A STUDY ON THE IMPACT OF LIGHT POLLUTION ON ECOLOGICALLY SENSITIVE ZONES

(CASE STUDY- ECO PARK, KOLKATA)

A thesis submitted towards partial fulfillment

Of the requirements for the degree of

Master of Technology in Illumination Technology and Design

Submitted by

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CERTIFICATE OF RECOMMENDATION

This is to certify that the thesis entitled **"A STUDY ON THE IMPACT OF LIGHT POLLUTION ON ECOLOGICALLY SENSITIVE ZONES -CASE STUDY OF ECO-PARK, KOLKATA" is** a bonafide work carried out by **Annesha Sil** under my / our supervision and guidance for partial fulfillment of the requirement of **Master of Technology (Illumination Technology and Design)** in **School of Illumination Science, Engineering and Design**, during the academic session 2019-2022.

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This foregoing thesis is hereby approved as a credible study of an engineering subject carried out and presented in a manner satisfactorily to warranty its acceptance as a prerequisite to the degree for which it has been submitted. It is understood that by this approval the undersigned do not endorse or approve any statement made or opinion expressed or conclusion drawn therein but approve the thesis only for purpose for which it has been submitted.

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I hereby declare that this thesis contains literature survey and original research work by the undersigned candidate, as part of his **Master of Technology (Illumination Technology and Design)** studies during academic session 2019-2022

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

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ACKNOWLEDGEMENT

It is a genuine pleasure to express my deep sense of thanks and sincere gratitude to my advisor Prof. (Dr.) Debashish Das & Prof Suchandra Bardhan of Department of Architecture, Jadavpur University for providing me with the opportunity to carry out my project work and their constant guidance and supervision. I would also like to thank them for providing me their valuable time and helpful suggestions and arrangement for visit to proposed project site at ECO PARK, Kolkata for gathering information, field survey works, data collections and instrument supports during simulation study on that subject.

I am highly indebted to Mr. Partha Sarathi Satvaya, Director of School of Illumination Science, Engineering and Design, Jadavpur University and Prof. (Dr.) Biswanath Roy, Department of Electrical Engineering, Jadavpur University, Dr. Kamalika Ghosh, Associate professor of Department of Electrical Engineering, Jadavpur University and Mr. Suddhasatwa Chakraborty, Assistant Professor of Department of Electrical Engineering, Jadavpur University for their valuable suggestions and encouragements during the project work.

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

I am also thankful to Mr. Samir Mandi and Mr. Pradip Pal, Illumination Engineering Laboratory for their warm cooperation during that project work.

Last but not the least, my special thanks to all my classmates who helped me directly in completing my thesis successfully.

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ABSTRACT

The lighting design in a park now-a-days is not only limited to general lighting but also it is focused to provide quality of lighting with the help of vast range of available luminaire with different sizes as well as colour with efficient use of energy, that opens up accurate characteristics of specific areas in any room of the building. That means quantity and quality of lighting are the main challenges to any designer before proceeding to design lighting in such areas.

This affordable area, Eco Park, a city park in Greater Kolkata's New Town (also known as Prakriti Tirtha), is now the biggest park in India. The park's 480 acres (190 ha) of land are surrounded by a lake body that is 104 acres (42 hectares) in size and has an island in the middle. A small area of ECO PARK is in consideration here.

This thesis is mainly focused to provide a low light pollution but energy efficient lighting design which can be used to renovate the existing lighting systems. The main objectives of the project are to propose outdoor lighting can be a source of undesirable phenomena known as light pollution. Too much of light pollution has consequences: it washes out starlight in the night sky, interferes with astronomical research, disrupts ecosystems, has adverse health effects and finally energy is wasted. The amount of light pollution mostly depends on the type of light source (it's spectral power distribution) and the luminaries intensity distribution curve. Also the placement and the reflective properties of the surface around it e.g. the walls of buildings, asphalt, grass, etc. are important. In this paper the analysis of factors describing amount of light pollution in the park alleys was carried out. The model of park path, with trees, shrubs, benches and grassy paths, illuminated by typical lighting luminaires, used in such applications, was done by professional lighting design software. Computations of light pollutions factors were done for MH, HPS, LED warm light and LED cold light lamps used in opal sphere type luminaires, used for the lighting of given park alley. The seasonal variation of landscape color and the amount of seasonal vegetation was taken under consideration. According to our calculations the amount of light pollution in landscape areas has a strong correlation with the season of the year. Additionally this effect, for each season, depends on the lamp's type. Before the designing, a thorough study on the literature of interior

lighting and relevant standards and guidelines on basics of outdoor lighting landscape design has been done to apply it technically and aesthetically to provide proper mood and attract the park by creating a favorable impression on visitor and animal, which are present in the ecological park.

CONTENT

CHAPTER-1

INTRODUCTION TO THE THESIS

1.1 INTRODUCTION:

In order to improve safety, nighttime aesthetics, accessibility, security, recreation and sports, as well as social and event usage, outdoor illumination of private gardens and public landscapes is referred to as **landscape lighting** or **garden lighting**. In Park, Human beings including birds, fishes and animals are stays. However, nowadays it ought to be a more environmentally friendly location as a result. Furthermore due to presence of public and animals, birds, insects etc. in the Park, some sizable area required some necessary to install suitable artificial lighting as a result, however care must be taken to ensure that the animals and human are not harmed by these lights. Here some portion of Eco Park lighting is in consideration.

1.2 HISTORY OF ECO PARK:

The largest park in India thus far is Eco Park (also known as Prakriti Tirtha), which is an urban park in New Town, Greater Kolkata. A 104 acres (42 hectares) water body with an island in the centre surrounds the park's 480 acres (190 ha) of land. Mamata Banerjee, the chief minister of West Bengal, conceptualized the park in July 2011. Along with many other governmental entities in charge of carrying out various activities inside the park, West Bengal Housing Infrastructure Development Corporation (HIDCO) serves as the overall organization overseeing the construction of the park.

The park is broken up into three main sections:

1) ecological zones, such as wetlands, grasslands, and urban forests,

2) theme gardens and open spaces, and

3) urban recreational areas.

In accordance with the various species of fauna that have been planted, the Eco Park is further divided into various sub-parts. In this park, there are also replicas of the Seven Wonders of the World for visitors to see. The park will contain a variety of settings, including grasslands, tropical tree gardens, bonsai gardens, tea gardens, cactus walks, heliconia gardens, butterfly gardens, play spaces, and an amphitheatre, per the proposal. Additionally, there are plans to create an eco-resort through a public-private cooperation, which will also feature a space for the display of crafts made in various parts of the state. The park's opening was performed by Mamata Banerjee on December 29, 2012.

1.3 AREA OF INTEREST IN ECO PARK:

The park has been divided into the following areas in accordance with the master plan created by Bengal Urban Infrastructure Development Limited:

- Active Zone: Including Seven Wonders, an Urban Museum, restaurants, food courts, and a crafts market
- Theme Area (North): Composed of the amphitheatre, children's play area, Chinese garden, formal garden, bonsai garden, cactus walk, butterfly garden, heliconia garden, mist house, and bamboo garden.
- Theme Area (South): Play area, tea plantation, water garden, and utility area
- Lake Area: Bridge connecting the island, Bengali restaurant, sculpture court, lakefront promenade, and wildflower meadows.
- Wetlands, grasslands, tropical ecosystems, and mixed moist deciduous woods make up three different eco-zones.
    - AMPHITHEATRE: The semi-circular open gallery was thoughtfully designed to hold up to 2,000 people. The theater-greenroom complex appears to be floating in space. Interesting brick-twisted pillars that I have never seen before can be found in the adjacent cuisine gallery. The KMDA completed the entire construction. On September 22, 2014, at 5:00 p.m., Minister Firhad Hakim officially opened the amphitheatre.
    - SEVEN WONDERS REPLICA: Egyptian Pyramids of Giza, Brazil's Christ the Redeemer, Great Wall of China, India's Taj Mahal, Great Sphinx of Giza, Petra in Jordan, Eiffel Tower in France, Colosseum of Rome in Italy, Moai Statues of Easter Island.
    - BUTTERFLY GARDEN: The garden is poised to consist of a large dome to enclose a plant habitat consisting of different species of flowering annuals and perennials that support a large range of butterflies organized around a circular body of water.
    - MASK GARDEN: Near the Northern parking lot and adjacent to the tea garden, this new zone has masks from various districts of West Bengal, then various states of India and finally from various countries of the world.
    - ROSE GARDEN: This space is a long stretch of walk with varieties of roses planted along, colorful fountains sprinkling by, sculptures to feast the eye and occasional benches to rest a little

FIG.1: ECOLOGICAL PARK LAYOUT

- DIFFERENT IMAGES OF ECOLOGICAL PARK AREA---

Entrance of the Butterfly Garden

Butterfly Lab

Roses blooming in the rose garden during winter

Replica of a temple from Bishnupur at the Eco Park

Walkway through the rose garden

Waterbody at Eco Park

Amphitheatre

Butterfly Lab

FIG.2: DIFFERENT IMAGE OF THE PORTION OF ECOLOGICAL PARK

1.4 AIM OF THE THESIS:

The Aim of the thesis is "To understand the impact of light pollution in ecologically sensitive zones"

1.5 OBJECTIVES OF THE THESIS:

Main objective of this Thesis work is-

- To Study the Light Pollution on eco-logical park
- To Study the Existing landscape Lighting system of Eco-Park, Kolkata
- To Understand the light pollution in Eco-Park, Kolkata
- To Study about the issues, problem and impact of light pollution in Eco-Park
- To propose recommendation & guideline for sustainable lighting design.

1.6 METHODOLOGY:

- On-site survey of the outdoor space, park.
- Study of the lighting positions of individual spaces to prepare the list of required lamps and luminaries if conventional light sources in use
- Measurement of the lighting parameters for the conventional lighting design.
- Problem identification of conventional lighting design with respect to energy efficiency and lighting requirements.
- Designed abiding relevant codes and standards.
- Corroborate the proposed design with software
- light source pollution and low energy consumption for an environmental aspect

CHAPTER-2

LITERATURE REVIEW,

RELEVENT CODES & GUIDELINE

BASIC OF LIGHTING:

2.1 INTRODUCTION

It is crucial to understand the fundamentals of lighting, including its characteristics and units, the qualities and features of light, how light is controlled, the various types of luminaries, and the protection ratings of luminaries, before creating illumination for any space.

2.2 UNITS AND TERMS OF LIGHT:

Lighting technology includes a number of technical terms and units which are used to describe the properties of light sources and the effects they produce.

i. Luminous flux – Measured in lumen (lm), luminous flux describes the total amount of light emitted by a light source.
ii. Luminous efficacy – Expressed in lumen per watt (lm/W), luminous efficacy describes the luminous flux of a lamp in relation to its power consumption.
iii. Luminous intensity – Luminous intensity is used to describe the flow of light in a given direction. It is obtained by dividing the number of lumens in that direction by the angular size of the beam, i.e., the solid angle (measured in steradians). Luminous intensity is measured in candela (cd) or lumen per steradian (lm/sr).
iv. Illuminance – Illuminance evaluates the density of luminous flux. It indicates the amount of luminous flux from a light source falling on an area. Measured in lux or lumen per square meter (lm/m^2), illuminance on a surface decreases with the square of its distance from the light source (inverse square law).
v. Luminance – Luminance describes the brightness of an illuminated surface. It is defined as the ratio of luminous intensity of a surface to the projected area of this surface, i.e., cd/m^2. It is the basis for describing perceived brightness.

