can help achieve significant in energy savings over conventional Highway road lighting technologies such as metal halide, and high-pressure sodium lamps. There are now more examples of LEDs being successfully adopted in pilot trials and large-scale rollouts, delivering greenhouse gas (GHG) reductions by as much as 50 to 70% *[International Energy Agency , 2007]*and generating significant budgetary savings that can be re-invested in other public services such as education, healthcare, or infrastructure. The urgency to replace old Highway lighting installations with more energy-efficient technologies can no longer be ignored.

It is vital that highway lighting improves pedestrian and motorized traffic safety, security, and visual comfort. The real problem as far asthe safety of the former group is concerned lies with possible hazardous irregularities in the pavement, such as holes, cracks, bumps, and Protruding kerb stones. A suitable horizontal Illuminance is required to make these clearly visible. Sufficiently high brightnesses in the street and its surroundings will enable motorist's to see at a glance the whole area, thus contributing to a feeling of security (both actual and perceived). The brightness needed is dependent not only on the Illuminance level and the spectrum of the light source employed but also on the reflection characteristics of road surface.

The basic Aim of Highway lighting for motorized traffic is thus to enhance the motorist's:

- Visual performance
- Visual comfort
- Alertness

The safety and comfort of a road user deteriorate considerably with the onset of darkness, particularly on those roads not provided with a well- designed and maintained lighting installation. Driving involves a continuous decision-making process based on information that reaches our senses. Good lighting is essential in keeping our visual performance at a high enough level during the hours of darkness. By visual performance is meant the ability of a motorist to continuously select and process, more or less subconsciously, that part of the visual information presented to him that is necessary for the safe control of his vehicle. For a high level of visual performance to be maintained, especially when driving for a long time, the road user must also feel comfortable in the visual environment. This also helps to keep the level of fatigue low. Many night-time accidents involve drivers that were sleepy or even asleep prior to the accident. Lighting may also contribute in keeping drivers alert because of its neurological influence *[Djokic, Cabarpaka and Djuretic, 2017]*.

Decisions to invest in Highway lighting installations can only be made sensibly if there is a clear insight into the purpose and benefits of highway lighting. For motorized traffic, highway road lighting should provide visual performance and visual comfort and help to keep the driver alert. Several studies have found that improved illumination can prevent night time accidents. *[Beyer and Ker, 2009]*.

India has the world's second largest road network, with around 63.73 lakh km.

The following are the lengths of several types of roads:

- National Highways: 1,44,634 kilometers
- Highways in the state: 1,86,908 km
- Other Roads: 59,02,539 km

National highways contribute significantly to the country's economic and social growth by facilitating the efficient movement of freight and passengers and expanding market access. In the previous eight years, MoRTH and its implementing agencies have executed a number of projects to increase the capacity of India's national highway system. The overall length of the country's National Highways as of 30 November 2022 was 1,44,634 km. The Indian Roads Congress (IRC) requires lighting on NHs in places like built-up sections, toll plaza areas, rest areas, truck lay-byes, bus bays and bus shelter locations, grade-separated structures, interchanges, flyovers, underpasses (vehicular and pedestrian), and overpasses. As a result, illumination is frequently added in the aforementioned road sections/locations in 4-lane and 6-lane projects. Lighting is also provided in toll plazas and other sites as specified in the respective concession agreements. The lighting scope of a project is determined based on the requirements assessed during the development of the Detailed Project Report (DPR) from safety and other technical factors, as well as proposals/suggestions received from many sources, including state governments.

The level and type of Lighting adopted for National Highway are based on its traffic importance, both vehicular and pedestrian. Inadequately designed Lighting installation may cause accidents which may be more severe than on normal roads. The aim in lighting the grade separated structures is same as that for lighting any other roads so far as vehicular traffic is considered. The same quality of lighting shall be maintained so that the drivers are given clear information with regard to their course and the presence and movement of other road users. It is desirable to achieve a higher standard of lighting without causing glare and avoiding a multiplicity and confusing array of luminaires, since in the absence of fulfillment of these requirements, the consequences of accidents might be graver. The light level required for different grade separated structures of National Highway must be referred from Indian Road Congress Manual, and after detailed study of the drawings and depending upon the road width and geometry the luminaire type, mounting height as well as the pole to pole spacing is considered.

The basic requirement is that drivers must be able to pick up their route very clearly and unmistakably in heavy traffic and bad weather conditions. When traffic is heavy, lighting must ensure strong visual assistance indicating the line of path to be followed without error on one hand when the driver arrives at a position 200-300 meters from the interchange and on the other hand when he is within the interchange. Any mistake in finding the correct turnout may result in waste of time and may be hazardous. The lighting must therefore be of a high standard to provide adequate illumination without producing unacceptable glare, and the arrangement of luminaires must be such that it does not produce a confusing array of sources, making defining the alignment of the road difficult and, at times, misleading. Thus, it will be significantly advantageous to build designs using both Street Light poles and High Masts, taking into account the economic element in terms of installation and running charges, as well as other criteria such as technical merit, safety features, and so on.

Motivation

LEDs are the most energy efficient option for road lighting today and can help achieve in maximum energy savings over conventional road lighting technologies such as high-pressure sodium lamps. In addition, the shift to LED based road lighting technologies would help reduce green house gasses (GHG) emissions which results to overall growth of the environment.

Globally, switching to LED-based efficient lighting can dramatically reduce GHG emissions by 670 MT year and associated energy costs by 50–70% [The Climate Group, 2012]. According to the International Energy Agency (IEA), lighting accounts for 19% of global power use and approximately 1.9 billion tons of CO2 emissions per year [International Energy Agency, 2007]. [International Energy Agency, 2007] Road illumination accounts for 4% of global total lighting and up to 40% of a city's annual electricity bill [The Climate Group, 2012]. As a result, it provides a potential for rapid victories and demonstrability, which may lead others, particularly private companies, to switch to an efficient lighting system.

Visual comfort is a subjective aspect related to road-lighting quality. If the degree of visual comfort is not good enough, a motorist's level of fatigue will increase and as a consequence, his visual performance and alertness will decrease. So both visual comfort and visual performance are important for road safety. Subjective studies have shown that the lighting level, the uniformity of the road surface luminance pattern and glare have an influence on visual comfort *[Bommel W.V, "Road lighting fundamentals technology and Application"]*. The same type of studies have been the basis for definitions of visual comfort metrics such as longitudinal uniformity, luminance gradient and discomfort glare marks the spectrum of the light source used has an influence on the last mentioned *[Bommel W.V, "Road lighting fundamentals technology and Application"]*. LEDs may sometimes have a special influence on visual comfort because they are available in a much wider range of spectra than are the conventional light sources. Their small light-emitting surfaces enable more pronounced beams to be produced, that in turn may influence Visual comfort. The basis for any lighting installation is the quantity of light available for a specific visual task in a given situation. A comprehensive set of regulations exist for workplaces which define the optimum lighting conditions for specific visual tasks to ensure that visual tasks can be performed correctly and without causing fatigue. The standards only relate to establishing good working practice regarding working conditions.

Objectives

The objectives of the thesis are as follows:

- To study different grade separated structures of national highway & their typical cross sections.

  Technical requirements and aesthetic considerations are taken into account depending upon on the project scope as provided from client end while designing the lighting installations for different grade separated structures.

- To study and Illumination design implementation of National Highway using modern energy efficient lighting technology like LED.

  Rapid development of LED-based light sources and related technologies revealed new perspectives for both design and control of National Highway lighting systems. Three properties of modern fixtures determine their high capabilities: extremely low onset time, dimmability and highly customizable photometric solids. Since an LED source lacks technological limitations specific to high-intensity discharge (HID) luminaires, it may yield substantial energy (money) savings by utilizing well-tailored, power-efficient installations to match the actual road configurations. Thus the lighting installation should be such that it meets the user needs and light level requirement as per the project scope.

- To Prepare the Bill of Quantities of the discussed National Highway project.

  Luminaire, Pole quantities & Mast quantities are calculated after completion of entire Lighting simulation design to estimate the project value.

CHAPTER 2

FEATURES OF LED ROADLIGHT LUMINAIRES

FEATURES OF LED ROADLIGHT LUMINAIRES

Road lighting is the application of illumination systems along roadways, primarily for the purpose of improving safety by increasing visibility of roadside hazards and by reducing the effects of glare from other light sources in the visual environment. A suitable horizontal Illuminance is required to make these clearly visible. Hence by providing sufficient brightness in the road surface with its surroundings will enable the motorist and pedestrians to see at a glance the whole area, thus contributing to a feeling of security.

The LED road lighting system is similar to conventional road lighting to the extent that the basic parts are the same – both systems have the pole, cabling, and the luminaire which houses the light source. However, while conventional lighting technologies include a single light source, the luminaire of an LED road light unit houses several parts, starting with multiple LED chips arranged in an array, combined with optics, heat management, and a driver – all enclosed in a high pressure die-cast aluminum and glass cover.

Different road lighting luminaire components are illustrated in figure 1 as shown. The principal features of LED road lighting luminaire system can be listed under the following headings:

1. Photometric features
2. Optical features
3. Electrical features
4. Mechanical features
5. Thermal features

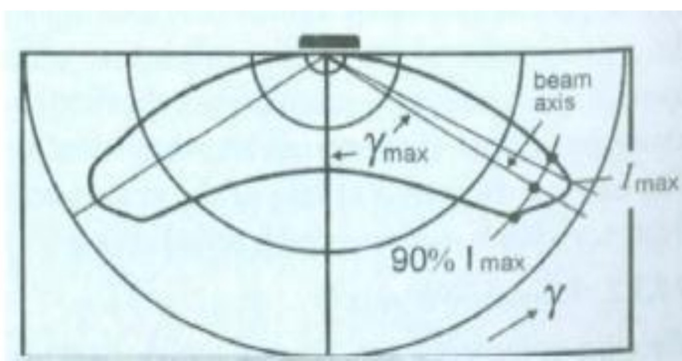
(a) **(b)**

(c) (d) (e)

Fig.2.1: Different components of LED Roadlight luminaire (a) LED chip (b) Array of LED module inPCB (c) Driver circuit (d) Luminaire heat sink (e) Mounting arrangement

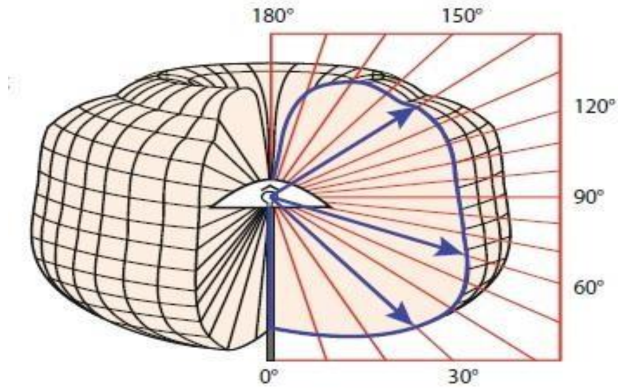
2.1 Photometric Features

2.1.1 Throw – It is the angle of the luminaire to direct the luminous flux in lateral direction of the road i.e., extent to which beam profile is distributed along the axis of the road. The throw is defined by the angle (Υ_{max}) that the beam axis makes with the downward vertical. The beam axis is defined by 90% of I_{max} in the vertical plane of maximum intensity as shown in figure 2.



(a)

Hence throw is signified by the angular stretch of the beam in longitudinal direction of road axis, i.e. vertical 0°-180° plane of road light intensity distribution curve.



(b)

Fig.2.2: (a) Polar LDC showing throw; (b) Spatial photometry of roadlight luminaire

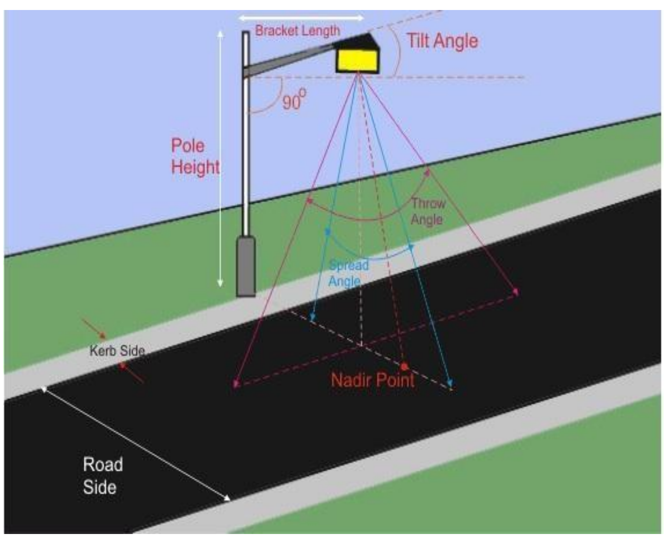
The degrees of throw are defined as follows –

$\Upsilon_{max} < 60°$: **Short throw**

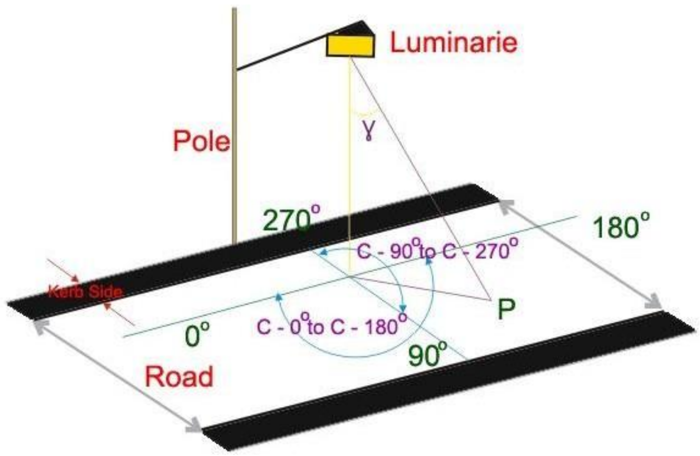
$60° \leq \Upsilon_{max} \leq 70°$: **Medium throw**

$\Upsilon_{max} \geq 70°$: **Long throw**

2.1.2 Spread: It is the angle of the luminaire to direct the luminous flux across the road. Spread is defined by position of the line on parallel to road axis touching the far side of 90% of I_{max} contour on the road surface as illustrated in figure 3.



(a)



(b)

Fig2.3: (a) Photometric definition of spread; (b) Photometric C-ϒ planes on road surface

The degrees of spread are defined as follows –

$\Upsilon_{90} < 45°$: **Narrow spread**

$45° \leq \Upsilon_{90} \leq 55°$: **Average spread**

$\Upsilon_{90} \geq 55°$: **Broad spread**

2.1.3 Control**:** Road lighting systems are an important part of the highway safety infrastructure across the world. Two important purposes of road lighting are to allow drivers to see the roadway further ahead than their own vehicle's headlamps allow and to reduce glare from other vehicles' headlamps. The photometric significance of control is the ability to controldiscomfort glare. It is quantified by metrics of Specific Luminaire Index (SLI) which specifies the Glare Control Mark (G). *National Lighting Code[SP 72: 2010]* defines glare control mark by –

$$\boldsymbol{G = SLI + 0.97\ log\ L_{av} + 4.41\ log\ h - 1.46\ log\ P} \quad (1)$$

SLI = Specific luminaire index

L_{av} = average maintained road luminance

h = luminaire mounting ht. – observer eye level (1.5m)

P = number of luminaires per kilometer

SLI is a function of luminaire photometric properties.

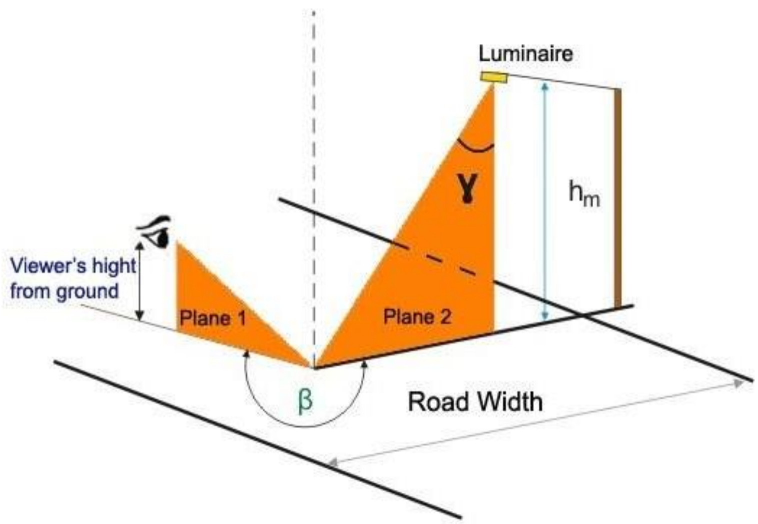


Fig.2.4: Observational & Incidence plane on road surface

The degrees of control are portrayed as –

SLI < 2 : **Limited control**	and	G < 3 : **Bad**
2 ≤ SLI ≤ 4 : **Moderate control**	and	G = 5 : **Moderate**
SLI > 4 : **Tight control**	and	G > 7 : **Good**

2.2 Optical Features

2.2.1 LED**:** LED lights are diodes that emit light, are digital, and are based on the same technology as computer chips. LEDs first appeared in the 1960s, emitting a low-intensity red light and were used as indicator lights. Over the years, LEDs have evolved rapidly and are now available across the visible, ultraviolet, and infrared wavelengths with very high brightnessand power. Current LEDs are very robust when sourced from quality manufacturers, of which there are a number in business today. High-quality LEDs typically have good color consistency, high lumen Efficacy and can maintain high lumen output over the LED's lifetime. As a digital technology, it is possible to manipulate the light colors and light levels across a continuum.

Led chips are basically of three types.

They area –

A. DIP Chip

B. SMD and

C. COB.

- DIP Chip**:**

DIP (Dual In-Line Package) LEDs are the traditional LED lights. It is what mostpeople think of when they picture LED lights. They look the most like a traditional light with the chip encased in hard plastic generally used with two straight parallel connecting pins. Figure shows a DIP chip.

Fig 2.5: DIP Led chip

- SMD*:*

SMD stands for Surface mounted diode and are much smaller and efficient LEDs than the previous DIP chips. They have become popular due to their versatility and are typically mounted and soldered onto a circuit board. SMD chips have become very important for the development of the LED industry as three diodes are able to be put on the same chip. As well as the brightness being significantly better, they have the capacity to change colour. Some of the chips are made small in order to be used in high end electronics such as laptop computer indicator lights. They are also standalone chips predominantly used LED strips or LED recessed down lights. Figure shows a SMD LED down lighter chip.

Fig 2.6: SMD Led Chip

- COB*:*

Chip on Board (COB) is the most recent development in LED technology. It usesmultiple diode chips typically around 9 or more. There is no casing with COB technology which enables a much denser LED array of light compared to SMD. COB chips are being used in an array of different devices. The great advantage of COB modules lies in the highly homogeneous light they emit. That means a consistent light beam is given off, without any visible individual light points. By then adding a ceramic substrate, the best conditions are

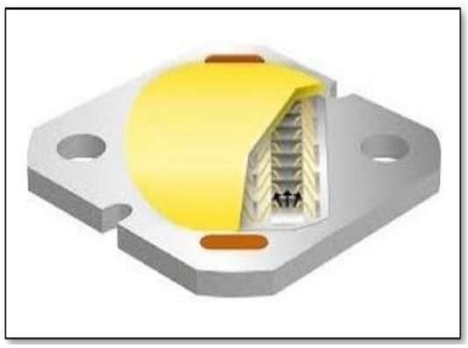
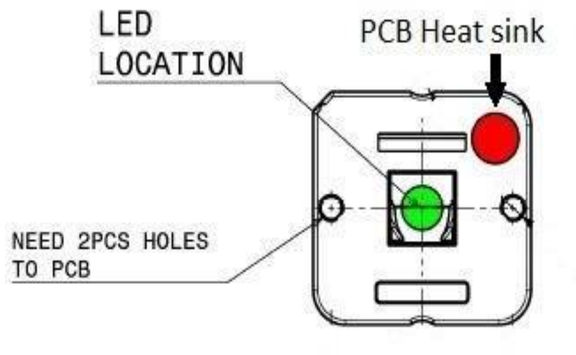


Fig 2.7: COB Led Chip

Created for optimal cooling, which in turn serves to increase efficiency and lengthen service life. Typically, in small devices such as cameras and Smartphone, this is due to a high amount of lumens created for a very small amount of energy. Figure shows a COBchip.

2.2.2 Lens: Optical lens manages the distribution of light. Specially designed lens systems should have a unique inner and outer profile to allow maximum spacing between the poles and cover higher road widths. Optics should be arranged in multiple layers to ensure adequate luminance and Illuminance uniformity in the unlikely event of individual LED failure.



(a) **(b)**

Fig.2.8: (a) Streetlight lens (b) LED lens data structure

Lens is an example of Refracting device which bends the light that passes through it as shown in figure 2.8. The angle through which the light is bent is dependent on both the shape of the lens aperture and its refractive index.

Refracting glass bowls were employed in the past sometimes as refractive medium for road-lighting luminaires, but now have became obsolete due to the fact that maintenance was not feasible enough because of their bulky weight and secondly “light pollution” wasn’t attained efficiently.

Today, in LED luminaires, advanced lens-type refractors, one for each individual LED point, are employed. These make it possible to shape the light beam profile to achieve design specifications. This allows the designer to adapt the light distribution to suit the actual luminaire spacing and road width.

In a nutshell, the objective of a luminaire lens is to manage the beam profile of the luminaire by creating multiple images of the light source which, overlap with each other to integrate a uniform luminance distribution pattern on road surface. If the intensity profile is not guided properly by the optical system it will result into glare to the eye of the motorist *[Bommel W.V, “Road lighting fundamentals technology and Application”]* which will impair his visual acuity and diminish visual performance and comfort which is expressed as –

$$Luminaire\ Glare\ Index = \frac{I_{85}}{A^{0.5}} \qquad (2.1)$$

I_{85}: luminous intensity at an elevation angle of 85° (cd)

A: apparent bright area of luminaire seen under 85° (sqmtr.)

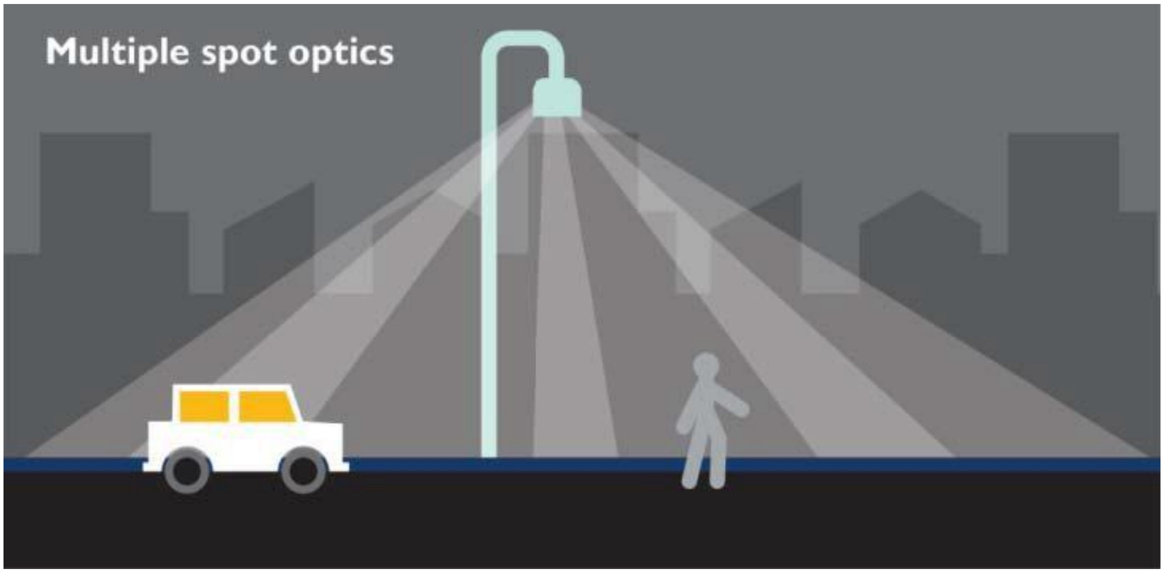


Fig.2.9: “Zebra effect” formation due to improper optics

The lens material should be such that it scatters the light while demonstrating the minimum amount of absorption. Usually a polycarbonate or shield is incorporated into the design to restrict at least some of the upward light so as to help limit some light pollution as illustrated in figure 2.10.

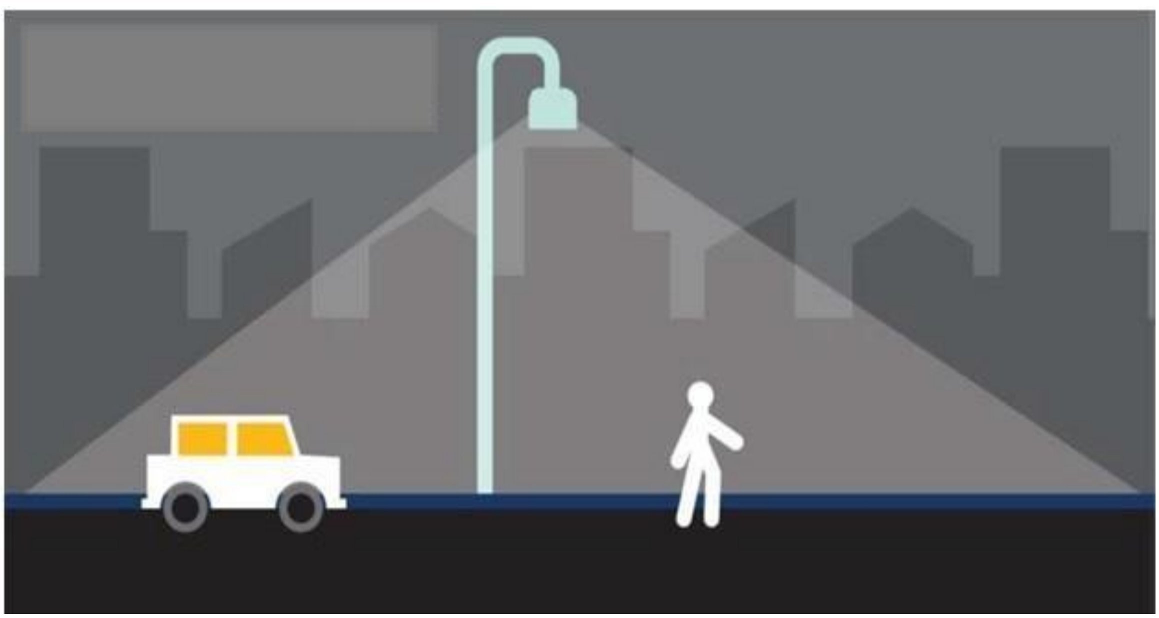


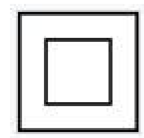
Fig.2.10: Uniform light distribution due to good optics

The light distribution from the luminaire and the efficiency with which it is formed by its optical components are key quality aspects of a luminaire. However, the mechanical, electrical and thermal aspects of the luminaire are also quite important. This feature dictates both the lifetime of the luminaire itself and its other systems it houses, like the lamp and gear.

2.3 Electrical Features

The construction of a luminaire should be such that it guarantees safety to the person involved in its maintenance. The *European Standard [BS EN IEC: 61140, 2001]* classifies luminaires according to the degree of protection afforded against electrical shock. The material and the insulation should be such that it will be capable of withstanding the electrical load for the running time with a tolerance voltage spikes. The degree of insulation against voltage spikes is described in table 2.1 as illustrated below –

Table 2.1: Electrical Insulation Class (BS EN: 61140, 2001)

SAFETY CLASS	PROTECTION	SYMBOL
I	Basic insulation with protective earth connector	
II	Double or reinforced insulation without earthing	
III	Extra-low-voltage circuits referred to as SELV (safety extra-low voltage)	

- Driver: The driver provides the right amount of current to the LEDs and is an important part of total system reliability. Besides providing a stable flow of current, the driver is responsible for all intelligence, such as dimming and sensor interfacing.

2.4 Mechanical Features

The mechanical characteristics of a luminaire has two major functions – it accommodates various components of luminaire, such as optical system, electrical system; provides protection against external foreign body influences.

The luminaire and its mounting arrangements should be of robust construction to ensure a good, steady positioning of the luminaire and its components. The luminaire should protect the optical and electrical components contained within it against exterior atmospheric dirt and humidity.

The degree of protection provided by the luminaire is classified according to the **Ingress Protection** code by the *European Standard [BS EN IEC: 60529, 2001]*. The IP system is an internationally recognized method to indicate the degree of protection against the ingress of dust, solid objects and moisture into an enclosure.

These vary from IP 00 (*no protection against from foreign bodies*) to IP 68 (*complete dust proof and applicable for continuous immersion in specific pressurized liquid*).

The IP rating normally has two numbers:

- Number 1 indicates Protection from solid objects or materials (detailed in Table 2.2)
- Number 2 indicates Protection from liquids (water) (detailed in Table 2.3)

Table: 2.2 – IP code according to protection against ingress of solid foreign bodies (IEC: 60529, 2001)

First Characteristic numerical	Object size protected against	Effective against
0	———	No protection against contact & ingress of object
1	>50 mm	Any large surface of the body, such as the back of ahand, but no protection against deliberate contact with a body part
2	>12.5 mm	Fingers or similar objects

3	>2.5 mm	Tools, thick wires, etc.
4	>1 mm	Most wires, slender screws,ants etc.
5	Dust protected	Ingress of dust is not entirely prevented, but it must not enter in sufficient quantity tointerfere with the satisfactoryoperation of the equipment.
6	Dust tight	No ingress of dust; complete protection against contact (dusttight). A vacuum must be applied.Test duration of up to 8 hours based on air flow.

Dust and watertight (or waterproof) luminaire covers must always be used in conjunction with a sealing strip fitted in a strip channel, provided in the luminaire housing, for maximum effect.

Due to the variation in temperature between the air inside and that outside the luminaire after switching on or off, pressure differences across the luminaire's cover-seal are bound to occur.

The seal or gasket should prevent corrosive gases, moisture and dust from being sucked into the luminaire during cooling off. The effectiveness with which the front cover seals the luminaire against ingress of solids and liquids, and the durability of this sealing function, is determined by the type and quality of the sealing material employed.

Table: 2.3 - IP code according to protection against ingress of liquid(IEC: 60529, 2001)

Second Numerical	Protected against	Effective against
0	Not protected	_____
1	Vertical condensation	Dripping water (vertically falling drops) shall have no Harmful effect.
2	Dripping water when tilted up to 15°	Vertically dripping water shall have no harmful effect when theenclosure is tilted at an angle up to 15° from its normal position.
3	Spraying water	Water falling as a spray at any angle up to 60° from the vertical with discharge rate of 0.07ltr./minfor 10 minutes
4	Splashing of water from every direction	Water splashing against the enclosure from any direction withdischarge rate of 0.07ltr./min for 10 minutes
5	Low pressure Water jets	Jet water at all direction (*keeping distance 2.5 to 3m*) to object surface1m^2/min. for 3 minutes [*nozzle dia.=6.3mm & discharge rate = 12.5ltr./min*]
6	High pressure Water jets	Jet water at all direction (*keeping distance 2.5 to 3m*) to object surface 1m^2/min. for 3 minutes [*nozzle dia.=12.5mm & discharge*

		rate = 100ltr./min]
7	Immersion up to 1m in liquid	Ingress of water in harmful quantity shall not be possible when the enclosure is immersed inwater under defined conditions of pressure and time (up to 1m Of submersion).
8	Immersion 1mor more	The equipment is suitable for continuous immersion in waterunder conditions which shall bespecified by the manufacturer.

Physical factors can either enhance or detract from the performance of the road light, so it is imperative to give these factors ample consideration when creating a lighting system.

Poles should be strong enough to carry and support the luminaire, should have the appropriate height, and should be properly spaced to achieve optimal lighting. Obstructive structures like trees should also be taken into consideration in planning for the layout of road lighting.

Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts. Where protection against vandalism is of paramount consideration, the impact resistance of the luminaire itself is also important in accordance with the *European Standard* [*BS EN IEC : 62262, 2002]* that defines so-called **IK codes** as illustrated in table 2.4 –

Table: 2.4 – Level of protection given by IK degree of luminaire (IEC:62262, 2002)

IK degree	Impact protection	Effective against
00	No protection	
01	Against 0.14 Joule	Equivalent to impact of 0.25kg mass dropped from 56mm of impact surface
02	Against 0.20 Joule	Equivalent to impact of 0.25kg mass dropped from 80mm of impact surface
03	Against 0.35 Joule	Equivalent to impact of 0.25kg mass dropped from 140mm of impact surface
04	Against 0.50 Joule	Equivalent to impact of 0.25kg mass dropped from 200mm of impact surface
05	Against 0.70 Joule	Equivalent to impact of 0.25kg mass dropped from 280mm of impact surface
06	Against 1.0 Joule	Equivalent to impact of 0.25kg mass dropped from 400mm of impact surface
07	Against 2.0 Joule	Equivalent to impact of 0.50kg mass dropped from 400mm of impact

		surface
08	Against 5.0 Joule	Equivalent to impact of 1.7kg massdropped from 300mm of impact surface
09	Against 10 Joule	Equivalent to impact of 5kg massdropped from 200mm of impact surface
10	Against 20 Joule	Equivalent to impact of 5kg massdropped from 400mm of impact surface

As evidently clear from the above table that IK classification provides a means of specifying the capacity of an enclosure to protect its contents from external impacts. These vary from **IK01** *(**Low impact resistance**: Protected against 0.14 joules impact. Equivalent of resistance to the impact of a 200 gm object falling from a height of 75 mm*), to **IK10** (***Vandal-proof****: Protected against 20 joules impact. able to withstand the impact of a 5 kg object falling from a height of 400 mm).*

2.5 Thermal Features

A considerable amount of the electrical energy supplied to the lamp is converted into heat. For a given LED/Driver combination, the working temperature reached by the luminaire is dependent upon three factors:

• The temperature rise inside the luminaire will be less as the volume increases.

• The ease with which heat produced inside the light source can be transferred through it to the air around it. Utilizing heat-conducting materials in the building of the housing is one technique to encourage air movement through it. The majority of metals performs well in this regard, whereas plastics are thermal insulators and cannot be used as housing materials for high power LEDs because of this.

• Large surface areas must be in contact with the surrounding air for effective heat dissipation. Because some floodlights and some LED luminaires are extremely sensitive to high temperatures, luminaires for high-power bulbs are equipped with cooling fins. Luminaires are designed to meet the conditions under which they are most likely to be used. The maximum ambient temperature, Ta, at which a luminaire can be operated safely, is indicated on the type label on the product.

CHAPTER3

BENEFITS OF LED BASED HIGHWAY ROAD LIGHTING SYSTEMS

BENEFITS OF LED BASED HIGHWAY ROAD LIGHTING

LED Based Highway road lighting solutions offers significant benefits and options which are not possible with conventional lighting. Some benefits hold true for all LED lighting applications, while others are specific to LED Highway road lighting.

The quality of a Highway road-lighting installation is expressed in terms of photometric criteria that influence both visual performance and visual comfort. There are two different categories of quality parameters: parameters using solely photometric units and parameters using performance metrics. The exact photometric parameters used in specifying, designing and measuring Highway road-lighting installations will be defined. For lighting installations designed mainly to suit the needs of motorized traffic. The lighting quality parameter employed for lighting level is the average luminance of the road surface between 60m and 160m in front of the driver. The area of road up to some 160m is the background area against which objects must be detected for most driving speeds.

3.1Technological benefits:

LEDs represent the next stage in the evolution of lighting technology, moving lighting solutions from analog to digital technology.

- High lumen efficacy: Currently, commercially available luminaires from quality suppliers typically have efficacy levels of 100 – 150 lm/W. However, with the efficacy levels of LEDs rapidly evolving, it is always recommended to consult with reliable manufacturers or industry representatives for the latest efficacy levels. In certain applications LED luminaires having efficacy upto 150 lm/W is also been employed.

- Directionality and Reduced Light Pollution: Light spilled outside the area to be lighted is a visible sign of a bad lighting installation. Itis most probably not cost-effective and is sure to waste energy with all the negative consequences for the environment. LEDs’ directionality contributes significantly to their energy saving potential. LEDs provide directional light, reducing light wastage and directing the light where it is most needed. This can also prevent unwanted dispersion of light to residences, nearby areas, and the night sky, thereby reducing light pollution as illustrated in figure 3.1.

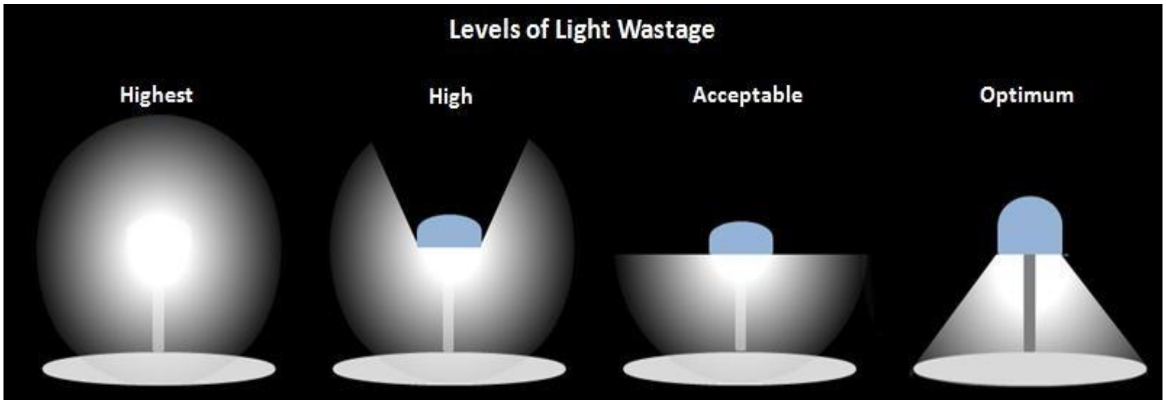


Fig.3.1: Using LED luminaire reduces "light pollution"

- Long lifespan: Laboratory testing and experience indicate that well-produced LED systems last 50,000 hours or more, depending on usage. This compares favorably against the 5,000 to 15,000 hour lifetime of most conventional lamps.

- Superior quality of light: LED lighting has a high CRI (*in the range of 80*) , which together with its white light, offers enhanced night time visibility, making the roads brighter and safer. Some initial research shows that LED road lamps achieve greater light penetration through fog.

- Extended controllability: LED lighting is a digital technology making dimming and similar control functions possible and easy. LED users can make precise adjustments to brightness, monitor fixture operation from a centralized location, and optimize energy efficiency by altering light output as needed. In addition, while conventional lighting technologies have shorter useful lives when they are dimmed, the effect on LEDs is the opposite: LED life is extended when dimmed.

3.2 Economic Benefits:

The strongest argument for a switch to LED road lighting is economic.The direct and indirect economic benefits of LED lighting include:

- Lower lifetime cost: During its much longer lifetime of 50,000 hours (compared to 15,000 hours or less for an alternative conventional technology), the total cost of ownership (TCO) of an LED road lighting system is lower by 50% or more. The TCO of a road lighting system includes energy, lamp replacement, and labor and maintenance costs.

- Income generation: Effective road lighting helps extend light hours in cities as well as rural areas. This promotes tourism; longer business hours for businesses such as food vendors, shops, entertainment centers; and other evening activities resulting in jobs and income generation.

- Savings along the energy sector value chain: By being more efficient, LED road lighting reduces the amount of energy needed from the grid and frees up capacity during peak hours. This allows governments to meet growing energy needs from existing infrastructure and avoid or postpone investments such as for power plants, transmission lines, and distribution networks. Similarly, in off-grid and rural areas, stand-alone solar LED road lighting can help governments meet urgent lighting needs as investments needed to extend the grid are still being made.

3.3Key Benefits of a Solar LED Road Lighting System

Depending on the context, solar LED road lights deliver additionalbenefits compared to grid-connected LED road lighting systems:

- Higher energy savings: Solar LED road lights provide 100% energy savings over conventional road lights, and hence higher savings on the energy bill.

- Lower initial investment in off-grid areas: When we factor in the cost of connecting an off-grid area to the electricity grid so it may have road lights, the initial cost of setting up road lights is much lower with solar LED lights.

- Energy access in off-grid areas: In many rural areas, solar road lights provide the only source of light. When situated in an off-grid community center, solar LED road lights help lengthen the work day, supporting increased economic activities, community interaction, and education-related activities. Community lighting also becomes the first step to energy access, as households start demanding and paying for energy access in their homes.

