ANALYSIS AND EVALUATION OF OUTDOOR PUBLIC LIGHTING DESIGN : "A WALK TO REMEMBER"

A Thesis Submitted Towards Partial Fulfilment of the Requirements for the Degree of

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IN

ILLUMINATION TECHNOLOGY & DESIGN

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MASTER OF TECHNOLOGY IN
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I hereby declare that this thesis contains literature survey and original research work by the undersigned candidate, as part of the thesis for the degree of **Master of Technology in Illumination Technology and Design**, in School of Illumination Science, Engineering and Design, studies during academic session 2022-2023.

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

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ANUBRATA SENGUPTA

LIST OF CONTENTS

LIST OF FIGURES

ABSTRACT

Lighting design is often considered both an art and an engineering discipline, guided by specific principles. Looking towards the future, the prospects for outdoor public lighting design and systems in India are diverse and promising. This expansive outlook involves the implementation of adaptive intelligent lighting systems, harmonizing lighting with the smart cities concept, prioritizing human health and well-being, infusing artistic and aesthetic considerations into designs, ensuring cost-effective maintenance practices, and establishing robust regulatory frameworks. By wholeheartedly embracing these opportunities and addressing associated challenges, India can pave the way for outdoor lighting that not only fulfils functional requirements but also contributes to sustainability, safety, and the overall enhancement of public spaces. The core of this thesis centers on a comparative analysis of outdoor public lighting design metrics in Rajarhat and Siliguri. This exploration has illuminated significant differences and opportunities within these distinct urban contexts. While Rajarhat demonstrated a higher deployment of luminaires, leading to concerns about light pollution and skyglow, Siliguri presented lower light levels, raising safety and security issues in poorly lit areas. Both cities confronted the challenge of light pollution to varying extents, emphasizing the need to strike a delicate balance between illumination and its ecological consequences.

1. INTRODUCTION

Light defines how we perceive and appreciate every other element in a design may it be colour, texture, space or form. Lighting or illumination is the deliberate use of light to achieve effects in the form of practical or aesthetic. It's often said that lighting is as much an art as it is engineering, but the art of design can be reduced to a series of guiding principles. "Lighting" is the application of light to spaces. Where the light is placed, at what relative intensities, and in what direction, can have a major impact not only on vision and visual comfort, but also perception. Lighting, therefore, can impact satisfaction, visibility, task performance, safety, security, sales, mood and atmosphere, aesthetic judgment and social interaction. It also tells a story about the space, for example how one can focus on the products at sale, or the type of restaurant, or maybe the kind of work ongoing. All these results that the space's lighting defines its personality and how people perceive it, which in turn affects how they feel about being there.

Psychological impact	Lighting effect	Light distribution
TENSE	Intense direct light from above	Non-uniform
RELAXED	Lower overhead lighting with some lighting at room perimeter, warm color tones	Non-uniform
WORK/VISUAL CLARITY	Bright light on workplane with less light at the perimeter, wall lighting, cooler color tones	Uniform
SPACIOUSNESS	Bright light with lighting on walls and possibly ceiling	Uniform
PRIVACY/INTIMACY	Low light level at activity space with a little perimeter lighting and dark areas in rest of space	Non-uniform

FIG 1.1: LIGHTING EFFECT AND PSYCHOLOGICAL IMPACT

The good lighting design is standing on four pillars as in : Has Function, Has Direction, Creates Space and Defines or Reflects Colour. Lighting is mainly of two forms, Indoor Lighting and Outdoor Lighting. Lighting of spaces also takes into consideration the public spaces outdoor that plays a crucial part of every user. Initially, in the Middle Ages, the lighting, that was not yet called public, was first concentrated near the places of power (the castle), before then extending to the bourgeois neighbourhoods. But with time, the necessity came irrespective of any place for better visual, safety, security and aesthetics. The lighting design of

outdoor public spaces plays a crucial role in creating a captivating and functional environment that caters to both safety and aesthetic aspects. Thoughtful illumination can transform these spaces into vibrant and inviting areas, fostering a sense of community and promoting night time activities. Carefully placed lighting fixtures, such as lampposts, wall-mounted luminaires, and ground lights, not only ensure visibility and security but also accentuate architectural features and landscape elements. Strategic use of different lighting techniques, such as uplighting, downlighting, and silhouette lighting, adds depth and drama to the surroundings, creating a captivating ambiance. Additionally, energy-efficient technologies, such as LED lighting with smart controls, help minimize environmental impact and maintenance costs. An expertly designed lighting plan for outdoor public spaces can truly enrich the nocturnal landscape, enhancing the overall urban experience for residents and visitors alike.

1.1 AIM

- To create a comparative study between the Outdoor Public Lighting design metrics of Rajarhat and Siliguri

This aim signifies the primary goal of the research, which is to conduct a comprehensive analysis and evaluation of the outdoor public lighting systems in two specific locations, Rajarhat and Siliguri. The term "design metrics" here implies that the study will focus on various quantitative and qualitative aspects related to the lighting infrastructure in these areas. This research aims to not only understand the lighting systems in isolation but also to compare and contrast them. It involves a side-by-side examination of lighting designs in Rajarhat and Siliguri individually to identify similarities, differences, strengths, and weaknesses.

- Planning out new designs and suggest a better solution considering all the factors affecting the design errors considering the Indian Standards:

This aim outlines the practical outcomes and contributions expected from the research. It implies that the study aims not only to analyze the existing lighting systems but also to propose improved designs that align with Indian standards

and regulations. This research goal involves using the insights gained from the comparative study to develop innovative outdoor public lighting designs. These new designs should address the shortcomings and errors identified in the existing lighting systems.

1.2 OBJECTIVES

Every research work is performed to achieve certain goals for a better and greener future. The objectives for the research work are:

- Rajarhat being a Smart City can be further polished in public lighting design as per the Indian Standards
- Strict adherence to the recommended metrics and avoid as much possible light pollution.
- Providing lighting solution promoting safety, security and accessibility preserving the urban nightscape
- Upgrading Public Lighting design of Siliguri to be at par with Smart City Standards considering the nearby geographical constraints for a better nightscape and economic boost post sun hours.
- Suggesting Energy Efficient designs considering the environmental sustainability and limited maintenance
- Promote more and more community engagement boosting the cultural and architectural enhancement keeping light pollution to the lowest.

2. LITERATURE SURVEY

Artificial light is an essential element of urban environments—not only after dark, but also as part of a city's identity. It affects residents' sense of safety and social inclusion, and also influences the degree to which cities can create an inviting environment for business and tourism. Lighting brings up a fantastic option for habitation development along with the aesthetic need for the residents. With a smart approach and considering the modern technologies, lighting can achieve all the goals required for any city considering all the infrastructural constraints being both economic and energy saving. A few recent works are discussed below as a review on the current scenario.

E. Spunei et al. in his work shared the importance of ugrading the public lighting system. Adding more, the work presents a case study advocating for smart outdoor illumination installations with energy management systems. Replacing outdoor light sources with LEDs and an energy management system resulted in a 40% energy reduction and higher luminance coefficients compared to sodium vapor sources.

Ganireddy Tilak Aditya et al. discussed the importance of energy efficiency in modern smart systems, particularly in outdoor lighting systems. Conventional bulbs are known to waste significant amounts of energy, so author concentrated on making smartness and efficiency crucial for reducing power consumption. The proposed lighting system aims to optimize energy usage by operating street lights in a smart and efficient manner. It utilizes MQTT, an IoT lightweight protocol, along with sensors and controllers to manage groups of lamps through an MQTT broker. This approach presents a promising solution to enhance energy efficiency in outdoor lighting systems.

Wojnicki et al. introduced a smart lighting design approach for outdoor lighting systems. The current design process is time-consuming and prone to errors due to its trial and error nature and involving multiple software components. To enhance the process, the authors propose automating transitions between selected stages, leading to the development of a prototype software component. This component integrates photometric calculations with photo-realistic rendering, significantly improving the design process and enhancing interaction with

designers. The proposed approach offers a more efficient and interactive way to optimize outdoor lighting design.

Ullman et al. focused on the operation and maintenance of lighting systems in substations of transmission systems. It is divided into two parts: the first part discusses indoor lighting in substation buildings, while the second part covers new outdoor lighting solutions, including fence lighting, road lighting, and work area lighting. The implementation of a new substation lighting system allows for monitoring and diagnosis during operation, with a particular emphasis on the condition of luminaires. This is crucial for inspection and common maintenance practices, such as Condition Based Maintenance (CBM). Overall, the article highlights the significance of efficient lighting management in substations, ensuring safety and optimal functioning through effective maintenance strategies.

Amjad Omar et al. highlights the significance of energy conservation to address carbon impact and global warming issues, leading to the emergence of smart street lighting systems with various features. These systems incorporate sensors for light intensity control and connectivity to monitor weather conditions and detect lamp failures remotely. The paper reviews multiple research studies on smart street lighting systems, offering a comparative analysis that underscores the limitations of each system. Additionally, it discusses current trends and provides insights into potential future developments in this field.

With time, works on the optimization techniques and design aspects increased with the demand and urbanization. There was a heavy growth in the field of optimizing the design and a few works are mentioned below.

C. Skandali et al. discussed on the optimization of outdoor lighting in contemporary cities and its potential negative effects on public areas, the environment, and driving safety. It advocates for the use of new technologies and smart lighting management systems to achieve a balanced approach between user needs, safety, sustainability, quality of life, and energy conservation in urban street lighting. The goal is to improve the existing conditions and create a harmonious relationship between lighting requirements and essential aspects for urban residents and the environment.

Igor Wojnicki et al. came up with the use of graph formalism to model outdoor lighting infrastructure for design and control purposes. The method has been tested both in laboratory and city-scale deployments. The paper suggests optimizing energy usage by dynamically controlling streetlights and considering the influence of control schemas in the design process. This approach leads to significant energy savings. The introduced optimization is also represented and modeled using graphs and graph transformations.

M. Corcione et al. explores the use of genetic algorithms for optimal lighting system design in outdoor tennis courts and football fields. It compares the performance of these algorithms with traditional optimization methods and evaluates computational times and calculation accuracy.

Every design takes into consideration the energy utilization and how to make it more efficient. Few works on the energy management and optimization technics have been discussed further.

Ahmad Farahat et al. in the paper presents an outdoor lighting solution focusing on energy-efficient performance in multipurpose outdoor environments. LED-based lights with advanced control strategies are utilized to achieve low energy consumption and high-quality light ambience. The approach optimizes LED drivers' performance at the component level and defines a control strategy at the system level. The solution was tested in a real environment and monitored through a Web-based application.

Z. Kaleem et al. proposes an energy-efficient ZigBee-based outdoor light monitoring and control system. The system utilizes wireless ZigBee devices and sensors to efficiently manage outdoor lights, resulting in significant energy savings of around 70.8% in the outdoor street environment. The prototype's installation and experimental results inside a university demonstrate the effectiveness of the proposed system.

Ahmad Farahat et al. focuses on implementing an outdoor lighting solution that emphasizes energy efficiency. Smart lighting technologies are utilized to address specific user needs while efficiently utilizing power resources. The approach considers light source selection, power management, and control scenarios for lighting scene rendering, following the Internet of Things vision.

But with the technological advancements, inclusion of cutting edge tools, implementation of sensors and control techniques, the optimal design can be achieved. The following paper has discussed on the works done in the area integrating new technology as a one.

Antonio del Corte-Valiente et al. discusses the need for improved outdoor lighting uniformity and presents a new algorithm to achieve energy-efficient performance in street lighting installations. The algorithm optimizes LED drivers' performance at the component level and defines a control strategy at the system level. The solution was tested in a real environment and monitored using a Web-based application.

N. Pavlov et al. proposes an energy-efficient ZigBee-based outdoor light monitoring and control system that can save around 70.8% of energy in the outdoor street environment. The system uses wireless ZigBee devices and sensors to optimize lighting parameters based on traffic intensity. The prototype's installation inside a university demonstrated its effectiveness.

N. Zotos et al. introduces an energy-efficient outdoor lighting management and monitoring system that adjusts lighting levels based on motion detection using proximity sensors. The system uses wireless personal area networks with IP technology to connect all nodes and enable remote control. Data regarding lamp parameters are transferred to the management system via bidirectional channels, optimizing energy consumption and lowering costs.

Ana Castillo Martinez et al. presents an algorithm to optimize outdoor lighting systems while ensuring minimum overall uniformity. A particle swarm optimization (PSO) algorithm is utilized to find the best configuration parameters for energy-efficient lighting. The algorithm was tested using DIALux software and data mining techniques. The proposed process optimization resulted in improved efficiency.

CHAPTER:

3. PUBLIC LIGHTING IN OUTDOOR SPACES

3.1 OUTDOOR LIGHTING DESIGN CONCEPTS

Outdoor lighting design involves the art and science of enhancing the aesthetics, safety, and functionality of outdoor spaces through the use of lighting fixtures and techniques. There are several design concepts to consider when designing outdoor lighting, including:

- **Layering:** Layering involves the use of different types of lighting fixtures to create depth and texture in an outdoor space. For example, a combination of path lights, spotlights, and uplights can be used to highlight different features of a garden or landscape.

- **Contrast:** Contrast is created by using lighting fixtures with different intensities, colors, and angles to highlight specific areas or objects. For example, a spotlight can be used to create a focal point on a tree or statue.

- **Directional lighting:** Directional lighting is used to highlight specific areas or objects by directing the light in a specific direction. For example, an uplight can be used to illuminate a tree or architectural feature.

- **Silhouetting:** Silhouetting involves placing a lighting fixture behind an object to create a dramatic effect. For example, placing a spotlight behind a statue can create a striking silhouette.

- **Color temperature:** Color temperature refers to the warmth or coolness of the light emitted by a fixture. Warm light (2700K-3000K) creates a cozy and intimate ambiance, while cool light (4000K-5000K) creates a more energetic and modern ambiance.

- **Energy efficiency:** Energy-efficient lighting fixtures can help reduce energy consumption and lower utility costs. LED lighting fixtures are a popular choice for outdoor lighting due to their long lifespan and low energy consumption.

- **Functionality:** The primary goal of outdoor lighting is to provide visibility and safety. The lighting should illuminate walkways, stairs, and entrances to prevent accidents and to ensure that people can see where they are going. It's important to choose the right level of brightness for each area and to use lighting fixtures that are durable and weather-resistant.

- **Highlighting:** Highlighting is a technique that focuses on illuminating specific features of your outdoor space, such as a water fountain or a statue. This technique can create a dramatic effect and draw attention to specific areas.

- **Ambiance:** Outdoor lighting can also be used to create a specific mood or ambiance. Soft, warm lighting can create a cozy and intimate atmosphere, while brighter lighting can create a more energetic and lively feel.

- **Automation:** Outdoor lighting can be automated using timers or motion sensors. This can help to save energy and ensure that your outdoor space is always well-lit when you need it.

By considering these design concepts and choosing the right lighting fixtures, outdoor spaces can be transformed into beautiful, safe, and functional environments that can be enjoyed day and night.

3.2 LIGHTING DESIGN FACTORS AND CONSIDERATIONS

Outdoor lighting design is an important aspect of enhancing the beauty and functionality of your outdoor space. Here are some additional details to consider when designing outdoor lighting:

Types of Lighting: There are various types of lighting options for outdoor lighting, including path lighting, flood lighting, spot lighting, and accent lighting. Path lighting is typically used to illuminate walkways and create a sense of direction, while flood lighting can provide broad coverage of a large area. Spot lighting can be used to highlight specific objects or features, and accent lighting can be used to enhance the aesthetic appeal of your outdoor space.

Lighting Fixtures: When choosing lighting fixtures for outdoor spaces, it is important to choose fixtures that are durable and weather-resistant. This is particularly important for outdoor lighting, as these fixtures will be exposed to the elements. Common materials for outdoor lighting fixtures include aluminum, brass, copper, and stainless steel.

Colour Temperature: The colour temperature of outdoor lighting can have a significant impact on the overall ambiance of your outdoor space. Warm white light (with a colour temperature around 2700-3000K) is typically used to create a cozy and inviting atmosphere, while cool white light (with a colour temperature around 5000-6500K) can create a more energetic and lively feel.

Light Pollution: Outdoor lighting can contribute to light pollution, which can be harmful to the environment and can disrupt the natural rhythms of animals and plants. When designing outdoor lighting, it is important to consider the impact that your lighting will have on the surrounding environment and to choose lighting fixtures and bulbs that minimize light pollution.

Safety: Safety is a crucial consideration when designing outdoor lighting. It is important to ensure that all walkways and entrances are well-lit to prevent accidents, and to use lighting fixtures that are properly grounded and installed to prevent electrical hazards.

Smart Lighting: Smart lighting systems can be used to control outdoor lighting remotely and to automate lighting schedules. This can help to save energy and can provide an added layer of security by allowing you to monitor your outdoor space from a distance.

Purpose: The purpose of your outdoor lighting will dictate the type of lighting you need. Are you lighting a pathway, illuminating a focal point, or enhancing the ambiance? Knowing the purpose of your lighting will help you select the appropriate fixtures and bulbs.

Location: The location of your outdoor lighting is also important. Consider the specific areas you want to illuminate, such as walkways, patios, or gardens. You should also consider the placement of your lighting fixtures to ensure that they are installed safely and effectively.

Power Source: Outdoor lighting can be powered by electricity, batteries, or solar power. Consider which power source is most convenient and cost-effective for your specific outdoor space.

Style: The style of your outdoor lighting should match the style of your home and outdoor space. This includes the type of fixtures and the finish of the lighting, such as bronze, copper, or black.

Energy Efficiency: Energy efficiency is an important consideration when designing outdoor lighting. LED bulbs are a popular choice for outdoor lighting because they are energy-efficient and have a long lifespan.

Maintenance: Outdoor lighting requires maintenance to ensure that it continues to function properly. Consider the upkeep required for your specific lighting fixtures, including bulb replacements, cleaning, and any repairs that may be necessary.

Safety and Security: Safety is a crucial consideration when designing outdoor lighting. Make sure that all electrical wiring is properly installed and grounded, and ensure that all lighting fixtures are weather-resistant to prevent electrical hazards.

By considering these factors, you can design outdoor lighting that enhances the beauty and functionality of your outdoor space while meeting your specific needs and preferences.

Overall, outdoor lighting design is an important aspect of creating a welcoming and functional outdoor space. By considering these factors, you can design a lighting plan that enhances the beauty and functionality of your outdoor space while minimizing its impact on the environment.

3.3 IMPACT OF INEFFICIENT LIGHTING DESIGN OF PUBLIC SPACES

Inefficient public lighting design in India has far-reaching and adverse consequences on various aspects of society, the environment, and the economy. One of the primary consequences is the high energy consumption that inefficient lighting systems demand. As one of the world's most populous countries, India faces massive energy demands, and inefficient lighting strains the power grid, increasing the need for electricity generation. Often, this energy generation relies on fossil fuels like coal and natural gas, leading to a surge in greenhouse gas emissions and further exacerbating climate change. In a time when international commitments like the Paris Agreement emphasize reducing carbon footprints, inefficient lighting design hampers India's progress toward meeting these

environmental goals. Light pollution is another critical consequence of inefficient public lighting. Poorly designed lighting fixtures contribute to excessive and misdirected artificial light that brightens the night sky. This phenomenon disrupts ecosystems and negatively impacts wildlife behavior. Nocturnal animals depend on natural darkness to carry out their essential activities, and excessive artificial lighting can alter their behaviours and migration patterns. Moreover, light pollution has adverse effects on human health, disrupting sleep patterns and circadian rhythms, leading to sleep disorders and related health issues. The financial burden of inefficient lighting is not to be underestimated. Municipalities and government agencies face substantial energy costs due to inefficient lighting systems, draining their budgets and leaving fewer resources available for essential services and infrastructure projects. This financial waste can impede economic growth and development in the country. Furthermore, inefficient lighting poses risks to public safety and security. Poorly placed lighting creates dark spots and shadows, increasing the likelihood of accidents and criminal activities. In contrast, well-designed public lighting promotes safer urban environments and fosters a sense of security among residents and visitors. The impact of inefficient lighting is not distributed evenly, creating disparities in development between urban and rural areas. Proper lighting in rural regions can contribute to road safety, boost economic activities, and improve the overall quality of life for residents. Addressing this imbalance is crucial for achieving more balanced development across the nation. The effects on wildlife are profound, with artificial lighting significantly disturbing natural behaviours and migration patterns. For instance, sea turtle hatchlings often become disoriented by bright lights on coastal regions, leading them away from the ocean and jeopardizing their survival. Protecting vulnerable species and preserving ecosystem balance necessitate addressing inefficient lighting. Inadequate lighting in public spaces also poses health risks. Poorly lit streets and parks increase the likelihood of accidents and injuries, while insufficient lighting can contribute to stress and anxiety, particularly in areas with high crime rates. Properly designed lighting can significantly improve public health and well-being. To address these pressing issues, a comprehensive approach is crucial. Embracing energy-efficient lighting technologies like LED bulbs, promoting smart lighting solutions, and considering local environmental and societal factors during the design process are essential steps. By doing so, India can achieve significant energy savings, reduce greenhouse gas emissions, enhance safety, improve quality of life, and pave the way for a more sustainable future for its citizens and the planet as a whole.

3.4 ADVANCEMENT AND GROWTH OF INDIAN LIGHTING INDUSTRY

The Indian lighting and lighting design industry has witnessed significant growth and transformation over the past few decades. With a rapidly expanding economy and increasing urbanization, there has been a surge in demand for innovative and energy-efficient lighting solutions across various sectors. This note provides an overview of the key aspects of the Indian lighting industry and its evolution in recent years.

Market Overview:

The lighting industry in India is a crucial part of the country's infrastructure development. It encompasses a wide range of products, including conventional lighting fixtures, light sources (such as incandescent, fluorescent, and halogen lamps), light-emitting diodes (LEDs), and smart lighting solutions. The market is driven by both residential and commercial segments, with the latter being more significant in terms of demand.

Shift towards Energy Efficiency:

In recent years, there has been a notable shift towards energy-efficient lighting solutions, primarily LED technology. LED lighting has gained popularity due to its lower energy consumption, longer lifespan, and reduced environmental impact. Government initiatives, such as the UJALA (Unnat Jyoti by Affordable LEDs for All) scheme, have played a significant role in promoting LED adoption and supporting the transition towards sustainable lighting.

Rapid Urbanization and Infrastructure Development:

Urbanization in India has led to an increased need for lighting solutions in urban areas, including street lighting, public spaces, commercial buildings, and residential complexes. The government's focus on infrastructure development and smart city initiatives has further fueled the demand for modern lighting designs that combine aesthetics, functionality, and energy efficiency.

Lighting Design Industry:

The concept of lighting design has gained prominence in India as architects, interior designers, and urban planners recognize the importance of lighting in enhancing the overall ambiance and aesthetics of spaces. Lighting design is not only about providing illumination but also involves creating moods, highlighting architectural features, and optimizing energy consumption.

Technological Advancements:

The lighting industry in India has experienced significant technological advancements. The integration of Internet of Things (IoT) and smart lighting solutions has led to the development of lighting systems that can be controlled and monitored remotely, offering greater flexibility and energy optimization.

Challenges and Opportunities:

While the Indian lighting industry has seen remarkable growth, it faces certain challenges, including price sensitivity, lack of awareness about energy-efficient options, and the presence of low-quality, counterfeit products in the market. However, these challenges also present opportunities for manufacturers and designers to innovate and offer cost-effective, high-quality solutions that cater to the diverse needs of the Indian market.

The Indian lighting and lighting design industry have evolved significantly, embracing energy-efficient technologies and incorporating innovative design approaches. With continued urbanization and infrastructure development, the demand for modern lighting solutions is expected to grow further, presenting immense opportunities for businesses and professionals in this sector. As sustainability and energy conservation become paramount, the industry's future lies in creating cutting-edge lighting solutions that not only illuminate spaces but also contribute to a greener and more efficient future.

CHAPTER:

4. LIGHTING ZONES AND THEIR DISCUSSION

4.1 ROAD LIGHTING

Road lighting is the installation of artificial lighting along roads and highways to enhance visibility and safety for drivers, pedestrians, and other road users during nighttime or low-light conditions. The primary purpose of road lighting is to illuminate the road surface, signs, and surroundings, reducing the risk of accidents and providing a more comfortable driving experience. It plays a crucial role in preventing collisions, guiding drivers, and improving overall road infrastructure.

FIG 4.1: ROAD LIGHTING

4.1.1 LIGHTING DESIGN APPROACH AND PRACTICES

Outdoor public road lighting plays a crucial role in ensuring safe and efficient transportation at night. Properly designed and maintained road lighting enhances visibility for drivers and pedestrians, reduces accidents, and improves overall safety. Here are some key concepts and best practices for outdoor road lighting:

Uniform Illumination : Aim to achieve uniform light distribution across the road surface, minimizing dark spots and glare. Uniform illumination ensures that drivers can clearly see the road ahead and react to any potential hazards.

Correct Light Levels : Determine the appropriate light levels for the road type and classification. For major highways, higher light levels are needed compared to local streets. Consider factors such as traffic volume, speed limits, and surrounding environment when deciding on light intensity.

Lighting Design for Specific Road Geometry : Adapt the lighting design to the specific geometry of the road. Different types of roads (e.g., straight, curved,

intersections) require different lighting layouts to maintain consistent illumination.

Use of Full-Cutoff Fixtures : Full-cutoff fixtures direct light downward and prevent light pollution by minimizing upward light emissions. This helps to preserve the night sky and reduce energy wastage.

Smart Lighting Controls : Implement intelligent lighting controls that adjust the intensity of the lights based on traffic flow and time of day. Dimming or turning off lights during low-traffic hours can save energy and reduce costs.

Energy Efficiency : Choose energy-efficient lighting technologies, such as LED (Light Emitting Diode) luminaires. LEDs consume less energy, have longer lifespans, and offer better light quality compared to traditional lighting sources like high-pressure sodium or metal halide lamps.

Maintenance and Regular Inspections : Establish a regular maintenance schedule to ensure that all lighting fixtures are functioning correctly. Burnt-out bulbs or malfunctioning fixtures should be promptly replaced to maintain consistent illumination.

Glare Control : Minimize glare by properly aiming luminaires and using appropriate shielding. Glare can impede visibility for drivers and create hazardous conditions.

Consider Surrounding Environment : Take into account the surrounding environment when designing road lighting. For instance, in residential areas, consider the impact on residents' comfort and safety.

Dark Sky Compliance : Comply with dark sky regulations when applicable to minimize light pollution and its adverse effects on the environment and wildlife.

Emergency Lighting : In areas prone to power outages or natural disasters, consider installing emergency lighting to maintain minimal illumination for safe evacuation and traffic flow.

Consultation with Experts : Engage with lighting designers, civil engineers, and relevant stakeholders to create a comprehensive lighting plan that meets local regulations and addresses specific road conditions.

By following these outdoor road lighting concepts and best practices, municipalities and transportation authorities can create safer and more sustainable road networks that benefit both drivers and pedestrians.

4.1.2 LIGHTING DESIGN FACTORS AND CONSIDERATIONS

When designing road lighting, several factors need to be considered to ensure the effectiveness, safety, and efficiency of the lighting system. The type and classification of the road play a crucial role in determining the required light levels and lighting layout. Major highways, with higher speeds and traffic volumes, will demand more intense illumination compared to residential streets. Additionally, the road geometry, including straight stretches, curves, intersections, and ramps, must be taken into account to achieve uniform light distribution across various road shapes.

Pedestrian safety is another essential consideration, especially if the road has pedestrian sidewalks or crossings. Adequate illumination around intersections and pedestrian crossings is crucial to ensure the safety and visibility of pedestrians. The surrounding environment is also a factor in lighting design, particularly in urban areas with nearby buildings, where glare and discomfort for residents must be minimized.

Achieving uniform light distribution across the road surface is essential to minimize dark spots and glare, providing a consistent and comfortable driving experience. Glare control is crucial to prevent reduced visibility and dangerous conditions caused by improperly aimed or excessively bright luminaires. Proper luminaire selection and shielding help in managing glare effectively.

The placement and height of lighting poles impact the light distribution and overall effectiveness of the lighting system. Properly positioned lighting poles are essential to achieve the desired light coverage. The choice of lighting technology, whether it's LED, high-pressure sodium, or metal halide, affects energy consumption, maintenance costs, and the quality of light produced. Energy efficiency and sustainability are emphasized in lighting design to reduce operational costs and minimize the environmental impact.

Safety and security are enhanced by providing adequate lighting, discouraging criminal activities, and promoting a sense of safety for drivers and pedestrians. Complying with local lighting standards, regulations, and dark sky ordinances is critical to meet legal requirements and minimize light pollution, ensuring responsible lighting practices.

Consideration of maintenance needs and accessibility to luminaires and control systems is essential for smooth upkeep and repairs. Proper planning for potential future growth and expansion can help avoid frequent modifications to the lighting design.

By carefully considering these factors, lighting designers can create road lighting systems that provide optimal visibility, safety, and sustainability for all road users. Properly designed road lighting not only reduces the risk of accidents but also enhances the overall driving experience and promotes safe and efficient transportation networks.

4.1.3 DESIGN ERRORS AND CONSTRAINTS

During the design process of outdoor road lighting, there can be various errors and constraints that may arise due to different factors. Some of the expected errors and constraints in road lighting design include:

- Budget Constraints : The availability of funds can be a significant constraint on the lighting project. Designers may need to work within tight budget limits,

potentially leading to compromises on the quality or scope of the lighting design.

- Regulatory Limitations : Local regulations and lighting standards must be adhered to, which may limit the design options or require specific lighting specifications that could affect the overall effectiveness of the lighting system.

- Technical Limitations : Some roadways may present technical challenges, such as limited electrical infrastructure or access points for installing lighting fixtures. Designers need to work within these limitations while still meeting lighting requirements.

- Environmental Concerns : In certain areas, there may be environmental restrictions related to light pollution or impacts on wildlife and vegetation. Compliance with dark sky regulations might constrain the design.

- Existing Infrastructure : Designing lighting for existing roadways can be challenging when trying to integrate new fixtures with the existing infrastructure, especially if the road has unique geometric characteristics.

- Traffic Disruption : Installation and maintenance of lighting systems may require temporary road closures or lane restrictions, which can cause traffic disruptions and require careful planning.

- Coordination with Other Utilities : Road lighting design may need to coordinate with other utilities like power, telecommunications, and gas, which can introduce additional complexities.

- Community Concerns : Local communities might have concerns about the aesthetics of lighting fixtures, potential glare, or light trespass into residential areas. Addressing these concerns may require adjustments to the design.

- Energy Efficiency Targets : There may be specific energy efficiency goals that need to be met, necessitating careful selection of lighting fixtures and controls to reduce energy consumption.

- Maintenance Accessibility : Designers need to consider the ease of maintenance and access to lighting fixtures for repairs and replacements. Installing fixtures in hard-to-reach locations can increase maintenance costs.

- Changing Road Conditions : Road lighting designers must consider future changes to the road, such as widening, realignments, or additions, to ensure the lighting design remains effective and scalable.

- Security Concerns : In some areas, security considerations may impact the design, such as ensuring there are no blind spots that could be exploited by potential criminals.

To mitigate errors and constraints, collaboration among designers, engineers, stakeholders, and local authorities is essential. A comprehensive understanding of the project requirements, careful planning, and a willingness to adapt the design when necessary are key to a successful road lighting project. Additionally, using advanced lighting simulation and modeling tools can help identify and address potential issues before implementation.

4.2 PARKING AREA LIGHTING

Parking area lighting is a critical aspect of urban and commercial infrastructure designed to provide illumination and enhance safety in parking lots and garages. These lighting systems ensure visibility for drivers, pedestrians, and security personnel during nighttime or low-light conditions, reducing the risk of accidents and criminal activities. Parking area lighting is strategically planned to cover the entire parking space uniformly, minimizing dark spots and ensuring a comfortable and secure environment for users. The choice of lighting technology, such as LED fixtures, offers energy efficiency, reducing operational costs and environmental impact. Additionally, lighting control systems, motion sensors, and timers can be incorporated to optimize energy usage and adapt to varying usage patterns. Properly designed parking area lighting not only enhances safety and visibility but also improves the overall user experience, encouraging

patronage and contributing to the overall success of commercial establishments and public facilities.

FIG 4.2: PARKING AREA LIGHTING

4.2.1 LIGHTING DESIGN APPROACH AND PRACTICES

Outdoor parking areas require proper lighting to ensure safety and security for drivers and pedestrians, especially during nighttime hours. Here are some essential lighting concepts and best practices for outdoor parking areas:

Uniform Illumination: The lighting should provide uniform illumination throughout the parking area, minimizing dark spots and shadows. This ensures visibility for drivers and pedestrians, reducing the risk of accidents and criminal activities.

Appropriate Light Levels: The light levels should be adequate for the size and purpose of the parking area. Typically, parking areas require lower light levels than, for example, sports fields or highways. The right light levels strike a balance between visibility and energy efficiency.

LED Lighting: Consider using LED (Light Emitting Diode) lighting fixtures. LEDs are energy-efficient, have a longer lifespan, and provide better light quality compared to traditional lighting options like high-pressure sodium (HPS) or metal halide (MH) fixtures.

Motion Sensors: Install motion sensors or occupancy sensors in less frequently used areas of the parking lot. These sensors can help save energy by only activating lights when movement is detected.

Dark-Sky Friendly Lighting: Choose fixtures with proper shielding and optics to minimize light pollution and skyglow. Dark-sky friendly lighting directs light downward to the ground, reducing wasteful upward light dispersion.

Pole Height and Spacing: Opt for appropriate pole height and spacing to ensure even coverage and prevent over-illumination or under-illumination. The spacing will depend on the type and power of the lighting fixtures.