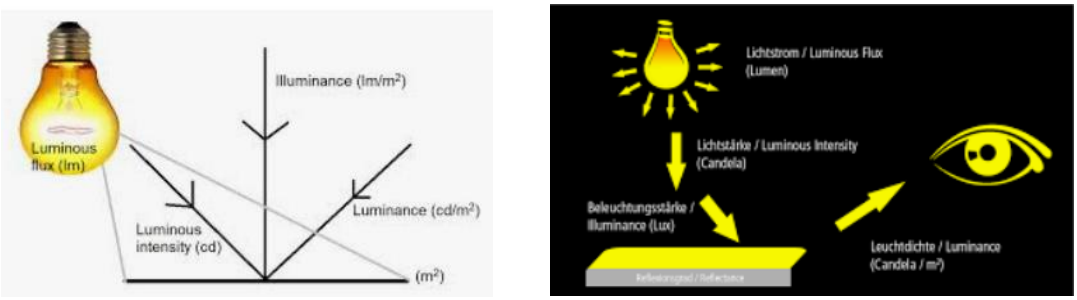


FIG.3: IMFORMATION ABOUT ILLUMINANCE, LUMINOUS INTENSITY & LUMINANCE

2.3 QUALITY & FEATURES OF LIGHTS:

i. Direct, indirect and diffused light – Direct light is obtained when the light source shines directly on the surface to be illuminated, without any filter. It can be used where focused lighting is required, but direct light also creates the risk of glare and harsh shadows. Indirect lighting is obtained when light falls upon a surface after being reflected off other surfaces such as wall, ceiling, etc. This kind of lighting is mainly used for ambience lighting. A big advantage of indirect lighting is that it produces no glare and doesn't create shadows. Diffused lighting is obtained by usage of filter over the light source. It generates a balanced distribution of light in a space, and is often used in a combination with direct and indirect light.

The pictures below show how 3-D objects are perceived under direct, indirect, and diffused light, creating different shadows and shaping the objects differently.

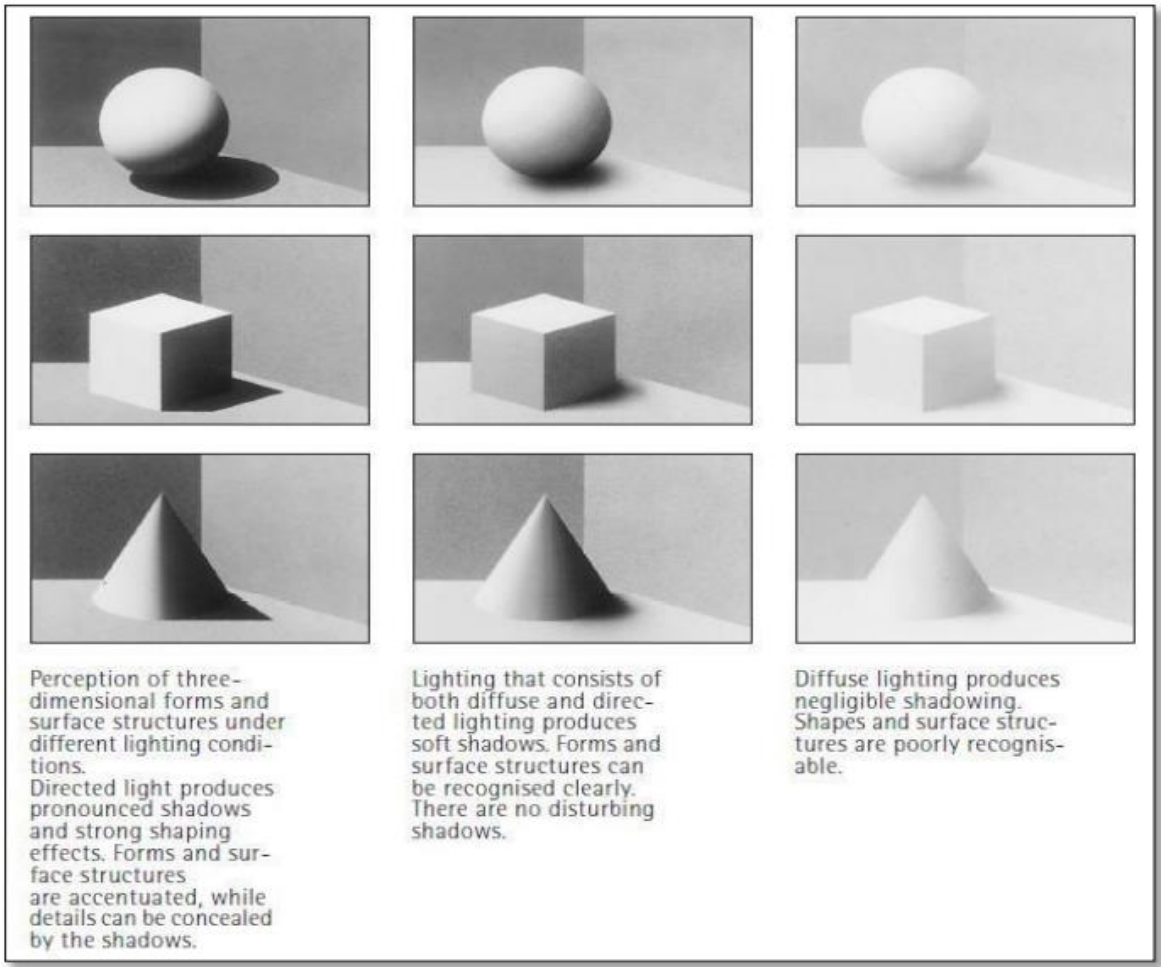


FIG.4: PERCEPTION OF THREE DIMENSIONAL FORMS AND SURFACE STRUCTURE UNDER DIFFERENT LIGHTING CONDITIONS

ii. Modeling – One essential aspect of lighting design is to reveal the three-dimensional impression of people and objects in space, and this has to be achieved by the balanced use of both light and shadows. As mentioned earlier, direct lighting creates harsh shadows, which in turn can conceal details of objects. On the other hand, indirect lighting creates negligible shadows, due to which shapes and structures are poorly recognizable. Hence both directional and diffused lighting is required for 3-D modeling of objects in a space. The picture below shows how 3-D modeling of an object is created by uniform lighting using several light sources.

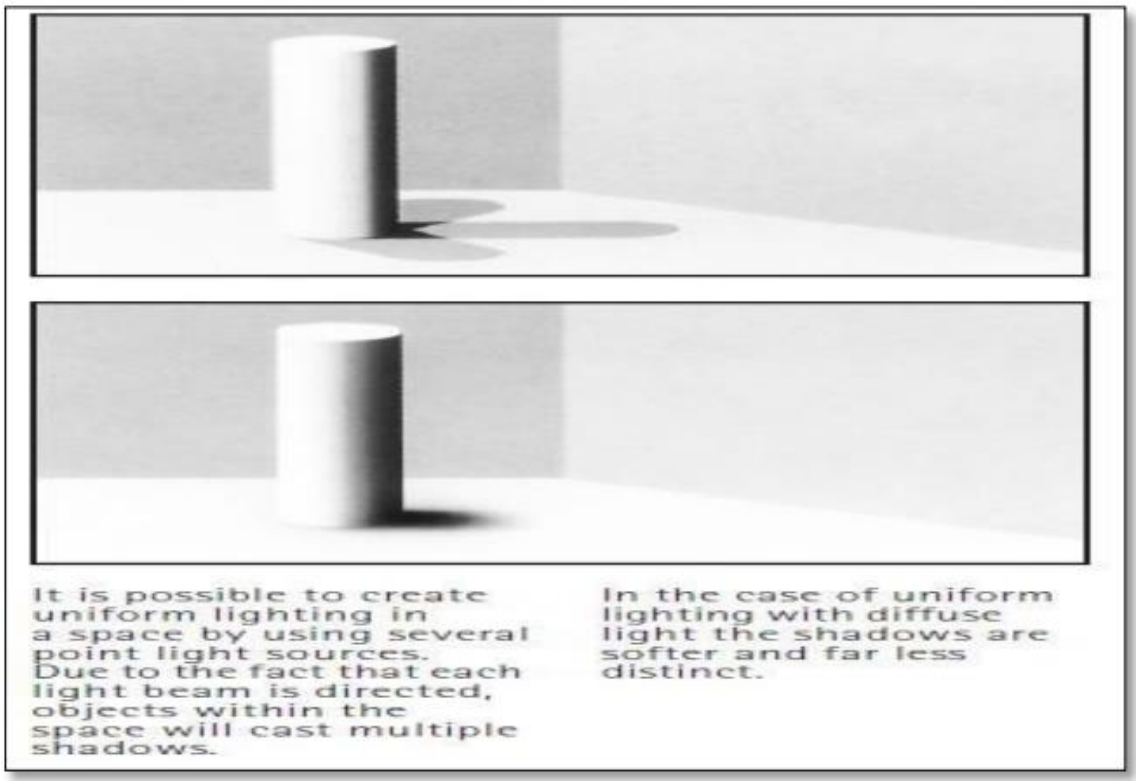


FIG.5: AN OBJECT IS CREATED BY UNIFORM LIGHTING USING SEVERAL LIGHT SOURCE

iii. Glare and UGR – The eye can adapt to a wide range of luminance. However, objects that are brighter than what the eye can adapt to result in glare. If the glare source is not too bright and does not directly interfere with vision, it is called discomfort glare. If the glare source is too bright and interferes with the vision, disability glare arises. Direct glare is caused by light sources visible to the eye, while indirect glare is caused when the light source is not visible to the eye, but very reflective or glossy surfaces cause bright splotches on them acting as indirect sources of glare.

FIG-6: UNDERSTRAND ABOUT GLARE

The Unified Glare Rating (UGR) formula has been recommended by the CIE for computation of UGR which evaluates the level of discomfort glare in a space. UGR inversely varies with the background luminance. The practical range of UGR is 10 to 30 where the lower value indicates least discomfort glare, while a higher value indicates intolerable discomfort glare. A room with UGR value less than 10 is usually assumed to not have discomfort glare. Usually an UGR value of less than or equal to 19 is considered good for commercial/office lighting.

CCT – Correlated Colour Temperature, specified in Kelvin, indicates the color of light emitted by a light source. It is the temperature of an ideal black body radiator that radiates light of comparable hue to that of the light source

2700K – 3500K light is called warm white colored light

4000K light is called natural white colored light 5000K light is termed as daylight

6000K – 6500K light is called cool white colored light

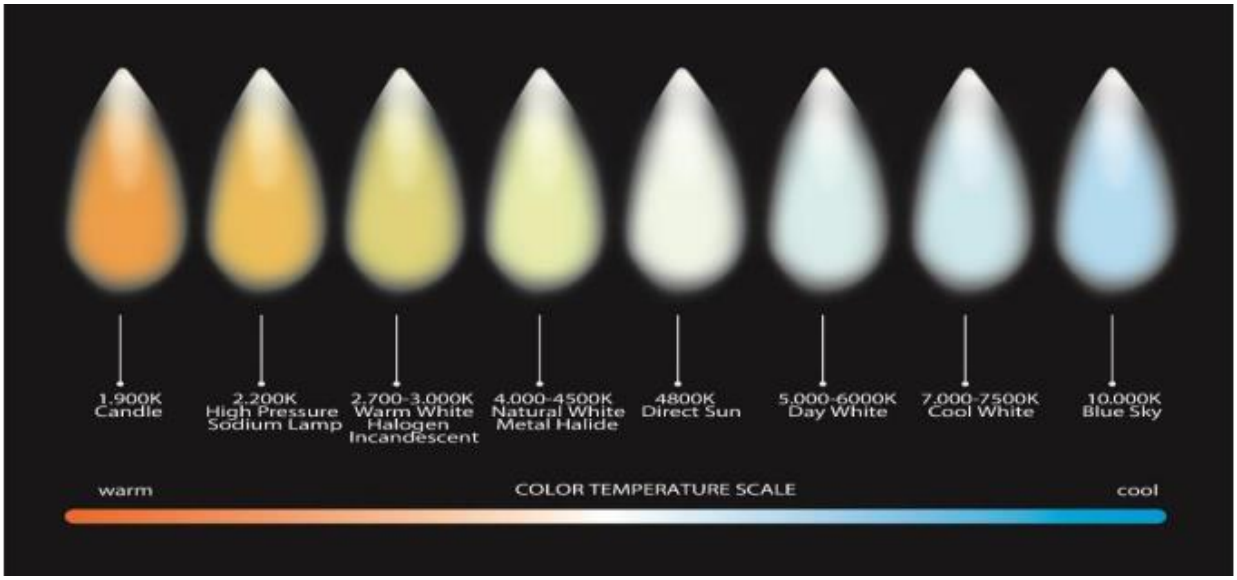


FIG. 7: UNDERSTAND ABOUT COLOR TEMPERATURE RANGE

iv. CRI – The Colour Rendering Index of a light source indicates the colour quality of the object it illuminates. The more the CRI, the more accurately it represents the original colour of the object. It is measured on a scale of 1-100, where 1 means monochromatic light is rendered and 100 means all colours are rendered. Sunlight produces a CRI of 100 Light sources with CRI of 85-90 are considered very well at colour rendering.