Climate change mitigation: As part of their climate change mitigation strategies, many utilities and countries are now setting targets for GHG Mitigation and energy generation from renewable sources. Solar LED road lights can be a good way for countries/ utilities to meet both these targets. Installation of solar LED lights can count as solar power generation, and a switch to solar LED lights helps reduce GHG emissions significantly.

- **When is solar LED the optimum choice?**

  As solar LED lighting has a higher initial investment cost compared to grid-connected LED lighting, we examine the situations where solar LED road lighting is the best option:

  • Limited, unstable, or no generation capacity: In most emerging markets, energy demand outstrips supply, and it may be difficult to increase generation capacity in time to meet growing demand for road lighting. This is especially true in many markets in South Asia and Africa.

  • Off-grid locations: For any area that is currently a mile or more away from an electricity grid, it is more cost-effective to install solar road lighting than to extend the grid. In areas with sparse population it is often faster and more economical to provide solar road lighting and similar off-grid solutions for other energy needs.

- Opportunity costs: Often, limited energy supply and competing demands from industry/essential services together impose significant constraints on the electricity grid. In instances such as this, and especially if energy costs are high, adding solar energy supply into the mix through solar LED road lights may be an effective way to provide significant relief during peak demand times.

  • New installation costs: In some cases, where energy costs are high and when lighting a road for the first time, it may be cost-effective over the product lifetime to opt for a solar solution. One can save on the cabling network between the poles (since no cabling is involved) and even reduce the number of poles needed per kilometer through smart design.

Fig.3.2: Solar LED luminaire with SPV panel

Having good quality components is not enough to ensure reliability of the system. In fact, precisely because the separate components need to be configured and integrated into a single system, solar LED lighting requires a system approach that looks at how the whole unit works optimally and not just the performance of each individual component (*SPV array, battery, charge controller)*. A solar LED lighting system as shown in figure 3.2 is more than just the sum of its parts: it requires seamless system integration and configuration to deliver the required functionality and performance. The key to a reliable and robust solar LED lighting system isto guarantee the quality of each component and to ensure their proper configuration and integration.

CHAPTER 4

OVERVIEW OF HIGHWAY GRADESEPARATED STRUCTURES

OVERVIEW OF HIGHWAY GRADE SEPARATED STRUCTURES

Grade separation is a method of aligning a junction of two or more surface transport axes at different heights (grades) so that they will not disrupt the traffic flow on other transit routes when they cross each other. The composition of such transport axes does not have to be uniform; it canconsist of a mixture of roads, footpaths, railways, canals, or airport runways. Bridges (overpasses or flyovers), tunnels (or underpasses), or a combination of both can be built at a junction to achieve the needed grade separation. In essence, *through grade separated structure traffic flows at different levels*. The advantage of having grade separated structure is that roads with grade separation generally allow traffic to move freely, with fewer interruptions, and at higher overall speeds; this is why speed limits are typically higher for grade-separated roads. In addition, reducing the complexity of traffic movements reduces the risk of accidents.

Different grade separation of a national highway is discussed below –

I. The grade separated structure which is provided for crossing of vehicles under the project highway is called **Vehicular Underpass** (VUP) as shown in figure 4.1.

II. The grade separated structure which is provided for crossing of vehicles overthe project highway is called **Vehicular overpass** (VOP) as shown in figure 4.2.

III. The grade separated structure which is provided for crossing of pedestrian under the project highway is called **Pedestrian underpass** (PUP) as shown in figure 4.3.

IV. The grade separated structure which is provided below the project highway for crossing of cattle is called **Cattle Underpass** (CUP).

V. The structure which is provided over the railway track lines to carry the project highway is called **Road over bridge** (ROB) as shown in figure 4.4.

VI. The structure which is provided under the railway track lines to carry the project highway is called **Road under bridge** (RUB).

Fig.4.1: Vehicular Underpass **Fig.4.2: Vehicular overpass**

Fig.4.3: Pedestrian Underpass **Fig.4.4: Road over bridge**

Lateral and Vertical clearance of Underpass

Lateral Clearance

- Full roadway width of cross road shall be carried through the vehicular underpass. The lateral clearance shall not be less than 12m (7m carriageway + 2x 2.5m shoulder on either side).
- For light vehicular underpasses the clearance should not be less than10.5m including 1.5m raised footpath on either side.
- For pedestrian and cattle underpass the lateral clearance shall not be less than 7m

Vertical Clearance

Table 4.1: Typical elevation of underpasses of project highway (IRC: 84, 2014)

Vehicular underpass	5.5m
Light Vehicular underpass	3.5m
Pedestrian underpass	3.0m (it can be increased to 4.5 if humungous animals are expected to cross project highway frequently)

- Trumpet interchanges as shown in figure 4.5, have been used where one highway terminates at another highway. These involve at least one loop ramp connecting traffic either entering or leaving the terminating expressway with the far lanes of the continuous highway. These interchanges are useful for highways as well as toll roads, as they concentrate all entering and exiting traffic into a single stretch of roadway, where toll booths can be installed. Trumpets are suitable at the locations where the side road exists on only one side of the freeway, and traffic is relatively low. Each entrance and exit consists of acceleration or deceleration lanes at each end. It requires only one bridge and is the most traditional way of grade separating a three way junction.

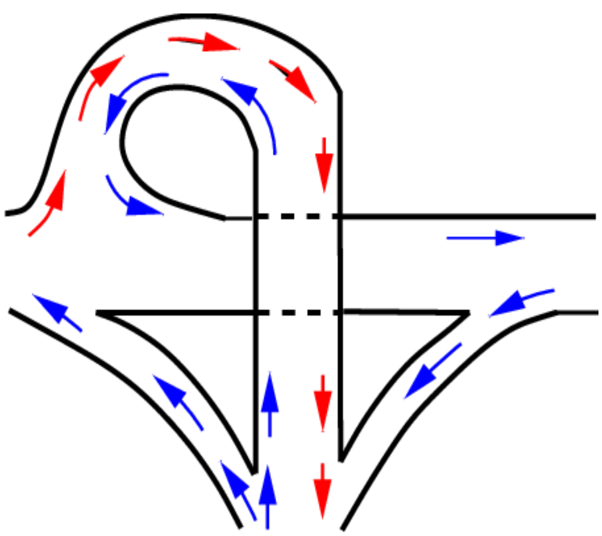



Fig.4.5: Trumpet Interchange

- The Diamond Interchange as illustrated in figure 4.6, is the simplest form of grade separated intersection between two roadways. The conflicts between through and crossing traffic are eliminated by a bridge structure. This particular intersection has four one way ramps which are essentially parallel to the major artery. The left turn crossing movement conflicts are considerably reduced by eliminating the conflict with the traffic in opposite direction. All the remaining left turn conflicts, merging and diverging maneuver conflicts take place at the terminal point of each ramp.

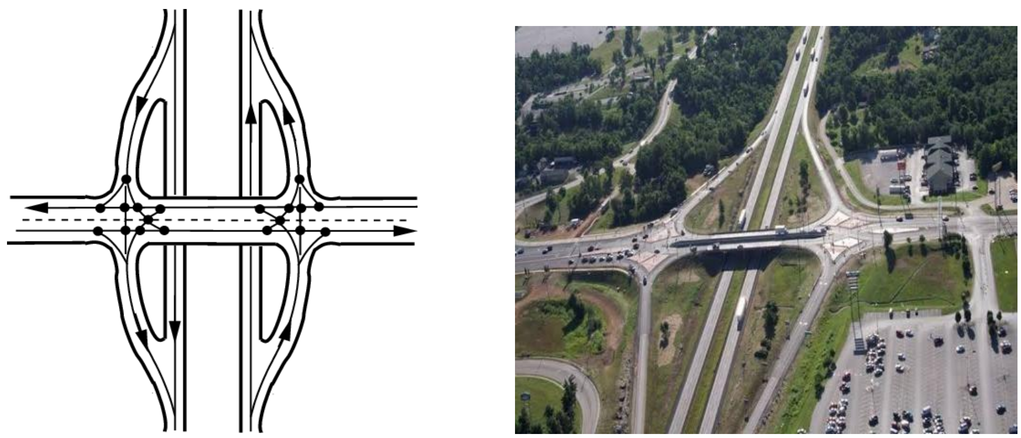


Fig.4.6: Diamond Interchange

- The Cloverleaf interchange as shown in figure 4.7 below eliminates all crossing movement conflicts by the use of weaving sections. This weaving section is a critical element of cloverleaf design. It replaces a crossing conflict with a merging, followed some distance farther by a diverging conflict. There are two points of entry and exit on each through roadway. The first exit is provided before the cross road structure allows right turn movements. The second exit, immediately after the cross road structure, allows for left turn movements. A weaving section is created between the exit and entry points near the structure. Sufficient length and capacity is to be provided to allow for a smooth merging and diverging operation.

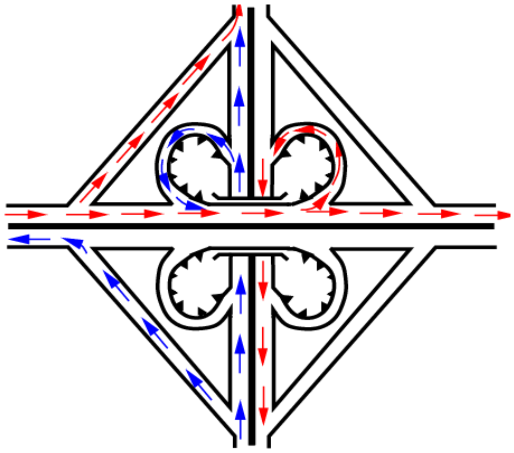


Fig.4.7: Cloverleaf Interchange

Right of Way

A minimum Right of Way (ROW) of 60 m should be available for development of a 6-lane highway as depicted in figure 4.8. The Authority would acquire the additional land required, if any.

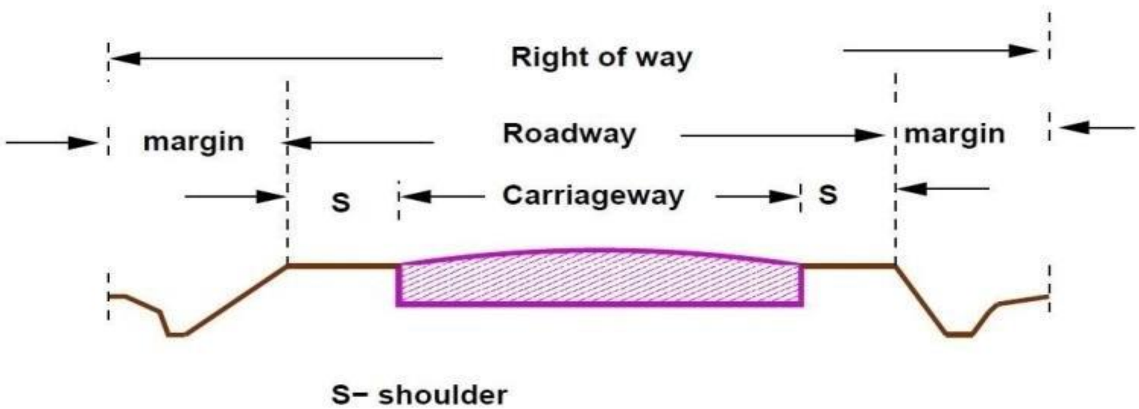
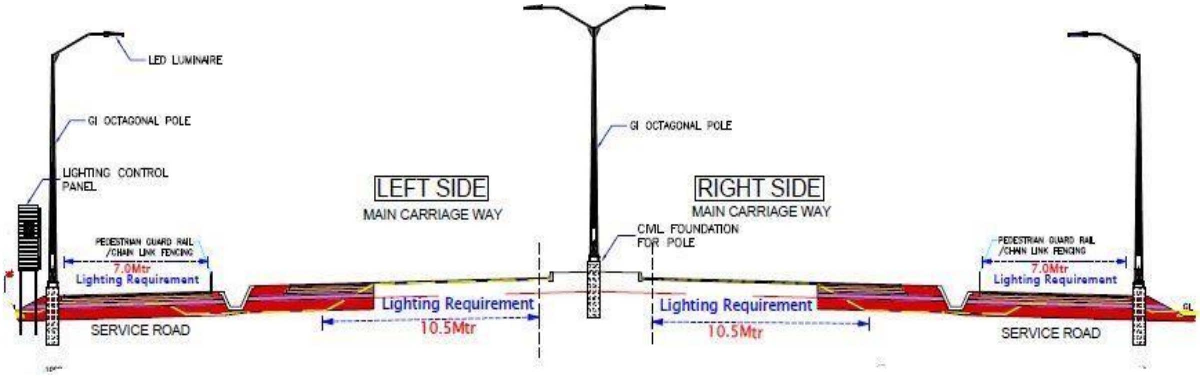


Fig.4.8: A typical Right of Way

Typical cross sections and Junctions

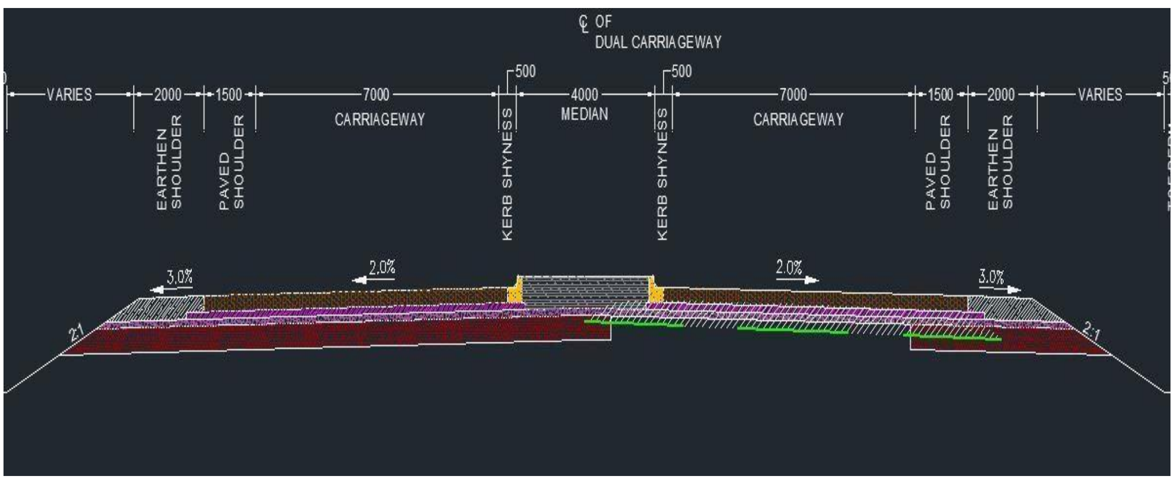
This section lays down the geometrical design of a typical 6 lane divided carriageway of a National highway. The standard lane width of the project highway shall be 3.5m.

Figure 4.9(a) shows typical cross sections for a typical 6 lane divided carriageway in plain terrain with service road on both sides and with depressed median.



(a)

Figure 4.9(b) shows typical cross sections for a typical 6 lane divided carriageway in plain terrain with service road on both sides and with raisedmedian.



(b)

Fig.4.9: Highway road surface with (a) depressed median (b) Raised median

There shall be interconnection between the service roads of both sides through underpasses which will facilitate cross movement of local traffic from one side to the other side and to facilitate change of direction of through traffic. Accordingly, the intersections on the service road including those at underpasses shall be designed for safe movements for all turnings. Encompassing safety requirement and also to have better traffic control following layouts are suggested for at-grade intersections below structures on the project highway.

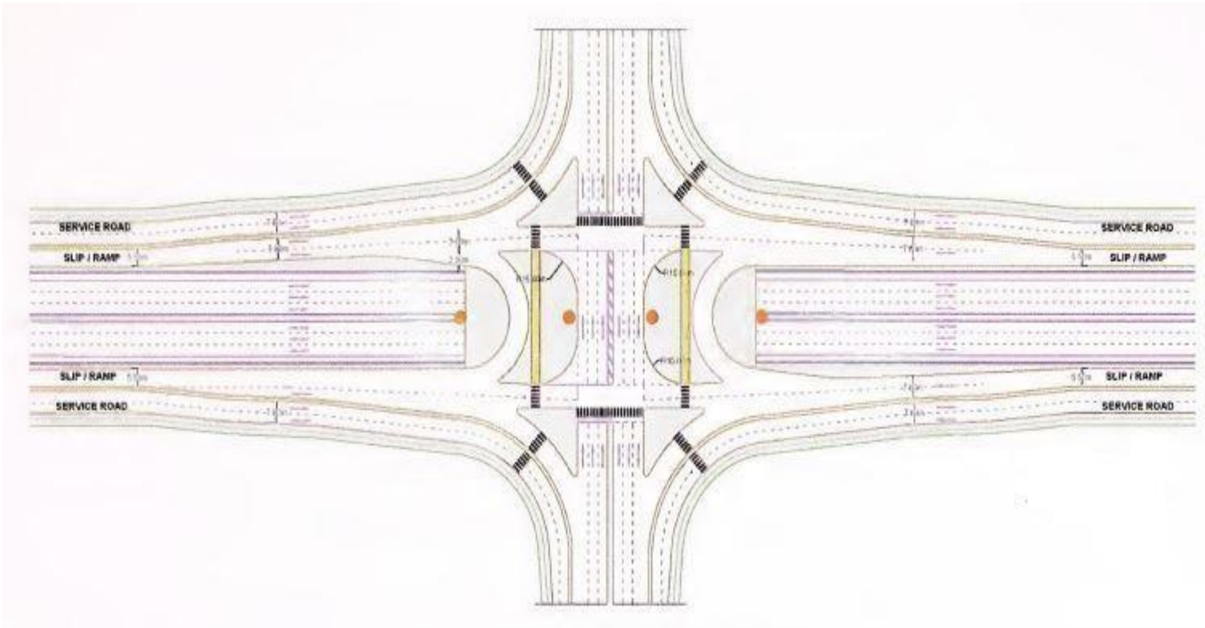


Fig.4.10: Four legged Major "+"Junction

Toll Plaza

A toll road, also known as a turnpike or tollway as illustrated in figure 4.11,is a public or private road for which a fee (or *toll*) is assessed for passage. It is a form of road pricing typically implemented to help recoup the cost of road construction and maintenance.

A motorist's visual performance can be assessed using a number of different performance criteria. The visibility of static objects (obstacles)and dynamic objects (other road users, including pedestrians) and the visibility of changes in the visual scene and the detection of relative movement are examples of important criteria. Detection just on the threshold of visibility is often not enough for safe driving. So uniform distribution of lighting through high mast is of paramount in toll areas.

The width of each toll lane shall be 3.2 m, except for the lane for over dimensioned vehicles, where it shall be 4.5m between each toll lane of the Toll Plaza, traffic islands are required to accommodate toll booth. These islands shall be of minimum 25 m length and 1.9 m width.

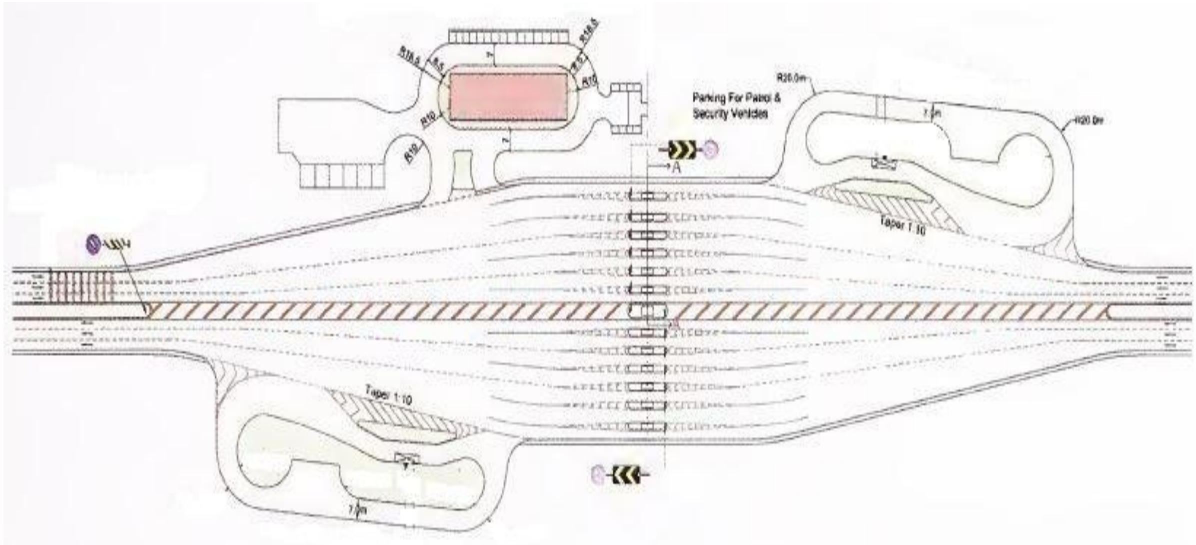


Fig.4.11: Typical floor plan layout of toll plaza

Adequate land for Toll Plaza shall be acquired to permit the provision of toll lanes for projected peak hour traffic of 20 years including all other buildings and structures to be accommodated at the Toll Plaza location depends on – stream of density of traffic, visibility of approach roads, reasonably away from road intersections.

Toll booths as shown in figure 4.12 may be provided of pre-fabricated materials or of masonry. The toll booths shall have adequate space for seating of toll collector, computer, printer, cash box, etc. It should have provision for light, fan and air conditioning. Toll booth shall be placed at the centre of each traffic island. The toll booth shall have large glass window to provide the toll collector with good visibility of approaching vehicles. The bottom of the toll window should be placed at such a height (0.9 m) above ground level so as to provide convenience of operation.

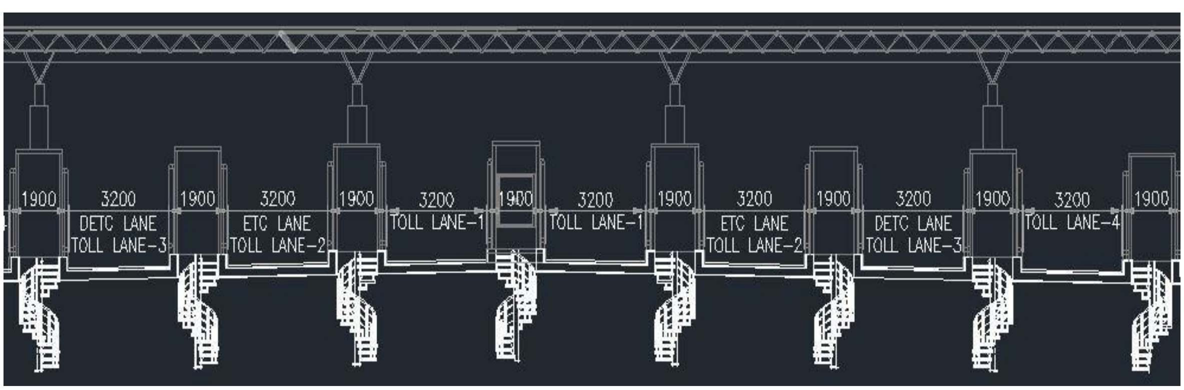


Fig.4.12: Typical elevation plan layout of Toll Island and lane

Canopy

All the toll lanes and toll booths shall be covered with a canopy. The canopy shall be wide enough to provide weather protection to toll operators, drivers and facilities. The canopy shall be of aesthetically pleasing design with cylindrical support columns located at traffic island sothat there is no restriction on visibility and traffic movement. The vertical clearance generally constructed at 6m from road level. Under canopy light is used to illuminate the toll lanes for vehicular passageway.

Truck Lay Bye

A paved area at the side of a highway as shown in figure 4.13, is designated for drivers to stop in, for emergency parking, or where vehicles can wait, with larger lay-bys possibly having facilities like food vendors or public telephones.

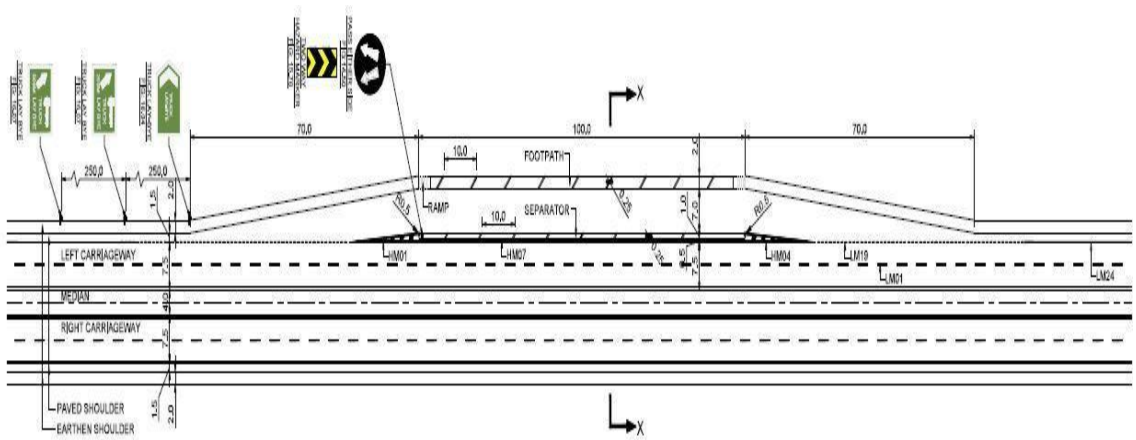


Fig.4.13: Typical plan layout of truck lay bye

Bus Bay & Passenger Shelters

A paved area at the side of highway as shown in the fig 4.14 is designated for dropping and picking up passengers.

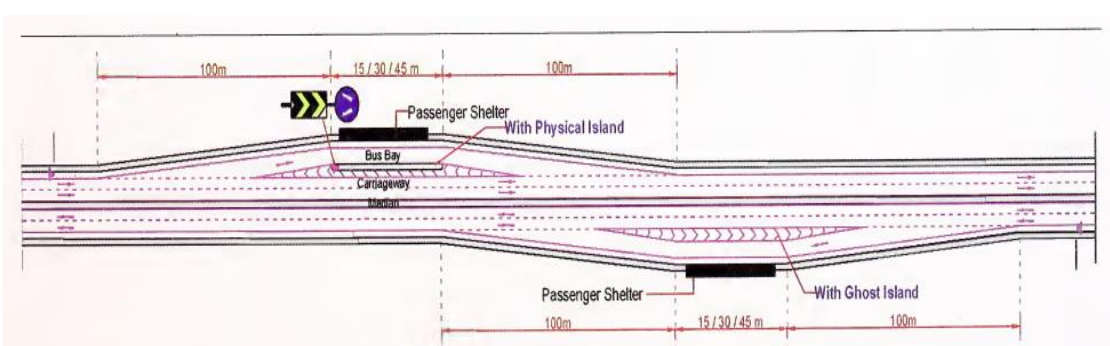


Fig.4.14: Typical plan layout of Bus bay & Passenger Shelter

At a glance in the following figure 4.15 the entire grade separated structures that needs to be illuminated as per standard is shown. The ***green highlighted*** zones indicated below are such areas where the volume of traffic composition is quite dense. Visual comfort is a subjective aspect related to road-lighting quality. If the degree of visual comfort is not good enough, a motorist's level of fatigue will increase and as a consequence, his visual performance and alertness will decrease. Hence sufficient and uniform lighting should be provided so that the visual performance and visual comfort of a motorist is satisfied. Also proper lighting arrangement also helps in visual guidance for pedestrian movement.

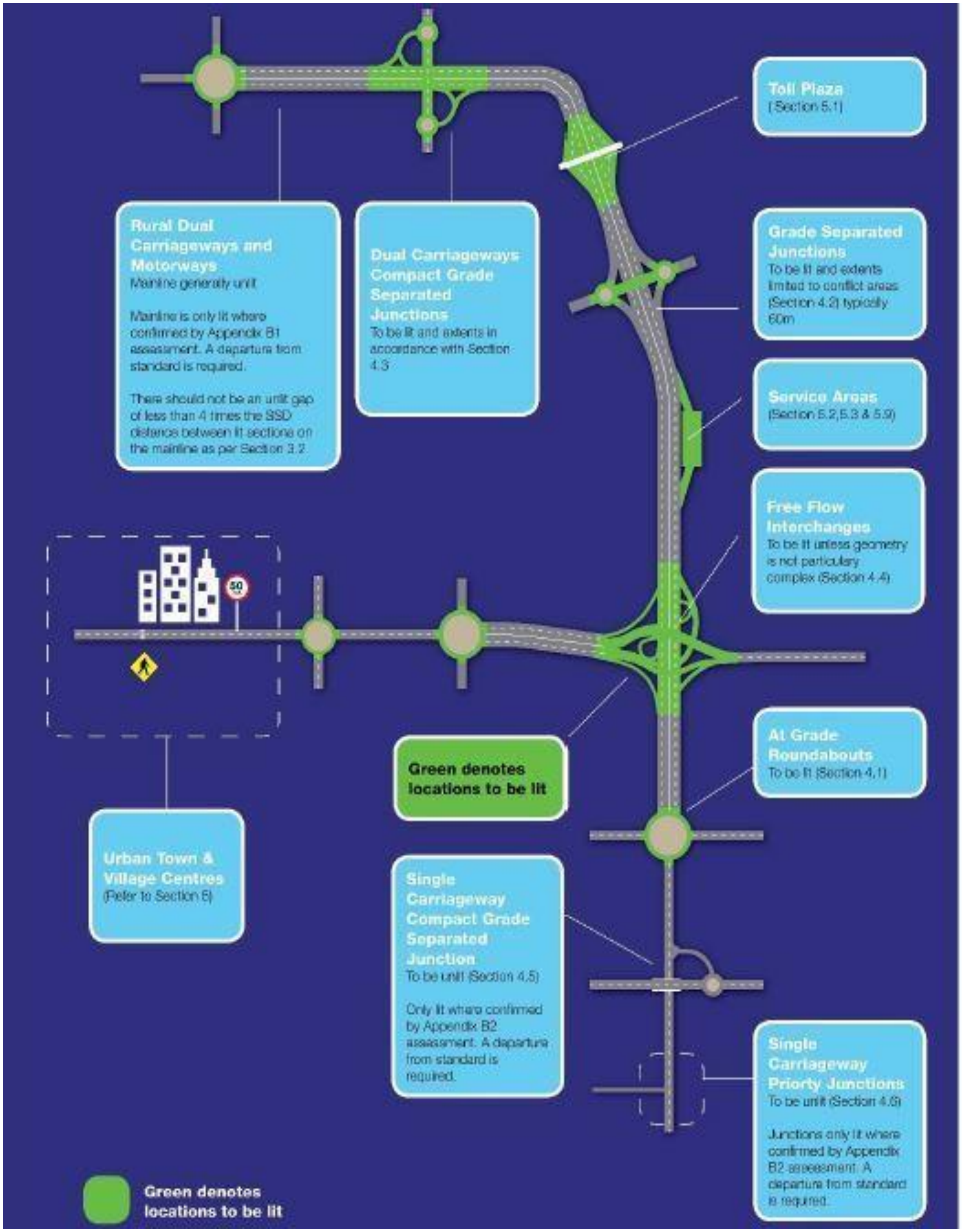


Fig 4.15: Representation of the Lighting Provision on the National Road Network

CHAPTER 5

NATIONAL RECOMMENDATIONS AND STANDARDS ON NATIONAL HIGHWAY ILLUMINATION DESIGN

NATIONAL RECOMMENDATIONS & STANDARDS

The main purpose of motorway lighting is to improve the visibility to the motorist. The lighting design of a national highway should ensure that it not only meets the requirements of the observer/driver, the required standards and codes, be energy and cost efficient, but also be easy to maintain in the long run, should be safe and appear comfortable to commuters.

The level and type of lighting adopted for a highway is based mainly on its traffic importance, both vehicular and pedestrian. The system of lighting to be provided should take into account all the relevant factors, such as the properties of the carriageway surface, difficulty of the geometry of the road in terms of separation of carriageways and of intersection density, quality of visual guidance and traffic-control signaling.

National Highway Authority of India (NHAI) recommends for lighting of highway by abiding the following standards –

1. **IRC:SP:87** – Indian Roads Congress for Manual specifications & standards for Six laning of highways through Public Private Partnership

2. **IRC:SP:84** – Indian Roads Congress for Manual specifications & standards for Four laning of highways through Public Private Partnership

3. **IRC:SP:73** – Indian Roads Congress for Manual specifications & standards for Two laning of highways through Public Private Partnership

4. **IRC:SP:92** – Indian Roads Congress for Guidelines of designing Interchanges in Urban area

5. **IS 1944-5(1981) –** Code of practice for lighting of public thoroughfare, Part 5: Lighting for grade separated junctions, bridges and elevated roads (Group D)

Decisions to invest in Highway based road-lighting installations can only be made sensibly if there is a clear insight into visual performance and visual comfort and help to keep the driver alert. The lighting design standards recommended for different grade separated structures are discussed as below –

- **Toll Plaza:** The toll plaza shall have lighting system to provide visibility to drivers for the use of facility especially to access the correct service lane and also to the toll collector. This would be done by interior and exterior lighting as discussed below.

  Interior: The toll booths and facility building office shall be illuminated adequately. Indoor lighting shall be with surface mounted luminaires. Lighting should be provided in such a manner that glare is avoided or minimized. The level of illumination shall be **200 to 300 Lux** as per **IS: 3646 part II**

  Exterior: Lighting of the Toll Plaza is important for enhancing the night visibility. The lighting system shall consist of the following major components.

  (i) High Mast lighting

  (ii) Lighting on both side approaches to the Toll Plaza

  (iii) Canopy lighting of complex

- **High Mast Lighting**: Normal low light poles are not able to give the required lighting conditions. It is, therefore, necessary to install high mast. A height of 30mtr. For the mast is considered suitable to have uniform spread of desired level of illumination in the Toll Plaza area for safe movement of vehicles.

- **Highway Lighting**: A minimum requirement of illumination on the road surface of **40 Lux** shall be ensured with overall *uniformity* factor E_{min} /E_{Avg} to be 0.4 and E_{Min} / E_{Max} to be 0.33 in transverse

  direction as per **IS 1944-1 and 2 (1970).** Lighting in minimum 500mtr. length on either side approaches of toll plaza shall be provided to enhance the safety at night on the Project Highway and to make the drivers conscious of their approaching the toll gate. These shall be provided on the mild steel welded tubular octagonal pole of 10 m or 9 m height from road surface and with 2 m overhang.

- **Canopy Lighting**: A higher level of illumination of **average 100 Lux** by mounting IP65 grade luminaires shall be provided at the toll gate and at toll booth locations. "Under canopy" luminaires shall be provided at the selected nodes of space frame of the canopy to ensure uniform illumination in each toll lane of width 3.2 mtr. To 4.5mtr.

- **Major Junction:** Where junctions involve a compact and complex system of roads at different levels, lighting by conventional technique leads to confusing array of columns which would impair or suppress the optical guidance. Lighting by high wattage light sources on high masts of suitable elevation offers the opportunity of providing adequate lighting with reduced number of columns at a reasonable cost. The mast used for high-mast lighting usually includes a mechanism for lowering the luminaire to ground level for maintenance. As the volume of traffic composition in 4 legged junctions is quite complex so higher level of illuminance is required for safe and smooth traffic transition. Standard dictates a **minimum** illumination level of **40 Lux** must be maintained in an approximate 30-40mtr. radius circle in the desired junction complex ensuring overall uniformity factor of E_{min} /E_{Avg} to be 0.4 and E_{Min} / E_{Max} to be 0.33 in transverse direction.

- **Minor Junction:** The level and type of lighting adopted for minor junction is same as major junction. Instead of High Mast Street light poles are used to meet the lighting requirements.

- **Underpass : "**Underdeck**"** luminaires of IP65 grade are installed either from wall mounted or ceiling mounted by maintaining a **minimum** light level of **40 Lux** throughout the access to exit zone.

- **Truck Lay Byes:** The Truck Lay Byes and 50 m length on the project highway on its either side shall be illuminated at night to provide a minimum illumination level of 40 lux. Suitably designed poles having aesthetic appeal and energy saving luminiares may be used to provide required illumination.

- **Bus bay & Passenger Shelter:** The level & type of lighting adopted for entire Bus bay area is similar as Truck Lay Bye, only excluding 50 m approach road area of its either side.

CHAPTER6

LIGHTING DESIGN METHODOLOGY & MEASUREMENT

LIGHTING DESIGN METHODOLGY & MEASUREMENT

To achieve the best overall outcome in a lighting installation, it is important to avoid the tendency of rushing straight into luminaire selection before determining more broadly what is required from the system. The use of a structured design process helps to avoid this. This chapter explains in detail the methodology used as illustrated in figure 6.1 in the successful completion of the project. The assumptions made, the luminaire specifications and the lighting designing tools used have also been mentioned in this chapter.

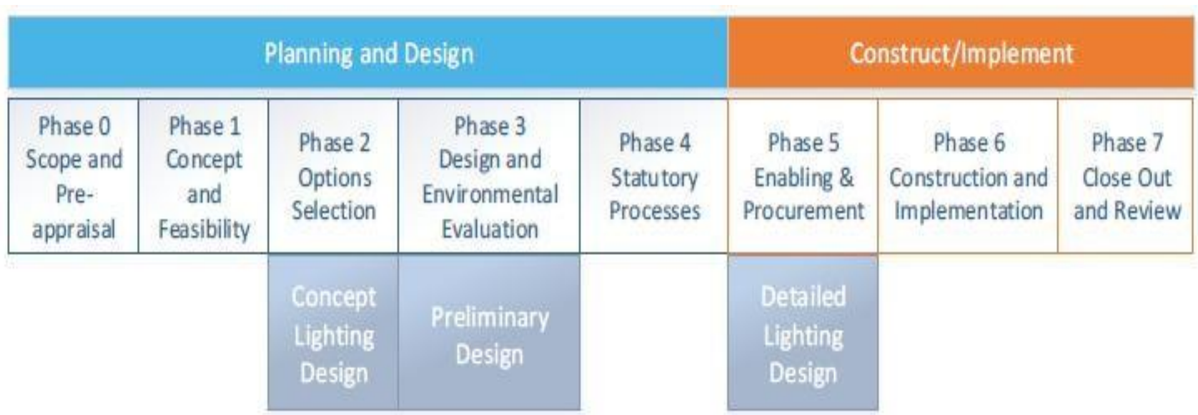


Fig.6.1: Process & lighting stage Alignment

Input Data:

Drawing of the area giving plan and elevation:

To initiate lighting design for a structure, it is essential to build the virtual structure on software, and that structure should be built with exact dimensions as the original space. For this we need AutoCAD layouts. This detail helps in deciding the length, width and height of the area. It also gives information about the type and any constraints in locating the luminaires. If AutoCAD layout is not available direct site survey can be conducted to get these details.

Reflection Properties of Surroundings:

This data helps in deciding the reflection factors of the ceiling, walls and floor. Normally the client does not specify this data. In such cases, the environmental condition prevailing in the area and experience of the designer helps in deciding the reflection properties.

Required Illumination Level:

Another important criterion before designing is to know what the client wants for this space. Tender documents contain the requirements of the client, i.e., the NHAI [National Highways Authority of India] regulatory body here. Some of the requirements are certain maintained average or minimum illuminace level values, uniformity ratio, design parameters, plan and profile of the project highway, chainage details etc.

Layout and Cross section of Machine and Tools:

This will help in location of luminaires such that light neither is nor obstructed by themand design becomes much more practical & optimized. From AutoCAD layout we have idea of elevation.

Method of Lighting:

During the actual lighting design phase of a lighting project, a lighting engineer has to perform lighting calculations in order to arrive at solutions that will satisfy the relevant lighting requirements. Lightning simulation software are being used to simulate and visualize any design virtually. At this stage, consideration is given to how the light is to be delivered. The fixtures may be recessed, surface mounted, wall mounted direct or indirect, type and distribution of floodlight to be chosen, necessary mast and pole height to illuminate the required area & optimizing at the same time, making it more economical.

Selecting the Lighting Equipment:

Once the method of lighting has been selected, the most appropriate lightsource can then be chosen followed by the luminaire.

The following attributes should be studied when choosing the light source:

- Light output (lumens)
- Total input wattage
- Efficacy (lumen per watt)
- Surface brightness / glare
- Colour characteristics
- Electrical characteristics
- Photometric attributes
- Requirement for control gear
- Thermal management

Choice of Luminaire:

The performance of a luminaire should be considered just as carefully as its cost. In the long term a well designed, well constructed luminaire will be cheaper than a poor quality unit; and the salient features of a good quality luminaire are:

- Sound electrical & mechanical construction with durable finish
- Adequate screening of high luminance lamps to minimize discomfort glare.
- Adequate heat dissipation to prevent over-heating of the lamp, wiring and ancillary equipment
- High light output ratio with the appropriate light distribution.
- Ease of installation, cleaning and maintenance.