Security Lighting: Consider integrating security lighting features, such as floodlights or spotlights, at key areas like entrances, exits, and pedestrian pathways. This helps deter criminal activities and enhances safety.

Backup Power Supply: Install emergency backup power systems to ensure that the lights remain operational during power outages, enhancing safety and security during critical times.

Lighting Control Systems: Employ smart lighting control systems that allow for remote monitoring and management. These systems can help adjust light levels, detect failures, and optimize energy usage.

Regular Maintenance: Implement a regular maintenance schedule to inspect and clean lighting fixtures, replace faulty bulbs promptly, and address any issues that might affect the performance of the lighting system.

Environmental Considerations: When planning the lighting system, consider the surrounding environment and wildlife. Avoid excessive lighting that may disturb nocturnal animals or disrupt nearby habitats.

Compliance with Regulations: Ensure that the lighting design and fixtures comply with local regulations, lighting standards, and safety codes.

Remember that each parking area is unique, so it's essential to assess specific requirements and constraints before finalizing the lighting design. By following these concepts and best practices, you can create a well-lit and safe outdoor parking area for users.

4.2.2 LIGHTING DESIGN FACTORS AND CONSIDERATIONS

Lighting design for parking areas involves a comprehensive approach that considers various factors to ensure optimal illumination, safety, and energy efficiency. The first step is to understand the purpose and use of the parking area. Different types of parking areas, such as commercial lots, residential complexes, or recreational facilities, have unique lighting requirements based on their intended activities and user needs.

Determining appropriate lighting levels is crucial for providing adequate visibility and security. The size and layout of the parking area, as well as the presence of pedestrian walkways, influence the recommended light levels. Achieving uniform illumination throughout the parking area is essential to minimize dark spots and shadows, ensuring a safe and comfortable environment for drivers and pedestrians.

The spacing and placement of light fixtures play a vital role in achieving even light distribution. Properly positioned fixtures prevent over-illumination or under-illumination, maximizing the effectiveness of the lighting system. Additionally, the choice of lighting technology is essential. LED fixtures are widely used due to their energy efficiency, longer lifespan, and superior light quality compared to traditional options.

The mounting height of the light fixtures also impacts the distribution and intensity of light. It is essential to select an appropriate mounting height that suits the specific size and layout of the parking area. Glare control is another critical consideration to enhance visual comfort for drivers and pedestrians. Well-designed fixtures with appropriate shielding and optics help reduce glare and prevent discomfort.

Safety and security are paramount in parking areas. Integrating security lighting features, such as motion sensors or floodlights, can enhance safety and deter criminal activities. Smart lighting control systems provide efficient energy

management, enabling remote monitoring and adjustments to the lighting levels as needed.

Designing an energy-efficient lighting system not only benefits the environment but also reduces operational costs for the facility. Minimizing the environmental impact of the lighting design is crucial. Using dark-sky friendly fixtures and minimizing light pollution help preserve nearby habitats and contribute to the preservation of the night sky.

Compliance with local regulations, lighting standards, and safety codes is a critical aspect of the lighting design process. Adhering to these regulations ensures the lighting system meets the required standards and promotes safety for all users.

Choosing durable and low-maintenance lighting fixtures is essential to reduce ongoing maintenance costs and ensure the lighting system remains operational and reliable over time.

By carefully evaluating and addressing all these factors, lighting designers can create a well-designed and effective lighting system that meets the specific requirements of the parking area. A thoughtfully designed parking area lighting system not only enhances safety and visibility but also promotes sustainability and provides a positive experience for users.

4.2.3 DESIGN ERRORS AND CONSTRAINTS

In the process of designing lighting for parking areas, several errors and constraints can arise that may impact the effectiveness, safety, and overall success of the design. Some common errors and constraints include:

- Insufficient Light Levels: Failing to provide adequate light levels can lead to decreased visibility and safety hazards in the parking area, potentially causing accidents or security issues.

- Over-Illumination: Excessive lighting can lead to light pollution, unnecessary energy consumption, and discomfort for users due to glare.

- Uneven Lighting: Inconsistent distribution of light can create dark spots and shadows, compromising safety and security for both drivers and pedestrians.

- Glare and Light Spill: Improperly shielded fixtures may cause glare for drivers and pedestrians, reducing visibility and creating discomfort. Light spill onto neighboring properties or roads can also be a concern.

- Inadequate Light Color Temperature: The wrong choice of light color temperature can affect the perception of the environment, potentially impacting security and aesthetics.

- Lack of Adaptability: Failure to incorporate lighting control systems can limit the adaptability of the lighting design to varying conditions or usage patterns.

- Ignoring Environmental Impact: Not considering the environmental impact, such as light pollution or disruption to wildlife, can lead to negative consequences for the surroundings.

- Ignoring Safety and Security Concerns: Neglecting to incorporate security lighting features or proper illumination in critical areas can compromise the safety and security of the parking area.

- Budget Constraints: Budget limitations can restrict the choice of lighting technology or the number of fixtures, affecting the overall quality and effectiveness of the lighting design.

- Space Constraints: Limited space or specific layout requirements may affect the placement and spacing of light fixtures, impacting the uniformity of lighting.

- Regulatory Compliance Issues: Failing to adhere to local regulations and lighting standards can result in legal complications and potential penalties.

- Maintenance Challenges: Designing a lighting system that is difficult to maintain or access can lead to higher maintenance costs and potential lighting failures.

- Changing Requirements: Designing a static lighting system without considering potential future changes in usage patterns or expansion can lead to inefficiencies or the need for costly modifications later on.

To avoid these errors and constraints, lighting designers need to conduct a comprehensive site analysis, consider all relevant factors, and engage in ongoing communication with stakeholders to ensure the design meets the specific requirements and limitations of the parking area. Regular evaluation and maintenance of the lighting system are also crucial to address any emerging issues and optimize its performance over time.

4.3 OUTDOOR PARKS, PLAYGROUNDS AND OPEN AREA LIGHTING

Outdoor parks, playgrounds, and open area lighting is a crucial aspect of urban and recreational infrastructure, providing illumination for public spaces during evening and nighttime hours. These lighting systems aim to enhance safety, extend usability, and create inviting environments for the community to enjoy outdoor activities. In parks and open areas, proper lighting ensures visibility on pathways, seating areas, and activity spaces, reducing the risk of accidents and promoting a sense of security. In playgrounds, adequate lighting is essential for children's safety, allowing them to play safely even after sunset. Moreover, well-designed lighting schemes in these spaces can contribute to the aesthetic appeal,

encouraging more people to use and appreciate these public areas. Incorporating energy-efficient technologies such as LED fixtures and smart control systems helps reduce energy consumption and maintenance costs, making outdoor park lighting environmentally friendly and economically sustainable. With proper attention to glare control, dark-sky-friendly fixtures, and lighting levels tailored to specific activities, outdoor parks, playgrounds, and open areas can become vibrant and welcoming community spaces that facilitate recreation and social engagement throughout the day and night.

4.3.1 LIGHTING DESIGN APPROACH AND PRACTICES

Outdoor public parks and open areas require thoughtful lighting concepts and best practices to ensure they are safe, attractive, and environmentally friendly. Proper lighting can enhance the overall ambiance and functionality of these spaces, making them enjoyable for visitors during both daytime and nighttime. Below are some key considerations and best practices for outdoor public parks and open area lighting:

Safety as a Top Priority: Safety should always be the primary concern when designing lighting for public spaces. Adequate illumination can prevent accidents, deter criminal activity, and create a sense of security for park visitors.

Balance with Natural Light: Whenever possible, try to preserve and enhance the park's natural lighting during the day. This not only helps reduce energy consumption but also provides a better overall experience for park-goers.

Energy Efficiency: Opt for energy-efficient lighting solutions such as LED lights. LEDs consume less energy, have a longer lifespan, and produce less light pollution compared to traditional lighting options.

Dark Sky Friendly: Light pollution can disrupt the natural environment and affect wildlife. Embrace dark sky-friendly principles by using shielded fixtures that direct light downward and prevent unnecessary glare and light spillage.

Zoning and Layering: Consider dividing the park into different zones and applying varying levels of lighting based on their functions. For example, active areas like sports fields might require brighter lighting, while pathways and seating areas may need softer, more ambient lighting.

Pathway Lighting: Properly illuminate pathways and walking trails to ensure safe navigation at night. Bollard lights, ground-recessed fixtures, or solar-powered path lights are popular choices for these areas.

Accent Lighting: Use accent lighting to highlight key park features, such as sculptures, fountains, trees, or architectural elements. Accent lighting can add visual interest and create focal points throughout the park.

Consider Natural Elements: Allow the lighting design to complement the park's natural elements. For example, using warm-toned lighting can harmonize with the natural colours of trees and vegetation.

Smart Lighting Control: Implement smart lighting controls, such as motion sensors or timers, to adjust lighting levels based on occupancy and time of day. This helps conserve energy and reduces operational costs.

Community Engagement: Involve the local community in the lighting design process. Seek feedback and take into account the needs and preferences of the people who will be using the park regularly.

Maintenance and Longevity: Choose durable fixtures and materials that can withstand outdoor conditions and require minimal maintenance. Regular maintenance is essential to ensure the lighting system remains effective and safe over time.

Regulations and Standards: Comply with local lighting regulations and safety standards. These regulations may cover light levels, color temperature, light trespass, and other important factors.

By following these lighting concepts and best practices, outdoor public parks and open areas can become inviting and pleasant places for people to enjoy day and night while promoting safety and environmental responsibility.

4.3.2 LIGHTING DESIGN FACTORS AND CONSIDERATIONS

When designing lighting for outdoor public parks and open areas, a comprehensive and thoughtful approach is essential to create an effective and well-balanced lighting scheme. Safety and security are of paramount importance, as proper illumination helps prevent accidents and deters criminal activity, providing a sense of security for park visitors during nighttime hours. Understanding the various activities and functions within the park, such as walking paths, sports fields, playgrounds, seating areas, and recreational spaces, is crucial to determine appropriate lighting levels and the types of fixtures needed.

The lighting design should also consider how it interacts with the park's natural environment, complementing the landscape, trees, and other natural elements to create a harmonious atmosphere. Dark sky compliance is vital to minimize light pollution, which can disrupt ecosystems and negatively impact wildlife. Implementing dark sky-friendly lighting solutions that minimize upward light and light spillage helps protect the night sky.

Energy efficiency is a key consideration in outdoor park lighting design. Opting for energy-efficient lighting technologies, such as LED fixtures, reduces energy consumption and the park's environmental footprint. Zoning and layering the lighting design based on usage and lighting requirements create depth and visual interest, ensuring each area receives the appropriate level of illumination.

Minimizing glare and light trespass is essential to ensure a comfortable and pleasant experience for park visitors and neighboring properties. The lighting

design should prioritize accessibility, ensuring that all paths and areas within the park are well-lit to promote easy navigation for people with disabilities and all park users.

Choosing durable lighting fixtures and materials that can withstand outdoor conditions and require minimal maintenance is crucial for the longevity of the lighting system. Regular maintenance is necessary to keep the lighting functioning optimally and ensure a safe environment.

Implementing smart lighting controls, such as motion sensors or timers, allows for adjustments to lighting levels based on occupancy and time of day, improving energy efficiency and reducing operational costs.

Community input is invaluable in the lighting design process. Involving the local community and seeking feedback from park users helps ensure that the lighting design meets their needs and preferences.

Adhering to local lighting regulations, safety standards, and environmental guidelines is vital to ensure compliance with relevant regulations and standards for public spaces.

Designing a lighting plan that fits within the available budget while meeting the essential lighting needs of the park is a key consideration. Balancing cost considerations with lighting requirements is essential to create an efficient and effective lighting design.

By carefully considering these factors, lighting designers can create a successful and aesthetically pleasing lighting design that enhances the usability, safety, and overall appeal of outdoor public parks and open areas. A well-designed lighting system fosters a positive and enjoyable experience for park visitors, encouraging community engagement and promoting the utilization of these important public spaces.

4.3.3 DESIGN ERRORS AND CONSTRAINTS

Designing lighting for outdoor public parks and open areas comes with its share of expected errors and constraints, which need to be carefully managed to achieve a successful lighting solution. Some common errors and constraints include:

- Budget Constraints: One of the most significant constraints is the available budget. Lighting designers must work within financial limitations while still aiming to create an effective and safe lighting design.

- Regulatory Compliance: There might be strict local regulations and lighting standards that need to be adhered to, such as light levels, color temperature, light trespass, and environmental guidelines. Failure to comply with these regulations can lead to delays and redesigns.

- Lighting Uniformity: Achieving consistent lighting levels throughout the park can be challenging, especially in large open areas. Uneven lighting can create dark spots or glaring areas, impacting the overall user experience and safety.

- Maintenance and Accessibility: Accessing lighting fixtures for maintenance can be difficult, especially for fixtures installed at higher elevations or in hard-to-reach locations. Maintenance planning should be considered during the design phase to ensure long-term functionality.

- Electrical Infrastructure: The availability and capacity of electrical infrastructure in the park area may limit the number and type of lighting fixtures that can be installed.

- Environmental Impact: The lighting design should aim to minimize the environmental impact, such as light pollution, excessive energy consumption, and disruption to local wildlife and ecosystems.

- Aesthetics and Architecture: Lighting designers must consider the aesthetics of the park and its surrounding architecture. The lighting fixtures should complement the park's design and enhance its visual appeal.

- Weather Resistance: Outdoor lighting fixtures must withstand various weather conditions, including rain, snow, extreme temperatures, and humidity. Choosing durable and weather-resistant fixtures is essential to ensure longevity.

- Light Spill and Glare: Light spillage onto neighboring properties or into the night sky can lead to complaints and environmental concerns. Careful positioning and shielding of fixtures are necessary to minimize light spill and glare.

- Changing Landscape: Outdoor parks are living spaces with changing vegetation and landscapes. Designers need to account for the growth of trees and foliage that might affect the distribution of light over time.

- Power Source: In remote or off-grid locations, the availability of a reliable power source can be a constraint. Solar-powered or low-energy lighting solutions may be more suitable in such cases.

- Safety and Security: Overlooking safety and security considerations in the lighting design can lead to accidents, criminal activities, or a general feeling of insecurity among park visitors.

Addressing these errors and constraints requires thorough planning, collaboration with relevant stakeholders, and a keen understanding of the park's unique requirements. By carefully navigating these challenges, lighting designers can create a lighting design that enhances the overall experience and functionality of outdoor public parks and open areas.

CHAPTER:
5. INDIAN STANDARDS

5.1 NATIONAL LIGHTING CODE 2010

The National Lighting Code 2010 provides guidance and regulations for illuminating engineering practices, covering various aspects of lighting systems for indoor and outdoor areas. It includes matters related to the science of illumination, coordination aspects, and energy management for lighting installations. The code aims to encourage good lighting practices that minimize light pollution, glare, and energy consumption while prioritizing safety, security, utility, and productivity.

The code is formulated to establish responsible social, commercial, and engineering conduct for designers, manufacturers, and suppliers of lighting. It seeks to build trust between the lighting industry and customers by integrating commerce and technology. However, it does not specify requirements for certain specialized areas like marine, railway rolling stock, theatre, television, and photography.

The document highlights the importance of energy conservation and safety in lighting, given that lighting equipment consumes an estimated 17 percent of India's energy consumption. The National Lighting Code serves as a comprehensive compilation of various Indian Standards to ensure continuity and cogency in lighting practices.

This code contains regulations and good practices that can be immediately adopted or enacted by various departments and public bodies. It establishes minimum provisions to protect the public's interests in lighting levels, quantity, and safety parameters. The code provides detailed guidelines for lighting professionals but allows flexibility for users, designers, architects, and consultants.

The National Lighting Code applies to various interior and exterior installations, including special areas such as hospitals, utilities, sports complexes, and metro railways, all under the supervision of qualified personnel. By following this code, stakeholders can improve the overall lighting system and contribute to energy conservation, safety, and reliability in lighting applications throughout the country.

5.2 IS 1944 : CODE OF PRACTICE FOR LIGHTING OF PUBLIC THOROUGHFARES

IS 1944 Part V is an Indian Standard adopted by the Indian Standards Institution in February 1981. The purpose of this part of the code is to address issues and considerations related to the design of street lighting installations for grade separated junctions, bridges, and elevated roads. While the detailed lighting designs outlined in IS 1944 Parts I and II should generally be applied to these situations, deviations may be necessary to accommodate specific conditions imposed by structural design or traffic requirements.

The code emphasizes the importance of individual assessment for each case, considering its unique merits. As a result, this part of the code does not offer specific optimum solutions or detailed recommendations. Instead, it aims to consolidate all technological details and workmanship processes that can help achieve the objectives outlined in the code.

Furthermore, the standard acknowledges the advancements in lighting techniques over the past decade, including the development of new and efficient light sources and the use of high masts. By incorporating these technological evolutions, IS 1944 Part V aims to provide up-to-date guidelines for designing street lighting installations in areas such as grade separated junctions, bridges, and elevated roads.

5.3 INDIAN ROAD CONGRESS

The Indian Roads Congress (IRC) is a premier professional body in India that plays a significant role in the development and maintenance of road infrastructure in the country. It was founded in 1934 with the objective of promoting the scientific and sustainable development of roads, bridges, and transportation systems in India. The IRC operates under the Ministry of Road Transport and Highways (MoRTH) and serves as an authoritative source of guidance for road engineering practices.

The primary functions of the Indian Roads Congress include:

Standards and Guidelines: The IRC formulates and updates technical standards, specifications, and guidelines related to road construction, design, and maintenance. These documents serve as essential references for highway engineers, contractors, and other stakeholders involved in the road infrastructure sector.

Research and Development: The IRC conducts research and development activities to explore innovative technologies, materials, and construction methods for road and bridge projects. This helps improve the quality, safety, and efficiency of road infrastructure in India.

Capacity Building: The Congress organizes training programs, seminars, workshops, and conferences to enhance the knowledge and skills of professionals in the road engineering sector. These events provide a platform for sharing experiences and best practices.

Advocacy: The IRC advocates for policies and practices that promote the sustainable and safe development of road networks across the country. It works closely with government agencies and other stakeholders to influence road infrastructure-related decisions.

Publications: The IRC regularly publishes technical journals, research papers, and reports on various aspects of road engineering and transportation. These publications contribute to the dissemination of knowledge within the industry.

Technical Committees: The Congress forms technical committees comprising experts from various disciplines to address specific road-related challenges and provide recommendations.

The Indian Roads Congress has played a vital role in shaping India's road infrastructure, and its contributions continue to be significant in meeting the

country's transportation needs. Through its efforts, the IRC continues to ensure that road development in India adheres to high-quality standards and embraces sustainable practices.

5.4 IS 1945: CODE OF PRACTICE FOR LIGHTING OF PUBLIC STREETS, ROADWAYS, AND OTHER OPEN SPACES

IS 1945 is an Indian Standard titled "Code of Practice for Lighting of Public Streets, Roadways, and other Open Spaces." It provides comprehensive guidelines and recommendations for the lighting design of public streets, roadways, and various open spaces. The standard was formulated by the Bureau of Indian Standards (BIS) to ensure safe, efficient, and visually comfortable lighting in urban and suburban areas.

The key objectives of IS 1945 are as follows:

Safety and Visibility: The standard emphasizes the importance of adequate illumination to ensure the safety of pedestrians, cyclists, and motorists using public streets and roadways. It sets criteria for illuminance levels and uniformity to provide clear visibility and minimize accidents.

Energy Efficiency: IS 1945 encourages the use of energy-efficient lighting technologies and design practices to reduce electricity consumption and promote sustainability in outdoor lighting installations.

Visual Comfort: The standard considers factors such as glare control and color rendering to create visually comfortable and pleasant lighting environments for pedestrians and motorists.

Aesthetics: IS 1945 recognizes the significance of outdoor lighting in enhancing the aesthetic appeal of public streets, roadways, and open spaces. It offers recommendations to achieve visually attractive lighting designs.

Selection of Lighting Fixtures: The standard provides guidance on the selection and placement of lighting fixtures suitable for different street and open space layouts, ensuring optimal coverage and light distribution.

Maintenance and Operation: IS 1945 outlines best practices for regular maintenance and operation of outdoor lighting installations to ensure long-term performance and sustainability.

Special Considerations: The standard addresses the specific requirements of different areas, such as residential streets, commercial zones, public parks, and recreational spaces, to tailor lighting solutions accordingly.

By adhering to the guidelines set forth in IS 1945, urban planners, lighting designers, and municipal authorities can create well-lit and safe public spaces that contribute to the overall well-being of residents and visitors. It also aids in minimizing light pollution and optimizing energy consumption, aligning with India's commitment to sustainable and responsible urban development.

5.5 IS 10322: CODE OF PRACTICE FOR LIGHTING OF PUBLIC AMENITIES—PARKS AND PLAYGROUNDS

IS 10322 is an Indian Standard titled "Code of Practice for Lighting of Public Amenities—Parks and Playgrounds." It serves as a comprehensive guideline for the lighting design of public parks and playgrounds, aiming to enhance safety, security, and overall usability during the evening and night hours.

The key objectives of IS 10322 are as follows:

Safety and Security: The standard emphasizes the importance of providing adequate and uniform illumination in public parks and playgrounds to ensure the

safety and security of visitors. Well-lit areas help prevent accidents and deter potential criminal activities.

Visual Comfort: IS 10322 considers aspects such as glare control and color rendering to create visually comfortable and pleasant lighting environments for people using these amenities.

Energy Efficiency: The standard encourages the use of energy-efficient lighting technologies and design practices to minimize electricity consumption and reduce the overall environmental impact.

Proper Light Distribution: IS 10322 offers recommendations for the selection and placement of lighting fixtures to ensure appropriate light distribution across the park or playground, avoiding dark spots and providing sufficient illumination throughout.

Aesthetics: The standard recognizes the significance of lighting in enhancing the aesthetic appeal of public amenities. It provides guidance on lighting design to complement the architectural and landscaping features of the park or playground.

Special Considerations: IS 10322 considers the specific requirements of different types of parks and playgrounds, such as recreational areas, children's play areas, and sports fields, to tailor lighting solutions accordingly.

Maintenance and Operation: The standard outlines best practices for the regular maintenance and operation of lighting installations to ensure long-term performance and efficiency.

By following the guidelines set forth in IS 10322, park authorities, urban planners, and lighting designers can create well-lit and inviting public spaces that promote recreational activities, enhance community life, and contribute to the overall well-being of residents and visitors. Additionally, the code helps in

minimizing light pollution, conserving energy, and aligning with India's commitment to sustainable urban development and responsible lighting practices.

Other notable standards considered for lighting design are here as follows:

IS 398: Code of Practice for Lighting of Public Streets and Roads—Minimum Requirements

IS 398 lays down the minimum requirements for street and road lighting to ensure adequate illumination and safety for pedestrians and vehicular traffic.

IS 7124: Code of Practice for Lighting of Road and Pedestrian Crossings

This standard provides guidelines for the lighting design of road crossings and pedestrian crossings to enhance visibility and safety for pedestrians and motorists.

CHAPTER:
6. LUMINAIRES IN OUTDOOR LIGHTING

Outdoor public lighting is a crucial aspect of urban planning and design, with luminaires playing a central role in its effectiveness and functionality. Luminaires refer to the devices used to distribute, control, and enhance light output in outdoor lighting systems. These fixtures are specifically designed to withstand outdoor conditions, ensuring durability, efficiency, and visual appeal. The proper selection and deployment of luminaires significantly impact the safety, security, aesthetics, and overall well-being of a community.

Proper illumination in outdoor public spaces is paramount to ensure the safety and security of pedestrians, cyclists, and drivers. Well-designed luminaires help to eliminate dark spots, shadows, and potential hiding places for criminals, thereby reducing the risk of accidents and criminal activities. Adequate lighting also enhances visibility and helps individuals feel more secure when moving through public areas at night.

Luminaires are essential for guiding people and vehicles along streets, pathways, and sidewalks. With proper lighting, it becomes easier for individuals to navigate through unfamiliar areas and locate important landmarks, such as bus stops, crosswalks, and public facilities.

Outdoor public lighting contributes significantly to the visual aesthetics and ambiance of a city or community. Thoughtfully designed luminaires not only provide illumination but can also serve as decorative elements, enhancing the overall urban environment and creating a positive impression on residents and visitors alike.

The choice of energy-efficient luminaires can lead to substantial energy savings and reduced environmental impact. LED (Light Emitting Diode) luminaires, for instance, consume significantly less energy compared to traditional lighting technologies, such as incandescent or fluorescent bulbs. By using energy-efficient luminaires, cities can lower operational costs and contribute to sustainability efforts.

Improperly designed or poorly controlled lighting can lead to light pollution, adversely affecting ecosystems and human health. Luminaires that are engineered

to direct light only where it is needed can minimize light spill and skyglow, promoting a healthier environment for wildlife and stargazing enthusiasts.

Outdoor public spaces, such as parks, plazas, and recreational areas, can benefit from well-designed luminaires that allow for nighttime activities and events. Proper lighting extends the usability of public spaces beyond daylight hours, fostering a sense of community and social engagement.

Adequate lighting is vital to create inclusive public spaces that cater to people of all ages and abilities. Well-lit pedestrian paths and accessible facilities ensure that everyone can enjoy outdoor spaces safely, including individuals with visual impairments or mobility challenges.

Luminaires are at the forefront of smart city initiatives, enabling adaptive lighting controls based on real-time data and user needs. Automated dimming, remote monitoring, and motion sensors can optimize energy usage while maintaining appropriate lighting levels in different areas.

Effective outdoor public lighting can enhance the attractiveness of commercial areas, encouraging increased foot traffic and supporting local businesses. Well-lit public spaces also foster a sense of pride in the community, leading to increased property values and potential economic development.

Luminaires are essential components in outdoor public lighting design, offering numerous benefits ranging from safety and security to energy efficiency and aesthetics. By selecting appropriate luminaires and integrating them into thoughtful lighting plans, urban planners and designers can create vibrant, inclusive, and sustainable outdoor environments that enhance the overall quality of life for residents and visitors alike.

6.1 TYPES OF LUMINAIRES USED FOR OUTDOOR PUBLIC LIGHTING

There are several types of luminaires commonly used in outdoor public lighting to cater to different lighting requirements and design considerations. These luminaires are designed to withstand harsh outdoor conditions, provide efficient lighting, and ensure longevity. Some of the most common types of luminaires used in outdoor public lighting include:

- Streetlights: Streetlights are perhaps the most ubiquitous type of luminaire in outdoor public lighting. They are designed to illuminate streets, roads, and highways, providing safe and well-lit transportation routes for pedestrians, cyclists, and drivers. Streetlights come in various designs, such as cobra head, shoebox, and decorative lanterns, each tailored to specific lighting needs and aesthetic preferences.

- Floodlights: Floodlights are powerful luminaires that emit a wide beam of light, typically used for large-area illumination. They are employed to light up parks, sports fields, building facades, and other open spaces, often providing security and enhancing visibility during outdoor events.

- Pathway Lights: Pathway lights are low-level luminaires specifically designed to illuminate pedestrian walkways, sidewalks, and paths in parks and public areas. They are designed to ensure safe navigation and prevent accidents by clearly defining the walking areas.

- Bollard Lights: Bollard lights are short, sturdy, and often decorative fixtures installed along pathways, driveways, and plazas. They serve as a combination of wayfinding elements and safety markers, guiding people while preventing vehicle encroachment.

- Wall-Mounted Lights: Wall-mounted luminaires are fixed to walls or vertical surfaces and are commonly used to illuminate building exteriors, facades, and

entryways. They provide both functional lighting and contribute to the architectural aesthetics of buildings.

- Area Lights: Area lights provide uniform illumination over large outdoor spaces, such as parking lots, public squares, and recreational areas. They are designed to distribute light evenly across the area while minimizing light pollution and energy consumption.

- Post-Top Lights: Post-top lights are luminaires mounted on top of poles or columns, often used in pedestrian zones, parks, and plazas. They can add a decorative touch while providing efficient and aesthetically pleasing lighting.

- Solar-Powered Lights: As sustainable lighting solutions gain popularity, solar-powered luminaires are becoming more common in outdoor public lighting. These luminaires harness solar energy during the day and use it to illuminate public spaces during the night, reducing dependence on the electrical grid and lowering operational costs.

- Smart Luminaires: With the rise of smart city initiatives, outdoor public lighting is also integrating smart luminaires. These fixtures can be remotely controlled and monitored, allowing for adaptive lighting based on real-time data, traffic patterns, or user needs. They help optimize energy usage and improve overall lighting efficiency.

Each type of luminaire serves a specific purpose in outdoor public lighting design, and their selection depends on factors such as the intended application, lighting requirements, energy efficiency goals, and the overall aesthetic vision of the urban environment.

6.2 IP RATING OF THE LUMINAIRES USED

The IP (Ingress Protection) rating is a standardized system used to indicate the level of protection provided by electrical enclosures against the intrusion of

foreign objects (like dust and debris) and moisture (such as water). The IP rating is expressed in the form of "IPXX," where "XX" represents two digits. Each digit corresponds to a specific degree of protection.

For outdoor luminaires, it is crucial to have a suitable IP rating to ensure their durability and performance in various environmental conditions. Here's a summary of IP ratings commonly used for outdoor luminaires:

IP65: This rating offers a high level of protection against dust and provides protection against low-pressure water jets from any direction. Luminaires with an IP65 rating are suitable for general outdoor use and can withstand rain and other environmental factors.

IP66: Luminaires with an IP66 rating provide a similar level of dust protection as IP65 but offer additional protection against powerful water jets and heavy splashing. They are suitable for outdoor locations where the fixtures might be exposed to more challenging weather conditions.

IP67: An IP67 rating ensures complete protection against dust and immersion in water up to 1 meter for a limited time. Luminaires with this rating are suitable for areas where the fixtures may encounter water immersion or extreme weather conditions.

IP68: Luminaires with an IP68 rating offer the highest level of protection against dust and are designed to withstand continuous immersion in water beyond 1 meter. These fixtures are suitable for underwater applications, such as fountain lighting or submerged installations.

IP44: While commonly used for indoor applications, IP44-rated luminaires can also be used in sheltered outdoor areas where they are protected from direct water exposure.

When selecting luminaires for outdoor public lighting, it's essential to consider the environmental conditions they will be exposed to. For typical outdoor installations, IP65 and IP66-rated luminaires are often suitable, as they offer a good balance of dust and water protection. However, in more extreme or specialized outdoor lighting scenarios, higher IP ratings like IP67 and IP68 may be necessary to ensure the luminaires' longevity and functionality.

6.3 ADVANCEMENT OF LUMINAIRES IN INDIAN MARKETS

The Indian government's initiatives to promote energy-efficient lighting, smart city projects, and sustainable development have driven the demand for modern luminaires designed for outdoor applications. Here are some of the commonly used luminaires, growth trends, advancements, and market leaders in the outdoor public lighting sector in India:

6.3.1 COMMONLY USED LUMINAIRES:

LED Streetlights: LED technology has gained widespread adoption due to its energy efficiency, long lifespan, and cost-effectiveness. LED streetlights are commonly used across India to replace traditional sodium vapor or mercury vapor lamps.

Solar-powered Luminaires: With a growing focus on renewable energy, solar-powered luminaires have gained popularity in rural and remote areas where grid electricity is scarce or unreliable.

Smart Luminaires: The concept of smart cities has led to the deployment of intelligent lighting solutions with adaptive controls, remote monitoring, and data-driven optimization for energy savings.

Decorative Post-Top Lights: In urban areas, decorative post-top lights are often used to enhance the aesthetics of public spaces and provide efficient lighting

6.3.2 GROWTH AND ADVANCEMENTS

Energy Efficiency Drive: There has been a notable shift towards energy-efficient lighting solutions like LED luminaires, driven by government policies and awareness campaigns.

Smart City Initiatives: The Indian government's Smart Cities Mission has accelerated the adoption of smart lighting solutions with IoT-based controls and data analytics for improved efficiency and urban management.

Solar Lighting Expansion: Solar-powered lighting solutions have witnessed growth, especially in remote areas and off-grid locations, contributing to rural electrification and sustainability efforts.

Urban Renewal Projects: Redevelopment and beautification projects in cities have led to the installation of modern and aesthetically appealing outdoor lighting fixtures.

6.3.3 MARKET LEADERS

Several domestic and international companies are active in the outdoor public lighting market in India. Some of the market leaders include:

Philips Lighting (now Signify): Signify, formerly known as Philips Lighting, is a global leader in lighting solutions and has a strong presence in the Indian market, offering a wide range of outdoor luminaires.

Havells: Havells India Limited is a prominent Indian electrical equipment company that provides outdoor lighting solutions for various applications.

Crompton Greaves (CG): CG is another major Indian manufacturer with a significant presence in the outdoor lighting segment, offering a diverse portfolio of luminaires.

Osram: Osram, a well-known international lighting company, has a significant presence in India and offers outdoor lighting products tailored to the Indian market.

Bajaj Electricals: Bajaj Electricals is a leading Indian manufacturer of lighting products, including outdoor luminaires used in public lighting projects.

It's important to note that the outdoor lighting market is dynamic, and new companies may have emerged, and the market landscape may have evolved beyond my last update.

CHAPTER:

7. INSTRUMENTS USED IN MEASUREMENT

7.1 LUX METER

A lux meter, also known as a light meter, is a handheld device or instrument used to measure illuminance, which is the amount of light falling on a given surface area. It is an essential tool in various fields, including photography, cinematography, architecture, lighting design, and industrial applications.

The lux meter works based on the principle of a photodiode or photodetector, which measures the intensity of light in lux (lx). Lux is the SI unit of illuminance and represents the amount of luminous flux (measured in lumens) falling on a square meter of a surface. The lux meter's sensor detects the light falling on it and converts the measurement into lux, providing a numerical value that indicates the brightness of the light source.

