STUDIES ON LIGHT POLLUTION IN VARIOUS LIGHTING APPLICATION AREAS

A thesis Submitted towards partial fulfillment of the requirements for the degree of

Master of Technology
In Illumination Technology & Design

Submitted by

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ABSTRACT

Light pollution has become an increasingly prevalent issue in our modern world, with adverse effects on the environment, human health, and wildlife. This thesis focuses on investigating and analyzing the extent of light pollution in various settings, specifically industrial indoor areas, roads, parking areas, and public places.

The study begins by examining the causes and sources of light pollution in these specific settings, including excessive and poorly directed artificial lighting. It explores into the implications of light pollution on energy consumption, sky glow, and the disruption of natural ecosystems and wildlife behavior.

The research methodology involves extensive data collection, including light intensity measurements, spatial analysis, and surveys to assess the perceptions and experiences of individuals affected by light pollution. The data is then analyzed using statistical methods to provide insights into the severity and patterns of light pollution in the studied areas.

The findings reveal alarming levels of light pollution in industrial indoor areas, roads, parking areas, and public places with horizontal illuminance and vertical illuminance respectively. Also uniformity take into account. The thesis highlights the detrimental effects on human health, such as sleep disturbances and increased risk of chronic diseases, as well as the disruption of nocturnal wildlife activities and migration patterns.

Furthermore, this thesis explores potential solutions and mitigation strategies to address light pollution in these specific contexts. It examines the effectiveness of various lighting technologies, design principles, and policy measures aimed at reducing light pollution and promoting energy-efficient lighting practices.

Ultimately, this research aims to raise awareness about the consequences of light pollution in industrial indoor areas, roads, parking areas, and public places. It provides valuable insights for policymakers, urban planners, lighting designers, and stakeholders to develop sustainable lighting solutions that minimize light pollution and promote a healthier and more harmonious coexistence between humans and the environment.

Keywords: Light pollution, over-illumination, Light trespass, Glare, Sky glow

LIST OF CONTENT

CHAPTER: 1

INTRODUCTION

INTRODUCTION

Light pollution, characterized by the excessive and inappropriate utilization of artificial illumination, has emerged as a significant ecological concern in contemporary times. This global problem affects urban and rural regions alike, disrupting the natural balance between day and night and adversely affecting various facets of the environment and human existence.[1]

The term "light pollution" denotes the unfavorable outcomes arising from the mismanagement and overuse of artificial light sources. Although originally associated with outdoor lighting, it now encompasses indoor lighting as well. The widespread prevalence of light pollution disrupts the natural darkness of the nocturnal sky, obscuring the view of stars, planets, and other celestial entities. Furthermore, it has detrimental effects on wildlife behavior, ecological processes, and overall biodiversity.[1][2]

In addition to its impact on astronomy and ecology, light pollution also poses risks to human well-being. Prolonged exposure to artificial light during nighttime disrupts the innate circadian rhythm, leading to sleep disorders, heightened stress levels, and potential long-term health consequences. Additionally, the glare and bright lights in urban areas contribute to visual discomfort, reduced visibility, and an increased likelihood of accidents.

A primary consequence of light pollution is the obscuration of stars and celestial objects in the night sky. In heavily light-polluted regions, only a fraction of stars remain visible, significantly diminishing the captivating beauty of the natural nighttime expanse. This impedes the enjoyment of stargazing and hinders scientific research and astronomical observations.

Furthermore, light pollution disrupts the natural cycles and behaviors of various organisms. Nocturnal creatures, such as birds, insects, and sea turtles, rely on darkness for navigation, feeding, mating, and other vital activities. Artificial light can disorient these organisms, affecting their reproductive patterns, disrupting ecosystems, and potentially leading to population decline.

Light pollution also has detrimental effects on human health. Excessive exposure to artificial nighttime illumination disrupts the circadian rhythm, the internal biological clock responsible for regulating sleep patterns and hormone production. This disruption is linked to various health issues, including sleep disorders, mood disorders, and an increased risk of chronic conditions such as obesity, diabetes, and certain types of cancer.[1][3]

Efforts to combat light pollution involve employing more efficient and appropriately shielded lighting fixtures that direct light downward, reducing glare and light leakage. Implementing lighting ordinances and regulations to control excessive outdoor lighting is also crucial. Increasing awareness, education, and promoting the significance of preserving natural darkness are essential in mitigating the impact of light pollution and restoring the splendor of the nighttime sky for future generations.

1.1 LITERATURE REVIEW

- **Light Pollution: a Study based on the Assessment of Actual Cases 2005 Meeting of Engineering Teachers and Researchers (EnIDI) Mendoza, Argentina Article · January 2006** [4]

  This study focuses on evaluating real-life instances of light pollution, which arises from unnecessary artificial lighting during nighttime. The presence of light pollution reduces visibility of the night sky and leads to wastage of energy. Excessive or faulty nighttime lighting adversely affects sky visibility. The study provides valuable insights into the impacts of light pollution, encompassing ecological systems, human health, economy, safety, social issues, and technical concerns. Distortion of the natural day and night cycle occurs due to excessive spectral range and intensity of artificial lighting. Light pollution alters the nocturnal habits, reproduction, and migration patterns of birds, bats, fish, and insects, and even affects their response to ultraviolet radiation. Sleep patterns, body temperature regulation, biological clocks, and mental health are all impacted by light pollution. Employing appropriate lighting practices can result in cost-effective systems. Excessive light and glare pose safety risks and hinder visibility. This paper elucidates the social and technical aspects of light pollution, while also offering fundamental lighting guidelines such as turning lights off after midnight, utilizing suitable beam angles and appropriate luminaires. Controlling upward flux, a crucial parameter for road lighting, plays a significant role in mitigating sky glow and light pollution. Various types of luminaires are employed to address light pollution, with or without adjustments to luminaire settings. The reduction of upward flux allows for achieving the desired outcomes with lower power consumption. This study holds substantial value as it is based on real-world scenarios, providing meaningful insights into the subject of light pollution.

- **Outdoor site-lighting performance: A comprehensive and quantitative framework for assessing light pollution**

  JA Brons MSc, JD Bullough PhD and MS Rea PhD
  Lighting Research Center, Rensselaer Polytechnic Institute, Troy, NY, USA, Received 8 April 2008; Revised 8 May 2008; Accepted 10 May 2008 [5]

  This study focuses on analyzing light pollution associated with outdoor site lighting. The performance of outdoor site lighting serves as a comprehensive approach for measuring and predicting light pollution. Primarily occurring during nighttime, light pollution is influenced by factors such as glow, trespass, and glare. Additionally, the phenomenon of light loss factor contributes to light pollution due to unnecessary upward and diffused light. Discomfort glare, which relates to the illuminance produced by the light source, surrounding environment, and ambient illuminance, is discussed, and a mathematical expression for calculating discomfort glare is presented. The extent of sky glow depends on the horizontal surface of the area, such as a car park, road, or playground, and is particularly affected by high reflectance surfaces like concrete or snow. Light trespass occurs when unwanted light infiltrates through windows, causing disturbance during sleep. To assess outdoor lighting performance, the Outdoor Site Lighting Performance (OSP) approach is employed, utilizing a virtual calculation "box" that encompasses the outdoor lighting system and incorporates inter-reflectance within this defined space. Software can be used to visualize these inter-reflectance. Minimizing glow, trespass, and glare is crucial for reducing light pollution.

- **The reality of light pollution: A field survey for the determination of lighting environmental management zones in South Korea.**

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  Received: 26 December 2017; Accepted: 29 January 2018; Published: 31 January 2018 [6]

  This paper presents an investigation into the reality of light pollution, highlighting its impact on living organisms. Artificial lighting is found to have adverse effects on both health and the environment. The improper and excessive use of artificial lighting leads to the generation of light pollution. The survey was conducted across various zones in Korea, including residential, semi-residential, and industrial areas. Following the classification by the CIE, the environmental lighting zones were categorized into En1, En2, En3, and En4. The vertical illuminance was measured under two conditions: before and after curfew. In response to the health-related concerns associated with light pollution, the Illuminating Engineering Society and the International Dark-Sky Association collaborated to establish legislation aimed at preventing light pollution. The Korean government recognized and approved the implementation of these light pollution prevention laws. During the survey, parameters such as space lighting, light trespass, and glare played significant roles. Light pollution was found to negatively impact work productivity, contribute to the risk of cancer, and disrupt the circadian cycle. This paper provides a concise discussion on light pollution, its effects, relevant standards, and associated legislation.

- **Evaluation of light pollution in the streets and the roads of AL-NAJAF city, IRAQ.**

Kufa Journal of Engineering Vol. 11, No. 3, July 2020, P.P. 62-76 Received 11 May 2020, accepted 2 July 2020 [7]

In this study, the levels of light pollution were assessed across various streets in Iraq. The environmental lighting zones, categorized as En1, En2, En3, and En4 by the CIE, were examined. The vertical illuminance was measured in these four zones under two conditions: before and after curfew. The paper discusses different roads, presents the measured illuminance data, and plots the average measured illuminance against the standard illuminance. This graphical representation effectively demonstrates the presence of light pollution. The field survey was conducted in five prominent towns, considering both pre-curfew and post-curfew scenarios. To measure the illuminance intensity, a light-sensing lens was positioned horizontally, capturing horizontal illuminance, which aided in assessing light pollution levels. Throughout the survey, it was noted that the light intensity was higher in shops, hotels, and restaurants compared to the opposite side of the road. These findings underscore the significance of raising public awareness about light pollution and the need for improvement in this regard.

1.2 PROBLEM DEFINITION

Light pollution is a widespread issue in contemporary society, adversely affecting the environment, human well-being, and wildlife. This study focuses on examining and analyzing the extent light pollution in distinct settings such as industrial areas, roads, parking lots, and public spaces. By gathering data and conducting statistical analysis, concerning levels of light pollution are detected. The phenomenon of light pollution is thoroughly examined, considering both national and international standards, as well as the CIE lighting Zone.

1.3 OBJECTIVES

The objectives of this thesis work are:

- To collect data for different area like, Industry, public place, parking zone & different roadway.
- To compare Average Illuminance with standard.
- To identify the different lighting zone and the area of light pollution.
- To study about energy Conservation & protection of human health & visual comfort and safety.

1.4 METHODOLOGY

Measuring light pollution follows a typical procedure that includes the following steps:

- Selecting Measurement site
- Choosing Measurement Instruments.
- Calibrating the Instruments.
- Establishing Measurement parameters.
- Conduct Measurement.
- Record Data.
- Data Analysis.
- Reporting and Interpretation.

1.5 THESIS OUTLINE

The thesis is divided into seven chapters.
In **chapter 1**, An introduction to the thesis work has been given. It also includes Literature Review, problem definition, objectives and Thesis outline.

In **chapter 2**, The basic theory and terminologies related to the light pollution are mentioned in brief, light pollution types, adverse impact of inefficient artificial lighting, reducing of light pollution and the light pollution measurement technique.

In **chapter 3**, The lighting standard and lighting environment zone for different places have also been outlined.

In **chapter 4**, Area of measurement and instruments details are discussed.

In **chapter 5**, It covers the discussion on measuring the necessary lighting parameters in various settings such as industrial area, green zones, public places, parking areas and different roadway.

In **chapter 6**, Results are analyzed and compared in terms of Average Illuminance with standard, various results are analyzed and the same is plotted in graphs.

In **chapter 7**, Conclusion of the thesis work is drawn and future scope of this work is highlighted.

At last, all the references have been given.

CHAPTER: 2

BACKGROUND THEORY

2.1 INTRODUCTION

Light pollution is a condition where artificial lighting is present in a manner that is unwanted, inappropriate or excessive [1] [2]. This term refers to the negative effects caused by poorly designed lighting, which can occur both during the day and at night. Light pollution is not just a result of a specific type of pollution or source, but it is also a contributing factor to the overall impact of various forms of pollution. Although light pollution. Urbanization is the main cause of this phenomenon, which is linked to health on can occur at any time of the day, it is particularly noticeable during the night due to the stark contrast with darkness. Sky glow resulting from light pollution is believed to impact 23% of the world's land area, with approximately 83% of people residing under light-polluted skies. Unfortunately, the area affected by artificial lighting continues to expand and has increased by at least 49% globally from 1992 to 2017 problems, ecosystem disruptions, and the degradation of scenic environments [1] [2].
The term "light pollution" is most commonly used to describe excessive artificial lighting in outdoor environments, but it also includes indoor lighting. The negative consequences of light pollution are numerous, and some of them may still be unknown. It competes with starlight in the night sky and can interfere with astronomical observatories, as well as disrupting ecosystems and causing adverse health effects, like any other form of pollution. [2]
Light pollution is a by-product of industrial civilization and can arise from a variety of sources such as building exteriors and interiors, advertising, outdoor area lighting (such as car parks), offices, factories, streetlights, and illuminated sporting venues. Although it is most severe in densely populated areas of North America, Europe, and Asia, even small amounts of light can create problems. Efforts to address the effects of light pollution began in the 1950s, but the global dark-sky movement only emerged in the 1980s with the founding of the International Dark-Sky Association (IDA). This movement has since spread globally with educational and advocacy organizations in many countries. [1][2]

2.2 Types:

Light pollution is a broad term that refers to multiple problems, all of which are caused by inefficient, unappealing, or (arguably) unnecessary use of artificial light [8] [14].There are several light pollution, including:

A. Sky glow
B. Glare
C. Light trespass
D. Over-illumination
E. Clutter

2.2.1 Sky glow:

Sky glow is a form of light pollution that arises when artificial light scatters through the atmosphere, resulting in a bright and diffuse glow in the night sky. This can create visibility problems for stargazers and astronomers, as well as disrupting the behavior and natural rhythms of nocturnal animals [3] [9]. Sky glow is often observed as a pink or orange glow above urban areas and can extend for several miles beyond. Excessive or poorly directed outdoor lighting, such as streetlights, building illumination, and advertising displays, is the primary cause of this phenomenon. Implementing energy-efficient lighting, directing light towards the ground instead of the sky, and utilizing shielded fixtures that limit light pollution are among the ways to mitigate the effects of sky glow as shown in fig 2.1.

Fig.2.1: Sky glow

2.2.2 Glare:

Glare is often the result of excessive contrast between bright and dark areas in the field of view. For example, glare can be associated with directly viewing the filament of an unshielded or badly shielded light. Light shining into the eyes of pedestrians and drivers can obscure night vision for up to an hour after exposure. Caused by high contrast between light and dark areas, glare can also make it difficult for the human eye to adjust to the differences in brightness [10] [11] [12]. Glare is particularly an issue in road safety, as bright and/or badly shielded lights

around roads may partially blind drivers or pedestrians unexpectedly, and contribute to accidents.
Glare can also result in reduced contrast, due to light scattering in the eye by excessive brightness, or to reflection of light from dark areas in the field of vision, with luminance similar to the background luminance.
The degree of Glare may be subdivided as follows:

A. Blinding Glare
B. Disability Glare
C. Discomfort Glare

Blinding glare as shown in fig 2.2 refers to the complete blinding effect experienced when looking directly at the Sun, resulting in temporary or permanent vision impairments.
Disability glare encompasses situations like being blinded by headlights of oncoming cars, light scattering in fog or in the eye, which reduces contrast. It also includes reflections from printed materials and dark areas that appear bright, leading to significant reduction in sight capabilities. [1][14]
Discomfort glare, while not inherently dangerous, can be extremely annoying and irritating. Prolonged exposure to discomfort glare may potentially result in fatigue. [15]

Fig.2.2: Glare

The blinding effect primarily arises from reduced contrast caused by excessive brightness and the reflection of light from dark areas within the field of vision, having similar luminance to the background. This type of glare is known as veiling glare and is a specific form of disability glare. (It should be noted that this is distinct from the loss of night vision accommodation, which occurs due to the direct impact of light on the eye.)