Design Tools:

1. DIALux evo 11.1 :

DIALux is user friendly lighting simulation software which is used to calculate the luminaire quantity required to achieve the illumination level on the area as per the standard. It also gives information on the total power consumption by the lighting load for the given area and also calculates the LPD value of the proposed lighting scheme which helps in identifying the most efficient lighting scheme. DIALux evo enables us to enjoy complete freedom for designing, whether it is an Indoor Area, or an Industrial Shed or an Exterior area.

2. AutoCAD 2023:

AutoCAD is a computer aided design & drafting application which provides complete information on the dimensions of the room like length, width and height of the room. And after the completion of the design, the same can be used to provide the lighting layout as well. AutoCAD drawings are saved using the DWG extension, and over the years this has become a standard format for exchanging technical drawings, to the extent that even programs such as Adobe Illustrator will recognize DWG files. AutoCAD also supports an even more widely recognized format called DXF which was specifically designed as an interchange format.

3. AGi32 19.10:

AGi32 is a software tool used to predict the lighting performance of electric luminaires and/or daylight inside a simulated environment. The environments that may be considered in AGi32 can range from a simple rectangular space to a multilevel interchange or complex auditorium. AGi32 is a stand-alone tool, meaning that no other software programs are required to create or output the calculations results.

However, a common manner of input and output in AGi32 involves the importing and exporting of DXF (Drawing Exchange Format) or DWG (AutoCAD native format) files from CAD software. DXF is an industry standard format that is generated by virtually any CAD software available. DWG is AutoCAD's native drawing format. Importing DXF and DWG Files provide background information about the underlying architecture and systems that are used in AGi32 as a template for creating the environment. AGi32 allows you to select from two calculation techniques, when simulating the lighting application. Direct Only Method is a simplified calculation technique used when reflected light need not be considered in the results. This mode lends itself particularly well to exterior lighting applications, sports and industrial interiors with low reflectance surfaces. Full Radiosity Method is used where reflected light is a major contributor and you wish to render the results.

4. Luxmeter:

It is an instrument used to measure the illumination level at different points in working area. There are two main conditions when a luxmeter is required.

a) Post Installation Audit: This is mainly required when the client wants to verify the simulated report with the practically achieved result. This is known as post installation audit.

b) Refurbishment: When an existing installation needs to be replaced with a more efficient lighting scheme (i.e. LEDs).

Design Methodology:

1. Client Meet & Discussion:

For any lighting designer, the foremost step is to have a formal discussion with the client or end user and other members of the design team, so as to get the essence of what function the space would serve for, and hence to have an idea about what needs to be done.

2. Obtaining the AUTOCAD layout & Project Scope:

After client meeting we need AutoCAD file & Project Scope of the work. AutoCAD layout provides us the exact length, width and height of particular area which help in proper selection and arrangement of the luminaire. Project scope is generally in a excel sheet format, if required the project scope is compared with the given AutoCAD drawings to meet client's requirement.

3. Study of guidelines:

Study the relevant codes, guide lines in detail.

I. IRC:SP:87 – *Manual specifications & standards for Six laning of highways*

II. IRC:SP:84 – *Manual specifications & standards for Four laning ofhighways*

III. IRC:SP:73 – *Manual specifications & standards for Two laning of highways*

IV. IRC:SP:92 – *Guidelines of designing Interchanges in Urban area*

V. IS 1944 – Part 5 – *Lighting for grade separated structures*

VI. IS 1944 – Part 1 and 2 – *Lighting for Primary & Secondary roads*

VII. IS 3646 – Part 2 – *Recommendation for indoor lighting design*

Design Simulation with the Site layout:

After following the guidelines we have to import the AutoCAD layout in the lighting design software e.g. DIALux version 4.13 /DIALux evo/ AGi32. During this import, one should take care about the dimension unit in the AutoCAD File.

Indoor area:

Indoor area design is done by DIALux4.13/DIALux evo.The steps involved in indoor lighting are as under.

STEP I – Deciding the type of area and type of task to be performed

In the first step after having AutoCAD layout we have to identify the typeof work to be done e.g. whether it is office area, industry shed area etc.

STEP II – Deciding the illuminance level required

Once the area type and task to be performed decided then as per IS 3646or relevant tender document recommendation illuminance level required can be found out.

STEP III – Finding out the dimension of the room

After importing the AutoCAD we can find the length, width and height. Once of the dimension of the area is found out, then the type of lighting arrangement can be decided.

STEP IV – Finding out the ceiling type

In this step we have to decide whether true ceiling or false ceiling is there. If it is true ceiling surface/ suspended mounted luminaires are chosen. In case of false ceiling recess mounted luminaire should be chosen.

STEP VI – Selecting the luminaire

Luminaire is chosen based upon the task performed in the area, illumination level required, type of ceiling and level of protection required for the specified area.

STEP VII – Selecting Maintenance Factor

Maintenance factor is chosen as per design requirement otherwise mentioned by the client. Generally for LED light sources we consider maintenance factor 0.8 (for indoor) and 0.85 for Outdoor.

STEP VIII – Finding out the work plane height

Depending upon the application of task area work plane height is to be considered for office area we consider table height say 0.76 meter above otherwise work plane height if mentioned from client end that can also be considered. The floor and for industrial shed area we consider null value, i.e. measurement to be performed at finished ground level.

STEP IX – Selecting the reflectance factors

Depending upon the area we have to select the reflectance factors of the room. For office area reflectance factors for ceiling, walls and floor are to be considered 70%, 50% and 20% respectively. For industry shed area reflectance factors for ceiling, walls and floor 50%, 30% and 10%. For underpass and overpass zones are quite dust prone ; reflectance factors are to be considered as 30%, 30%, 10% respectively for ceiling, walls and floor.

STEP X – Software simulation

To find out luminaire quantity we have to simulate DIALux software afterall the above steps done. In DIALux to simulate the design we have to select calculate option.

STEP XI – Output

After software simulation done we have to select output option in DIALux. In output we have to choose summary option to find out required illuminance levels and luminaire quantity for a particular task.

Street:

In case of Street lighting, the area boundaries are not defined. The length normally varies from installation to installation. Hence the Lumen formula cannot be applied accurately as it is. In case of street lighting instead of finding out the number of luminaires as in case of indoor or exterior lighting, the spacing between the poles is calculated. Once the spacing is known then the same is extrapolated to find out the number of luminaires for a stretch of road. The steps involved in street lighting design by DIALux 4.13/DIALux evo are as under –

STEP I – Deciding the type of road as per IS 1944 and IRC: SP–87/SP-84 recommendation

Based on the road location and composition of traffic, whether the road belongs to Group A or Group B or classified as National highway is decided.

STEP II – Deciding the illuminance level required

Once the road type is decided then as per IS 1944 and IRC: SP–87/SP-84 recommendation illumination level and uniformity can be found out.

STEP III – Selecting Maintenance Factor

Maintenance factor is chosen as per design criteria or otherwise mentioned by the client. However, for normal use the maintenance factor normally varies from 0.60 to 0.85. Generally for conventional light sources we consider maintenance factor 0.60 and for LED light sources 0.85.

STEP IV – Determining the Pole layout

From the AutoCAD layout of the road the width of the carriageway can be decided. Once the road width is found out, then the type of pole layout arrangement can be decided. In general practice the following approach can be considered –

- Mounting height [h_m] ≅ Road width → SINGLE SIDED
- 2 × Mounting height [h_m] ≅ Road width → OPPOSITE
- 1.5 × Mounting height [h_m] ≅ Road width → STAGGERED
- 1.25 × Mounting height [h_m] ≅ Road width → CENTRALVERGE

Pole placement layout is a function of many design factors, such as –

(a) Maintained horizontal illuminance level at road surface

(b) Road width

(c) Feasibility in laying of cabling tray

(d) Environmental restrictions

(e) Constraints in pole commissioning in practical site

The pole layout needed to be considered with respect to road width asillustrated in figure 29 as shown below –

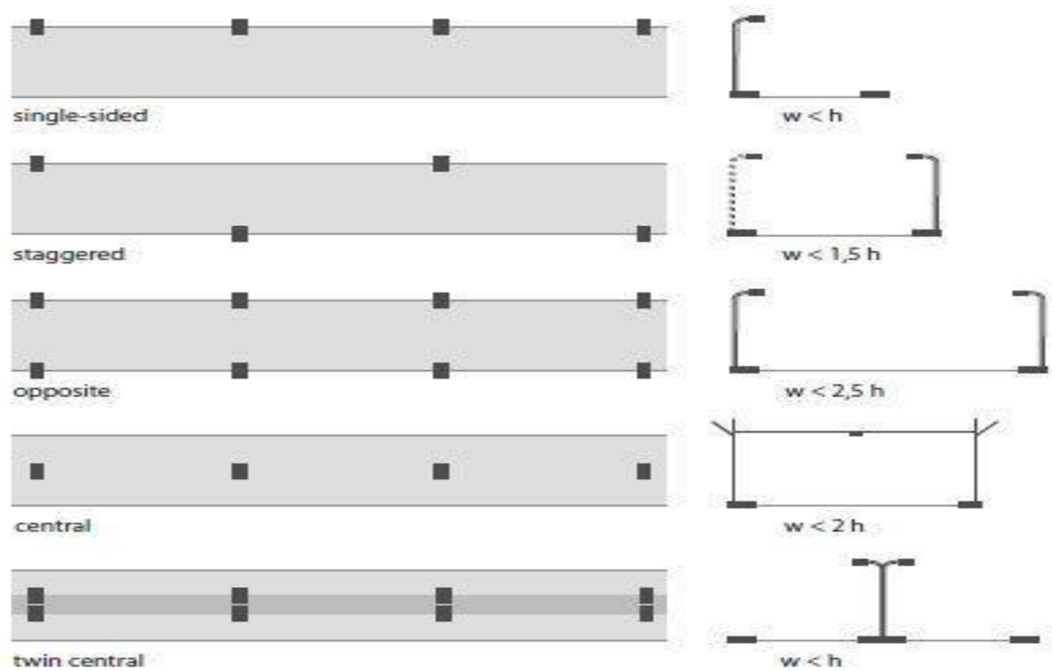


Fig: 6.2: Pole Layout as per Road width

STEP V- Street Arrangement

In the arrangement option in DIALux we can arrange the roadway, median, sidewalk, bicycle lane as per client’s requirement or according to drawing layout.

STEP VI – Deciding the mounting height, angle of the tilt and outreach

Depending upon the width of the road, type of arrangement and geometry of road the mounting height required is decided. The mounting height should normally be equal to width of the road but should not exceed 10 meter. Normally the angle of tilt should be 0, 10, 15 & 20 degree depending upon requirement. The pole should be located as close as possible to the edge of road. Also, the outreach should be selected in such a way that the effective width after selecting outreach should match with the mounting height. However, the outreach should normally limit to 1.5 meters. If the arrangement selected is other than single side arrangement then the width of road for individual pole should be taken as equal to half of the actual road width.

STEP VII– Selecting the light source

There is no hard and fast rule for selecting the light source. Depending on the customers liking this is selected. Nowadays the LED luminaires, are the common light sources for street lighting.

STEP IX – Deciding the spacing between luminaires

To achieve good uniformity standard we have to decide spacing between two poles. Normally the spacing between poles is minimum 3 & maximum 3.5 times to the pole height.

STEP X – Software simulation

To find out luminaire quantity we have to simulate in DIALux or AGi32 software after all the above steps done. In case of AGi32 Software there are 2 options for calculation; one is direct only method and another one is full radiosity method. We will select direct only method to simulate.

STEP XI – Output

After software simulation done we have to select output option in DIALux. In output we have to choose planning data option and valuechart option in valuation field to find out required illuminance levels and uniformity for a particular task.

STEP XII – Pole quantity

In DIALux there is default length of the street for simulation. To find out actual luminaire quantity we have to use following formula for a single sided arrangement. In similar manner luminaire quantity can also be determined. If the arrangement is *opposite* or *central verge* then actual luminaire quantity should be multiplied by two. In case of AGi 32 software we can select the length of street manually for eg. If we select the length of street as 50 m, lighting simulation is done for the mentioned length only and pole quantity is finally calculated from the below given formula.

$$\therefore \quad \textbf{Total number of poles in chainage} = \frac{\textbf{Total length of the road in meter}}{\textbf{Spacing between poles in meter}} + \mathbf{1}$$

Exterior area

Exterior area design is done by AGi32 software. Here grade separated exterior area e.g. major junction, toll plaza, toll canopy & amenity area has been done with software. The steps involved in indoor lighting are as under –

STEP I – Deciding the type of area and type of task to be performed

In the first step after having AutoCAD layout we have to identify the typeof work to be done e.g. whether it is junction area or rest area.

STEP II – Finding out the dimension of the area

Once the area type and task to be performed decided then as per standard illuminance level required can be found out. To do this we have to import the AutoCAD layout into the AGi32 software by import option. During this import, one should take care about the dimension unit in the AutoCAD File.

STEP III – Selecting Maintenance Factor

Maintenance factor is chosen as discussed earlier otherwise mentioned by the client. Generally for conventional light sources we consider maintenance factor 0.60 and for LED light sources 0.85.

STEP IV – Selecting the luminaire

Luminaire is chosen based upon the application, traffic volume, visual guidance, intersection density in the area. Generally in outdoor area we use flood light [from medium beam *(TYPE 3 and 4)* to narrow beam *(TYPE 1)*]. Depending upon illuminance required we have to select suitable wattage of the lamps.

STEP V- Mounting height of luminaire

Depending upon illuminance and uniformity required high mast height should be selected. Because higher the mast height greater will be the uniformity attained but cost the design will also increase simultaneously. Hence to achieve optimization both combination of medium beam *(TYPE 3 and 4)* and narrow beam *(TYPE 1)* to be employed such that by installing relatively smaller mast height the design specifications can be maintained.

STEP VII – Aiming of Luminaires

To achieve good uniformity we have to select suitable tilt and orientation. Too much tilt of luminaires results in improved uniformity (E_{min}/E_{avg}) but in compromise of maintained illuminance level and ULR (Upward light ratio). Stringent care has to given such that ULR remains within 7% to 10% so that it will not cause "*Skyglow*". Hence possibility of "*Light Pollution*" is minimized.

STEP VIII – Software simulation

To simulate this software we have to choose calculation option. In calculation option there are direct only method and radiosity method. We will select direct only method to simulate.

STEP IX – Output

Unlike DIALux in AGi32 software we can view simultaneously result in case of any change in high mast location, height or change of luminaries tilt. To view output we have select statistics window. There we can find average illuminance, uniformity.

In a nutshell, Lighting design is, in fact, the planning of our visual environment. Good lighting design aims to create perceptual conditions which allow us to work effectively and orient ourselves safely while promoting a feeling of well-being in a particular environment and at the same time enhancing that same environment in an aesthetic sense. The physical qualities of a lighting situation can be calculated and measured. Ultimately it is the actual effect the lighting has on the user of a space, his subjective perception, that decides whether a lighting concept is successful or not.

LIGHTING MEASUREMENTS

CIE Method:

Field Calculation

The field of calculation should be typical of the area of the road which is of interest to the driver. In the longitudinal direction of the relevant area, the field of calculation shall enclose two luminaires in the same row. When there is more than one row of luminaires and the spacing of the luminaires differs between rows, the field of calculation shall lie between two luminaires in the row with the larger or largest spacing. In the transverse direction it should cover whole width of the Carriageway.

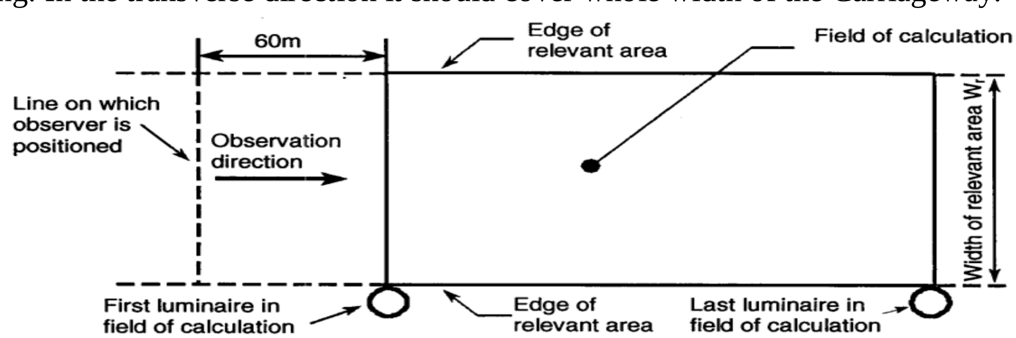


Fig6.3: Field Calculation for Carriageway Illuminance

Position of Calculation Points:

The calculation points shall be evenly spaced in the field of calculation as shown In Figure. The first and last transverse rows of calculation points are spaced at One half the longitudinal spacing between points from the boundaries of the Calculation field.

The spacing of the points in the longitudinal and transverse directions shall be Determined as follows:

a) In the longitudinal direction D = S/N

Where D is the spacing between Points in the longitudinal direction, in meters;

S is the spacing between luminaires in the same row, in metres;

N is the number of calculation points in the longitudinal direction with the Following values: for $S < 30$ m, N = 10; for $S > 30$ m, the smallest integer Giving $D \leq 3$ m. The first transverse row of calculation points is spaced at a distance D/2 beyond the first luminaire (remote from the observer).

b) In the transverse direction The spacing (d) in the transverse direction is determined from the formula:

$$D = W_L/3$$

Where d is the spacing between points in the transverse direction, in meters; W_L is the width of the lane, in meters. The outermost calculation points are spaced d/2 from the edges of the lane.

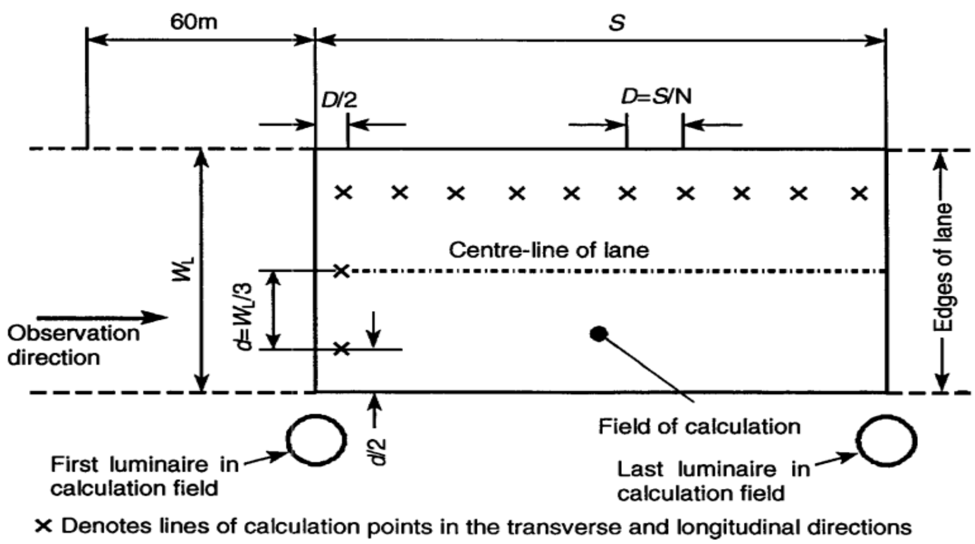


Fig6.4: Position of Calculation Points

Nine Point Method -

For Practical onsite measurement, the nine point method is most acceptable. The fig illustrates the layout of a point measuring grid and used to determine the average Illuminance level on a road stretch for a new installation.

Measuring Grid –

Whatever may be the type of measurement to be made, a decision must be made concerning the number and positions of the measuring Points, in other words the measuring grid must be defined. A few spot checks are made to see that the measured values are in accordance with those specified in the lighting simulation design.

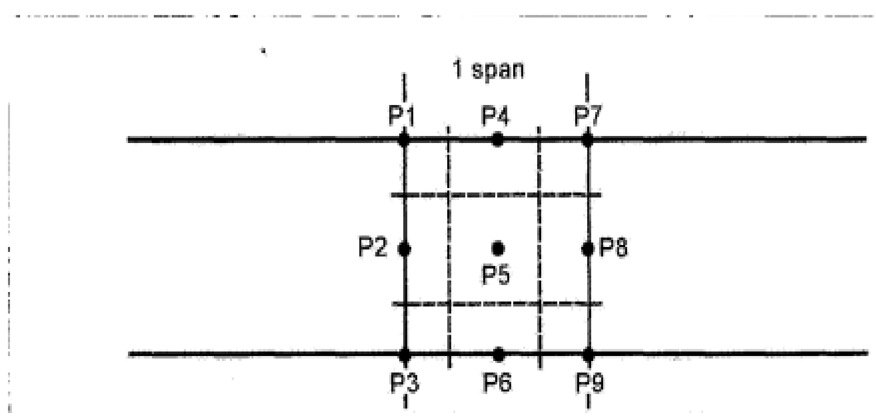


Fig 6.5: 9 Point Measuring Grid

CHAPTER7

CASE STUDY FOR DIFFERENT GRADE SEPARATED STRUCTURES

The objective of this chapter is to guide for designing and maintaining illumination standards followed by the National Highway Authority. In recent years, there has been an increased interest in sustainability and energy reduction in the transportation sector. Whether driven by cost reduction targets or environmental concerns, a large shift towards sustainable design and operation is being adopted. Amid this rapid growth, lighting is one the key element that can support your goals for cost reduction, operational efficiency, safety, and sustainability, while at the same time delivering a memorable brand experience.

There are different sections in a highway. These sections are classified as Main carriageway, service or slip road, flyover, major bridge, major junction, toll plaza, bus lay bye, truck lay bye, tunnel and vehicular underpass etc. Different sections of a highway requires different types of lighting arrangement. This project requires lighting design a part of National Highway **NH–17 (New NH No – 66)**; this project necessitates the construction of lighting for National Highway NH-17 (New NH No - 66). it starts from Panvel & terminates at Cape Comorin. The project involves the upgradation of a 39.6 Km Veer (Wadpale) To Bhogaon Khurd section NH–17 from km 108/400 to Km 148/0. In this span the highway has main carriageway, service road, flyover, major bridge, major junction, Rest area, bus lay bye, truck lay bye, toll plaza and vehicular underpass.

Major Junction

A junction, when discussed in the context of transport, is a location where traffic can change between different routes, directions, or sometimes modes, of travel. Major junction connects highway with another roadway. The complexity of traffic volume in a 4–legged/3-legged major junction is quite critical. Lighting design for these areas is very crucial for the importance of its purpose. Before setting out for designing these areas some studies need to be conducted and some practical consideration are to be addressed. At interchanges, roads pass above or below each other, using grade separation and slip roads. The terms motorway junction and highway junction typically refer to this layout.

Design Aim:

To provide uniform illumination over the junction area and on the street level. The designed illumination level & uniformity must meet the required value. The lighting installations must provide visual comfort and it should not create much glare. Mainly the installations must be economically viable.

- Required illuminance level : Minimum 40 Lux
- Overall uniformity : ≥ 0.40
- Overall min./max. ratio : ≥ 0.33

Layout & description of major junctions:

Considering one of the Major Junctions of NH–66 for better understanding of lighting design, analyzing software AGi32 has been used for describing the area and achieving the recommended values as per NHAI standard. Typical plan layout of chainage 125+170 of "Y-Type" or 4legged major junction of NH - 66 as illustrated in figure 7.1 below –

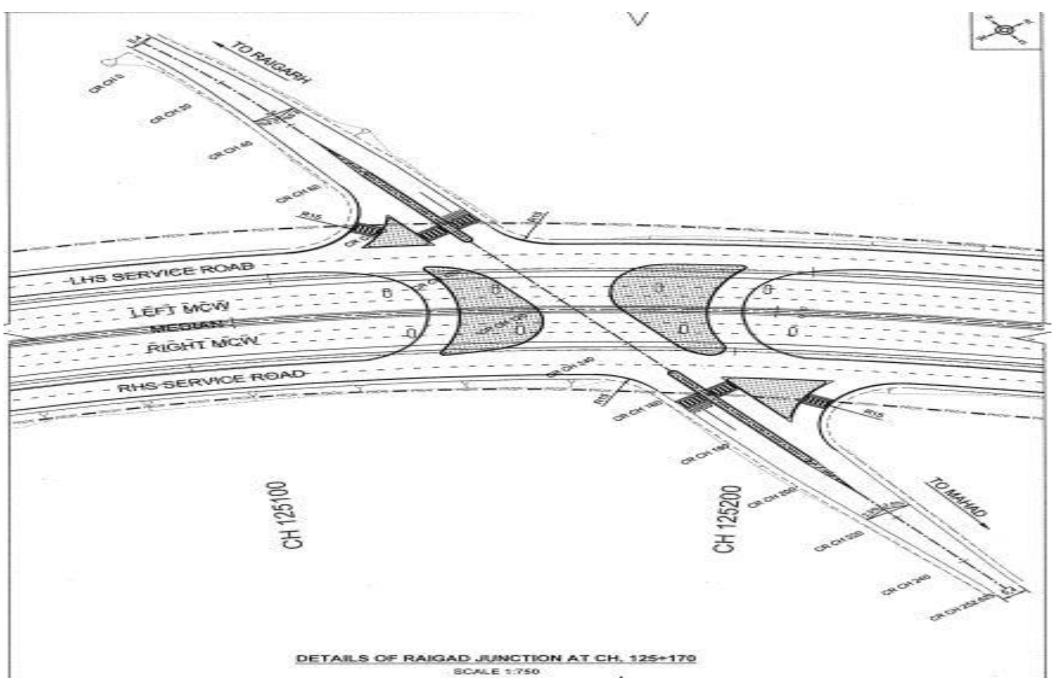


Fig 7.1: Plan layout of Y-Type Major junction

Simulation of Major junction as shown in figure 7.2 is mainly based on positioning calculation surfaces over the roads of Highway. To illuminate this area two high masts are considered on grass island & design has been done using floodlight arrangement (medium beam & narrow beam) having symmetric distribution. The Lux levels and uniformity achieved in this area must meet the value recommended by IRC Standard

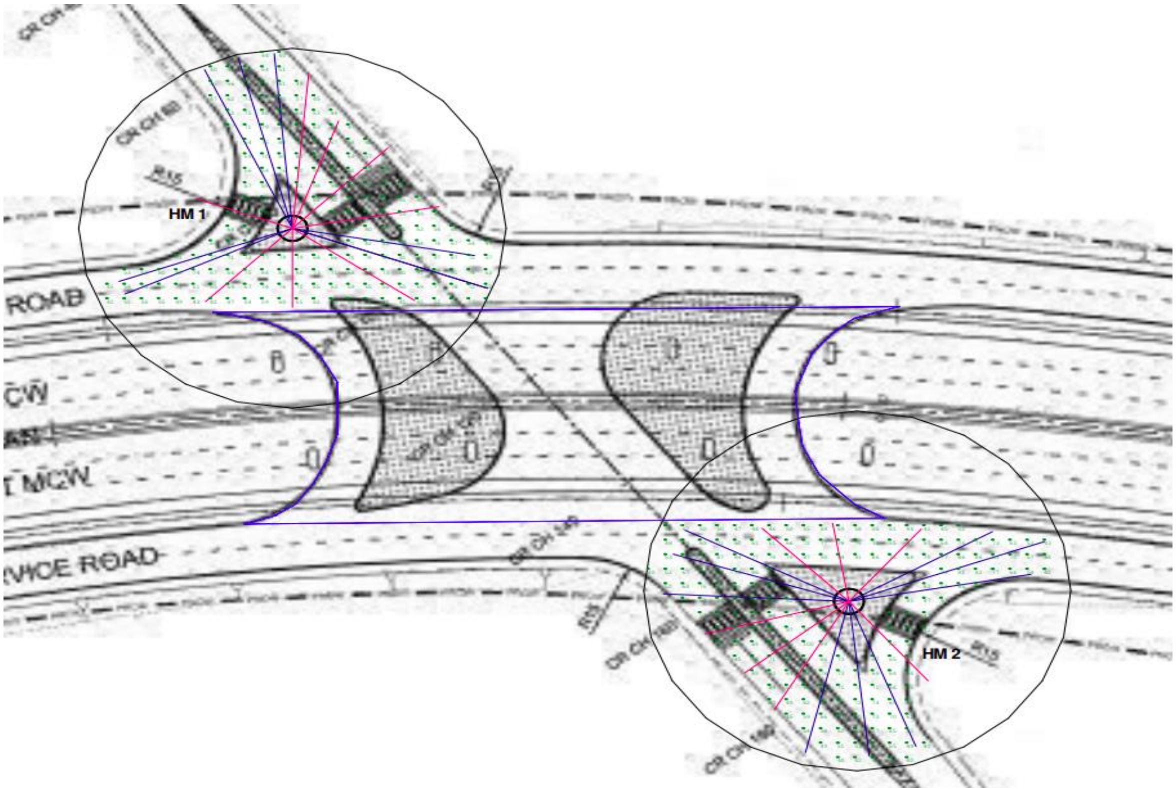


Fig 7.2: Simulated layout of the design

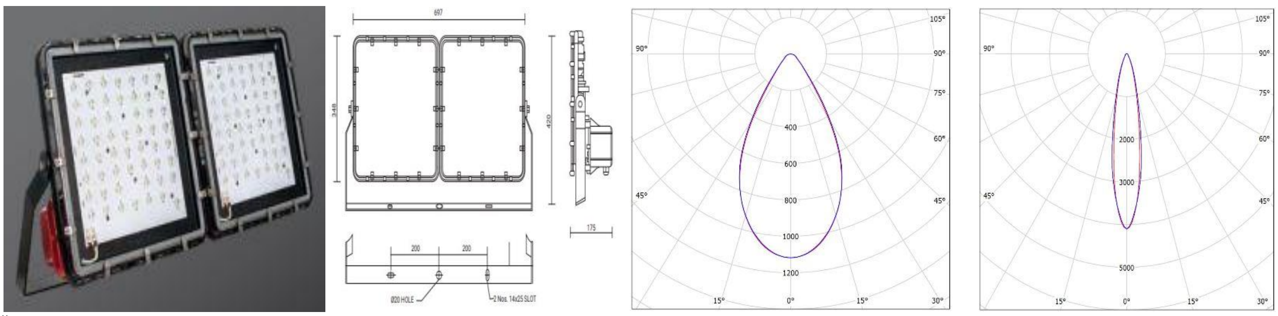
Design Considerations for the lighting implementation

- Number of high mast : 2
- Mast height : 25 from Ground level
- Maintenance factor : 0.85
- Maintained Illuminance zone: 120mtr. diameter area of trafficdirection for the LHS & RHS Major Junction

Luminaire used

- Rectangular PDC Aluminum housing LED floodlight (as shown infigure)
- Luminous flux : 62500 Lumen

- Luminaires/HighMast : 16 Nos.
- Wattage : 500 Watt
- System efficacy : 125 lm/W
- Beam angle and photometry type : 60 & 10 degree [NEMA TYPE – 4 &1]
- CCT : 5700K
- CRI : 80
- IP 66 protected



(a) (b) (c) (d)

Fig 7.3: (a) Floodlight image (b) floodlight dimension (c) 60 deg (d) 10 deg Polar Curve

7.1Table of Result overview of Y type MJ

Photometric results	**Average Illuminance (E_{avg}) [Lux]**	**Minimum Illuminance (E_{min}) [Lux]**	**Maximum Illuminance (E_{max}) [Lux]**	**Overall Uniformity (E_{min}/ E_{avg})**	**Overall Min/max (E_{min}/ E_{max})**
Recommended Value as per standard	**N/A**	**40**	**N/A**	≥ 0.40	≥ 0.33
Achieved Result (MJ@LHS)	**66.68**	**40**	**98**	**0.60**	**0.41**
Achieved Result (MJ@RHS)	**65.12**	**40**	**100**	**0.61**	**0.40**

Design Aim:

To provide uniform illumination over the junction area and on the street level. The designed illumination level & uniformity must meet the required value. The lighting installations must provide visual comfort and it should not create much glare. Mainly the installations must be economically viable.

- Required illuminance level : Minimum 40 Lux
- Overall uniformity : ≥ 0.40
- Overall min. /max. ratio : ≥ 0.33

Layout & description of major junctions:

Considering one of the 3-legged junctions of NH–66 for better understanding of lighting design, analyzing software AGi32 has been used for describing the area and achieving the recommended values as per NHAI standard. Typical plan layout of chainage 130+590 of "T-Type" major junction of NH-66 as illustrated in figure 7.4 below –

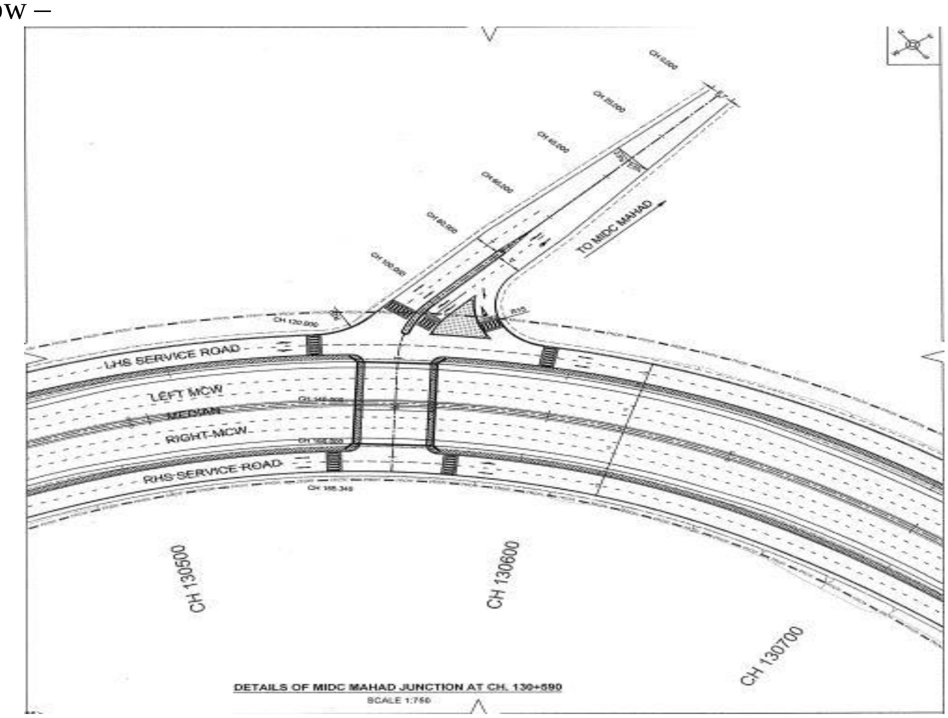


Fig 7.4: Plan layout of 3 legged T-Type Major junction

Simulation of Major junction as shown in figure 7.5 is mainly based on positioning calculation surfaces over the roads of Highway. To illuminate this area only one highmast is considered in grass island & design has been done using floodlight arrangement (medium and narrow beam; *NEMA TYPE-4 & TYPE 1*) having symmetric distribution. The Lux levels and Uniformity achieved in this area must meet the value recommended by IRC Standard.

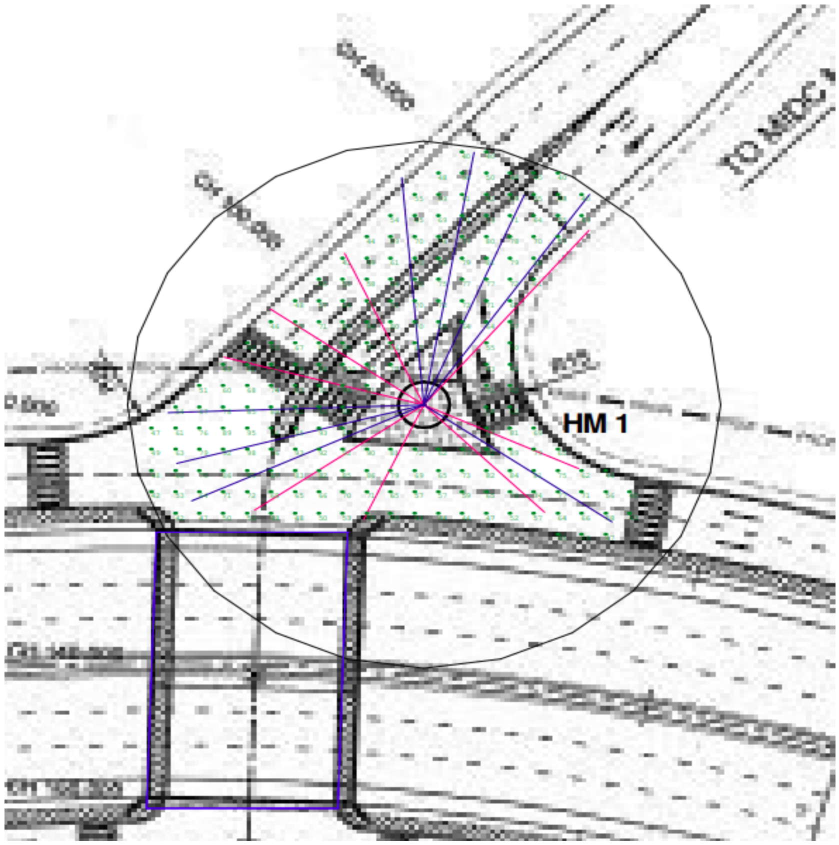


Fig 7.5: Simulated layout of the design

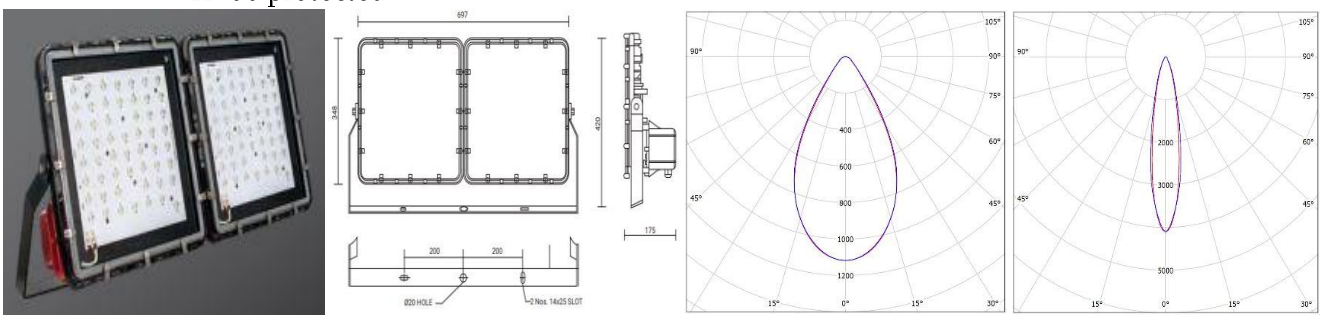
Design Considerations for the lighting implementation

- Number of high mast : 1
- Mast height : 25 from Ground level
- Maintenance factor : 0.85
- Maintained Illuminance zone:-120mtr. diameter area of boxjunction

Luminaire used

- Rectangular PDC Aluminum housing LED floodlight (as shown infigure 7.6)
- Luminous flux : 62500 Lumen
- Luminaires/HighMast : 16 Nos.

- Wattage : 500 Watt
- System efficacy : 125 lm/W
- Beam angle and photometry type : 60 degree and 10 degree [NEMATYPE–4 and TYPE–1]
- CCT : 5700K
- CRI : 80
- IP 66 protected



(a) (b) (c) (d)

Fig 7.6: (a) Floodlight image (b) floodlight dimension (c) 60 degree (d) 10 degree Polar curve

7.2 Table of Result overview of T type MJ

Photometric results	Average Illuminance (E_{avg}) [Lux]	Minimum Illuminance (E_{min}) [Lux]	Maximum Illuminance (E_{max}) [Lux]	Overall Uniformity (E_{min}/E_{avg})	Overall Min/max (E_{min}/E_{max})
Recommended Value as per standard	**N/A**	**40**	**N/A**	≥ 0.40	≥ 0.33
Achieved result	**66.63**	**40**	**100**	**0.60**	**0.40**

Toll Plaza

Toll Plazas consist of distinct driving areas: *Approach/Departure Roads/Zones, Queuing/Areas* and *Toll Collection Islands* as shown in figure 7.7. The approach and departure road is the first area where the driver experiences when entering a toll plaza facility. The approach and departure zones and the queuing area are the most critical areas for drivers due to the lighting level changes to the toll collection booth due to driver familiarity, congestion and potential pedestrians. The toll collection canopy provides the means to provide luminaires to provide the necessary illuminance for the collection areas roadway surface.