Lux meters are calibrated to accurately measure different levels of illuminance, allowing users to assess lighting conditions in various environments. They can be used to determine if a space has adequate lighting for specific tasks, assess the uniformity of lighting across an area, or verify compliance with lighting standards and regulations.

In photography and cinematography, lux meters help determine the appropriate exposure settings for capturing images or recording videos under different lighting conditions. In architectural and lighting design applications, lux meters are used to assess and optimize lighting layouts for maximum efficiency and user comfort.

Overall, lux meters are valuable tools that provide objective and quantitative data about light levels, aiding professionals and enthusiasts in making informed decisions regarding lighting setups, energy efficiency, and visual comfort in a wide range of applications.

FIG 7.1: LUX METER USED IN EXPERIMENT

7.2 MEASURING TAPE

A measurement tape, also known as a measuring tape or tape measure, is a flexible and portable tool used to measure the length, width, or height of various objects and spaces. It is one of the most commonly used measuring instruments and is indispensable in fields such as construction, carpentry, tailoring, interior design, and many more.

A typical measurement tape consists of a ribbon-like strip made of durable materials, such as metal or reinforced fabric, which is marked with units of measurement along its length. The most common units used are inches and feet in the imperial system and centimeters and meters in the metric system. The tape is wound around a compact case or reel, making it easy to carry and store.

To use a measurement tape, the user extends the tape along the surface to be measured, ensuring it is taut and straight. The measurement is read at the point where the end of the tape aligns with the other edge or surface being measured. The clear markings on the tape allow for precise measurements, making it a reliable and versatile tool.

Measurement tapes come in various lengths, typically ranging from a few feet or meters up to 100 feet or more, depending on the intended application. Some measurement tapes also have additional features, such as self-locking mechanisms to hold the tape in place during measurement and markings for both imperial and metric units on the same tape.

FIG 7.2: MEASURING TAPE

CHAPTER:

8. CASE STUDY AND RESULT ANALYSIS OF PUBLIC LIGHTING DESIGN PARAMETERS FOR RAJARHAT AND SILIGURI

8.1 CASE STUDY OF RAJARHAT

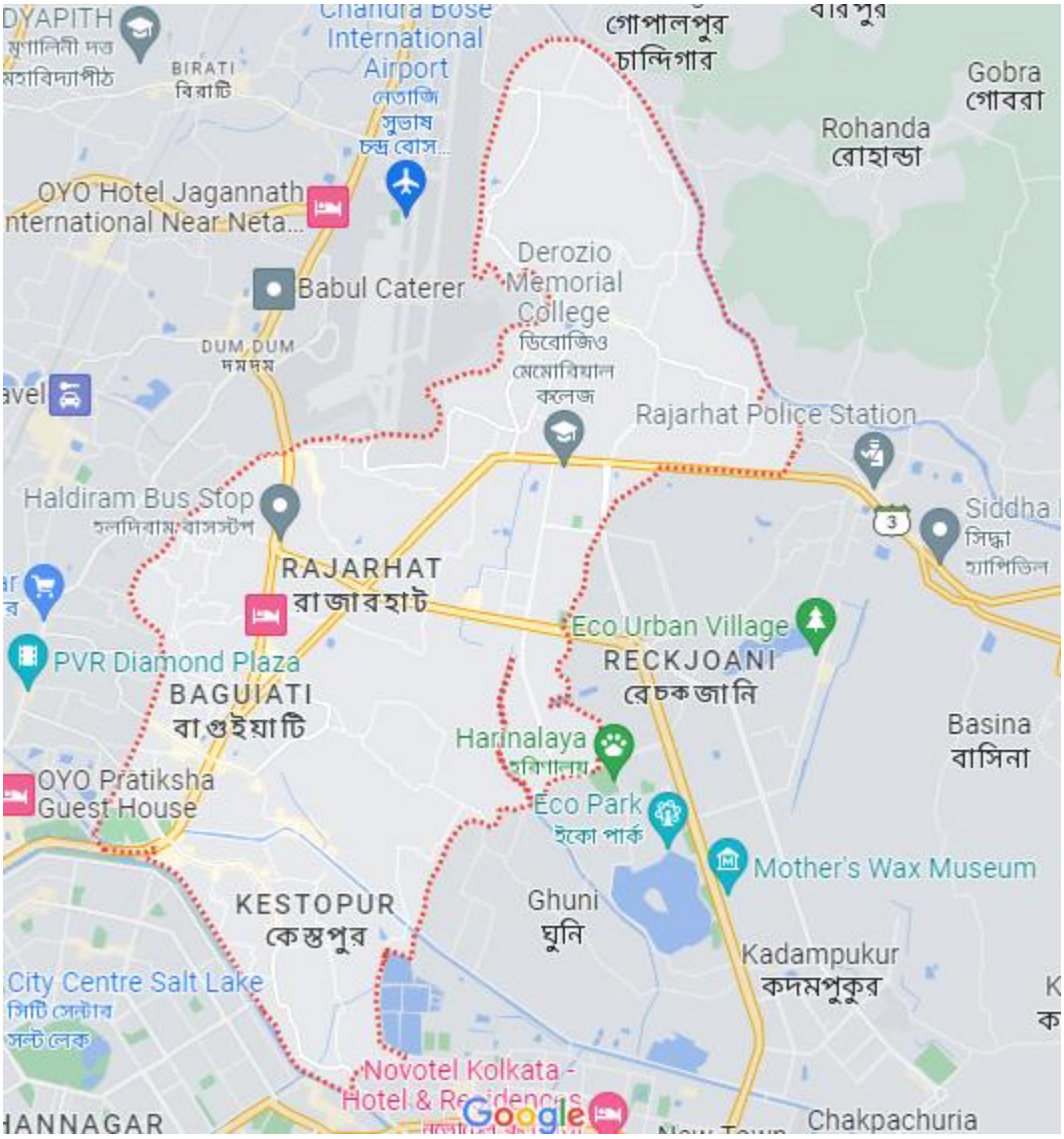


FIG 8.1: CITY MAP OF RAJARHAT

8.1.1 ZONE: OUTDOOR PARKING AREA LIGHTING

Parking Area 1:

Pole Length: 7m

Parking Area Length – 4.2m

Walking Area length – 6m

Both Side double sided luminaire – 2x2 Luminaire each

Distance between two poles – 20m

Poles: 6

Length of Road: 1.5Km

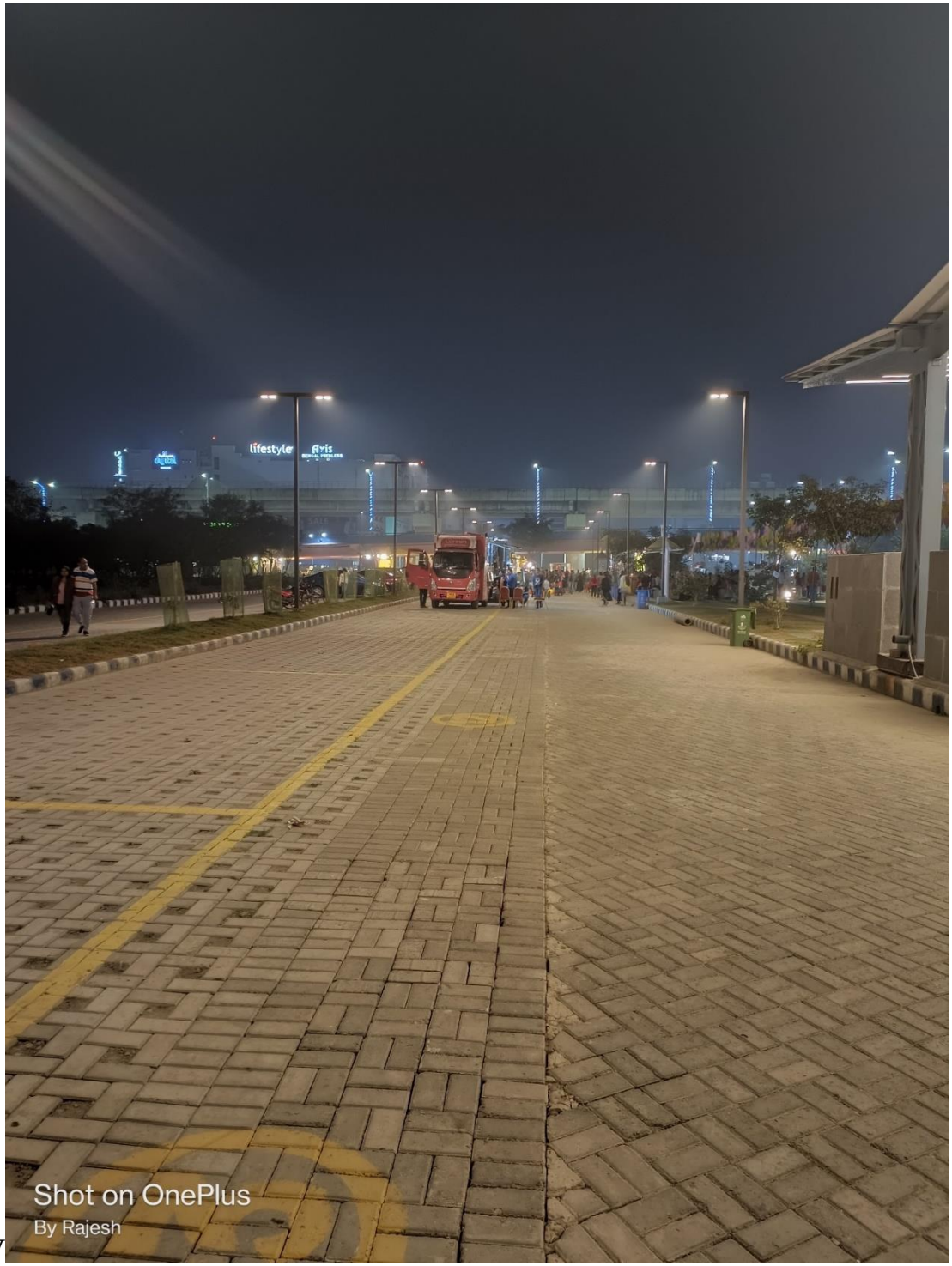
Data Set:

1. Parking Area:

	1	2	3
1 – 5m	65	77	66
2 Pole – 0m	85	105	88
3 – 5m	44	60	64

2. Parking Area:

	1	2	3
1 – 5m	65	64	52
2 Pole – 0m	82	114	119
3 – 5m	76	98	110



V

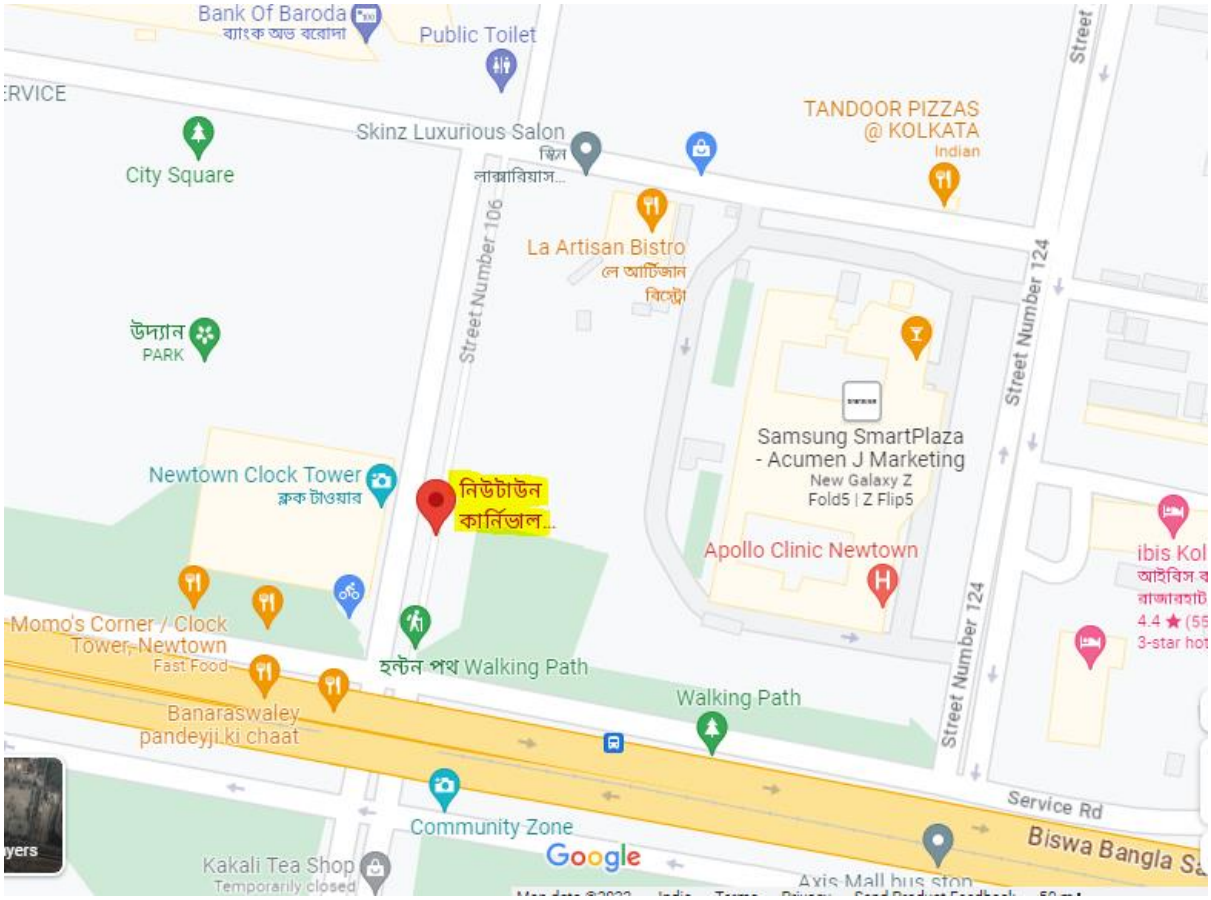


FIG 8.1: RAJARHAT PARKING AREA SITE

Parking Area 2:

Pole Length: 7m

Parking Area Length – 5m

Both Side double sided luminaire – 2x2 Lumiaire each

Distance between two poles – 20m

Poles: 6

Length of Road: 1.5Km

Data Set :

1. Parking Area:

	1 – 0m	2 – 2.5m	3 – 5m
1 – 5m	45	55	56
2 Pole – 0m	59	76	96 – Pole position
3 – 5m	45	60	54

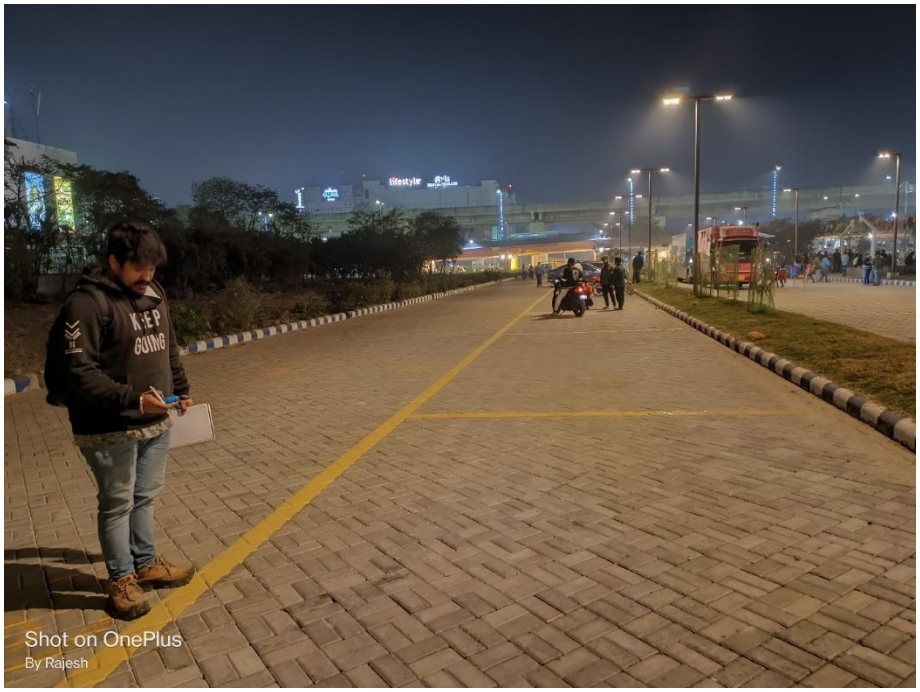


FIG 8.2: RAJARHAT PARKING AREA SITE

Discussion:

Both the parking Area was over-illuminated with a large amount of light pollution and the area was receiving heavy lights from the nearby sources of the park,

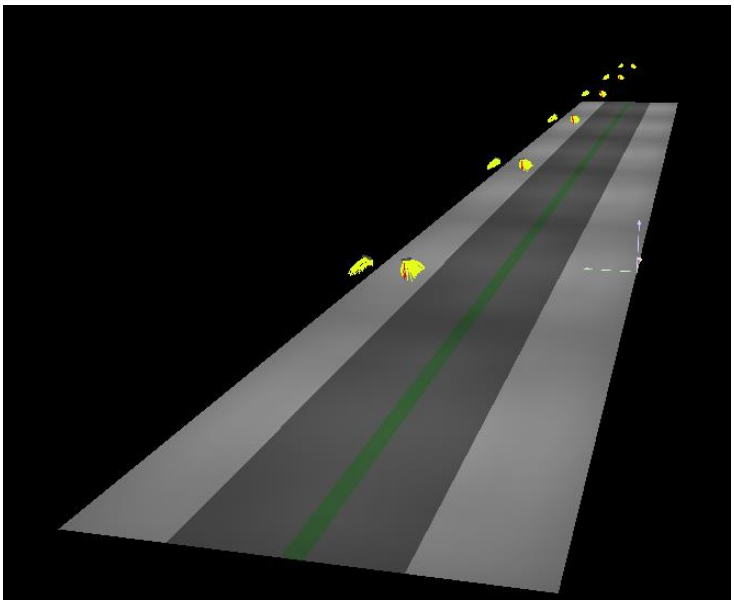
walking area and foodtrucks parked over there. So it was necessary to bring down the number of light sources in each pole to one and increase the pole distance to keep it as per the standard average of 50lux and also the design has an uniformity of 0.75 which is very good as per the standard of > 0.25

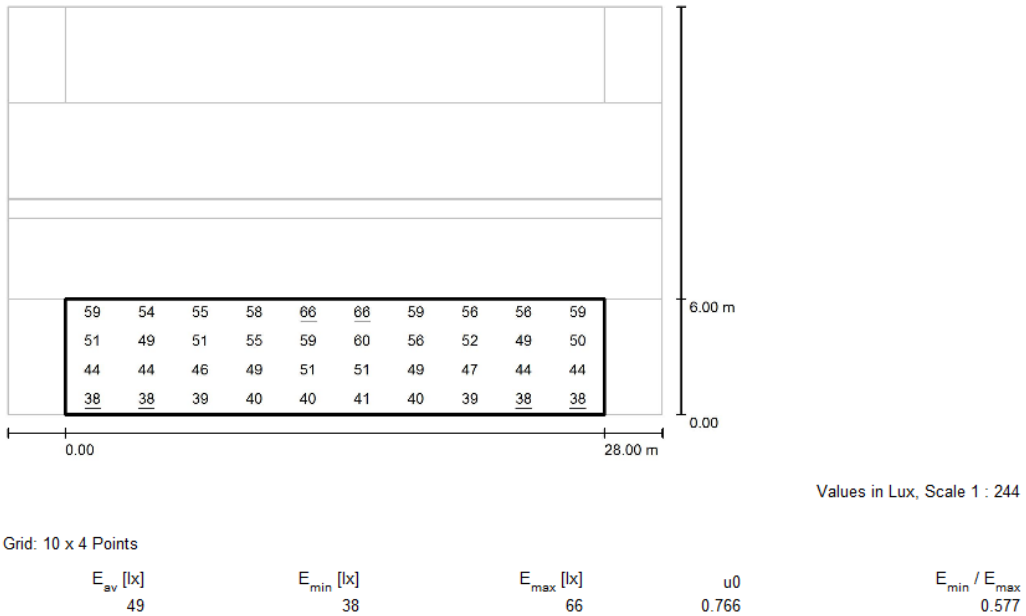
Suggested Dialux Design of both the area together:

Luminaire: Surya 150 Watt

Mounting Height: 10m

Distance Between Poles: 28m





Values in Lux, Scale 1 : 244

Grid: 10 x 4 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
49	38	66	0.766	0.577

Parking Area 3

High Mast with 6 Luminaires Floodlight

Below the mast 477

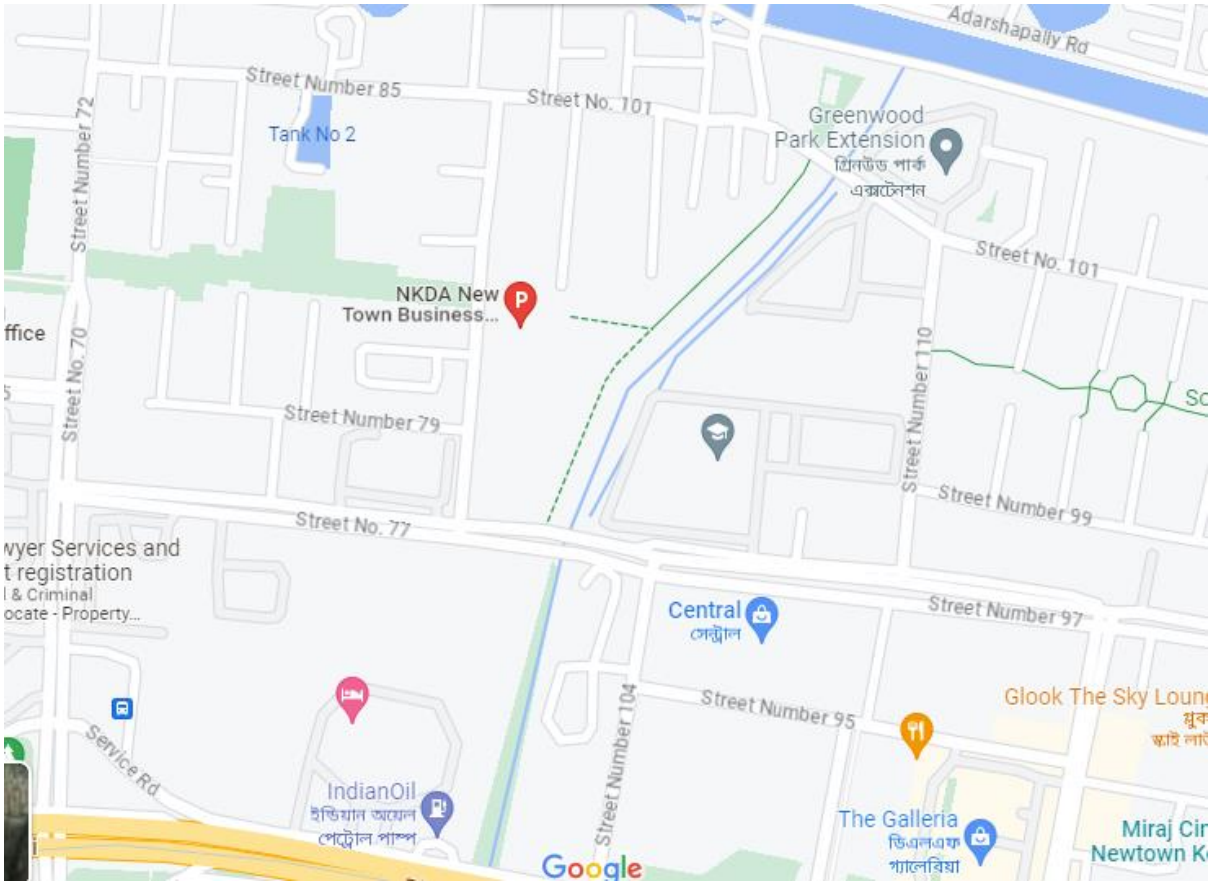
Length – 20m

	1	2	3	4
From Mast 10 m	241	254	307	316
20 m	81	73	84	56
30 m	37	32	54	28

FIG 8.3: RAJARHAT PARKING AREA SITE WITH HIGH MAST

Discussion:

The area is not at all illuminated as there was only 1 High Mast working in the front section instead of the other two. The light patch was due to one only 1 source and it was illuminated considering the area under the source only. Other areas were dark with cars parked and might cause accident as there was almost 0 illuminance. In order to resolve the design, other high masts must be illuminated along with occupancy sensors for better efficient design and energy will be used only if the area is occupied.



Statistical Analysis:

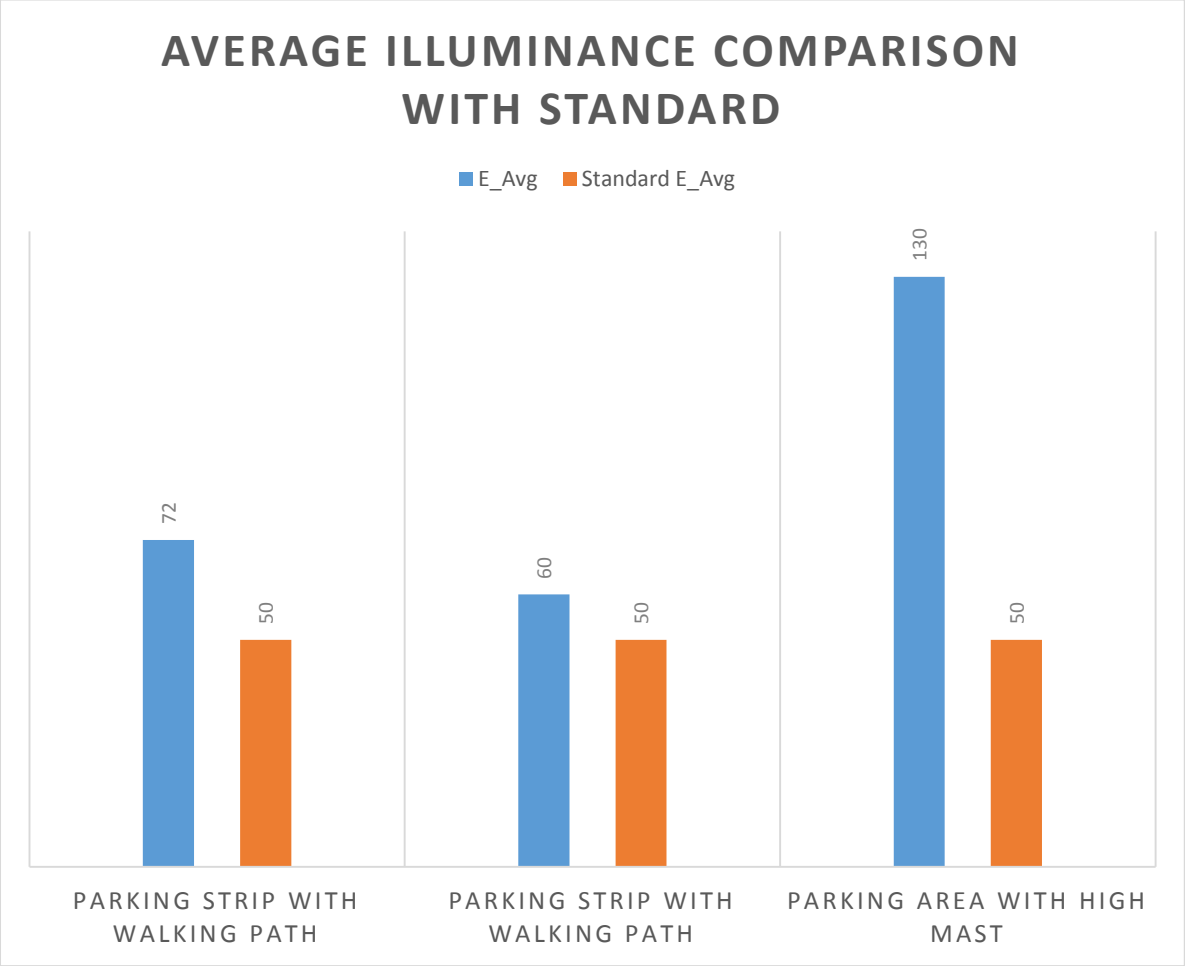


Fig 8.4 : Comparative Study of Average Illuminance Rajarhat Parking

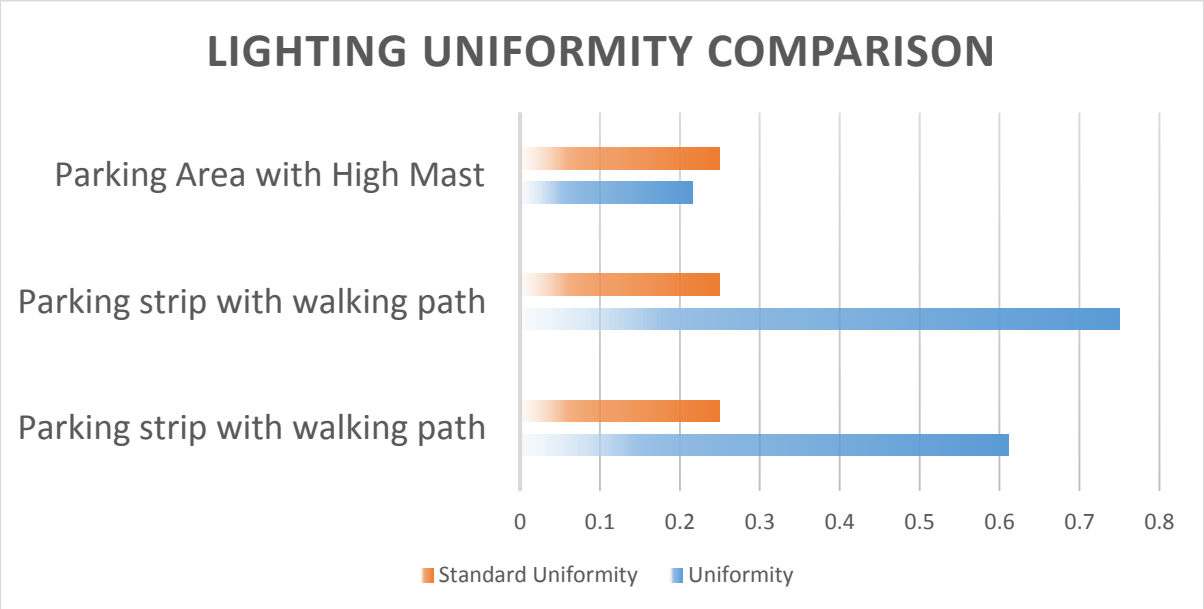


Fig 8.5: Comparative Study of Uniformity with Standard Rajarhat Parking

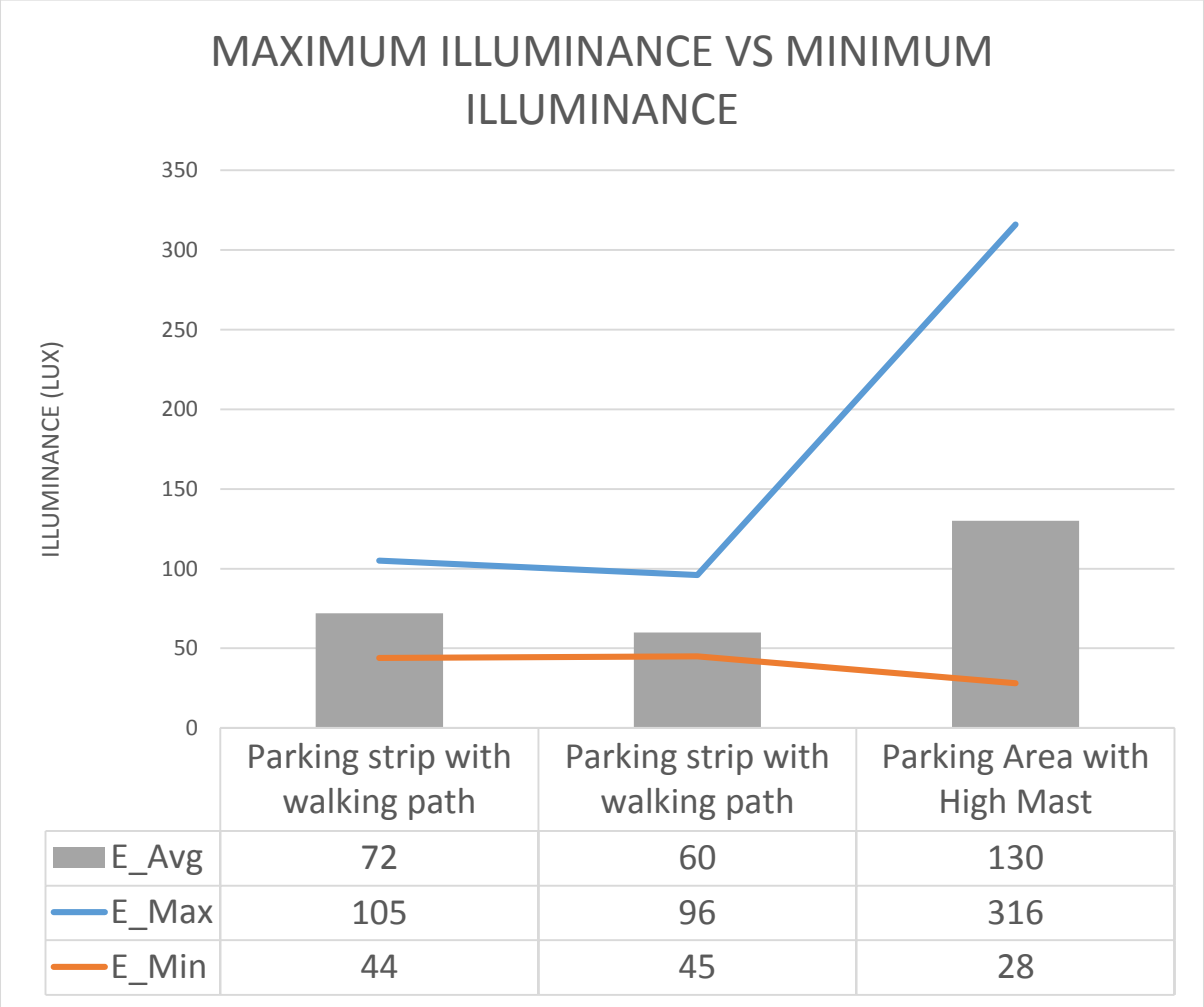


Fig 8.6: Max vs Min Illuminance with the calculated Average Illuminance Rajarhat Parking

Discussion:

The standard illuminance levels at all the sites have been exceeded, which may lead to the occurrence of sky glow in the vicinity as well as light pollution affecting nearby activities. The proposed designs have already undergone discussion, and the general design parameters that can be reviewed are outlined below:

1. Reduction in Luminaire Quantity: The utilization of a reduced number of luminaires is recommended, taking into account all design standards, with the primary aim of minimizing both energy consumption and maintenance costs.