2.2.3 Light Trespass:

Light trespass is the term used to describe the presence of unwanted or excessive artificial light that infiltrates a property or area where it is neither required nor desired .Unwanted light that enters one's property, such as light shining over a neighbor’s fence, is known as light trespass. This is often caused by bright exterior lights that enter homes through windows, causing sleep disturbance. To address this issue, some cities in the United States have implemented outdoor lighting standards to protect citizens' rights against light trespass. To assist them, the International Dark-Sky Association has created model lighting ordinances.[1] The Dark-Sky Association was established to combat sky glow, which reduces the visibility of stars by limiting light emitted more than 90° above nadir. By doing so, they have also reduced the light output in the 80-90° range, which is the main cause of most light trespass issues.[13][14][16]

Fig: 2.3: Light Trespass

It often results from light spillover between neighboring properties, such as when a strong light crosses over a fence and enters someone's home. It can also be caused by outdoor lighting fixtures that are misdirected, leading to light pollution and disturbing the natural rhythms and activities of nocturnal animals. The condition of light trespass is easily observed from figure 2.1.3 .Light trespass can negatively affect human health by causing sleeplessness and headaches. To combat this problem, some cities have established outdoor lighting standards, and the International Dark-Sky Association has formulated model lighting ordinances aimed at reducing light pollution and light trespass. [19]

2.2.4 Over-illumination:

Over-illumination refers to excessive or unnecessary lighting that surpasses the actual lighting requirements of a given space or situation. It occurs when there is an excessive amount of artificial light that is brighter or more intense than needed, resulting in wastage of energy and resources. Over-illumination can have several negative impacts, including:

Energy Waste: Excessive lighting consumes unnecessary energy, leading to higher electricity usage and increased carbon emissions, which contribute to environmental problems such as climate change. [3][11][14]

Light Pollution: Over-illumination contributes to light pollution, which is the excessive and misdirected artificial light that interferes with the natural darkness of the night sky. Light pollution not only obstructs astronomical observations but also disrupts ecosystems, affects wildlife behavior, and disturbs human sleep patterns.[3][14]

Fig: 2.4: Over-illumination

Glare and Discomfort: Excessive lighting can create glare, which is the excessive brightness that causes discomfort and visual impairment. Glare can make it difficult to see properly, leading to eyestrain and reduced visibility, especially in situations like driving at night. [10][15]

Economic Costs: Over-illumination results in unnecessary expenses for lighting infrastructure, maintenance, and energy bills. It adds financial burdens to individuals, businesses, and municipalities, diverting resources that could be used more effectively elsewhere.

To mitigate over-illumination, it is important to adopt lighting practices that prioritize efficiency and sustainability. This can include using lighting controls such as dimmers, timers, and motion sensors to adjust lighting levels based on actual needs, using energy-efficient lighting technologies, and implementing lighting design strategies that focus on directing light where it is needed without causing unnecessary brightness or glare. By reducing over-illumination, it can conserve energy, reduce light pollution, improve visual comfort, and minimize the environmental impact of excessive artificial lighting. What is the over-illumination, figure 2.1.4 justify the over-illumination.

2.2.5 Clutter:

Clutter refers to excessive groupings of lights. Groupings of lights may generate confusion, distract from obstacles (including those that they may be intended to illuminate), and potentially cause accidents. Excessive clustering of lights, whether it's poorly designed street lights or brightly illuminated advertisements near roads, can have detrimental effects, especially on roads and highways. This can lead to confusion and distractions for drivers, impeding their visibility of important signs and obstacles that the lights are supposed to illuminate. As a result, accidents can occur. [8][14][15]

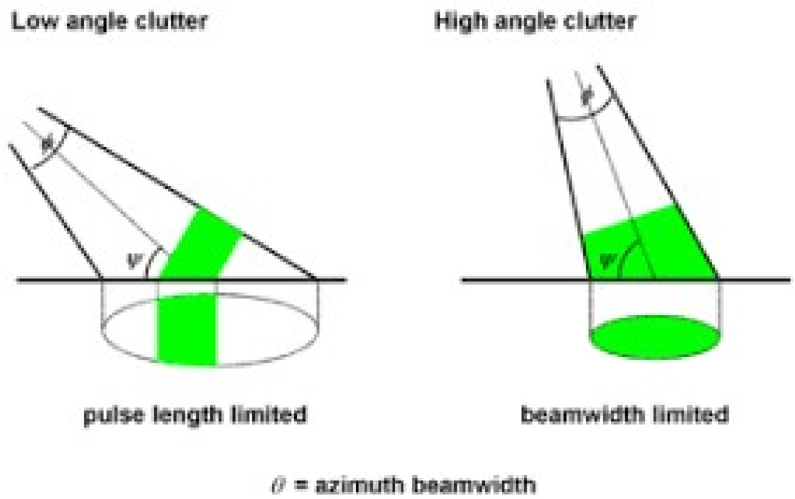

Fig.:2.5: Clutter

The issue of light clutter becomes even more concerning when the purpose behind installing and designing lights is to deliberately distract drivers. In such instances, lights may be strategically positioned to divert attention away from the road or create visual disturbances that disrupt drivers' focus and concentration. This intentional use of lighting contributes to accidents by diverting attention and causing drivers to lose sight of crucial information while driving.

To prioritize road safety, it is crucial for authorities and organizations responsible for lighting installations to meticulously consider the placement, design, and intensity of lights. The goal should be to enhance visibility, minimize distractions, and offer clear guidance to drivers, ultimately fostering a secure driving environment. [1].Low Angle Clutter & High Angle Clutter is shown in figure .2.1.5

2.3 Adverse Impacts of In-efficient Artificial Lighting

When discussing the negative consequences of inaccurately directed and excessively bright lighting, it is important to focus on aspects that are likely to capture the audience's attention. While not everyone may have an interest in studying the night sky, almost everyone wants to ensure their finances are wisely utilized and energy is conserved effectively. Additionally, there are less apparent yet equally significant facets to consider in the lighting discourse, such as the effects on health and wildlife, which are continually being unveiled with increasing depth[1][2][14].

The adverse impacts of poorly aimed and over-bright lighting are:

1. Energy wastage**:** The excessive consumption of energy worldwide is primarily attributed to lighting, accounting for a quarter of the total. Numerous studies have demonstrated that various forms of over-illumination, including non-beneficial upward-directed night-time lighting, contribute to energy waste.[15]

2. Impact on human health and psychology Extensive research on the effects of excessive light on the human body suggests that light pollution or excessive light exposure can have detrimental effects on human health. Therefore, it is essential to consider human health as a key factor when determining appropriate interior lighting.

3. Health consequences of over-illumination or improper light composition may include an increase in the frequency of headaches, worker fatigue, medically defined stress, heightened anxiety or excitement, and more.

4. Fluorescent lighting commonly found in office settings has been found to raise blood pressure by approximately eight points. In the United States, there is evidence suggesting that light levels in most office environments contribute to increased stress levels and worker errors.

5. Various published studies also indicate a correlation between exposure to light at night and an elevated risk of certain types of cancer due to the suppression of the body's normal production of melatonin during nocturnal hours.

6. Disruption of ecosystems Natural light and dark patterns are integral to the functioning of ecosystems, and any disturbance to these patterns can have widespread effects on animal behavior. Light pollution can disrupt animal navigation, alter competitive interactions, disturb predator-prey relationships, and

impact animal physiology.

7. Effects on astronomy: The presence of sky glow hinders astronomers from observing celestial bodies such as stars and planets. This obstacle significantly impairs the field of astronomy. [12]

2.4 Reducing Light Pollution

Reducing light pollution encompasses various measures, such as diminishing sky glow, minimizing glare, preventing light trespass, and reducing visual clutter[1][3][14]. The most effective approach to reducing light pollution depends on the specific issue at hand in each case. Potential solutions include:

- Employing light sources with the minimum required intensity to fulfill their intended purpose.

- Implementing timers, occupancy sensors, or manual controls to switch off lights when they are not needed.

- Enhancing lighting fixtures to ensure more precise direction of light towards the desired areas while minimizing side effects.

- Adapting the types of lights used to emit light waves that are less likely to cause significant light pollution problems.

- Assessing existing lighting plans and considering redesigns, eliminating unnecessary lighting based on actual requirements.

2.5 Light Pollution Measurement Technique

Measuring light pollution typically involves assessing the brightness and visibility of the night sky due to artificial lighting sources. Here are some common techniques used for light pollution measurement:

Sky Quality Meters (SQMs): SQMs are portable devices equipped with a photodiode sensor that measures the brightness of the night sky. They provide a numerical value known as the sky quality meter reading (in magnitudes per square arc second, or mag/arcsec^2). SQMs are often used for quick and easy measurements at various locations. [1][3]

Digital Cameras: Digital cameras, especially those capable of long-exposure photography, can be used to capture images of the night sky. By analyzing the images, researchers can assess the level of light pollution based on the visibility of stars, constellations, and other celestial objects. Software tools like SQM-L and Loss of the Night app can help analyze the images and estimate light pollution levels.

Radiometry: Radiometric measurements involve using specialized equipment to quantify the amount of light emitted by different sources and its impact on the night sky. These instruments, such as spectrometers or radiometers, measure the intensity of light in various wavelengths. Radiometry can provide detailed spectral information, allowing researchers to study the specific contributions of different types of light sources.

Sky glow Mapping: Sky glow mapping involves creating detailed maps of light pollution in a particular area or region. This technique typically employs a combination of measurements from various instruments and devices. Sky glow maps provide a visual representation of light pollution levels, highlighting areas with higher or lower levels of artificial lighting. [9]

Citizen Science Initiatives: Many light pollution monitoring efforts involve citizen scientists who contribute data using their own equipment, such as SQMs or digital cameras. Online platforms and mobile apps allow individuals to share their measurements, creating a comprehensive dataset for studying light pollution on a global scale. [1]

It's worth noting that light pollution measurement techniques can vary depending on the specific objectives of the study and the available resources. Different instruments and methods may be used to capture different aspects of light pollution, such as sky brightness, spectral composition, or visibility of celestial objects.

CHAPTER: 3

LIGHTING STANDARD

& ENVIRONMENT ZONE

3.1 LIGHTING STANDARD

- **NATIONAL LIGHTING CODE (NLC), 2010**

The NATIONAL LIGHTING CODE (NLC) encompasses the following areas [19]:

a) Providing guidance on illuminating engineering practices for different types of occupancies.

b) Offering guidance on sound engineering practices for designing, selecting, installing, and maintaining indoor and outdoor lighting systems.

c) Covering matters related to the science of illumination, including the physics of light, electric light sources, luminaires, and photometry.

d) Addressing coordination aspects to consider when designing lighting systems, such as day-lighting.

e) Including aspects of energy management and conservation in lighting installations, including design guidelines and best practices for efficient and effective use of light sources.

The primary objective of this code is to establish clear requirements for responsible social, commercial, and engineering conduct among lighting designers, manufacturers, and suppliers. Lighting technology plays a crucial role in achieving social safety and environmental goals. The code aims to promote good lighting practices and systems that minimize light pollution, glare, light trespass, and energy consumption while ensuring safety, security, utility, and productivity.

The lighting industry is characterized by fragmentation and relatively low technical barriers to entry. Despite its essential role in safety operations, it faces comparatively low levels of regulation. As a result, end users and consumers often lack accurate and reliable information regarding what constitutes a safe, reliable, and efficient lighting system. This code seeks to foster trust between the industry and its customers by integrating commerce and technology, providing reliable standards and guidelines.

- **Code of Practice for Interior Illumination [IS 3646(part1):1992]**

This Indian standard was adopted by the Bureau of Indian Standards following the approval of the final draft by the Illuminating Engineering and Luminaires sectional committee, as sanctioned by the Electro-technical Division council. [18]

The main objective of this code is to outline the factors that should be considered to achieve effective lighting. It primarily focuses on the illumination of working interiors, including factories, workshops, offices, commercial premises, public buildings, hospitals, and schools. The code aims to fulfill two key objectives: facilitating clear visibility of tasks and creating a visually pleasant and conducive environment. [18]

Good lighting is characterized by its suitability in terms of both quality and quantity for two purposes: providing a well-lit and favorable environment for users and enabling efficient visibility of important elements or details. The recommendations provided in this code are applicable to artificial, natural, or hybrid lighting systems. Moreover, it emphasizes the importance of maintaining high lighting standards whenever a building is occupied, treating the lighting of a building as a service.

While the conventional planning methods described in this code are continuously researched, certain situations may necessitate considering the luminance patterns across the entire visual field. Therefore, a well-coordinated approach among the architect, consultant, and illumination engineer is crucial when implementing a sound lighting system. It is essential for these parties to exchange lighting-related information from the planning stage to the installation phase.

- **Code of practice for Industrial Lighting [IS 6665-1972]**

This Code encompasses the principles and practices governing effective lighting in various industrial premises. It provides recommendations regarding the desired level of illumination and quality standards based on general lighting principles. [19]

Industrial lighting encompasses a wide range of visual tasks, operating conditions, and economic considerations. Visual tasks can vary in size, brightness, transparency, surface characteristics, and shape. Lighting should be tailored to ensure adequate visibility during the transformation of raw materials into finished products. Furthermore, given the presence of physical hazards in manufacturing processes, lighting should contribute significantly to safety and accident prevention. In situations where operations require quick visual perception, lighting should compensate by enhancing visual speed.

Not only does lighting serve as a production tool and safety aid, but it also contributes to the overall environmental conditions of the workspace. The lighting system should be integrated into a well-planned environment that enhances user comfort and well-being.

The design and selection of lighting equipment are influenced by various economic factors. While project costs and ongoing lighting expenses are important considerations, it is equally crucial to evaluate the overall lighting costs in relation to other plant facilities and labor expenses.

A good industrial lighting system should address two key aspects: a) sufficient quantity of illumination. b) High quality of illumination.

- **NATIONAL BUILDING CODE, (NBC) 2016**

The Code comprises regulations that can be readily adopted or implemented by various departments, municipal administrations, and public entities. Its primary objective is to ensure public safety by establishing minimum provisions for structural integrity, fire safety, and health considerations in buildings. As long as these fundamental requirements are met, the choice of materials and design and construction methods is left to the expertise of building professionals. Additionally, the Code addresses administrative provisions, development control rules, and general building requirements. It encompasses fire safety measures, specifications for materials and structural design, guidelines for electrical installations, lighting, air conditioning, heating, and lift installation. Furthermore, it includes provisions for ventilation, acoustics, plumbing services (such as water supply, drainage, sanitation, and gas supply), construction safety regulations, and rules for the installation of signs and outdoor display structures. The current edition of the Code also covers aspects related to the structural use of glass, escalators, moving walks, information and communications enabled installations, solid waste management, landscape planning and design, as well as asset and facility management.[20]

The Code also addresses industrialized systems of building and the need for architectural control. With the anticipated increase in population, the housing problem will become more pressing. Urban population growth in India is expected to continue at a rapid pace, resulting in increased demand for accommodation. Consequently, the speed of construction becomes crucial, necessitating a focus on industrialized building systems. Simultaneously, architectural control becomes essential to prevent the creation of unattractive and slum-like conditions in our urban areas, given the heightened building activity.

The major changes incorporated in this third revision of the Code are as follows:

a) Provisions for association of need based professionals and agencies have been updated to ensure proper discharge of responsibilities for accomplishment of building project.

b) With a view to ensuring ease of doing business in built environment sector, a detailed provision for streamlining the approval process in respect of different agencies has been incorporated in the form of an integrated approval process through single window approach for enabling expeditious approval process, avoiding separate clearances from various authorities.

c) Further, with a view to meeting the above objective, the provision on computerization of approval process has been detailed, enabling online submission of plans, drawings and other details, and sanction thereof, aiding in speedier approval process.

d) The mechanism of ensuring certification of structural safety of buildings by the competent professional and peer review of design of buildings, have been further strengthened.

e) Requirements for accessibility in buildings and built environment for persons with disabilities and the elderly have been thoroughly revised and updated.

f) Provisions on fire and life safety have been thoroughly revised to meet the challenges of modern complex building types including the high rises.

g) Latest structural loading and design and construction codes including those relating to wind load, earthquake resistant design of buildings, steel design and foundations have been incorporated with a view to ensuring structural safety of buildings including against a disaster.

h) Provisions relating to all building and plumbing services have been updated keeping also in view the latest international practices as related to the country.

j) Provisions have been updated to ensure utilization of number of new/alternative building materials and technologies to provide for innovation in the field of building construction.

k) Construction management guidelines have been incorporated to aid in timely completion of building projects with desired quality in a safe manner within the budgeted cost.

m) Guidance has been provided for making buildings and built environment energy efficient and environmentally compatible, through the newly introduced and updated chapter on sustainability, namely Part 11 Approach to Sustainability.

n) New chapters have been added on structural use of glass; escalators and moving walks; information and communication enabled installations; solid waste management; and asset and facility management. The new Part on Approach to Sustainability has also been duly incorporated in the Code.

The comparison of the measurement lighting zone is done with these standard .After analysis it can be decided whether light pollution is occuring or not.

3.2 ENVIRONMENT ZONE

The Environment Management Zones adopted by South Korean LPPA is divided into four zones [6] [7].

En1: Green Zones used for Ecological Purpose and wildlife protection
En2: Green Zones used for agricultural purposes
En3: Residential and semi-residential zones
En4: Commercial and industrial areas.

According to the international standards set by CIE for mitigating light pollution, the areas are categorized into four distinct environmental zones. These zones are determined based on the specific purpose of an area and the appropriate level of lighting needed for each zone [6] [7].