FIG.8: UNDERSTAND ABOUT CRI

vi. Ambient, task, accent, and atmospheric lighting – Ambient lighting or general lighting provides consistent room lighting. It is the most important type of lighting, and is put on first when entering a room, for example, a ceiling lamp. Task or functional lighting is used for a particular activity, for example, reading or writing. A table lamp is a good example 26 of this type of lighting. Sometimes when we want to attract more attention towards an object, we can focus light on to it so that light falls directly on that object. This is called accent lighting, and is usually used for aesthetic purposes. Atmospheric lighting, as its name suggests, creates the ambiance of a room. Therefore, the choice of lighting depends upon the room's purpose. This kind of lighting is very crucial in the hospitality environment to create the right ambiance and attract more customers, and give them a pleasant feeling. The pictures below show examples of ambient lighting in a living room, task lighting in a study room, and accent plus atmospheric lighting in a restaurant respectively.

2.4 CONTROLLING OF LIGHT:

Many times the direct light beam out of luminaries is not required on a surface, or sometimes even the light output cannot reach the required surface due to some constraints. It is then that various optical phenomena can be used to control and direct the light beam in a desired way.

i. Reflection – The phenomenon of reflection can be used to control light falling on a surface by incorporating specially designed reflectors in a luminaire.

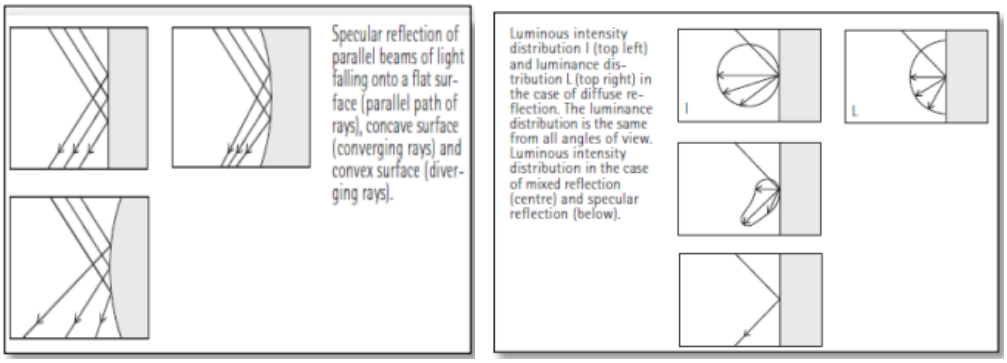


FIG.9: DIFFUSE & SPECULAR REFLECTION

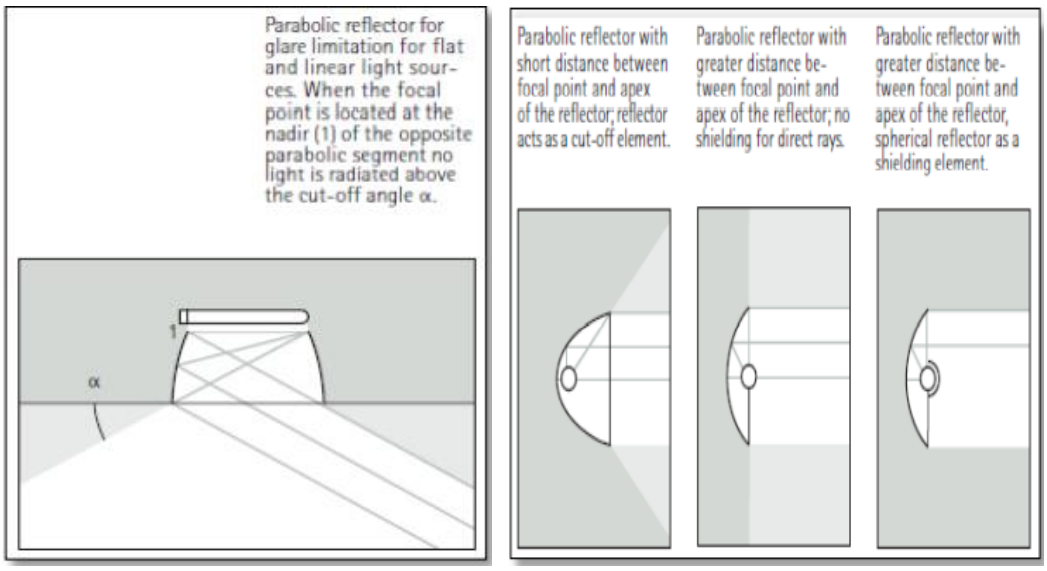


FIG.10: USAGE OF PARABOLIC REFLECTORS

ii. Transmission – Transmission of light can either be total or partial. For total transmission of light, transmitting materials in luminaires are transparent. In case of requirement of partial transmission or diffused light, or light of any particular colour, textured covers, filters, etc may be used over the luminaires.

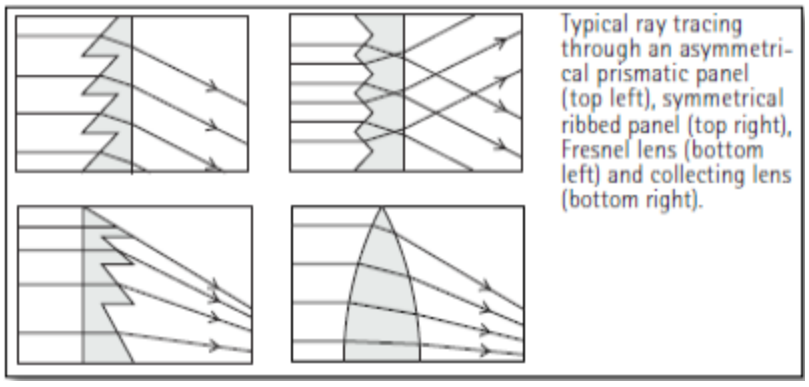


FIG.11: RAY TRACING THROUGH PRISMS AND DIFFERENT KINDS OF LENS

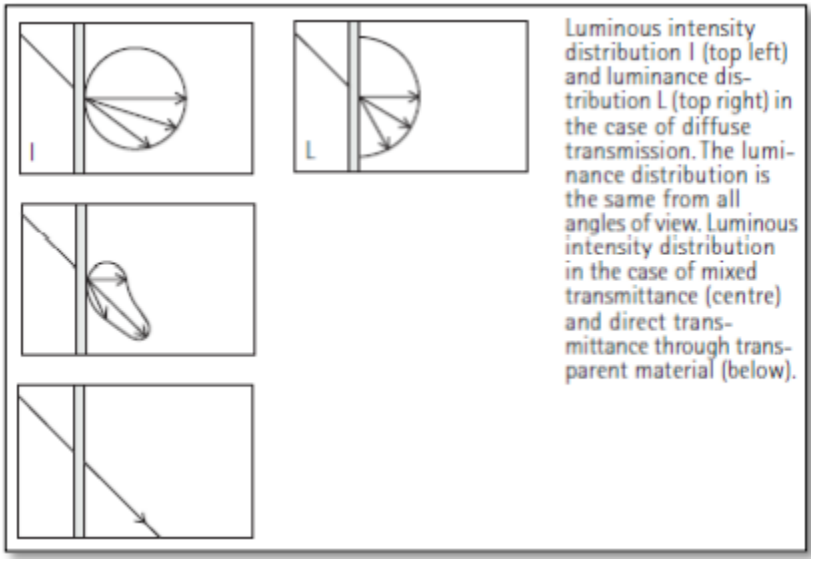


FIG.12: DIFFERENT WAYS OF TRANSMISSION OF LIGHT THROUGH DIFFERENT MEDIUMS

iii. Absorption – In construction of luminaires, absorption is primarily used for shielding light sources, mainly for the purpose of visual comfort. Examples of components used as shields are louvers, barn doors, baffles, etc.

iv. Refraction – Prisms or lenses, often in combination with reflectors are used to refract the light beam, i.e., change its path in a desired direction on a surface.