2. Consideration of Surrounding Light Sources: During the initial stages of design, it is imperative to account for light emanating from nearby sources such as billboards, shop entrances, building facade lighting, adjacent parks, and streetlights. This comprehensive approach is essential to curtail project costs. Furthermore, the government should take stringent measures against excessive use of facade lighting in public and commercial properties to mitigate light pollution and glare.

3. Implementation of Automated Controls: Incorporating automated occupancy and ambient light sensors into the design is highly advisable. This feature will significantly reduce energy consumption on a larger scale when lighting is unnecessary or when spaces are unoccupied. The light sources will autonomously dim themselves, maintaining the minimum illumination required for visibility by approaching vehicles.

4. Emphasis on Uniform Distribution: The design must prioritize uniformity to eliminate any uneven patches of light and minimize glare for the occupants.

In conclusion, the excessive illuminance levels at the sites have raised concerns about sky glow and light pollution. To address these issues, it is vital to re-evaluate design parameters, including reducing luminaire numbers, considering surrounding light sources, implementing automated controls, and maintaining uniform distribution. These measures will not only enhance lighting efficiency but also contribute to a reduction in energy consumption and associated costs while mitigating the negative effects of excessive artificial lighting on the environment and human activities.

8.1.2 ZONE: PUBLIC PARKS, SITTING AREA AND COMMON SPACES

Public Statue:

Luminaire used : Isolite- 150W X 4

Vertical Illuminance (anti-clockwise):

	Face	Right	Back	Left
Vertical Illu	940	280	25	25

Vertical Illuminance Anti Clockwise: On Podium

	Face	Right	Back	Left
Vertical Illu	230	75	75	55

Horizontal Illuminance Anti Clockwise: On Podium

	Face	Right	Back	Left
Vertical Illu	30	32	32	12

BackLight Horizontal:

Left – 33, Middle – 12, Right – 30

FIG 8.7: RAJARHAT PUBLIC STATUE

Discussion:

The design consists of 4 high bay light used each of 150 Watt to describe the statue along with that the background is filled with pictures and description having one spotlight each. The area is over-illuminated and the design can be updated with only 2 high bay luminaire used to focus on the statue. The main motive of design is to highlight and wash light all over the statue but in this case there is a heavy light patch focusing and causing discomfort. An example of the design to focus on the curvatures and design elements of the statue has been given below using 4 spotlights on four corners of the statue. The design has achieved the minimum requirement of 10lux along with the every details visible for the statue.

Suggested Dialux Design:

Park Pathway

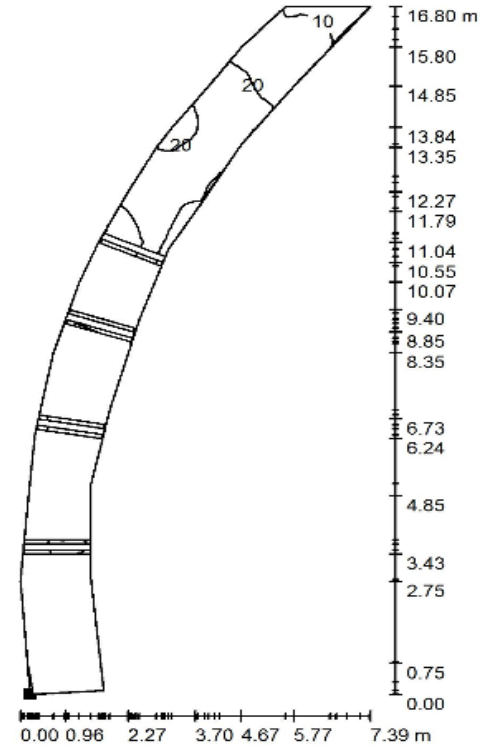
Luminaire: Bollards of height .634

Area taken into consideration – 2m X 2m Bollard at the center

	1 – 1m	2 – 0m	3 – 1m
1 – 1m	24	37	17
2 – 0m	38	2600	22
3 – 1m	19	36	20

FIG 8.8: PARK PATHWAY NEAR CENTRAL MALL

Suggested Dialux Design:



E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
20	2.09	30	0.106	0.069

Discussion:

Every park design is developed considering the ambience of the area and not making it over illuminant. The park in the case is receiving lights from external sources in the nearby areas and resulting in addition to the ambient lighting. Dialux design has been made taken into consideration the nearby sources and standard average illuminance.

Park OAT

Area under OAT- 18m X 8m

Luminaires: 28 Striplight – 4m and 3m each – 14 each

	1 – 1m	2 – 9m	3 – 18m
1 – 1m - front	173	318	176
2 – 4m	172	413	161
3 – 8m - back	204	314	178

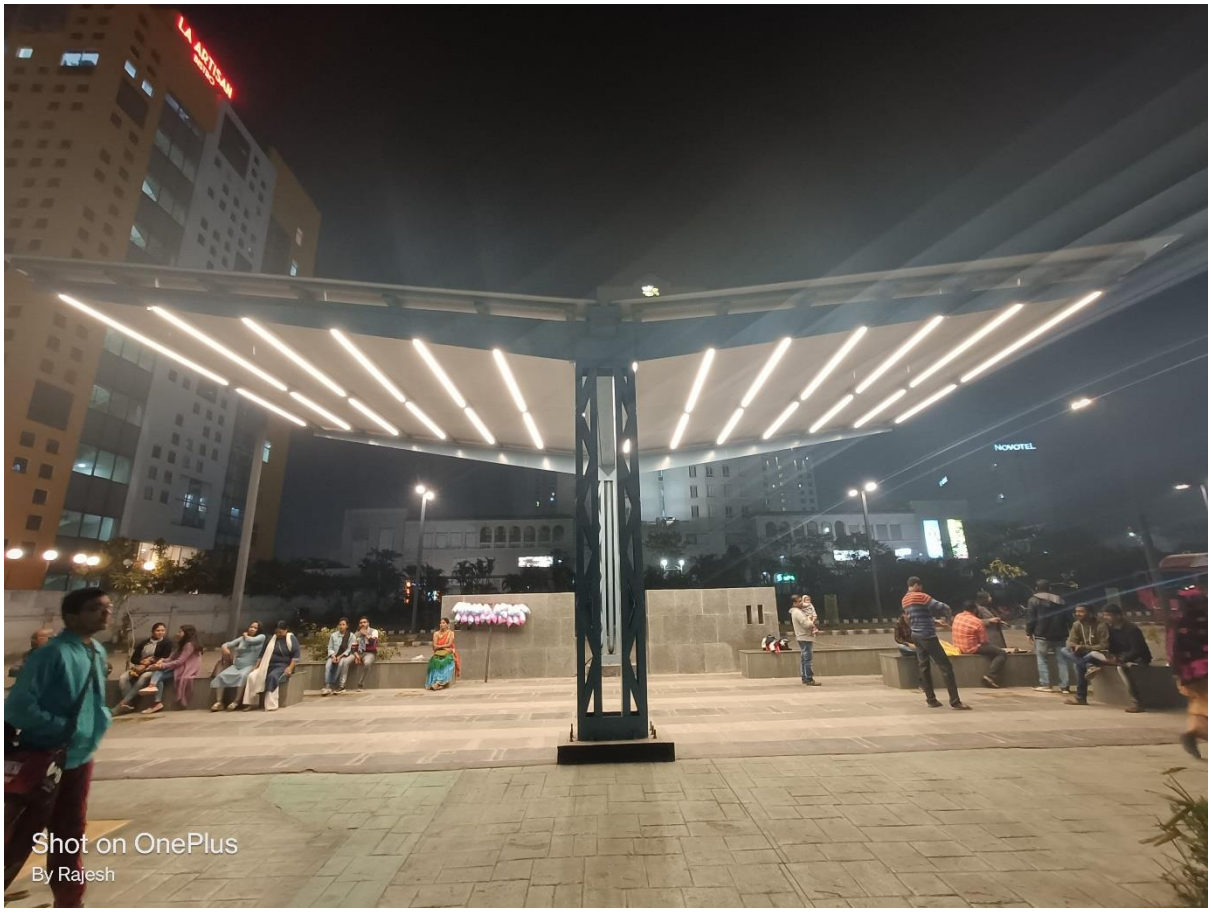
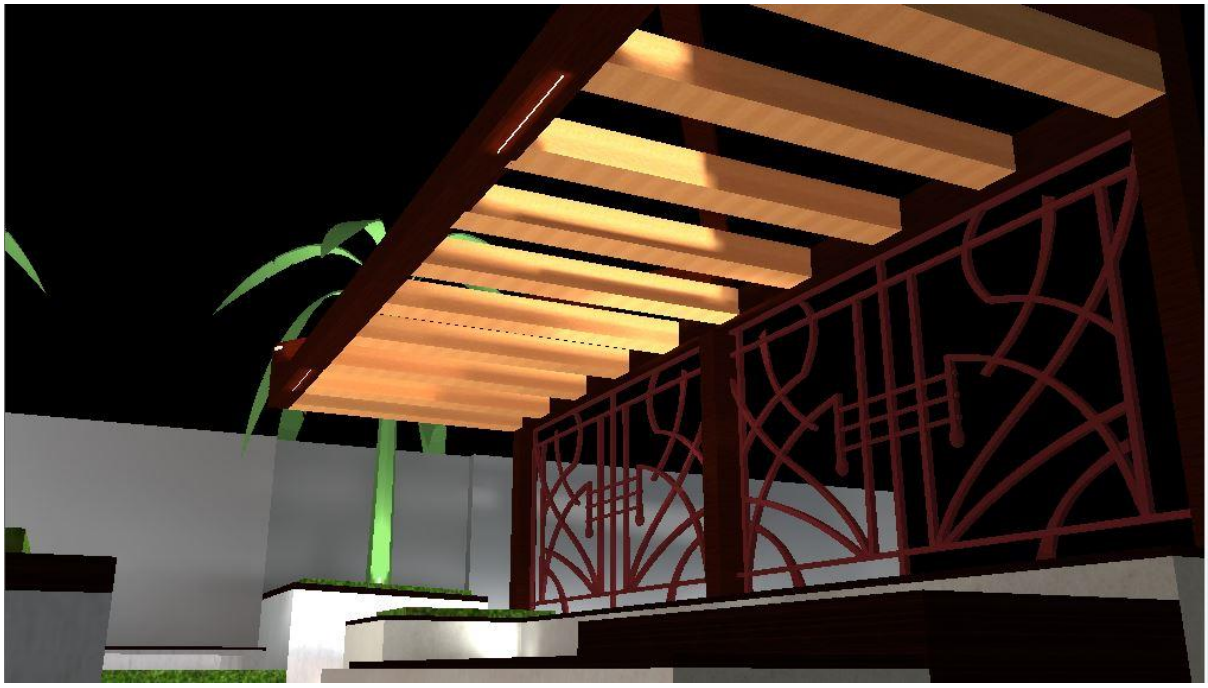


FIG 8.9: OAT IN THE RAJARHAT AREA

Discussion:

The area under OAT in the site is very much over illuminated as per the calculation and the data set. Multiple strip lights have been used on the structure which can be reduced to maintain the standard Illuminance. In the DiaLux design only 3 Striplights have been used as a downlighter to maintain the standard illuminance considering all the surrounding light sources.

Suggested Dialux Design:



Exterior Scene 1 / Ampetheatre / Value Chart (E, Perpendicular)

3.25	3.26	3.26	3.25	2.91	2.90	8.30	10	7.01	4.13	2.62	2.62	2.01	2.01	2.00	1.99
3.26	3.26	3.26	3.27	2.93	5.75	4.19	4.18	8.92	4.42	2.63	2.65	2.02	2.01	2.00	2.00
3.78	3.78	3.84	3.88	4.71	2.87	3.55	3.59	4.75	6.85	2.82	2.72	2.21	2.21	2.24	2.21
6.49	7.07	7.00	7.37	4.73	3.99	4.31	4.32	4.34	6.07	6.25	5.25	5.51	5.55	4.90	4.05
12	13	13	11	7.51	5.88	5.00	4.72	4.97	5.97	7.48	9.51	11	11	9.37	7.07
17	19	19	16	11	8.20	6.72	6.31	6.74	8.53	11	14	17	17	14	11
20	23	22	19	13	10	8.30	7.82	8.22	10	14	18	21	21	18	13
21	24	23	20	15	11	9.52	9.02	9.42	12	15	19	22	22	19	14

3.20 m

0.00

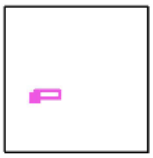
0.00

9.34 m

Values in Lux, Scale 1 : 67

Not all calculated values could be displayed.

Position of surface in external scene:
Marked point: (7.129 m, 18.088 m, 3.801 m)



Grid: 64 x 32 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
9.07	1.99	24	0.219	0.083

Sitting Area Covered under the Bridge Sitting and Playing Area

Luminaire used – Magik 80Watt

Difference between Luminaires – 5.5m

Area covering the calculation – 5.5m X 5m

Number of seats under the area – 4X2 with 2m difference each

	1 – 1m	2 – 3m	3 – 5m	7m
1 – 1m	150	352	832	532
2 – 2m middle of chairs	154	385	403	
3 – 3m	149	301	652	348

Discussion:

The area is over illuminated using multiple down lights in a short area under the bridge. The design and the paintings of the walls cause high reflection of the light sources creating a more illuminated area. This area cause glare and discomfort to the occupants due to very high lux levels. The number of luminaires need to be reduced to keep the average illuminance to the standard of 50Lux. Also occupancy sensors must be added to reduce energy consumption.

FIG 8.10: SITTING AREA UNDER THE BRIDGE

Statistical Analysis:

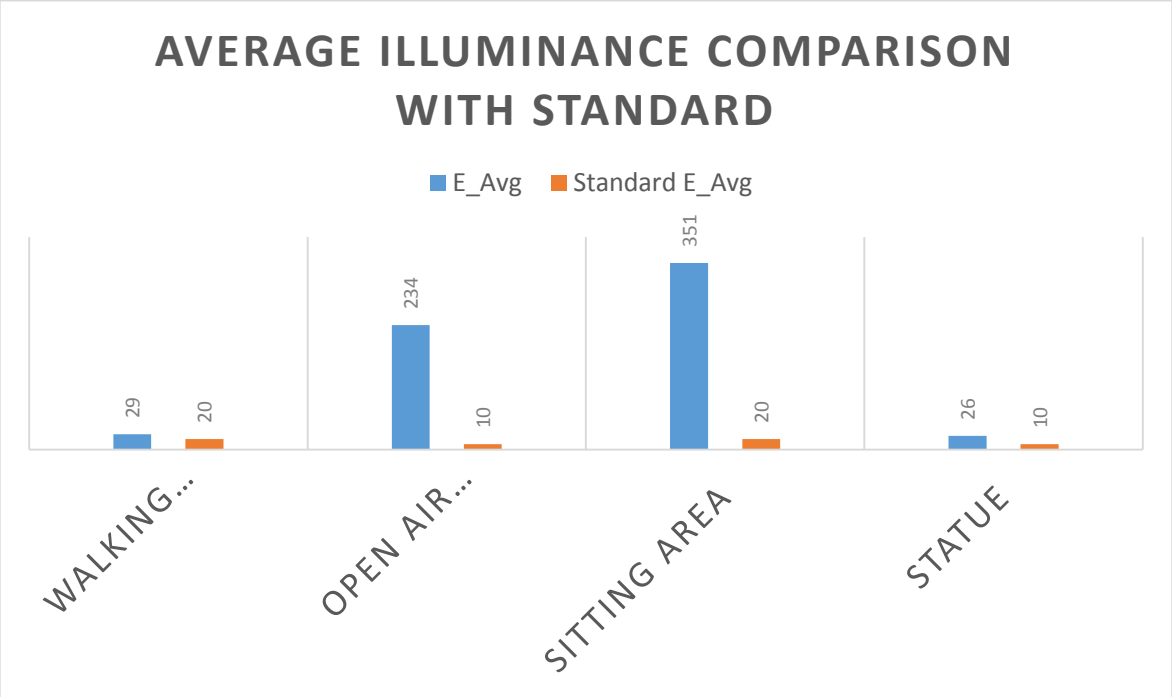


Fig 8.11: Comparative Study of Average Illuminance

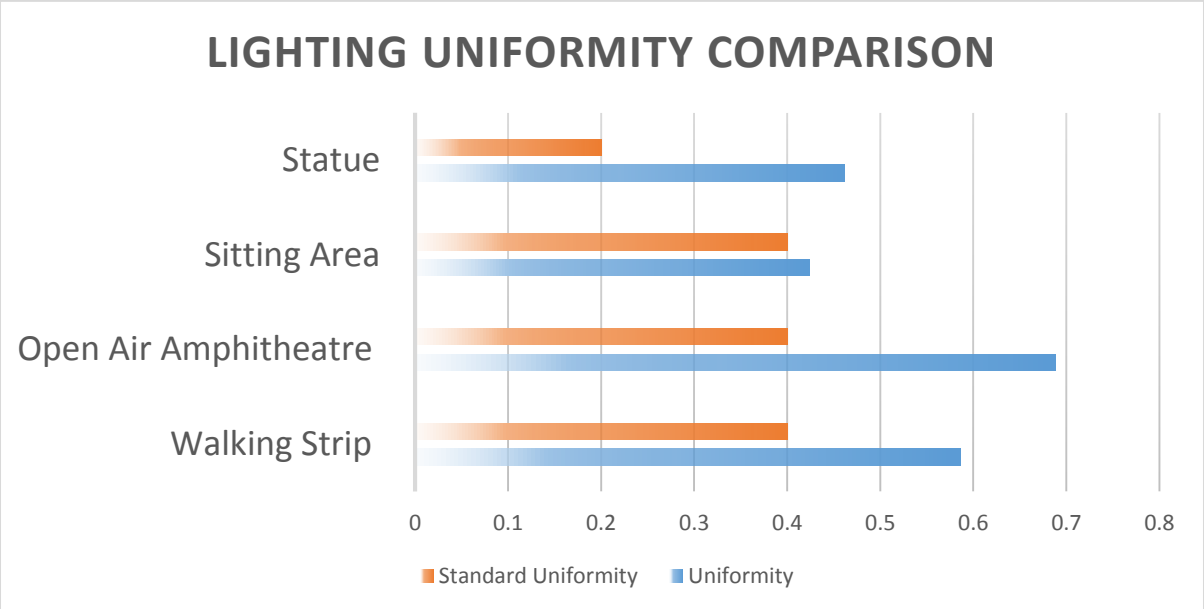


Fig 8.12: Comparative Study of Uniformity with Standard

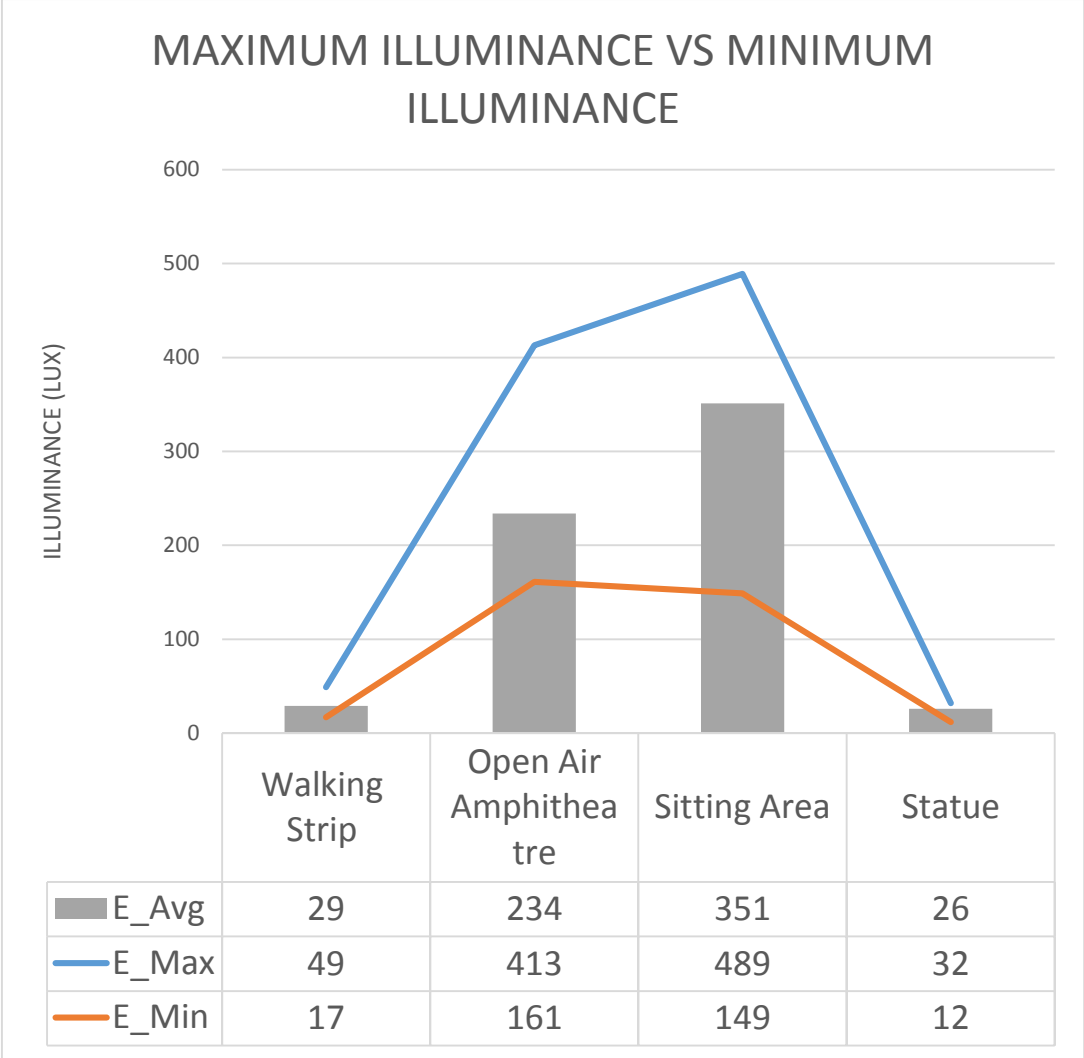


Fig 8.13: Max vs Min Illuminance with the calculated Average Illuminance

Discussion:

From the statistical data it is clearly visible that the measured average illuminance is comparatively very high with the rated standard. This might cause glare and discomfort to the occupants resulting in multiple visual problems. Also excessive light levels will cause light pollution as well as sky glow in the area. Considering all the factors, the proposed designs have already undergone discussion, and the general design parameters that can be reviewed are outlined below:

1. Reduction in Luminaire Quantity: The recommendation is made to utilize a reduced number of luminaires, considering all design standards, with the primary aim of minimizing both energy consumption and maintenance costs. By strategically reducing the number of luminaires, not only can energy costs be saved, but also a reduction in the environmental impact associated with luminaire production and disposal can be achieved.

2. Consideration of Surrounding Light Sources: During the initial stages of design, it is imperative that light coming from nearby sources such as billboards, shop entrances, building facade lighting, and streetlights is taken into account. This comprehensive approach is essential for managing project costs. Furthermore, stringent measures should be taken by the government against the excessive use of facade lighting in public and commercial properties to mitigate light pollution and glare. A balanced approach between aesthetics and sustainability in urban lighting design can be strived for through collaboration involving designers, architects, and local authorities.

3. Implementation of Automated Controls: The incorporation of automated occupancy and ambient light sensors into the design is highly advisable. This feature will lead to a significant reduction in energy consumption on a larger scale when lighting is unnecessary or when spaces are unoccupied. The light sources will autonomously dim themselves, maintaining the minimum illumination required for visibility, especially by approaching vehicles. Enhanced energy efficiency and real-time data for continuous optimization can be provided by modern technology advancements, such as IoT-based lighting control systems.

4. Emphasis on Uniform Distribution: The prioritization of uniformity in the design is essential to eliminate any uneven patches of light and minimize glare for the occupants. It also provides enhanced visual comfort and improved safety in various applications in public spaces, can be achieved through uniform light distribution.

In conclusion, the concerns raised about sky glow and light pollution due to excessive illuminance levels at the sites necessitate a re-evaluation of design parameters. This includes the recommendation to optimize luminaire quantity, the imperative need to account for nearby light sources, the highly advisable integration of automated controls, and the essential emphasis on uniform light distribution. These measures will not only enhance lighting efficiency but will also lead to substantial reductions in energy consumption and associated costs. Moreover, they play a vital role in mitigating the adverse impacts of excessive artificial lighting on the environment and human activities, particularly in addressing sky glow, light pollution, glare and visual discomfort.

8.1.3 ZONE: ROAD LIGHTING WITHIN CITY

Road 1:

Pole height: 7m

Make: Crompton

Arrangement: 2 Side Arrangement each with a luminaire

Distance between poles: 15m

Road Width : 10m on both side

	1	2 – 3m	3- 6m	4 – 9m	5 -12m	6-15m
1 –	160	244	110	110	230	130
2 –	197	252	78	148	250	176
3 –	257	238	58	185	266	226

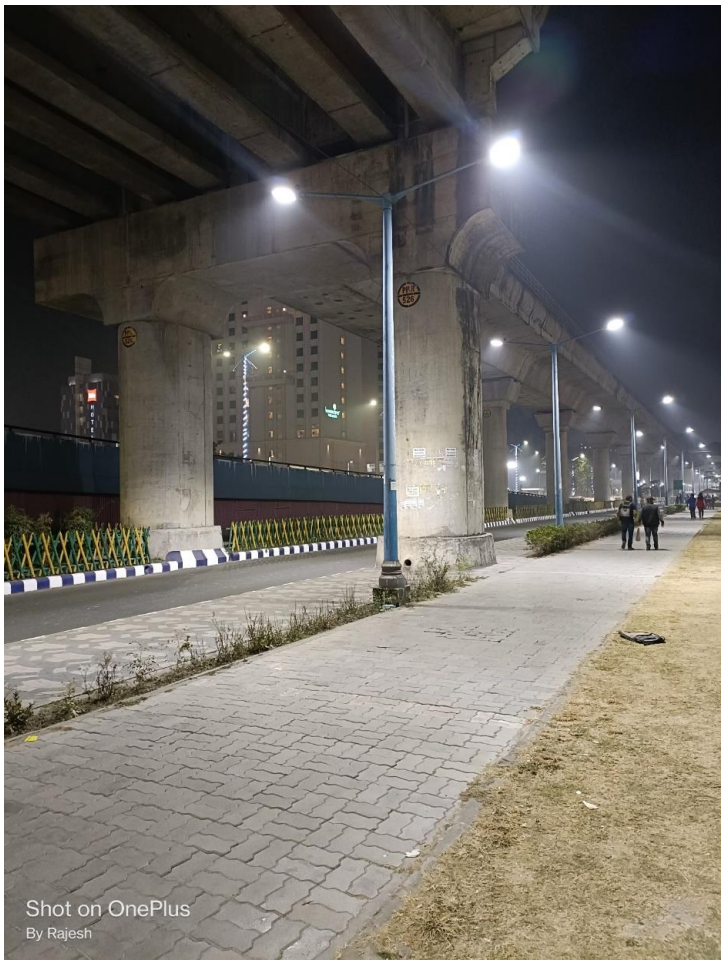


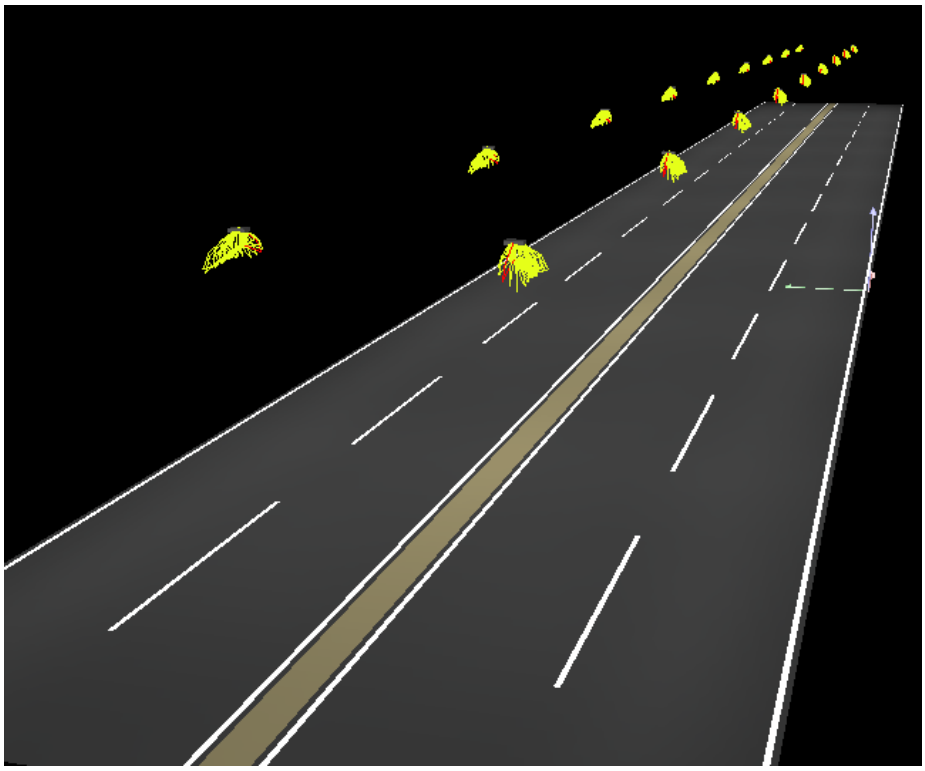
FIG 8.14: STREET LIGHTING NEAR AXIS MALL

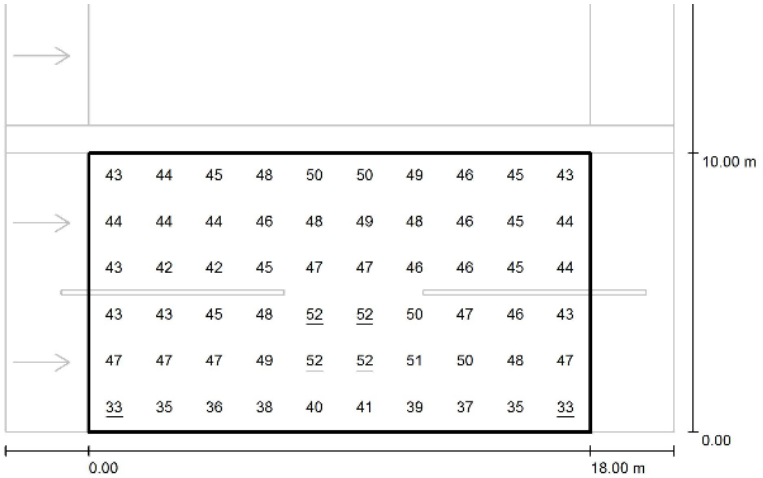
Suggested Dialux Design :

Luminaire : Surya 150 Watt

Mounting Height: 9m

Distance Between Poles: 18m





Values in Lux, Scale 1 : 172

Grid: 10 x 6 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
45	33	52	0.740	0.634

Discussion:

The site is having very high illuminance considering the standard and can cause discomfort to the motorist and pedestrians. The DiaLux design has been updated considering the area and the nearby light sources. The 45Lux average illuminance has been designed considering all the lights from billboards and nearby buildings to add into the Average Illuminance to avoid any light pollution and also keeping the standard values in consideration. The pole height has been increased along with the pole distance between each other, to reduce the number of luminaires used. This will save energy as well as the maintenance required for the luminaires.