Table: 3.2.1: Description of lighting environment management zone

Zones by CIE			
Zone	**Surroundings**	**Lighting Environment**	**Examples**
En1	natural	Intrinsically dark	national parks or protected sites
En2	rural	low district brightness	agricultural or residential rural areas
En3	suburban	Medium district brightness	industrial or residential suburbs
En4	urban	high district brightness	town centers and commercial areas

CIE has adopted the concept of environmental zones described in Table 3.2.1. For vertical illuminanace CIE has provide limits for the different environmental as shown in below table 3.2.2:

Table: 3.2.2: Standard for light pollution by CIE

Light Technical Parameter	Application Conditions	Lighting Environmental Zones			
		En1	En2	En3	En4
Vertical illuminance (lux)	Before curfew	2.0	5.0	10.0	25.0
	After curfew	0.0	1.0	2.0	5.0

CHAPTER: 4

EXPERIMENTAL PROCEDURE

4.1 AREA OF MEASUREMENT

Measurement of light pollution typically involves assessing the brightness of the night sky in different areas to understand the level of artificial light present. The measurement is expressed in lux. Various parameters are taken into account to determine the extent of light pollution in a given area. These are the measuring area:

1. Industrial Area
2. Green Zone
3. Public place / park
4. Parking Area
5. Roadway

4.1.1 Industrial Area

Industrial lighting refers (as shown in fig 4.1) to the lighting systems and fixtures specifically designed for use in industrial settings such as factories, warehouses, production facilities, and other industrial environments. Industrial lighting serves the purpose of providing adequate illumination for tasks, ensuring worker safety, enhancing productivity, and creating a suitable working environment [19].

Key considerations in industrial lighting design include:

1. Brightness and Uniformity: Industrial spaces often require high levels of brightness to ensure clear visibility and safety. Lighting fixtures should be strategically placed to provide uniform illumination across the entire workspace, minimizing shadows and dark spots.

2. Durability and Reliability: Industrial lighting fixtures must be durable and able to withstand harsh conditions such as high temperatures, dust, moisture, vibrations, and potential impacts from machinery or equipment. This ensures longevity and minimizes the need for frequent maintenance or replacement.

3. Energy Efficiency: Given the typically large scale of industrial facilities, energy efficiency is crucial to reduce operating costs and environmental impact. Industrial lighting systems often incorporate energy-efficient technologies such as LED (Light Emitting Diode) lighting, which provides high levels of illumination while consuming less energy compared to traditional lighting sources.

4. Task-specific Lighting: Different industrial tasks may require specific lighting conditions. For example, precision assembly work may require

focused task lighting, while general work areas may benefit from evenly distributed overhead lighting. Adjustable lighting fixtures or task-specific lighting solutions can be employed to meet these requirements.

5. Safety Considerations: Industrial lighting should adhere to safety regulations and standards. Emergency lighting systems, exit signs, and illuminated safety signs should be incorporated to ensure the safety and well-being of workers in case of power failures or emergencies.

6. Control Systems: Industrial lighting may utilize control systems such as occupancy sensors, timers, or daylight harvesting systems to optimize energy usage. These systems can automatically adjust lighting levels based on occupancy or utilize natural daylight to reduce the reliance on artificial lighting.

Overall, industrial lighting plays a critical role in providing safe and productive working environments in industrial settings. By combining efficient and durable lighting fixtures with suitable design considerations, industrial lighting aims to enhance visibility, ensure worker safety, and contribute to overall operational efficiency within industrial facilities.[17]

Fig.4.1.1: Rolling Mill

Fig.4.1.2: ECR Room

Fig.4.1.3: Raw Material Storage Area

Fig.4.1.4: Electrical Panel Room

Fig.4.1.5: Conference Room

Fig.4.1.6: Canteen

Fig.4.1.7: Furnace Bay

Fig.4.1.8: Packing Area

Fig. 4.1.9: Loading Area

Fig.4.1.10: Outside Road

4.1.2 Green Zone

Green zone lighting refers (as shown in fig 4.2) to the practice of using environmentally-friendly and energy-efficient lighting solutions in outdoor areas, particularly in urban and suburban settings. The goal of green zone lighting is to minimize light pollution, reduce energy consumption, and promote sustainability while still providing adequate illumination for safety and visibility [17] [18].

Key features and considerations of green zone lighting include:

1. Dark Sky Compliance: Green zone lighting aims to minimize light pollution by adhering to dark sky principles. This involves directing light downwards and reducing upward light emissions, preventing unnecessary light spillage into the sky. Shielding and proper positioning of lighting fixtures can help achieve this objective.

2. Energy Efficiency: Green zone lighting prioritizes energy-efficient lighting technologies to minimize energy consumption and reduce carbon emissions. LED (Light Emitting Diode) lighting is often used due to its high energy efficiency, long lifespan, and controllability. LEDs consume less energy compared to traditional lighting sources, resulting in significant energy savings.

3. Smart Lighting Controls: Implementing smart lighting controls can further enhance the energy efficiency of green zone lighting. Timers, motion sensors, and dimming capabilities can be used to adjust lighting levels based on occupancy and ambient light conditions, ensuring that lights are only active when needed.

4. Proper Light Levels: Green zone lighting focuses on providing the appropriate level of illumination for safety and visibility without over-lighting. Careful consideration is given to the specific lighting requirements of the area, such as footpaths, parks, parking lots, or public spaces, to avoid excessive or unnecessary lighting that contributes to energy waste.

5. Sustainable Materials: The use of sustainable materials in lighting fixtures, such as recyclable and eco-friendly components, aligns with the principles of green zone lighting. Choosing fixtures made from environmentally conscious materials can reduce the environmental impact associated with manufacturing, usage, and disposal.

6. Community Engagement: Green zone lighting initiatives often involve community engagement and education to raise awareness about the

importance of sustainable lighting practices. Encouraging public participation and support for responsible lighting choices can lead to broader adoption of green zone lighting principles.

By implementing green zone lighting strategies, communities can enjoy well-lit outdoor spaces while minimizing light pollution, reducing energy consumption, and promoting environmental sustainability. It helps preserve natural darkness, protects wildlife habitats, and contributes to creating healthier and more sustainable living environments.

Fig. 4.2.1: Green Zone at Rajarhat

Fig. 4.2.2: Green Zone at Jadavpur University

4.1.3 Public place/park

Public place and park lighting refers (as shown in fig 4.3) to the lighting systems and fixtures specifically designed for outdoor areas that are accessible to the public, such as parks, plazas, pedestrian walkways, and recreational spaces. The primary goal of public place lighting is to provide adequate illumination for safety, security, and enhancing the overall user experience in these areas [17] [18].

Key considerations for public place and park lighting include:

1. Safety and Security: Lighting in public spaces is essential for ensuring the safety and security of visitors. Well-lit pathways, entrances, and gathering areas help prevent accidents, deter criminal activities, and provide a sense of security for those utilizing the space during evening or nighttime hours.

2. Visibility and Way-finding: Effective lighting design helps improve visibility and way-finding within the public area, ensuring that visitors can navigate the space comfortably and safely. Lighting should be evenly distributed to eliminate dark spots and shadows, allowing people to see clearly and identify potential hazards.

3. Aesthetics and Ambiance: Public place lighting also serves an aesthetic purpose by enhancing the visual appeal and ambiance of the space. Thoughtful lighting design can create a welcoming and inviting atmosphere, accentuating architectural features, landscape elements, and focal points within the park or public area.

4. Energy Efficiency: Sustainable lighting practices should be employed to minimize energy consumption and reduce environmental impact. LED lighting technology is commonly used due to its energy efficiency, long lifespan, and versatility. LED fixtures can provide high-quality illumination while consuming less energy compared to traditional lighting sources.

5. Light Pollution Mitigation: Public place lighting should aim to minimize light pollution to preserve natural darkness and reduce its impact on the surrounding environment. This involves proper positioning and shielding of lighting fixtures to direct light downward and limit light spillage into the night sky.

6. Flexibility and Control: Lighting systems in public places may incorporate smart controls that allow for flexibility and efficient management. These controls can include timers, motion sensors, and dimming capabilities to

adjust lighting levels based on occupancy, activity levels, or natural light conditions.

7. Consideration for Specialized Areas: Public places often include specialized areas, such as playgrounds, sports courts, or picnic areas. Lighting design should take into account the specific requirements of these areas, such as task-specific lighting for playing fields or adequate lighting for seating and gathering spaces.

By implementing well-designed and energy-efficient lighting solutions in public places and parks, communities can create safer, more welcoming, and visually appealing environments for residents and visitors to enjoy day or night.

Fig.4.3.1: Road Along Green Zone

Fig.4.3.2: In front of Electrical Engineering Department

Fig.4.3.3: OAT at Jadavpur University

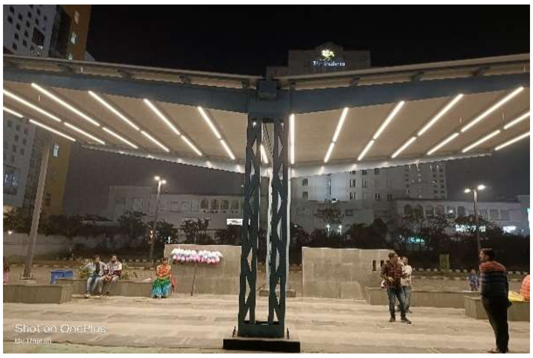

Fig.4.3.4: Open Amphitheater

Fig.4.3.5: Common Space under bridge   Fig.4.3.6: Public Statue

4.1.4 Parking Area

Parking area lighting refers (as shown in fig 4.4) to the lighting systems and fixtures specifically designed for illuminating parking lots or parking areas.[17][18] The primary purpose of parking area lighting is to provide adequate visibility and enhance safety and security for vehicles and pedestrians using the parking facility, particularly during nighttime hours.

Key considerations for parking area lighting include:

1. Adequate Illumination: The lighting design should ensure that the entire parking area is evenly and adequately illuminated, minimizing dark spots and shadows. This enhances visibility for drivers and pedestrians, making it easier to navigate, locate vehicles, and identify potential hazards.

2. Uniform Distribution: Lighting fixtures should be strategically placed to provide uniform illumination throughout the parking area. This helps maintain consistent lighting levels and reduces contrast, improving overall visibility and minimizing eye fatigue.

3. Height and Mounting: Lighting fixtures are typically mounted on poles or structures at an appropriate height to ensure effective coverage. The height should be chosen to minimize obstructions and shadows while providing optimal light distribution.

4. Safety and Security: Parking area lighting should prioritize safety and security. Well-lit parking lots deter criminal activities and help create a sense of security for users. Adequate lighting also assists in preventing accidents, reducing the risk of trips, slips, and other potential hazards.

5. Energy Efficiency: Utilizing energy-efficient lighting technologies, such as LED (Light Emitting Diode) fixtures, can significantly reduce energy consumption and operating costs. LED lights have a long lifespan, consume less energy compared to traditional lighting sources, and provide high-quality illumination.

6. Motion Sensors and Timers: Incorporating motion sensors and timers into parking area lighting systems can further enhance energy efficiency. Motion sensors can detect movement and activate lighting only when needed, reducing unnecessary energy consumption. Timers can be programmed to control lighting schedules, ensuring that lights are active during peak usage times.

7. Light Pollution Mitigation: Parking area lighting should be designed to minimize light pollution. Properly directed and shielded fixtures can help reduce upward light emissions and light spillage into the night sky, preserving natural darkness and minimizing the impact on the surrounding environment.

8. Maintenance and Durability: Parking area lighting fixtures should be durable, weather-resistant, and easy to maintain. This ensures reliable operation, minimizes downtime for repairs, and extends the lifespan of the lighting system.

By implementing effective parking area lighting solutions, parking facilities can provide a safer and more secure environment for vehicle owners and pedestrians. Well-designed lighting systems enhance visibility, deter criminal activities, and contribute to overall user satisfaction and confidence in the parking facility.

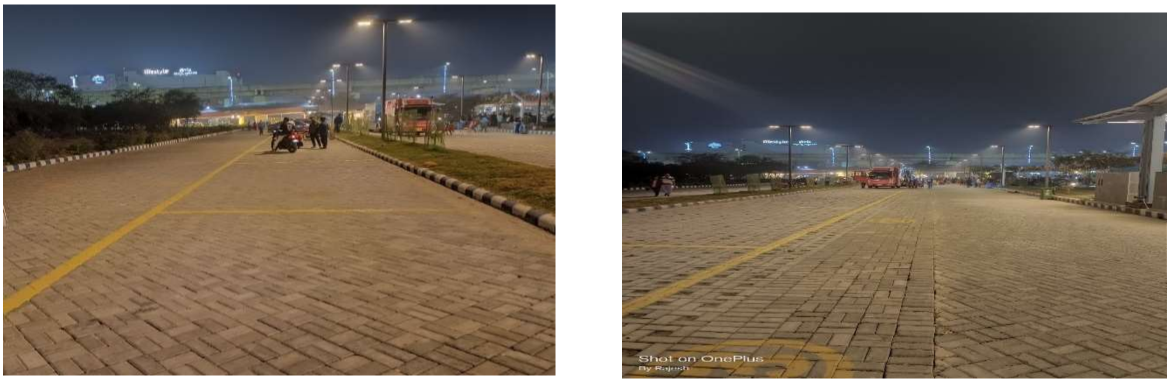

Fig.4.4.1: Different Parking Area

Fig. 4.4: Parking Area with One High Mast

4.1.5 Roadway

Roadway lighting refers (as shown in fig 4.5) to the lighting systems and fixtures specifically designed for illuminating roads, highways, and streets. The primary purpose of roadway lighting is to provide visibility, enhance safety, and guide drivers and pedestrians during nighttime or low-light conditions [1] [17].

Key considerations for roadway lighting include:

1. Illumination Levels: Roadway lighting should provide sufficient illumination to ensure clear visibility for drivers and pedestrians. Illumination levels are typically determined by guidelines and standards that take into account factors such as road type, traffic volume, speed limits, and surrounding environment.

2. Uniformity and Consistency: Lighting design should aim for uniformity and consistency in light distribution along the roadway. This helps minimize shadows, contrasts, and glare, providing a more comfortable and safer driving experience. Uniform lighting also assists pedestrians in navigating sidewalks and crosswalks.

3. Proper Light Distribution: Lighting fixtures are strategically positioned and aimed to direct light onto the roadway and surrounding areas, while minimizing light spillage into adjacent properties or the night sky. This helps reduce light pollution and preserve natural darkness.

4. Color Temperature: The choice of color temperature for roadway lighting affects the perception of the surrounding environment and the visibility of objects. Generally, warmer color temperatures (around 2700K-3000K) are

preferred as they provide better visual acuity and reduce glare compared to cooler color temperatures.

5. Energy Efficiency: Utilizing energy-efficient lighting technologies, such as LED (Light Emitting Diode) fixtures, helps reduce energy consumption and operating costs. LED lights offer long lifespans, consume less energy compared to traditional lighting sources, and provide high-quality illumination.

6. Smart Lighting Controls: Roadway lighting systems may incorporate smart controls, such as dimming or adaptive lighting, to optimize energy usage. These controls can adjust lighting levels based on traffic flow, time of day, or ambient light conditions, providing the right amount of light when and where it is needed.

7. Maintenance and Durability: Roadway lighting fixtures should be designed to withstand harsh outdoor conditions, including temperature fluctuations, moisture, dust, and vibrations. Easy access for maintenance and quick replacement of faulty components is essential to minimize disruptions and ensure consistent lighting performance.

8. Safety Considerations: Roadway lighting should prioritize safety by properly illuminating intersections, pedestrian crossings, and other high-risk areas. Adequate lighting assists in identifying potential hazards, road signs, and traffic signals, reducing the risk of accidents and improving overall road safety.

By implementing well-designed and properly maintained roadway lighting systems, communities can enhance road safety, improve visibility, and provide a more comfortable driving and walking experience during nighttime or low-light conditions.[19]

Fig.4.5.1: Different Road way at Rajarhat Area

Fig. 4.5.2: Different Road at Rajarhat Area

4.2 INSTRUMENT DETAILS

4.2.1 Lux-meter:

A lux meter is a device used to measure the level of illuminance or the amount of light falling on a surface. It is typically expressed in lux (lx), which is a unit of measurement representing the illuminance. Lux meters are commonly used in various industries and applications, including photography, architecture, horticulture, and workplace safety [21].

Lux meters consist of a light sensor or photo-detector that captures the light and converts it into an electrical signal. The sensor is usually calibrated to respond to the sensitivity of the human eye to different wavelengths of light. The device may also have a digital display or analog dial that shows the measured illuminance in lux.