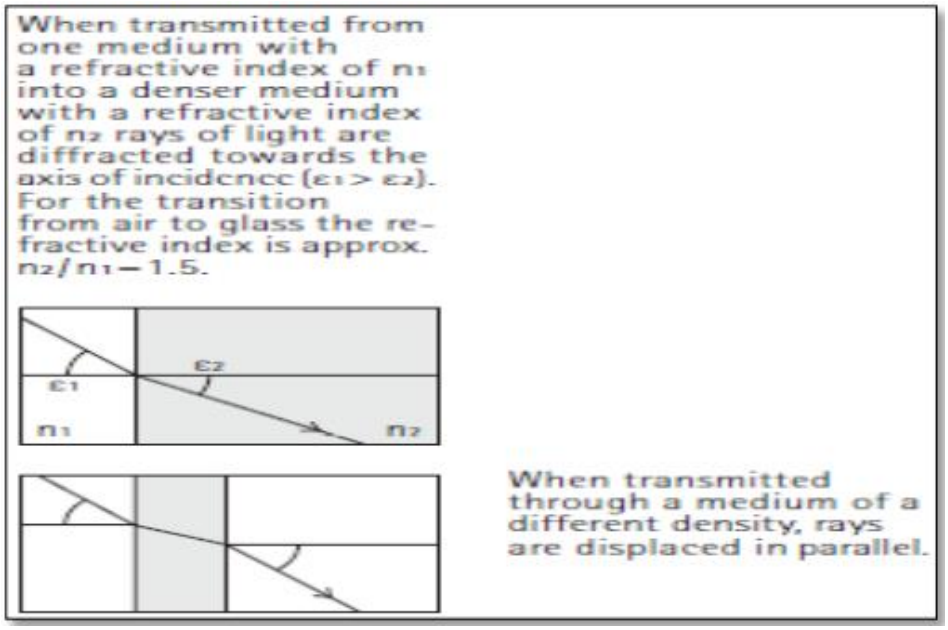


FIG.13: EFFECT OF REFRACTION OF LIGHT THROUGH DIFFERENT MEDIUMS

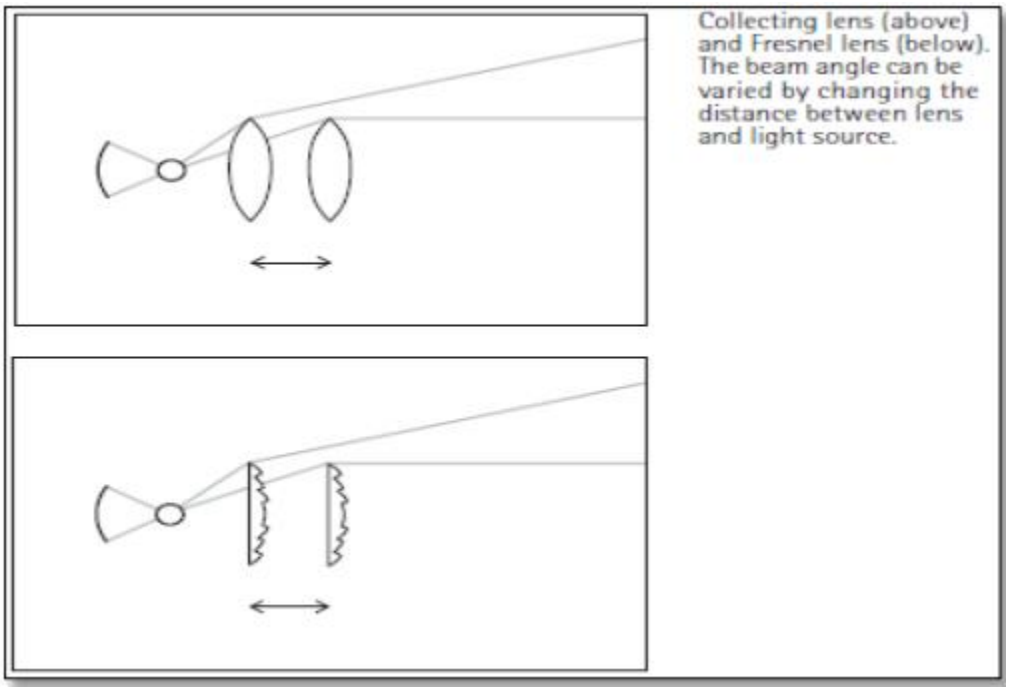


FIG.14: EFFECT OF REFRACTION OF LIGHT THROUGH DIFFERENT LENS

v. Interference - Interference is described as the intensification or attenuation of lightwhen waves are superimposed. From the lighting point of view interference effects are exploited when light falls on extremely thin layers that lead to specific frequency ranges being reflected and others being transmitted. By arranging the sequence of thin layers of metal vapour according to defined thicknesses and densities, selective reflectance can be produced for specific frequency ranges. The result can be that visible light is reflected and infrared radiation is transmitted. Reflectors and filters designed to produce coloured light can be manufactured using this technique. Interference filters, so-called dichroic filters, have a high transmission factor and produce particularly distinct separation of reflected and transmitted spectral ranges.

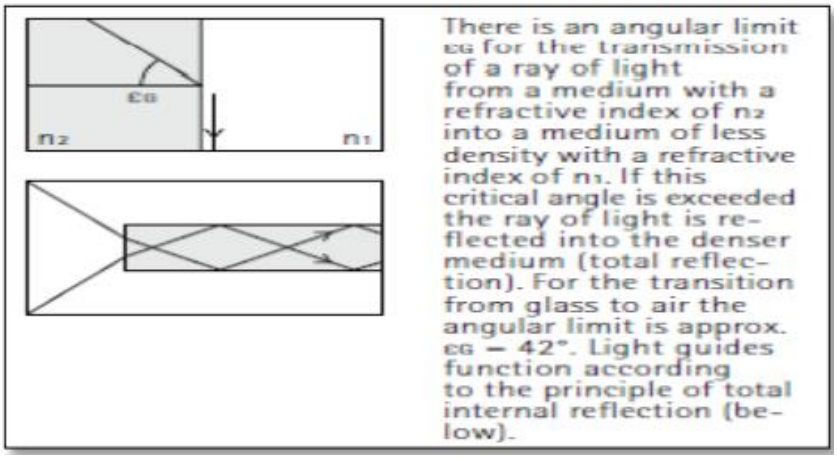


FIG.15: INTERFERENCE PROPERTY OF LIGHT

The pictures below show a Fresnel lamp with barn doors, a luminaire with louvers and a set of luminaires with reflective surfaces respectively.

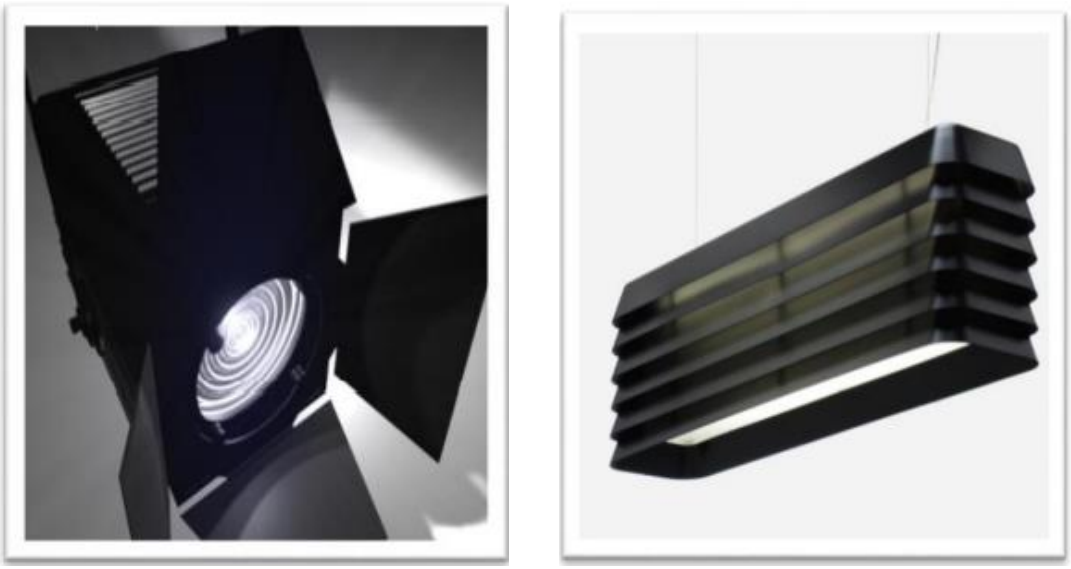


FIG.16: A FRESNEL LAMP WITH BARN DOORS AND A PENDANT LUMINAIRE WITH LOUVERS

2.5 LUMINAIRE RATINGS:

i. IP rating - The IP Code (Ingress Protection) consists of the letters IP followed by two digits. It indicates the degrees of protection provided to a luminaire against the intrusion of solid objects and moisture. It is written in the form of IPXY, where X represents a number indicating the level of protection against solid objects, and Y

represents a number indicating the level of protection against moisture/liquids. X is in the range of 0- 6, and Y being in the range of 0-8.

Protection level against solid objects - X	**Object size protected against**
0	Not protected
1	>50mm
2	>12.5mm
3	>2.5mm
4	>1mm
5	Dust Protected
6	Dust Tight

Protection level against moisture/liquid - Y	**Protected against**
0	Not protected
1	Dripping water
2	Dripping water when tilted up to 15 degrees
3	Spraying water up to 60 degrees from vertical
4	Splashing water
5	Water jets
6	Heavy seas
7	Immersion up to 1mm
8	Immersion beyond 1mm or submersion

TABLE-1: DIFFERENT PROTECTIONS LEVEL AGAINST SOLID & LIQUID

ii. IK rating - IK rating is represented as IK and a number from 00 to 10, which indicates the degree of protection provided by the electrical enclosures against external mechanical impacts.

- IK00 - There is no Protection.
- IK01 - Protected against 0.14 joules of impact (this is the equivalent to the impact of a 0.25kg mass dropped from 56mm above)
- IK02 - Protected against 0.2 joules of impact (this is the equivalent to the impact of a 0.25kg mass dropped from 80mm above)
- IK03 - Protected against 0.35 joules of impact (this is the equivalent to the impact of a 0.2kg mass dropped from 140mm above)
- IK04 - Protected against 0.5 joules of impact (the equivalent to the impact of a 0.25kg mass dropped from 200mm above the impacted surface)
- IK05 - Protected against 0.7 joules of impact (the equivalent to the impact of a 0.25kg mass dropped from 280mm above the impacted surface)
- IK06 - Protected against 1 joules of impact (the equivalent to the impact of a 0.25kg mass dropped from 400mm above the impacted surface)
- IK07 - Protected against 2 joules of impact (the equivalent to the impact of a 0.5kg mass dropped from 400mm above the impacted surface)
- IK08 - Protected against 5 joules of impact (the equivalent to the impact of a 1.7kg mass dropped from 300mm above the impacted surface)
- IK09 - Protected against 10 joules of impact (the equivalent to the impact of a 5kg mass dropped from 200mm above the impacted surface)
- IK10 - Protected against 20 joules of impact (the equivalent to the impact of a 5kg mass dropped from 400mm above the impacted surface)

2.6 ULTRAVIOLET LIGHT

Ultraviolet light is a small portion of the electromagnetic spectrum.

There are mainly three type of light is available.

- UVA - 315nm-400nm
- UVB - 280nm-315nm
- UVC - 100nm-280 nm

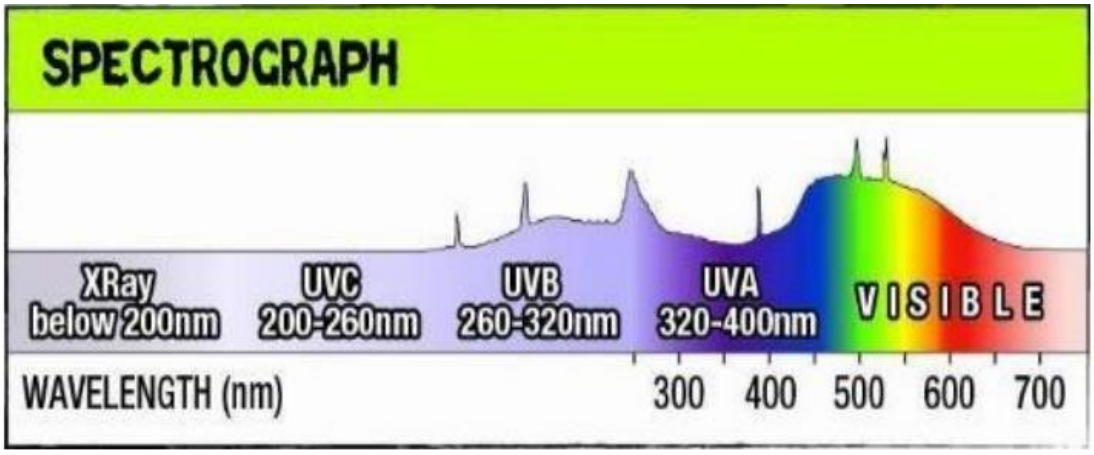


FIG.17: UNDERSTAND ABOUT THE SPECTAL RANGE

2.7 INFRARED LIGHT

Infrared radiation (IR), also known as thermal radiation, is that band in the electromagnetic radiation spectrum with wavelengths above red visible light between 780 nm and 1 mm. Common artificial sources include heating devices, and infrared lamps used and in the home and in infrared saunas for health purposes. Industrial sources of heat such as steel/iron production also fall into the infrared region. Lasers are a special source of IR emitted over one or more extremely narrow wavelength bands.