The extent of lighting at toll plazas shall cover the following areas:

a) Approach, Queue, Recovery and Departure Zones

b) Toll Island Canopies

c) Toll Booths.

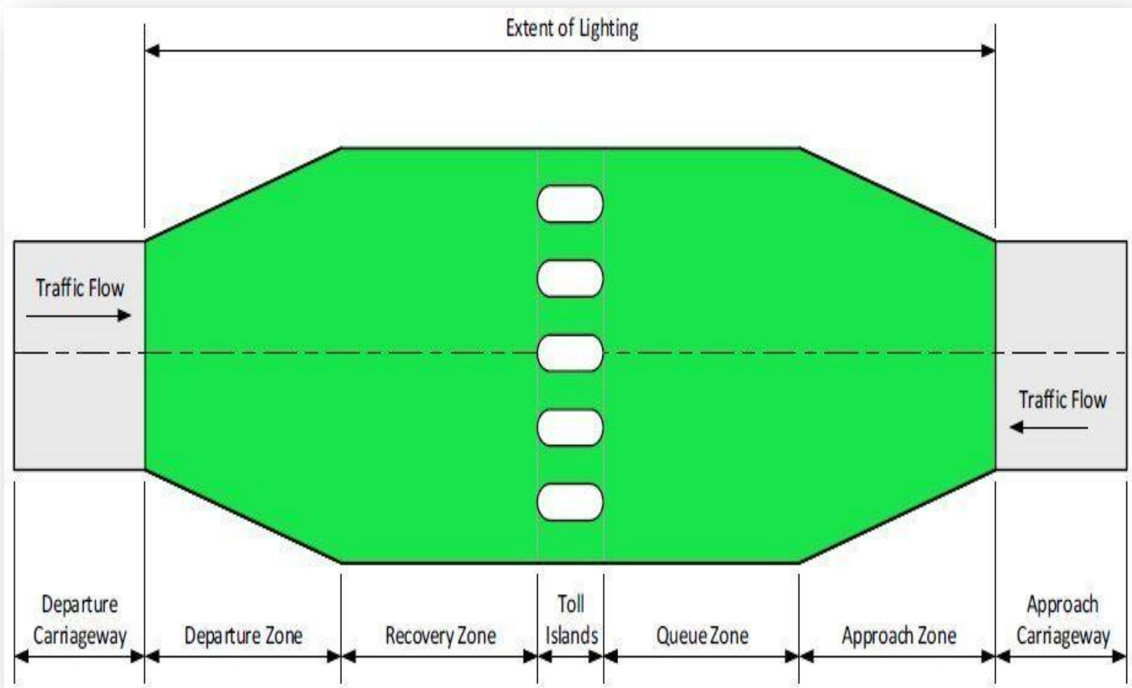


Fig7.7: Different zones (green) of toll plaza required to be lit

Design Aim:

To provide uniform illumination over the entire toll plaza and on the approach road to the each toll lane. The designed illumination level & uniformity must meet the required value. The lighting installations must provide visual comfort and it should not create much glare. Mainly the installations must be economically viable.

- Required illuminance level 1 : Minimum 40 Lux (*For Toll plaza& approach road*)
- Required illuminance level 2 : Average 100 Lux (*For Toll canopyzone*)
- Overall uniformity : ≥ 0.40
- Overall min./max. ratio : ≥ 0.25 (For toll plaza)

  : ≥ 0.33 (For Approach road)

Layout & description of Toll plaza:

All lighting luminaires proposed shall be full cut off LED luminaires. Due to the width of the highway and toll plaza as illustrated in figure 7.8 shown below, the 30 meter mounting height mast provides excellent uniformity throughout the tolling facility. All octagonal poles on the edge of the approach road will be equipped with house-side light shields to control light trespass. "Under canopy" luminaires are provided for maintaining Illuminance level at the queuing zone of the toll lane.

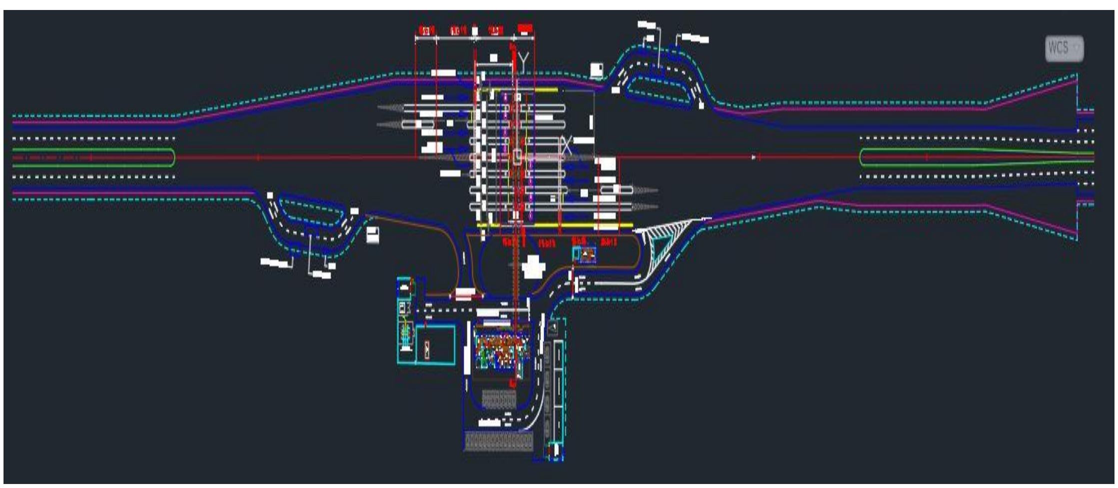


Fig 7.8: Plan layout of 8 lane toll plaza with approach road and weigh bridge

For lighting arrangement of toll canopy the detailed cross sectional layout of the toll plaza is also required to mount the canopy luminaire to illuminate the toll lanes.

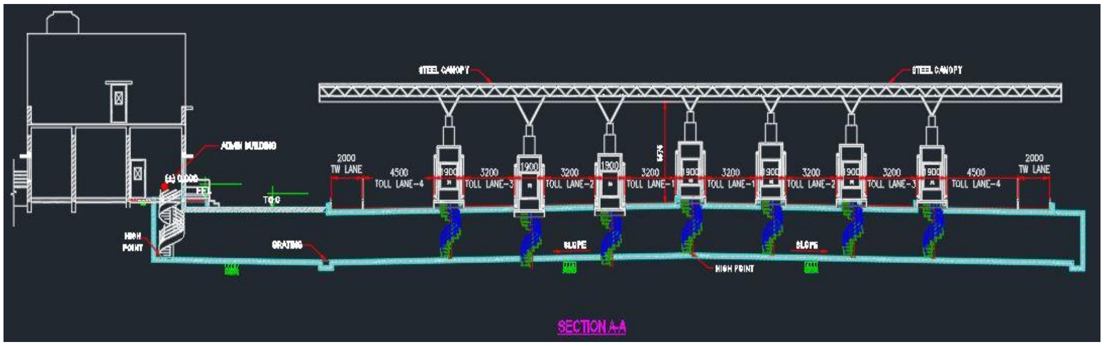


Fig 7.9: Elevation view of the toll canopy with toll booths

Simulation of the toll plaza located at CH: 135+750 is mainly based on positioning different lighting arrangement in different zones as shown infigure 7.10. To illuminate both left hand side & right hand side of the entire toll plaza area four 30m high masts are considered as per recommended standard. To achieve the light level in approach road on either side opposite arrangement street light poles are proposed maintaining proper spacing to attain good uniformity. For each toll lane containing the toll booths under canopy luminaires are mounted in each lane to obtain the desired illuminance level such that transitioning of traffic through the queuing zone becomes smooth.

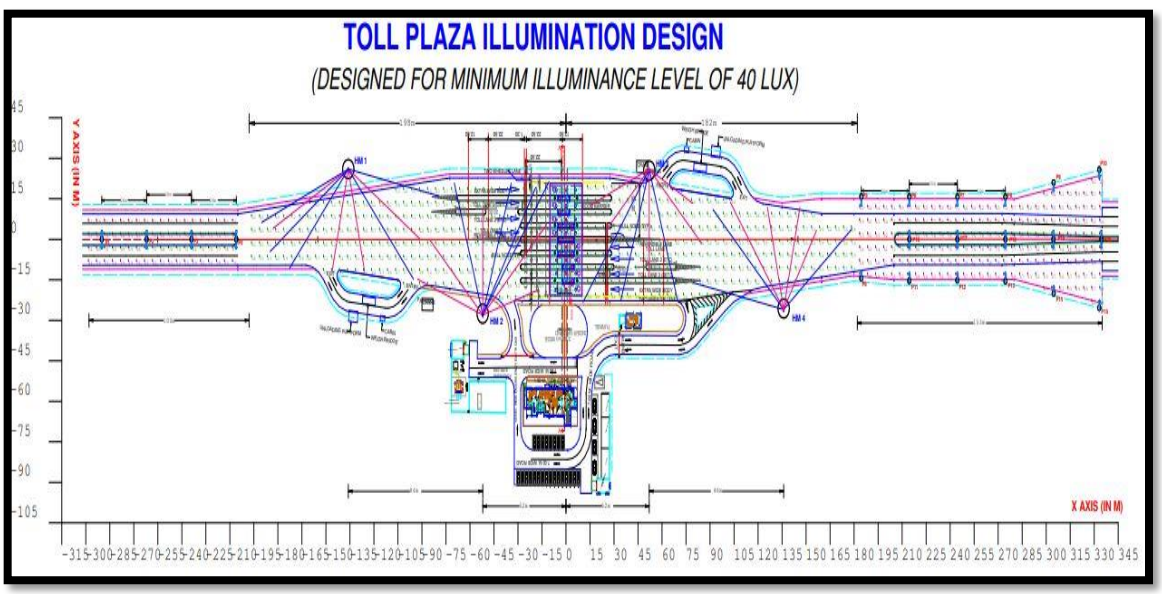
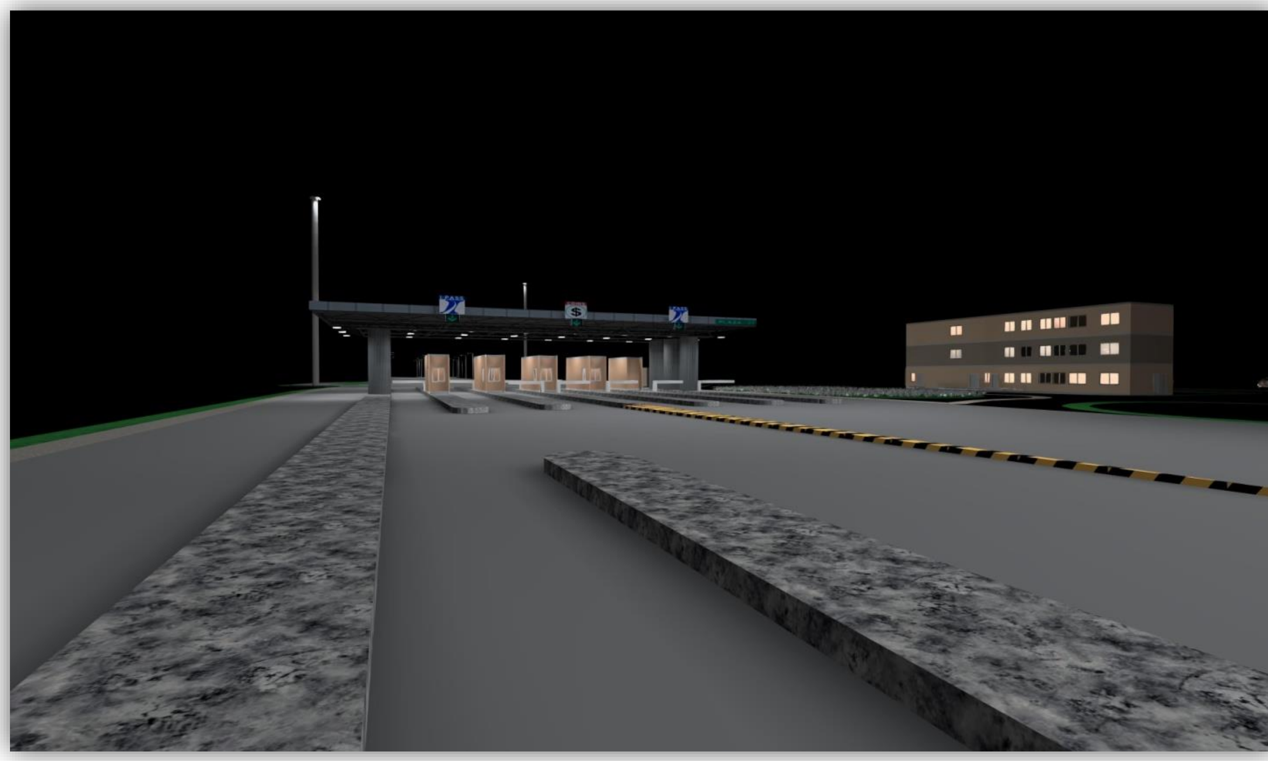
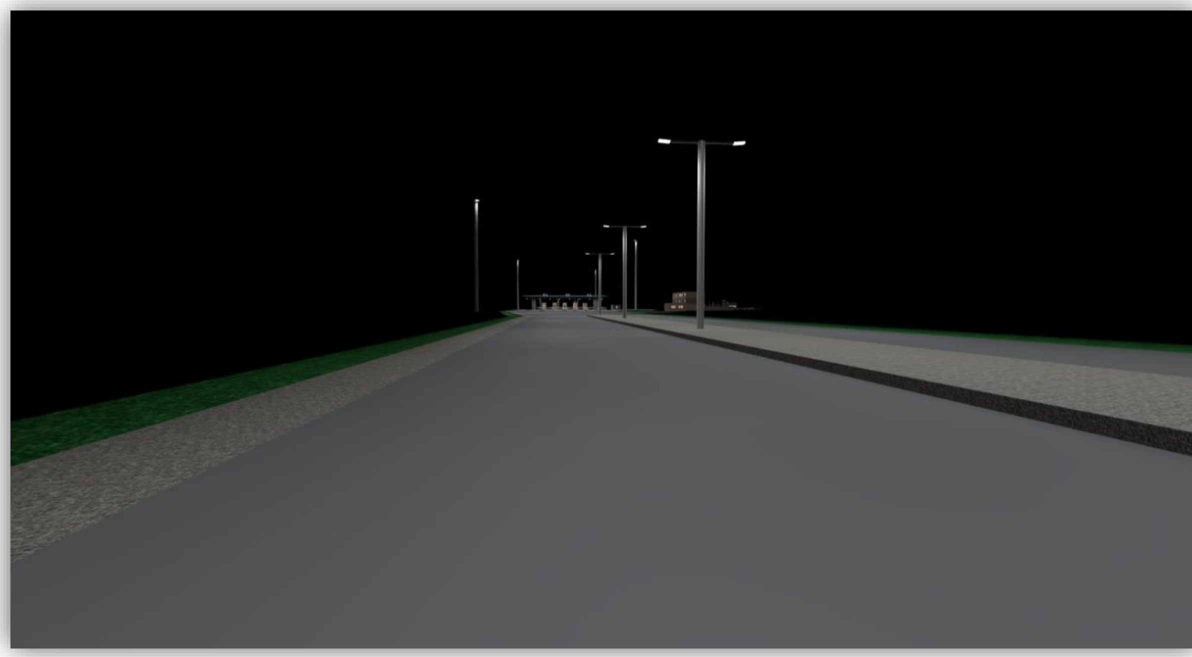


Fig 7.10: Simulated layout of the design



(a)

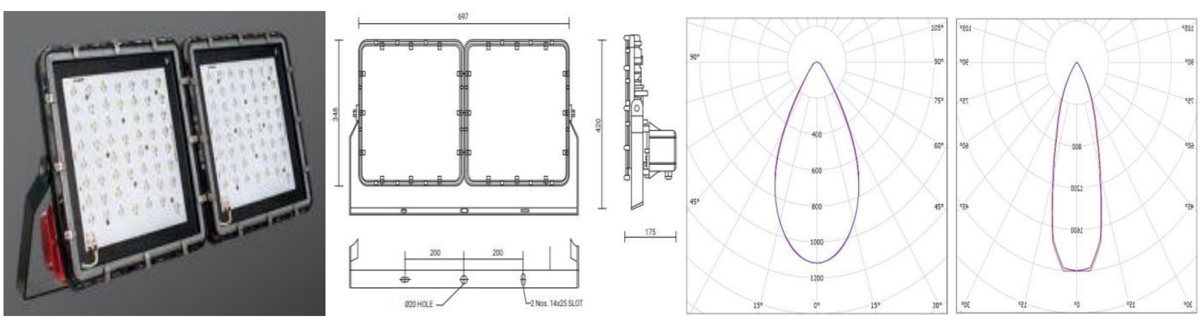


(b)

Fig 7.11: (a) & (b) 3D Render View of Toll Plaza

Design Considerations for the lighting implementation

- Number of High Mast : 4
- Mast height : 30 from Ground level
- Maintenance factor : 0.85
- Maintained Illuminance zone: 200mtr. (Approx) longitudinal at either side of toll plaza
  Luminaire Used
- Rectangular shaped PDC Aluminum housing LED floodlight (as shown infigure 36)
- Luminous flux : 62500 Lumen
- Luminaires/Highmast : 9 Nos. for LHS of Toll Plaza
- Luminaires/Highmast : 8 & 7 Nos. for RHS of Toll Plaza
- Wattage : 500 Watt
- System efficacy : 125 lm/W
- Beam angle and photometry type : 60 degree & 30 degree
  [NEMA TYPE – 4 & 3]
- CCT : 5700K
- CRI : 80
- IP 66 protected



(a) (b) (c) (d)

Fig 7.12: (a) Floodlight image (b) floodlight dimension (c) 60 degree (d) 30 degree Polar curve

FOR TOLL PLAZA APPROACH ROAD

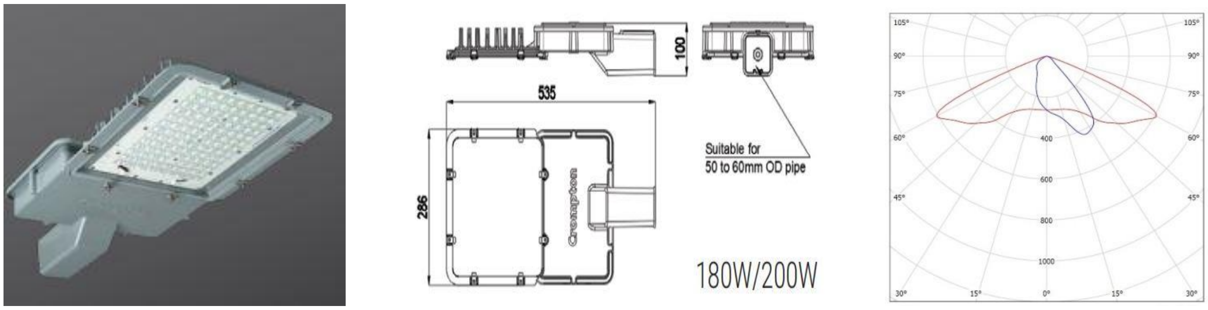
The traffic capacity in access and departure zone of a toll lane is quite dense. Hence sufficient illumination should be provided so as to maintain smooth visual guidance. Furthermore uniform lighting distribution in approach road toward toll plaza guarantees good visual transient adaptability. In order to achieve that octagonal poles with proper spacing as per dictated by the highway lighting standard are proposed in either side of toll plaza.

Design Considerations for the lighting implementation

- Pole Arrangement : Opposite sided and Central verge
  (Double Pole arm on median)
- Mounting height : 9 m from road level
- Spacing between poles : 30m on RHS & 28m on LHS
- Maintained Illuminance zone: 250mtr. (Approx) longitudinally at either side [LHS and RHS] of toll plaza

Luminiare Used

- Aerodynamically designed PDC Aluminum housing LEDstreetlight (as shown in figure 37)
- Luminous flux : 22500 Lumen
- No. of Luminaires used : 8 nos. for LHS of approach road
- No. of Luminaires used : 22 nos. for RHS of approach road
- Wattage : 180 Watt
- System efficacy : 125 lm/W
- Throw : Short
- Control : Tight control [SLI > 4]
- Photometry type : Cut-off
- CCT : 5700K
- CRI : 80
- IP 66 protected



(a) (b) (c)

Fig 7.13: (a) Street light image (b) Street light dimension (c) Polar curve

FOR TOLL CANOPY ISLAND

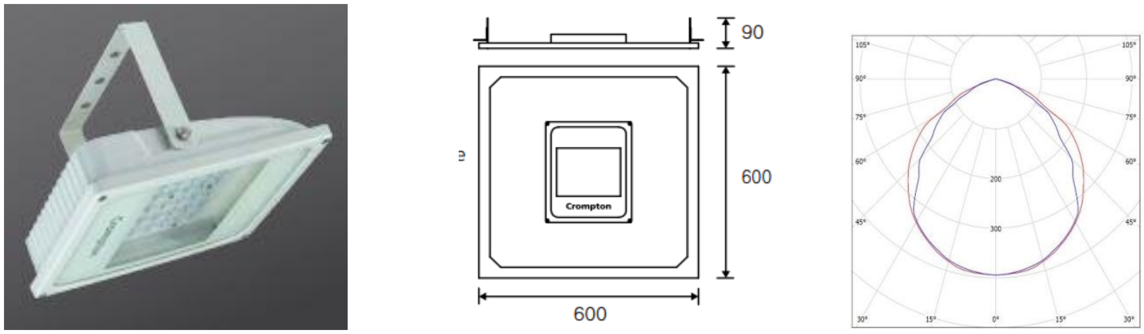
In toll canopy area tolling taxes are collected in toll booths. To ensure safe and hazardless traffic transition in toll islands proper “undercanopy”luminaires are to be mounted such that sufficient light level is maintained in each toll lane so that motorist’s visual performance and visual comfort is satisfied. Moreover, by providing optimized canopy illumination its make the job easier for the motorist to judge their course of driving and also to detectany sudden pedestrian movement accurately.

Design Considerations for the lighting implementation

- Luminaire Arrangement : Under Canopy surface mounted
- Mounting height : 6 m from road level
- Position of luminaires : Mounted at every toll lane to maintain required level

Luminaire Used

- PDC Aluminum housing LED under canopy (No Lens)luminaire (as shown in figure 38)
- Luminous flux : 8800 Lumen
- Number of Luminaire used : 24 nos.
- Wattage : 80 Watt
- System efficacy : 110 lm/W
- Beam angle : 120 degree
- CCT : 5700K
- CRI : 80
- IP 66 protected



(a) (b) (c)

Fig 7.14: (a) under canopy fixture image (b) luminaire dimension (c) Polar curve

7.3 Table of Result overview

FOR TOLL PLAZA

Photometric results	Average Illuminance(E_{avg}) [Lux]	Minimum Illuminance (E_{min}) [Lux]	Maximum Illuminance (E_{max}) [Lux]	Overall Uniformity (E_{min}/ E_{avg})	Overall Min/max (E_{min}/ E_{max})
Recommended Value as per standard	**N/A**	**40**	**N/A**	≥ 0.40	≥ 0.33
Achieved Result (LHS of Toll Plaza)	**62.55**	**40**	**102**	**0.64**	**0.39**
Achieved Result (RHS of Toll Plaza)	**61.56**	**40**	**95**	**0.65**	**0.42**

7.4 Table of Result overview

FOR APPROACH ROAD

Photometric results	Average Illuminance (E_{avg}) [Lux]	Minimum Illuminance (E_{min}) [Lux]	Maximum Illuminance (E_{max}) [Lux]	Overall Uniformity (E_{min}/ E_{avg})	Overall Min/max (E_{min}/ E_{max})
Recommended Value as per standard	**N/A**	**40**	**N/A**	≥ 0.40	≥ 0.33
Achieved Result (Approach Road of TP LHS)	**64.74**	**43**	**87**	**0.66**	**0.49**
Achieved Result (Approach Road of TP RHS)	**65.17**	**40**	**90**	**0.61**	**0.44**

7.5 Table of Result overview

FOR TOLL CANOPY

Photometric results	Average Illuminance (E_{avg}) [Lux]	Minimum Illuminance (E_{min}) [Lux]	Maximum Illuminance (E_{max}) [Lux]	Overall Uniformity (E_{min}/ E_{avg})	Overall Min/max (E_{min}/ E_{max})
Recommended Value as per standard	**150**	**N/A**	**N/A**	≥ 0.40	≥ 0.33
Achieved result	**152.29**	**88**	**211**	**0.58**	**0.42**

Fly-over / Typical Cross Section V-B

Flyover is a high-level overpass, built above main highway project, what had been an at-grade intersection. It is a structure which joints two or more points which are separated by an accessible route/s or a man made structure to cut the traffic for faster mode of travelling.

Junctions create a conflict between different streams of traffic and require special treatment. Flyovers help to streamline the traffic control system by helping to reduce traffic congestion. Reduced horizontal curvature reduces risk of off-road crashes. The impact of the flyover construction to curb traffic congestion problem has been reflected in terms of traffic decongestion, time saving and fuel saving.

Design Aim:

To provide uniform illumination over the flyover road surface and on the at grade service road level. The designed illumination level & uniformity must meet the required value. The lighting installations must provide visual comfort and it should not create much glare. Mainly the installations must be economically viable.

- Required illuminance level : Minimum 40 Lux
- Overall uniformity : ≥ 0.40
- Overall min./max. ratio : ≥ 0.33

Layout & street profile of flyover:

Considering one of the Major flyovers as illustrated in figure 7.5 of NH– 66 for better understanding of lighting design, analyzing software DIALux & AGi32 has been used for describing the area and achieving the recommended values as per NHAI standard. The street profile of flyover chainage 125+170 of is mentioned as follows –

- Flyover crash barrier : (*width : 0.5m, height : 1m*)
- Paved shoulder [LEFT] : (*width : 2m ; tarmac : R3,* q_0 *– 0.07*)
- Main carriageway [LEFT] : (*width : 10.5m ; no. of lanes: 3 ; tarmac : R3,* q_0 *– 0.07*)
- Median : (*width : 0.6 m ; Height : 0.0m*)
- Main carriageway [RIGHT] : (*width : 10.5m ; no. of lanes: 3 ; tarmac : R3,*q_0 *– 0.07*)
- Paved shoulder [RIGHT] : (*width : 2m ; tarmac : R3,* q_0 *– 0.07*)
- Flyover crash barrier : (*width : 0.5m, height : 1m*)
- Slip road : (*width : 7m ; no. of lanes: 2 ; tarmac : R3,* q_0 *– 0.07*)

Design is proposed for **Road type R3** with an **Average luminance factor of road surface q_0 = 0.07**

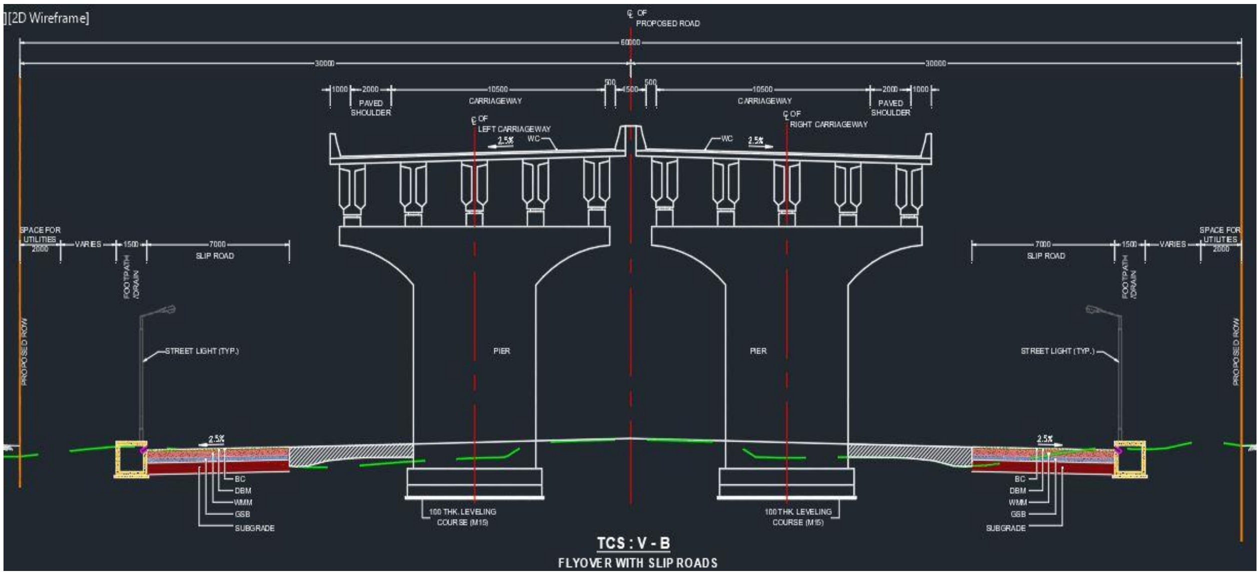
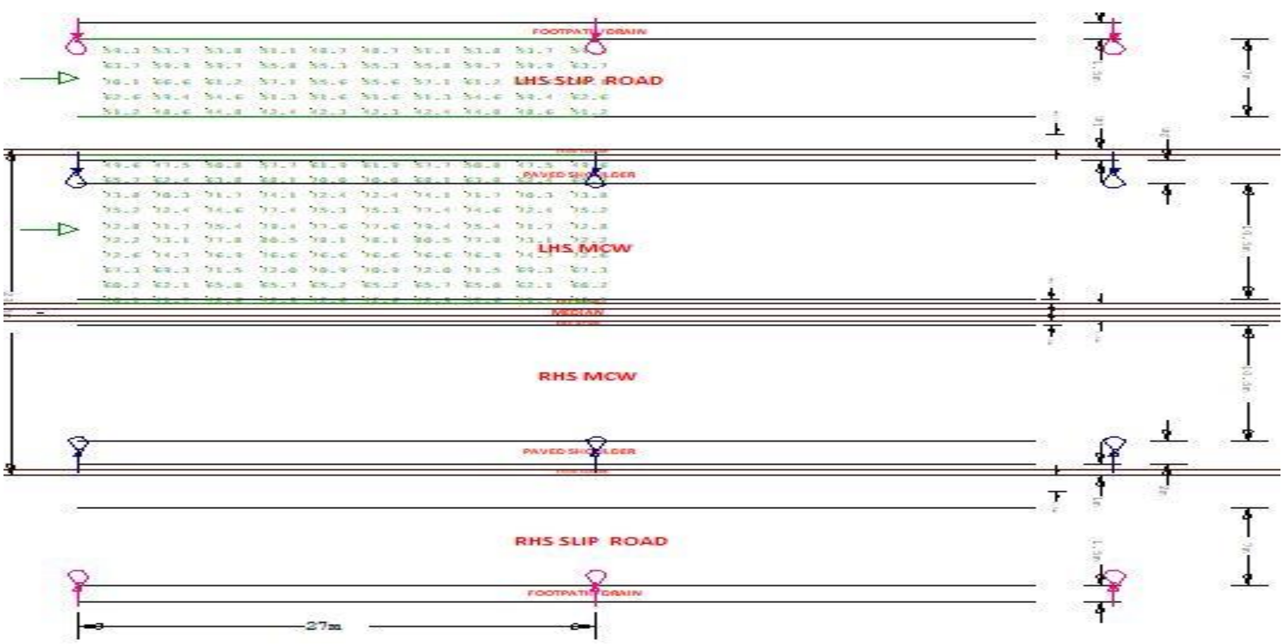
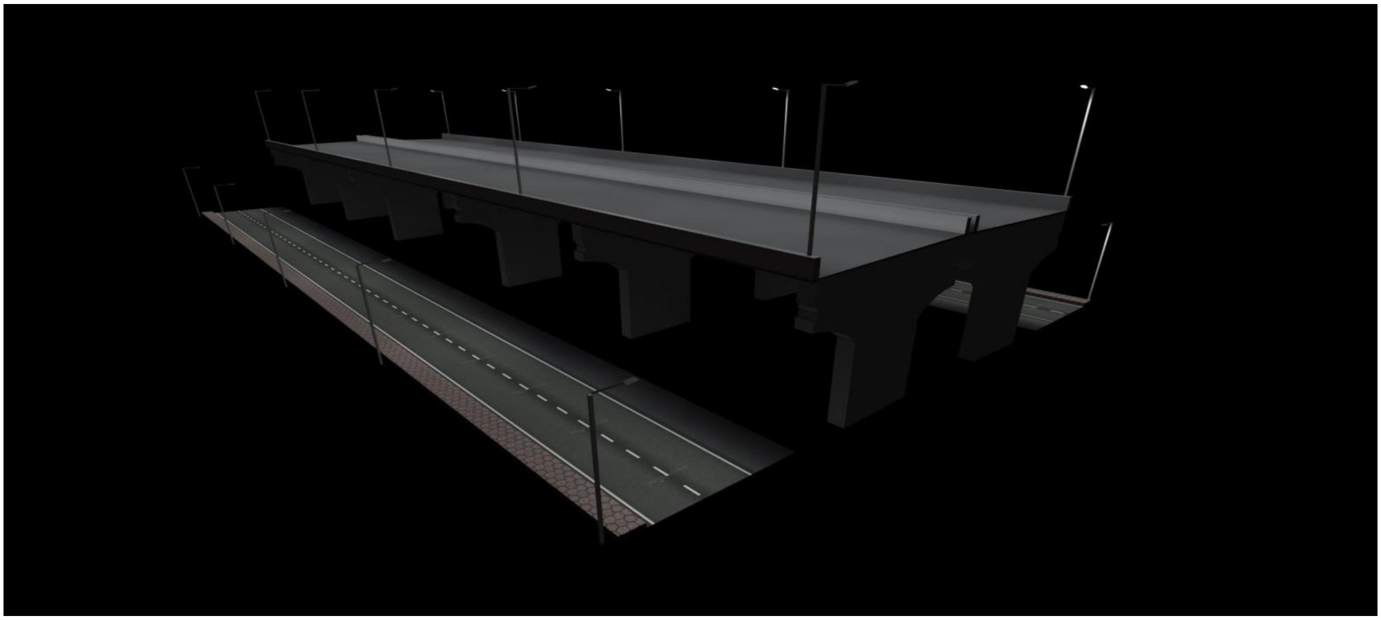


Fig 7.15: Street profile representation of flyover

Simulation of flyover illumination design is mainly based on positioning calculation field [*BSEN 13201-3 2015*] over the elevated flyover road surface& at grade slip road surface. To illuminate the area generally single pole dual arm street light poles with opposite pole layout arrangement is considered from the flyover crash barrier. By commissioning single pole dual arm layout the aspect of design becomes much more optimized as no additional poles are proposed to illuminate the service road, which results in economically feasible approach, But in this case as the width of the variable area adjacent to flyover is not known so separate poles are considered to illuminate each area.The Lux levels and uniformity achieved in this area must meet the value recommended by *IRC Standard.*



(a)



(b)

Fig 7.16: Simulated layout of the design (a) Simulated Layout of Design (b) 3D rendering of the flyover

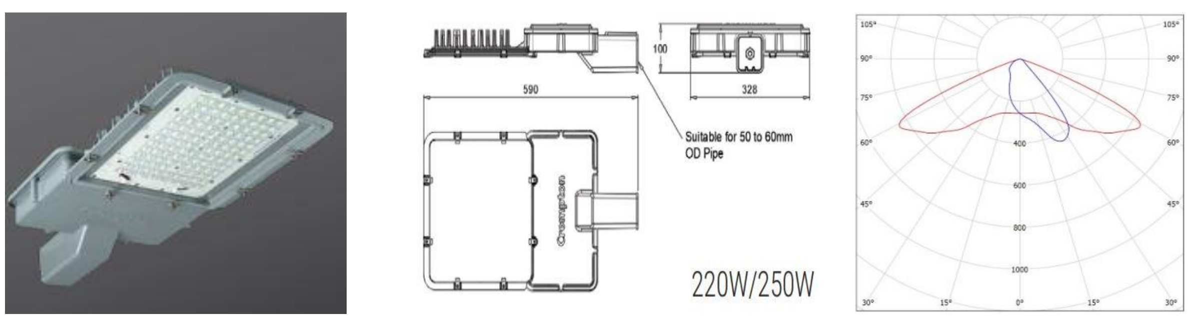
Design Considerations for the lighting implementation

- Pole Arrangement : Opposite sided For Flyover & Single sided for Slip road (as illustrated infigure 40)
- Mounting height : 9 m from the top of Crash barrier over Flyover & 9m from ground level for Slip road
- Spacing between poles : 27m
- Maintenance factor : 0.85

The Light loss factor [LLF or MF] is a depreciation factor based on how the light output of a fixture decreases with time. All photometric calculations for illumination design should use the LLF that corresponds to the luminaire used. For LED the LLF is based on how well the luminaire dissipates heat and on how well the luminaire and the optics are well encapsulated. An LED luminaire that dissipates heat well will have lamp lumen depreciation slower, and will have a higher LLF than a luminaire that does not dissipate heat well.

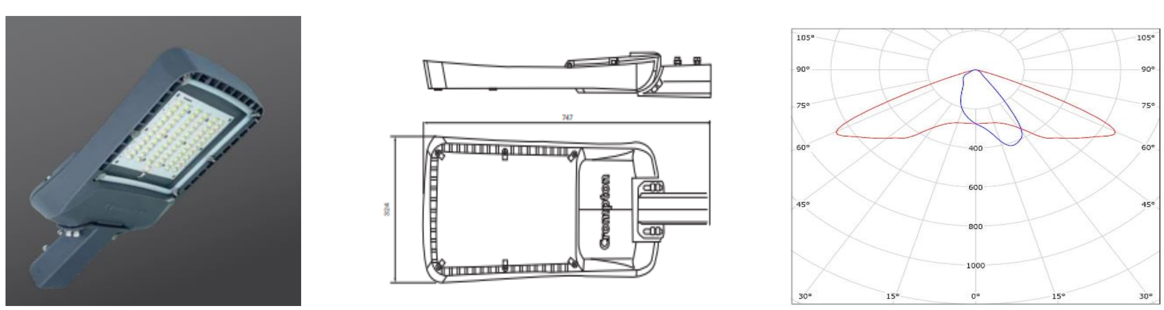
Luminaire used

- Aerodynamically designed PDC Aluminum housing LED streetlight (as shown in figure 41)
- Luminous flux : 36250 Lumen (For Main Carriageway) & 18750 (For Slip Road)
- Wattage : 250 Watt (For Main Carriageway) & 150 Watt (For Slip Road)
- System efficacy : 145 lm/W (For MCW) & 125 lm/W (For Slip Road)
- Throw : Short
- Control : Tight control [SLI > 4]
- Photometry type : Cut-off
- CCT : 5700K
- CRI : 80
- IP 66 protected



(a) (b) (c)

Fig 7.17: (a) 250 W Street light image (b) Street light dimension (c) Polar curve



(a) (e) (f)

Fig 7.18: (d) 150 W Street light image (e) Street light dimension (f) Polar curve

7.6 Table of Result overview

FOR FLYOVER MAIN CARRIAGEWAY

Photometric results	Average Illuminance (E_{avg}) [Lux]	Minimum Illuminance (E_{min}) [Lux]	Maximum Illuminance (E_{max}) [Lux]	Overall Uniformity (E_{min}/ E_{avg})	Overall Min/max (E_{min}/ E_{max})
Recommended Value as per standard	**N/A**	**40**	**N/A**	$\geq \mathbf{0.40}$	$\geq \mathbf{0.33}$
Achieved result	**67**	**40**	**80.5**	**0.60**	**0.50**

7.7 Table of Result overview

FOR SERVICE ROAD

Photometric results	Average Illuminance (E_{avg}) [Lux]	Minimum Illuminance (E_{min}) [Lux]	Maximum Illuminance (E_{max}) [Lux]	Overall Uniformity (E_{min}/ E_{avg})	Overall Min/max (E_{min}/ E_{max})
Recommended Value as per standard	**N/A**	**40**	**N/A**	$\geq \mathbf{0.40}$	$\geq \mathbf{0.33}$
Achieved result	**55.2**	**42.3**	**80**	**0.77**	**0.60**

❖ Position of Calculation points in road surface [CIE 140 – 2000]

If ,“S” be the spacing between two luminaires (in meter) –

“D” be the logitudinal distance between two gird points (in meter) – “N” be the no. of calculation points in longitudinal direction chosen such that –

If, $S \leq 30m$; then $N = 10$

$S > 30m$; then N is the smallest integer that makes $D \leq 3m$

In transverse direction spacing (d) between grid points (in meter) –

$d = W_L/3$; W_L is the width of the lane (in meter)

Pole & Luminaire Quantity

The Length of the above discussed Typical Cross section as mentioned in project scope is 1100m. So as per simulation design 250 W & 150 W luminaires are used for the Elevated Flyover Carriageway & Slip Road for a span of 27m.