Road 2:

Pole Height: 9m

Pole Arrangement: 1 Side Arrangement each with a luminaire

Distance between poles: 23m

Road Width : 11m

Poles: 7

Data Set:

	1 – 1m	2 – 11m	3 – 20
1 –Pole	54	49	45
2 – 3m	71	73	76
3 – 6m	110	88	82
4 – 9m	125	96	94

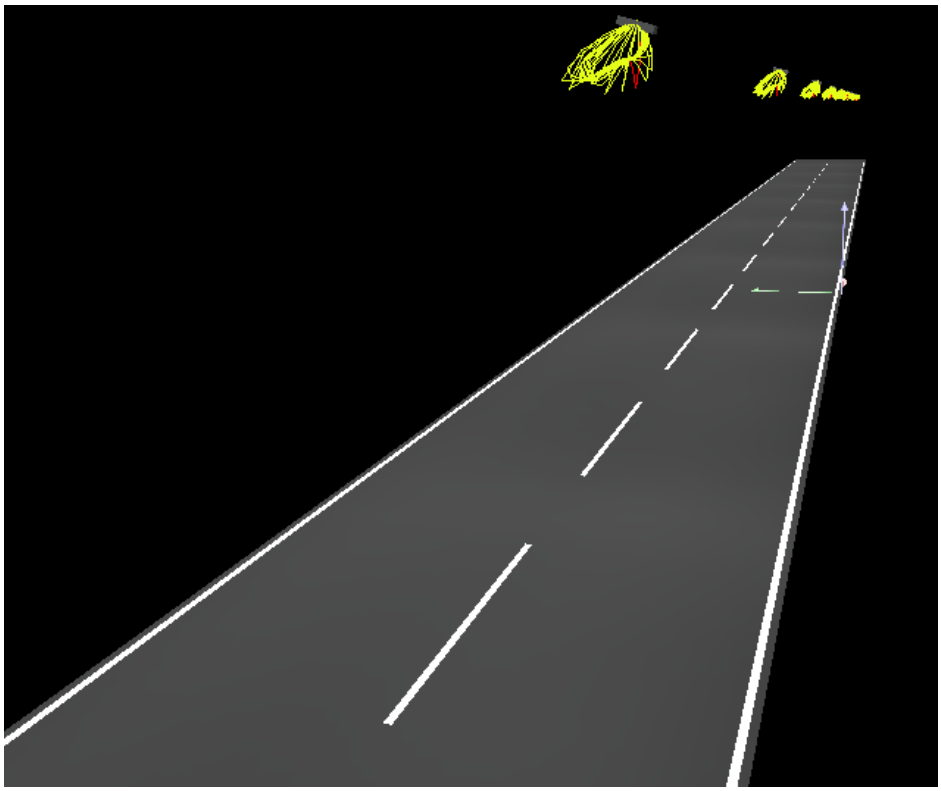
FIG 8.15: STREET LIGHTING NEAR CENTRAL RAJARHAT

Suggested Dialux Design:

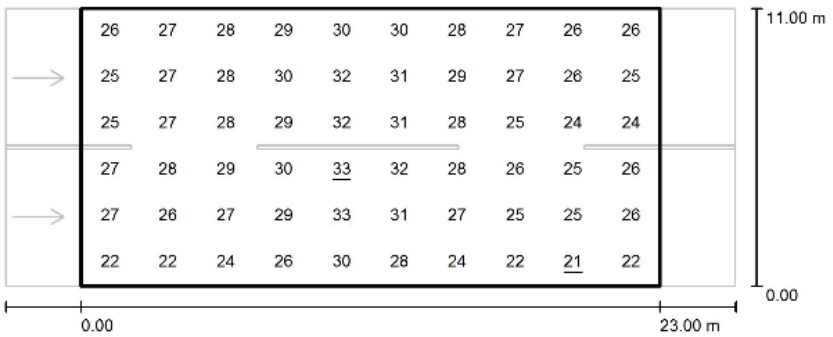
Luminaire : Surya 150 Watt

Mounting Height: 10m

Distance Between Poles: 23m



Street 1 / Valuation Field Roadway 1 / Value Chart (E)



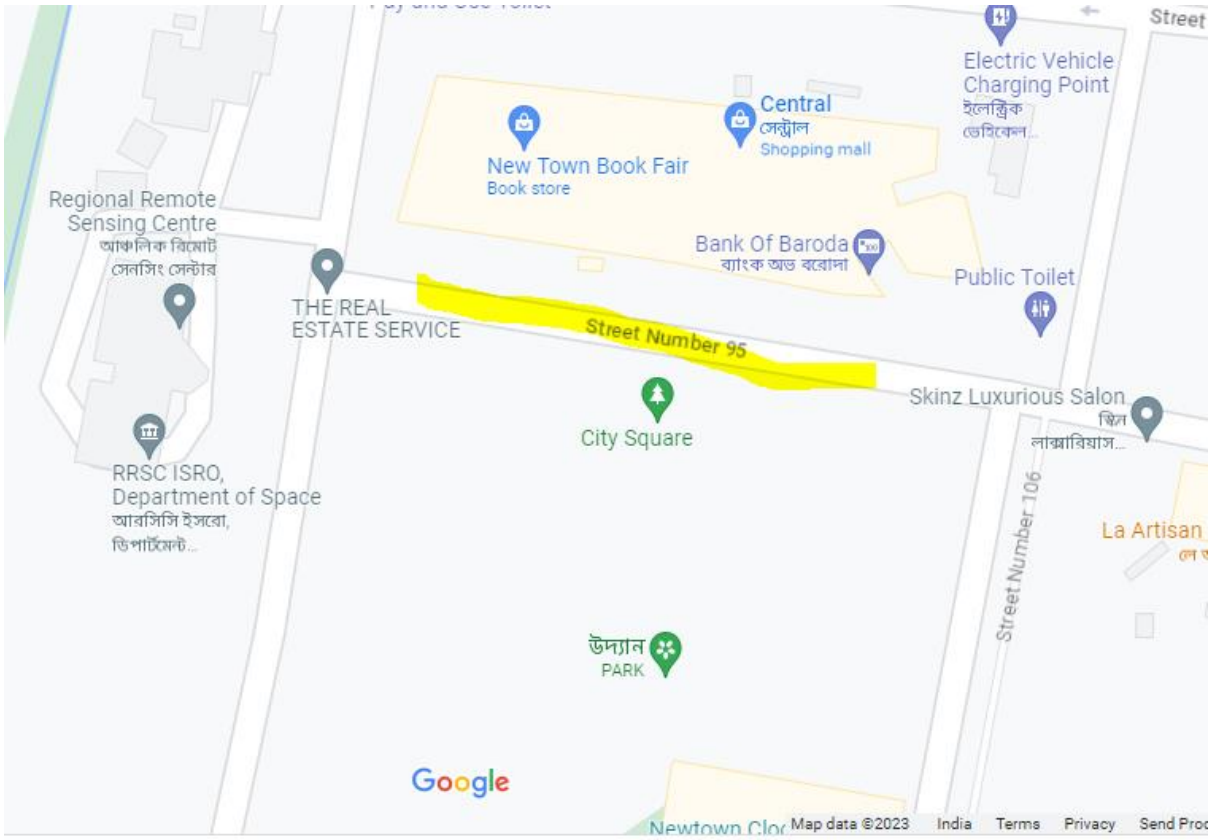
Values in Lux, Scale 1 : 208

Grid: 10 x 6 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
27	21	33	0.771	0.629

Discussion:

The site is having poles on one side and small shops on the other. As per the calculated and measured data set, the site design is having high illuminance and might cause discomfort to the occupants. Considering the measured values from the site, the design can be updated to reduce the amount of illuminance at each point. The dialux design has been developed considering the area and the nearby light sources. The 27Lux average illuminance has been achieved keeping in consideration all the lights from billboards, facade and nearby buildings to add in to the average illuminance resulting in a much highr illuminance. The pole height has been increased along with the pole distance between each other, to reduce the number of luminaires used. This will save energy as well as the maintenance required for the luminaires.



Road 3:

Pole height: 11 m

Arrangement: 2 Side Arrangement each with a luminaire

Distance between poles: 25m

Road Width : 10 m

	1 – 3m	2 – 6m	3 – 9m	4- 12m	5 – 15m	6 – 18m
1 –Pole	77	59	60	56	76	76
2 – 2m	105	64	62	34	42	45
3 – 4m	85	33	36	48	45	75
4 – 6m	60	33	36	48	45	85
5 – 8m	80	45	52	50	71	90

FootPath and CycleWay:

	1 – 3m	2 – 6m	3 – 9m	4- 12m	5 – 15m	6 – 18m	7 – 21m
1 –Pole Footpath 1	73	58	19	15	18	23	52
2 –Pole Footpath 2	94	94	86	72	60	75	82
3 - Cycle	75	45	19	9	8	21	40

Service Road: 6m width

	1 – 5m	2 – 10m	3 – 15m	4-20m
1 –Pole	50	52	44	62
2 – 3m	67	56	54	73
3 – 6m	62	58	68	78

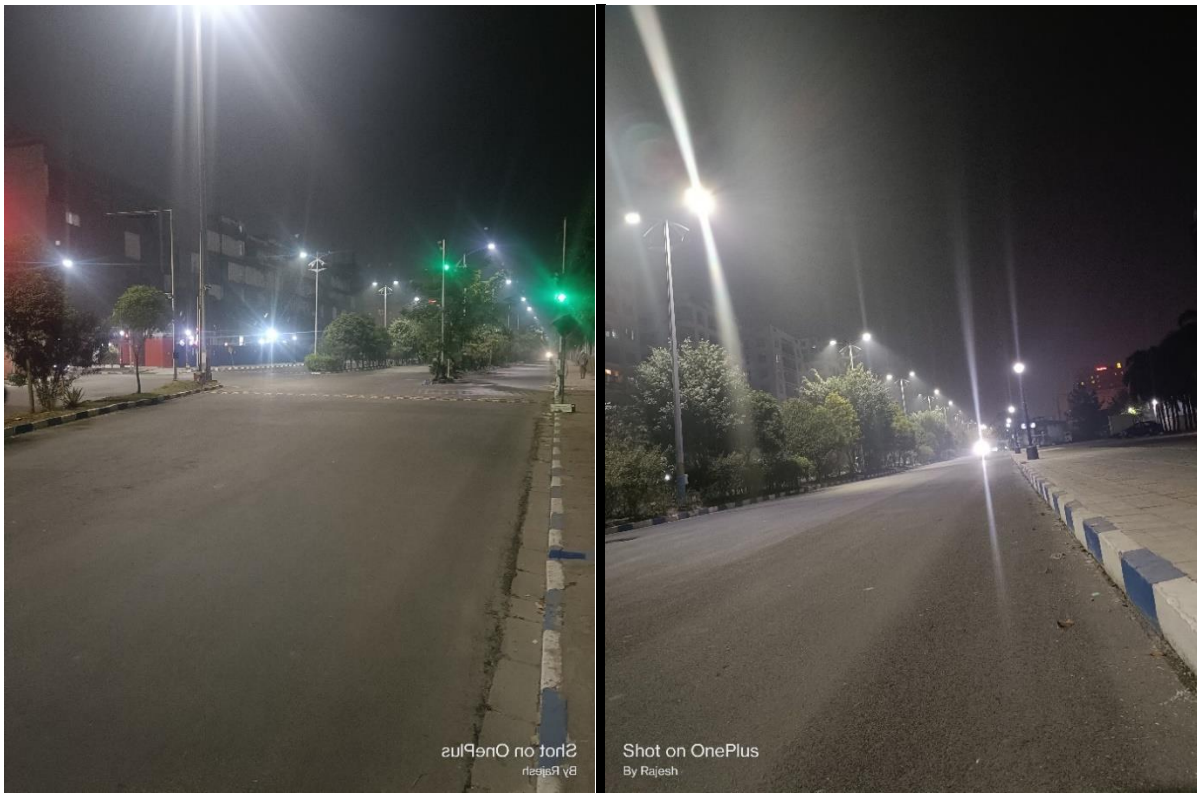


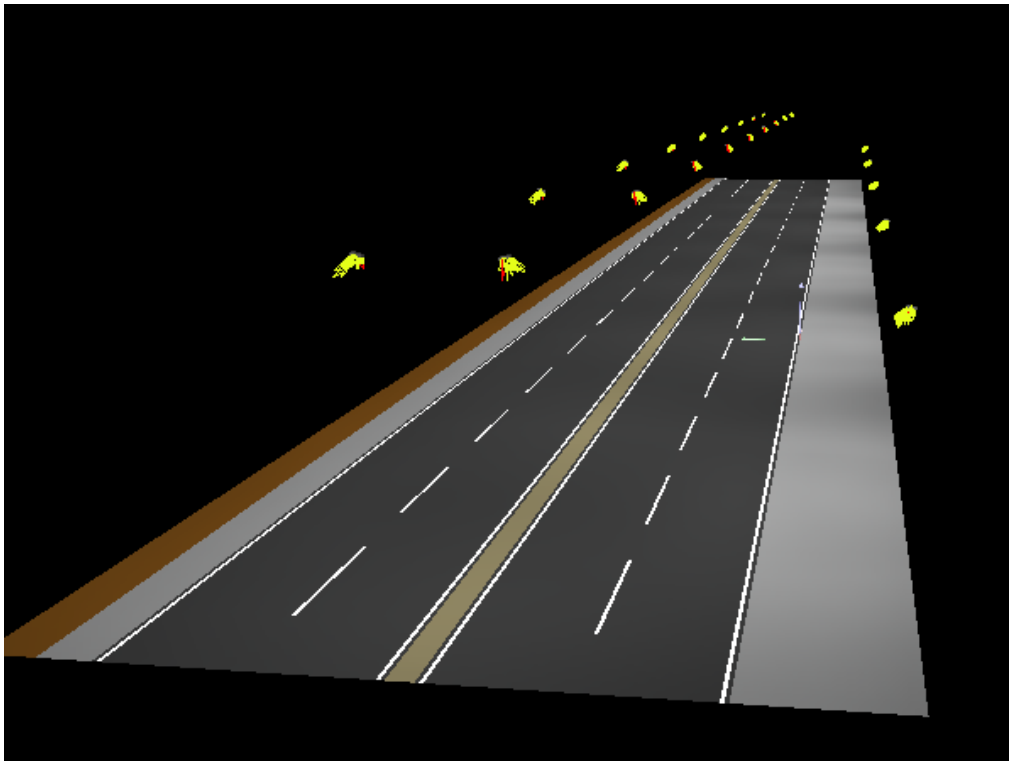
FIG 8.16: STREET LIGHTING IN RAJARHAT

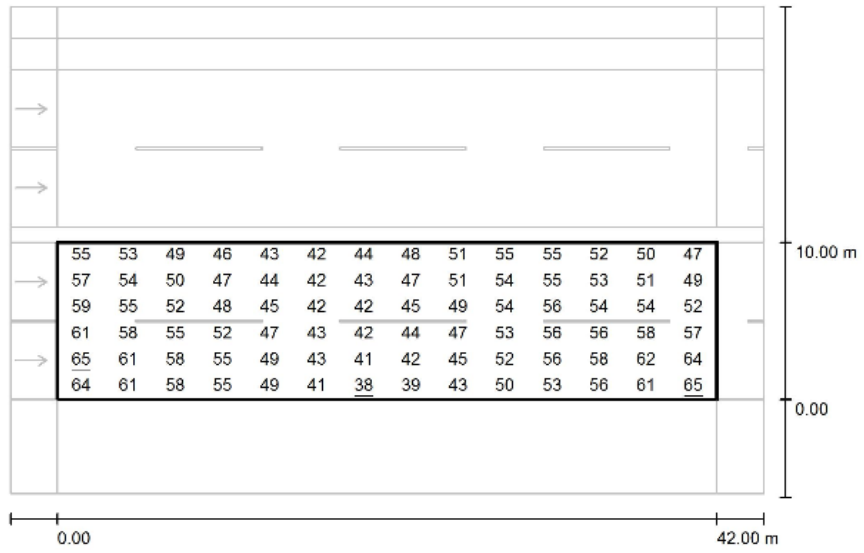
Suggested Dialux Design:

Luminaire : Surya 200 Watt

Mounting Height: 13m

Distance Between Poles: 30m





Values in Lux, Scale 1 : 344

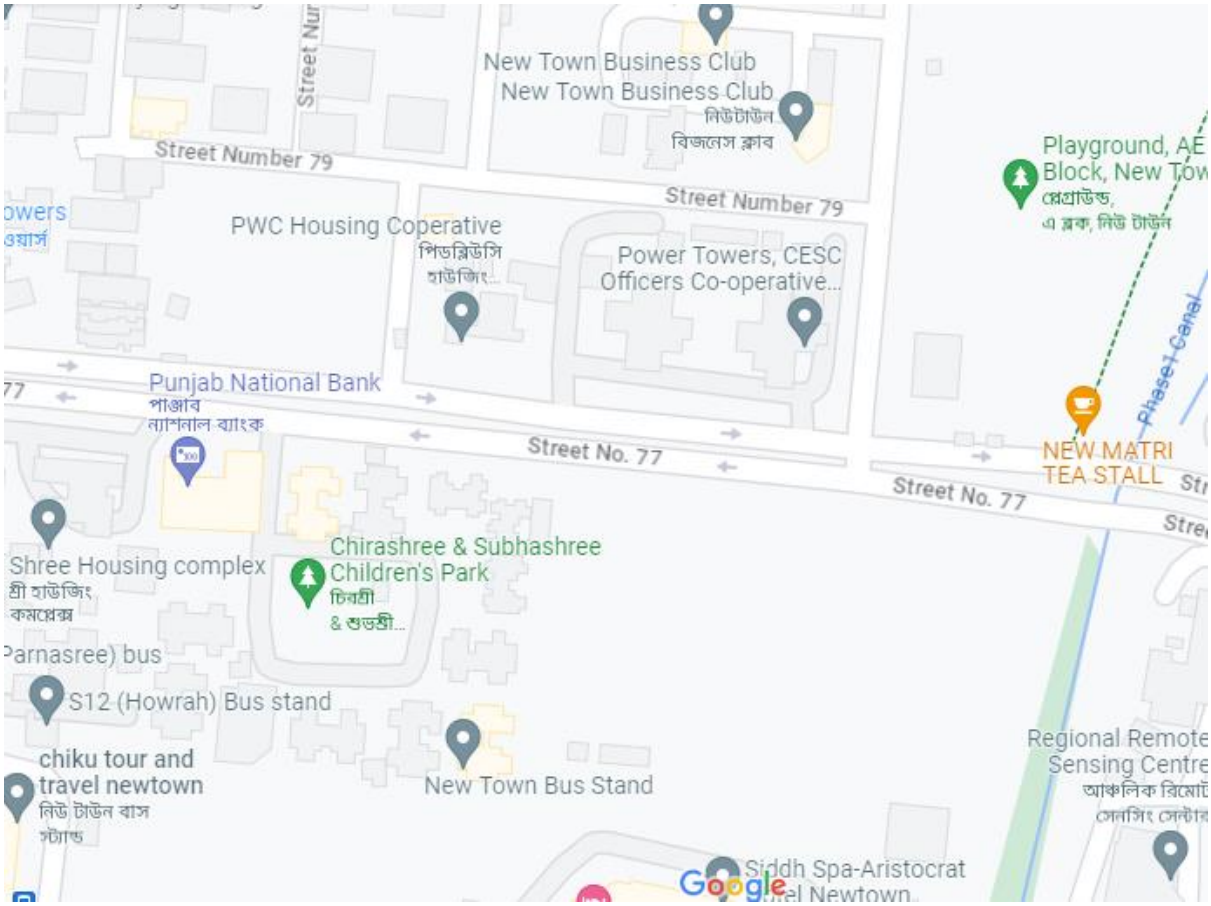
Grid: 14 x 6 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
51	38	65	0.746	0.589

Discussion:

The site is having important 2 lane along with one service road, footpath and cycleway. The roads are well illuminated but few modification in the design can be done which will effectively lower down the operational and maintenance cost.

The standard of 50 lux has been achieved in Dialux with a much better design increasing the pole height and the distance between two poles. This will result in a much distributed light along the roads also with less usage of luminaires. The operational and maintenance cost will be decreased with this much economic dialux design. Also smart controlled luminaires can be used in order to save much more energy.



Road 4:

Pole height: 13 m

Arrangement: 1 Side Arrangement each with a luminaire

Distance between poles: 30m

Road length: 14m

Poles: 12 nos

	1 – 1m	2 – 10m	3 – 30m
1 – 1m Pole	46	32	79
2 – 7m	40	44	67
3 – 14m	21	16	25

FIG 8.17: STREET LIGHTING NEAR PARKING AREA

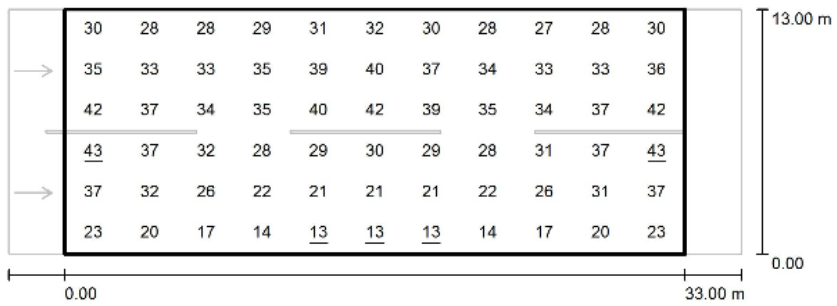
Suggested Dialux Design:

Luminaire : Surya 200 Watt

Mounting Height: 13m

Distance Between Poles: 30m

Street 1 / Valuation Field Roadway 1 / Value Chart (E)



Values in Lux, Scale 1 : 279

Grid: 11 x 6 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
30	13	43	0.442	0.307

Discussion:

The lighting design in the site is a bit different as smart controllers have been used but the average illuminance of the road is less than the standard with respect to the usage. The DiaLux design has been updated considering the area and the nearby light sources. The 30Lux average illuminance has been designed considering all the lights from billboards and nearby buildings to add into the Average Illuminance to avoid any light pollution and also keeping the standard values in consideration. The pole height has been increased along with the pole distance between each other, to reduce the number of luminaires used. This will save energy as well as the maintenance required for the luminaires.

Statistical Analysis:

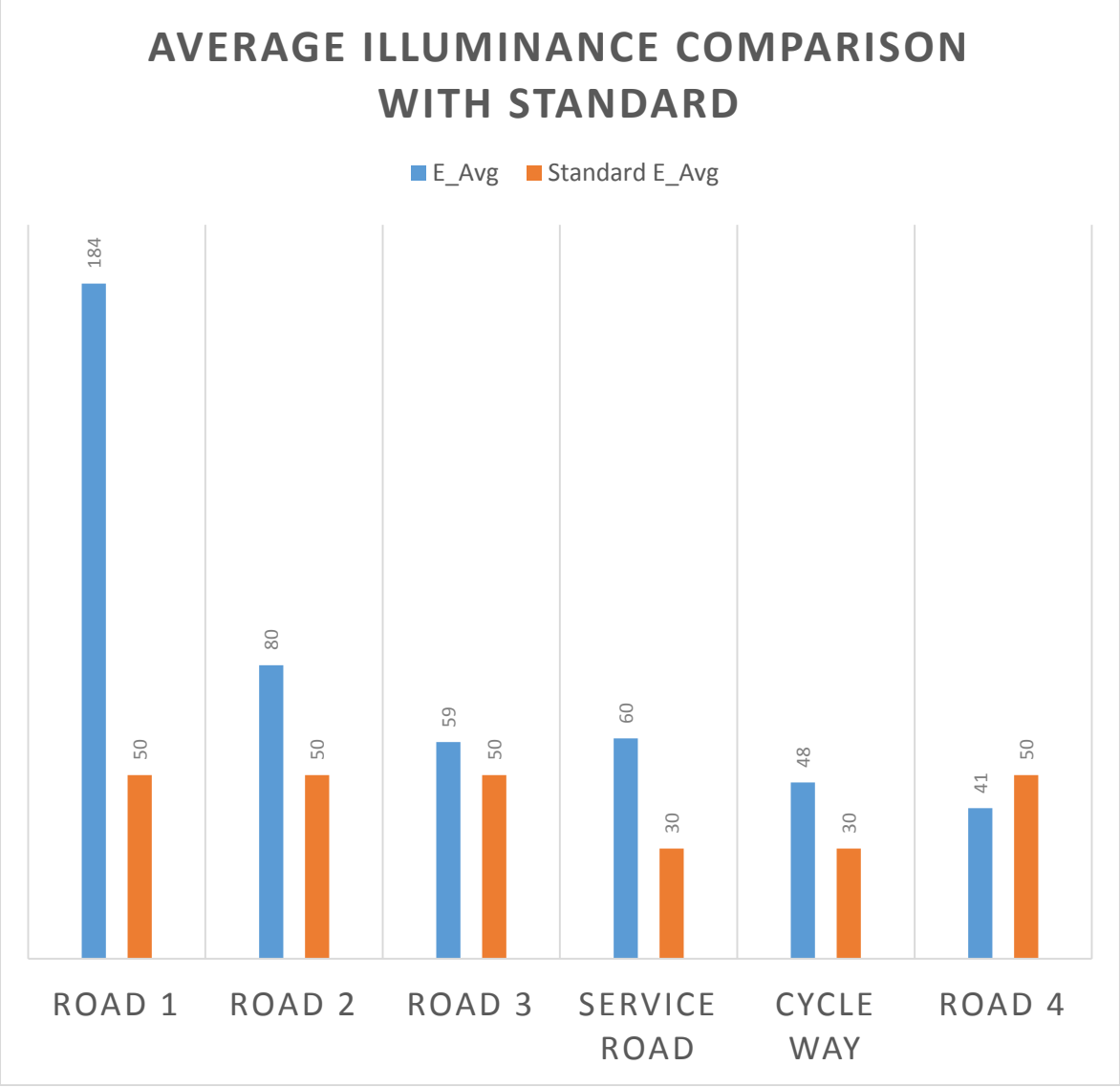


Fig 8.18: Comparative Study of Average Illuminance

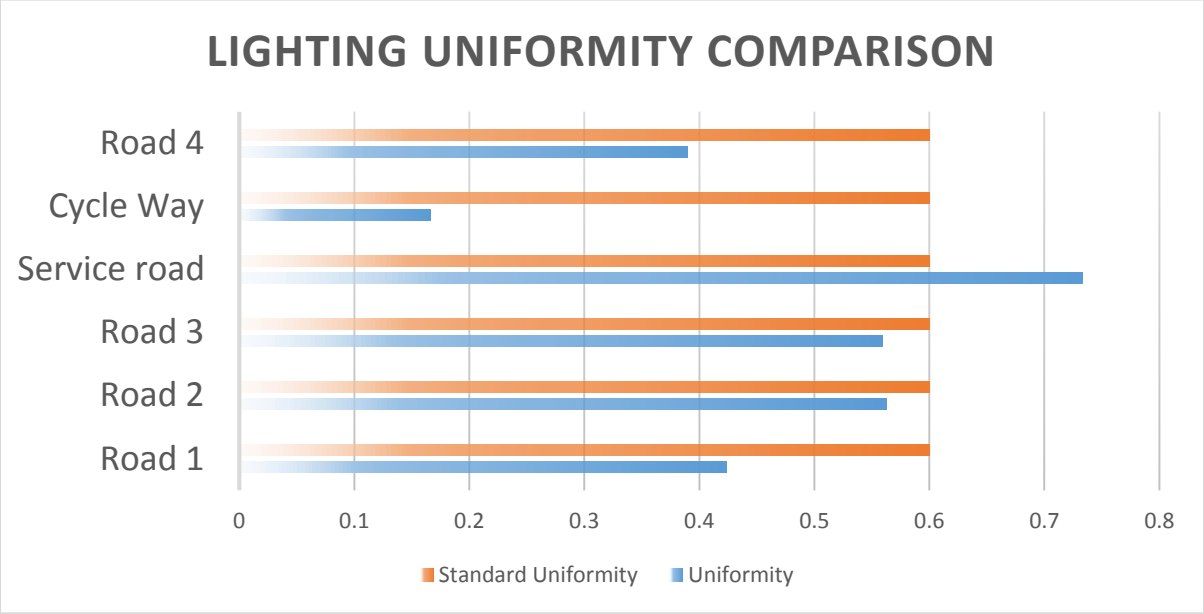
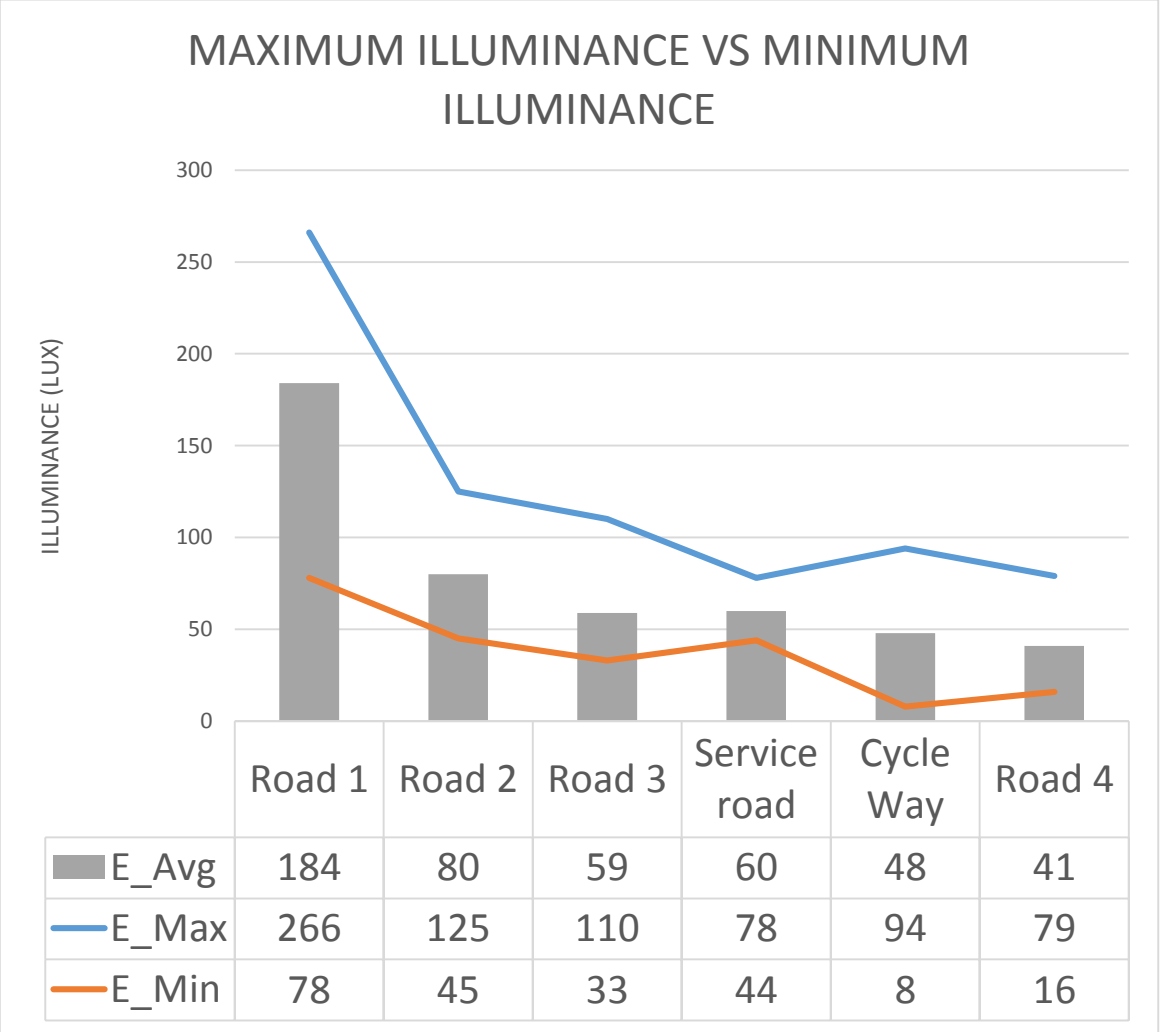


Fig 8.19: Comparative Study of Uniformity with Standard



	Road 1	Road 2	Road 3	Service road	Cycle Way	Road 4
E_Avg	184	80	59	60	48	41
E_Max	266	125	110	78	94	79
E_Min	78	45	33	44	8	16

Fig 8.20: Max vs Min Illuminance with the calculated Average Illuminance

Discussion:

From the statistical data it is clearly visible that the measured average illuminance is comparatively very high with the rated standard. This might cause glare and discomfort to the motorist and pedestrians resulting in multiple visual problems. The standard uniformity level was not achieved in most of the cases, creating dark patches on the way. Considering all the factors, the proposed designs have already undergone discussion, and the general design parameters that can be reviewed are outlined below:

1. Reduction in Luminaire Quantity: A recommendation is made for the utilization of a reduced number of luminaires, in accordance with all design standards, with the primary objective of minimizing both energy consumption and maintenance costs. By strategically reducing the number of luminaires, not only can energy costs be saved, but also a reduction in the environmental impact associated with luminaire production and disposal can be achieved. Additionally, the potential for enhanced light support for vehicles and pedestrians to feel safe and secured on the way.

2. Consideration of Surrounding Light Sources: During the initial stages of design, it is imperative that light coming from nearby sources such as billboards, shop entrances, building facade lighting, and streetlights is taken into account. This comprehensive approach is essential for project cost management. Furthermore, stringent measures should be taken against the excessive use of facade lighting in public and commercial properties to mitigate light pollution and glare, emphasizing the importance of balancing aesthetics and sustainability in urban lighting design through collaboration involving designers, architects, and local authorities.

3. Implementation of Automated Controls: Highly advisable is the incorporation of automated occupancy and ambient light sensors into the design. This feature will lead to a significant reduction in energy consumption on a larger scale when lighting is unnecessary or when spaces are unoccupied. The light sources will autonomously dim themselves, maintaining the minimum illumination required for visibility, especially by approaching vehicles.

4. Emphasis on Uniform Distribution: The prioritization of uniformity in the design is essential to eliminate any uneven patches of light and minimize glare

for the occupants. Enhanced visual comfort and improved safety in various public space applications can be achieved through uniform light distribution. Furthermore, opportunities for reduced energy consumption through precise design planning are created when uniform light distribution is the focal point of the lighting scheme.

5. Energy Efficiency: Choosing of energy-efficient lighting technologies, such as LED (Light Emitting Diode) luminaires. LEDs consume less energy, have longer lifespans, and offer better light quality compared to traditional lighting sources like high-pressure sodium or metal halide lamps.