- IR-A 780 nm - 1.4 µm
- IR-B - 1.4-3 µm

IR-C, also known as far-IR - 3 µm-1 mm

2.8 **IESNA-ILLUMINATION ENGINEERS SOCIETY NORTH AMERICA:**

In the lighting profession among all other reference documents, the IESNA is the most important document to refer to for lighting design. One professional is able to achieve its mission of improving the lighted environment by assembling the people who are proficient in lighting and transferring that skill into executions for the sake of general people.

DESIGNING CONCEPT AS PER IESNA:

As per IESNA several conditions influence the lighting designing of a park:

- The style of architectural and interior design which strongly reflects the user's own sense of style. Luminaire styles and the types of lighting effects in lighting design should respond to traditional, transitional, contemporary styles. A key step of the design process is to review luminaire selections and lighting effects with the owner.

- Divergence in lighting methodologies and illuminance throughout the residence must follow the number of users living in it and their age. Depending on occupancy, works, and time of day, lighting control devices can be applied in straightforward operations.

- Hours of use are another condition to be considered. The lighting decisions and controls may be well influenced by use patterns like, some residences require near twenty-four hours operation and some require either dark hours or daylight hours on weekends.

- Activities in daily life categories spaces along with their design in the house. Some residences are quite active and will have spaces and equipment to support sports or exercising activities, whereas some residences will have activities like entertaining, cooking, reading, dedicated life of raising children etc. A good lighting design will detail these life activities and serve an outline of lighting needs.

- Sustainability aspects should be a vital factor on the designer's design selections. Efficient and long-lasting lamps can result in energy saving and low maintenance. Simple sensor-controlled lighting devices can have a positive influence on energy use.

2.9 ECBC – ENERGY CONSERVATION BUILDING CODE:

"The Energy Conservation Building Code (ECBC) was developed and released by the Govt. of India on 27th May 2007, as a first step towards promoting energy efficiency in the building sectors". ECBC sets minimum energy standards for buildings in India. The state governments have the flexibility to modify the code to suit local needs by giving notice. Now days, many states are following ECBC, wherein most of building construction activities are happening.

The objective of the Energy Conservation Building Code (Code) is "to provide minimum requirements for the energy-efficient design and construction of buildings and their systems".

The new ECBC 2021 has been revised to introduce new and advanced technologies. It incorporates extra parameters that are related to renewable energy integration. It is one of the first building energy codes to recognize beyond code performance. In ascending order of efficiency, three levels of energy performance standards are included in the code known as ECBC, ECBC Plus and Super ECBC.

According to the new ECBC 2021, the norms applicable to:

- The casing and cover of building
- Mechanical bodies and appliances, like thermostat, ventilation, air-conditioner, water-heater.
- Indoor and outdoor lighting
- Electrical power and motors, and unconventional energy bodies.

Interior Lighting Power

The installed lighting power in the interior of a building should not outstrip the interior LPD allowed limit determined in obedience with the code. There are 2 methods mentioned in ECBC 2021 known as "Building Area Method" and "Space Function Method".

BUILDING AREA METHOD:

- Determination the allowed lighting power density from the provided tables for each appropriate building area type.

- For each building area type, calculate the gross lighted floor area.

- The addition of products of the total lit floor area of every building area multiplied by the permitted LPD for that building area type gives actual interior lighting power allowance.

SPACE FUNCTION METHOD:

- Identification of the appropriate area type from the tables enlisted below.

- Calculate the total Watt/m^2 for each area type in a area is consider.

- The different areas of the specific Ecological park cannot outstrip the total wattage to be compliance as per given tables.

2.10 SP-72 : NATIONAL LIGHTING CODE (NLC): 2010

According to this code, basic social safety and environmental objectives is achieved significantly by lighting technology. The code informs about how light pollution, glare, light trespass and energy uses can be minimized by good lighting practices and systems while maintaining safety, security and productivity.

Lighting levels and quantity, and safety parameters for public interest, a set of minimum provisions has been highlighted in it. Detailed guidelines have been provided along with the scope of integrity for the lighting designers that help in choosing the right lighting products and method.

Lighting design for large varieties of interior and exterior installations along with hospitals, sports complexes etc can be done with the help of this code under the control of qualified persons.

The National Lighting Code provides the following ideas of:

- ❖ Various types of occupancies in illuminating engineering practices.

- ❖ Design, selection, installation and maintenance of lighting system for indoor and outdoor spaces.

- ❖ Physics of life, electric light sources, luminaries and photometry related to science of illumination.

- ❖ Coordination of day lighting with the artificial lighting in lighting design.

- ❖ Effective and efficient use of light sources with the help of energy management and energy conservation in lighting installation.

2.11 NATIONAL BUILDING CODE(NBC) : 2005

The National Building Code (NBC), provides guidelines for regulating the building construction activities in all over India. All kinds of building construction like, PWD or any other government construction department, Pvt. Construction organizations adopt the model of NBC. Organizational directives, development control acts and common building needs like fire safety, building material, design and construction, plumbing services etc. are the main focus of this code.

Some important features of NBC:

1. The building projects are successfully carried out with a complete philosophy and direction along with Integrated Multidisciplinary Approach and theoretical knowledge to plan, design, construction, and maintenance stages.

2. Chain of alterations in the process of building authorization.

3. Certification by assuring the safety to the buildings from earth quakes like catastrophic by architect.

4. Certificate renewal periodically for structural, fire and electrical safety of occupied buildings.

5. Sanctioning plans of residential buildings up to 500 m^2 by engineers and architects.

6. Advancement by innovative building materials and technologies

7. Revised fire safety provisions with the inclusion of new categories of starred hotels, heritage structures and archaeological monuments.

CHAPTER-3

ASPECTS OF THE LANDSCAPE LIGHTING

3.1 INTRODUCTION

Since the dawn of time, firelight made of wood, candles, and animal-plant oil fells has been used in luminaries, sconces, and lanterns to illuminate the public landscape and gardens for aesthetic, security, mobility, and social events. Individuals of all ages are present within these visitors, therefore to enhance the visual experience of visitors; we should employ artificial lighting and make proper use of daylight. As is well known, lighting contributes to a pleasant atmosphere. A lovely and relaxing environment is created for guests by using the right landscape lighting design. However, it is important to remember that these animals' daily life cycles are unaffected by the artificial lighting. Because lighting without adequate lighting design can be extremely unsafe for both employees and animals. Therefore, we must choose the right luminaries, maintain a safe distance between both the lamp and the animals, and consider the lighting's time, intensity, and other factors.

3.2 ARTIFICAL LIGHTING IN ECO-PARK

There are many different species of potentially deadly animals housed in eco-parks Thus; it is required for safety reasons. Additionally, breading requires adequate heat, which artificial light may supply. Also Excessive, improper, or intrusive lighting can worsen light pollution, yet even correctly chosen lighting fundamentally modifies the environment. It is believed that urbanization has a negative impact on ecosystems, ecological services, and aesthetic landscapes.

3.2.1 ILLUMINATE SERVICE AREA AND PROTECTION OF NIGHT AMINAL

There are service spaces outside it where the animal is fed, cared for, and observed; if these places are indoors, they must be kept well-lit at all times. Additionally, because the aquarium is located indoors, artificial lighting is required inside the visitor area. The study claims that because some species, like owls and bats, prefer light to gloomy environments, we must manage the amount of daylight. A good lighting plan is necessary to control daylight.

3.2.2 SAFTEY AND SECURITY

The safety of both visitors and employees must always be a concern when there are animals around. Without artificial lighting or insufficient natural light, things may get deadly. We must therefore install the bare minimum of visible artificial lighting. However, bear in mind that animals are unaffected by this artificial light.

3.2.3 FOR AQUARIUM AND BUTTERFLY STORE AREA

In addition to illuminating an aquatic world for your enjoyment, aquarium lighting plays a significant function. Additionally, lighting supplies energy and oxygen to support your pets' general health as well as the development of photosynthesis-dependent plants and animals. Fish, plants, and corals all require light to thrive healthily.

3.2.4 FOR AMPHITHEATER LIGHTING

Lighting is used in theatre to set the correct mood for each play. Here, the use of light hues combined with both up lighting and down lighting approaches produces a classic and incredibly romantic hacienda vibe. Lighting is also utilized to shape backdrops and give the stage a sense of depth and interest. The lighted palm tree makes the ideal backdrop for this gorgeous contemporary patio. Lighting can be used in theatre to establish how day and night are perceived. Lighting can have the same impact in a garden. You may extend your outdoor enjoyment of a warm summer evening throughout the night by installing lighting to landscape.

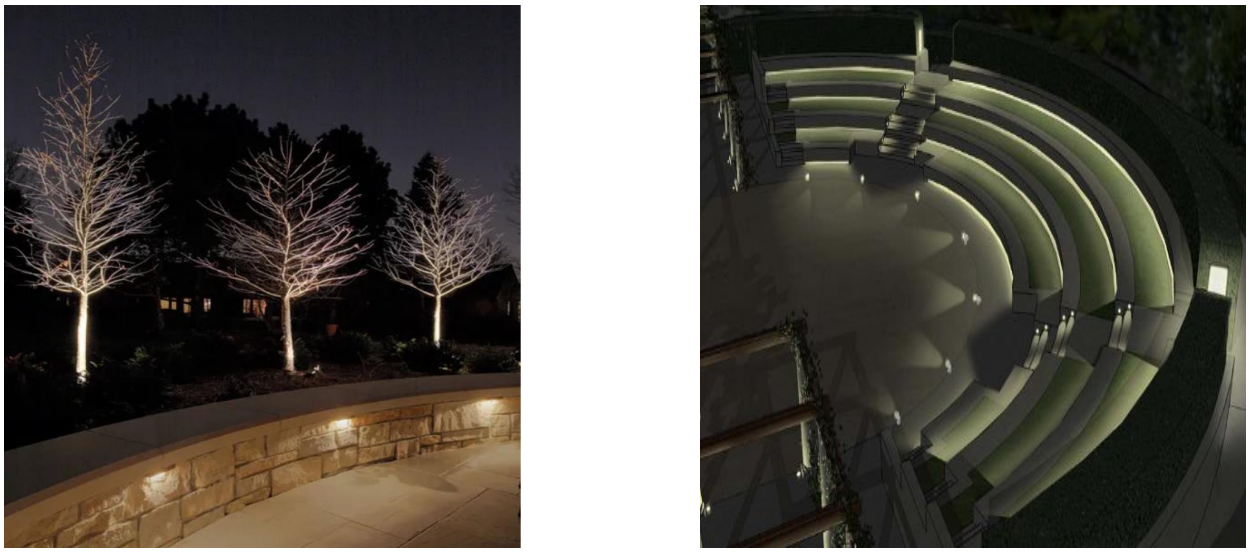


FIG. 18: IMAGES OF AMPHITHEATER LIGHTING

3.2.5 PATHWAY & WATERBODY LIGHTING

A park in a neighborhood or business district is more than just a green space. It is a place to breathe in optimism and relax after a busy day at work or at home. Choosing the ideal landscape lighting solution is to ensuring that these parks are used to their full potential. Landscape lighting refers to the outdoor lighting used in gardens, parks, and estates. It not only gives off a positive energy and adds a beautiful touch, but it also ensures the security and safety of visitors. To illuminate the park walkways, LEDs can be used as recessed lights, lanterns, strip lights, bollard lights, and more. But it's crucial to put them at a secure distance. The positioning of the lights should avoid obstructing the path of the visitor. Make sure the landscape light sources are used to

direct people as they up the stairs while lighting the stairways. Both too bright and too dark lighting should be avoided. The light beams may be problematic for a bystander if they are overly intense and invasive.

The greatest way to highlight tree lines and perhaps a body of water in some kind of a park is with the appropriate landscape lighting. Lights along the margins can be used to illuminate the water bodies. To add depth to the illumination and produce a gorgeous setting, some lights may be submerged. Additionally, spotlights placed at the base of trees contribute to the amazing effect.