Fig. : 4.1: Lux Meter

Lux meters are valuable tools for assessing lighting conditions in different environments. They can help ensure that lighting meets recommended standards for various activities, such as workplace lighting for optimal productivity or proper lighting levels for photography and filming. Lux meters can also be used to evaluate the effectiveness of lighting systems, identify areas of excessive or insufficient lighting, and aid in energy efficiency by optimizing lighting designs.

Overall, lux meters provide a quantitative measurement of illuminance, allowing for objective assessment and control of lighting conditions in various applications.

4.2.2 Measurement Tape:

A measurement tape, also known as a measuring tape or tape measure, is a flexible and retractable tool used for taking linear measurements. It consists of a long, thin strip of metal or plastic with markings that indicate units of length, typically in inches and/or centimeters. [22]

The tape measure is housed in a compact case or handle, which allows for easy storage and portability. The case usually includes a mechanism that allows the tape to be extended and retracted smoothly.

Fig.4.2: Measurement Tape

Once the desired measurement is taken, the tape can be locked in place using a locking mechanism on the case, ensuring that the measurement remains unchanged. After use, the tape can be retracted back into the case for safe storage.

Measurement tapes are widely used in various industries and applications, including construction, carpentry, sewing, crafting, and interior design. They are versatile tools that allow for quick and accurate measurements of length, width, height, and other dimensions.

Overall, measurement tapes are essential tools for both professionals and individuals, providing a simple and reliable method for measuring and obtaining accurate dimensions.

CHAPTER: 5

MEASUREMENT OF LIGHT POLLUTION

5.1 INDUSTRIAL ZONE (ALUMINIUM FOIL DIVISION)

Aluminum, a metallic element with a silver-white appearance, is known for its lightweight properties and is the most abundant metal. In India, the aluminum industry holds great significance as a key player in the country's economy, following closely behind the iron and steel industry. Its applications span across various sectors, including the production and distribution systems of modern electrical systems, household utensils, the foil industry, and the manufacturing of aircraft and rail coaches, among others. Shyam Metallic, my company, specializes in the manufacturing of aluminum foil. As a leading provider, it offer high-quality house foil, flexible packaging foil, and cater to industries such as pharmaceuticals, FMCG, and dairy. The annual rolling capacity stands at 40,000 MT per annum. At Shyam Metallic,it utilize Achenbach's two high-speed, 4-High Non-Reversing foil universal rolling mills for aluminum production. These mills are equipped to handle light (9-12 micron) and ultra-light gauges (5.5 micron) with a maximum width of 2150 mm and a minimum width of 1250 mm. The mills are supported by various ancillary equipment, including a rewinder, HGSS, AFS, roll grinder, furnace, Roil pure system, OMR, and a fully equipped quality laboratory.
These are following area where the average Illuminance are measured. (Location Pakuria, Howrah)

(a) UNIVERSAL FOIL MILL (ALUMINUM ROILLING MILL)
(b) ECR (ELECTRICAL CONTROL ROOM)
(c) ELECTRICAL PANEL ROOM
(d) FURNACE BAY
(e) PUMP HOUSE
(f) RAW MATERIAL STORAGE AREA
(g) FINISH MATERIAL STORAGE AREA
(h) PACKING AREA
(i) LOADING AREA
(j) STORE ROOM
(k) OFFICE
(l) CONFERENCE ROOM
(m) CANTEEN
(n) OUTSIDE ROAD

5.1.1 UNIVERSAL FOIL MILL (ALUMINUM ROILLING MILL)

An area of 6 sq. Meter has been taken at Aluminium rolling mill (referred fig 5.1.1.b), to measure illuminance on the working plane. The measurement area has been divided in to six grid points at a distance of 1 meter, two in rows(i.e. 1,2) and distance of 1 meter in three columns (i.e. A,B,C). Two luminaries as shown in fig.5.1.1.a. has been observed at mounting height of 3 meter acting as primary light source and specification of these two light sources are given below. The average illuminance value has been calculated to be 325 lux by averaging illuminance value of all six grid points.

Table 5.1.1: Illuminance Measurements (in Lux) for Rolling Mill

Grid(1:1)M	A	B	C
1	330	315	352
2	320	308	330

Fig.5.1.1.a: Flame proof LED

- Specification of Lamp : 40 watt flame proof LED
  (Model: FLP INT. WELLGLASS **FWL1315-40-CDL**)
  Wattage: 40 W
  Rated Voltage: 150 -270 VAC,
  Frequency: 50 Hz
  CCT: 5000 K
  CRI: >70
  Make: CROMPTON
- No of luminaire : 2 PC
- Mounting Height: 3 Meter
- Area : 2 Meter X 3 Meter
- Average Illuminance : 325 Lux

Fig.:5.1.1.b: Aluminium Rolling Mill

5.1.2 ECR (ELECTRICAL CONTROL ROOM)

An area of 27 sq. Meter has been taken at Electrical Control Room (referred fig.5.1.2.b), to measure illuminance on the working plane. The measurement area has been divided into twelve grid points at a distance of 2 meter in four rows (i.e. 1,2,3,4) and distance of 2.25 meter in three columns(i.e. A,B,C). Six luminaries as shown in fig.5.1.2.a has been observed at mounting height of 3.5 meter acting as primary light source and specification of these six light sources are given below. The average illuminance value has been calculated to be 530 lux by averaging illuminance value of all twelve grid points.

Table 5.1.2: Illuminance Measurements (in Lux) for ECR

Grid(2:2.25) M	A	B	C
1	428	625	631
2	394	390	465
3	498	517	585
4	581	655	589

Fig.5.1.2.a. Square Shape LED

- Specification of Lamp : 36 watt 2 x 2 ft. square shape LED
  LED SLIM PANEL 36 W
  (Product Code: PCVP036C2018)
  Wattage: 36 W
  Rated Voltage: 220 V AC, 50 Hz
  CCT: 6500 K
  CRI: >80
  Make: MAGIK
- No of luminaire : 6 PC
- Mounting Height/ Suspension Height : 3.5 Meter , (1.5 Meter)
- Area : 6 Meter X 4.5 Meter
- Average Illuminance : 530 Lux

Fig: 5.1.2.b: Electrical Control Room

5.1.3 ELECTRICAL PANEL ROOM

An area of 16 sq. Meter has been taken at Electrical Panel Room (referred in fig 5.1.3.b), to measure illuminance on the working plane. The measurement area has been divided in to six grid points at a distance of 4 meter in three rows (i.e. 1,2,3) and distance of 1 meter in two columns(i.e. A,B). Eight luminaries as shown in fig.5.1.3.a has been observed at mounting height of 3 meter acting as primary light source and specification of these six light sources are given below. The average illuminance value has been calculated to be 172 lux by averaging illuminance value of all six grid points.

Table 5.1.3: Illuminance Measurements (in Lux) for Electrical Panel Room

Grid(4:1)M	A	B
1	243	198
2	180	140
3	125	151

- Specification of Lamp : 20 watt LED TUBE
  Cat. Ref.: LTT8-20
  Wattage: 20 W
  Rated Voltage: 220 V AC, 50 Hz
  CCT: 6500 K
  Rated Lumen: 2100 lm
  Make: Crompton
- No of luminaire : 8 pc
- Mounting Height : 3 Meter
- Area : 8 Meter X 2 Meter
- Average Illuminance : 172 Lux

Fig.5.1.3.a: Tube light

Fig: 5.1.3.b: Electrical Panel Room

5.1.4 FURNACE BAY

An area of 72 sq. Meter has been taken at Furnace Bay (referred in fig 5.1.4.a), to measure illuminance on the working plane. The measurement area has been divided in to eight grid points at a distance of 2 meter in two rows (i.e. 1,2) and distance of 4 meter in four columns (i.e. A,B,C,D). Twelve luminaries as shown in fig.5.1.4.a has been observed at mounting height of 13 meter acting as primary light source and specification of these light sources are given below. The average illuminance value has been calculated to be 274 lux by averaging illuminance value of all eight grid points.

Table 5.1.4: Illuminance Measurements (in Lux) for Furnace Bay

Grid(2:4)M	A	B	C	D
1	240	255	266	313
2	299	328	306	183

- Specification of Lamp : 200W Flood light LED,
  Model No.: LHB11-200-CDL/60-M,
  Wattage: 200 W
  Rated Voltage: 240 V AC, 50 Hz
  CCT: 6500 K
  CRI: >80
  Make: Crompton
  No of luminaire: 12 pc
- Mounting Height : 13 Meter
- Area : 6 Meter X 12 Meter
- Average Illuminance :274 Lux

Fig. 5.1.4.a: Flood LED

Fig.:5.1.4.b: Furnace Bay

5.1.5 PUMP HOUSE

An area of 96 sq. Meter has been taken at Pump House (referred in fig 5.1.5.b), to measure illuminance on the working plane. The measurement area has been divided in to twelve grid points at a distance of 4 meter in three rows (i.e. 1,2,3) and distance of 4 meter in four columns (i.e. A,B,C,D). Eight luminaries as shown in fig.5.1.5.a has been observed at mounting height of 3.25 meter acting as primary light source and specification of these light sources are shown below. The average illuminance value has been calculated to be 74 lux by averaging illuminance value of all twelve grid points.

Table 5.1.5: Illuminance Measurements (in Lux) for Pump House

Grid(4:4)M	A	B	C	D
1	88	94	79	59
2	77	75	62	40
3	79	92	80	60

- Specification of Lamp : 20 watt LED TUBE
  Cat. Ref.: LTT8-20
  Wattage: 20 W
  Rated Voltage: 220 V AC, 50 Hz
  CCT: 6500 K
  Rated Lumen: 2100 lm
  Make: Crompton
- No of luminaire : 8 pc
- Mounting Height : 3.25 Meter
- Area : 8 Meter X 12 Meter
- Average Illuminance : 74 Lux

Fig.5.1.5.a: Tube light

Fig .5.1.5.b: Pump House

5.1.6 RAW MATERIAL STORAGE AREA

An area of 128 sq. Meter has been taken at Raw Material Storage Area (referred in fig 5.1.6.b), to measure illuminance on the working plane. The measurement area has been divided in to twelve grid points at a distance of 4 meter in three rows (i.e. 1,2,3) and distance of 4 meter in four columns (i.e. A,B,C,D). Sixteen luminaries as shown in fig.5.1.6.a has been observed at mounting height of 13 meter acting as primary light source and specification of these light sources are given below. The average illuminance value has been calculated to be 172 lux by averaging illuminance value of all twelve grid points.

Table 5.1.6: Illuminance Measurements (in Lux) for Raw Material Storage Area

Grid(4:4)M	A	B	C	D
1	50	48	30	48
2	110	100	80	78
3	373	427	382	334

- Specification of Lamp : 200W Flood light LED,
  Model No.: LHB11-200-CDL/60-M,
  Wattage: 200 W
  Rated Voltage: 240 V AC, 50 Hz
  CCT: 6500 K
  CRI: >80
  Make: Crompton
- No of luminaire : 8 X 2 =16 PC
- Mounting Height : 13 Meter
- Area : 8 Meter X 16 Meter
- Average Illuminance : 172 lux

Fig. 5.1.6.a: Flood LED


Fig.:5.1.6.b: Raw Material Storage Area

5.1.7 FINISH MATERIAL STORAGE AREA

An area of 96 sq. Meter has been taken at Finish Material Storage Area (referred in fig 5.1.7.b), to measurement of illuminance on the working plane. The measurement area has been divided in to nine grid points at a distance of 4 meter, three in rows (i.e. 1,2,3) and distance of 4 meter, three in columns (i.e. A,B,C). .Twelve luminaries as shown in fig.5.1.7.a has been observed at mounting height of 13 meter acting as primary light source and specification of these light sources are shown below. The average illuminance value has been calculated to be 233 lux by averaging illuminance value of all nine grid points.

Table 5.1.7: Illuminance Measurements (in Lux) for Finish Material Storage Area

Grid(4:4)M	A	B	C
1	160	230	218
2	270	240	233
3	240	255	250

- Specification of Lamp : 200W Flood light LED,
  Model No.: LHB11-200-CDL/60-M,
  Wattage: 200 W
  Rated Voltage: 240 V AC, 50 hz
  CCT: 6500 K
  CRI: >80
  Make: Crompton
- No of luminaire :12 pc
- Mounting Height: 13 Meter
- Area : 8 Meter X 12 Meter
- Average Illuminance :233 lux

Fig. 5.1.7.a: Flood LED

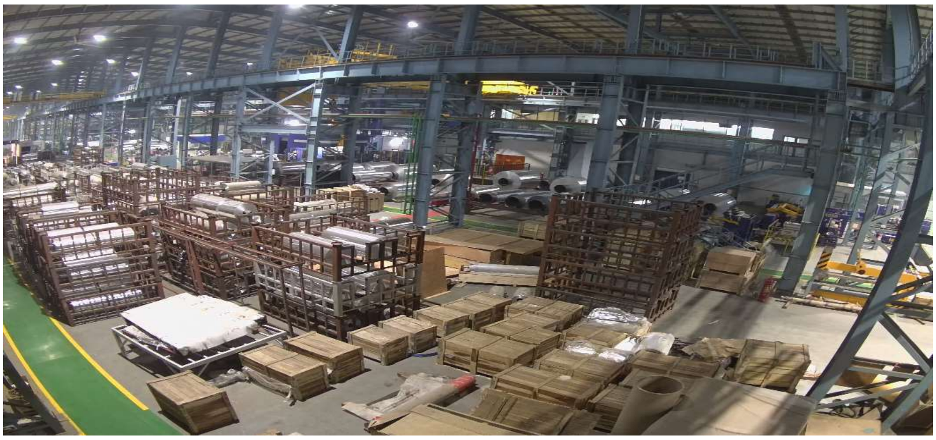

Fig.5.7.2: Finish Material Storage Area

5.1.8 PACKING AREA

An area of 96 sq. Meter has been taken at Packing Area (referred in fig 5.1.8.b), to measure of illuminance on the working plane. The measurement area has been divided in to eight grid points at a distance of 3 meter, two in rows (i.e. 1,2) and distance of 4 meter, four in columns (i.e. A,B,C,D).Twelve luminaries as shown in fig.5.1.8.a has been observed at mounting height of 13 meter acting as primary light source and specification of these light sources are shown below. The average illuminance value has been calculated to be 208 lux by averaging illuminance value of all eight grid points.

Table 5.1.8: Illuminance Measurements (in Lux) for Packing Area

Grid(3 : 4)M	A	B	C	D
1	140	173	260	245
2	221	183	140	303

- Specification of Lamp : 200W Flood light LED,
  Model No.: LHB11-200-CDL/60-M,
  Wattage: 200 W
  Rated Voltage: 240 V AC, 50 Hz
  CCT: 6500 K
  CRI: >80
  Make: Crompton

Fig. 5.1.8.a: Flood LED

- No of lamp/luminaire :12 PC
- Mounting Height:13 Meter
- Area : 8 Meter X 12 Meter
- Average Illuminance : 208 lux

Fig.5.1.8.b: Packing Area

5.1.9 LOADING AREA

An area of 96 sq. Meter has been taken at Loading Area (referred in fig 5.1.9.b), to measurement of illuminance on the working plane. The measurement area has been divided in to fifteen grid points at a distance of 4 meter, three in rows (i.e. 1,2,3) and distance of 3 meter, five in columns (i.e. A,B,C,D,E).Eight luminaries as shown in fig.5.1.9.a has been observed at mounting height of 10 meter acting as primary light source and specification of these light sources are given below. The average illuminance value has been calculated to be 345 lux by averaging illuminance value of all fifteen grid points.

Table 5.1.9: Illuminance Measurements (in Lux) for Loading Area

Grid(4:3)M	A	B	C	D	E
1	326	366	375	338	265
2	430	399	451	316	274
3	330	315	352	313	330

- Specification of Lamp :
  ZENITH PLUS LED FLOOD LIGHT
  (Product Code: FWZP200W0844)
  Wattage: 200 W
  Rated Voltage: 220 V AC, 50 Hz
  CCT: 3000 K
  Make: MAGIK
- No of lamp/luminaire : 8 pc
- Mounting Height : 10 Meter
- Area : 8 Meter X 12 Meter
- Average Illuminance : 345 lux

Fig.5.1.9.a: Flood LED

Fig.:5.1.9.b: Loading Area

5.1.10 STORE ROOM

An area of 20 sq. Meter has been taken at Store (referred in fig 5.1.10.b), to measure illuminance on the working plane. The measurement area has been divided in to twelve grid points at a distance of 2 meter, six in rows (i.e. 1,2,3,4,5,6) and distance of 1 meter, two in columns (i.e. A,B).Four luminaries as shown in fig.5.1.10.a has been observed at mounting height of 4 meter acting as primary light source and specification of these light sources are given below. The average illuminance value has been calculated to be 95 lux by averaging illuminance value of all twelve grid points.