6. Maintenance and Regular Inspections **:** Establish a regular maintenance schedule to ensure that all lighting fixtures are functioning correctly. Burnt-out bulbs or malfunctioning fixtures should be promptly replaced to maintain consistent illumination.

A problem is consistently encountered by motorists when encountering any dark patches on the road. This problem is compounded by several factors, including the recommendation for optimizing luminaire quantity, the imperative necessity to consider nearby light sources, the highly advisable integration of automated controls, and the essential emphasis on achieving uniform light distribution. The implementation of these measures is not only expected to enhance lighting efficiency but also anticipated to result in significant reductions in energy consumption and associated costs. Furthermore, a crucial role is played by these measures in mitigating the adverse impacts of excessive artificial lighting on the environment and human activities, particularly in addressing issues such as sky glow, light pollution, glare, and visual discomfort.

8.2 CASE STUDY OF SILIGURI

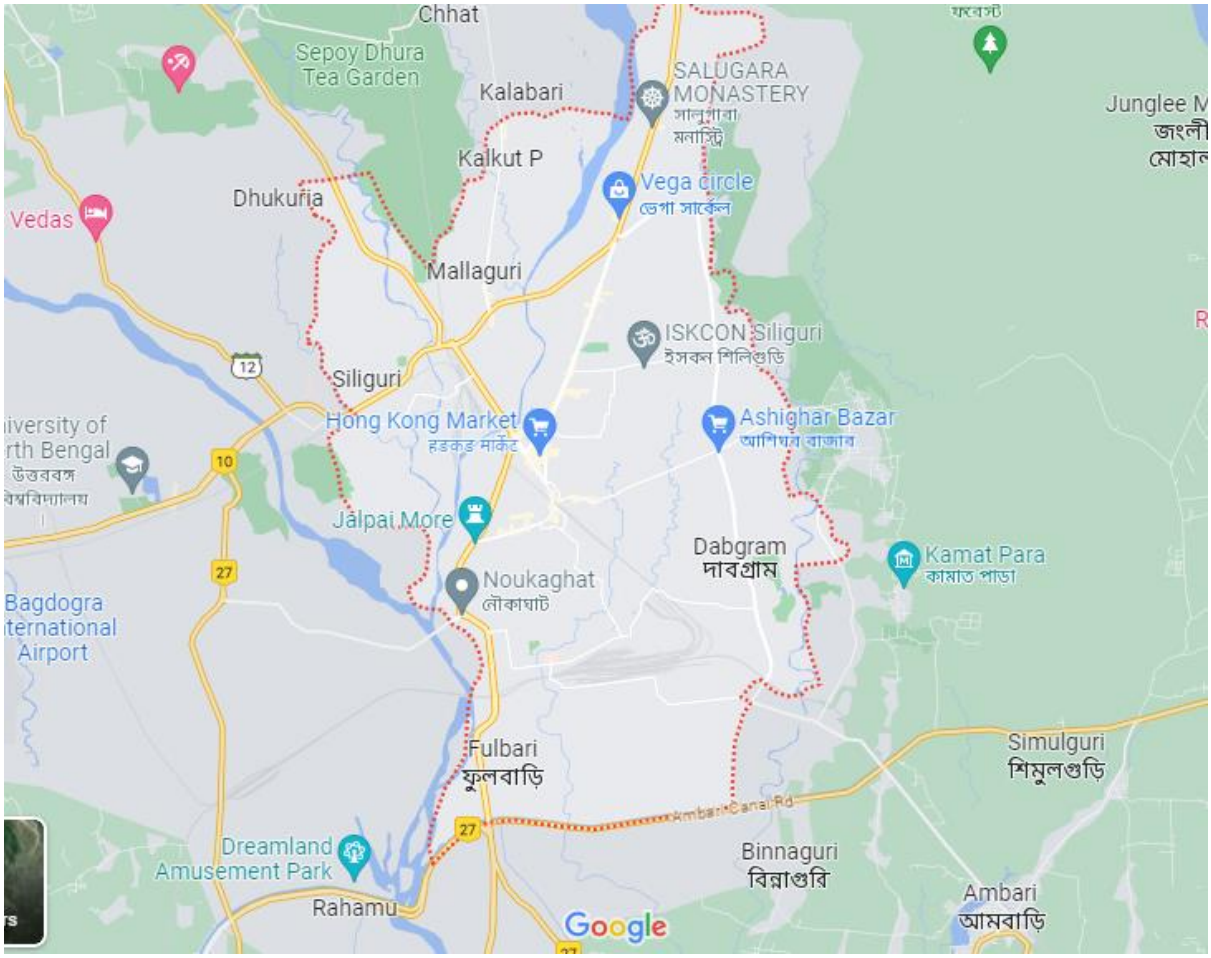


FIG 8.21: MAP OF SILIGURI

8.2.1 ZONE: ROAD LIGHTING WITHIN CITY

Road 1-

Road Size: 16m Double sided with separation pavement in the middle

Pole Height: 11m

Pole Arrangement : Along the Median Double Sided

Pole Spacing: 20m

Readings:

	0m	8m	16m
10m	26	34	48
5m	35	43	57
0m	40	56	62
5m	39	50	58
10m	28	40	50

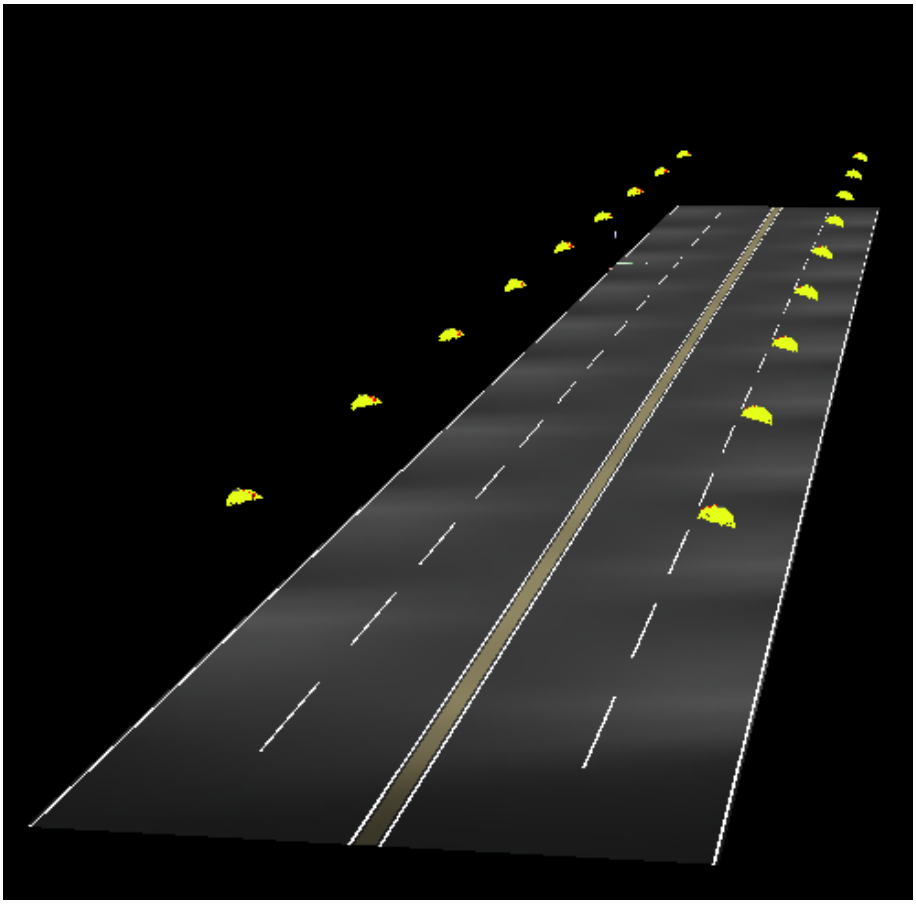
FIG 8.22: SEVOKE ROAD OF SILIGURI

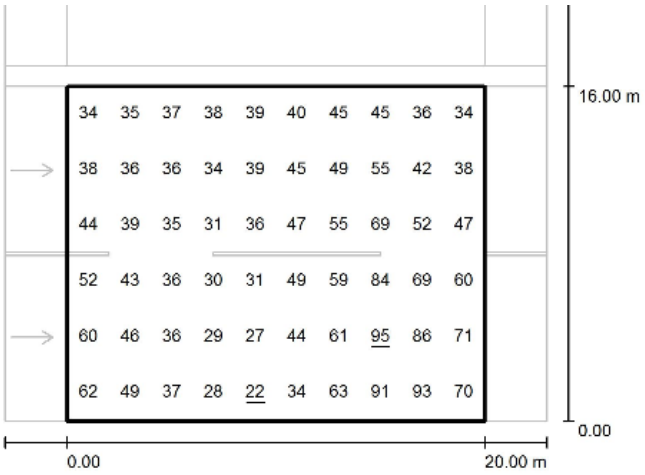
Suggested Dialux Design:

Luminaire: Surya 250 Watt

Mounting Height: 10m

Distance Between Poles: 20m





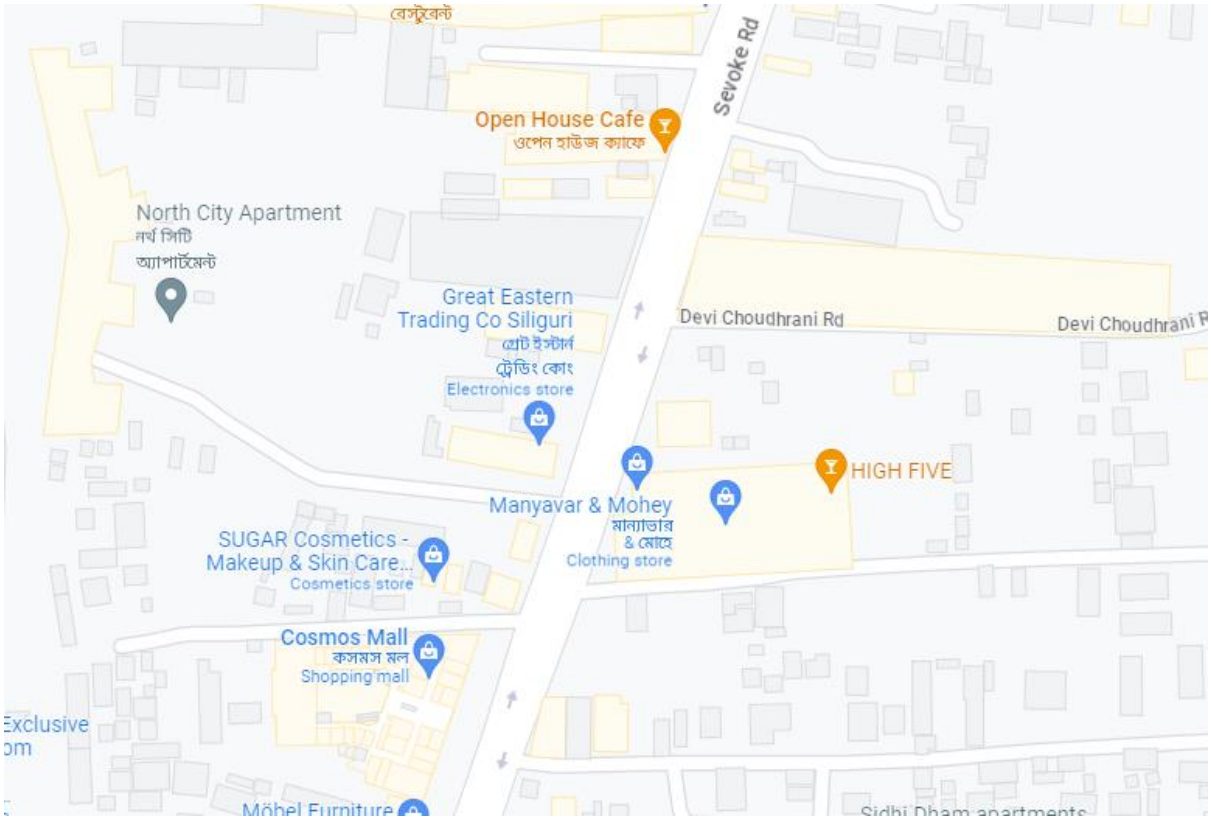
Values in Lux, Scale 1 : 259

Grid: 10 x 6 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
48	22	95	0.456	0.231

Discussion:

The Siliguri Hill Kart Road which combines with the ASEAN International Highway is not much illuminated in certain area while it is not at all illuminated in most of the parts. Those area are mainly covered by nearby façade light sources. In order to resolve the issue, Dialux design has been proposed changing the pole configuration from median to sideways keeping the luminaire to 250Watt and the distance between poles same increasing the mounting height. This is one of the most important road of the area and needs illumination in most of the places along with installation of high masts in junctions. The suggested change in configuration will uniformly distribute the light over the road for motorists to have a better visual.



Road 2-

Road Size: 10m Single Road Bridge

Pole Height: 9 m

Pole Arrangement : Staggered

Pole Spacing: 15m /13m

Readings:

	0m	5m	10m
7.5m	10	7	13
4m	25	21	28
0m	38	32	34
4m	27	26	21
7.5m	12	9	5

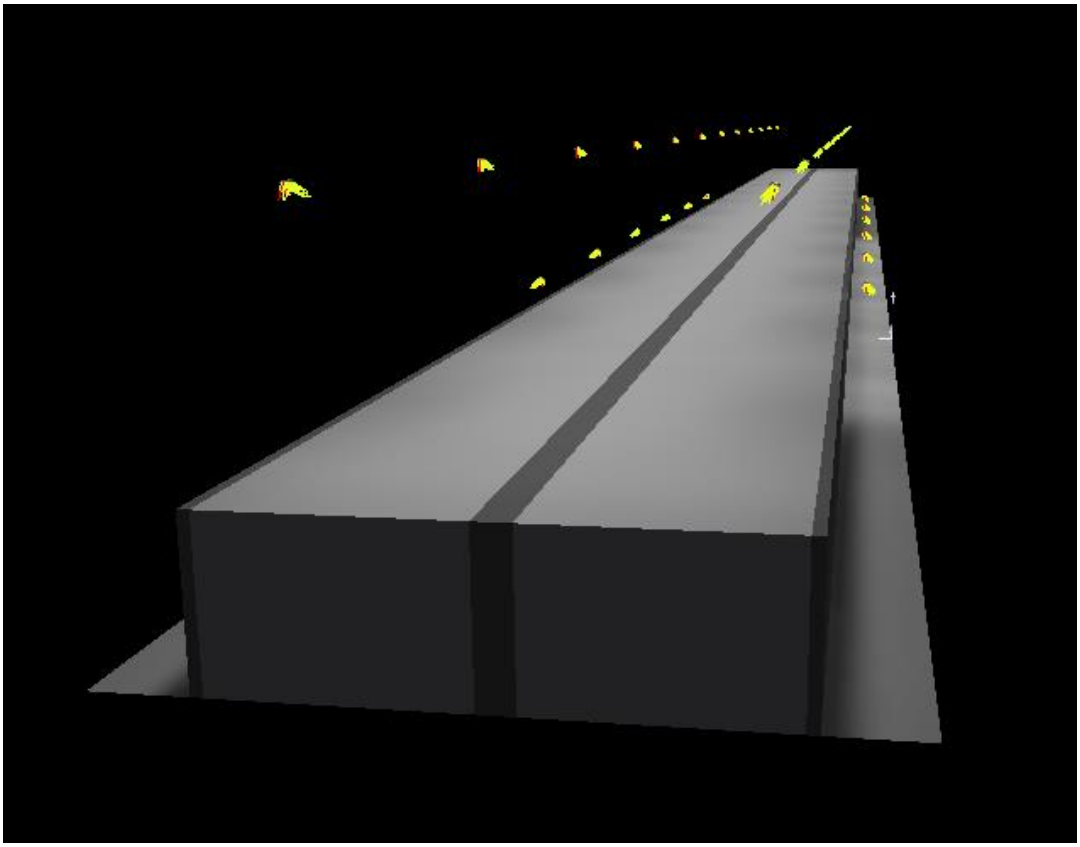
FIG 8.23: VENUS MORE BRIDGE ROAD OF SILIGURI

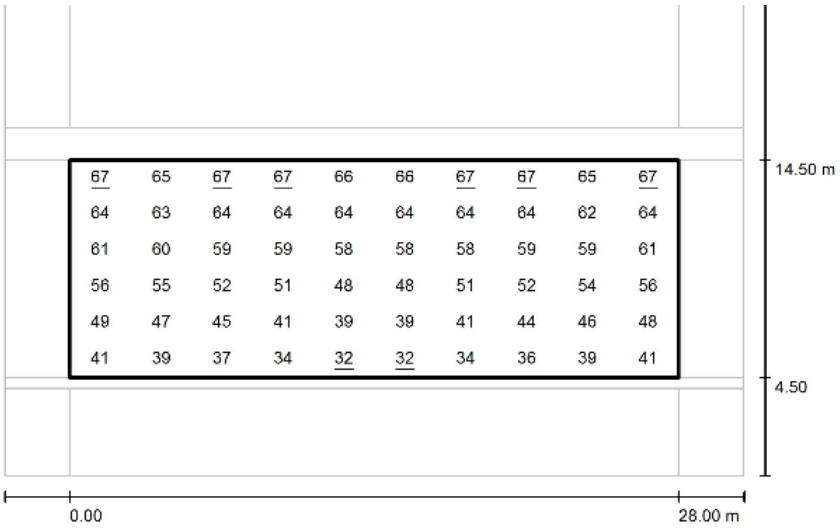
Suggested Dialux Design:

Luminaire: Surya 200 Watt

Mounting Height: 10m

Distance Between Poles: 28m





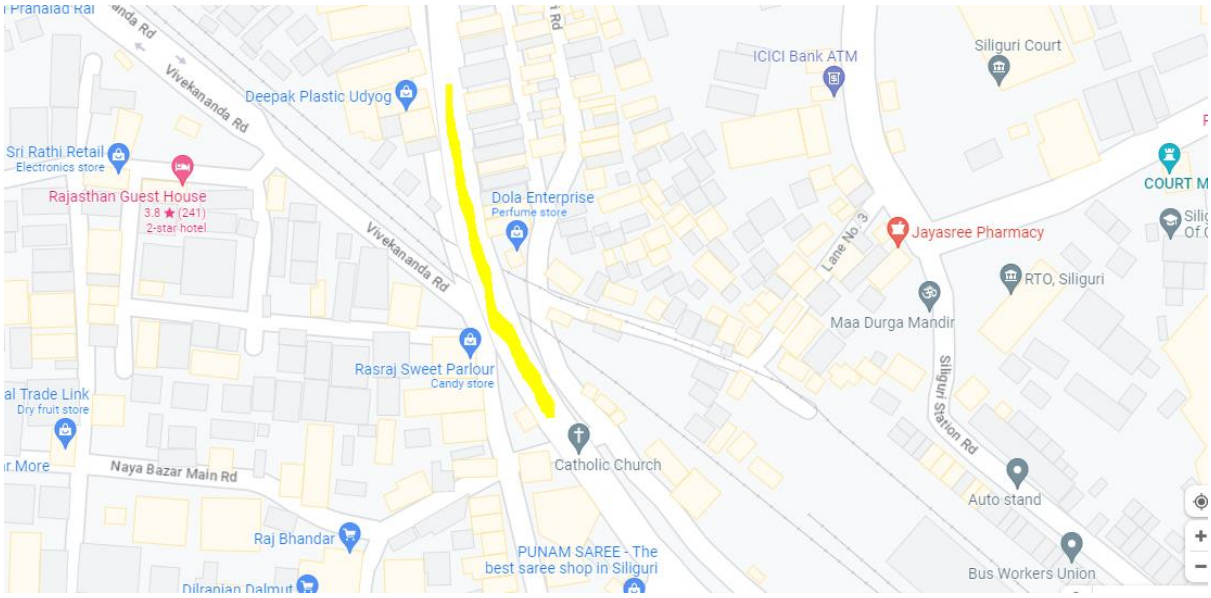
Values in Lux, Scale 1 : 244

Grid: 10 x 6 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
54	32	67	0.598	0.478

Discussion:

The area over the bridge was not sufficiently illuminated and might cause problem as there is no surrounding light sources adding in to mitigate the gap. The Dialux design showed a better performance increasing the distance between poles and mounting height along with the use of high power 200Watt Luminaire. The bridges must not be less illuminated as accidents can happen anytime. The suggested design has attained 50lux with and uniformity nearby 0.6 perfect as per the standards. This does not create light pollution nor and visual discomfort to the user.



Road 3-

Road Size: 7m Single Road with designer facade

Pole Height: 11 m

Pole Arrangement : One Sided

Pole Spacing: 30m

Readings:

	0m	2.5m	5m
15m	27	12	9
7.5m	28	17	10
0m Pole	26	14	10
7.5m	29	14	7
15m	22	15	8

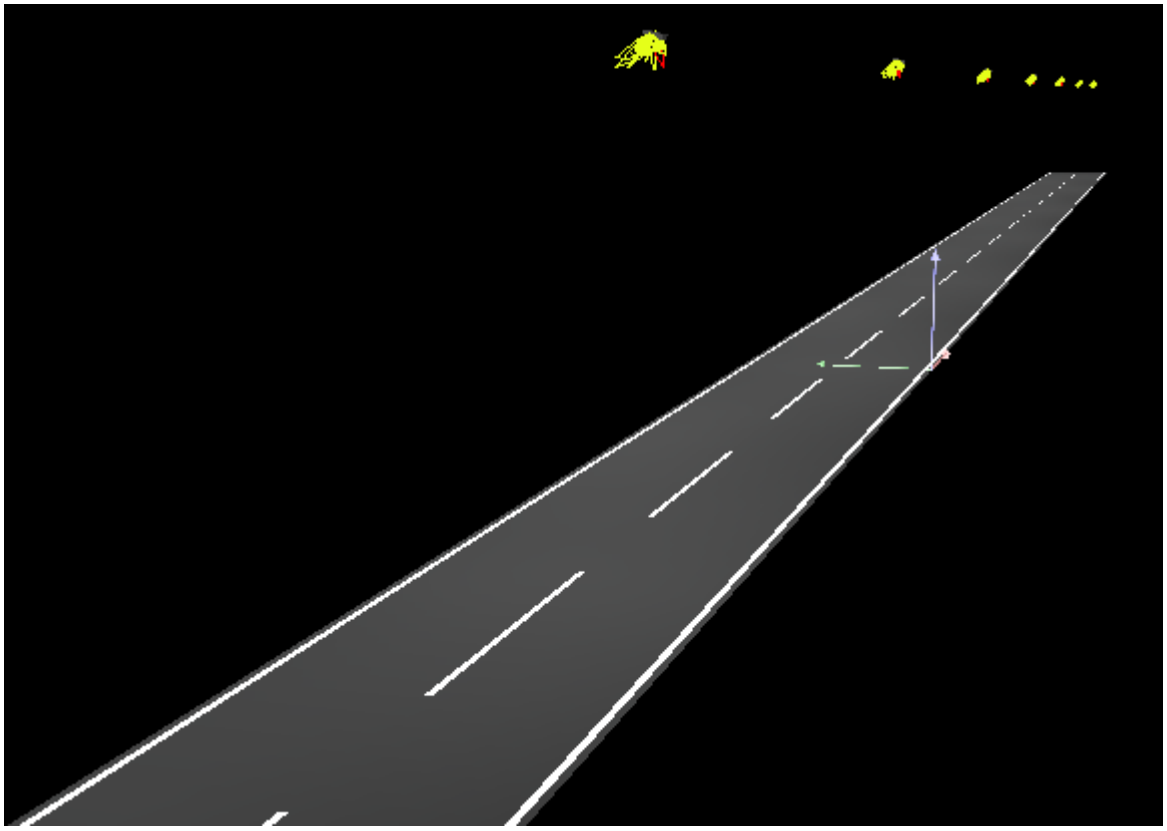
FIG 8.24: MAHANANDA ROAD OF SILIGURI

Suggested Dialux Design:

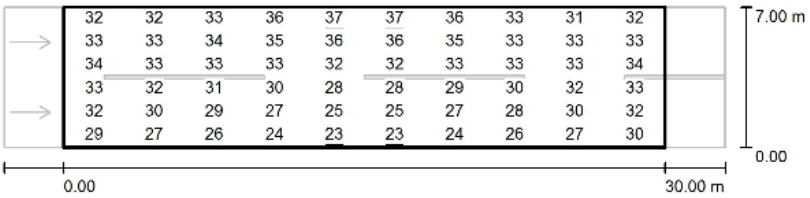
Luminaire: Surya 200 Watt

Mounting Height: 11m

Distance Between Poles: 30



Street 1 / Valuation Field Roadway 1 / Value Chart (E)



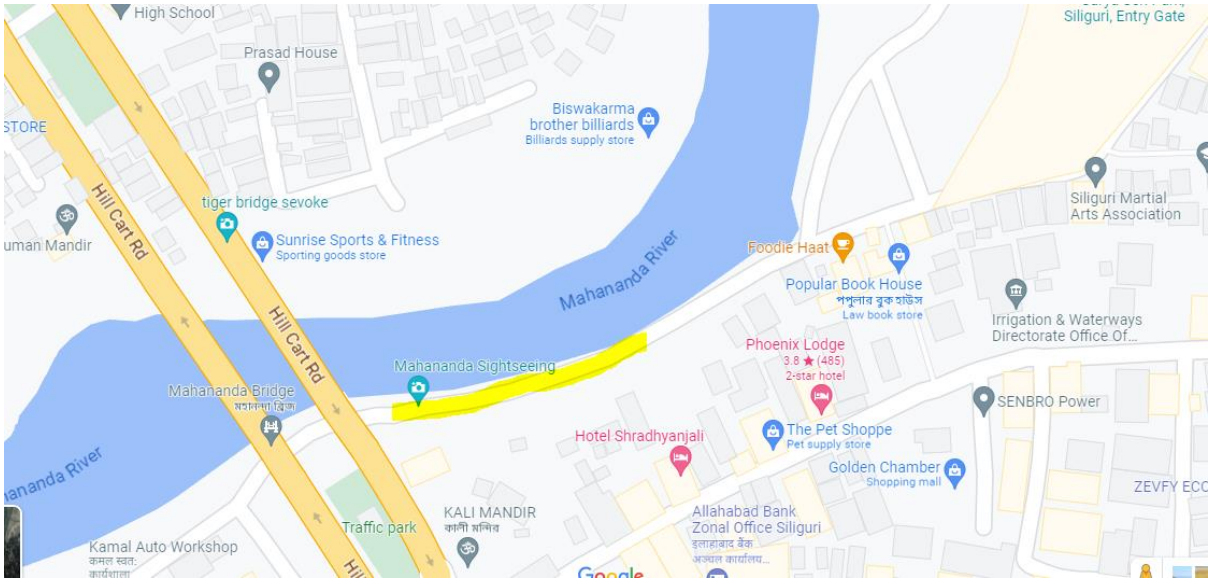
Values in Lux, Scale 1 : 258

Grid: 10 x 6 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
31	23	37	0.728	0.610

Discussion:

The road and the nearby area was dark and the street light could not meet the basic standard demands. Multiple luminaires were not working due to lack of maintenance and the roads were not fit for pedestrians with respect to safety and security. The Dialux design has been developed keeping the same distance between the poles just increasing the pole height by 1 m and adjusting the boom length for uniform distribution. The values came nearly perfect to the standards after the design and the nearby light sources might add up to this value.



Road 4 –

Road Size: 6m Single Road with pedestrian path on both side.

Pole Height: 7 m

Pole Arrangement : Double Sided

Pole Spacing: 20m

Readings:

	0m	3m	6m
10m	33	24	20
5m	34	28	21
0m Pole	38	31	27
5m	37	30	24
10m	34	26	17

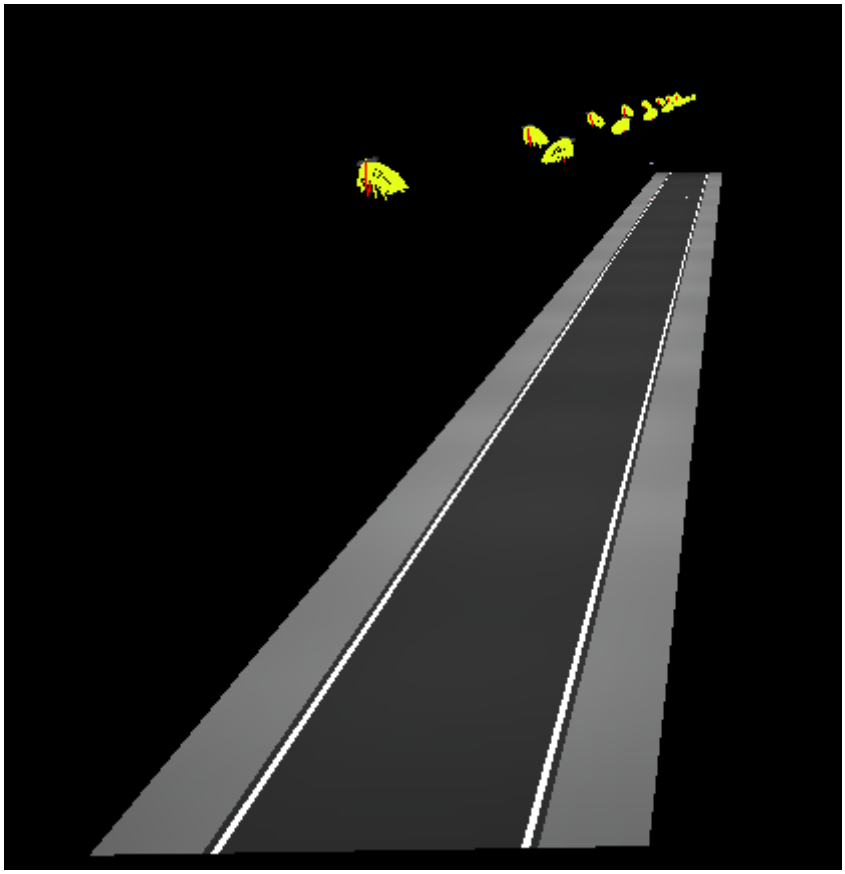
FIG 8.25: ROAD NEAR DABGRAM

Suggested Dialux Design:

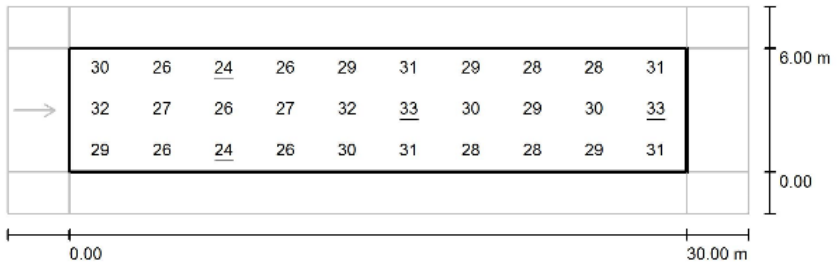
Luminaire: Surya 150 Watt

Mounting Height: 12m

Distance Between Poles: 30m



Street 1 / Valuation Field Roadway 1 / Value Chart (E)



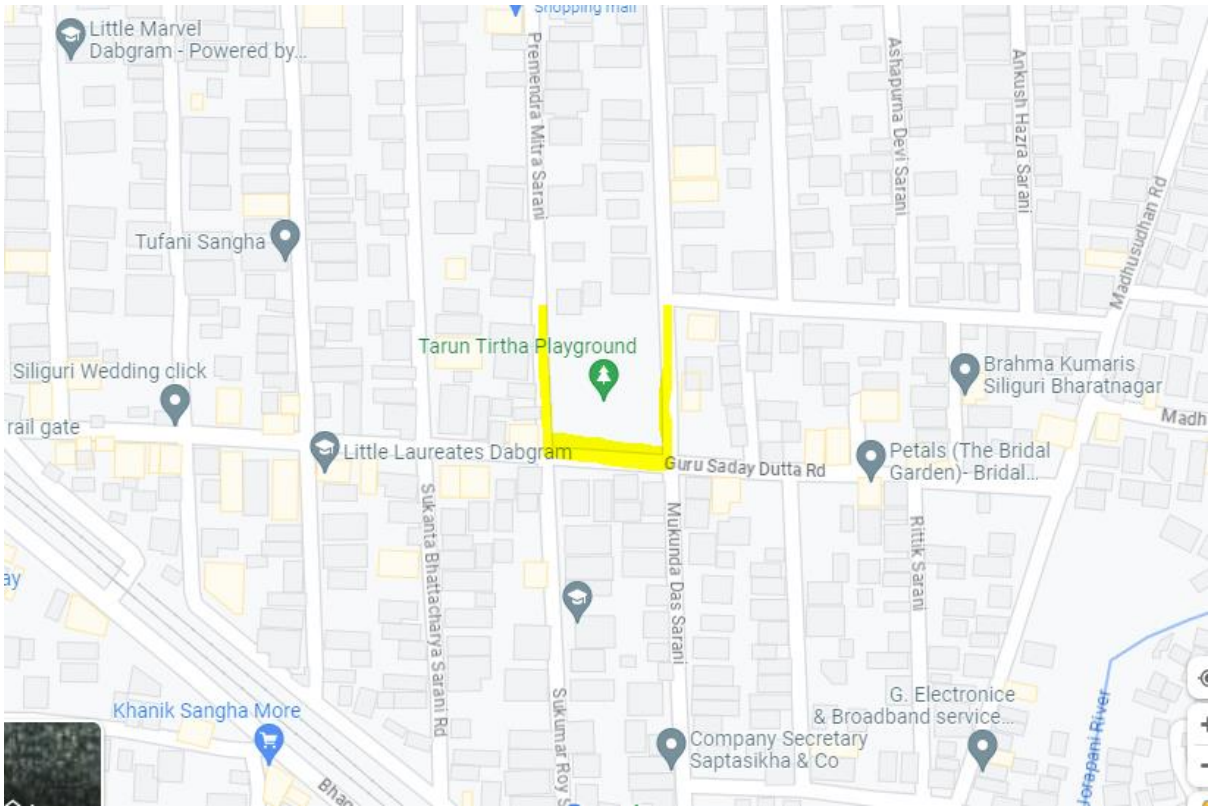
Values in Lux, Scale 1 : 258

Grid: 10 x 3 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
29	24	33	0.844	0.733

Discussion:

This site is beside a sitting area along with 2 walking path where multiple people come for evening walk or to take a stroll. The current illumination distribution is not at all goo with multiple dark patches along the way. The dialux design has been developed to resolve the optimum lux issue along with a very good distribution of light. It also covers the walking area with a minimum requirement of 20lux.