FIG. 19: IMAGES OF PATHWAY & WATER BODY LIGHTING

3.3 EFFECT OF ARTIFICAL LIGHTING ON ANIMALS AND HUMAN BEING

Understanding the distinction between nocturnal and diurnal organisms is necessary before we can comprehend the effects of artificial light. Diurnal species are those that spend the majority of their waking hours awake and sleeping at night. Bees, squirrels, songbirds, and even people are among these. Animals that are nocturnal sleep during the day and are active at night. These include creatures like cats, frogs, bats, and moths. Both are impacted by artificial light, but in different ways. Animals see light differently than people do. The majority of animals are sensitive

to UV, violet, and blue light, however certain birds are also sensitive to longer-wavelength yellow and orange light, and some snakes are able to sense infrared light.

3.3.1 EFFECT ON FISHES AND PLANT

- UV Rays: UV-A and UV-B light waves penetrate the ocean's surface but are filtered out by the water as they move through it. It has been discovered that coral tissue's DNA and RNA are destroyed by UV-A and UV-B light waves. Many corals have developed adaptations as a result to lessen the effects of these dangerous rays.

  UV A – 315nm-400nm

  UV B – 280nm- 315nm
- Heat Problems - Because incandescent lights heat water unevenly, the aquarium's water in the vicinity of the lights will be noticeably warmer than the water in other parts of the aquarium. Some fish species may suffer injury from changes in water temperature, or they may start swimming only in the cooler parts of an aquarium. LED lights come in a variety of colors and almost never generate heat.

3.3.2 EFFECT ON HUMAN

Even people are susceptible to the negative impacts of artificial light. The human species is a diurnal one (which means that we are awake during the day, and sleep at night). When awake, nocturnal creatures prefer well-lit places. But humans also require a dark cycle in terms of physiology. Humans create the essential hormone melatonin, which aids in the body's cell regeneration, during night when it is dark. It has been proven that significant disruptions to the day/night cycle, including shift work, interfere with the generation of melatonin.

- The hormone melatonin is produced at significantly lower amounts by night shift workers, making them more vulnerable to some malignancies as well as other health problems.
- Additionally, compared to the general population, shift workers had greater incidence of heart issues and reproductive issues.

3.4 ASPECTS OF PARK LIGHTING DESIGN

Typically, exterior lighting for commercial, industrial, or public purposes is made to ensure a secure working environment. It might also be needed to support trade or human amenity. For protection, astronomy, or dark sky tourism, on the other hand, areas of darkness, seasonal management of artificial light, or minimal sky glow may be required. The regulatory requirements and Australian standards pertinent to the activity and area must be taken into account when setting lighting goals.

The particular areas and times that require artificial light should be specified in the objectives. If colour difference is necessary, it should be taken into account. It should also be decided whether some sections should remain dark, either to contrast with illuminated regions or to prevent light spill. The lighting goals should include pertinent animal needs.

3.4.1 USE APPROPRIATE LIGHT

For the function, the lighting intensity should be suitable. Use only the bare minimum of lights—both in terms of quantity and intensity—to illuminate the space safely and securely at the precise moment needed to achieve the lighting goals. Early design stages should determine the least quantity of light required illuminating an object or region, and just that intensity of light should be provided.

- LOW GLARE
  Regardless of how the project is to be developed, high quality, low glare lighting should always be a key concern. Low glare lighting increases nighttime visibility for the user, eases eye strain, enhances night vision, and directs light where it is required.
- INTENSITY OF LIGHT USED
  New bulb varieties now produce much more light per unit of energy thanks to technological advances. As an illustration, LED lights generate two to five times as much light as incandescent bulbs. The most crucial factor in ensuring that an area is not overlit is the amount of light generated (lumen), not the amount of energy utilised (watt).
- USE DARK COLOURED SURFACE
  The sky glow can be enhanced by light reflected from highly polished, shining, or light-colored surfaces like white-painted infrastructure, polished marble, or white sand. During the front-end engineering design phase, alternatives to painting storage tanks white to reduce interior heating should be investigated. The need to examine the surface should be taken into account when evaluating surface reflectance because darker surfaces would need more light to be seen.

3.5 TYPE OF LUMINEAR USED

Plants are crucial to the garden landscape because they serve as its hair and create a gentle atmosphere. Plants are employed extensively and in a wide variety of plant species in urban landscape design. The vibrant colors and the symmetry of the plant landscape and sunlight can create some excellent aesthetic results. There are bright spots in the city's vertical landscape at night in many cities where plants serve as the primary structure for a three-dimensional lighting landscape. During the holidays, the landscape is more three-dimensionally lit to create city features. Lighting and lanterns decide on an LED lamp belt to encircle a plant as a model.

Here some things need to be in considered:

1. Decide which aspects of your yard you enjoy. A pond or a particularly imposing tree can be the subject; emphasizing them with light will draw attention to them.

2. Areas that might not stand out during the day should be given drama. A plain stone wall can assume a completely different personality at night when illuminated by light and shadow.
3. Consider function. You need to have lighting so you can roam about your yard without fear of being hurt. This includes any decks with stairs or winding pathways.

A. FLOOD LIGHTS AND SPOT LIGHTS:

Beam spread is the key distinction between a spotlight and a floodlight. Spotlights emit a focused, slender beam of light that is typically angled at 45 degrees. A spotlight will be your greatest option if you want to draw attention to specific display spots, such as architectural details or landscape aspects, because it is simpler to target and control. Typically, floodlights have a wider beam spread of up to 120 degrees. Use a floodlight to illuminate large areas, such as a driveway or parking lot. It improves visibility and safety in general. The beam width in feet is far more crucial to know than the desired beam spread's breadth. It ensures that the subject is appropriately illuminated and that all the things you're looking for are lit up.

Formula refers to;
Beam Width = Angle of Beam x 0.018 x Distance from Light Bulb

FIG.20: IMAGE OF SPOT LIGHT

B. IN GROUND LIGHT:

An In-ground light, also known as a well light, is often a circular fixture that is installed underground and is frequently used to light driveways and walks. The elegance and visibility of the items in your yard are greatly enhanced by in-grounds. An uptight effect that illuminates the entire tree or structure contributes to the drama and ambiance. It also casts shadows on the people who are standing about the yard—people you wouldn't normally be able to see at night. Even though up lighting can be a powerful lighting option on its own, it works best when combined with spotlights. The actual light effect is what sticks out because in-ground lights are buried in the ground. When using an in-ground

light, be careful to use it to create a noticeable presence in your yard. Focus on trees and garden walls instead of garden gnomes or short flowerbeds.

For safer passage through gates and lot areas, driveways may also be illuminated with in-ground lights. To accommodate cars that drive over them, these must have the appropriate vehicular weight ratings. Pick one that is sturdy and can support a lot of weight. Additionally, it is strongly advised to choose an LED choice because they have precise color temperatures, shine brilliantly in low light, and have a long lifespan. An inground that provides all of this is the WAC Landscape Lighting LED 3 inch. inground Light.

FIG.21: IMAGE OF GROUND LIGHT

C. OUTDOOR POST LIGHT:

Without the dazzling brilliance of floodlights, post lights (and its sturdy siblings, bollard lights) help accent the pathway to your home and set an ambiance. Tall posts are excellent for lighting lengthy expanses of space that are difficult to see in the dark, such as driveways. Paths and tiny alcoves are ideal places for shorter posts.

FIG.22: IMAGE OF OUTDOOR POST LIGHT

D. PATH LIGHT:

All yards ought to have path lights, which are a fundamental outdoor fixture. Path lights are smaller and shorter than post lights, but they both produce light markers that run down a line. Path lights naturally increase safety while also enhancing curb appearance. All

yards ought to have path lights, which are a fundamental outdoor fixture. Path lights are smaller and shorter than post lights, but they both produce light markers that run down a line. Path lights naturally increase safety while also enhancing curb appearance.

FIG.23: IMAGE OF PATH LIGHT

E. DECK AND STEP LIGHT:

Deck and step lights are incorporated right into the hardscape or decking of a yard and are used as an accent to architectural aspects and to provide safe passage on dark stairs. Additionally, they can be utilised to illuminate gathering places and shine light down stone walls.

FIG.24: IMAGE OF STEP LIGHT

F. UP LIGHT:

Deck and step lights are incorporated right into the hardscape or decking of a yard and are used as an accent to architectural aspects and to provide safe passage on dark stairs. One of the simplest types of outdoor lighting is up lighting. With a taller building or tree, drama

can be produced. Depending on the size of the tree, you can opt to draw attention to its trunk, the underside of its canopy, or both.
Put to use with: Spotlights and well lights

FIG.25: IMAGE OF UP LIGHT

G. SILHOUETTING:

This is a great effect for drawing attention to dramatic forms that may be hiding in plain sight. Make sure that the light source itself cannot be seen by positioning it behind the object and shining it in the direction of the viewer's primary point of view.
Use With: Well lights and spotlights.

FIG.26: IMAGES OF SILHOUETTING

H. GRAZING:

If you have a yard with a lot of hardscape, this can be a terrific alternative. To generate dramatic light and shadow play, grazing entails positioning the light near to the flat surface and focusing directly up or down the surface. The goal is to utilise a texture across a flat plane, thus uneven or irregular patterns work best. You can graze up or down. As it is frequently used in hotel and restaurant design, this can give the space an expensive feel.

Use with: Hard cape lights and well lights

FIG.27: IMAGE OF GAZING

I. MOON LIGHT:

When your space has larger trees, this method of using lighting is especially effective. The light source is positioned high in the tree and is pointed downward, flooding the ground and tree branches with light. When combined with an open-branched tree, it produces a stunning effect.

By positioning two spotlights halfway to three quarters up the tree, you may get both a spotlighting and a moonlighting effect. The dramatic effect can be achieved by aiming one light up and one light down; the year-round vegetation will conceal the light sources.

Use alongside: Spotlights

FIG.28: IMAGE OF MOON LIGHT

CHAPTER-4

LIGHT POLLUTION

IN LANDSCAPE LIGHTING

4.1 INTRODUCTION:

One of the lighting trends in modern lighting technology that is developing most quickly is outdoor lighting. These days, lighting for roads, illumination of scenery and objects, and advertising light are all quite popular. Environments become more appealing and welcoming with lighting and illumination. Additionally, enhanced lighting improves public safety. Many individuals were unaware that the use of outdoor lighting can be linked to harmful alteration of the natural levels of darkness of the night sky because of the benefits associated with illumination and negative connections with darkness. The term "light pollution" generally refers to this effect.

4.2 LIGHTPOLLUTION KEY POINT:

Increased levels of nighttime brightness, light trespass, or glare are just a few examples of how light pollution might seem. Nowadays, it is frequently feasible to observe that cities and towns are illuminated by a brilliant dome of light in the night sky. The effects of sky glow, glare, light trespass, and light clutter are getting worse every year as a result of the rise of illuminated outdoor areas. By directly lighting the atmosphere and by reflecting light from objects that have been purposely or accidentally illuminated nearby, light luminaries used for various purposes outdoors add to the amount of light pollution. The spectrum characteristics of the light source employed in a particular luminary, its position, and the manner in which it disperses light all affect how much light pollution is present (intensity distribution curve).

Due to lighting regulations and design guidelines for streets, parking lots, hospitals, campuses of colleges and universities, malls, and residential neighborhoods, light luminaries used in this type of application must emit the most desirable portion of their luminous flux downward into the lower half space (Fig. 1). Therefore, light pollution is not much impacted by this type of illumination.