Table 5.1.10: Illuminance Measurements (in Lux) for Store Room

Grid(2:1)M	A	B
1	85	90
2	108	88
3	116	98
4	120	101
5	94	80
6	75	88

- Specification of Lamp : 20 watt LED TUBE
  Cat. Ref.: LTT8-20
  Wattage: 20 W
  Rated Voltage: 220 V AC, 50: 50 Hz
  CCT: 6500 K
  Rated Lumen: 2100 lm
  Make: Crompton
- No of lamp/luminaire : 4 pc
- Mounting Height: 4 M
- Area : 10 X 2 M2
- Average Illuminance :95 Lux

Fig 5.1.10.a: Tube light

Fig.:5.1.10.b: Store

5.1.11 OFFICE

An area of 16 sq. Meter has been taken at office (referred in fig 5.1.11.b), to measure illuminance on the working plane. The measurement area has been divided in to four grid points at a distance of 2 meter, two in rows (i.e. 1,2) and distance of 2 meter, two in columns (i.e. A,B).Four luminaries as shown fig. 5.1.11.a. has been observed at mounting height of 2.5 meter acting as primary light source and specification of these light sources are given below. The average illuminance value has been calculated to be 1075 lux by averaging illuminance value of all four grid points.

Table 5.1.11.x: Illuminance Measurements (in Lux) for Office Desk

Grid (2:2)M	A	B
1	1340	1023
2	1309	1020

Table 5.1.11.y: Illuminance Measurements (in Lux) for Office

Grid (2:2)M	A	B
1	1001	980
2	975	950

- Specification of Lamp : 36 watt 2 x 2 ft. square shape LED
  LED SLIM PANEL 36 W
  (Product Code: PCVP036C2018
  Wattage: 36 W
  Rated Voltage: 220 V AC,
  Frequency: 50 Hz
  CCT: 6500 K
  CRI: >80
  Make: MAGIK

Fig.5.1.11.a: Square shape LED

- No of lamp/luminaire : 4 pc
- Mounting Height: 2.5 Meter
- Area : 4 Meter X 4 Meter
- Average Illuminance :1075 lux

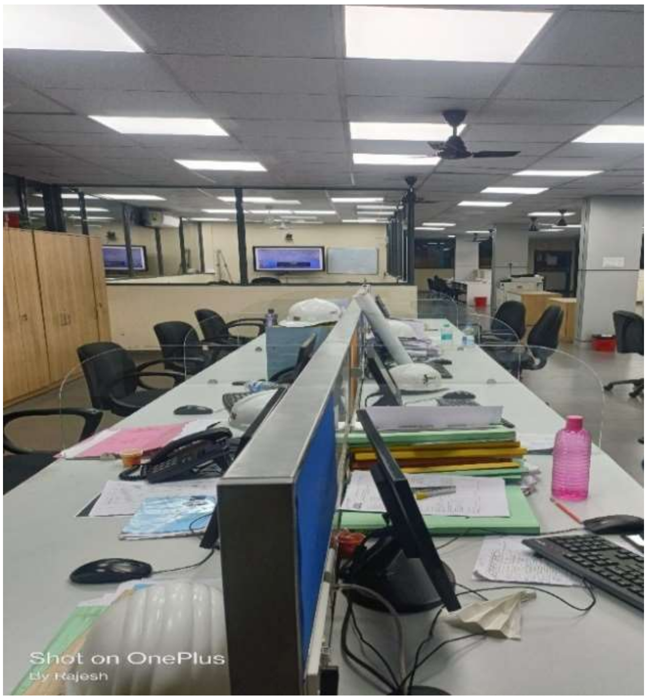

Fig.:5.1.11.b: Office

5.1.12 CONFERENCE ROOM

An area of 60 sq. Meter has been taken at Conference (referred in fig 5.1.12.b), to perform measurement of illuminance values. The measurement area has been divided in to five & ten grid points at a distance of 4 meter, three in rows (i.e. 1,2,3) and distance of 3 meter, two in columns (i.e. A,B,C) for conference room & points at a distance of 1 meter, six in rows (i.e. 1,2,3,4,5,6) and distance of 1 meter, three in columns (i.e. A,B,C) for conference room table. Nine luminaries as shown in fig.5.1.12.a has been observed at mounting height of 2.5 meter acting as primary light source and specification of these light sources are referred in fig. 5.1.12.a. The average illuminance value has been calculated to be 1164 lux by averaging illuminance value of all grid points.

Table 5.1.12.x: Illuminance Measurements (in Lux) for Conference Room

Grid(4:3)M	A	B	C
1	950	-	885
2	-	1500	-
3	980	-	800

Table 5.1.12.y: Illuminance Measurements (in Lux) for Conference Room (table)

Grid(1 X 1)M	A	B	C
1	-	1150	-
2	1150	-	1155
3	1500	-	1500
4	1217	-	1217
5	1150	-	1150
6	-	1155	-

- Specification of Lamp : 36 watt 2 x 2 ft. square shape LED
  LED SLIM PANEL 36 W
  (Product Code: PCVP036C2018
  Wattage: 36 W
  Rated Voltage: 220 V AC, 50 Hz
  CCT: 6500 K
  CRI: >80
  Make: MAGIK

Fig.5.1.12.a: Square shape LED

- No of lamp/luminaire : 9 PC
- Mounting Height: 2.5 Meter
- Area : 10 Meter X 6 Meter
- Average Illuminance :1164 lux

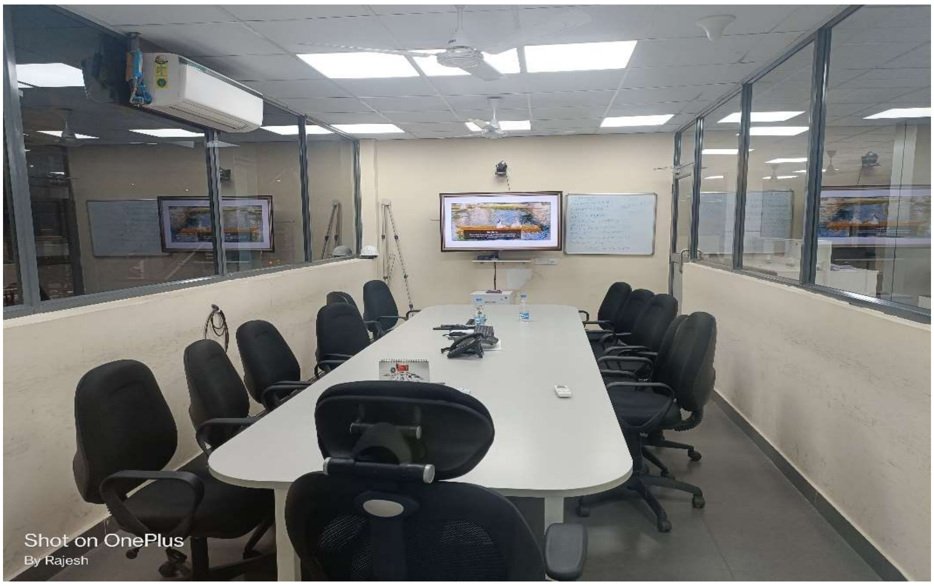

Fig 5.1.12.b: Conference Room

5.1.13 CANTEEN (TABLE)

An area of 8 sq. Meter has been taken at Canteen (referred in fig 5.1.13.b), to measure illuminance on the working plane.The measurement area has been divided in to four grid points at a distance of 1 meter, two in rows (i.e. 1,2) and distance of 2 meter, two in columns (i.e. A,B). Eight luminaries as shown in fig.5.1.13.a has been observed at mounting height of 4 meter acting as primary light source and specification of these light sources are given below. The average illuminance value has been calculated to be 80 lux by averaging illuminance value of all grid points.

Table 5.1.13: Illuminance Measurements (in Lux) for Canteen

Grid(1:2)M	A	B
1	72	80
2	94	75

- Specification of Lamp : 20 watt LED TUBE
  Cat. Ref.: LTT8-20
  Wattage: 20 W
  Rated Voltage: 220 V AC, 50 Hz
  CCT: 6500 K
  Rated Lumen: 2100 lm
  Make: Crompton
- No of lamp/luminaire : 8 pc
- Mounting Height :4 Meter
- Area 2 Meter X 4 Meter
- Average Illuminance : 80 lux

Fig 5.1.13.a: Tube light

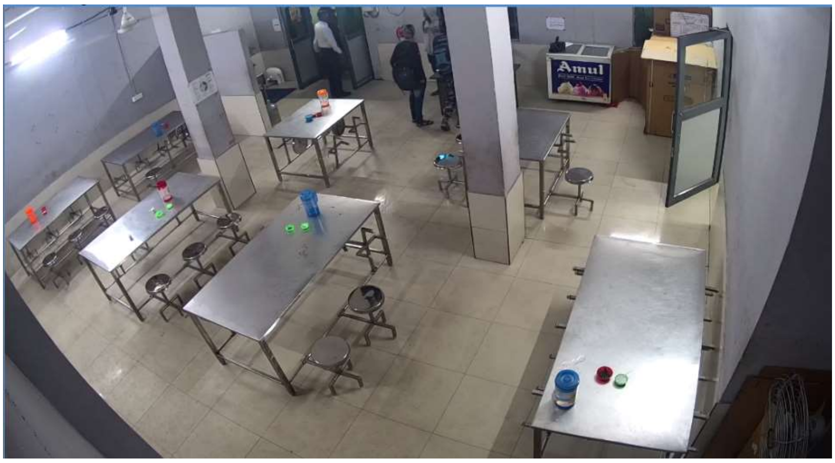

Fig. 5.1.13.b: Canteen

5.1.14 OUTSIDE ROAD

An area of 90 sq. Meter has been taken at Outside Road (referred in fig 5.1.14.b), to measurement of illuminance on the working plane. The measurement area has been divided into twelve grid points at a distance of 1 meter, six in rows (i.e. 1,2,3,4,5,6) and distance of 4 meter, two in columns (i.e. A,B). Two luminaries as shown in fig.5.1.14.a has been observed at mounting height of 3 meter acting as primary light source and specification of these light sources are given below. The average illuminance value has been calculated to be 165 lux by average illuminance value of all twenty four grid points.

Table 5.1.14: Illuminance Measurements (in Lux) for Outside Road

Grid (1: 4)	A	B
1	220	15
2	6	135
3	859	170
4	8	287
5	23	180
6	66	12

- Specification of Lamp :
  ZENITH PLUS LED FLOOD LIGHT
  (Product Code: FWZP200W0844
  Wattage: 200 W
  Rated Voltage: 220 V AC, 50 Hz
  CCT: 3000 K
  Make: MAGIK
- No of luminaire : 2 PC
- Mounting Height: 3 Meter
- Area : 10 Meter X 9 Meter
- Average Illuminance : 165 lux

Fig.5.1.14.a: Flood LED


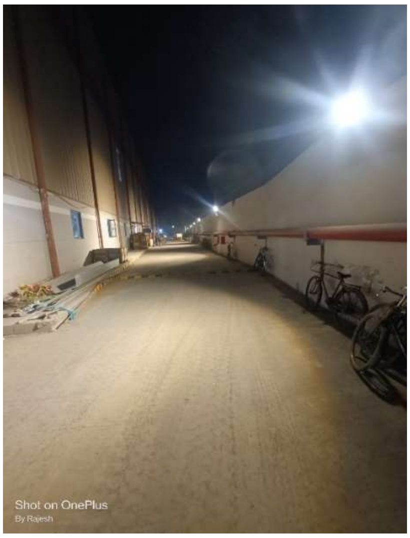

Fig .5.1.14.b: Outside Road

Out of the 14 areas of industry mentioned earlier, 11 areas conform to the standard average illuminanace, while three specific areas –Conference room, office, outside road experience high levels of light pollution in terms of both horizontal and vertical illuminance which is referred in table 5.1.15.

Table: 5.1.15. Average Horizontal & Vertical Illuminance data

Sl No	Area Name	Average. Horizontal Illuminance(Lux)	Average Vertical Illuminance (Lux)
1.	Office	1075	706
2.	Conference Room	1164	525
3.	Outside Road	165	221

5.2 GREEN ZONE

Green Zone lighting is eco-friendly or sustainable lighting, focuses on minimizing the environmental impact of artificial lighting while still meeting necessary illumination requirements .The main key objectives of green zone lighting is to reduce light pollution.

For Green Zone lighting measurements are done at Jadavpur University & Rajarhat Kolkata.

5.2.1 GREEN ZONE AT JADAVPUR UNIVERSITY

The measurement has been taken at Green Zone (Jadavpur university referred at fig.5.2.1), to measure illuminance values on the working plane.The four measurement values (distance of 5 Meter, two in row (i.e.1,2) are in the corner of the square shape green zone and one is at center. One luminaire has been observed at mounting height of 3 meter acting as primary light source .The average illuminance value has been calculated to be 19 lux by averaging illuminance value of all five grid points.

Table 5.2.1: Illuminance Measurements (in Lux) for Green Zone

Grid (5:5) M	A	B	C
1	34	-	12
2	-	19	-
3	22	-	7

- Specification of Lamp :
  LED FLOOD LIGHT
  Rated Voltage: 220 V AC, 50 Hz
  CCT: 3000 K
  Make: CROMPTON
- No of luminaire : 1 PC
- Mounting Height: 3 Meter.
- Area : 5 Meter X 5 Meter
- Average Illuminance : 19 lux

Fig.5.2.1: Green Zone

5.2.2 GREEN ZONE AT RAJARHAT

The measurement has been taken at Green Zone (Rajarhat referred at fig.5.2.2), to measure illuminance on the working plane.The measurement area(750 Sq. Meter) has been divided in to fifteen grid points at a distance of 7.5 meter, three in rows (i.e. 1,2,3) and distance of 12.5 meter, five in columns (i.e. A,B,C,D,E). Luminaries specification of these light sources are given below. The average illuminance value has been calculated to be 31 lux by averaging illuminance value of all fifteen grid point.

Table 5.2.2: Illuminance Measurements (in Lux) for Green Zone

Grid(7.5:12.5)M	A	B	C	D	E
1	45	15	26	28	20
2	28	8	10	56	33
3	60	30	40	38	30

Table 5.2.2: Specification of Lamp:

Sl No	Specification	QTY	Make
1	Profile light[3 x 2] both side	20	Unknown
2	10 watt bollard[LBLSN-10-CDL]	20	Crompton
3	Flood light 200 watt	3	Unknown

- Rated Voltage : 220 V , 50 Hz
- Area : 15 Meter X 50 Meter
- Average Illuminance : 31 lux

Fig.5.2.2 Green Zone

5.3 PUBLIC PLACE/ PARK

Public place lighting plays a crucial role in ensuring safety, security, and visibility in various outdoor settings such park, green zone, Amphitheater , stadium etc. It involves the strategic placement and design of lighting fixtures to illuminate public spaces during the night time or low light conditions.

The measurements are done at Rajarhat Smart city & Jadavpur University.

a. Road along green zone- Rajarhat smart city

b. Open Amphitheater - Rajarhat smart city

c. Common Area under Bridge - Rajarhat smart city

d. Public statue- Rajarhat

e. OAT – Jadavpur University

f. In front of Electrical Engineering Department.

5.3.1 ROAD ALONG GREEN ZONE- RAJARHAT SMART CITY

The measurement has been taken at Road along Green Zone (Rajarhat referred at fig.5.3.1), to measure illuminance on the working plane. Here the area of measurement is 4 Sq. Meter. The measurement area has been divided in to eight grid points at a distance of 1 meter, three in rows (i.e. 1,2,3) and distance of 1 meter, three in columns (i.e. A,B,C).Two luminaries has been observed to be acted as primary light source. The average illuminance value has been calculated to be 27 lux by averaging illuminance value of all eight grid points.

Table 5.2.2: Illuminance Measurements (in Lux) for Road along green zone.

Grid (1:1) M	A	B	C
1	24	37	17
2	38	-	22
3	19	36	20

Measurement of Light Pollution

- Specification of Lamp :
  Bollards, Voltage: 220 V AC,

- No of lamp/luminaire : 2 PC
- Mounting Height : 0.634 Meter
- Area : 2 Meter X 2 Meter
- Average Illuminance : 27 lux

Fig. 5.3.1: Road along Green Zone

5.3.2 OPEN AMPHITHEATER - RAJARHAT SMART CITY

The measurement has been taken at Open Amphitheater (Rajarhat referred at fig.5.3.2), to measure illuminance on the working plane. Here the area of measurement is 128 Sq. Meter. The measurement area has been divided in to nine grid points at a distance of 4 meter, three in rows (i.e. 1,2,3) and distance of 8 meter, three in columns (i.e. A,B,C).Forty-two luminaries has been observed to be acted as primary light source. The average illuminance value has been calculated to be 234 lux by averaging illuminance value of all nine grid points.