So Total number of pole,

= Total Length/Pole Spacing

= 1100/27

= 40.74 = 41 (Approx)

For above TCS Street light pole arrangement is Opposite Sided, so total Street Light Pole becomes,

= 41 * 2 = 82 Nos. for flyover Carriageway

Similarly Luminaire Quantity will be 82 Nos.

Same will be applicable for Service Road

Fly-over / Typical Cross Section V-A

Design Aim:

To provide uniform illumination over the flyover road surface and on the at grade service road level. The designed illumination level & uniformity must meet the required value. The lighting installations must providevisual comfort and it should not create much glare. Mainly the installations must be economically viable.

- Required illuminance level : Minimum 40 Lux
- Overall uniformity : $\geq$ 0.40
- Overall min./max. ratio : $\geq$ 0.33

Layout & street profile of flyover:

Considering one of the Major flyovers as illustrated in figure 7.19 of NH– 66 for better understanding of lighting design, analyzing software DIALux & AGi32 has been used for describing the area and achieving the recommended values as per NHAI standard. The street profile of flyover mentioned as follows –

- Flyover crash barrier : (*width : 0.5m, height : 1m*)
- Paved shoulder [LEFT] : (*width : 2m ; tarmac : R3, q_0 – 0.07*)
- Main carriageway [LEFT] : (*width : 10.5m ; no. of lanes: 3 ; tarmac : R3, q_0 – 0.07*)
- Median : (*width : 1.5 m ; Height : 0.0m*)
- Main carriageway [RIGHT] : (*width : 10.5m ; no. of lanes: 3 ; tarmac : R3,q_0 – 0.07*)
- Paved shoulder [RIGHT] : (*width : 2m ; tarmac : R3, q_0 – 0.07*)
- Flyover crash barrier : (*width : 0.5m, height : 1m*)
- Slip road : (*width : 7.5m ; no. of lanes: 2 ; tarmac : R3, q_0 – 0.07*)

Design is proposed for **Road type R3** with an **Average luminance factor of road surface q_0 = 0.07**

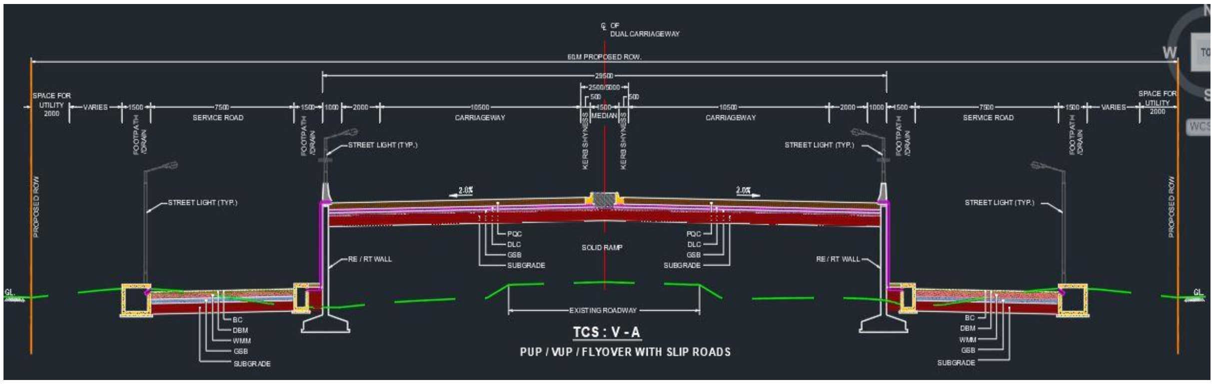
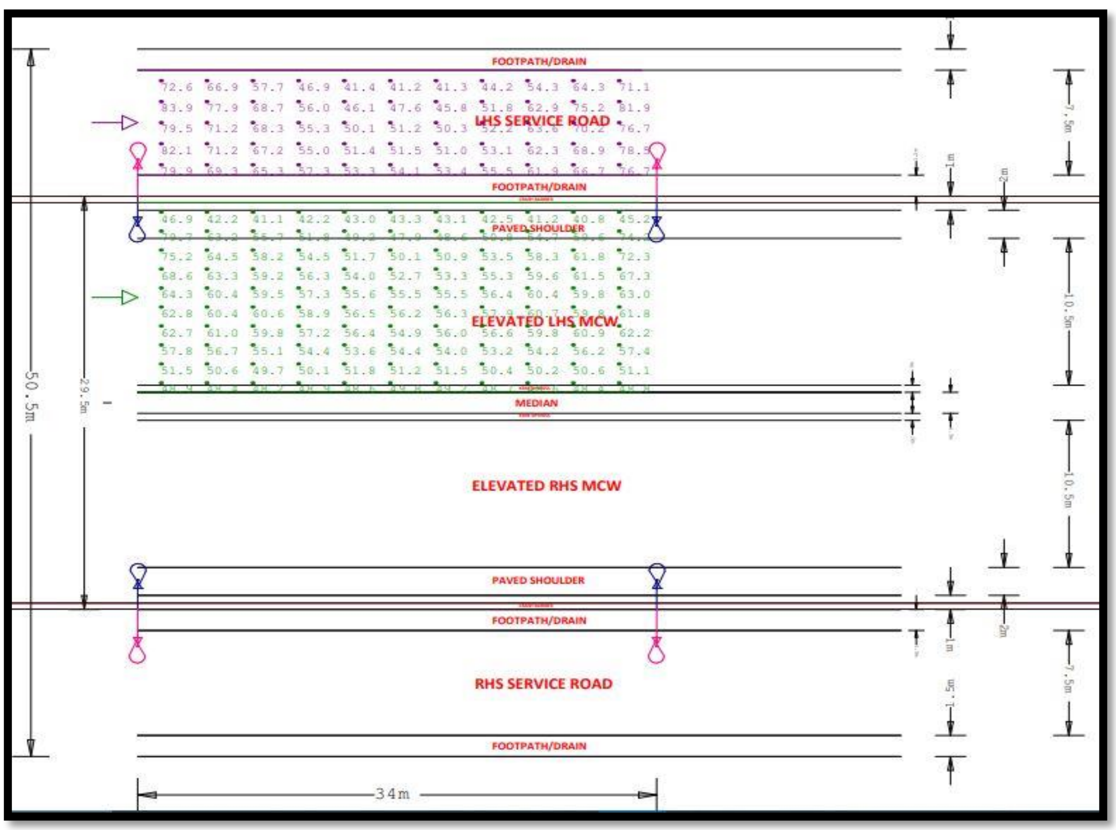
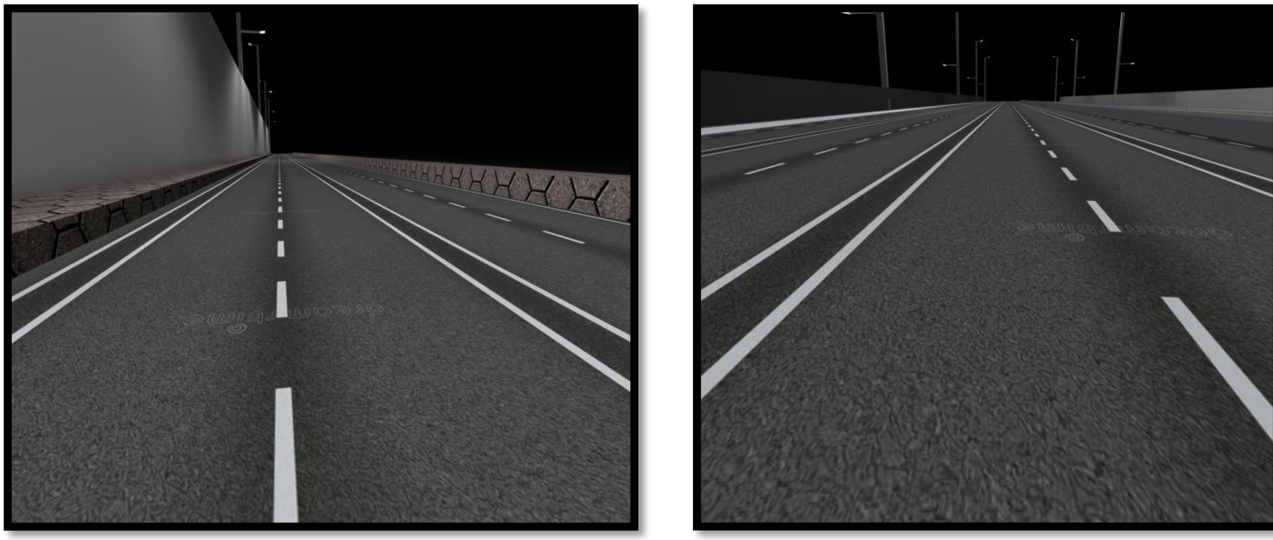


Fig 7.19: Street profile representation of flyover

Simulation of flyover illumination design is mainly based on positioning calculation field [*BSEN 13201-3 2015*] over the elevated flyover road surface& at grade service road surface. To illuminate the area generally single pole dual arm street light poles with opposite pole layout arrangement is consideredfrom the flyover crash barrier. By commissioning single pole dual arm layout the aspect of design becomes much more optimized as no additional poles are proposed to illuminate the service road, which results in economically feasible approach. The Lux levels and uniformity achieved in this area must meet the value recommended by *IRC Standard*



(a)



(b)

Fig 7.20: (a) Simulated Layout of Design (b) 3D rendering of the flyover

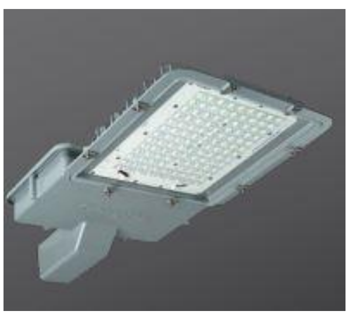
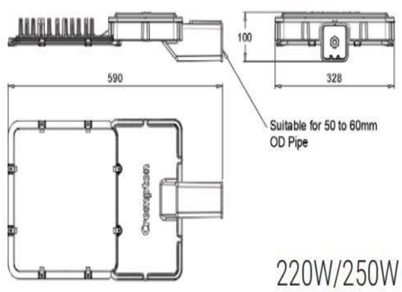
Design Considerations for the lighting implementation

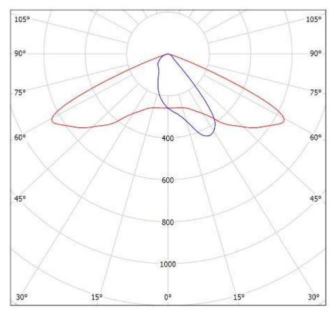
- Pole Arrangement : Opposite twin central or differential height double arm pole (as illustrated in figure 7.20 (a))
- Mounting height : 9 m from the top of Crash barrier over Flyover & 9m from ground level for Service road
- Spacing between poles : 34 m
- Maintenance factor : 0.85

The Light loss factor [LLF or MF] is a depreciation factor based on how the light output of a fixture decreases with time. All photometric calculations for illumination design should use the LLF that correspondsto the luminaire used. For LED the LLF is based on how well the luminaire dissipates heat and on how well the luminaire and the optics are well encapsulated. An LED luminaire that dissipates heat well will lamp lumen depreciation slower, and will have a higher LLF than a luminaire that does not dissipate heat well.

Luminaire used

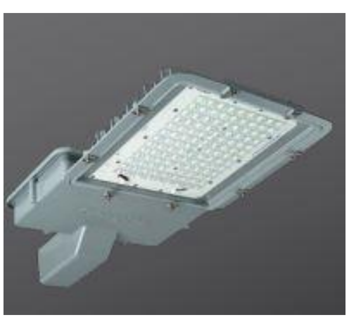
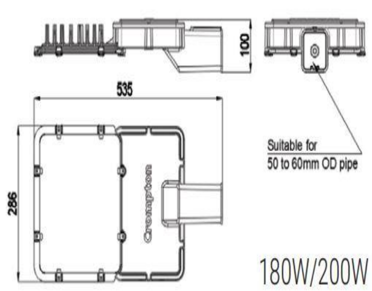
- ➢ Aerodynamically designed PDC Aluminum housing LED streetlight (as shown in figure 41)
- ➢ Luminous flux : 36250 Lumen (For Main Carriageway) & 27000 (For Service Road)
- ➢ Wattage : 250 Watt (For Main Carriageway) & 200 Watt (For Service Road)
- ➢ System efficacy : 145 lm/W (For MCW) & 135 lm/W (For SR)
- ➢ Throw : Short
- ➢ Control : Tight control [SLI > 4]
- ➢ Photometry type : Cut-off
- ➢ CCT : 5700K
- ➢ CRI : 80
- ➢ IP 66 protected

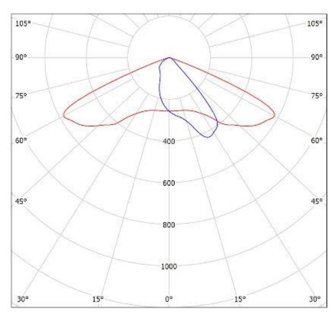





(a) **(b)** **(C)**

Fig 7.21: (a) 250 W Street light image (b) Street light dimension (c) Polar curve



(d) **(e)** **(f)**

Fig 7.22: (d) 200 W Street light image (e) Street light dimension (f) Polar curve

7.8 Table of Result overview

FOR FLYOVER MAIN CARRIAGEWAY

Photometric results	Average Illuminance (E_{avg}) [Lux]	Minimum Illuminance (E_{min}) [Lux]	Maximum Illuminance (E_{max}) [Lux]	Overall Uniformity (E_{min}/ E_{avg})	Overall Min/max (E_{min}/ E_{max})
Recommended Value as per standard	**N/A**	**40**	**N/A**	$\geq \mathbf{0.40}$	$\geq \mathbf{0.33}$
Achieved result	**55.08**	**40.8**	**79.7**	**0.74**	**0.51**

7.9 Table of Result overview

FOR SERVICE ROAD

Photometric results	Average Illuminance (E_{avg}) [Lux]	Minimum Illuminance (E_{min}) [Lux]	Maximum Illuminance (E_{max}) [Lux]	Overall Uniformity (E_{min}/ E_{avg})	Overall Min/max (E_{min}/ E_{max})
Recommended Value as per standard	**N/A**	**40**	**N/A**	$\geq \mathbf{0.40}$	$\geq \mathbf{0.33}$
Achieved result	**61.34**	**41.2**	**83.9**	**0.67**	**0.49**

❖ position of Calculation points in road surface [CIE 140 – 2000]

If ,“S” be the spacing between two luminaries (in meter) –

“D” be the longitudinal distance between two gird points (in meter) –

“N” be the no. of calculation points in longitudinal direction chosen such that –

If, $S \leq 30m$; then $N = 10$

$S > 30m$; then N is the smallest integer that makes $D \leq 3m$

In transverse direction spacing (d) between grid points (in meter) –

$d = W_L/3$ W_L is the width of the lane (in meter)

Pole & Luminaire Quantity

The Length of the above discussed Typical Cross section as mentioned in project scope is 9800m. So as per simulation design 250 W & 200 W luminaires are used for the Elevated Flyover Carriageway & Service Road for a span of 34m.

So Total number of pole,

= Total Length/Pole Spacing

= 9800/34

= 288.23 = 289 (Approx)

For above TCS Street light pole arrangement is Opposite Sided Twin Central, so total Street Light Pole becomes,

= 289*2 = 578

Luminaire Quantity will be

= 578*2

= 1,156 Nos.

Typical Cross Section VII

Design Aim:

To provide uniform illumination over the road surface including the paved shoulder The designed illumination level & uniformity must meet the required value. The lighting installations must provide visual comfort and it should not create much glare. Mainly the installations must be economically viable.

- Required illuminance level : Minimum 40 Lux
- Overall uniformity : $\geq$ 0.40
- Overall min. /max. ratio : $\geq$ 0.33

Layout & street profile:

Considering one of the Major flyovers as illustrated in figure 7.23 of NH– 66 for better understanding of lighting design, analyzing software DIALux & AGi32 has been used for describing the area and achieving the recommended values as per NHAI standard. The street profile of TCS mentioned as follows –

- crash barrier : (*width : 0.5m, height : 1m*)
- Paved shoulder [LEFT] : (*width : 2m ; tarmac : R3,* q_0 *– 0.07*)
- Main carriageway [LEFT] : (*width : 10.5m ; no. of lanes: 3 ; tarmac : R3,* q_0 *– 0.07*)
- Median : (*width : 1.5 m ; Height : 0.0m*)
- Main carriageway [RIGHT] : (*width : 10.5m ; no. of lanes: 3 ; tarmac : R3,* q_0 *– 0.07*)
- Paved shoulder [RIGHT] : (*width : 2m ; tarmac : R3,* q_0 *– 0.07*)
- crash barrier : (*width : 0.5m, height : 1m*)
- Slip road : (*width : 7.5m ; no. of lanes: 2 ; tarmac : R3,* q_0 *– 0.07*)

Design is proposed for **Road type R3** with an **Average luminance factor of road surface** q_0 **= 0.07**

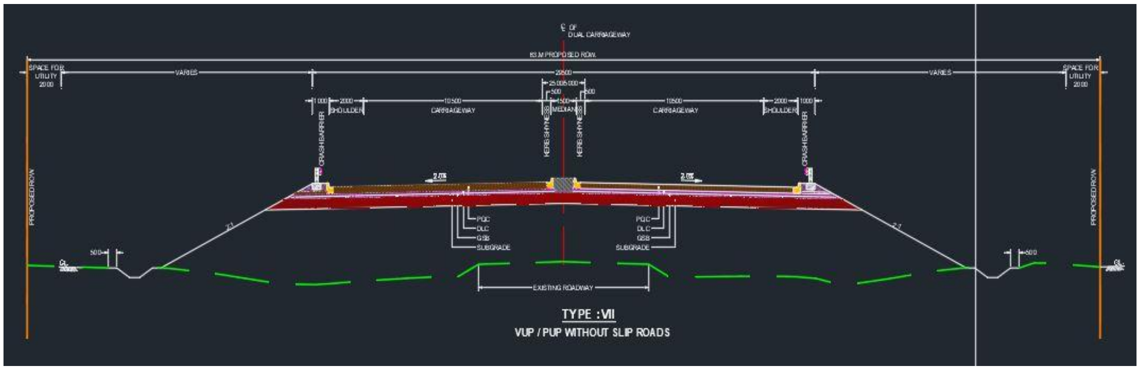
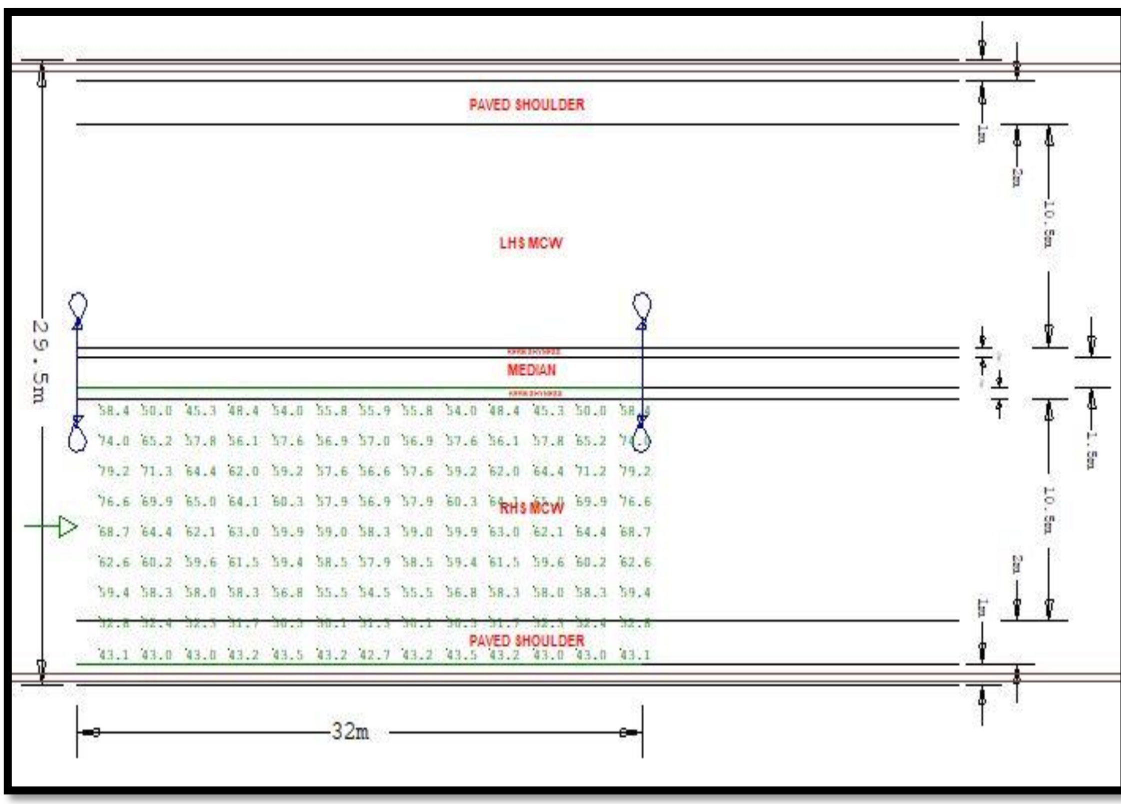


Fig 7.23: Street profile representation of Typical Cross section

Simulation of Typical Cross Section illumination design is mainly based on positioning calculation field [*BSEN 13201-3 2015*] over the road surface. To illuminate the stretch of road double arm pole on median has been considered. By commissioning double arm pole layout the aspect of design becomes much more optimized as no additional poles are proposed to meet the required minimum illuminance level, which results in economically feasible approach. The Lux levels and uniformity achieved in this area must meet the value recommended by *IRC Standard*



(a)

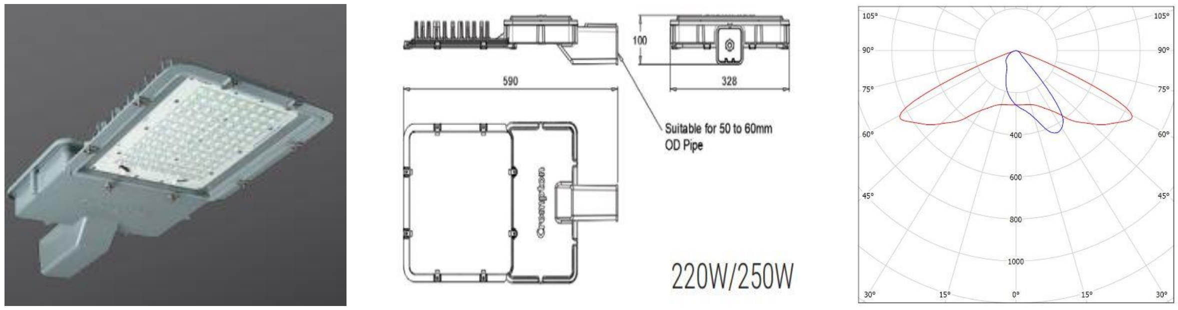
Fig 7.24: (a) Simulated Layout of Design (b) 3D rendering of the design

Design Considerations for the lighting implementation

- Pole Arrangement : Double arm Pole on Median or Twin Central Arrangement (as illustrated infigure 7.24 (a))
- Mounting height : 9 m from Road level
- Spacing between poles : 32m
- Maintenance factor : 0.85

<u>Luminaire used</u>

- Aerodynamically designed PDC Aluminum housing LED streetlight (as shown in figure 41)
- Luminous flux : 36250 Lumen
- Wattage : 250 Watt
- System efficacy : 145 lm/W
- Throw : Short
- Control : Tight control [SLI > 4]
- Photometry type : Cut-off
- CCT : 5700K
- CRI : 80
- IP 66 protected



(a) (b) (C)

Fig 7.25: (a) 250 W Street light image (b) Street light dimension (c) Polar curve

7.10. Table of Result overview

FOR MAIN CARRIAGEWAY

Photometric results	Average Illuminance (E_{avg}) [Lux]	Minimum Illuminance (E_{min}) [Lux]	Maximum Illuminance (E_{max}) [Lux]	Overall Uniformity (E_{min}/ E_{avg})	Overall Min/max (E_{min}/ E_{max})
Recommended Value as per standard	**N/A**	**40**	**N/A**	$\geq \mathbf{0.40}$	$\geq \mathbf{0.33}$
Achieved result	**57.55**	**42.7**	**79.2**	**0.74**	**0.54**

❖ Position of Calculation points in road surface [CIE 140 – 2000]

If ,"S" be the spacing between two luminaires (in meter) –

"D" be the logitudinal distance between two gird points (in meter) –

"N" be the no. of calculation points in longitudinal direction chosen such that –

If, $S \leq 30m$; then $N = 10$

$S > 30m$; then N is the smallest integer that makes $D \leq 3m$

In transverse direction spacing (d) between grid points (in meter) –

$d = wl/3$; W_L is the width of the lane (in meter)

Pole & Luminaire Quantity

The Length of the above discussed Typical Cross section as mentioned in project scope is 600m. So as per simulation design 250 W luminaire is used for the Main Carriageway for a span of 32m.

So Total number of pole,

= Total Length/Pole Spacing

= 600/32

= 18.75 = 19(App)

For above TCS Street light pole arrangement is Twin Central, so total Street Light Pole becomes,

= 19

Luminaire Quantity will be

= 19*2

= 38

Vehicular Under Pass (VUP)

An underpass is a subway structure containing a road or pedestrian passageway running underneath the project highway. An underpass is one of the most useful structures for highway since without any obstruction of Crossing Road Traffic, and easily flow out the traffic on main road.

Design Aim:

Given the relatively-slow speed of pedestrians and cyclists, the delay in adaptation when entering a relatively dark underpass during the hours of daylight is not usually a problem as far as their ability to see possible obstacles is concerned. The lighting levels needed here during the hours of darkness will thus suffice. The designed illumination level & uniformity must meet the required value.

- Required illuminance level : Minimum 40 Lux
- Overall uniformity : ≥ 0.40
- Overall min./max. ratio : ≥ 0.33

Layout & description of VUP:

Lighting should address the street-adjacent pedestrian or bike way pavement in underpasses. Illuminance criteria, when fully deployed, are a robust set of quantitative values that influence visibility, visual performance, and visual comfort and attention.

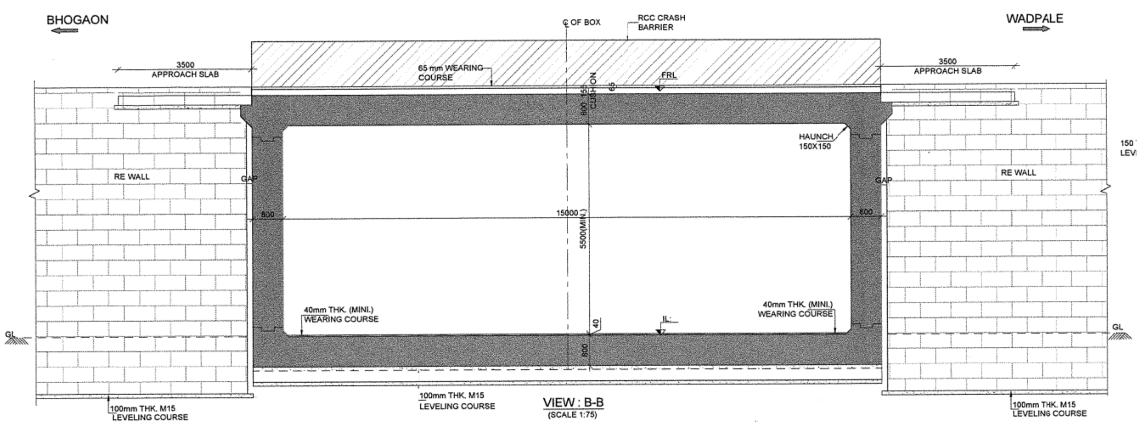


Fig 7.26: Cross sectional view of Vehicular Under-Pass CH: 140+324

Considering one of the VUP in chainage 140+324 of NH–66 as illustrated in figure 7.26 and 7.27, for better understanding of lighting design, analyzing software DIALux 4.13 has been used for describing the area and achieving the recommended values as per NHAI standard.

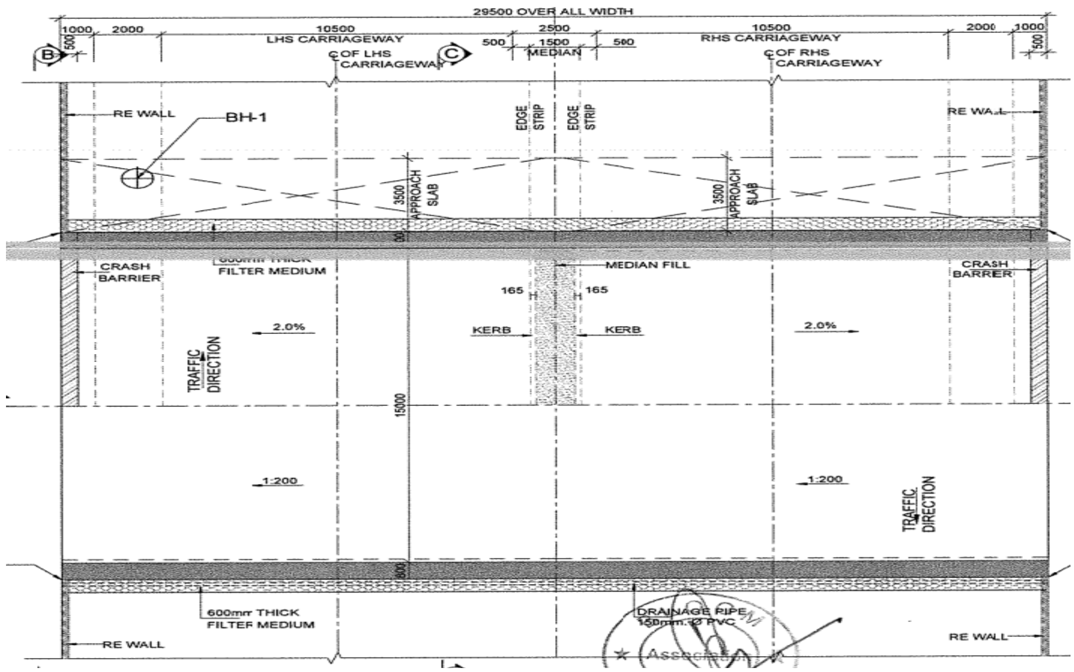
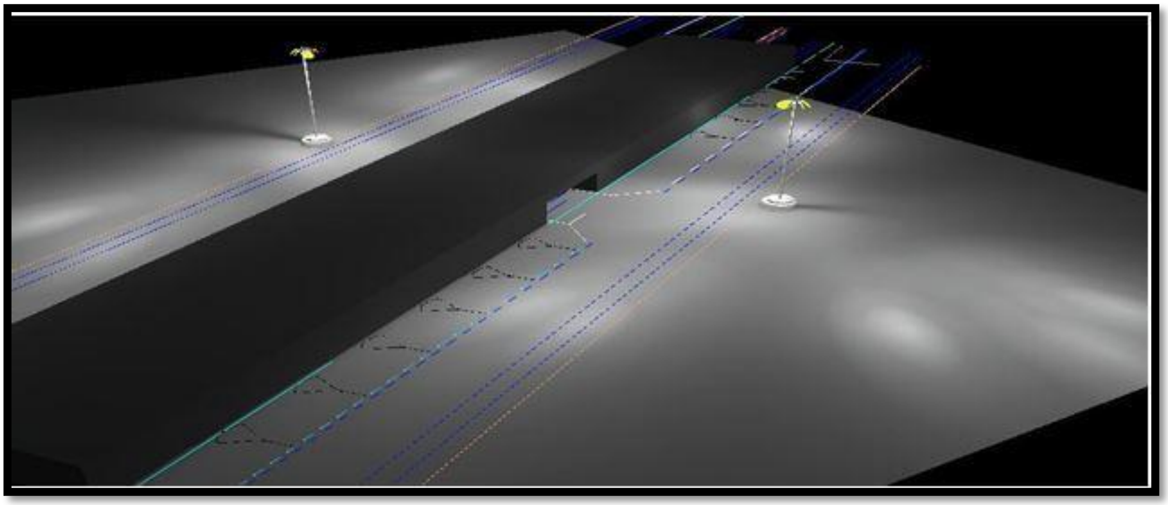


Fig 7.27: Plan view of Vehicular Under-Pass CH: 140+324

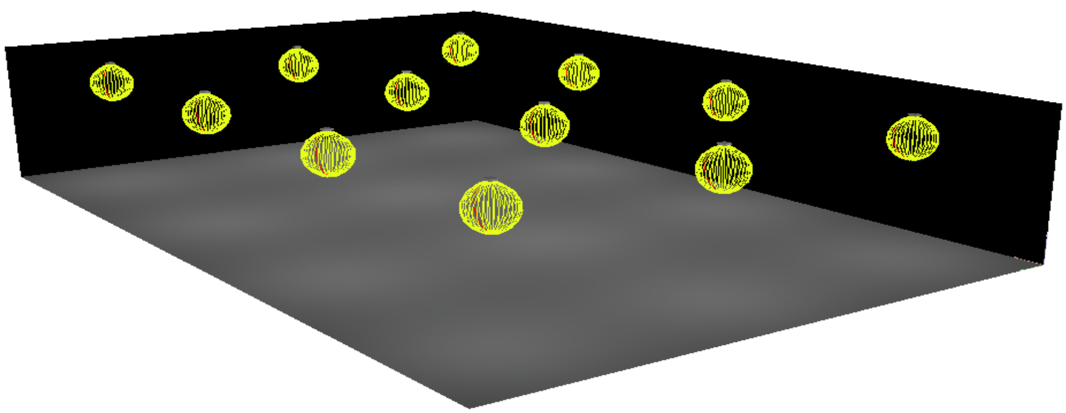
Simulation of the VUP located at CH: 140+324 is mainly based on positioning different lighting arrangement in different zones. An underpass is generally not in need of daytime lighting if the bright exit occupies a quite large part of the field of view when seen from a distance equal to the stopping distance of the motorist. Obstacles in such a tunnel or underpass are silhouetted against this bright exit. Daylight penetrating the tunnel may brighten a small stretch of road surface and walls at the entrance and exit.

Design Considerations for the lighting implementation

“Under deck” luminaires are mounted either from ceiling or wall to illuminate the entire passageway as illustrated in figure 7.28. Hence it is stringent to provide uniform illumination over the subway area so as to contribute to the feeling of safety.



(a)



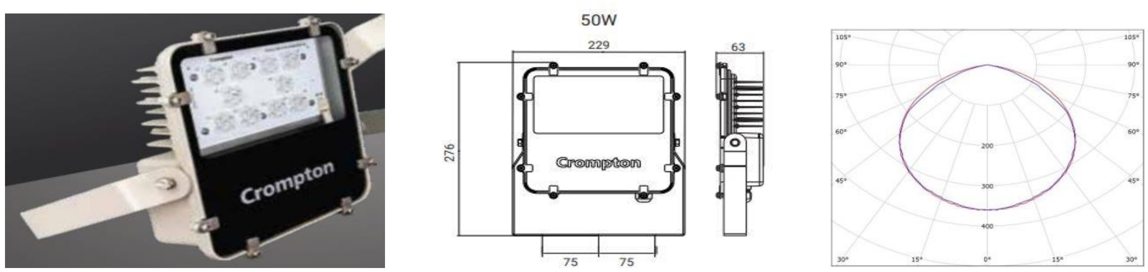
(b)

Fig 7.28 (a) & (b): Simulated design of the layout

Similar design approach is considered for Light Vehicular Underpass Vehicular overpass (VOP), Pedestrian underpass (PUP). The only exception is that in PUP as the mounting elevation is small relative to VUP, so in PUP instead of underdeck luminaire; industrial degree IP65 level protected battens are used as surface mounted.

Luminaire used

- PDC Aluminum housing LED Floodlight luminaire (as shown in figure 45)
- Luminous flux : 5500 Lumen
- Luminaires Used : 12 nos.
- Wattage : 50 Watt
- System efficacy : 110 lm/W
- Beam angle : 120 degree (No Lens)
- CCT : 5700K
- CRI : 80
- IP 66 protected



. (a) (b) (c)

Fig 7.29: (a) under deck fixture image (b) luminaire dimension (c) Polar curve

7.11 Table of Result overview

FOR VUP

Photometric results	Average Illuminance (E_{avg}) [Lux]	Minimum Illuminance (E_{min}) [Lux]	Maximum Illuminance (E_{max}) [Lux]	Overall Uniformity (E_{min}/ E_{avg})	Overall Min/max (E_{min}/ E_{max})
Recommended Value as per standard	**N/A**	**40**	**N/A**	$\geq \mathbf{0.40}$	$\geq \mathbf{0.33}$
Achieved result	**70**	**40**	**97**	**0.57**	**0.41**

Highway Road lighting

The main purpose of road lighting is to provide appropriate lighting levels for driver and pedestrian safety. However, with LED road lighting, many additional objectives can be met such as reduction in peak energy demand, lower energy bills, improved lighting levels/aesthetics, lower GHG (GreenHouse Gases) emissions, and lighting for roads in off-grid areas.

Design Aim:

The amount of light required on a road to reveal objects i.e. vehicles, pedestrians and obstructions depend upon the amount or density of traffic composition, the speed of the traffic volume. The quality of a road- lighting installation is expressed in terms of photometric criteria that influence both visual performance and visual comfort. There are twodifferent categories of quality parameters: parameters using solely photometric units and parameters using performance metrics. Design specifications solely based on photometric parameters such as lighting level, uniformity are the primary aspect that is aimed to satisfy motorist's or pedestrians.

- Required illuminance level : Minimum 40 Lux
- Overall uniformity : ≥ 0.40
- Overall min./max. ratio : ≥ 0.33

Layout & street profile of roadway:

Considering one of the major TCS (Typical Cross Section) for project highway of NH–31D as shown in figure 46 for better understanding of lighting design, analyzing software DIALux has been used for describing the area and achieving the recommended values as per NHAI standard.

Slip road [LEFT]	*(width : 7m ; no. of lanes: 2 ; tarmac : R3,* q_0 *– 0.07*)
Footpath /Drain	*(width : 2m*)

Drain[LEFT]	(*width : 1m*)
Main carriageway [LEFT]	(*width : 10.5m ; no. of lanes: 3 ; tarmac : R3, q_0 – 0.07*)
Median	(*width : 2.5m ; Height : 0.0m*)
Main carriageway [RIGHT]	(*width : 10.5m ; no. of lanes: 3 ; tarmac : R3, q_0 – 0.07*
Drain[RIGHT]	(*width : 1m*)
Footpath/Drain	(*width : 2m*)
Slip road [Right]	(*width : 7m ; no. of lanes: 2 ; tarmac : R3, q_0 – 0.07*)

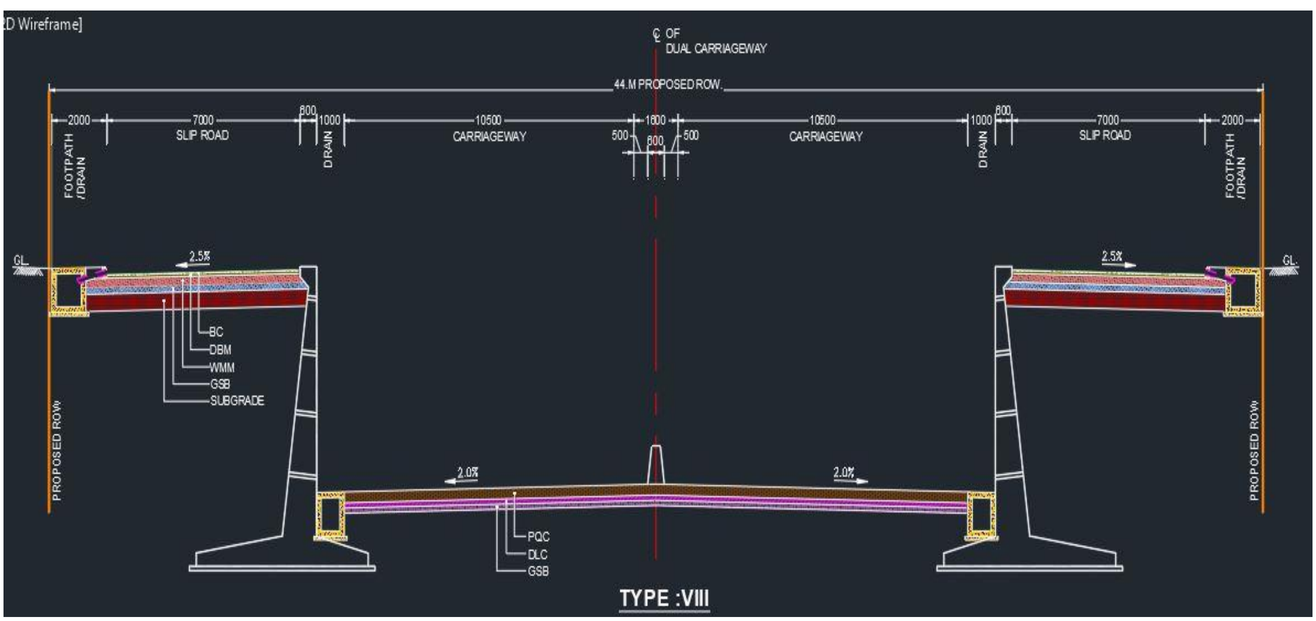


Fig 7.30: Typical Cross Section of National Highway

For lighting level, the average horizontal illuminance ($E_{H,avg}$) is used in conjunction with the value of the local minimum horizontal illuminance ($E_{H,min}$). The requirement of average horizontal illuminance should guarantee a sufficiently high adaptation level and consequently sufficient sensitivity for contrast seeing. The local minimum horizontal illuminance should ensure safe movement by providing good visibility of obstacles at all locations in the path of the pedestrians.