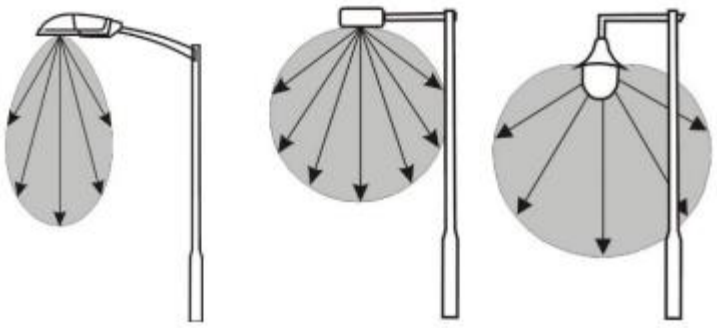


FIG.29: Examples of intensity distribution for typical outdoor luminaries where luminous flux mainly is emitted downwards

When lighting green spaces, such as landscapes, parks, and green roofs, where a place's appearance and aesthetics are crucial, there is another problem to consider. According to regulatory requirements, the designer may use any sort of luminary for lighting this type of location to produce the desired lighting result. Any kind of light intensity distribution curve is possible for luminaries. It is widely known that the luminous flux of a luminary should also be sent upward into upper half space in areas where it is anticipated that the lit environment would look more attractive. Additionally, it is well-known and shown in the literature that using luminaries where the light distribution occurs in the upper half of the space has a substantial impact on the development of light pollution in the area. Additionally, the amount of seasonal vegetation and the seasonal fluctuation in the colour of the landscape (measured in terms of its spectral reflectance factor) may have an effect on light pollution levels, and these factors will vary according to the season.

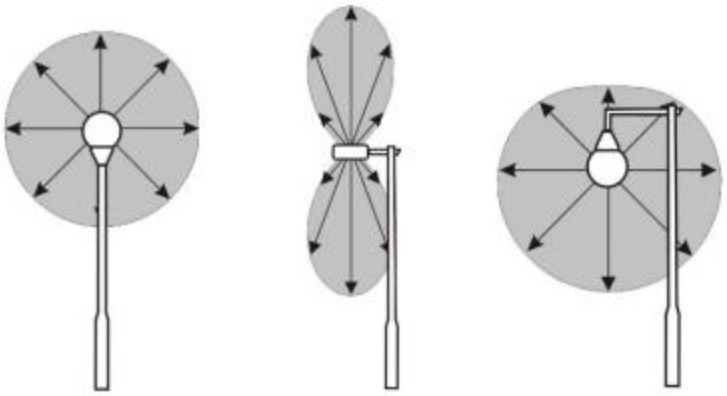


FIG.30: Examples of intensity distribution for typical outdoor luminaries where luminous flux is emitted downwards and upwards

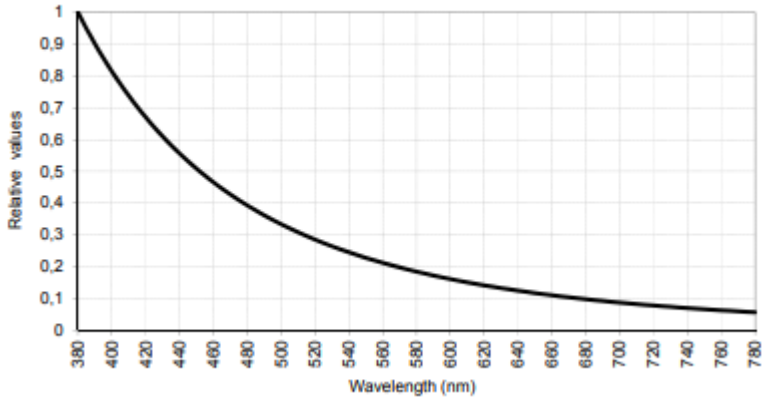
4.3 FACTORS WHICH ARE DESCRIBING LIGHT POLLUTION:

Numerous cited scientific articles that present various numerical models of artificial sky light are available. An understanding of atmospheric optics is necessary to comprehend the arithmetic underlying sky-glow prediction models. Direct light into the atmosphere from upward-directed or insufficiently protected sources, as well as light that has partially scattered back toward the earth after reflection from the ground or other surfaces, results in a diffuse glow that can be seen from a great distance. For particle sizes far smaller than the wavelength λ of light, the Rayleigh and Mie theories are used to describe molecular and aerosol scattering, respectively. The Mie theory eventually leads to the Rayleigh equation as particle size decreases. The dependence of the scattering on wavelength decreases as the molecular structure approaches and exceeds the size ofλ. As a result, Mie scattering is irrespective of wavelength λ while Rayleigh scattering is

significantly wavelength dependent. At a distance r, scattering of unpolarized light with intensity I_0 will occur, with the intensity I(θ) of the Rayleigh wave.

The scattering angle, which is not wavelength dependent, θ is represented by the symbol. It describes the volume of the particleϑ, n is the refraction index, and m is the number of scattering particles. All the variables in equation aside from I_0 andλ —retain their constant values under the same outdoor conditions. It is also possible to incorporate the angle θ dependence into the constant value defined by k because it is not wavelength dependent.

In actuality, Rayleigh scattering is reliant on factor λ^{-4}. (Spectral Rayleigh scattering factor)



GRAPH-1: Rayleigh scattering factor plotted as function of wavelength

Polychromatic light sources are employed in outdoor applications. By integrating the intensity spectrum over wavelength, it is possible to calculate the total dispersed light and quantify the visible sky glow caused by outdoor lighting. Because of this, the amount of light pollution is influenced by the type of light source utilized (specifically, the luminary's spectral power distribution, or SPD). As a result, the amount of light pollution will differ depending on the type of lamp utilized outdoors.

Rayleigh limiting sky glow indicate can be calculated also as photometric Φ parameter by weighting each spectral value by V(λ) photopic luminous efficiency function

This expression depends only on lamp spectral distribution and spectral Rayleigh scattering factor λ-4. Comparison of photometric Rayleigh limited sky glow indicate. This lamp spectral distribution and spectral Rayleigh scattering factor λ-4. Comparison of photometric Rayleigh limited sky glow indicate, for two different with SPDs light sources, can be done by:

4.4 IMPACT OF LIGHT POLLUTION IN FLORA AND FAUNA

Technology, particularly artificial nighttime lighting (ALAN), frequently has unanticipated environmental effects. Here discusses how different creatures perceive light as well as how ALAN affects flora and animals. The effects of light intensity, colour spectrum, illumination duration, and timing are broken down into separate categories in the reactions to ALAN. As varied as the environments they inhabit, so too are the ways in which species perceive light. The information from natural light is frequently hampered by ALAN. Rarely neutral, it often has major effects that go beyond what is perceptible to humans. Many creatures use information such as the direction of light or the reflection of UV light by reproductive plant parts as a means of communication or exploring. Even while adopting basic technical steps could increase the conservation of species, habitats, and economic well-being, contemporary lighting systems frequently lacks sustainable planning. It is highlighted as a serious trend the growing usage of ALAN with high intensities in the blue region of the spectrum, such as fluorescent light and LEDs. Larger vertebrates' principal circadian signal is blue light, which also has a significant effect on the orientation of many insect species. The first step further towards sustainable lighting should be to gain a better knowledge of how different artificial light kinds and sources affect organisms' perceptions of ALAN. Such information serves as the foundation for the creation of remedies to save biodiversity again from negative consequences of outdoor illumination.

4.5 RESPONSE OF LIGHT

Light is not neutrality; it is the principal energy source for the majority of primary producers and a key regulator of many psychological and physiological processes. It is a crucial signal for development, spatial movement, orientation, and communication, causing the formation of social structures and the transfer of energy through the food chain. Light-related reactions are complex and extremely species-dependent. By modifying trophic, social, and competitive interactions while obscuring seasonal and daily cycles, ALAN is employed improperly to threaten biodiversity and has the potential to change community makeup, ecosystem functions, and characteristics.

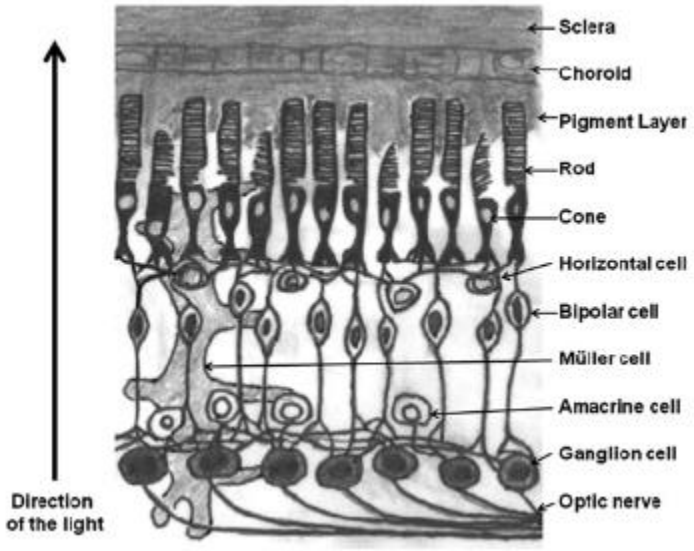


FIG.31: The inner eye of vertebrates is covered in the retina, a layer of light-sensitive neurons and receptors (Image illustrated by Sibylle Schroer)

4.5.1 RESPONSE IN PLANT

The stomata open and the chloroplasts move as a result of a plant's adaptation to its light environment, which changes how the plant grows. Phytochrome network signals, including as photoperiodic blooming induction, leaf maturity, and abscission, modify growth in response to periodic and seasonal needs. The germination of seeds, the lengthening of seedlings, the development, shape, and quantity of leaves, as well as the production of chlorophyll, is just a few of the additional reactions that it controls. The phytochrome system allows plants to compare the length of dark periods and grow out of the shadow and into the light (Keller et al. 2011). Light intensity, wavelength spectrum, and duration all affect how we react physiologically.

The corresponding day-lengths for plants with light-dependent floral induction are crucial. When the days are longer than their essential day-length, long-day plants produce flower buds. These plants bloom during the summer in northern latitudes. When the days are shorter than their essential day-length, short-day plants trigger flowering. In the northern hemisphere, they bloom in the spring or fall. Flowers develop on day-neutral plants regardless of the duration of the day. Instead of measuring the exact duration of light and darkness, long-day Arabidopsis adjusts its perception of day-length to the phase angle of circadian cycles in relation to the light-dark cycle.

4.5.2 RESPONSE IN ARTHROPODS

Arthropods employ visual cues to identify host plants, prey, and partners as well as to orient themselves and avoid predators. ALAN works like a vacuum because light attracts a lot of insects. It has the power to remove them from their native environment (Eisenbeis 2006). The variety of behaviors that insects exhibit around artificial light sources is attempted to be explained by a number of ideas. Their navigational habits are one factor. Through retinal pictures of the sky, its opto-motor system regulates the course. As long as the animal moves in a straight line, the retinal image does not change; however, as the animal rotates, the signal changes. Body movements that compensate for the disturbance that causes involuntary rotation can be used to stop it. The animal will rotate until its previous retinal image has been restored (Wehner 1984; Frank 2006).

Additionally, until the eye pigments have returned to their dark-adapted locations, an insect flying from artificial light into darkness or from darkness into light may be functionally blind. Aquatic arthropods like amphipods may be subject to similar mechanisms that influence both abundance and composition. Predator buildup is caused by the strong attraction of disoriented prey to ALAN sources. For instance, the bridge spider (Larinioides sclopetarius) is drawn to artificial lights in environments built by humans, which causes it to rapidly boost its reproductive activity when there is a periodic surplus of emerging water insects (Heiling 1999). However, nocturnal spiders differ in their capacity to profit from prey attraction to artificial light. The majority of orb spider species are rather light-sensitive, and some even require complete darkness to build their webs, such as the Silver-sided Sector Spider (Zygiella x-notata) and the Walnut Orb-Weaver Spider (Nuctenea umbratica) (Zschokke and Herberstein 2005).