Statistical Analysis:

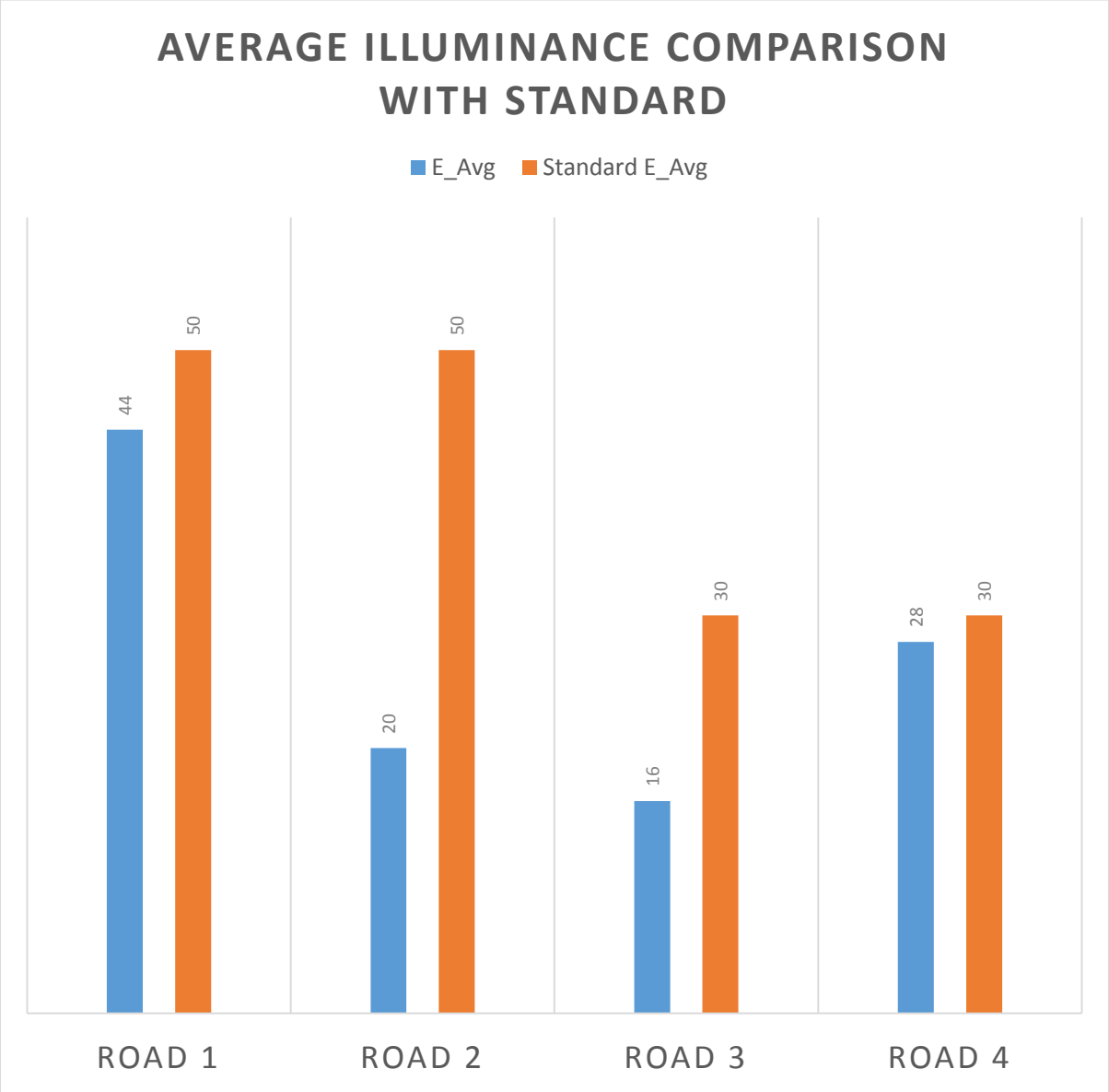


Fig 8.26: Comparative Study of Average Illuminance

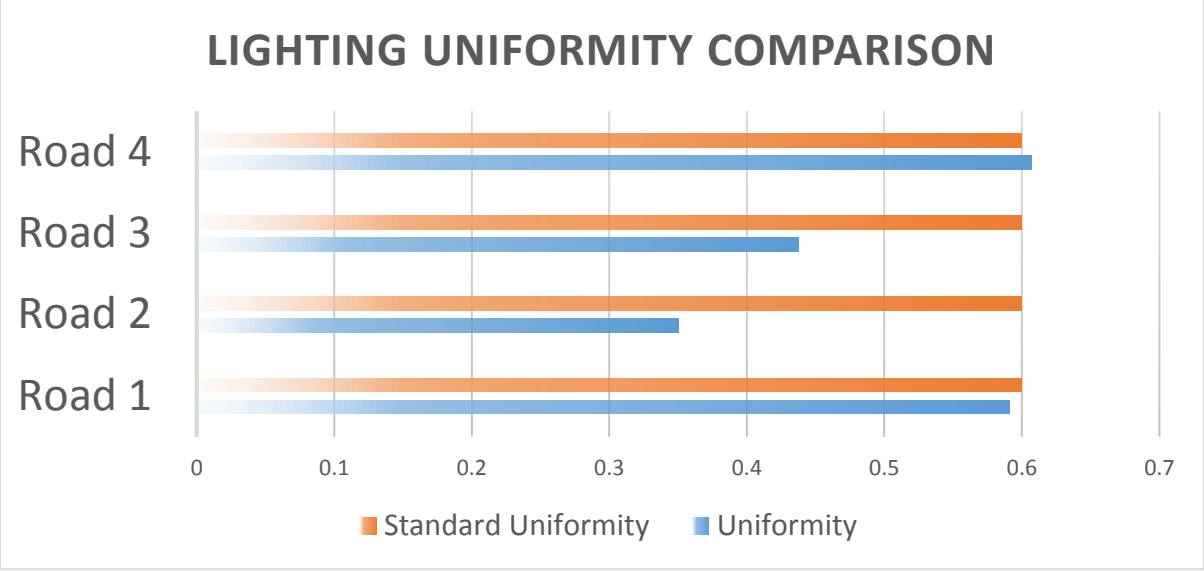
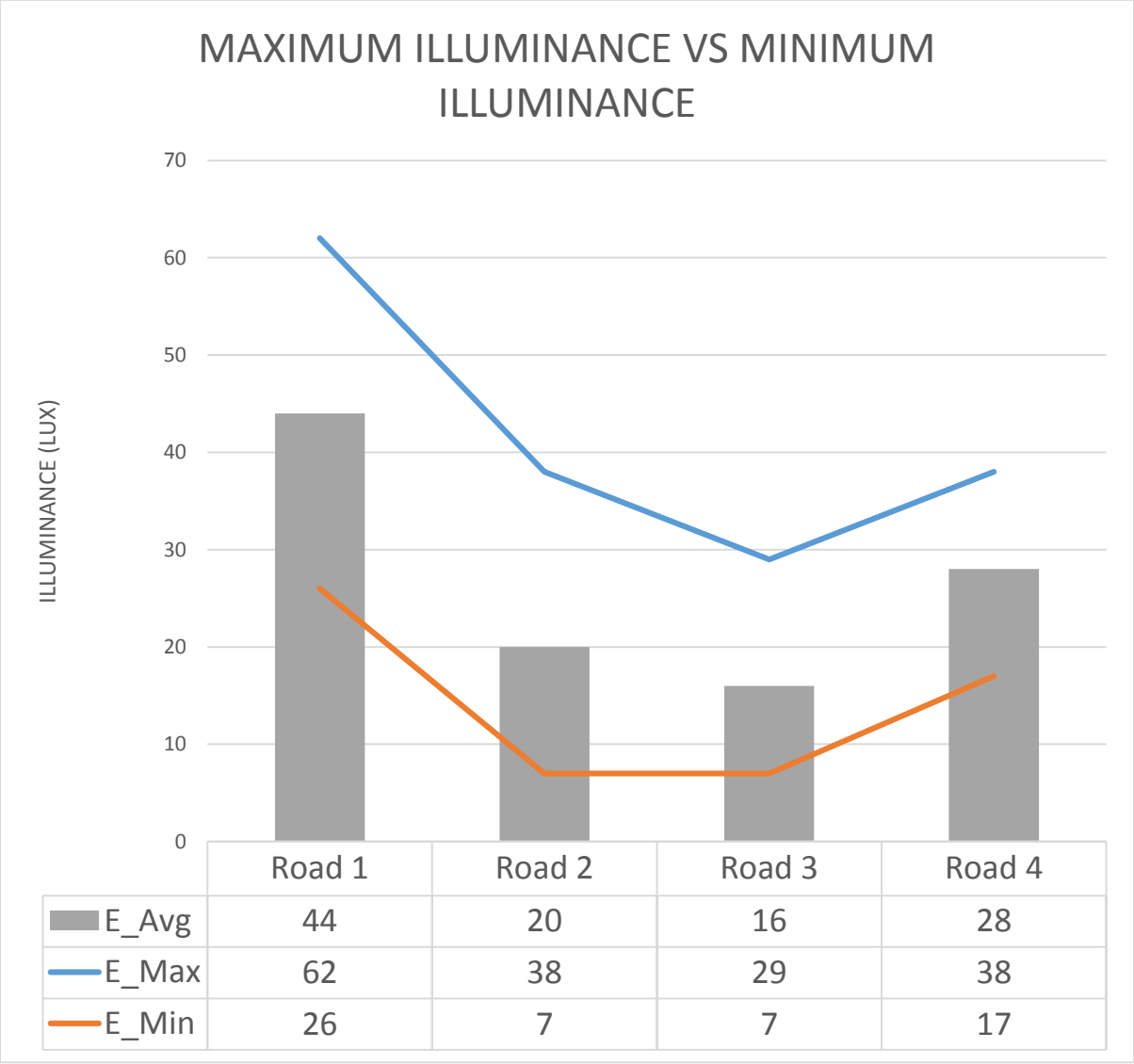


Fig 8.27: Comparative Study of Uniformity with Standard



	Road 1	Road 2	Road 3	Road 4
E_Avg	44	20	16	28
E_Max	62	38	29	38
E_Min	26	7	7	17

Fig 8.28: Max vs Min Illuminance with the calculated Average Illuminance

Discussion:

From the statistical data it is clearly visible that the measured average illuminance is comparatively low with the rated standard. This might cause discomfort to the motorist and pedestrians due to multiple dark patches and low luminance in the area. The standard uniformity level was not achieved in most of the cases, creating dark patches on the way. Considering all the factors, the proposed designs have already undergone discussion, and the general design parameters that can be reviewed are outlined below:

1. Increase the number of luminaires used: A recommendation is made for the utilization of a more number luminaires, in accordance with all design standards. Use of better luminaires with more luminance can also be incorporated with the primary objective of minimizing both energy consumption and maintenance costs. By strategically using high power luminaires in low quantity, not only can energy costs be saved, but also a reduction in the environmental impact associated with luminaire production and disposal can be achieved. Additionally, the potential for enhanced light support for vehicles and pedestrians to feel safe and secured on the way.

2. Consideration of Surrounding Light Sources: During the initial stages of design, it is imperative that light coming from nearby sources such as billboards, shop entrances, building facade lighting, and streetlights is taken into account. This comprehensive approach is essential for project cost management. Furthermore, stringent measures should be taken against the excessive use of facade lighting in public and commercial properties to mitigate light pollution and glare, emphasizing the importance of balancing aesthetics and sustainability in urban lighting design through collaboration involving designers, architects, and local authorities.

3. Implementation of Automated Controls: Highly advisable is the incorporation of automated occupancy and ambient light sensors into the design. This feature will lead to a significant reduction in energy consumption on a larger scale when lighting is unnecessary or when spaces are unoccupied. The light sources will autonomously dim themselves, maintaining the minimum illumination required for visibility, especially by approaching vehicles.

4. Emphasis on Uniform Distribution: The prioritization of uniformity in the design is essential to eliminate any uneven patches of light and minimize glare for the occupants. Enhanced visual comfort and improved safety in various public space applications can be achieved through uniform light distribution. Furthermore, opportunities for reduced energy consumption through precise design planning are created when uniform light distribution is the focal point of the lighting scheme.

5. Energy Efficiency: Choosing of energy-efficient lighting technologies, such as LED (Light Emitting Diode) luminaires. LEDs consume less energy, have longer lifespans, and offer better light quality compared to traditional lighting sources like high-pressure sodium or metal halide lamps.

6. Maintenance and Regular Inspections **:** Establish a regular maintenance schedule to ensure that all lighting fixtures are functioning correctly. Burnt-out bulbs or malfunctioning fixtures should be promptly replaced to maintain consistent illumination. There have been multiple cases where the luminaires are not working.

A problem is consistently encountered by motorists when encountering any dark patches on the road. This problem is compounded by several factors, including the recommendation for optimizing luminaire quantity, the imperative necessity to consider nearby light sources, the highly advisable integration of automated controls, and the essential emphasis on achieving uniform light distribution. The implementation of these measures is not only expected to enhance lighting efficiency but also anticipated to result in significant reductions in energy consumption and associated costs. Furthermore, a crucial role is played by these measures in mitigating the adverse impacts of excessive artificial lighting on the environment and human activities, particularly in addressing issues such as sky glow, light pollution, glare, and visual discomfort.

8.2.2 ZONE: PUBLIC PARKS, SITTING AREA AND COMMON SPACES

Area 1: Public Sitting Area along the banks of Mahananda

Pavement Length: 3m

Luminaire: Bollards

Distance between Bollards: 10m

Arrangement: One Side

Readings:

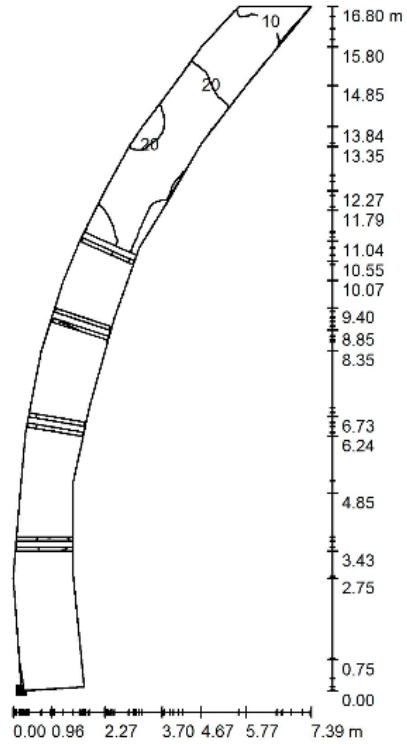
Pole	0m	3m	6m	10m
0 m	13	8	9	11
3m	5	7	6	6

FIG 8.29: MAHANANDA SITE BEAUTIFICATION PARK

Discussion:

The area is dark and not at all safe for the pedestrians to have a stroll late in the evening as there is not the optimum required light. The beautification project along the banks of Mahananda was focused for the usage after sunset and yet due to lack of maintenance multiple luminaires are not working and the remaining few is not providing optimum illuminance. The following dialux design has been developed to provide an example on how the area can be illuminated using multiple bollards.

Suggested Dialux Design:



E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
20	2.09	30	0.106	0.069

Area 2: Statue with a green lawn in front.

Area of the lawn: 15m x 3m

Luminaire used: 8 Bollards along the border and 2 Flood Light projecting on statue

Distance Between Bollards : 3m

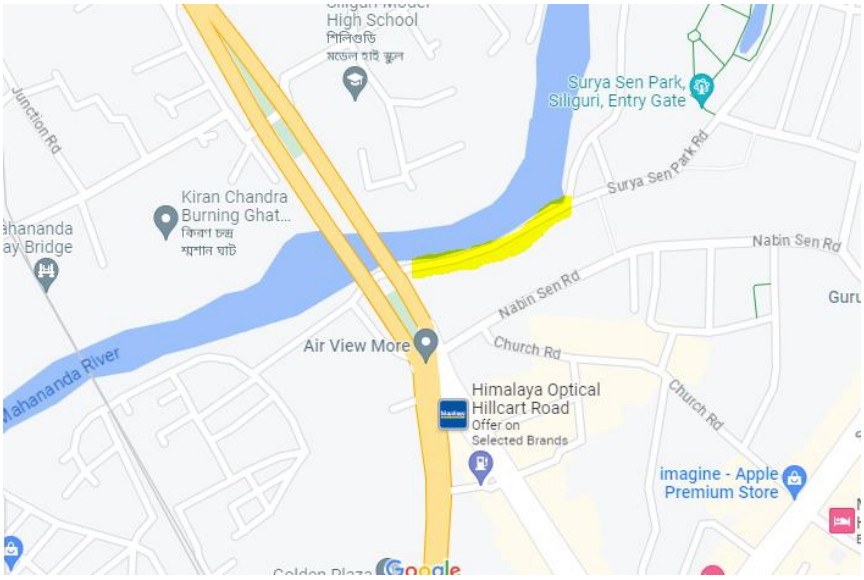
Readings:

	0m	3m	7m	10m
0m	26	34	43	57
3m	17	24	38	51

Discussion:

The area with the statue in front of it is a bit over illuminated with the use of multiple floodlights in a small area. This will cause immense glare and discomfort to the observers. Also a lot of energy is wasted due to the usage of so many floodlights. In the dialux design, only a few uplighters have been used to show and cascade the designs as well as to wash the statue with optimum light in order for the observers to view perfectly.

Suggested Dialux Design:



Area 3: Playing field with sitting area on all sides

Area of the field: 150m x 120m

Luminaires: 6 Floodlight, 3 on each side

Readings:

	20m	40m	60m	80m	100m	120m	140m	150m
80m	6	4	8	11	13	8	8	5
50m	3	5	5	6	7	10	7	9
25m	12	12	13	8	11	17	14	12
0m	30	28	28	29	31	27	23	22

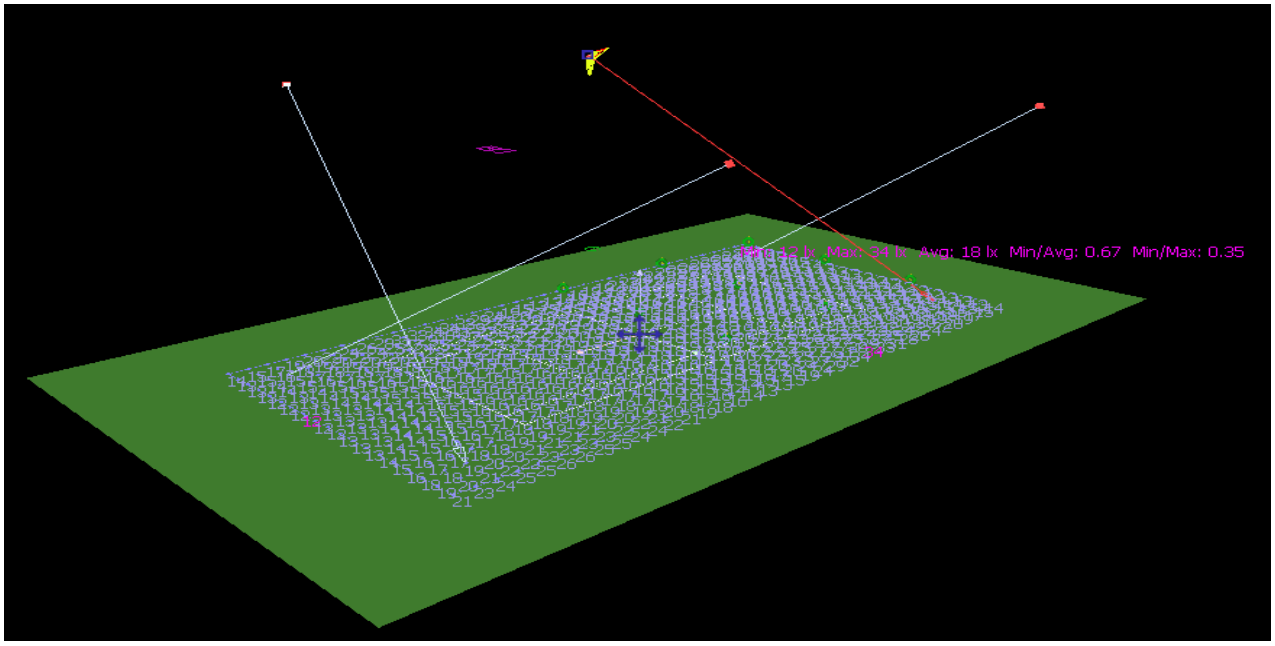
FIG 8.30: FIELD IN DABGRAM FULBARI

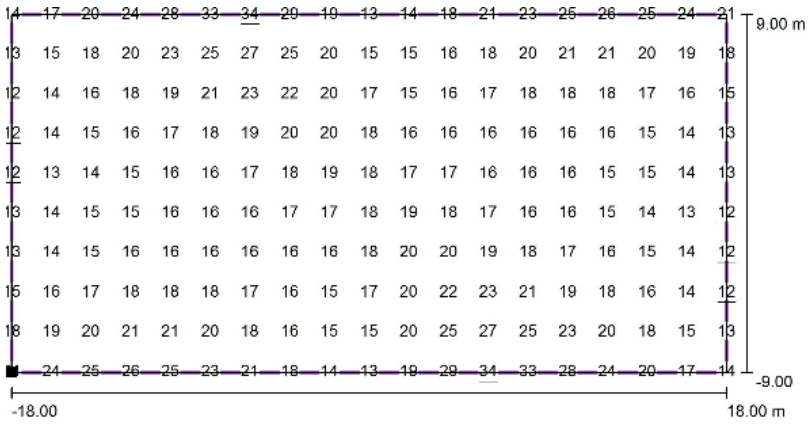
Discussion:

There was multiple dark spot all throughout the field with very less uniformity. The field was not optimum to be used during darkness due to low and improper placing of flood lights. The below dialux design has been created with 4 floodlights on four corners to focus on the playing area. The standard of 20Lux

was approximately achieved along with a very good uniformity for the occupants not to face any dark spots.

Suggested Dialux Design:

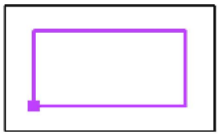




Values in Lux, Scale 1 : 258

Not all calculated values could be displayed.

Position of surface in external scene:
Marked point: (-18.000 m, -9.000 m, 0.000 m)



Grid: 37 x 19 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
18	12	34	0.67	0.35

Statistical Analysis:

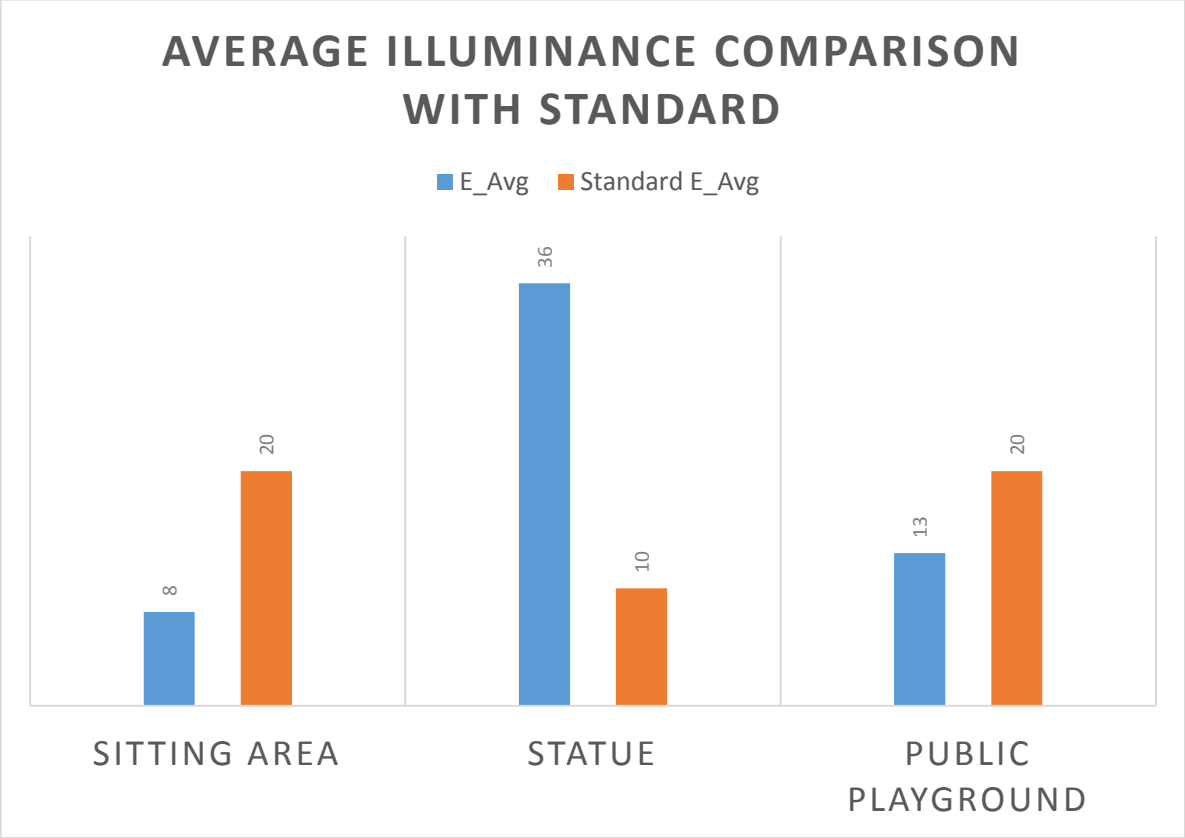


Fig 8.31: Comparative Study of Average Illuminance

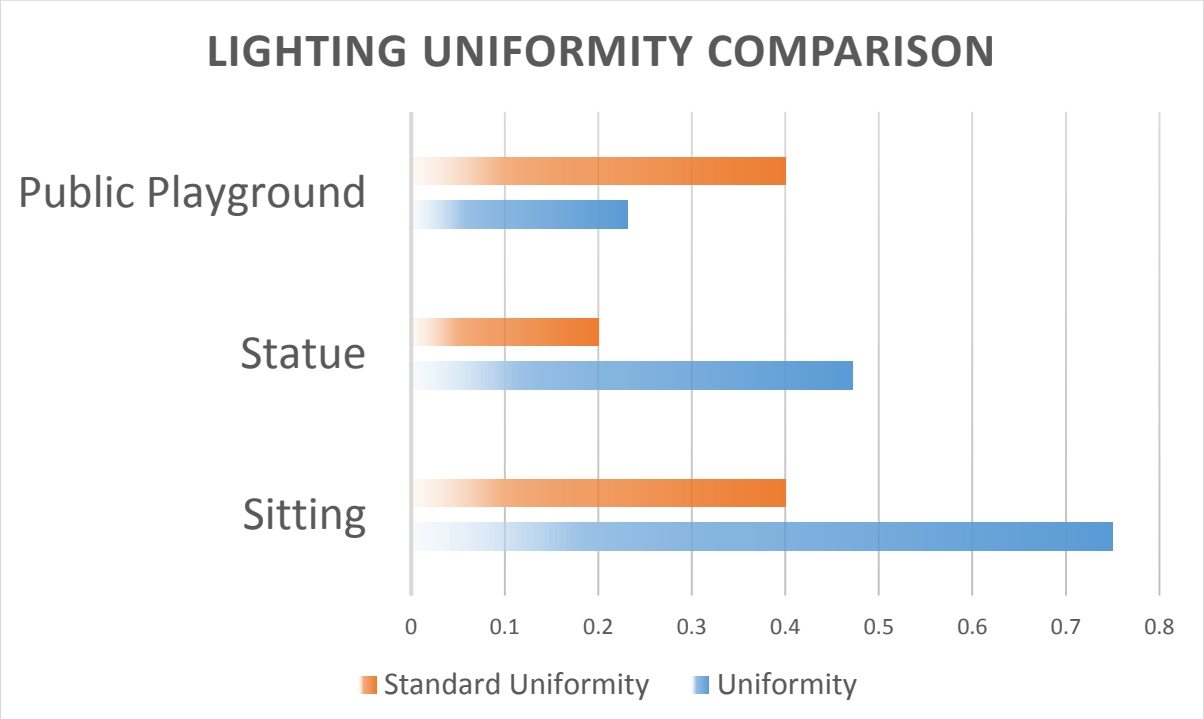


Fig 8.32: Comparative Study of Uniformity with Standard

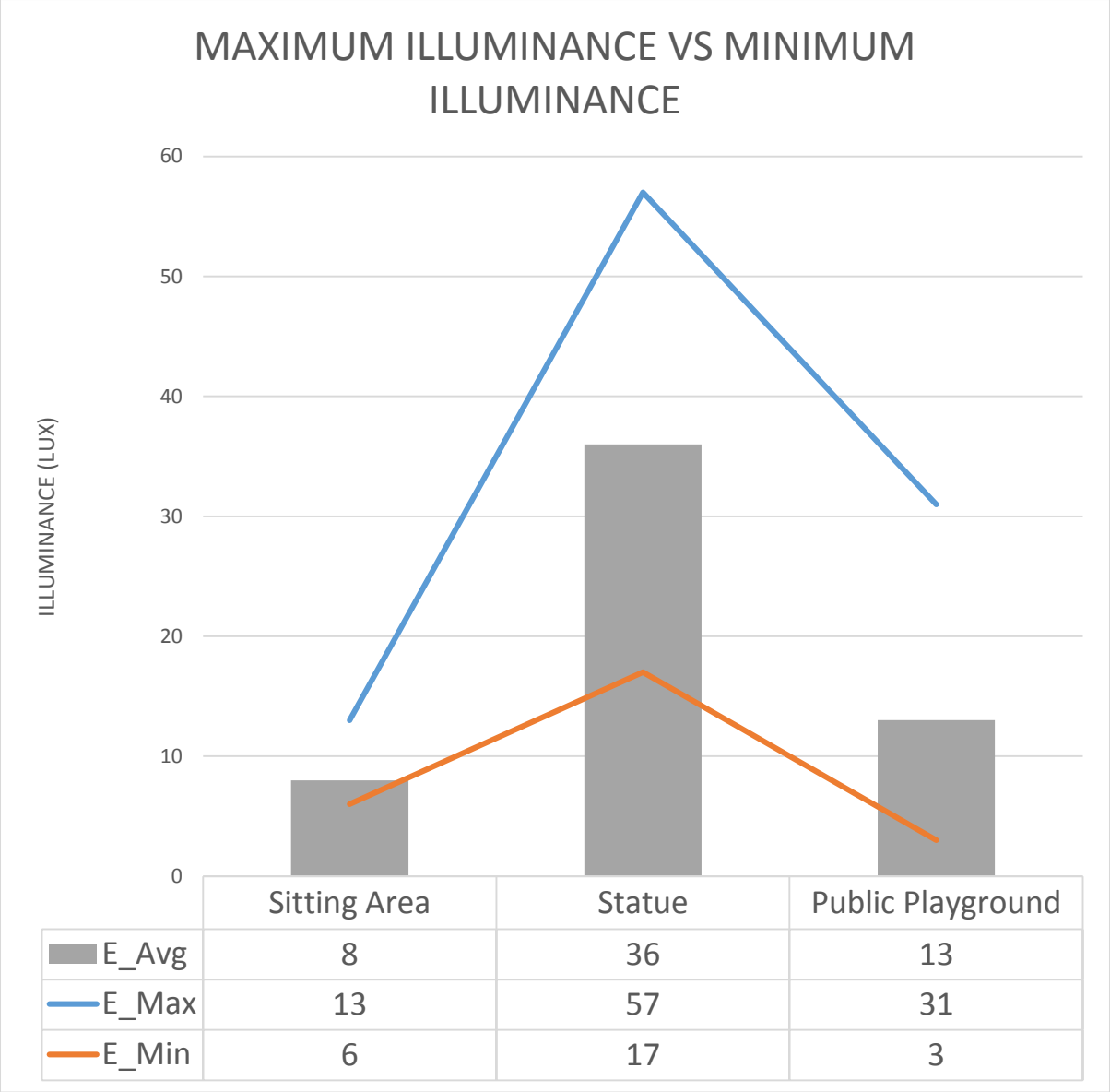


Fig 8.33: Max vs Min Illuminance with the calculated Average Illuminance

Discussion:

From the statistical data it is clearly visible that the measured average illuminance is comparatively low with the rated standard. Considering all the factors, the proposed designs have already undergone discussion, and the general design parameters that can be reviewed are outlined below:

1. Safety as a Top Priority: Safety should always be the primary concern when designing lighting for public spaces. Adequate illumination can prevent accidents, deter criminal activity, and create a sense of security for park visitors.

2. Increment in Luminaire quantity and quality: The recommendation is made to utilize a increased number of luminaires, considering all design standards, considering the primary aim of minimizing both energy consumption and maintenance costs. The use of high powered luminaires must also be in the design parameters considering the cost effective and the future maintenance cost to be incurred.