Table 5.3.2: Illuminance Measurements (in Lux) for Open Amphitheater

Grid (4: 8)M	A	B	C
1	173	318	176
2	172	413	161
3	204	314	178

- Specification of Lamp :
  Strip-light, Voltage: 220 V AC,

- No of lamp/luminaire : 28 pc strip-light : length(4Meter)
  & 14 pc strip-light : length(3 Meter)
- Area : 8 Meter X 16 Meter
- Average Illuminance : 234 lux

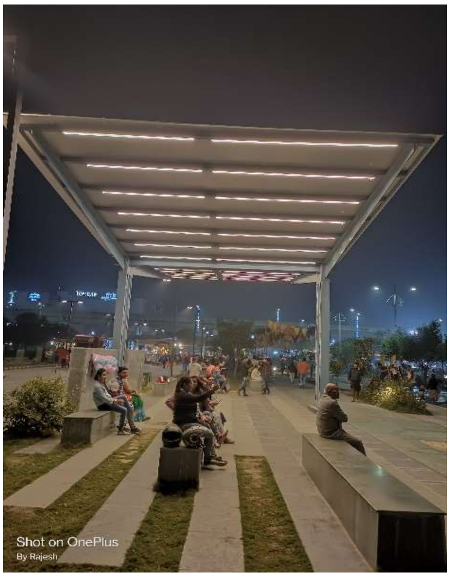

Fig. : 5.3.2: Open Amphitheater

5.3.3 COMMON SITTING AREA UNDER BRIDGE - RAJARHAT

The measurement has been taken at Common sitting under bridge (Rajarhat referred at fig.5.3.3), to perform measurement of illuminance values. Here the area of measurement is 12 Sq. Meter. The measurement area has been divided in to twelve grid points at a distance of 1 meter, three in rows (i.e. 1,2,3) and distance of 2 meter, four in columns (i.e. A,B,C,D). Two luminaries has been observed to be acted as primary light source. The average illuminance value has been calculated to be 385 lux by averaging illuminance value of all nine grid points.

Table 5.3.3: Illuminance Measurements (in Lux) for Common Area under Bridge

Grid (1: 2)M	A	B	C	D
1	150	352	832	532
2	154	362	403	390
3	149	301	652	348

- Specification of Lamp :
  Flood LED light, 80 watt, Voltage: 220 V AC,
  Make: Magik
- Area : 2 Meter X 6 Meter
- Average Illuminance : 385 lux

Fig.: 5.3.3: Common Area under Bridge

5.3.4 PUBLIC STATUE- RAJARHAT

The measurement has been taken at Public statue (Rajarhat referred at fig.5.3.4), to perform measurement of illuminance values. Here the area of measurement is 12 Sq. Meter. Both horizontal & vertical illuminance measurement are done.Four luminaries has been observed to be acted as primary light source.The average illuminance value has been calculated to be 213 lux by averaging illuminance value of all nine grid points.

Table 5.3.4: Illuminance Measurements (in Lux) for Public Statue- Rajarhat

Grid	1(Face)	2(Right)	3(Back)	4(Left)
1(vertical)	940	280	25	25
2(vertical)	230	75	75	55
3(Horizontal)	30	32	32	12

- Specification of Lamp :
  Flood LED light, 150 watt, Voltage: 220 V AC,
  Make: Isolite
- No of luminaire : 4 PC
- Average Illuminance : 213 lux

Fig.5.3.4: Public Statue

5.3.5 OAT – JADAVPUR UNIVERSITY

The measurement has been taken at OAT (Jadavpur University referred at fig.5.3.5), to perform measurement of illuminance values. Here the area of measurement is 360 Sq. Meter. The measurement area has been divided in to nine grid points at a distance of 9 meter, three in rows (i.e. 1,2,3) and distance of 10 meter, three in columns (i.e. A,B,C).Thirty luminaries has been observed to be acted as primary light source. The average illuminance value has been calculated to be 318 lux by averaging illuminance value of all nine grid points.

Table 5.3.5: Illuminance Measurements (in Lux) for OAT-Jadavpur University

Grid (9: 10)M	A	B	C
1	227	358	350
2	204	454	406
3	139	374	342

- Specification of Lamp :
  Square shape light (consist of 4 tube), Voltage: 220 V AC,
  Make: Philips
- No of luminaire : 6 x 5 =30 PC
- Area : 18 Meter x 20 Meter
- Average Illuminance : 318 lux

Fig. 5.3.5: OAT at Jadavpur University

5.3.6 IN FRONT ELECTRICAL ENGINEERING DEPARTMENT AT JADAVPUR UNIVERSITY

The measurement has been taken at In-front of Electrical Engineering Department (Jadavpur University referred at fig.5.3.6), to perform measurement of illuminance values. Here the area of measurement is 12 Sq. Meter. The measurement area has been divided in to six grid points at a distance of 2 meter, two in rows (i.e. 1,2) and distance of 3 meter, three in columns (i.e. A,B,C).One luminaire has been observed to acting as primary light source. The average illuminance value has been calculated to be 106 lux by averaging illuminance value of all six grid points.

Table 5.3.6: Illuminance Measurements (in Lux) for In front of Electrical Engineering Department.

Grid (2: 3)M	A	B	C
1	39	358	37
2	57	98	51

- Specification of Lamp :
  Tube light, 220v, 50 Hz
- No of luminaire : 1 PC
- Area : 2 Meter x 6 Meter
- Average Illuminance : 106 lux

Fig.5.3.6: In-front of Electrical Engineering Department

5.4 PARKING AREA

Parking Lighting refers to the lighting fixtures and systems used to illuminate parking areas such as parking lots, parking garage and car park. These lights are typically installed to provide visibility, enhance safety and ensure proper navigation for both drivers and pedestrians in parking facilities.

The measurements are:

a. Parking strip area with one side Road -1

b. Parking Strip area with one side Road – 2

c. Car Parking Area with One High Mast

5.4.1 PARKING STRIP AREA WITH ONE SIDE ROAD -1

A long parking strip with walking area on one side and Parking on the other side(referred in fig 5.4.1).The Area of parking Strip is 42 Sq. Meter and walking strip area is 60 Sq. Meter.The measurement area(Parking Strip) has been divided in to nine grid points at a distance of 2.1 meter, three in rows (i.e. 1,2,3) and distance of 5 meter, three in columns (i.e. A,B,C).
The measurement area(walking Strip) has been divided in to nine grid points at a distance of 5 meter, three in rows (i.e. 1,2,3) and distance of 3 meter, three in columns (i.e. A,B,C). The average illuminance value has been calculated to be 72 lux & 86 lux by averaging illuminance value for Parking strip and walking strip respectively.

Table 5.4.1: Illuminance Measurements (in Lux) for parking & walking strip

Parking Strip: (4.2 Meter X 10 Meter)

Grid (2.1: 5)M	A	B	C
1	65	77	66
2	85	105	88
3	44	60	64

Walking Strip :(10 Meter x 6 Meter)

Grid (5:3)M	A	B	C
1	65	64	52
2	82	114	119
3	76	98	110

- Specification of Lamp :
  LED light (Both Side double sided luminaire – 2 Luminaire each)
- No of luminaire : 2PC
- Pole to pole distance : 7 Meter
- Length of Stretch : 1.5 KM
- Average Illuminance(Parking Strip) : 72 lux
- Average Illuminance(Walking Strip): 86 lux

Fig. 5.4.1 Parking strip area with one side Road -1

5.4.2 PARKING STRIP AREA WITH ONE SIDE ROAD -2

The measurement has been taken a long parking strip with walking area on one side and Parking on the other side referred in fig 5.4.2.The Area of parking Strip is 50 Sq. Meter. The measurement area(Parking Strip) has been divided in to nine grid points at a distance of 5 meter, three in rows (i.e. 1,2,3) and distance of 2.5

meter, three in columns (i.e. A,B,C) The average illuminance value has been calculated to be 60 lux by averaging illuminance value of all nine grid points.

Table 5.4.2: Illuminance Measurements (in Lux)

Parking Strip: (10 Meter X 5 Meter) for parking strip.

Grid (5:2.5) M	A	B	C
1	45	55	56
2	59	76	96
3	45	60	54

- Specification of Lamp : LED light (Both Side double sided luminaire – 2 Luminaire each)
- No of lamp/luminaire : 2PC
- Pole to pole distance : 7 Meter
- Length of Stretch : 1.5 KM
- Average Illuminance: 60 lux

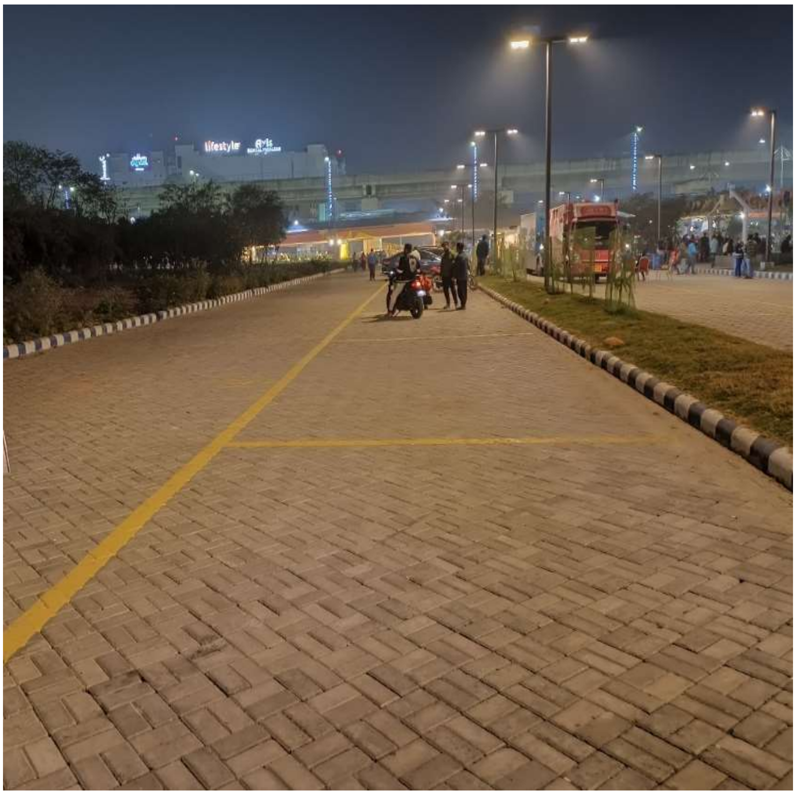

Fig. 5.4.2 Parking strip area with one side Road -2

5.4.3 CAR PARKING AREA WITH ONE HIGH MAST

The measurement has been taken for an outdoor Parking Lot (referred in fig 5.4.3) with one High Mast installed in the middle with six luminaires. Calculations were taken with on all side 10m away from the mast (i.e.1,2,3,4). The illuminance values are referred in table 5.4.3 and other details are discussed below.

Table 5.4.3: Illuminance Measurements (in Lux)

Grid	1	2	3	4
1(From Mast 10 M)	288	254	320	333

- Average Illuminance: 299 lux
- Specification of Lamp : Flood LED (specification : Unknown)
- No of lamp/luminaire : 6PC

Fig. 5.4.3 Car Parking Area with One High Mast

Out of the three car parking area mentioned earlier, two areas conform to the standard average illuminanace,but one car parking area(with one high mast) light pollution is noticeable in terms of both horizontal and vertical illuminance which is referred in table 5.4.4.

Table 5.4.4: Average Horizontal & Vertical Illuminance data

Sl No	Area Name	Average Horizontal Illuminance(Lux)	Average Vertical Illuminance (Lux)
1.	Car Parking with one high mast	299	120

5.5 ROADWAY

Roadway lighting refers to the illumination provided along roads, streets, highways and other transportation routes to enhance visibility and safety for motorists and pedestrians during night time or low light conditions .Roadway lighting plays a crucial role in improving visibility, reducing accident and creating a comfortable environment for driver and pedestrians.

These are the measurements area:

a. One Side Road with side walking & cycling
b. Road (one side parking & other side shop)
c. Footpath, cycle way, Service Road
d. One Road lane with Smart-automatic Street light

5.5.1 ONE SIDE ROAD WITH SIDE WALKING & CYCLING

The measurement has been taken on road (One Side Road with side walking & cycling at Rajarhat referred at fig.5.5.1), to perform measurement of illuminance values. Here the area of measurement is 150 Sq. Meter. The measurement area has been divided in to eighteen grid points at a distance of 5 meter, three in rows (i.e. 1,2,3) and distance of 3 meter, six in columns (i.e. A,B,C,D,E,F). Four luminaries has been observed at acting as primary light source.The average illuminance value has been calculated to be 184 lux by average illuminance value of all eighteen grid points.

Table 5.5.1: Illuminance Measurements (in Lux) for Roadway

Grid (5:3) M	A	B	C	D	E	F
1	160	244	110	110	230	130
2	197	252	78	148	250	176
3	257	238	58	185	266	226

- Specification of Lamp : 220 volt (Unknown)(make : Crompton)
- No of lamp/luminaire : 4 PC (2 side arrangement)
- Pole to pole distance : 15 Meter
- Pole Height : 9 Meter
- Area : 10 Meter X 15 Meter
- Average Illuminance: 184 lux

Fig.5.5.1 One Side Road with side walking & cycling

5.5.2 ROAD (ONE SIDE PARKING & OTHER SIDE SHOP)

The measurement has been taken on road (One Side Road with side parking & one side shop at Rajarhat referred at fig.5.5.2), to perform measurement of illuminance values. Here the area of measurement is 200 Sq. Meter.The measurement area has been divided in to twelve grid points at a distance of 3 meter, four in rows (i.e. 1,2,3,4) and distance of 10 meter, three in columns (i.e. A,B,C). Two luminaries has been observed at acting as primary light source.The average illuminance value has been calculated to be 80 lux by average illuminance value of all twelve grid points.

Table 5.5.2: Illuminance Measurements (in Lux) for Roadway

Grid (3:10)M	A	B	C
1	54	49	45
2	71	73	76
3	110	88	82
4	125	96	94

- Specification of Lamp: 220 volt. (Unknown)
- No of lamp/luminaire : (1 side arrangement)
- Pole to pole distance : 23 Meter
- Pole Height : 9 Meter
- Area : 10 Meter X 20 Meter
- Average Illuminance: 80 lux

Fig.: 5.5.2 Road (one side parking & other side shop)

5.5.3 FOOTPATH, CYCLE WAY, SERVICE ROAD

The measurement has been taken on road (Footpath, cycle way & service road at Rajarhat referred at fig.5.5.3), to perform measurement of illuminance values. Two luminaries has been observed at acting as primary light source.
The measurement area(Footpath) has been divided in to twenty one grid points at a distance of 1 meter, three in rows (i.e. 1,2,3) and distance of 3 meter, seven in columns (i.e. A,B,C,D,E,F,G).The average illuminance value has been calculated to be 49 lux by average illuminance value of all grid points.
The measurement area(Footpath) has been divided in to thrity grid points at a distance of 1 meter, five in rows (i.e. 1,2,3,4,5) and distance of 4 meter, six in columns (i.e. A,B,C,D,E,F).The average illuminance value has been calculated to be 59 lux by average illuminance value of all grid points.
The measurement area(Footpath) has been divided in to twelve grid points at a distance of 3 meter, three in rows (i.e. 1,2,3) and distance of 5 meter, four in columns (i.e. A,B,C,D).The average illuminance value has been calculated to be 60 lux by average illuminance value of all grid points.