As to maintain the required horizontal illuminance level with specified road width following pole arrangement as illustrated in figure 7.31 is adopted.

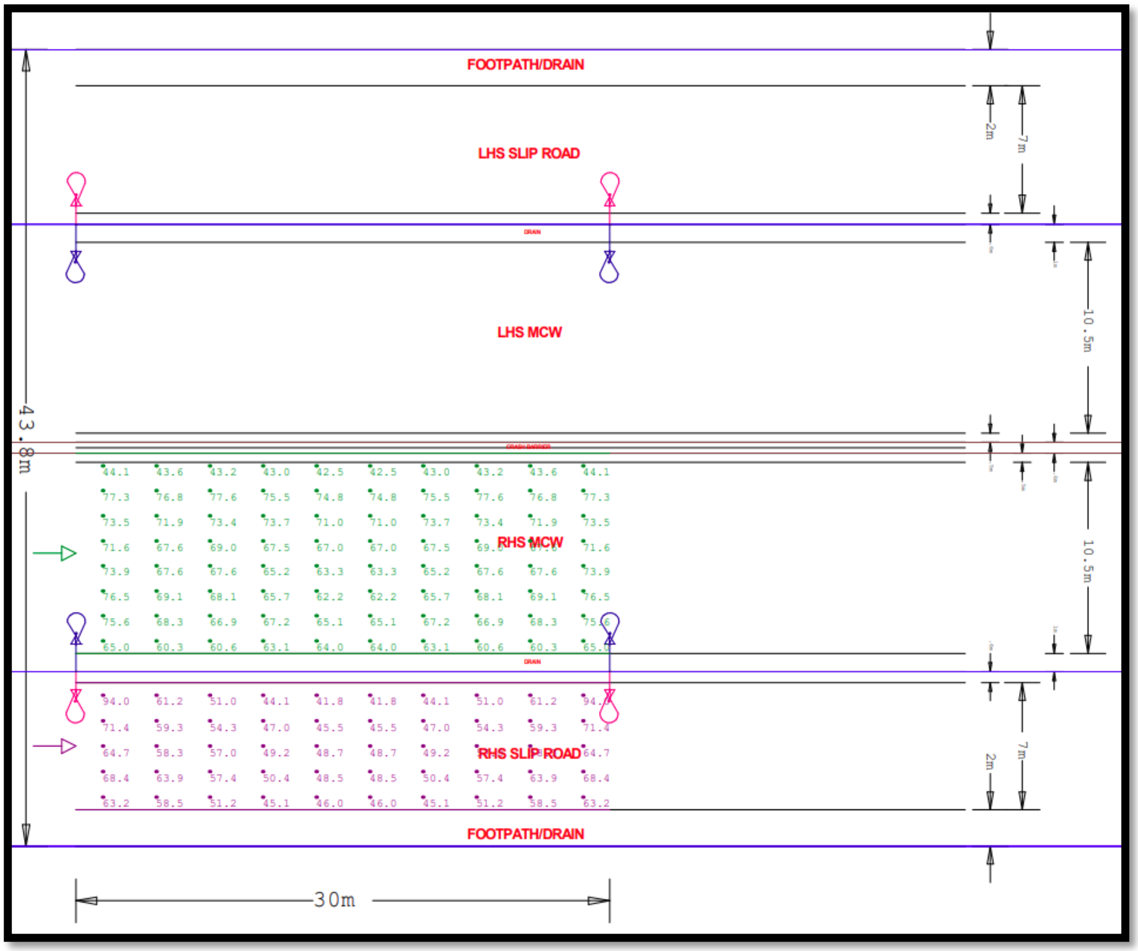


Fig 7.31: Simulated design & Pole arrangement layout in highway road project

The safety and comfort of a road user deteriorates considerably with the onset of darkness, particularly on those roads not provided with a well-designed and maintained lighting installation. Driving involves a continuous decision-making process based on information that reaches our senses. Good lighting is essential in keeping our visual performance at a high enough level during the hours of darkness.

Fig 7.32: Simulated 3D rendering of the design

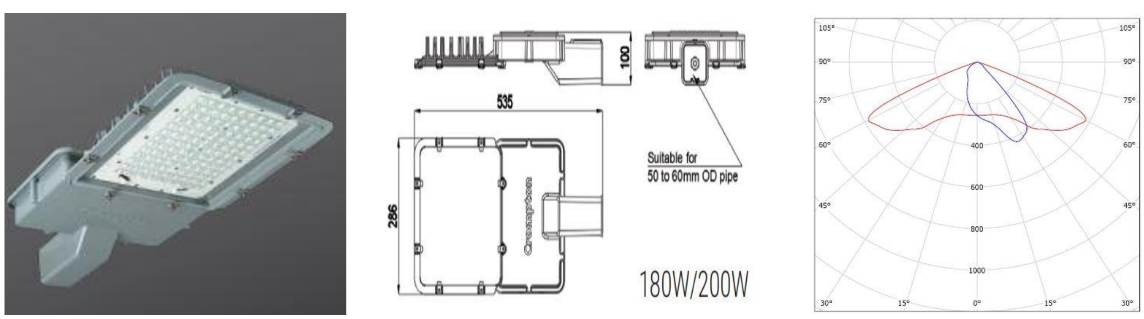
For lighting level both the average and the minimum horizontal illuminance are used. But a separate requirement for uniformity is needed as well. A high level of average horizontal illuminance combined with a low value of local minimum illuminance, just fulfilling its requirement, could result in a situation where objects in the dark zone become invisible. This because the eyes adapt to the very high lighting level given by the high average horizontal illuminance. The criterion usually used to provide for overall uniformity is the minimum & average horizontal illuminance. The difference between average and the minimum value should not be great, smaller the ratio poorer will be the uniformity thus the visual performance for the objects seen against the low luminance part of the road surface. By visual performance is meant the ability of a motorist to continuously select and process, more or less subconsciously, that part of the visual information presented to him that is necessary for the safe control of his vehicle. For a high level of visual performance to be maintained, especially when driving for a long time, the road user must also feel comfortable in the visual environment. A good overall uniformity ensures that all spots on the road are sufficiently visible.

Design Considerations for the lighting implementation

- ➢ Pole Arrangement : Opposite sided Twin Central (Single arm Towards Service road)
- ➢ Mounting height : 9 m from road level
- ➢ Spacing between poles : 32m
- ➢ Maintenance factor : 0.85

Luminaire used

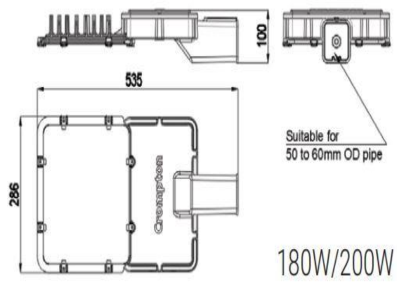
- ➢ Aerodynamically designed PDC Aluminum housing LED streetlight (as shown in figure 55)
- ➢ Luminous flux : 27000 Lumen [Main Carriageway] ; 24300 Lumen [Slip Road]
- ➢ Wattage : 200 Watt [Carriageway] ; 180 Watt [Slip]
- ➢ System efficacy : 135 lm/W
- ➢ Throw : Short
- ➢ Control : Tight control [SLI > 4]
- ➢ Photometry type : Cut-off
- ➢ CCT : 5700K
- ➢ CRI : 80
- ➢ IP 66 protected



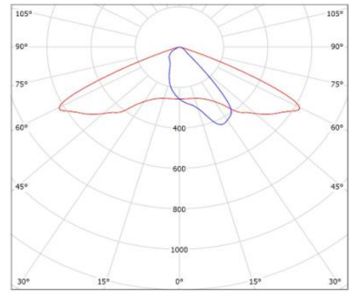
(a) (b) (c)

Fig 7.33: (a) 200 W Street light image (b) Street light dimension (c) Polar curve

(c)



(d)



(e)

Fig 7.34: (c) 180 W Street light image (d) Street light dimension (e) Polar curve

7.12 Table of Result overview

FOR HIGHWAY MAIN CARRIAGEWAY

Photometric results	Average Illuminance (E_{avg}) [Lux]	Minimum Illuminance (E_{min}) [Lux]	Maximum Illuminance (E_{max}) [Lux]	Overall Uniformity (E_{min}/ E_{avg})	Overall Min/max (E_{min}/ E_{max})
Recommended Value as per standard	**N/A**	**40**	**N/A**	$\geq \mathbf{0.40}$	$\geq \mathbf{0.33}$
Achieved result	**66**	**42.5**	**77.6**	**0.64**	**0.55**

7.13 Table of Result overview

FOR HIGHWAY SLIP ROAD

Photometric results	Average Illuminance (E_{avg}) [Lux]	Minimum Illuminance (E_{min}) [Lux]	Maximum Illuminance (E_{max}) [Lux]	Overall Uniformity (E_{min}/ E_{avg})	Overall Min/max (E_{min}/ E_{max})
Recommended Value as per standard	**N/A**	**40**	**N/A**	$\geq \mathbf{0.40}$	$\geq \mathbf{0.33}$
Achieved result	**56**	**41.8**	**94**	**0.75**	**0.44**

An important comfort aspect of road lighting is the lengthwise uniformity of the distribution pattern on the road in front of a motorist. A continuously-alternating sequence of bright and dark strips (*zebra affect*) on the road disappearing under the vehicle while driving may or may not have a negative effect on visual performance, but is always experienced as being uncomfortable if the brightness difference between bright and dark areas is too great. So it is very crucial that the illuminance gradient is not too large so it may cause visual adaptation problems. In the design approach such performance metrics are taken under considerations & executed thoroughly.

❖ Position of Calculation field in Main Carriageway [CIE 140 –2000]

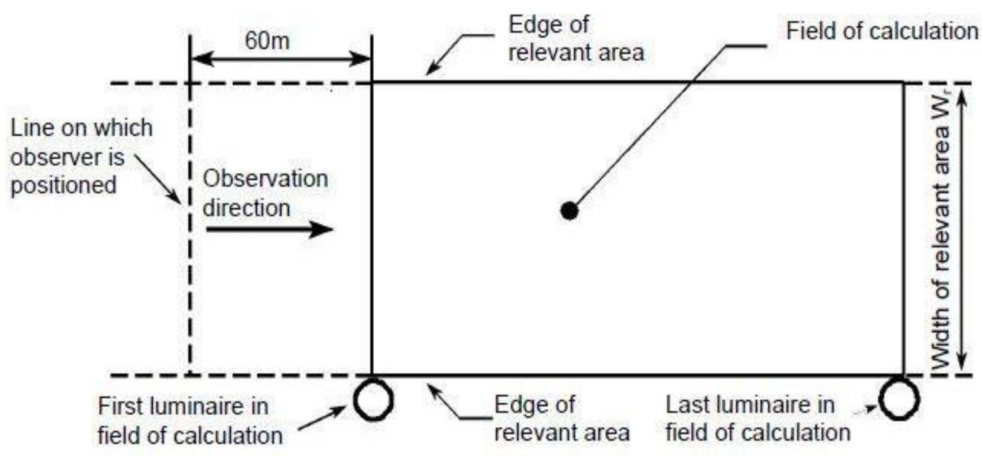


Fig 7.35: Field of calculation in road lighting measurement

If , "S" be the spacing between two luminaires as illustrated infigure 51 (in meter) –

"D" be the logitudinal distance between two gird points (in meter) – "N" be the no. of calculation points in longitudinal direction chosen such that –

If, $S \leq 30m$; then $N = 10$

$S > 30m$; then N is the smallest integer that makes $D \leq 3m$

In transverse direction spacing (d) between grid points (in meter) –

$d = wl/3$; W_L is the width of the lane (in meter)

Bus lay bay

A bus lay–bay, bus pullout, or off-line bus stop is a designated spot on the side of a highway where buses may pull out of the flow of traffic to pick up and drop off passengers. It is often indented into the sidewalk or other pedestrian area. A bus bay is, in a way, the opposite of a bus bulb. With a bus bulb, the point is to save the bus the time needed to merge out of and back into moving traffic, at the cost of temporarily blocking that traffic while making a stop. With a bus bay, the goal is to not block traffic flow while the bus is stopped, but at the cost of the time necessary to merge back into flowing traffic.

Design Aim:

To provide uniform illumination in the bus bay area such that the visual guidance of the motorist and pedestrian results into good visibility. The designed illumination level & uniformity must meet the required value. The lighting installations must provide visual comfort and it should not create much glare. Mainly the installations must be economically viable.

- Required illuminance level : Minimum 40 Lux
- Overall uniformity : ≥ 0.40
- Overall min. /max. ratio : ≥ 0.33

Layout & description of Bus lay bye

A Bus Bay is an indented space adjacent to a traffic lane as illustrated in figure 52, designed to let buses embark and disembark passengers, without hindering the flow of traffic.

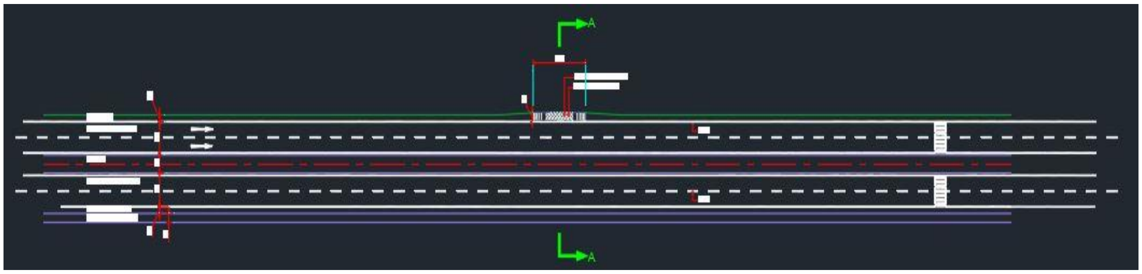


Fig 7.36: Plan layout of dual side bus bay

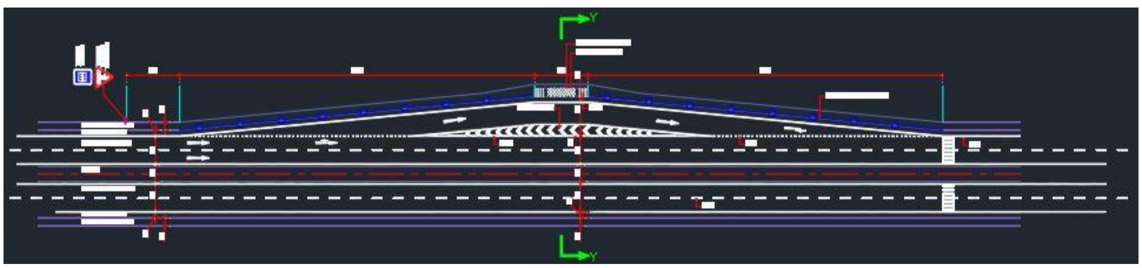


Fig 7.37: Plan layout of Single side bus bay

It is a paved area at the side of a highway designated for drivers to stop in, for emergency parking, or where vehicles can wait, with larger lay- bys possibly having facilities like food vendors or public telephone, amenities etc. Hence it is paramount that the illuminance level maintained is adequate enough to satisfy the visual comfort and performance.

Design Considerations for the lighting implementation

Simulation of bus bay illumination design as shown in figure 7.38 is mainly based on positioning calculation field over the entire paved road surface. To illuminate the area single sided street light pole layout arrangement is considered for Single Sided Bus Bay & Twin Central arrangement is considered for both hand side/dual side Bus Bay.

- Pole Arrangement : Single sided (Single Sided Bus Bay) &

  Twin Central (Dual Side Bus Bay)
- Mounting height : 9m from road level
- Spacing between poles : 34m
- Maintenance factor : 0.85

If bus shelter is present in the proposed lighting calculation then to illuminate the shelter localized lighting approach is to be considered. But one key quality need to be kept in mind that *weatherproof (IP65) batten* must be employed so that during any adverse climatological scenarios fixtures should not go out of commission. Lighting quality parameters should be addressed such that the visual requirements and safety of commuters is accentuated.

In case of Single sided Bus Bay illumination design, Apart from Bus Bay area Street Light Pole is proposed for the main carriageway also.

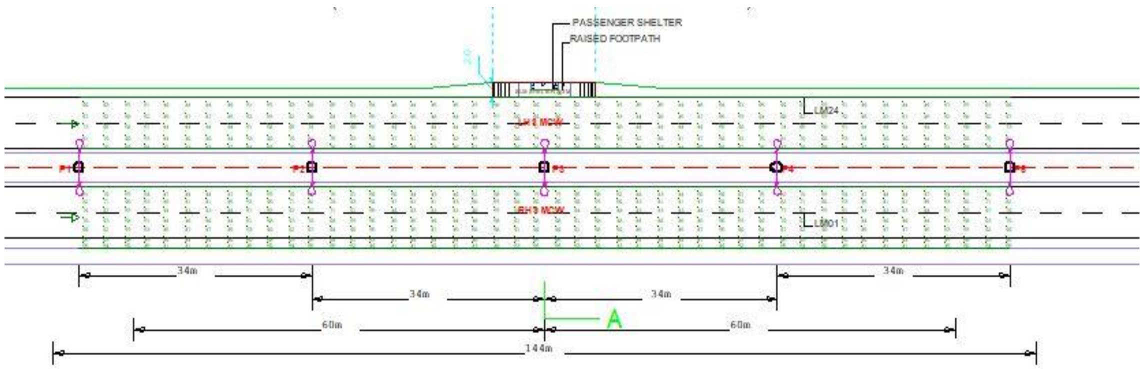


Fig 7.38: Simulated Design of dual side bus bay

Fig 7.39: Simulated 3D rendering of the design

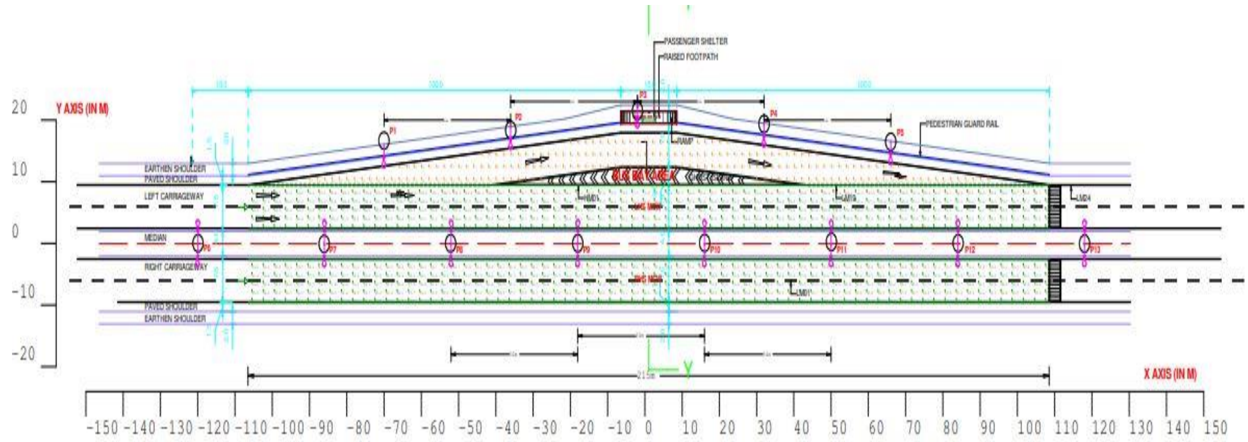


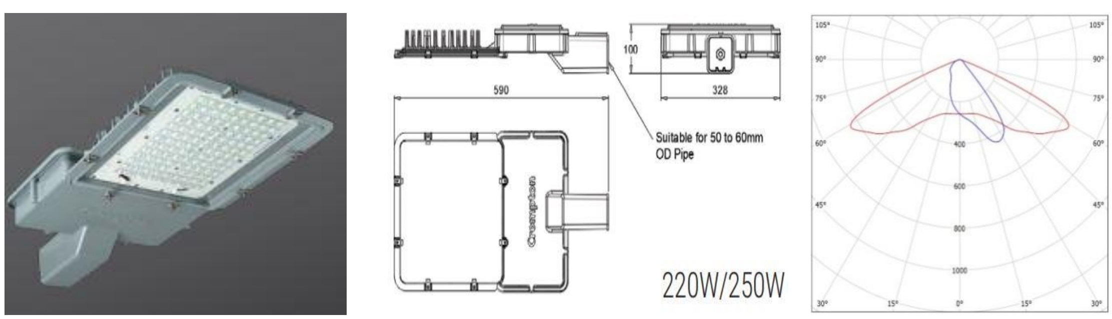
Fig 7.40: Simulated Design of Single side bus bay

Fig 7.41: Simulated 3D rendering of the design

The Light loss factor [LLF or MF] is a depreciation factor based on how the light output of a fixture decreases with time. All photometric calculations for illumination design should use the LLF that correspondsto the luminaire used. For LED the LLF is based on how well the luminaire dissipates heat and on how well the luminaire and the optics are well encapsulated. An LED luminaire that dissipates heat well will lamp lumen depreciation slower, and will have a higher LLF than a luminaire that does not dissipate heat well. During the proposed design approach LLF is considered to be 0.85 by signifying the *Recoverable* and *Non- Recoverable factors* of the insipient luminaire and lamp characteristicsand maintenance intervals.

Luminaire used

- Aerodynamically designed PDC Aluminum housing LED streetlight (as shown in figure 55)
- Luminous flux : 31250 Lumen
- Luminaires used : 10 nos. for Dual Side Bus Bay
- Luminaires used : 21 nos. for LHS & RHS Bus Bay including Main Carriageway
- Wattage : 250 Watt
- System efficacy : 125 lm/W
- Throw : Short
- Control : Tight control [SLI > 4]
- Photometry type : Cut-off
- CCT : 5700K
- CRI : 80
- IP 66 protected



(a) (b) (c)

Fig 7.42: (a) 250 W Street light image (b) Street light dimension (c) Polar curve

7.14 Table of Result overview

FOR DUAL SIDE BUS BAY

Photometric results	Average Illuminance (E_{avg}) [Lux]	Minimum Illuminance (E_{min}) [Lux]	Maximum Illuminance (E_{max}) [Lux]	Overall Uniformity (E_{min}/ E_{avg})	Overall Min/max (E_{min}/ E_{max})
Recommended Value as per standard	**N/A**	**40**	**N/A**	≥ 0.40	≥ 0.33
Achieved Result(RHS)	**54.68**	**40**	**82**	**0.71**	**0.49**
Achieved Result(LHS)	**56**	**40**	**82**	**0.73**	**0.49**

****NOTE** During Lighting Calculation paved shoulder of RHS Carriageway was included.**

7.15 Table of Result overview

FOR SINGLE SIDE BUS BAY INCLUDING MCW

Photometric results	Average Illuminance (E_{avg}) [Lux]	Minimum Illuminance (E_{min}) [Lux]	Maximum Illuminance (E_{max}) [Lux]	Overall Uniformity (E_{min}/ E_{avg})	Overall Min/max (E_{min}/E_{max})
Recommended Value as per standard	**N/A**	**40**	**N/A**	≥ 0.40	≥ 0.33
Achieved Result(Bus Bay)	**80.64**	**46**	**109**	**0.57**	**0.42**
Achieved Result(LHS MCW)	**79.58**	**40.6**	**111.2**	**0.51**	**0.37**
Achieved Result(RHS MCW)	**56**	**40.7**	**84.7**	**0.73**	**0.48**

Activity levels influence illuminance criteria. High activity levels demand greatest illuminance to address the volumes of vehicular and pedestrian traffic. Lighting is required for visibility of a bus bay area and it adds to the safety of all features of a road lighting design. Illuminance criteria, when fully deployed, are a robust set of quantitative values that influence visibility, visual performance, and visual comfort and attention.

Truck Lay bye

Truck lay byes are paved area at the side of a highway designated for drivers to stop in, for emergency parking primarily and also to provide temporary resting place for the tired truck drivers along the highway These will be segregated from the usual travel way of traffic on the highway. These are generally provided at areas/sections of freight activity and generally at 30km intervals.

Design Aim:

To provide uniform illumination in the truck bay area and the way-bridge section such that the visual guidance of the driver results into good visibility during the night time. The designed illumination level & uniformity must meet the required value. The lighting installations must provide visual comfort and it should not create much glare. Mainly the installations must be economically viable.

- Required illuminance level : Minimum 40 Lux
- Overall uniformity : ≥ 0.40
- Overall min./max. ratio : ≥ 0.33

Layout & description of Truck lay bye

Considering one of the truck bay's of NH–66 as illustrated in figure 7.43 and figure 7.44 for better understanding of lighting design. Illumination design approach is similar to bus lay bye.

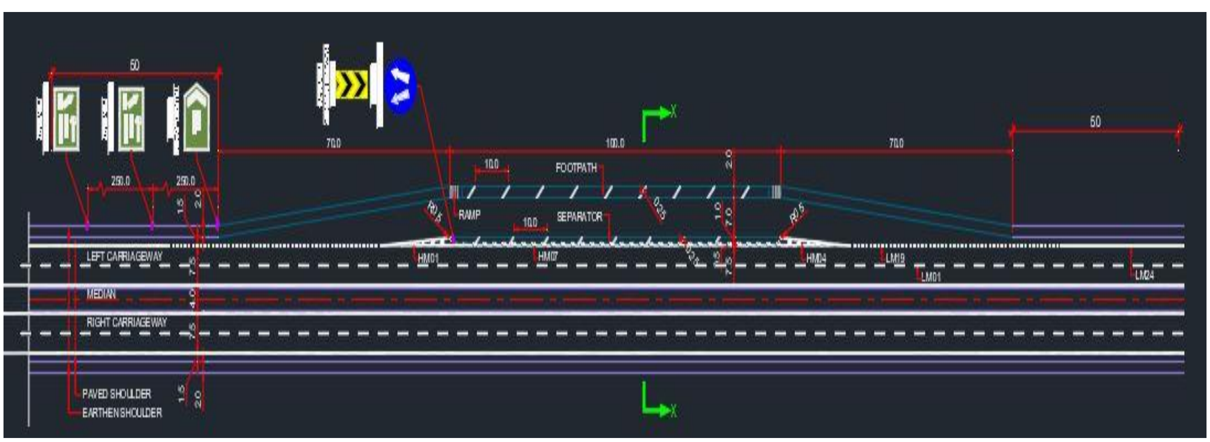


Fig.7.43: Plan layout of truck bay

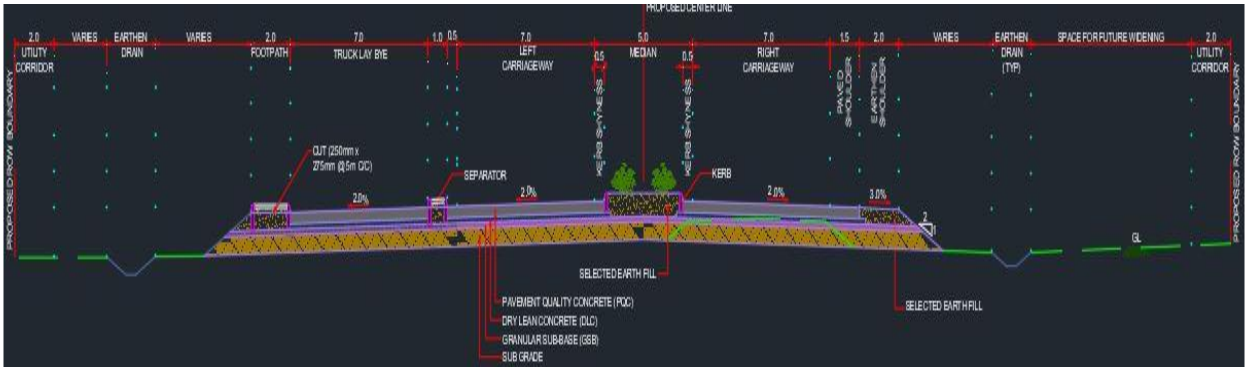


Fig.7.44: Typical cross-sectional layout of truck bay

Design Considerations for the lighting implementation

Simulation of truck bay illumination design as shown in figure 7.45 is mainly based on positioning calculation field over the entire paved bay area. Light design should be concentrated on the bay area and also the approach road so as to maintain a superior visual guidance at night time tothe motorist. To illuminate the area single sided street light pole layout arrangement is considered.

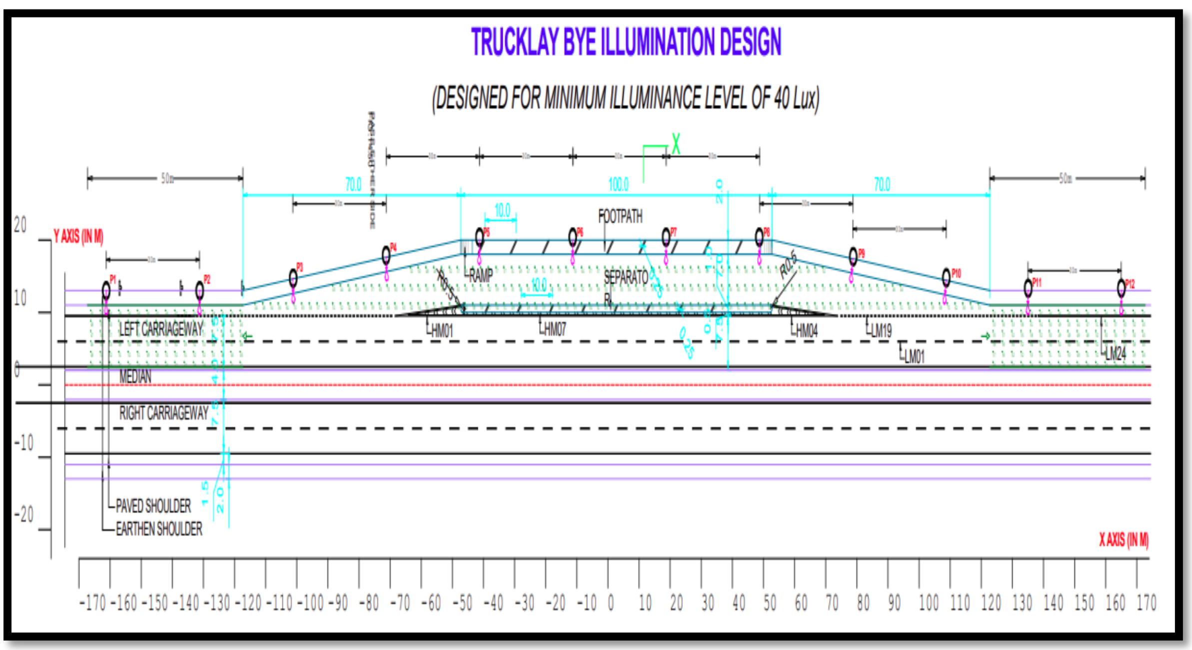
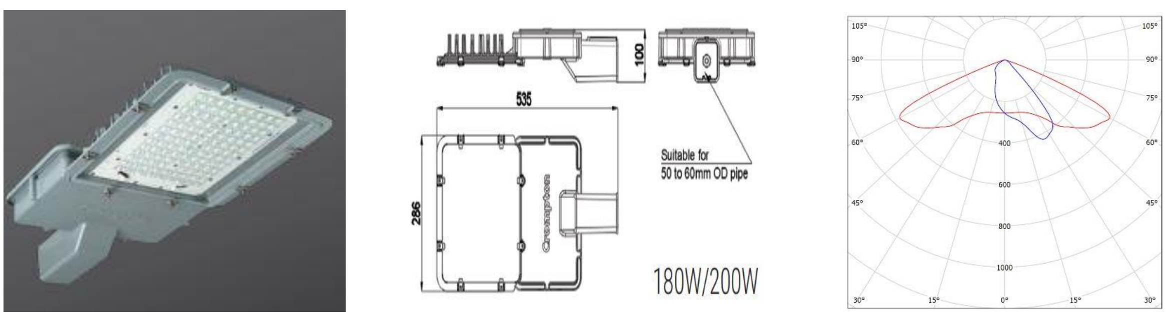


Fig.7.45: Simulated design of truck bay

Luminaire used

- Aerodynamically designed PDC Aluminum housing LED streetlight (as shown in figure 59)
- Luminous flux : 27000 Lumen
- Luminaires used : 12 Nos.
- Wattage : 200 Watt
- System efficacy : 135 lm/W
- Throw : Short
- Control : Tight control [SLI > 4]
- Photometry type : Cut-off
- CCT : 5700K
- CRI : 80
- IP 66 protected



(a) (b) (c)

Fig 7.46: (a) Street light image (b) Street light dimension (c) Polar curve

7.16 Table of Result overview

Photometric results	Average Illuminance (E_{avg}) [Lux]	Minimum Illuminance (E_{min}) [Lux]	Maximum Illuminance (E_{max}) [Lux]	Overall Uniformity (E_{min}/ E_{avg})	Overall Min/max (E_{min}/ E_{max})
Recommended Value as per standard	N/A	40	N/A	≥ 0.40	≥ 0.33
Achieved Result (Truck Lay Bye)	56.2	44	70	0.78	0.63
Achieved Result (Approach Road LHS)	49.1	41	60	0.83	0.68
Achieved Result (Approach Road RHS)	50.4	41	61	0.81	0.67

Fig 7.47: Simulated 3D rendering of the design

Wayside Rest Area

Development of road side amenities along the state highways for providing safe stopping points for highways commuters such as car/bus passengers and truckers at regular intervals with required amenities during journey with an aim to reduce driving related fatigue and enhance total travel experience. Include rest areas features like: parking areas, resting areas, restroom facilities, orientation and travel information, and other facilities for the convenience of the traveling public.

Design Aim

Rest area is a public facility, located next to a large thoroughfare such as a motorway or highway, at which drivers and passengers can rest, or refuel without exiting onto secondary roads. Space facilities at reasonable intervals to dissemination information, reduce shoulder stops and driver fatigue accidents, improve motorist safety and provide travelers with opportunities for rest and comfort.

Rest areas are essential safety features on the highway system that help address driver fatigue, a major cause of serious accidents. Studies reveal *[“Drowsy driving and Automobile crashes”, NCSDR and NHTSA (1998)]* that 15 to 20 minute break improves individual performance, even among sleep-deprived people. Hence is of paramount significance to provide uniform illumination in the wayside amenity area such that the visual guidance of the driver results into good visibility during the night time. Also adequate illuminance level should be maintained at parkingspot so that a motorist can judge his course of his driving. The designed lighting level & uniformity must meet the required value framed by National highway standard.

- Required illuminance level : Minimum 40 Lux
- Overall uniformity : ≥ 0.40
- Overall min./max. ratio : ≥ 0.25

Layout & description of wayside rest area

Figure 7.48 illustrates one of the wayside amenity areas of the project highway. Stringent care has to be obeyed for lighting design of this type of area such that fruition of visual comfort and performance along with a sense of alertness is fulfilled.

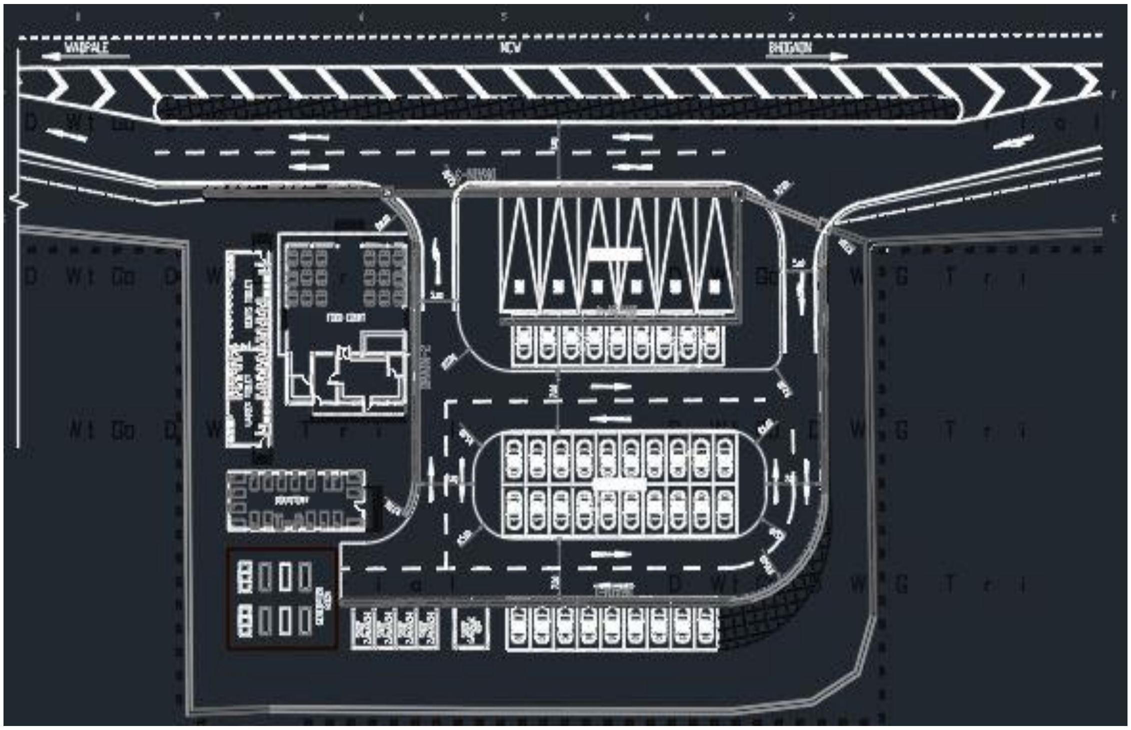


Fig.7.48: Plan layout of amenity area in NH-66

Size facilities based on the type of road system served projected traffic for a stipulated time frame, traffic composition and projected usage.

Design Considerations for the lighting implementation

To have a greater coverage of the entire area it is feasible to illuminate thewayside area using high mast. The advantage of using high mast in the design approach is that it provides improved visibility, uniform distribution of light in space which results into less severe illuminance gradient. Furthermore, high mast allocation reduces the geometric space location required by street light poles that may cause traffic interruption.In the lighting design of secondary service road that is entrance to wayside area street light arrangement is proposed.