3. Implementation of Automated Controls: The incorporation of automated occupancy and ambient light sensors into the design is highly advisable. This feature will lead to a significant reduction in energy consumption on a larger scale when lighting is unnecessary or when spaces are unoccupied. The light sources will autonomously dim themselves, maintaining the minimum illumination required for visibility, especially by approaching vehicles. Enhanced energy efficiency and real-time data for continuous optimization can be provided by modern technology advancements, such as IoT-based lighting control systems.

4. Emphasis on Uniform Distribution: The prioritization of uniformity in the design is essential to eliminate any uneven patches of light and minimize glare for the occupants. It also provides enhanced visual comfort and improved safety in various applications in public spaces, can be achieved through uniform light distribution.

5. Consider Natural Elements: Allow the lighting design to complement the park's natural elements. For example, using warm-toned lighting can harmonize with the natural colours of trees and vegetation.

6. Community Engagement: Involve the local community in the lighting design process. Seek feedback and take into account the needs and preferences of the people who will be using the park regularly.

When designing lighting for outdoor public parks and open areas, a comprehensive and thoughtful approach is essential to create an effective and well-balanced lighting scheme. Safety and security are of paramount importance, as proper illumination helps prevent accidents and deters criminal activity,

providing a sense of security for park visitors during nighttime hours. Understanding the various activities and functions within the park, such as walking paths, sports fields, playgrounds, seating areas, and recreational spaces, is crucial to determine appropriate lighting levels and the types of fixtures needed.

8.2.3 ZONE: OUTDOOR PARKING AREA LIGHTING

Area Size: 94m X 60m

Luminaire Used – 2 Flood Light at random position and throw

Readings:

	20m	40m	60m	80m
10m	47	96	74	36
20m	21	47	45	22
30m	14	17	14	9
40m	3	6	6	4
50m	11	9	5	2

FIG 8.34S: PARKING AREA NEAR MAHANANDA

Discussion:

The area is not at all illuminated as there was only few floodlights working in the front section instead of the whole area. The light patch was due to one only 1 source and it was illuminated considering the area under the source only. Other areas were dark with cars parked and might cause accident as there was almost 0 illuminance. In order to resolve the design, high masts must be installed along with occupancy sensors for better efficient design and energy will be used only if the area is occupied.

Statistical Analysis:

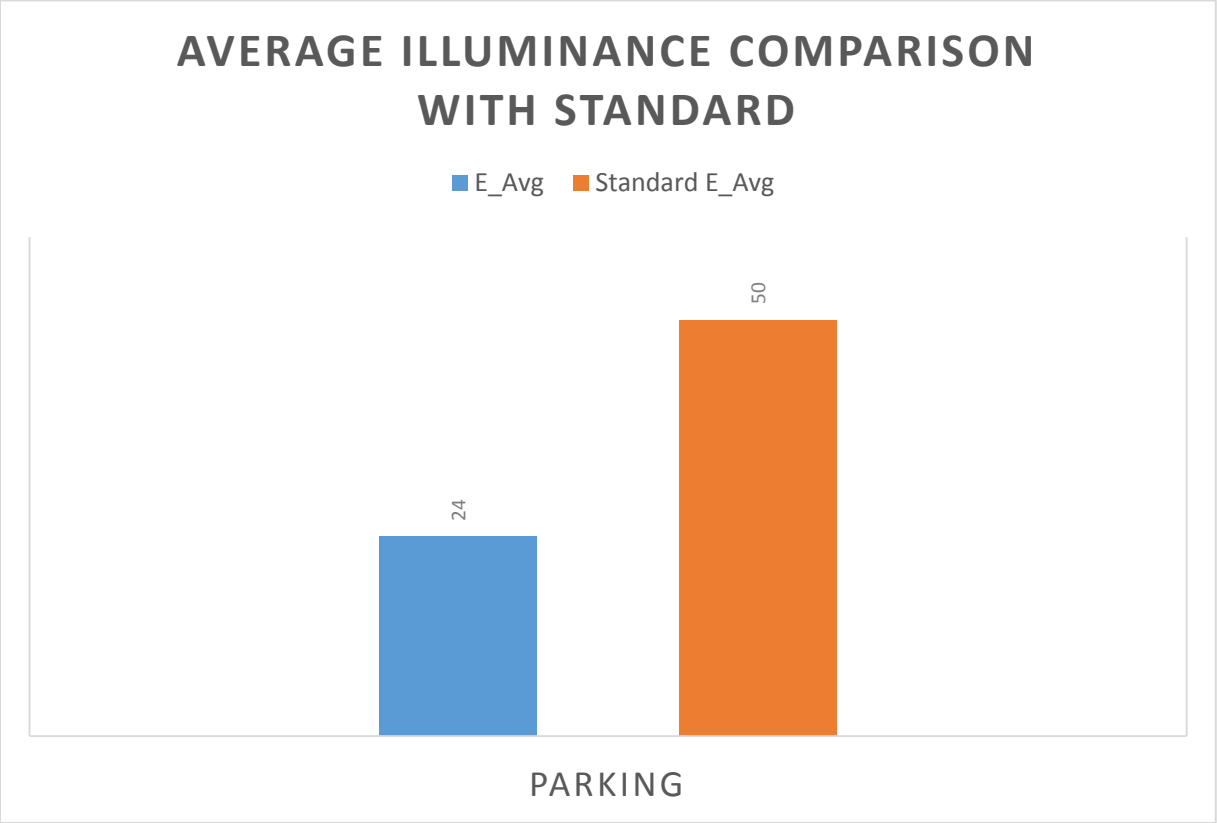


Fig: Comparative Study of Average Illuminance

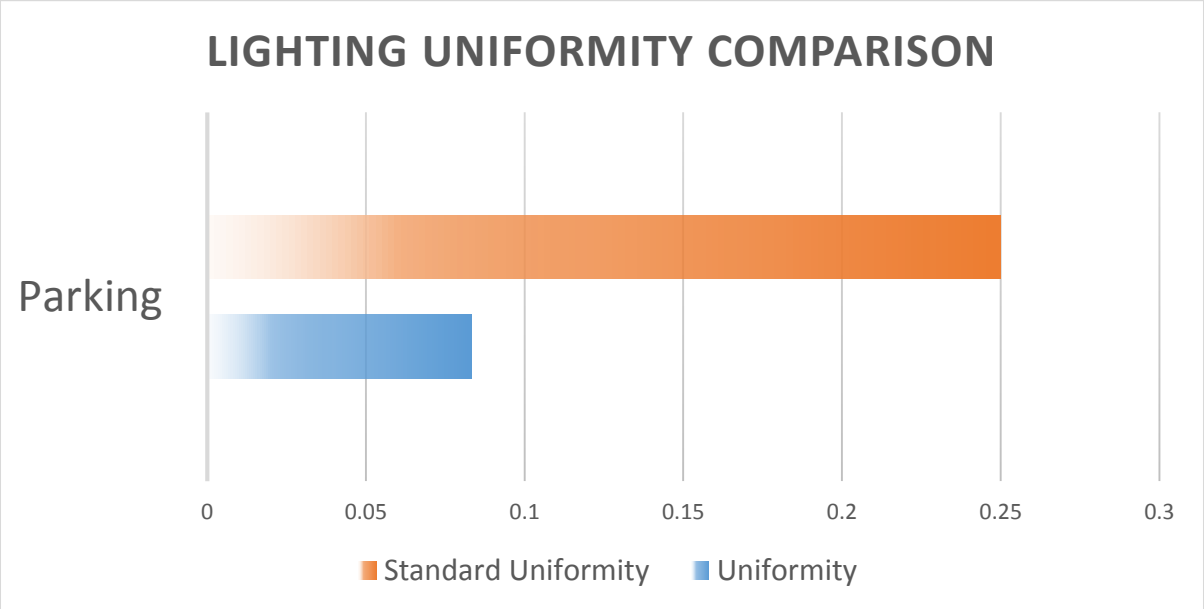


Fig: Comparative Study of Uniformity with Standard

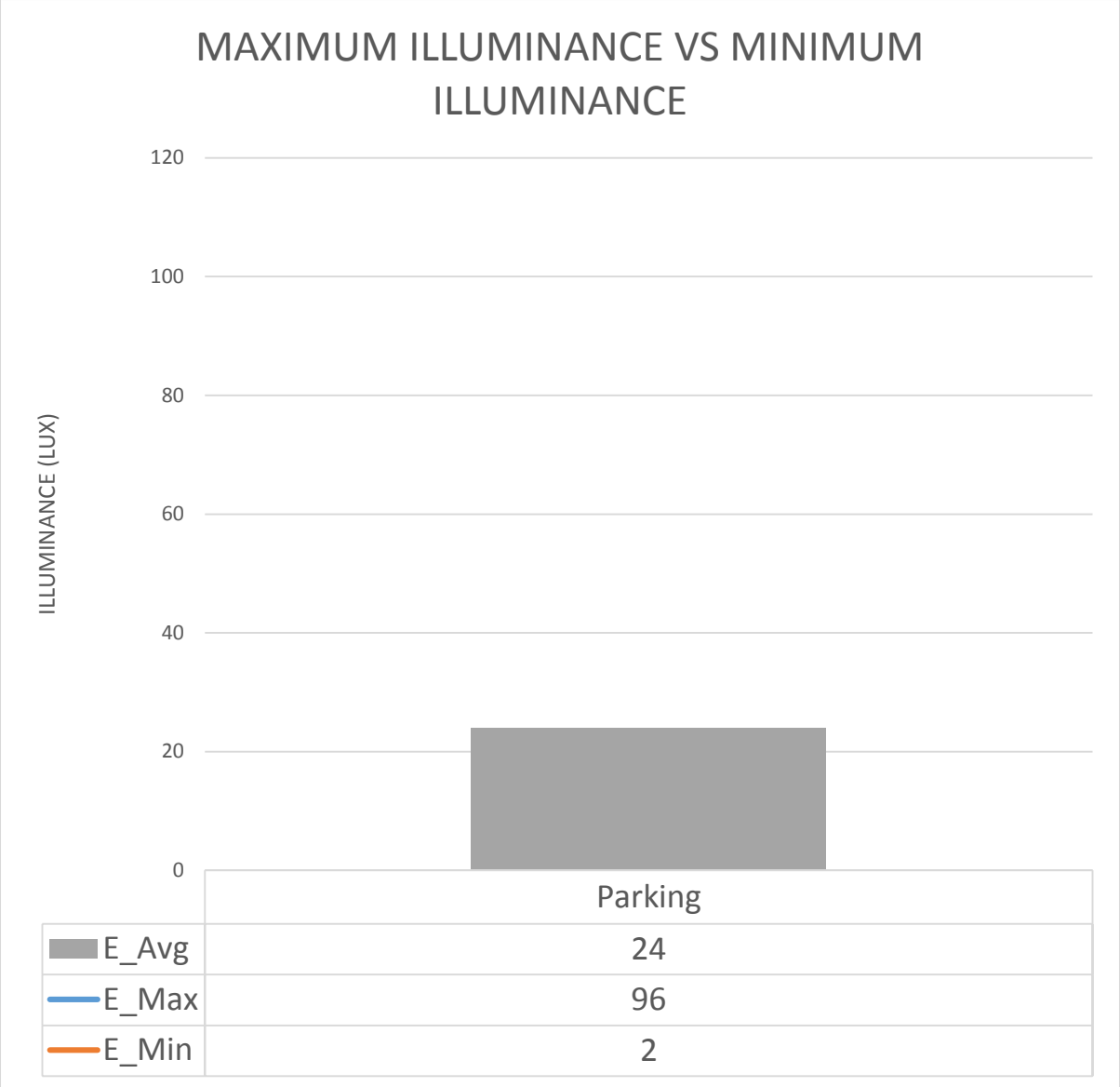


Fig: Max vs Min Illuminance with the calculated Average Illuminance

Discussion:

There is a huge need to increase the illuminance level in the parking area considering the low amount. . Considering all the factors, the proposed designs have already undergone discussion, and the general design parameters that can be reviewed are outlined below.

1. Appropriate Light Levels: The light levels should be adequate for the size and purpose of the parking area. Typically, parking areas require lower light levels than, for example, sports fields or highways. The right light levels strike a balance between visibility and energy efficiency.

2. Consideration of Surrounding Light Sources: During the initial stages of design, it is imperative to account for light emanating from nearby sources such as billboards, shop entrances, building facade lighting, adjacent parks, and streetlights. This comprehensive approach is essential to curtail project costs. Furthermore, the government should take stringent measures against excessive use of facade lighting in public and commercial properties to mitigate light pollution and glare.

3. Implementation of Automated Controls: Incorporating automated occupancy and ambient light sensors along with motion sensors into the design is highly advisable. This feature will significantly reduce energy consumption on a larger scale when lighting is unnecessary or when spaces are unoccupied. The light sources will autonomously dim themselves, maintaining the minimum illumination required for visibility by approaching vehicles.

4. Emphasis on Uniform Distribution: The design must prioritize uniformity to eliminate any uneven patches of light and minimize glare for the occupants.

Parking area lighting is a critical aspect of urban and commercial infrastructure designed to provide illumination and enhance safety in parking lots and garages. These lighting systems ensure visibility for drivers, pedestrians, and security personnel during nighttime or low-light conditions, reducing the risk of accidents and criminal activities. Parking area lighting is strategically planned to cover the entire parking space uniformly, minimizing dark spots and ensuring a comfortable and secure environment for users. The choice of lighting technology, such as LED fixtures, offers energy efficiency, reducing operational costs and environmental impact. Additionally, lighting control systems, motion sensors, and timers can be incorporated to optimize energy usage and adapt to varying usage patterns. Properly designed parking area lighting not only enhances safety and visibility but also improves the overall user experience, encouraging patronage and contributing to the overall success of commercial establishments and public facilities.

8.3 LOCATION SELECTION AND DISCUSSION FOR RAJARHAT AND SILIGURI

Rajarhat is considered as a Green City as well as a Smart City by the Government and is in the top of the budding new age infrastructure and design. Rajarhat, situated in the eastern part of Kolkata, India, has rapidly emerged as a prominent satellite township in recent years, lauded for its modern infrastructure and meticulous urban planning. Notable features of Rajarhat encompass its strategic location, with close proximity to Netaji Subhas Chandra Bose International Airport and well-connected city center, its burgeoning status as an IT and business hub, replete with IT parks and tech startups, its pioneering smart city initiatives incorporating cutting-edge technology, a burgeoning real estate market offering diverse housing options, an array of educational institutions that beckon students and academics, a vibrant commercial and retail landscape, eco-friendly green spaces fostering a healthier lifestyle, a rich cultural tapestry with frequent cultural events and artistic showcases, modern infrastructure ensuring convenience and comfort, and a promising trajectory of future growth propelled by ongoing development projects and investments. Rajarhat's amalgamation of contemporary amenities, prime location, and sustainable development makes it an attractive choice for both businesses and residents, positioning it as a dynamic urban center within Kolkata and India at large.

While Siliguri, another location that has been considered in the design measurement has its own salient features and a key contender in the future growth. Siliguri, nestled at the foothills of the Himalayas, thrives as a strategic trade and commercial hub, thanks to its unique location near the borders of Nepal, Bhutan, and Bangladesh. This city boasts a host of positive features, including its economic significance, robust educational infrastructure, healthcare facilities, and excellent connectivity via road, rail, and air. Siliguri's growth is evident in its expanding commercial and retail sectors, as well as its burgeoning real estate market. Its role as a gateway to popular tourist destinations has further fueled its economic development, making Siliguri a promising urban center in eastern India with a rich tapestry of opportunities and benefits for its residents and businesses alike.

The comparative study of the two areas with respect to the growth and development can be discussed as follows:

Features:

Rajarhat: Located in the eastern part of Kolkata, Rajarhat is known for its strategic proximity to the Netaji Subhas Chandra Bose International Airport, making it a

preferred choice for businesses and residents looking for easy connectivity. It has emerged as a significant IT and business hub, home to numerous IT parks, software companies, and technology startups, thereby creating a robust job market. The city has actively embraced smart city initiatives, enhancing the quality of life with features like intelligent traffic management and waste management systems. Its real estate market has witnessed substantial growth, offering diverse housing options, and it boasts a range of well-established educational institutions, commercial spaces, green areas, and cultural attractions. Modern infrastructure, including wide roads and well-planned utilities, contributes to the city's comfort and convenience. Rajarhat's ongoing development projects and investments ensure a promising future.

Siliguri: Situated at the foothills of the Himalayas, Siliguri is a vital trade and transit hub near the borders of Nepal, Bhutan, and Bangladesh. Its economic significance stems from its role as a commercial center, facilitating trade in tea, timber, and agricultural products. The city offers numerous educational institutions and healthcare facilities, bolstering its growth. Excellent road, rail, and air connectivity through Bagdogra Airport promote trade and tourism, and Siliguri serves as a gateway to popular tourist destinations. It has seen significant growth in commercial and retail sectors, including malls and markets, and the real estate sector has experienced substantial development.

Future Scope:

Rajarhat: Rajarhat's future looks promising with ongoing development projects, a thriving tech ecosystem, and improved infrastructure. It is poised to continue attracting businesses and residents, ensuring sustained growth.

Siliguri: Siliguri's future is bright, with its position as a gateway to tourist destinations, expanding trade networks, and a growing urban population. It is likely to continue evolving as a pivotal economic and commercial center in the region.

Lighting Design:

Rajarhat: Given its modern and planned infrastructure, lighting design in Rajarhat is likely to prioritize energy-efficient, smart lighting solutions. These may include

LED streetlights, automated lighting controls, and aesthetically pleasing illumination in commercial and residential areas.

Siliguri: Siliguri, with its diverse landscape encompassing both urban and natural surroundings, may have a lighting design that balances functionality and aesthetics. Streetlights in commercial areas, as well as the enhancement of tourist spots, could be key elements of the city's lighting design.

Rajarhat and Siliguri differ in terms of their economic drivers, geographical features, and urban development patterns. Rajarhat's growth is propelled by its IT sector and modern urban planning, while Siliguri's economic significance stems from trade and its role as a tourist gateway. Both cities have bright prospects for the future, with potential for further expansion and improvements in lighting design to enhance the urban experience.

8.4 COMPARATIVE STUDY BETWEEN RAJARHAT AND SILIGURI OUTDOOR LIGHTING DESIGN AS MEASURED

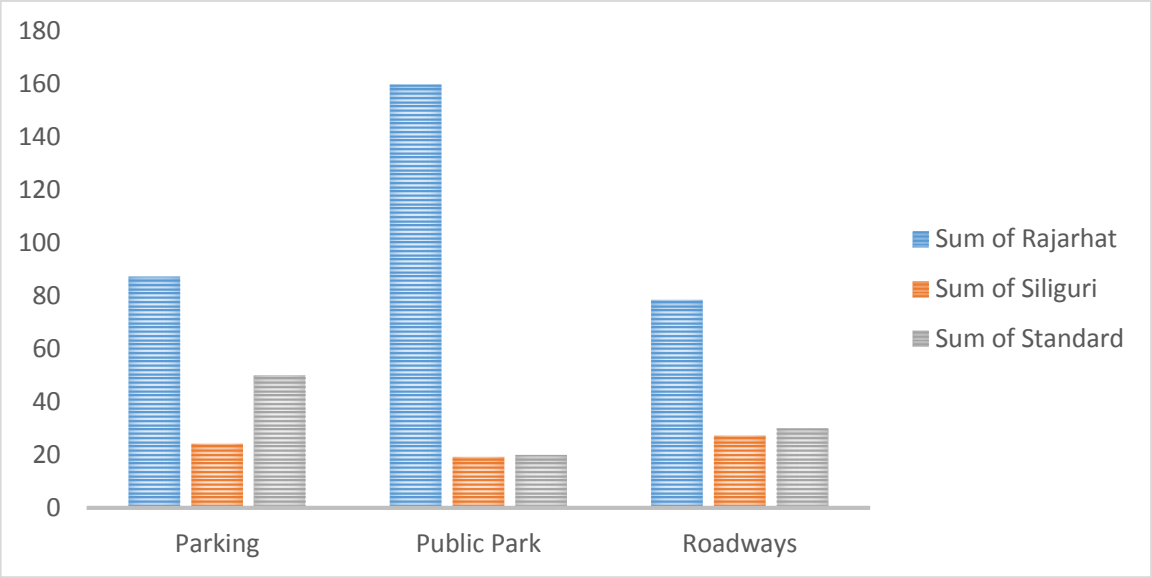


Fig 8.35: Comparative study of cumulative average illuminance

Discussion:

The statistical data shows the huge difference between the average illuminance of each area between Rajarhat and Siliguri. There has been multiple discussion on the suggested lighting design to be at par with the standard. The detailed comparative study are here as follows:

Use of Luminaires: When choosing lighting fixtures for outdoor spaces, it is important to choose fixtures that are durable and weather-resistant. This is particularly important for outdoor lighting, as these fixtures will be exposed to the elements. In case of Rajarhat, the use of luminaires are more compared to that in Siliguri, which have both positive and negative effects as over-illuminance might cause light pollution and sky glow whereas in case of Siliguri the low light level and multiple faults in the luminaires used may result in huge security gap in city planning.

Light Pollution: Outdoor lighting can contribute to light pollution, which can be harmful to the environment and can disrupt the natural rhythms of animals and plants. When designing outdoor lighting, it is important to consider the impact that your lighting will have on the surrounding environment and to choose lighting fixtures and bulbs that minimize light pollution. In case of Rajarhat, there is a huge prospect of Light pollution and skyglow due to over illuminance in most of the area. In case of Siliguri, the light pollution and sky glow will cause major disruption in the nearby jungles of Baikunthapur, Gorumara etc. along with the lowerbase Himalayas jungle. But if seen from long distance, Siliguri does not emit much of SkyGlow which is a good point for nearby natural habitat.

Safety and Security: Safety is a crucial consideration when designing outdoor lighting. It is important to ensure that all walkways and entrances are well-lit to prevent accidents, and to use lighting fixtures that are properly grounded and installed to prevent electrical hazards. The low light levels of Siliguri along with certain dark areas may result in concerns regarding safety and security.

Smart Lighting: Smart lighting systems can be used to control outdoor lighting remotely and to automate lighting schedules. This can help to save energy and can provide an added layer of security by allowing you to monitor your outdoor

space from a distance. Rajarhat has already started implementing occupancy sensor based lighting in certain areas where the light is auto dimmed if there is no occupant or pedestrians in the streets. Siliguri must also take measures incorporating such designs for an energy efficient environment and low operational cost. It will pave a way for much more human – nature interaction in that area.

MEASUREMENT DATASET

Location	Zone	Area	E_Max	E_Min	E_Avg	Uniformity	Standard E_Avg	Standard	Standard Uniformity
Rajarhat	Parking	Parking strip with walking path	105	44	72	0.611111111	50	NLC	0.25
	Parking	Parking strip with walking path	96	45	60	0.75	50	NLC	0.25
	Parking	Parking Area with High Mast	316	28	130	0.215384615	50	NLC	0.25
	Public Park	Walking Strip	49	17	29	0.586206897	20	NLC	0.4
	Public Park	Open Air Amphitheatre	413	161	234	0.688034188	10	NLC	0.4
	Public Park	Sitting Area	489	149	351	0.424501425	20	NLC	0.4
	Public Park	Statue	32	12	26	0.461538462	10	NLC	0.2
	Roadways	Road 1	286	78	184	0.423913043	50	IRC	0.6
	Roadways	Road 2	125	45	80	0.5625	50	IRC	0.6
	Roadways	Road 3	110	33	59	0.559322034	50	IRC	0.6
	Roadways	Service Road	78	44	60	0.733333333	30	IRC	0.6
	Roadways	Cycle Way	94	8	48	0.166666667	30	IRC	0.6
	Roadways	Road 4	79	16	41	0.390243902	50	IRC	0.6
Siliguri	Parking	Parking	96	2	24	0.083333333	50	NLC	0.25
	Public Parks	Sitting Area	13	6	8	0.75	20	NLC	0.4
	Public Parks	Statue	57	17	36	0.472222222	10	NLC	0.2
	Public Parks	Public Playground	31	3	13	0.230769231	20	NLC	0.4
	Roadways	Road 1	62	26	44	0.590909091	50	IRC	0.6
	Roadways	Road 2	38	7	20	0.35	50	IRC	0.6
	Roadways	Road 3	29	7	16	0.4375	30	IRC	0.6
	Roadways	Road 4	38	17	28	0.607142857	30	IRC	0.6

9. AREA WISE RECOMMENDATION

The city of Rajarhat being a Smart City needs few more modification and enhancement regarding the lighting design along with the regular maintenance to avoid any fault and dark patch. The following are the area wise recommendation.

1. Road Lighting:

The measured data reveals that the measured average illuminance exceeds the rated standard, potentially causing glare and discomfort for motorists and pedestrians. Uniformity levels were often not met, leading to dark patches on the road. To address these issues, proposed design changes include reducing the number of luminaires to save energy and reduce maintenance costs, considering surrounding light sources during initial design, implementing automated controls for energy savings, prioritizing uniform light distribution for visual comfort and safety, adopting energy-efficient LED lighting, and establishing regular maintenance schedules. These measures aim to enhance lighting efficiency, reduce energy consumption, and mitigate adverse environmental and visual impacts associated with excessive artificial lighting, including sky glow, light pollution, glare, and visual discomfort.

2. Public Parks, Sitting Area and Common Spaces Lighting

The average illuminance exceeds the rated standard, potentially leading to glare, discomfort, and visual issues for occupants while also contributing to light pollution and sky glow in the area. To address these concerns, proposed design revisions include reducing luminaire quantity to save energy and decrease maintenance costs, considering nearby light sources during initial design, implementing automated controls for energy efficiency, and emphasizing uniform light distribution for enhanced visual comfort and safety. The main concern of these area is to maintain the aesthetic and natural instance in the greenery avoiding over illumination. This helps in maintain the both human and natural habitat of the area.

3. Parking Area Lighting

From the measurement it is observed that few areas are over illuminated while few sits lack proper lighting due to non-operational light sources. So design parameters must be revisited and proper maintenance must take place in order to avoid any issue. Smart lighting with occupancy and motion sensors can be used to make the design more energy efficient and workable.

Coming to the city of Siliguri considering the importance in Trade and Tourism, multiple visitors come for different purpose making this city always busy, Being the gateway to the North East, the beautification and proper lighting is very much important. The following are the area wise recommendation:

1. Road Lighting:

The measured data indicates that the measured average illuminance falls below the rated standard, potentially causing discomfort for motorists and pedestrians due to numerous dark patches and low luminance in the area. Uniformity standards were also frequently unmet, resulting in unevenly lit areas. To address these issues, proposed design revisions include increasing the number of luminaires, incorporating higher luminance luminaires for energy efficiency, considering nearby light sources during initial design, implementing automated controls for energy savings, emphasizing uniform light distribution, and adopting energy-efficient LED luminaires. These measures aim to improve lighting efficiency, enhance safety, and reduce energy consumption and costs, while also mitigating the adverse impacts of excessive artificial lighting on the environment and human activities, including issues such as sky glow, light pollution, glare, and visual discomfort.

2. Public Parks, Sitting Area and Common Spaces Lighting

The public parks and sitting areas along with the fields were low lit and can raise security concerns post sunset. Proper utilization of luminaires along with the regular maintenance is very much important to mitigate the issue pertaining the safety of the occupants. Also governing bodies must consider the usage of smart lighting with automation to reduce the operational cost and energy usage.

3. Parking Area Lighting

In the city of Siliguri usually occupants park on roads and pavements, but there are a few parking area. From the measurement it is observed that the areas are not at all illuminated and lack proper lighting due to non-operational light sources. So design parameters must be revisited and proper maintenance must take place in order to avoid any issue. Smart lighting with occupancy and motion sensors can be used to make the design more energy efficient and workable.

10. CONCLUSION

A comprehensive comparative study was undertaken to evaluate the outdoor public lighting design metrics in two distinct Indian cities, Rajarhat and Siliguri. The primary objective was to propose lighting solutions that align with Indian standards and regulations while addressing the unique characteristics and challenges of each location. The work on the thesis came with a few observation and recommendation as follows

1. Luminaire Usage Discrepancy:

Rajarhat demonstrated a significantly higher utilization of luminaires, resulting in enhanced illumination throughout the city. However, this raised concerns about the potential for excessive light pollution and skyglow, which can adversely affect the environment and human health. Siliguri exhibited lower light levels, raising safety and security concerns, especially in poorly lit areas.

2. Lighting Intensity Variation:

Siliguri exhibited lower light levels in various areas, particularly in densely populated zones. This disparity in lighting intensity generated concerns regarding safety and security, especially in poorly lit regions where pedestrian and resident safety was compromised.

3. Impact on Environment and Natural Habitats:

The study highlighted the issue of light pollution in both cities, albeit in different ways. Rajarhat faced the risk of excessive light pollution and skyglow due to its intense illumination, impacting the surrounding environment. While Siliguri had a comparatively lower impact on nearby natural habitats, it still needed to address light pollution in its urban planning.

4. Safety and Security Considerations:

Rajarhat demonstrated its commitment to safety by featuring well-lit walkways and deploying occupancy sensor-based lighting in select areas. In contrast, Siliguri raised concerns about the safety of pedestrians and residents due to inadequate lighting in dark zones, warranting immediate attention.

5. Potential of Smart Lighting Solutions:

Both Rajarhat and Siliguri showcased the potential benefits of implementing smart lighting systems. In Rajarhat, the use of occupancy sensors highlighted the potential for energy-efficient lighting solutions, reducing unnecessary power consumption. Siliguri was encouraged to adopt smart lighting technologies to improve energy efficiency, enhance urban sustainability, and promote interaction between humans and nature.

The following recommendations has been concluded.

1. Balancing Luminaire Usage (Rajarhat):

Rajarhat should consider optimizing its luminaire placement to reduce light pollution while maintaining adequate illumination.

2. Enhanced Lighting (Siliguri):

Siliguri needs to prioritize safety and security by increasing lighting in poorly lit areas, ensuring the well-being of pedestrians and residents.

3. Smart Lighting Solutions (Both Locations):

Both cities should explore the integration of occupancy sensors and smart lighting systems to achieve energy efficiency and enhance overall living conditions.

4. Community Engagement and Compliance to Standard:

The study underscores the importance of continuous community engagement in the outdoor public lighting design process to ensure that lighting solutions meet the needs and preferences of the local population. Adherence to Indian standards and regulations is vital to ensure the safety and quality of outdoor lighting.

Rajarhat and Siliguri have the opportunity to create a brighter, safer, and more sustainable urban future by addressing the disparities and challenges revealed in this comparative study. By minimizing the environmental impact of outdoor lighting, preserving their cultural and aesthetic identity, and embracing responsible lighting practices, both cities can pave the way for a more environmentally friendly and safer urban environment

11. FUTURE SCOPE

The future scope of Indian outdoor public lighting design and systems is promising and encompasses various aspects driven by technological advancements, sustainability concerns, urbanization trends, and evolving user expectations. Here are some key areas of future scope:

1. Smart Lighting Infrastructure: Integration of Internet of Things (IoT) technology will enable smart lighting systems. These systems can adjust brightness based on real-time data, such as traffic flow or weather conditions, leading to energy savings and improved safety.

2. Energy Efficiency: Continued emphasis on energy efficiency will drive the adoption of LED lighting and advanced control systems. These technologies reduce energy consumption and maintenance costs, aligning with India's sustainability goals.

3. Solar-Powered Lighting: Given India's abundant sunlight, solar-powered outdoor lighting will become more prevalent. Solar streetlights and other solar-powered fixtures can operate independently from the grid, reducing the strain on conventional energy sources.

4. Environmental Sustainability: Designs will prioritize eco-friendly materials, reduce light pollution, and consider the ecological impact. Dark sky-friendly lighting designs will help preserve the natural environment and improve stargazing opportunities.

5. Adaptive Lighting: Adaptive lighting systems will become mainstream, responding to pedestrian and vehicular movement. This enhances safety and reduces energy waste during low-traffic hours.

6. Integration with Smart Cities: As Indian cities transform into smart cities, outdoor lighting will integrate with broader urban infrastructure systems. Lighting will play a role in traffic management, security, and data collection for urban planning.

7. Health and Well-being: Lighting systems will incorporate human-centric lighting principles, considering the impact of light on human circadian rhythms and overall well-being. This can enhance the quality of public spaces.

8. Artistic and Aesthetic Considerations: Outdoor lighting design will blend aesthetics with functionality. Creative lighting designs will enhance the cultural and architectural identity of urban areas.

9. Cost-Effective Maintenance: Proactive maintenance strategies, including predictive analytics and remote monitoring, will minimize downtime and reduce maintenance costs. This is crucial for ensuring long-term sustainability.

10. Regulatory Frameworks: Stricter regulations and standards related to outdoor lighting, especially to curb light pollution, will come into effect. Compliance with these regulations will be a significant focus for designers and municipalities.

11. Community Engagement: Public input and community engagement will play a more substantial role in outdoor lighting design. Inclusion of local preferences and needs will lead to more user-friendly and culturally sensitive designs.

12. Resilience Planning: Given the increasing frequency of extreme weather events, lighting systems will need to be resilient and capable of withstanding adverse conditions.

13. Retrofitting Existing Infrastructure: The retrofitting of existing lighting infrastructure with energy-efficient and smart technologies will be a priority to upgrade older cities.

14. Research and Innovation: Ongoing research in areas like material science, optics, and lighting technology will continue to drive innovation, leading to more efficient and sustainable outdoor lighting solutions.

The future scope of Indian outdoor public lighting design and systems is broad and evolving. It encompasses technological advancements, sustainability, aesthetics, and user-centric considerations, all aimed at creating safer, more energy-efficient, and aesthetically pleasing public spaces.

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