Table 5.5.3.a: Illuminance Measurements (in Lux)

Footpath [2 Meter X 18 Meter]

Grid (1:3)M	A	B	C	D	E	F	G
1	73	58	19	15	18	23	52
2	94	94	86	72	60	75	82
3	75	45	19	9	8	21	40

Table 5.5.3.c: Cycle way [4 Meter X 20 Meter]

Grid (1:4)M	A	B	C	D	E	F
1	77	59	60	56	76	76
2	105	64	62	34	42	45
3	85	33	36	48	45	85
4	60	33	36	48	45	85
5	80	45	52	52	71	90

Table 5.5.3.c: Service Road [6 Meter X 15 Meter]

Grid (3:5)M	A	B	C	D
1	50	52	44	62
2	67	56	54	73
3	62	58	68	78

- Specification of Lamp : Unknown
- No of lamp/luminaire : (2 side arrangement)
- Pole to pole distance : 25 Meter
- Pole Height : 11 Meter
- Average Illuminance(Foot Path): 49 lux
- Average Illuminance(Cycle way): 59 lux
- Average Illuminance(Service Road): 60 lux

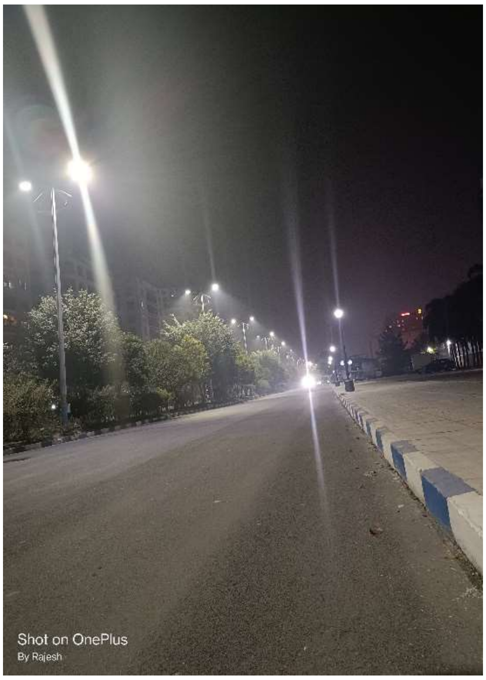

Fig .5.5.3: Footpath, cycle way, Service Road

5.5.4 ONE ROAD LANE WITH SMART-AUTOMATIC STREET LIGHT

The measurement has been taken on road (Smart automatic street light at Rajarhat referred at fig.5.5.4), to perform measurement of illuminance values. The measurement area has been divided in to nine grid points at a distance of 7 meter, three in rows (i.e. 1,2,3) and distance of 10 meter, three in columns (i.e. A,B,C).The average illuminance value has been calculated to be 41 lux by average illuminance value of all nine grid points.

Table 5.5.4: Illuminance Measurements (in Lux) for roadway

Grid (7:10)M	A	B	C
1	46	32	79
2	40	44	67
3	21	16	25

- Specification of Lamp : 220 volt (Make-Unknown)
- No of lamp/luminaire : (1 side arrangement)
- Pole to pole distance : 23 Meter
- Pole Height : 13 Meter
- Area : 14 Meter X 20 Meter
- Average Illuminance: 41 lux

Fig. 5.5.4 One Road lane with Smart-automatic Street light

From the table 5.5.5 data, both horizontal illuminance and vertical illuminance level indicate that light pollution occurring at the respective place.

Table: 5.5.5 Average Horizontal & Vertical Illuminance data

Sl No	Area Name	Average Horizontal Illuminance(Lux)	Average Vertical Illuminance (Lux)
1.	One side Road with side walking and & cycling	184	68

CHAPTER: 6

RESULT ANALYSIS

6.1 SUMMARY REPORT

This summary report provides a concise overview of the required average illuminance level and existing illuminance level. The comparative study for different measurement area are describe in table 6.1.

Table 6.1: Comparative study for different measurement Area.

Different Zone	Area Name	E Max (in lux)	E Min (in lux)	E Avg (in lux)	U= E_{Min} / E_{Avg}	Required E_{Avg} (in lux)
Industrial Area	Universal Foil Mill	352	308	325	0.95	300
	ECR Room	655	390	530	0.74	500
	Electrical Panel Room	243	125	172	0.73	150
	Furnace Bay	328	183	274	0.67	200
	Pump House	94	40	74	0.54	100
	Raw Material Storage Area	427	30	172	0.17	200
	Finish Material Storage Area	270	160	233	0.69	200
	Packing Area	303	140	208	0.67	200
	Loading & Dispatch Area	451	265	345	0.77	300
	Store	120	75	95	0.79	100
	Office	1340	950	1075	0.88	750
	Conference Room	1500	800	1164	0.69	750
	Canteen	94	72	80	0.90	150
	Outside Road	859	6	165	0.04	20
Green Zone	Green zone at Rajarhat	60	8	31	0.26	20
	Green zone at Jadavpur University	34	7	19	0.37	20
Public Park / Place	Road Along Green zone	38	17	27	0.63	20
	Open Amphitheater	413	161	234	0.69	20
	Common Sitting area under bridge	652	149	385	0.39	200
	OAT at Jadavpur University	454	139	318	0.44	300
	In front of Electrical Engineering Department	358	37	106	0.35	100

Different Zone	Area Name	E Max (in lux)	E Min (in lux)	E Avg (in lux)	U= E_{Min} / E_{Avg}	Required E_{Avg} (in lux)
Parking Area	Parking Strip with one side road -1	105	44	72	0.61	70
	Parking Strip with one side road -2	96	45	60	0.75	70
	Car Parking with one high Mast	333	254	299	0.85	70
Different Roadway	One Side Road with side walking & cycling	266	58	184	0.32	30
	Road (one side parking & other side shop)	125	45	80	0.56	30
	Footpath	94	8	49	0.16	30
	Cycle way	105	33	59	0.56	30
	Service Road	78	44	60	0.73	30
	One Road lane with Smart-automatic street light	79	16	41	0.39	30

6.2 RESULT ANALYSIS

The analysis described in the thesis focuses on assessing light pollution by examining the average illumination and uniformity of light in a specific study area. The following steps are followed to perform the analysis:

- Defining the Study Area:

The study area is selected based on specific regions or locations, such as industrial areas, green zones, public places, parking areas, and different roadways. This step helps to narrow down the focus of the analysis.

- Obtaining Light Pollution Data:

Information about the lighting conditions in the study area is gathered. This can be done using various sources such as light pollution maps, satellite imagery, or lux meters. The data collected should include measurements of average illumination levels and uniformity.

- Calculating Average Illumination:

Multiple points within the study area are selected to measure the illuminance level. The average illuminance is calculated by summing up all the measurements and dividing the sum by the total number of points. It is important to choose a small grid size to obtain more accurate results.

- Assessing Uniformity:

To assess uniformity, the illuminance levels at different locations within the study area are compared. If there is a significant variation in illuminance levels, it indicates non-uniform lighting and potential light pollution hotspots. Both the average illuminance and minimum illuminance can be used to determine the overall uniformity.

- Creating Visual Representation:

The measurement data collected is used to create a graph that visually represents the average illumination across the study area. Different color-coding techniques can be employed to represent different levels of average illumination. This graph provides a clear visual representation of the distribution of light pollution in the study area.

- Analysing the Result:

The graph illustrating the average illumination is analysed to identify areas with high levels of illumination. The focus should be on regions where the average illuminance is elevated and there is a lack of uniformity in lighting. This analysis helps in identifying specific areas that require attention regarding light pollution mitigation.

- Comparing with Standards:

To evaluate the results of light pollution analysis, it is essential to compare the data with relevant standards or guidelines. In this case, the analysis considers only the average illuminance and overall uniformity. By comparing the obtained data with standard average illuminance levels, it becomes possible to determine if the study area complies with recommended guidelines or if corrective measures need to be taken.

6.2.1 Comparison of Illuminace in Industrial Area

This graphical representation is for Aluminium Foil Industry where the average Illuminance measured(referred in chapter 5.1) at difference places like Universal Foil Mill ,ECR Room, Panel Room, Pump House, Furnace Bay, different storage area, store ,office, canteen, out-side road etc. referred in figure 6.2.1

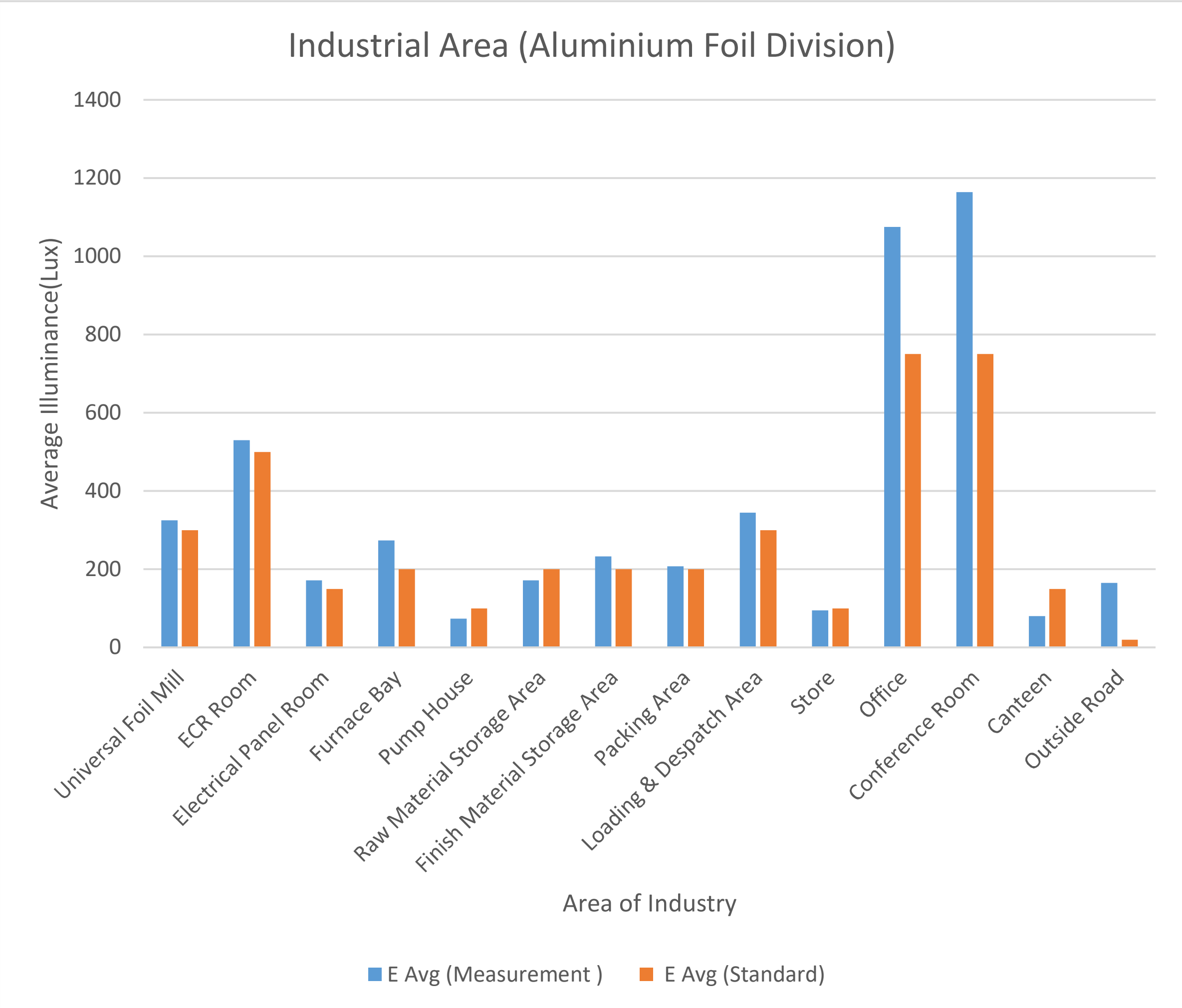

Fig.6.2.1: comparison of average illuminance at different place of Industrial area.

Average Horizontal & vertical illuminance value at office, conference room and outside road have been referred in table 5.1.15 which is clearly justifying that light pollution is occurring at those places.

6.2.2 Comparison of Illuminace in Green Zone

This is the representation of Green Zone lighting measured at Rajarhat and Jadavpur University.It is important to note that the specific lighting analysis for a particular green zone would require a detailed assessment considering factors like local environment goals of the space and user requirements.

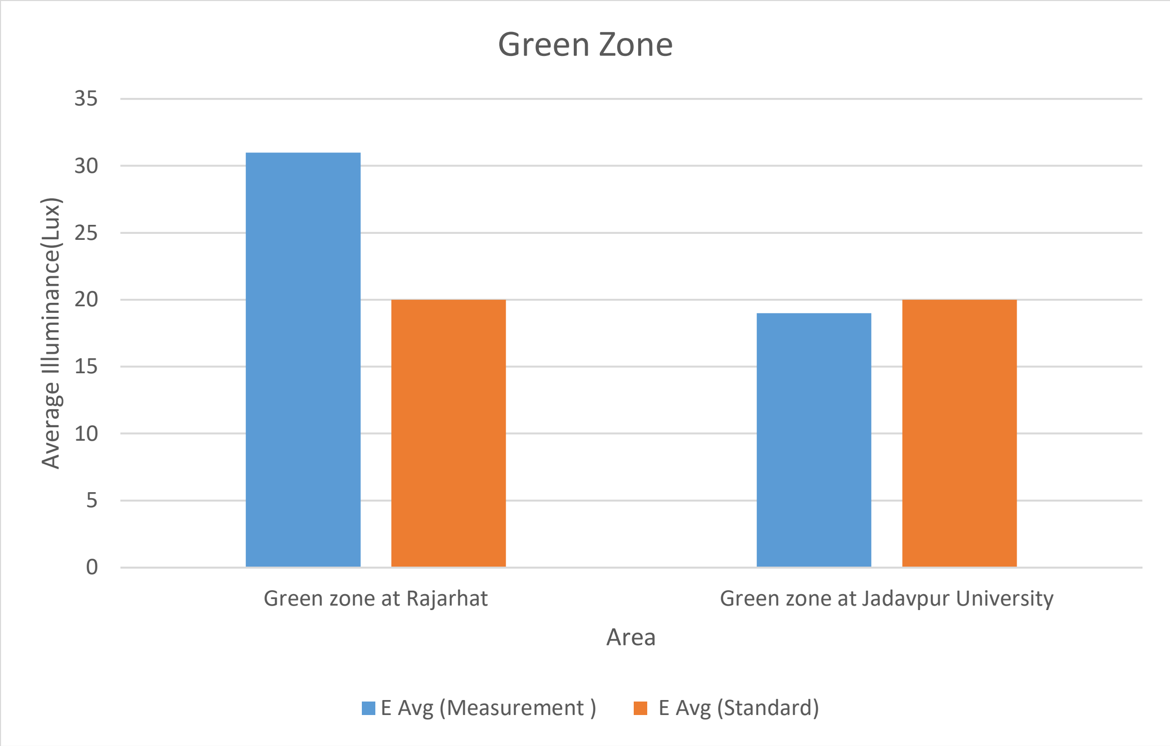

Fig .6.2.2: comparison of average illuminance at different green zone

From this representation which is referred in figure 6.2.2, it has observed the comparison between measured average Illuminance and Standard average Illuminance. As per standard the result can be accepted.

6.2.3 Comparison of Illuminace in Public Place / Park

The analysis of lighting in public places or park involve evaluating the effectiveness ,safety, energy efficiency and aesthetics of lighting installations .The main key aspect that are typically considered during such an analysis like Illuminance level and overall Uniformity.

The Measurement are done at Rajarhat and Jadavpur University area. The comparison of Measurement average Illuminance and Standard average Illuminance is referred in figure 6.2.3.

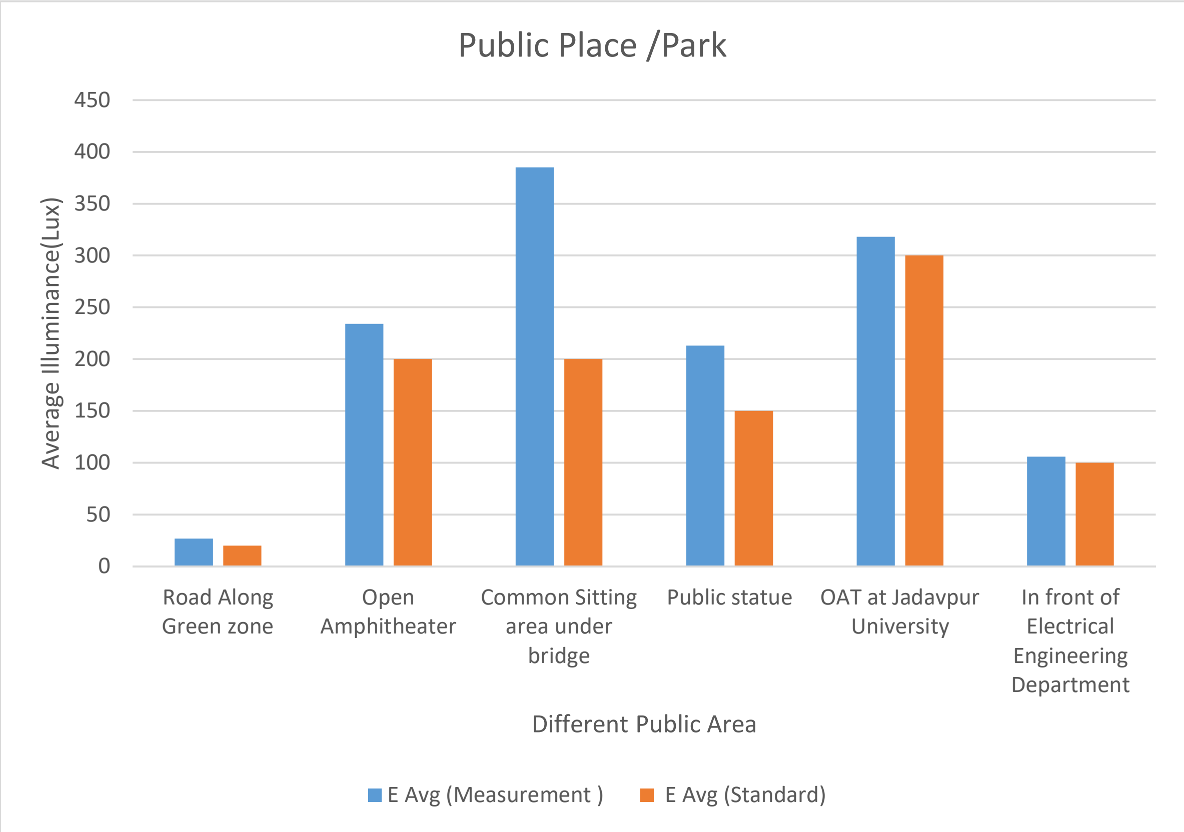

Fig .6.2.3: comparison of average illuminance at different Public Park or places

From this representation it is observed that common sitting area under Bridge is higher average Illuminance as compared to standard. But it can accept because of types. It can be consider as indoor type common space. And other area measurement result can be accepted.