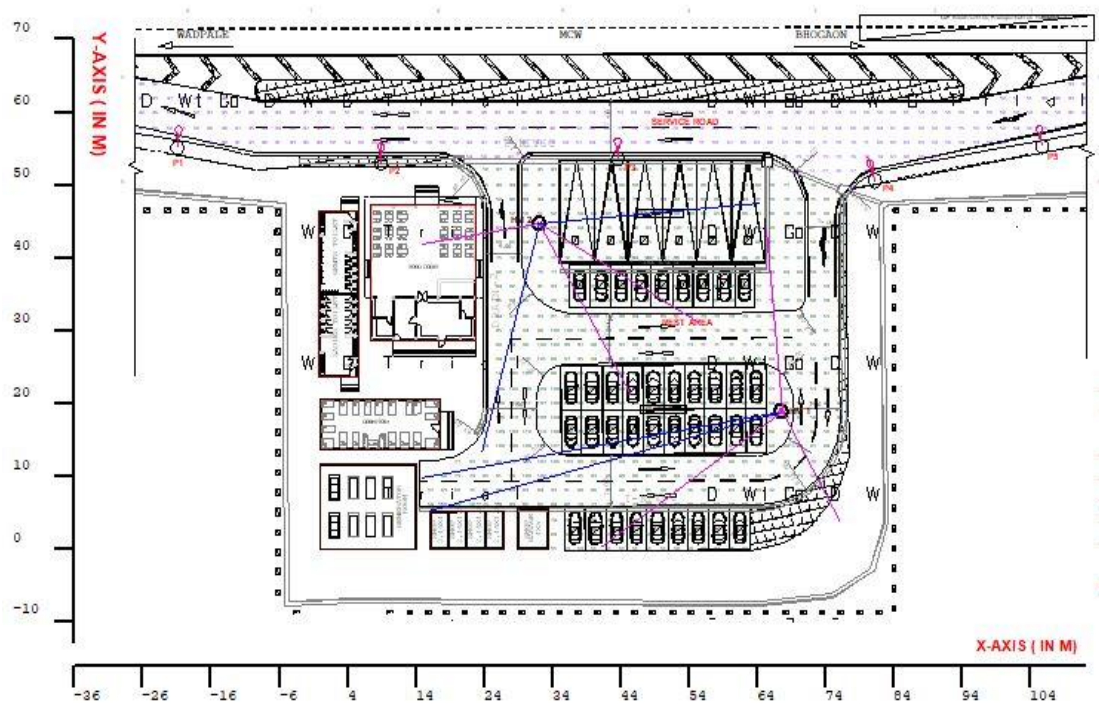
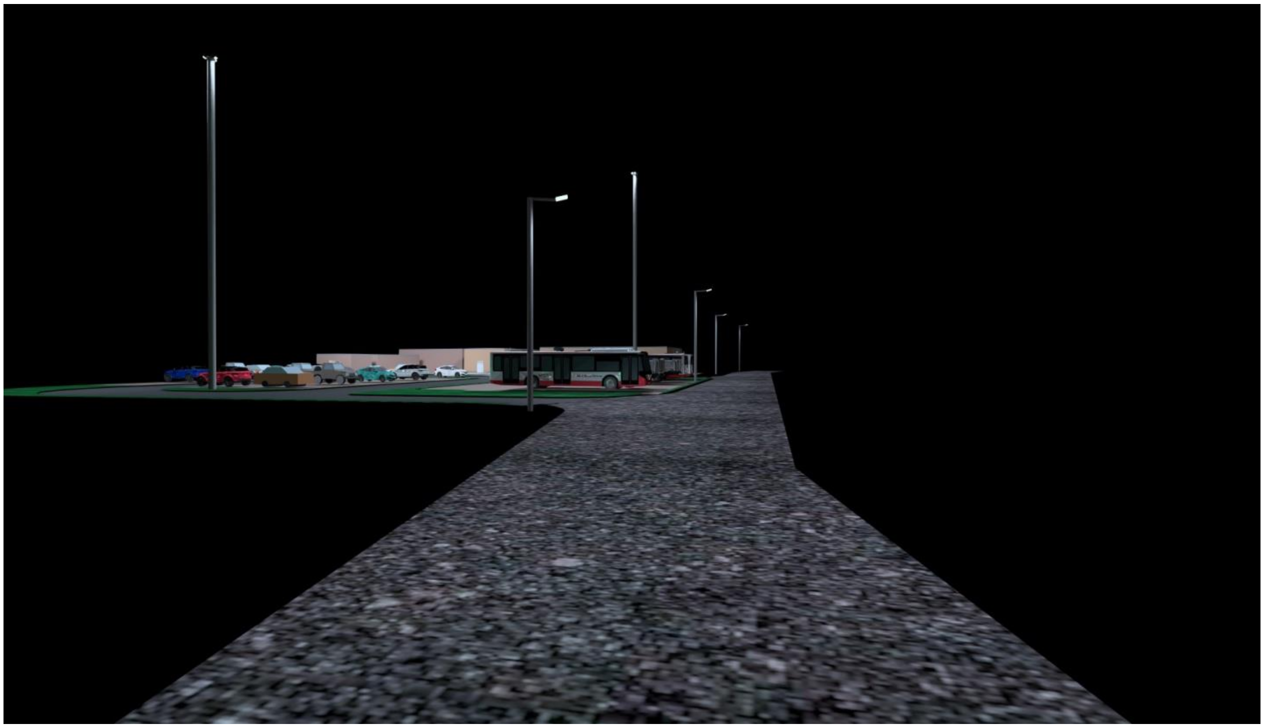


Fig.7.49: Simulated layout of the design

As illustrated in figure 7.49 the area is illuminated with two high masts along with street lights. As this is a public rest area too many high mast cannot be used in design approach because it may cause a cumbersome effort during maintenance down the timeline.



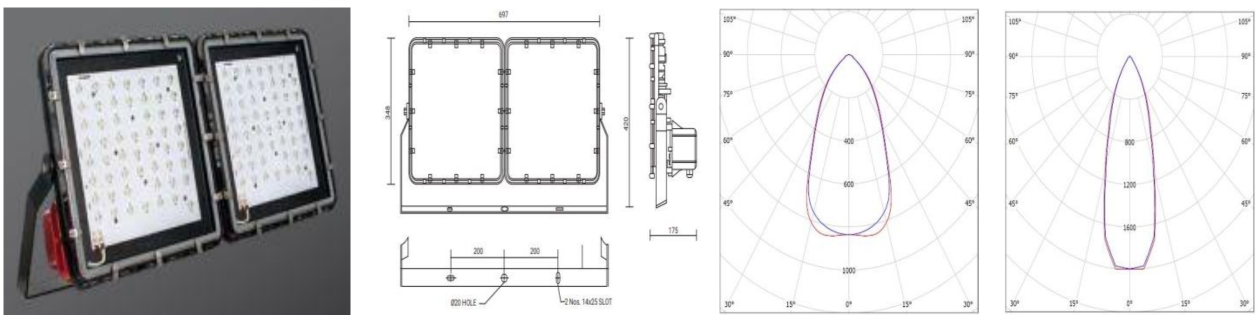
(a)

(b)

Fig.7.50 (a) & (b): Simulated 3D rendering of the design

Luminaire used

- Rectangular PDC Aluminum housing LED floodlight (as shown infigure 63)
- Luminous flux : 55000 & 62500 Lumen
- No. of High Mast : 2 Nos.
- Luminaires/Highmast : 5 Nos.
- Wattage : 500 Watt
- System efficacy : 110 lm/W & 125lm/W
- Beam angle and photometry type : 60 degree & 30 degree
  [NEMA TYPE– 3 & 4]
- CCT : 5700K
- CRI : 80
- IP 66 protected

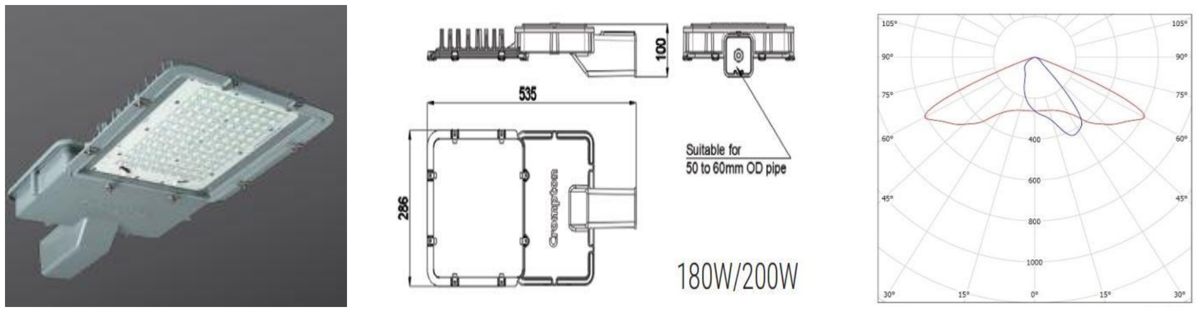


(a) (b) (c) (d)

Fig 7.51: (a) Floodlight image (b) floodlight dimension (c) 60 degree Polar curve (d) 30 degree polar curve

Luminiare Used

- Aerodynamically designed PDC Aluminum housing LEDstreetlight (as shown in figure 64)
- Luminous flux : 22500 Lumen
- Nos. of Luminaire used : 5 Nos.
- Wattage : 180 Watt
- System efficacy : 125 lm/W
- Throw : Short
- Control : Tight control [SLI > 4]
- Photometry type : Cut-off
- CCT : 5700K
- CRI : 80
- IP 66 protected



(a) (b) (c)

Fig 7.52: (a) 180 W Street light image (b) Street light dimension (c) Polar curve

7.17 Table of Result overview

FOR REST AREA

Photometric results	Average Illuminance (E_{avg}) [Lux]	Minimum Illuminance (E_{min}) [Lux]	Maximum Illuminance (E_{max}) [Lux]	Overall Uniformity (E_{min}/ E_{avg})	Overall Min/max (E_{min}/ E_{max})
Recommended Value as per standard	**N/A**	**40**	**N/A**	≥ 0.40	≥ 0.25
Achieved Result (Rest Area)	**76.76**	**41**	**112**	**0.53**	**0.37**
Achieved Result (Sec. Service Road)	**55.12**	**40**	**80**	**0.73**	**0.50**

Decisions to invest in Highway-lighting installations can only be made sensibly if there is a clear insight into the purpose and benefits of Highway Road lighting. The pioneer objective of Highway road lighting is to ensure visual comfort and visual performance for the motorist. An added benefit is that lighting makes the task of driving easier. This is particularly the case for the older driver, for whom the glare from oncoming traffic can result in a marked impairment of the capacity to discern objects. So stringent care has to be adopted by the lighting design practitioners such that all the visual requirements get implemented without compromising human performance metrics.

CHAPTER 8

RESULT ANALYSIS

Introduction

Light plays a central and manifold role in the design of a visual environment. Work and movement are only possible when we have light to see by; architecture, people and objects are only visible if there is visualsensation. Apart from simply making our surroundings visible light determines the way we perceive an environment, influences the way we feel and the aesthetic effect and atmosphere in a space. What is really required of lighting design that it meets all the lighting requirements – design concepts that form an integral part of the overall infrastructural design and produce a visual environment that supports various activities, promotes superior visual performance and feeling of well-being and is in line with the architectural design.

Today people are much more aware of their requirements and they believe in personalizing their surroundings & lighting plays a major role in that. Making of their own style statement, would demand a unique & compatible lighting solutions. This "humanization" of lighting has taken the lighting designer's attention from Light bulbs, the incandescent sources to the visual emotion through perfect lighting experience. The energy-efficient lighting solutions save monetary expenditures, as well as the environment. Being the lighting engineers our aim is to inspire people to live a greener life. The greener life means a life under the essence of nature accompanied by the sustainable development of technology & in the context of Lighting science & Engineering. The greener life aliases to the LED technology. Now a days, the benefits of LED lighting is well known to us specially to the engineers & technocrats working in this field.

Project Constraints

The true challenge of qualitative lighting design is developing a concept capable of meeting a wide range of objectives through a lighting installation that is both technically and aesthetically consistent. In contrast to quantitative concepts, which derive one general set of lighting qualities from a given profile of project requirements, almost invariably leading to a uniform and thus standard design using luminaires, qualitative lighting design must deal with complex patterns of required lighting qualities. From a technical, economic, and design standpoint, the goal of lighting design should be to create a solution that avoids a confusing and distracting jumble of lighting fixtures designed to cover a specific area.

Conclusion

The first task concept development has to deal with is the allocation of specific lighting qualities to the lighting tasks defined as a result of the project analysis; to define the lighting conditions that are to be achieved in specific locations. To begin with, this concerns the quantity and the various other criteria of the light in the individual areas, plus the order of importance of these individual aspects within the overall lighting concept. The allocation of lighting qualities to the individual lighting tasks in a project gives rise to a catalogue of design objectives, which takes into account the different requirements the lighting has to fulfill.

A practice-oriented design concept must therefore first describe how the desired lighting effects can be realized within the basic conditions and restrictions inherent to the project. The design concept may be required to correspond to specific standards, and it must keep within the budget with regard to both the investment costs and the operating costs.

Outdoor lighting defines beauty of the city, economic efficiency, safety and security. The outdoor luminaires consumes more power and gives out more lumen output compared to indoor. So the lighting design should be designed in such a way that the energy consumption for particular area has to be optimized and light pollution problems have to be minimized. Hence the lighting concept must also be coordinated with other engineering work to be effected on the project.

The result of the project analysis is a series of lighting tasks that are allocated to specific areas within the project highway, all of which form a characteristic matrix of requirements for a visual environment. The next phase following the project analysis is the development of a qualitative lighting design concept that outlines an idea of the qualities the lighting should possess such that visual performance and comfort of an observer becomes enhanced.

Future scope of work

Besides the objective requirements which result from the activities performed in a visual environment, attention must also be paid to the demands that stem from the users themselves. Many of these are concerned with the possibility of gaining better views of highway side surroundings. Another psychological aspect that has to be fulfilled is highlighting of a clearly structured environment as this is especially important in areas that are potentially subjected to danger.

Lighting, along with architectural infrastructure is improving the world regularly in terms of visualization. Lighting designers are trying their best to offer a dynamic world to the present & future generation, keeping in mind about energy efficient with smart handling lighting solution.

We know about the various advantages of green energy enabled smart highway lighting system but this is still lacking in terms of quality and comprehensiveness. To attain an energy efficient solution for highway lighting system different approaches can be identified considering alternative energy sources, accepting adaptive nature of lighting and exploiting modern technologies & protocols for various network layouts for example Smart, low cost, energy-efficient standalone highway lighting system can be incorporated. This specially scrutinizes green hybrid energy sources to ensure adequate power supply to lamppost and it integrates Iot based network configuration considering real time vehicle status for adaptive and seamless highway lighting operation. It also suggests competent communication protocols for successful data propagation and distribution. Web based controlling; monitoring & maintenance with featured applications can also be presented in the proposed system to unleash the potentiality of a smart standalone lighting system (SSLS) for highway application.

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Annexure

JINDAL STEEL PLANT MAIN SHED AREA

- Software Used : DIALux 4.13 & AutoCAD
- Project in Brief :

Preparing detail Illumination Design & BOQ of Bay Areas, ECR Building & Internal Streets with LED Luminaires. Initially the design has been done considering the exact luminaire type & Location as mentioned by client later optimized design was submitted as per our luminaire type & Location.

COMMON FACILITY CENTRE - KHUSJUNGLE INDUSTRIAL PARK

- Software Used : DIALux 4.13 & AutoCAD
- Project in Brief:

Illumination Design of Paint Booth, Finished Goods Store, Raw Material Store , Administrative Block & Exterior Area. Preparing Detail Illumination Design of the respective areas creating 3D Models, Selecting appropriate luminaire as per application also keeping energy saving in mind.

ADDITIONAL COAL HANDLING PLANT (10MTPA) AT RAJMAHAL OCP, EASTERN COALFIELDS LIMITED

- Software Used : DIALux 4.13 & AutoCAD
- Project Brief :

Prepared Illumination Design of Main Substation Building, Coal Receiving Complex, Coal Crushing Building, Junction Transfer House, Rapid Load Station, Coal Conveyor Gallery, Typical Periphery Area & Internal streets Following IS 6665 -1972.

ESIC NAGAR METRO STATION - MUMBAI METRO LINE 2B (MMRDA)

- Software Used : DIALux evo , DIALux 4.13 & AutoCAD
- Project in Brief :

Prepared Detailed Illumination design of Elevated Metro Station & Concourse Level . Studied AutoCAD drawings of respective areas in detail and its need, accordingly lighting design has been done on above mentioned Simulation Software.

SHILPA BIOCARE PVT LTD - KADECHUR INDUSTRIAL AREA

- Software Used : DIALux4.13 & AutoCAD
- Project In Brief :

Prepared Illumination Design & BOQ of Production Block & Warehouse of above mentioned Project after understanding Client's requirement using appropriate LED luminaires as per application.

Annexure

6 LANING OF VARANASI -AURANGABAD SECTION OF NH-2

- Software Used : Agi32
- Project in Brief :

Prepared Illumination Design of Typical Cross Sections after studying in detail Lighting Schedule & AutoCAD drawings of TCS.

ADIBASI BHAWAN AT JUNGLEKHAS MOUZA, WARD NO-13 JHARGRAM

- Software Used : Agi32 & DIALux 4.13
- Project in Brief :

Prepared Illumination Design & BOQ of Auditorium, Admin Block, OAT & Landscape under observation of PWD also design was done as per IS Standard & using energy efficient luminaires.

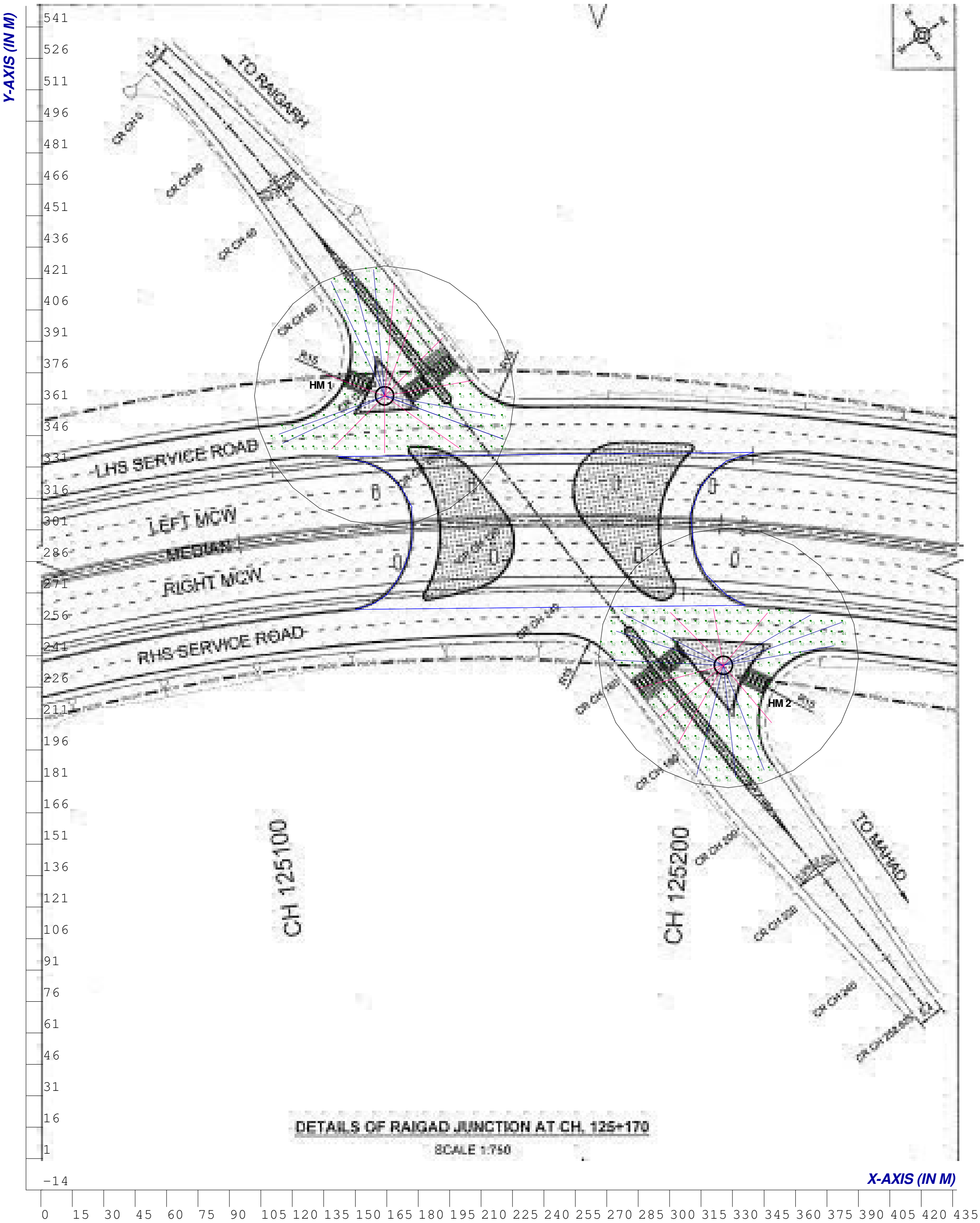
BAUXITE YARD AREA ,VEDANTA - LANJIGARH

- Software Used : Agi32
- Project in Brief :

Prepared Exterior Illumination Design of above mentioned area as per client's requirement using LED Floodlight Luminaires. The design aim was to meet the target illuminance level & provide uniform illumination over the working areas.

MAJOR JUNCTION ILLUMINATION DESIGN (CH 125+70)

(DESIGNED FOR MINIMUM ILLUMINANCE LEVEL OF 40 LUX)



DESIGN CONSIDERATIONS :

FOR MJ @LHS

NUMBER OF HIGHMAST : 1 NOS. (HM 1)
HEIGHT OF HIGHMAST : 25 M FROM GL
LUMINAIRES/HIGHMAST : 16 NOS
LUMINAIRE USED : 500 W LED FLOOD LIGHT
LUMINAIRE USED : 500 W LED FLOOD LIGHT
GRID SIZE : 5 M X 5 M

FOR MJ @RHS

NUMBER OF HIGHMAST : 1 NOS. (HM 2)
HEIGHT OF HIGHMAST : 25 M FROM GL
LUMINAIRES/HIGHMAST : 16 NOS
LUMINAIRE USED : 500 W LED FLOOD LIGHT
LUMINAIRE USED : 500 W LED FLOOD LIGHT
GRID SIZE : 5 M X 5 M

Luminaire Schedule

Symbol	Qty	Label	LLF	Description	Total Lamp Lumens
	15	E	0.850	CFS-506-500-57-60D-HL2-GL-NBR	62500
	17	A	0.850	CFS-506-500-57-10D-HL2-GL-NBR	62500

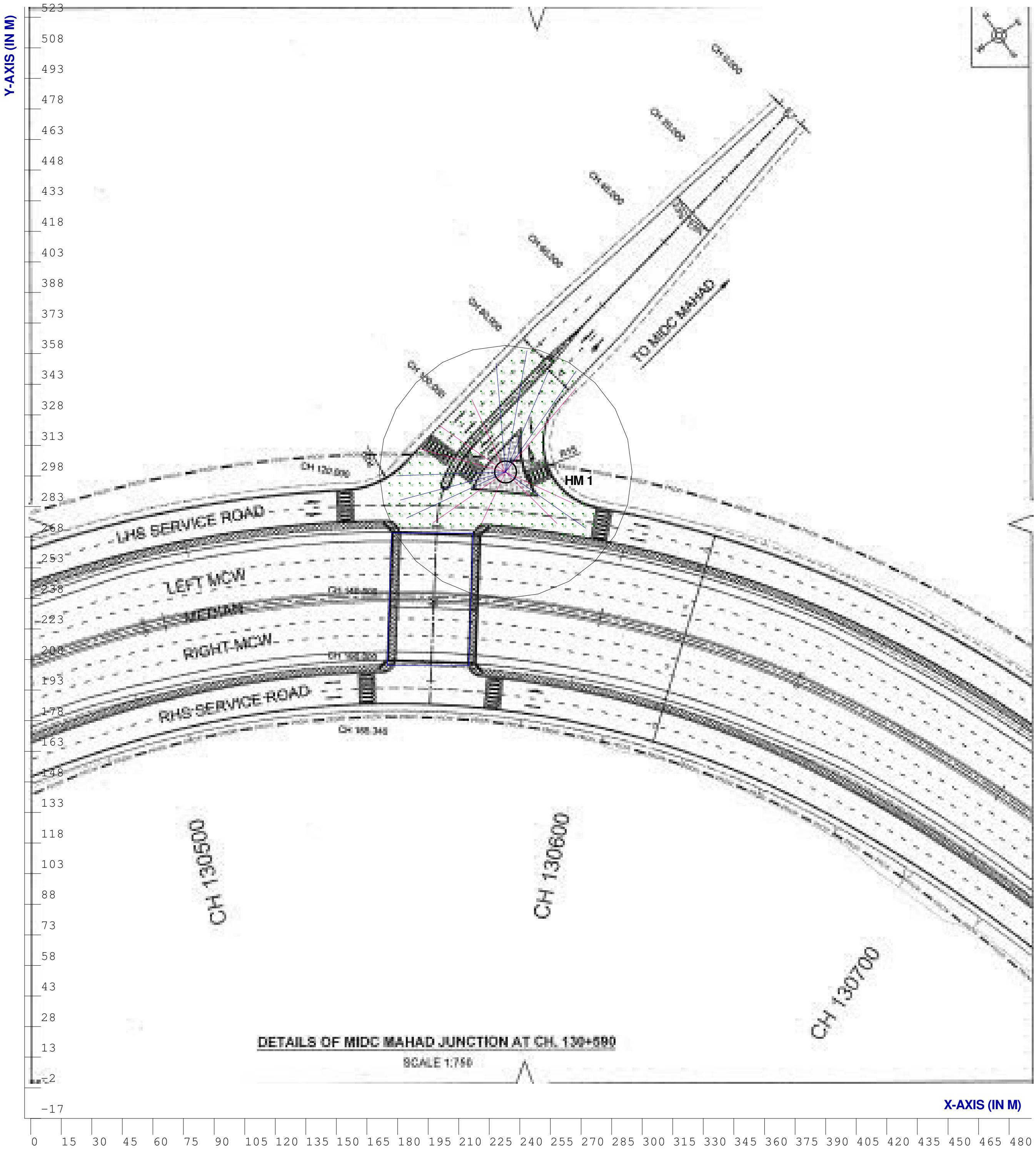
Calculation Summary

Label	CalcType	Units	Avg	Max	Min	Min/Avg	Min/Max
MAJOR JUNCTION LHS	Illuminance	Lux	66.68	98	40	0.60	0.41
MAJOR JUNCTION RHS	Illuminance	Lux	65.12	100	40	0.61	0.40

**** NOTE ****
1. HORIZONTAL CALCULATION GRID IS TAKEN AT GROUND LEVEL .
2. FLYOVER AS OBSTRUCTION IS CONSIDERED AS PER AutoCAD LAYOUT DURING LIGHTING DESIGN SIMULATION .

MAJOR JUNCTION ILLUMINATION DESIGN OF WADPALE BHOGAON (CH 130+590)

(DESIGNED FOR MINIMUM ILLUMINANCE LEVEL OF 40 LUX)



DESIGN CONSIDERATIONS :

NUMBER OF HIGHMAST : 1 NOS. (HM 1)
HEIGHT OF HIGHMAST : 25 M FROM GL
LUMINAIRES/HIGHMAST : 16 NOS
LUMINAIRE USED : 500 W LED FLOOD LIGHT
LUMINAIRE USED : 500 W LED FLOOD LIGHT
GRID SIZE : 5 M X 5 M

** NOTE **
1. HORIZONTAL CALCULATION GRID IS TAKEN AT GROUND LEVEL .
2. FLYOVER AS OBSTRUCTION IS CONSIDERED AS PER AutoCAD LAYOUT DURING LIGHTING DESIGN SIMULATION .

Calculation Summary

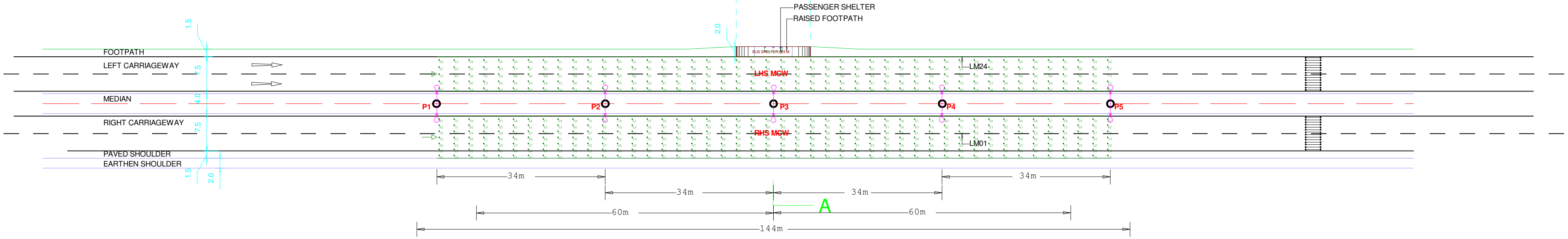
Label	CalcType	Units	Avg	Max	Min	Min/Avg	Min/Max
MAJOR JUNCTION LHS	Illuminance	Lux	66.63	100	40	0.60	0.40

Luminaire Schedule

Symbol	Qty	Label	Total Lamp Lumens	LLF	Description
	8	A	62500	0.850	CFS-506-500-57-60D-HL2-GL-NBR
	8	C	62500	0.850	CFS-506-500-57-10D-HL2-GL-NBR

ILLUMINATION DESIGN OF BUSBAY BHS

(DESIGNED FOR MINIMUM ILLUMINANCE LEVELOF 40 LUX)



LHS RHS MCW :

NUMBER OF STREET LIGHT POLES : 5 Nos. (P1 To P5)
POLE HEIGHT : 9 Mtr FROM ROAD LEVEL
ARRANGEMENT : DOUBLE ARM ON MEDIAN (P1 TO P6)
BRACKET ARM LENGTH: 2 Mtr
TILT : 15 DEGREE
DISTANCE BETWEEN POLES : 34 M
LUMINAIRE : 250W LED STREET LIGHT
MAINTENANCE FACTOR : 0.85

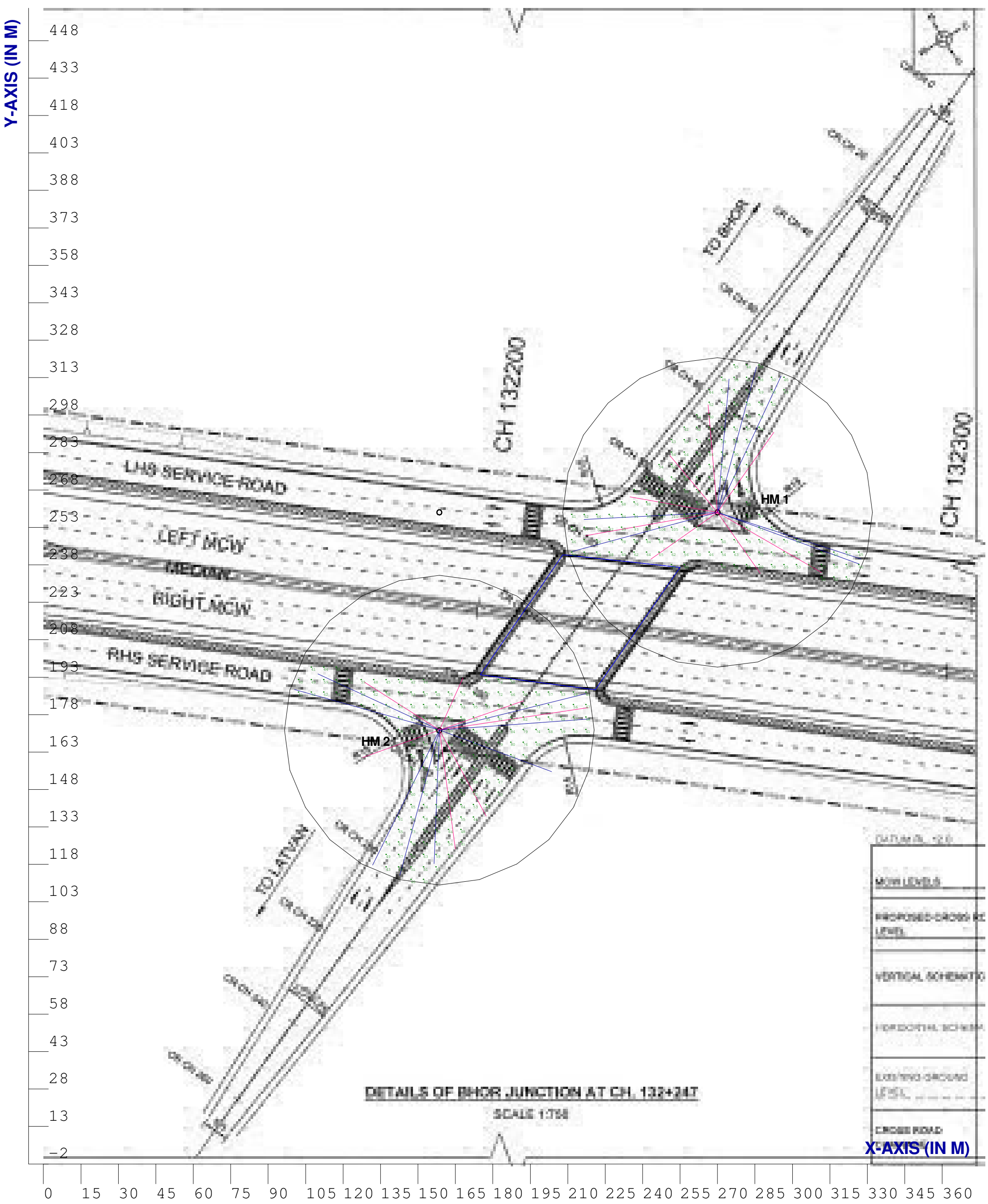
Calculation Summary

Label	CalcType	Units	Avg	Max	Min	Min/Avg	Min/Max
LHS MCW_Illum	Illuminance	Lux	56.00	82	40	0.71	0.49
RHS MCW_Illum	Illuminance	Lux	54.68	82	40	0.73	0.49

NOTE :
1.HORIZONTAL CALCULATION GRID IS CONSIDERED AT GROUND LEVEL .
2.BUS SHELTER OBSTRUCTION CONSIDERED DURING ILLUMINATION DESIGN CALCULATIONS.

MAJOR JUNCTION ILLUMINATION DESIGN (CH 132+247)

(DESIGNED FOR MINIMUM ILLUMINANCE LEVEL OF 40 LUX)



DESIGN CONSIDERATIONS :

FOR MJ @LHS

NUMBER OF HIGHMAST : 1 NOS. (HM 1)
HEIGHT OF HIGHMAST : 25 M FROM GL
LUMINAIRES/HIGHMAST : 15 NOS
LUMINAIRE USED : 500 W LED FLOOD LIGHT
LUMINAIRE USED : 500 W LED FLOOD LIGHT
GRID SIZE : 5 M X 5 M

FOR MJ @RHS

NUMBER OF HIGHMAST : 1 NOS. (HM 2)
HEIGHT OF HIGHMAST : 25 M FROM GL
LUMINAIRES/HIGHMAST : 15 NOS
LUMINAIRE USED : 500 W LED FLOOD LIGHT
LUMINAIRE USED : 500 W LED FLOOD LIGHT
GRID SIZE : 5 M X 5 M

Luminaire Schedule

Symbol	Qty	Label	Arrangement	Total Lamp Lumens	LLF	Description
	15	A	SINGLE	62500	0.850	CFS-506-500-57-10D-HL2-GL-NBR
	15	B	SINGLE	62500	0.850	CFS-506-500-57-60D-HL2-GL-NBR

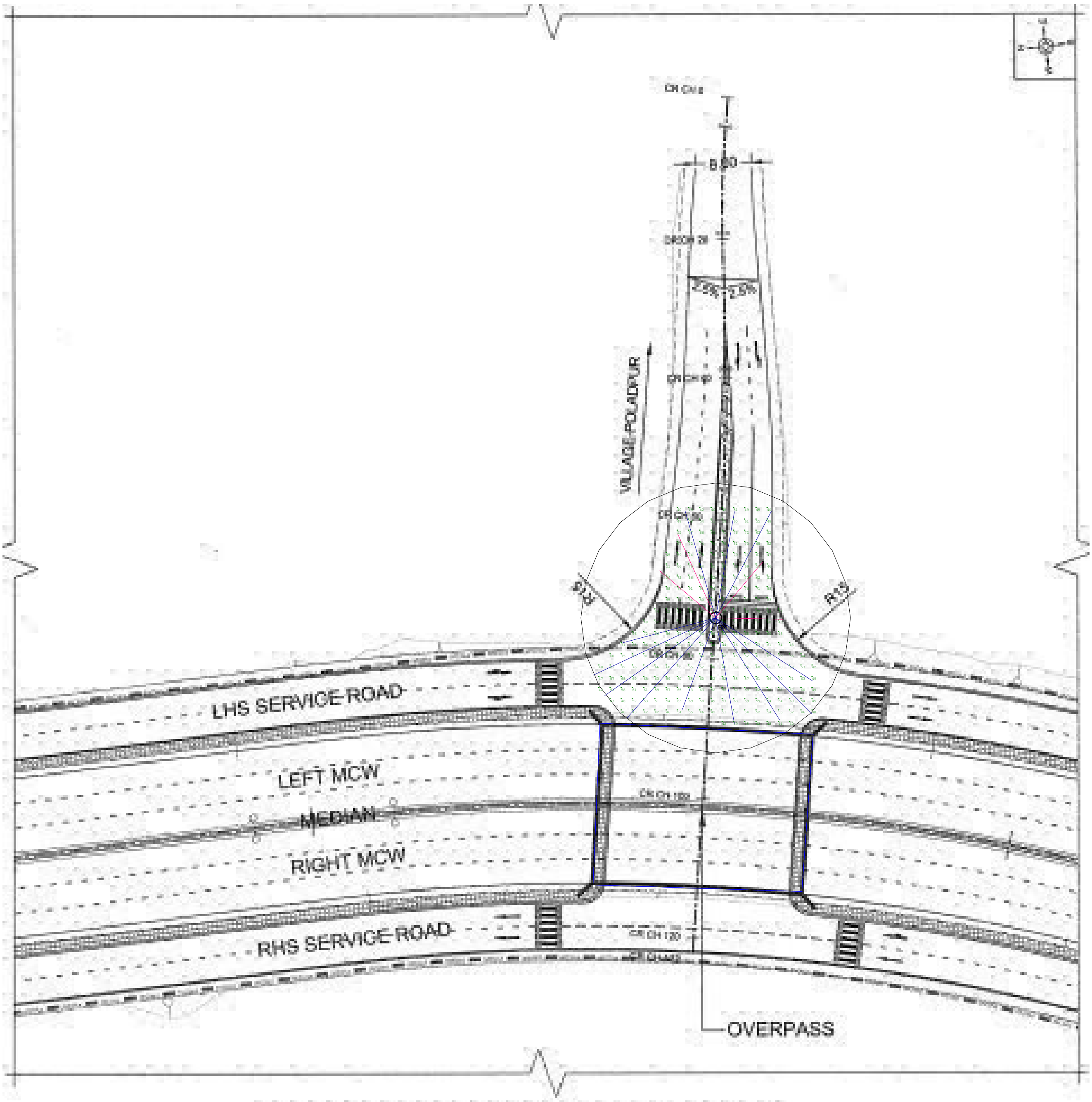
Calculation Summary

Label	CalcType	Units	Avg	Max	Min	Min/Avg	Min/Max
MAJOR JUNCTION LHS	Illuminance	Lux	68.76	110	40	0.58	0.36
MAJOR JUNCTION RHS	Illuminance	Lux	63.93	95	40	0.63	0.42

**** NOTE ****
1. HORIZONTAL CALCULATION GRID IS TAKEN AT GROUND LEVEL .
2. VUP AS OBSTRUCTION IS CONSIDERED AS PER AutoCAD LAYOUT DURING LIGHTING SIMULATION SIMULATION .

MAJOR JUNCTION ILLUMINATION DESIGN (CH 143+965)

(DESIGNED FOR MINIMUM ILLUMINANCE LEVEL OF 40 LUX)



DETAILS OF MAHABALESHWAR (POLADPUR) JUNCTION AT CH. 143+965

DESIGN CONSIDERATIONS :

FOR MJ @LHS

NUMBER OF HIGHMAST : 1 NOS. (HM 1)
HEIGHT OF HIGHMAST : 25 M FROM GL
LUMINAIRES/HIGHMAST : 15 NOS
LUMINAIRE USED : 500 W LED FLOOD LIGHT
LUMINAIRE USED : 500 W LED FLOODLIGHT
GRID SIZE : 5 M X 5 M

** NOTE **
1. HORIZONTAL CALCULATION GRID IS TAKEN AT GROUND LEVEL .
2. VOP AS OBSTRUCTION IS CONSIDERED AS PER AutoCAD LAYOUT DURING LIGHTING SIMULATION SIMULATION .