6.2.4 Comparison of Illuminace in Parking Area

The analysis of lighting in parking area involves assessing various factor related to visibility, safety, energy efficiency and user experience. The main key aspect that are typically considered during such an analysis like Illuminance level and overall Uniformity.

This is the representation of different parking area lighting measured at Rajarhat.

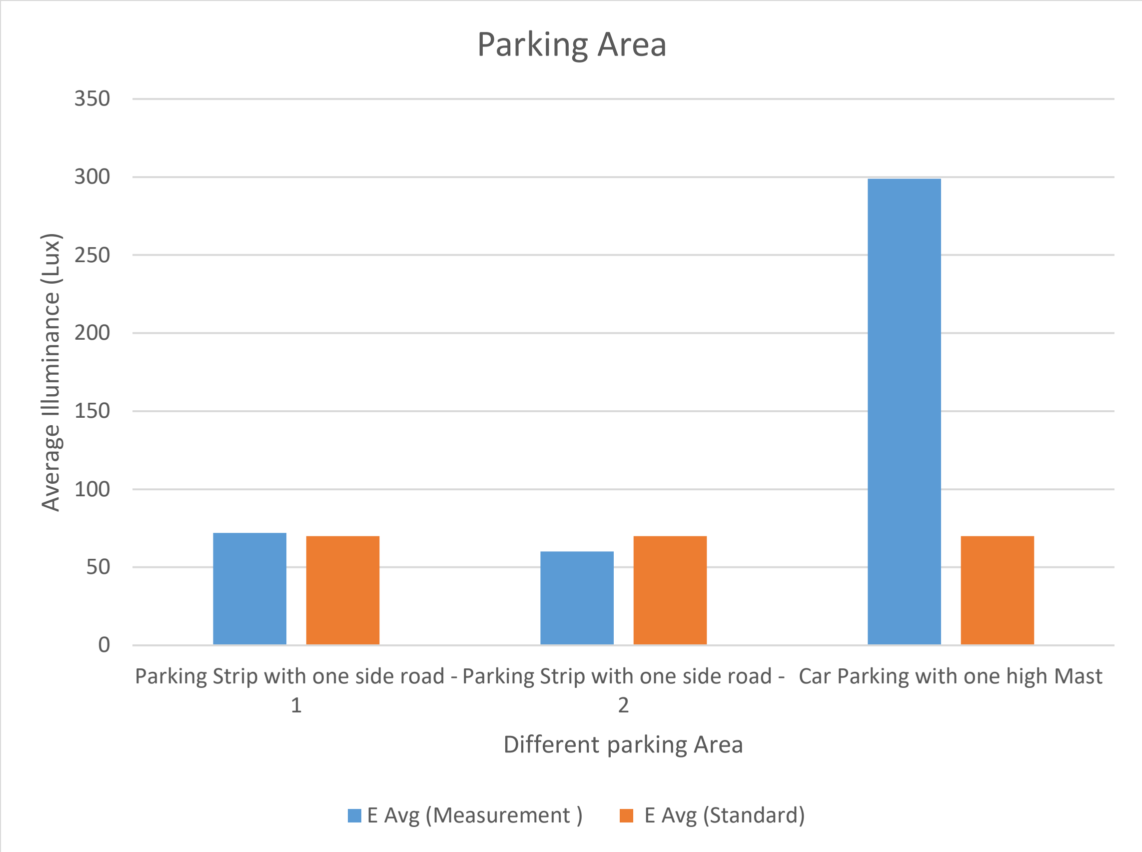

Fig .6.2.4: comparison of average illuminance at different parking area.

From this representation it is observed that car parking with one high mast is higher average Illuminance as compared to standard which is referred in figure 6.2.4. The average Illuminance value is noticeable for car parking with one high mast area and other area measurement result can be accepted.

6.2.5 Comparison of Illuminace in Public Place / Park

The Analyzing roadway lighting involves evaluating various aspects related to visibility, safety, energy efficiency and compliance with lighting standard. The main key factor average Illuminance is typically considered in result analysis.

This is the representation of different road area lighting measured at Rajarhat.

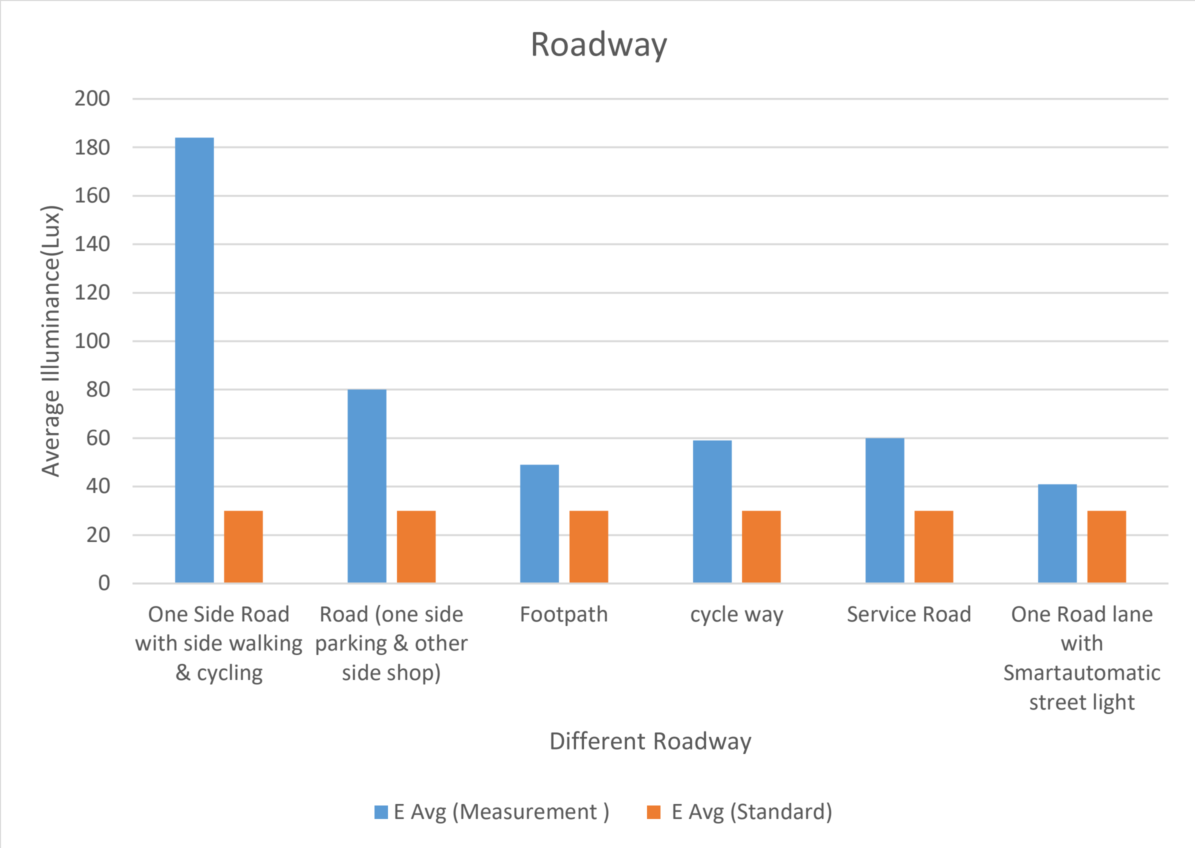

Fig .6.2.5: comparison of average illuminance at different roadway.

From this representation it is understand that average Illuminance for different kind of road and except one road with side walking & cycling area light can be accepted. The average illuminance level of one road with side walking & cycling area is higher than standard.

Overall, this step-by-step guide provides a systematic approach to analysing light pollution by assessing average illumination and uniformity, visualizing the data, and comparing it with relevant standards. This analysis can help identify areas of concern and guide efforts to mitigate light pollution for the benefit of human health, wildlife, and ecosystems.
By analyse the light pollution results using the CIE lighting zone system, it would typically compared the measured values of sky brightness and colour temperature against the defined thresholds for each zone .Based on the measurement result it can determine the appropriate lighting zone for the area.

A. Industrial area : En 3(zone 3) referred in table 6.2.1
B. Green zone : En1 (zone :1) referred in table 6.2.2
C. Public park /place : En 2 & En 3(zone 2,3) referred in table 6.2.3
D. Parking Area : En 2(zone 2) referred in table 6.2.4
E. Different Roadway : En4 (zone 4) referred in table 6.2.5

Table 6.2.1: CIE lighting zone for Industrial Area

Sl. No	Area Name	E_{avg} (in lux)	Lighting Zone (CIE)
1	Universal Foil Mill	325	En 3 (zone 3)
2	ECR Room	530	En 3 (zone 3)
3	Electrical Panel Room	172	En 3 (zone 3)
4	Furnace Bay	274	En 3 (zone 3)
5	Pump House	74	En 3 (zone 3)
6	Raw Material Storage Area	172	En 3 (zone 3)
7	Finish Material Storage Area	233	En 3 (zone 3)
8	Packing Area	208	En 3 (zone 3)
9	Loading & Dispatch Area	345	En 3 (zone 3)
10	Store	95	En 3 (zone 3)
11	Office	1075	Light Pollution
12	Conference Room	1164	Light Pollution
13	Canteen	80	En 3 (zone 3)
14	Outside Road	165	Light Pollution

Table 6.2.2: CIE lighting zone for Green Zone

Sl. No	Area Name	E_{avg} (in lux)	Lighting Zone (CIE)
1	Green zone at Rajarhat	31	En1 (zone 1)
2	Green zone at Jadavpur University	19	En1 (zone 1)

Table 6.2.3: CIE lighting zone for Public Park / Place

Sl. No	Area Name	E_{avg} (in lux)	Lighting Zone (CIE)
1	Road Along Green zone	27	En2 (zone 2)
2	Open Amphitheater	234	En3 (zone 3)
3	Common Sitting area under bridge	385	En3 (zone 3)
4	Public statue	213	En3 (zone 3)
5	OAT at Jadavpur University	318	En3 (zone 3)
6	In front of Electrical Engineering Department	106	En2 (zone 2)

Table 6.2.4: CIE lighting zone for Parking Area

Sl. No	Area Name	E_{avg} (in lux)	Lighting Zone (CIE)
1	Parking Strip with one side road -1	72	En2 (zone 2)
2	Parking Strip with one side road -2	60	En2 (zone 2)
3	Car Parking with one high Mast	299	Light Pollution

Table 6.2.5: CIE lighting zone for Different Roadway

Sl. No	Area Name	E_{avg} (in lux)	Lighting Zone (CIE)
1	One Side Road with side walking & cycling	184	Light Pollution
2	Road (one side parking & other side shop)	80	En4 (zone 4)
3	Footpath	49	En4 (zone 4)
4	Cycle way	59	En4 (zone 4)
5	Service Road	60	En4 (zone 4)
6	One Road lane with Smart-automatic street light	41	En4 (zone 4)

The table (referred in Table :6.2.1,6.2.2,6.2.3,6.2.4,6.2.5)above demonstrate that the majority of the regions meet the standard of illuminance,with only a few areas(office,conference room,outside road,car parking area with one high mast, One Side Road with side walking & cycling area) being impacted by light pollution.

CHAPTER: 7

CONCLUSION & FUTURE SCOPE

7.1 CONCLUSION

The studies emphasize the important of implementing responsible lighting practices to mitigate light pollution. Inefficient lighting practices result in significant energy wastage. By adopting energy efficient lighting technologies and implementing smart lighting solutions, substantial energy savings can be achieved. Lack of environment awareness for some segment of society, which was represented by using very high lighting in different area. There are no specification, limitations and legislations for lighting. Though lighting standard exist but maximum people never follow. Light pollution has been detected in six experiment zones in this study.

7.2 FUTURE SCOPE

Studying light pollution in various lighting application areas offers numerous opportunity for future studies.

To ensure accurate outcomes, it is crucial to reduce the grid size and gather relevant data (Light specification, mounting height, beam angle etc.) for the analysis of result. Develop new methods or tools to accurately quantify and measured light pollution in different application areas. Investigate the specific effect of light pollution on different aspects of environment, human health and wildlife. Focus on understanding how different lighting application contribute to light pollution. Calculate the cost in term of power or illumination which is wasted. Develop energy efficient sustainable lighting solution with maintained lighting standard. Controlling the wasted light in terms of light pollution, on a large scale has the potential to meet the daily electricity demand. Assess public awareness and perceptions of light pollution and its impact in various lighting application area.

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ANNEXURE

METRAVI® | DIGITAL LUX METER | 1300

INTRODUCTION

Model 1300 is a Stable, Safe, Reliable Mini Digital Light Meter, widely used in Lightening Enterprises, Agriculture and Animal Husbandry, Mining Enterprises, Laboratory, Office, Household Street lights construction and others.

- 4 Digits Backlit LCD Display
- MAX – MIN Record Function
- Data Hold
- Auto Power Off
- Low Battery Indication
- Measures in Lux and in Foot Candle

GENERAL TYPE

- LCD display : 4 digits LCD display. The max display is 9999.
- Overload indication : When illumination is over 199,999 Lux, "OL" will be displayed.
- Battery low power display : Prompt " ". New battery should be replaced in time.
- Sampling rate : 2/s.
- Sensor type :Silicon photocell.
- Impact strength : Can withstand the impact of landing from 1 meters height.
- Battery requirement : 1.5V batteries (AAA) x3
- Product size : 160 x 50 x 28mm
- Weight : 118g

ENVIRONMENT SPECIFICATION

- Indoor use
- Maximum operating height : 2000m
  Safety : EN61326-1
- Pollution level : 2
- Working temperature and humidity : 0°C ~ 40°C (not greater than 80%RH) 40°C ~ 50°C (not greater than 45%RH)
- Storage temperature and humidity : -20°C ~ 60°C (not greater than 75%RH)

*Technical Specifications & Appearance are subject to change without prior notice

METRAVI® | DIGITAL LUX METER | 1300

ELECTRICAL SPECIFICATION

- **Accuracy** : 0 ~ 9999 Lux, ±(4%rdg + 8dgts)
  ≥10000 Lux, ± (5%rdg + 8dgts)
- **Environment temperature** : 23°C±3°C
- **Environment humidity** : ≤ 80%RH

TECHNICAL SPECIFICATION

1. Wind Speed and Temperature

Function	Range	Resolution	Accuracy	Description
Illumination	0 ~ 9999 Lux	1 Lux	± (4%rdg+8rdg)	(regulate in the standard of 2856K color temperature flat lamp) Note: 1FC=10.76 Lux
	≥10000 Lux	10 Lux	± (5%rdg+10dgts)	
Range	0 ~ 199, 999 Lux			Auto-ranging
Samling Time	0 ~ 12		0.5s	Refresh sampling in 0.5s
Overload Indication			OL	Shows ”OL”.
MAX/MIN Measurement			MAX/MIN	Shows “MAX/MIN”.
Data Hold			HOLD	Shows “HOLD”
Backlight			BL	Manually ON and OFF.
Auto Power off			5mins	Automatically power off after 5mins wihout operation.
Low Battery			3.0 ~ 3.5V	Shows low battery prompt when power is 3.0 ~ 3.5V.

*Technical Specifications & Appearance are subject to change without prior notice