Luminaire Schedule

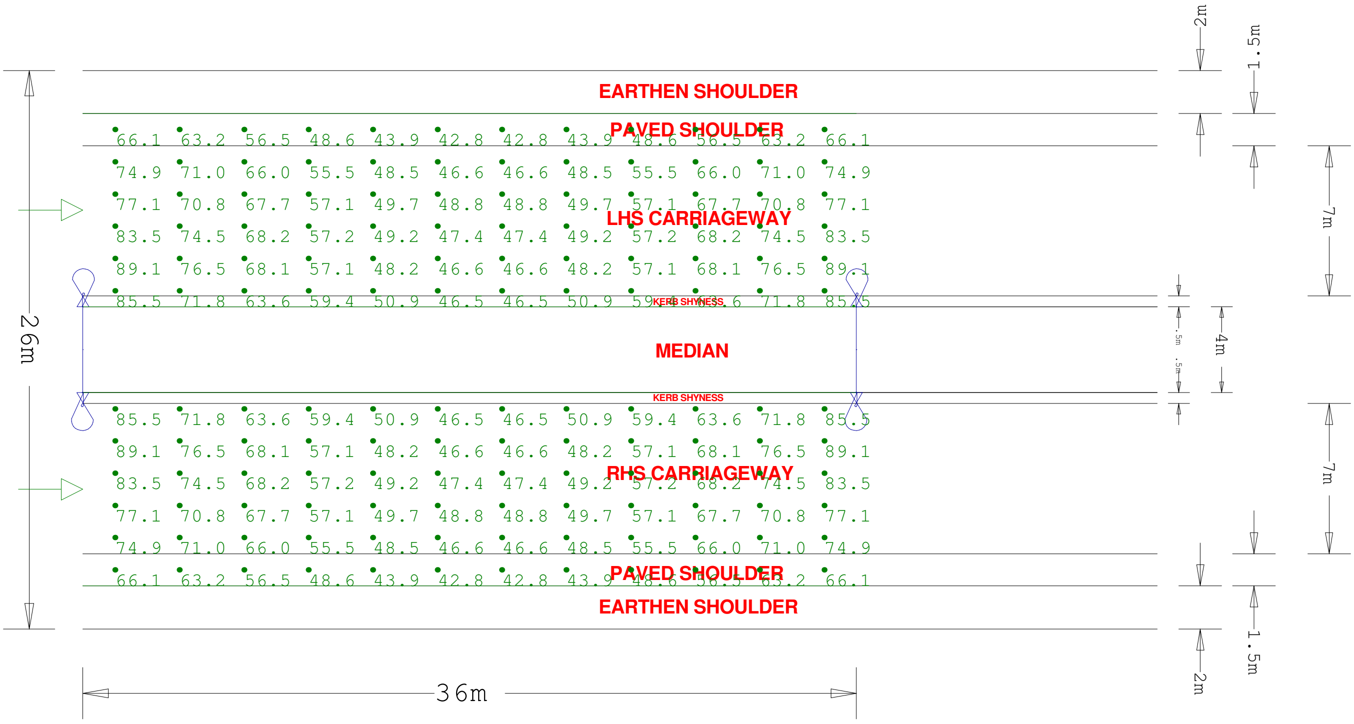
Symbol	Qty	Label	Arrangement	LLF	Description
→	4	B	SINGLE	0.850	CFS-506-500-57-60D-HL2-GL-NBR
→	12	A	SINGLE	0.850	CFS-506-500-57-10D-HL2-GL-NBR

Calculation Summary

Label	CalcType	Units	Avg	Max	Min	Min/Avg	Min/Max
MAJOR JUNCTION LHS	Illuminance	Lux	59.83	91	40	0.67	0.44

TCS TYPE I/II A ILLUMINATION DESIGN

(DESIGNED FOR MINIMUM ILLUMINANCE LEVEL OF 40LUX)



DESIGN CONSIDERATIONS (MCW SIDE) :

POLE HEIGHT : 9 Mtr FROM ROAD LEVEL
ARRANGEMENT : DOUBL ARM POLE ON MEDIAN / TWIN CENTRAL
ROAD WIDTH : 7 M CARRIAGEWAY + 1.5 M PAVED SHOULDER + 0.5 M KERB SHYNESS
BRACKET ARM LENGTH: 2 Mtr
TILT : 15 DEGREE
LUMINAIRE : 250 LED STREET LIGHT
MAINTENANCE FACTOR : 0.85

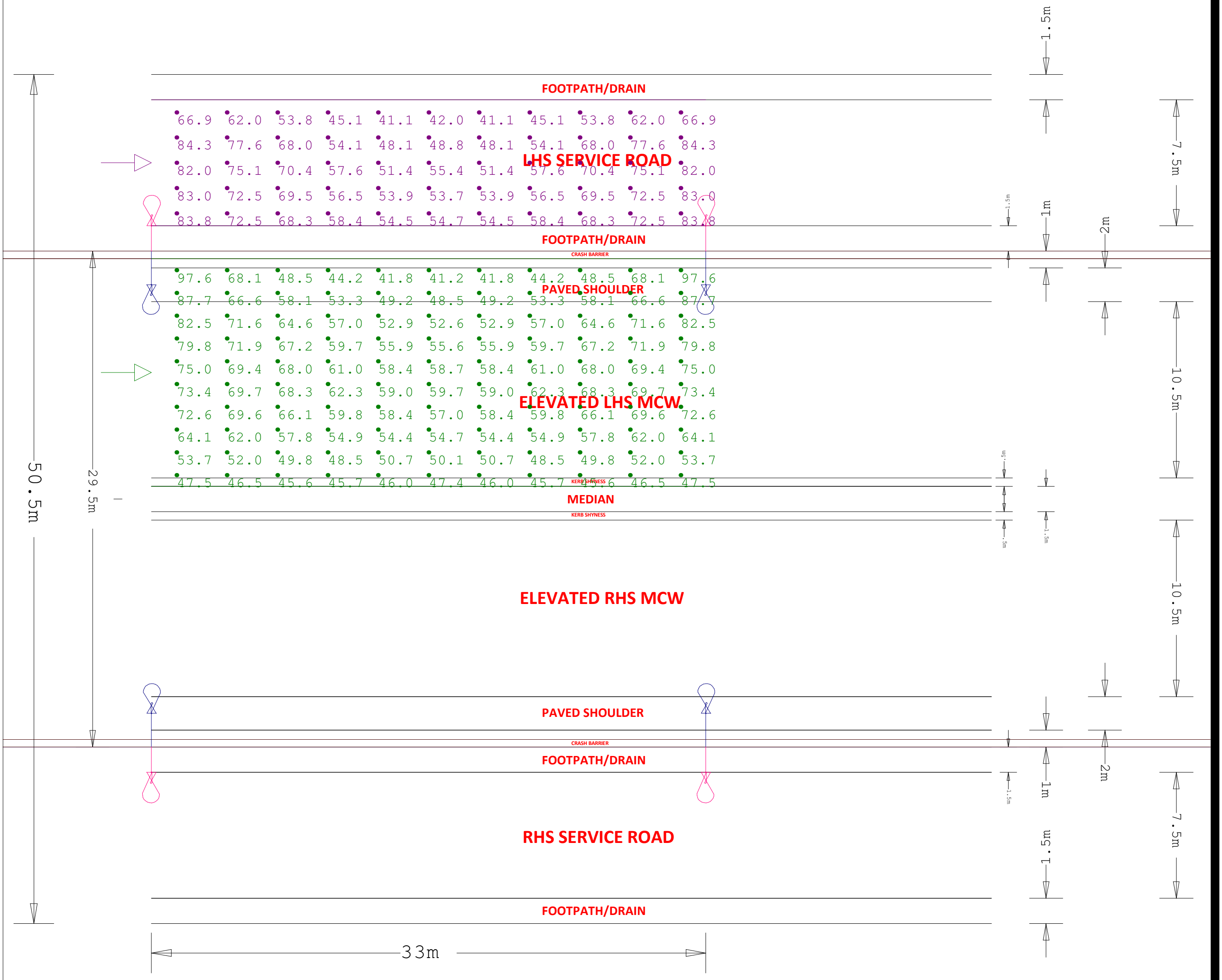
Calculation Summary							
Label	**CalcType**	**Units**	**Avg**	**Max**	**Min**	**Min/Avg**	**Min/Max**
LHS MCW_Illum	Illuminance	Lux	61.1	89.1	42.8	0.70	0.48
RHS MCW_Illum	Illuminance	Lux	61.1	89.1	42.8	0.70	0.48

POLE SPACING : 36 M

NOTE :
HORIZONTAL ILLUMINANCE LEVEL IS CONSIDERD AT EL 0 Mtr ABOVE G/L WITHOUT CONSIDERING ANY OBSTRUCTIONS

TCS TYPE V A ILLUMINATION DESIGN

(DESIGNED FOR MINIMUM ILLUMINANCE LEVEL OF 40LUX)



DESIGN CONSIDERATIONS :

FOR MCW

POLE HEIGHT : 9 Mtr ABOVE CRASH BARRIER ON ELV. CW
ROAD WIDTH : 10 M ELEV. CARRIAGEWAY + 2 M PAVED SHOULDER + 0.5 M KERB SHYNESS
ARRANGEMENT : OPPOSITE TWIN CENTRAL
BRACKET ARM LENGTH: 2 Mtr
TILT : 15 DEGREE
LUMINAIRE : 250 W LED STREET LIGHT
MAINTENANCE FACTOR : 0.85

FOR SERVICE ROAD

POLE HEIGHT : 9 Mtr ABOVE GROUND LEVEL
ROAD WIDTH : 7.5 M SERVICE ROAD ON BOTH LHS & RHS
ARRANGEMENT : OPPOSITE TWIN CENTRAL
(Single Arm Towards Service Road)
BRACKET ARM LENGTH: 1.5 Mtr
TILT : 5 DEGREE
LUMINAIRE : 200 W LED STREET LIGHT
MAINTENANCE FACTOR : 0.85

Calculation Summary

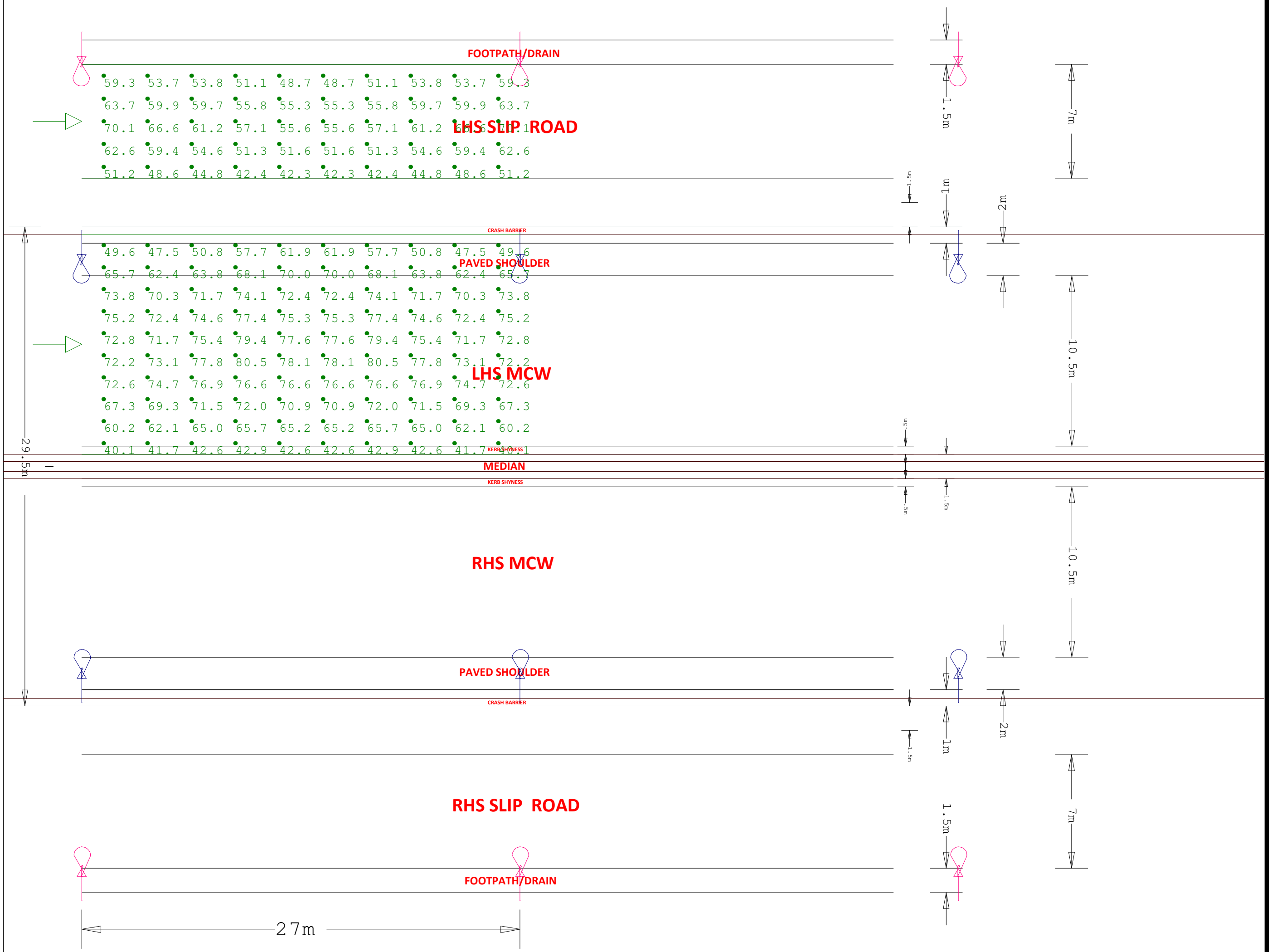
Label	CalcType	Units	Avg	Max	Min	Min/Avg	Min/Max
LHS MCW_Illum	Illuminance	Lux	60.20	97.6	41.2	0.68	0.42
LHS SERVICE ROAD_Illum	Illuminance	Lux	63.19	84.3	41.1	0.65	0.49

POLE SPACING : 33 M

NOTE :
HORIZONTAL ILLUMINANCE LEVEL AT EL 6 Mtr & 0 Mtr ABOVE G/L CONSIDERING CB & ELEVATED BRIDGE AS OBSTRUCTIONS
ELEVATED CARRIAGEWAY AS 6M HEIGHT HAS BEEN CONSIDERED AS OBSTRUCTION

TCS TYPE V B ILLUMINATION DESIGN

(DESIGNED FOR MINIMUM ILLUMINANCE LEVEL OF 40LUX)



DESIGN CONSIDERATIONS :

FOR MCW

POLE HEIGHT : 9 Mtr ABOVE FLYOVER
ROAD WIDTH : 10.5 M CARRIAGEWAY ON FLYOVER + 2 M PAVED SHOULDER ON FLYOVER + 0.5 M KERB SHYNESS
ARRANGEMENT : OPPOSITE SIDED ARRANGEMENT
BRACKET ARM LENGTH: 1.5 Mtr
TILT : 15 DEGREE
LUMINAIRE : 250 W LED STREET LIGHT
MAINTENANCE FACTOR : 0.85

FOR SLIP ROAD

POLE HEIGHT : 9 Mtr ABOVE GROUND LEVEL
ROAD WDITH : 7 M SLIP ROAD ON LHS & RHS
ARRANGEMENT : SINGLE SIDED ARRANGEMENT
BRACKET ARM LENGTH: 1.5 Mtr
TILT : 5 DEGREE
LUMINAIRE : 150 W LED STREET LIGHT
MAINTENANCE FACTOR : 0.85

Calculation Summary							
Label	CalcType	Units	Avg	Max	Min	Min/Avg	Min/Max
LHS MCW_Illum	Illuminance	Lux	67.0	80.5	40.1	0.60	0.50
LHS SLIP ROAD_Illum	Illuminance	Lux	55.2	70.1	42.3	0.77	0.60

POLE SPACING : 27 M

NOTE :
HORIZONTAL ILLUMINANCE LEVEL IS CONSIDERED AT EL 12.5 Mtr & 0 Mtr ABOVE G/L CONSIDERING CB & ELEVATED BRIDGE AS OBSTRUCTIONS
FLYOVER HAS BEEN CONSIDERED AS 12.5 M HEIGHT ABOVE GROUND LEVEL

TCS TYPE VII ILLUMINATION DESIGN

(DESIGNED FOR MINIMUM ILLUMINANCE LEVEL OF 40 LUX)

DESIGN CONSIDERATIONS (MCW SIDE) :

POLE HEIGHT : 9 Mtr FROM ROAD LEVEL
ROAD WIDTH : 10.5 M CARRIAGEWAY + 2 M PAVED SHOULDER + 0.5 M KERB SHYNESS
ARRANGEMENT : DOUBL ARM POLE ON MEDIAN / TWIN CENTRAL
BRACKET ARM LENGTH: 2 Mtr
TILT : 20 DEGREE
LUMINAIRE : 250 LED STREET LIGHT
MAINTENANCE FACTOR : 0.85

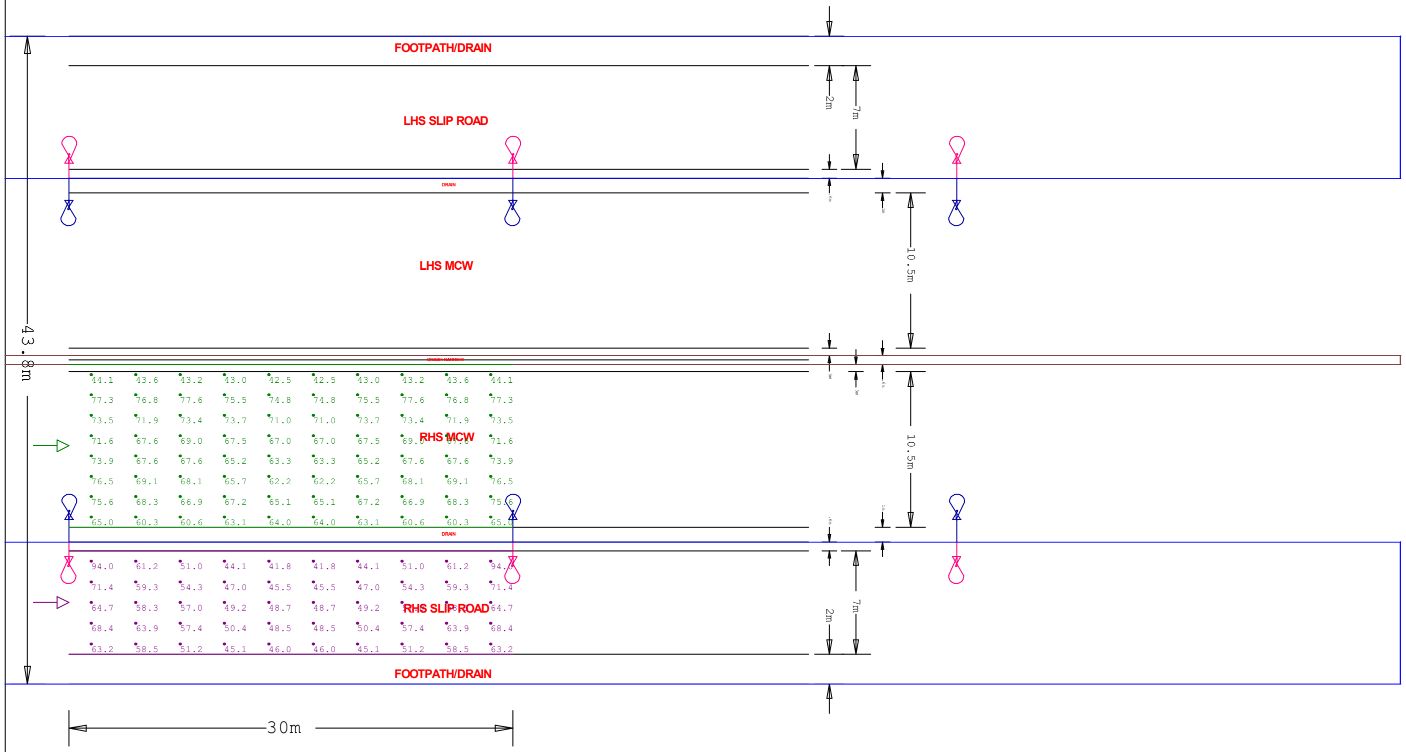
Calculation Summary							
Label	**CalcType**	**Units**	**Avg**	**Max**	**Min**	**Min/Avg**	**Min/Max**
RHS MCW_Illum	Illuminance	Lux	57.55	79.2	42.7	0.74	0.54

POLE SPACING : 32 M

NOTE :
HORIZONTAL ILLUMINANCE LEVEL IS CONSIDERED AT EL 0 Mtr ABOVE G/L CONSIDERING CRASH BARRIER AS OBSTRUCTION

TCS TYPE VIII ILLUMINATION DESIGN

(DESIGNED FOR MINIMUM ILLUMINANCE LEVEL OF 40 LUX)



DESIGN CONSIDERATIONS :

FOR MCW

POLE HEIGHT : 9 M ABOVE G/L LEVEL
ROADE WIDTH : 10.5 M CARRIAGEWAY + 0.5 M KERB SHYNESS
ARRANGEMENT : OPPOSITE TWIN CENTRAL
BRACKET ARM LENGTH: 1.5 Mtr
TILT : 20 DEGREE
LUMINAIRE : 200 W LED STREET LIGHT
MAINTENANCE FACTOR : 0.85

FOR SLIP ROAD

POLE HEIGHT : 9 M ABOVE ELEV. SLIP ROAD
ROAD WIDTH : 7 M SLIP ROAD ON BOTH LHS & RHS
ARRANGEMENT : OPPOSITE TWIN CENTRAL
(Single Arm Towards Slip Road)
BRACKET ARM LENGTH: 1 Mtr
TILT : 5 DEGREE
LUMINAIRE : 180 W LED STREET LIGHT
MAINTENANCE FACTOR : 0.85

Calculation Summary

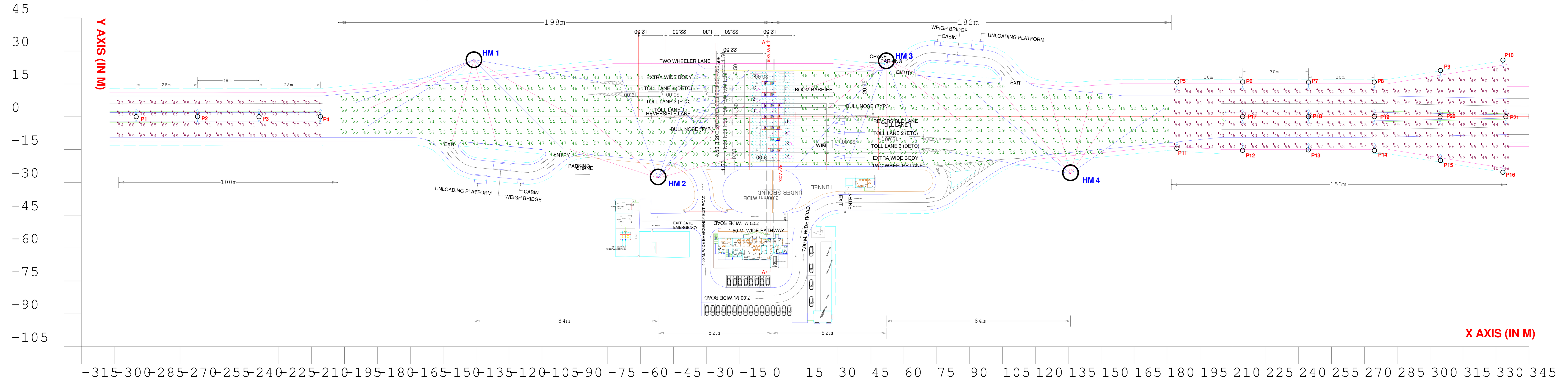
Label	CalcType	Units	Avg	Max	Min	Min/Avg	Min/Max
RHS MCW_Illum	Illuminance	Lux	66.0	77.6	42.5	0.64	0.55
RHS SLIP ROAD_Illum	Illuminance	Lux	56.0	94.0	41.8	0.75	0.44

POLE SPACING : 30 M

NOTE :
HORIZONTAL ILLUMINANCE LEVEL IS CONSIDERED AT EL 6.5 Mtr & 0 Mtr ABOVE G/L CONSIDERING CB, ELEV. SLIP ROAD AS OBSTRUCTION.
ELEV. SLIP ROAD AS 6 M HEIGHT IS CONSIDERED
POLE IS CONSIDERED AT THE EDGE OF DRAIN AREA

TOLL PLAZA ILLUMINATION DESIGN

(DESIGNED FOR MINIMUM ILLUMINANCE LEVEL OF 40 LUX)



DESIGN CONSIDERATIONS :
(LHS OF TOLL PLAZA)
NUMBER OF HIGHMAST : 2 NOS (HM 1 TO HM 2)
HEIGHT OF THE HIGHMAST : 30 M FROM GL
LUMINAIRES / HIGHMAST : 9
LUMINAIRE :
500 W LED FLOOD LIGHT /B
500 W LED FLOOD LIGHT /C
MEASUREMENT GRID : 5 M X 5 M

DESIGN CONSIDERATIONS :
(RHS OF TOLL PLAZA)
NUMBER OF HIGHMAST : 2 NOS (HM 3 TO HM 4)
HEIGHT OF THE HIGHMAST : 30 M FROM GL
LUMINAIRES / HIGHMAST : 8 & 7
LUMINAIRE :
500 W LED FLOOD LIGHT /B
500 W LED FLOOD LIGHT /C
MEASUREMENT GRID : 5 M X 5 M

DESIGN CONSIDERATIONS :
(TOLL PLAZA CANOPY AREA)
NUMBER OF LUMINAIRE : 24 NOS
MOUNTING HEIGTH OF LUMINAIRE :
5.575 M FROM GL
LUMINAIRE : 80 W UNDER CANOPY /A
MEASUREMENT GRID : 1.5 M X 1.5 M

DESIGN CONSIDERATIONS :
(LHS APPROACH ROAD)
NUMBER OF STREET LIGHT POLES : 4 NOS (P1 -P4)
HEIGHT OF THE POLE : 9 M FROM GL
ARRANGEMENT : TWIN-CENTRAL
(DOUBLE ARM POLE ON MEDIAN)
BRACKET ARM LENGTH : 1.5 M
LUMINAIRE TILT : 5 DEGREE
LUMINAIRE:
180 W LED STREET LIGHT /F
DISTANCE BETWEEN POLES : 28 M APPROX
MEASUREMENT GRID : 5 M X 5 M

DESIGN CONSIDERATIONS :
(LHS APPROACH ROAD)
NUMBER OF STREET LIGHT POLES : 17 NOS (P5 -P21)
HEIGHT OF THE POLE : 9 M FROM GL
ARRANGEMENT : TWIN-CENTRAL (DOUBLE ARM POLE ON MEDIAN)
& OPPOSITE SIDED ARRANGEMENT
BRACKET ARM LENGTH : 1.5 M
LUMINAIRE TILT : 20 DEGREE
LUMINAIRE:
180 W LED STREET LIGHT /F
DISTANCE BETWEEN POLES : 30 M APPROX
MEASUREMENT GRID : 5 M X 5 M

Calculation Summary

Label	CalcType	Units	Avg	Max	Min	Min/Avg	Min/Max
APPROACH ROAD OF TP LHS	Illuminance	Lux	64.74	87	43	0.66	0.49
APPROACH ROAD OF TP RHS	Illuminance	Lux	65.17	90	40	0.61	0.44
LHS OF TOLL PLAZA	Illuminance	Lux	62.55	102	40	0.64	0.39
RHS OF TOLL PLAZA	Illuminance	Lux	61.56	95	40	0.65	0.42
TOLL CANOPY AREA	Illuminance	Lux	152.29	211	88	0.58	0.42

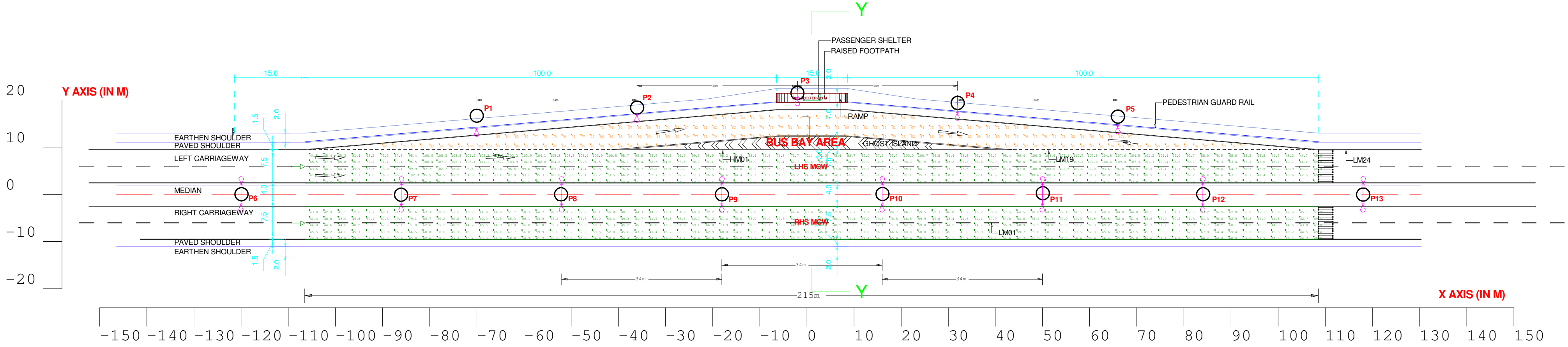
Luminaire Schedule

Symbol	Qty	Label	Total Lamp Lumens	LLF
	24	A	8800	0.850
	15	B	61885	0.850
	18	C	62500	0.850
	30	F	22500	0.850

** NOTE **
1.CANOPY , TOLL BOOTH & ADMIN BUILDING ARE TAKEN AS OBSTRUCTION DURING ILLUMINATION DESIGN CALCULATIONS .
2.HORIZONTAL CALCULATION GRID IS TAKEN AT GROUND LEVEL .

ILLUMINATION DESIGN OF BUSBAY LHS - RHS

(DESIGNED FOR MINIMUM ILLUMINANCE LEVEL OF 40 Lux)



LHS RHS MCW :

NUMBER OF STREET LIGHT POLES : 8 Nos. (P6 - P13)
POLE HEIGHT : 9 Mtr FROM ROAD LEVEL
ARRANGEMENT : DOUBLE ARM ON MEDIAN
BRACKET ARM LENGTH: 2 Mtr
TILT : 15 DEGREE
DISTANCE BETWEEN POLES : 34 M
LUMINAIRE : 250W LED STREET LIGHT
MAINTENANCE FACTOR : 0.85

BUS BAY AREA :

NUMBER OF STREET LIGHT POLES : 5 Nos. (P1 - P5)
POLE HEIGHT : 9 Mtr FROM ROAD LEVEL
ARRANGEMENT : SINGLE SIDED ARRANGEMENT
BRACKET ARM LENGTH: 2 Mtr
TILT : 15 DEGREE
DISTANCE BETWEEN POLES : 34 M
LUMINAIRE : 250W LED STREET LIGHT
MAINTENANCE FACTOR : 0.85

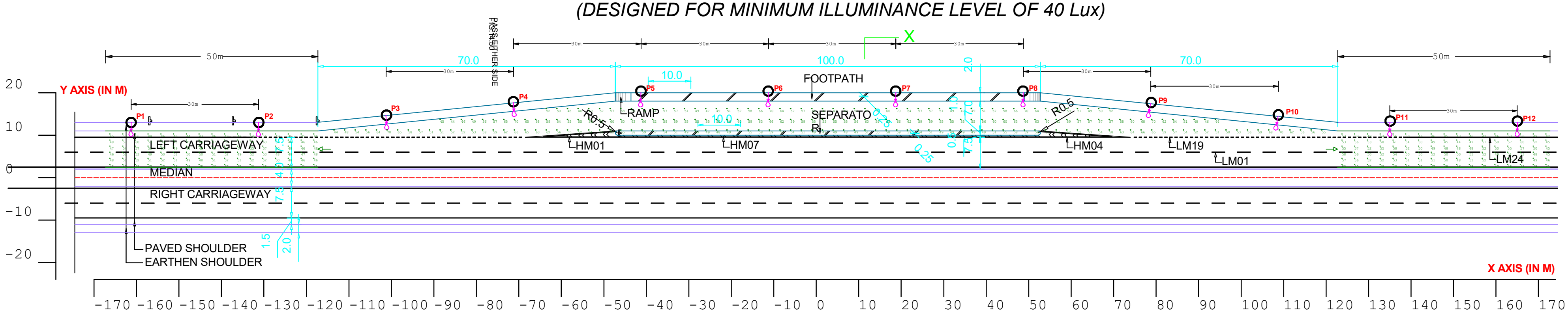
Calculation Summary

Label	CalcType	Units	Avg	Max	Min	Min/Avg	Min/Max
BUS BAY AREA	Illuminance	Lux	80.64	109	46	0.57	0.42
LHS MCW_Illum	Illuminance	Lux	79.58	111.2	40.6	0.51	0.37
RHS MCW_Illum	Illuminance	Lux	55.99	84.7	40.7	0.73	0.48

NOTE :
1.HORIZONTAL CALCULATION GRID IS CONSIDERED AT GROUND LEVEL .
2.BUS SHELTER OBSTRUCTION CONSIDERED DURING ILLUMINATION DESIGN CALCULATIONS.
3.MCW ILLUMINATION CONTRIBUTION CONSIDERED DURING ILLUMINATION DESIGN CALCULATIONS.

TRUCKLAY BYE ILLUMINATION DESIGN

(DESIGNED FOR MINIMUM ILLUMINANCE LEVEL OF 40 Lux)



APPROACH ROAD (LHS & RHS MCW) :

NUMBER OF STREET LIGHT POLES : 4 Nos. (P1 - P2 & P11 - P12)
POLE HEIGHT : 9 Mtr FROM ROAD LEVEL
ARRANGEMENT : SINGLE SIDED ARRANGEMENT
BRACKET ARM LENGTH: 1.5 Mtr
TILT : 15 DEGREE
DISTANCE BETWEEN POLES : 30 M
LUMINAIRE : 200W LED STREET LIGHT
MAINTENANCE FACTOR : 0.85

TRUCKLAY BYE AREA :

NUMBER OF STREET LIGHT POLES : 8 Nos. (P3 - P10)
POLE HEIGHT : 9 Mtr FROM ROAD LEVEL
ARRANGEMENT : SINGLE SIDED ARRANGEMENT
BRACKET ARM LENGTH: 1.5 Mtr
TILT : 10 DEGREE
DISTANCE BETWEEN POLES : 30 M
LUMINAIRE : 200W LED STREET LIGHT
MAINTENANCE FACTOR : 0.85

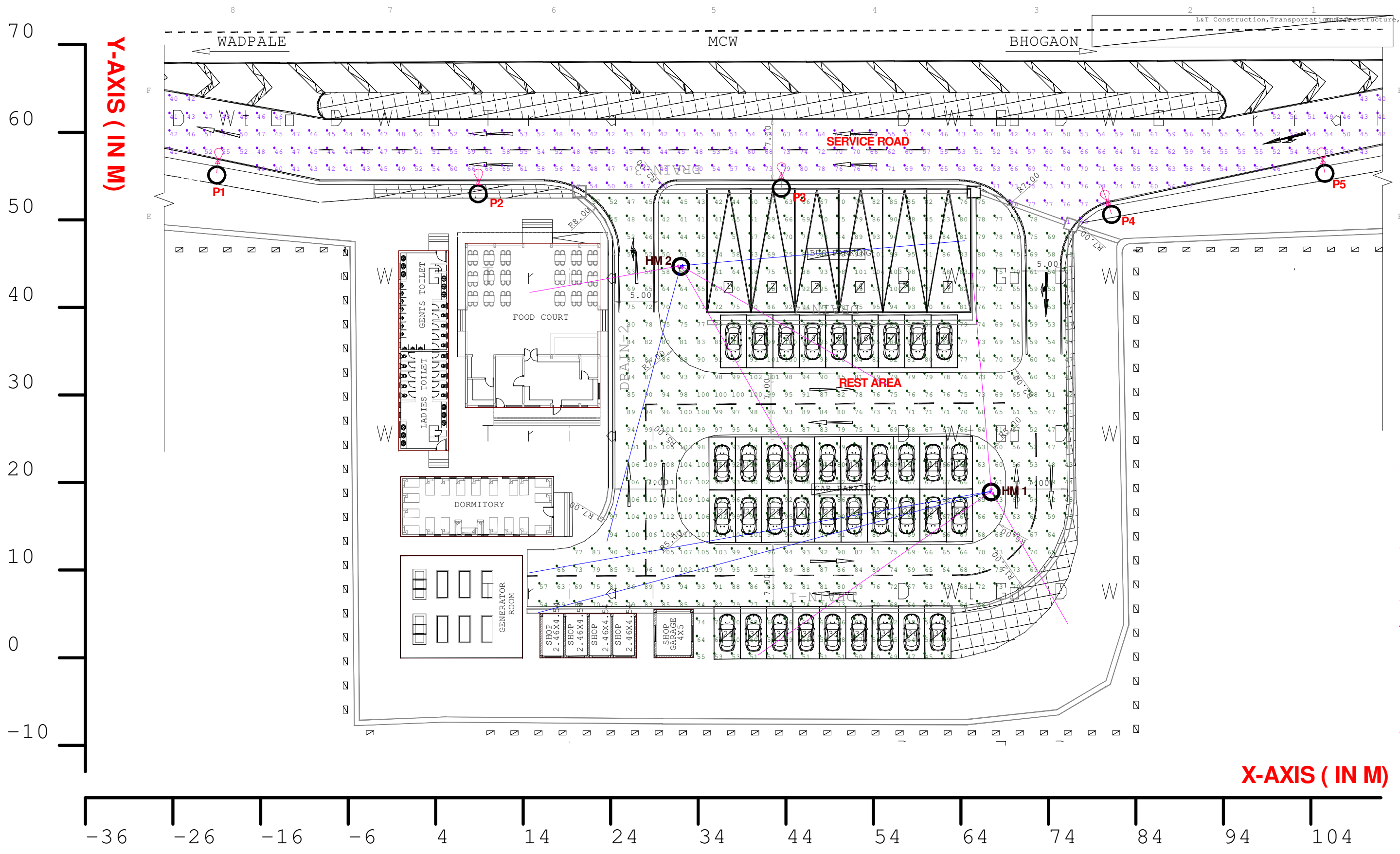
Calculation Summary

Label	CalcType	Units	Avg	Max	Min	Min/Avg	Min/Max
APPROACH ROAD LHS_Illum	Illuminance	Lux	49.1	60	41	0.83	0.68
APPROACH ROAD RHS_Illum	Illuminance	Lux	50.4	61	41	0.81	0.67
TRUCK LAY BYE	Illuminance	Lux	56.2	70	44	0.78	0.63

NOTE :
1.HORIZONTAL CALCULATION GRID IS CONSIDERED AT GROUND LEVEL WITHOUT ANY OBSTRUCTIONS .
2.MCW ILLUMINATION CONTRIBUTION CONSIDERED DURING ILLUMINATION DESIGN CALCULATIONS.

REST AREA EXTERIOR ILLUMINATION DESIGN

(DESIGNED FOR MINIMUM ILLUMINANCE LEVEL OF 40 LUX)



DESIGN CONSIDERATIONS
(REST AREA)

NUMBER OF HIGHMAST : 2 NOS (HM 1 & HM 2)
HEIGHT OF THE HIGHMAST : 25 M FROM GL
LUMINAIRES PER HIGHMAST : 5 NOS .
MEASUREMENT GRID : 2 M X 2 M

LUMINAIRE USED:
500 W LED FLOODLIGHT
500 W LED FLOODLIGHT

DESIGN CONSIDERATIONS
(SERVICE ROAD)

NUMBER OF STREET LIGHT POLE : 5 Nos.
(P 1- P 5)
HEIGHT OF THE POLE : 9 M FROM GL
ARRANGEMENT : SINGLE SIDED
LUMINAIRE : 180 W LED STREET LIGHT
BRACKET ARM LENGTH : 1 M
TILT : 15 DEGREE
MEASUREMENT GRID : 2 M X 2 M

Calculation Summary

Label	CalcType	Units	Avg	Max	Min	Min/Avg	Min/Max
REST AREA	Illuminance	Lux	76.76	112	41	0.53	0.37
SERVICE ROAD	Illuminance	Lux	55.12	80	40	0.73	0.50

Object Summary

Label	Type
DORMITORY	Rect-Flat
FOOD COURT	Rect-Flat
GENERATOR ROOM	Rect-Flat
SHOP	Rect-Flat
SHOP GARAGE	Rect-Flat
TOILET	Rect-Flat

NOTE :
HORIZONTAL CALCULATION GRID IS CONSIDERED AT GROUND LEVEL WITH BUILDING OBSTRUCTIONS