The photoperiod frequently works in conjunction with other physical or biological background information in arthropods, just like it does in plants, including temperature, wetness, humidity, cues from food, and nonspecific density.

The key photoperiod for the initiation, maintenance, or termination of diapauses or for inducing migration varies by species and frequently depends on the origin of the species (Veerman 2001). It is believed that animals residing in the far north have a longer critical photoperiod than those living near the equator. According to Van Geffen et al. (2014), artificial light shortens the pupation period of the noctuid moth Mamestra brassicae, demonstrating that ALAN can prevent diapauses when the weather is favorable.

4.5.3 RESPONSE IN BIRD & REPTILES

There are numerous bird species that hold visual perception world records. The oilbird has been found to have the highest sensitivity to light in birds (Steatornis caripensis). The cave-dwelling bird breeds underground, where daylight is frequently denied and the bird only forages for fruit at night. The oilbird has the highest rod density of any vertebrate, with 1 million rods per millimeter. On the other side, with 380.000 cones per mm2, the brown falcon (Falcoberigora), a diurnal fast-flying raptor, holds the record for the density of cones in vertebrate eyes (Martin et al. 2004). The pectens in avian eyes decrease the retina's blood vessel density, resulting in sharper vision. Even in the lack of information from the eyes or related neurotransmitters, birds and reptiles are able to perceive illumination.

It is now widely known that ALAN caused the individual daylength in birds to extend. When stimulation from rising light intensities reaches a specific threshold, male birds probably begin singing at dawn. The timing of dawn song varies depending on the species because of this threshold. The beginning of the blackbird's (Turdusmerula) dawn song varies by up to five hours along an urban gradient that runs from an urban forest to the city centre (Nordt and Klenke 2013). The time it takes for singing to start before dawn increases by 1.5 to 2 minutes per lux (Da Silvaet al. 2014). Street illumination has an impact on the timing of morning song; this effect is largest in species that begin singing naturally earlier, such as the blackbird or robin (Erithacus rubecula), and is negligible in species that begin singing naturally later, such as the chaffinch (Fringilla coelebs)

ALAN disrupts the circadian rhythm of birds in urban agglomerations and suppresses melatonin even at low light levels (de Jong et al. 2016). Blackbirds (Turdus merula), robins (Erithacus rubecula), and big tits (Parus major) are recognised for beginning their morning singing earlier in the season, but blue tits (Parus caeruleus) begin their sunset singing earlier. In reptiles, a circadian entrainment to photoperiod was also noticed for the species Anolis sagrei's hatching synchronisation (Nash et al. 2015). The hatching times of the lone lizard eggs are coordinated in the early hours of the day. Males typically hatch after females. At this time, it is unknown how ALAN will affect this synchronization.

4.5.4 RESPONSE IN MAMMALS

Although eutherian mammals evolved visual and nonvisual photoreception capabilities, which are typical for nocturnal lifestyles, they were able to avoid the predominately diurnal predator activity in the Meso-zoic era, often known as the age of reptiles (Gerkemaet al. 2013). Therefore, it is believed that the fundamental evolutionary force behind mammals' nocturnal vision is the pressure of predation (Jacobs 2009). According to Hölker et al. (2010), the widespread use of artificial light has unanticipated consequences that are today endangering this significant evolutionary achievement. The majority of animal activity is nocturnal, crepuscular, or rhythmic. Some rodents, squirrels, and primates, including humans, are exceptions since they are primarily

nocturnal and have adapted their visual perception to daylight. The majority of nocturnal creatures, like armadillos and bats, have few cones. The animals become momentarily blinded by exposure to greater light as these can readily become saturated by light intensities exceeding 120 cd m2 (light level at twilight). Blue light stimulates the circadian response to light in higher animals, such as humans. The most efficient wavelengths are those near 480 nm. In comparison to the sensitivity of the greenish wavelength range at 555 nm, it is twice as sensitive at this wavelength. Melanopsin photoreceptors, not optical sensitivity, are what sense this circadian signal. Mammals are primarily nocturnal, which may have contributed to their predominantly dichromatic eyesight (Jacobs 2009). Primates also acquired the capacity to perceive the colour red. It is described how to use trichromatic eyesight to discover food for omnivorous animals (Vorobyev 2004). In some species, the males' vision remained dichromatic while the females evolved trichromatic vision (Jacobs 1994).

Mammals that live in temperate climates reproduce according to the seasons so that their young are born in the spring or summer, when their chances of survival are at their highest. Long-day breeders whose reproductive season is in the spring include species with brief incubation or gestation periods, like hamsters, and species with yearly cycles, like horses. Short-day breeders, like sheep and goats, which have gestation periods of about 5 to 6 months, breed in the fall. The relationship between photoperiod and reproduction is the pineal hormone melatonin (Gerlach and Aurich 2000). The direction of change, not the exact length of each day, determines the reproductive state. Rams that are continuously introduced to long and short days at intervals of one month maintain a high level of testicular function.

When revealed to ALAN instead of simulated midnight treatment, the night-active mouse lemurs (Microcebusmurinus) become less active and stop eating in order to adapt to seasonal changes. In order to acclimate to the long-day photoperiod, the core temperatures under exposure to ALAN are much greater at night and during the daytime resting period. It inhibits locomotion, especially in exposed microhabitats, perhaps as a result of increased predation danger. The diurnal mouse does not increase its activity during the lit hours, which results in decreased overall activity and a relatively untapped temporal niche that may encourage the invasion of alien species that are less sensitive to light. Extensive light exposure causes weight gain, even when caloric intake and physical activity are kept constant, according to several studies on mammals.

4.6 PARK ALLEY LIGHTING DESIGN RECOMMENDATIONS AND RULES

Technically there is almost lack of regulations concerning lighting of green areas. Lighting standard EN 12464-2 “Light and lighting” does not consist recommendation on lighting and illumination landscapes, parks and other green arears. This issue is described in the document CIE 115:2010 “Lighting of roads for motor and pedestrian traffic” and in this project designing parameters were derived from this CIE publication. The CIE distinguishes 6 lighting classes (P1 to P6) of the park

alley. The higher class in the rating needs higher illuminance. Due to CIE recommendations, depending on the class of lighting, illuminance on the parks paths should be no less than (2÷15) lx. Because only moderate pedestrian traffic (no bicycle and motor traffic) will take place on park alley under consideration it was assumed as lighting class P4. This means that the average illuminance on the alley should not be less than 5 lx. There is so many different ways for achieving design goal for this kind of places. It is possible to use any type of luminaire with any value of luminous flux, luminous efficacy, color temperature, color rendering and light intensity distribution curve. Commonly in lighting of residential green paths are used luminaries with the opal sphere lamp . This kind of luminaire distributed diffused light with almost uniform intensity which could be with good approximation described by equation . This luminaire luminous intensity will not vary with the view point of an observer and 50% of its luminous flux is emitted in upper half space and 50% is emitted in down half space.

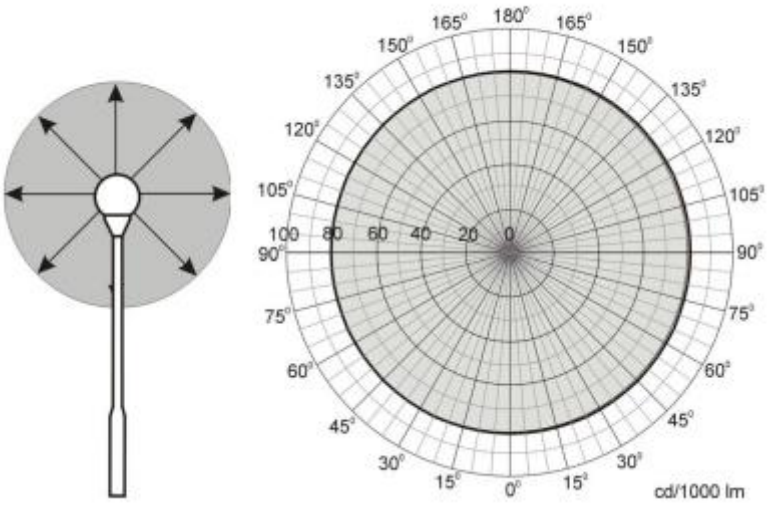


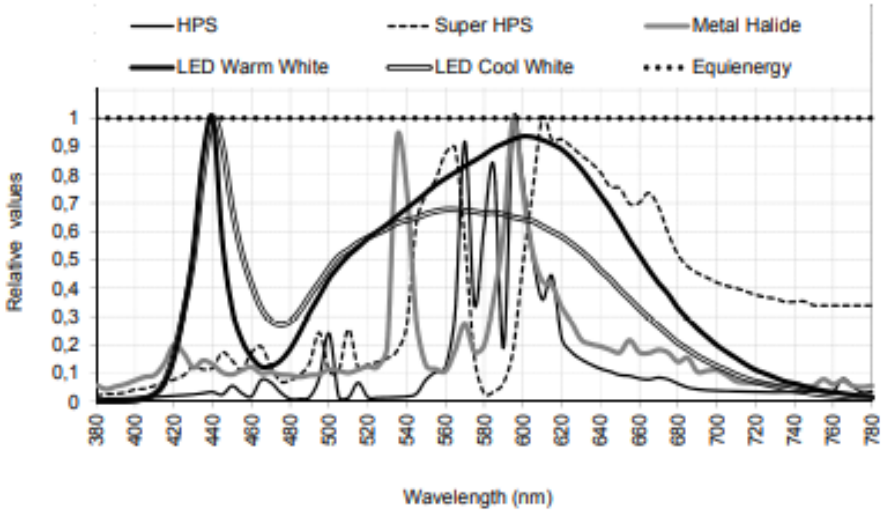
FIG.32: The opal sphere luminaries type intensity distribution curve example

In the last two decades we can notice the dynamic development of new, more efficient type of light sources

Light source type	Chromaticity coordinates		CCT	CRI	Efficacy
	x	y	[K]	-	[lm/W]
HPS	0.5217	0.4692	2071	20	380
Super HPS	0.4692	0.4079	2554	85	210
Metal Halide	0.4355	0.4100	3073	80	311
LED Warm White	0.4048	0.3894	3500	83	313
LED Cool White	0.3449	0.3528	5012	85	303
Equienergy	0.3333	0.3333	5455	95	180

TABLE-2: LIGHT SOURCES PARAMETER

We are not only witnessing the introduction of new, more efficient technologies, but also go to the history of the old solutions that have accompanied people through the last century [4, 5, 6, 7]. According to this fact we can see that High Pressure Sodium (HPS) lamps are replaced in outdoor applications by Metal Halide (MH) and Light Emitting Diodes (LED) lamp which are different with SPDs.



GRAPH-2: Spectral power distribution of contemporary light sources used for park alleys lighting

4.7 DESIGN OF PARK ALLEY LIGHTING

In order to analyze the impact of seasons (summer and winter), on the effect of light pollution there were create, with DIALux 4.12 software, virtual model of park alley. The dimensions of this alley are 65 m x 18 m. In this alley were located three types of trees. Provided by DIALux database Tree 01 has a crown in the shape of spheres, second (provided by DIALux database as Tree 04) is with truncated cone and the third (provided by DIALux database as Tree 02) in the shape of an ellipsoid. Modeled it was also hedge by using solid-shaped cuboids. In the ground of ally there is grass. Parameters of those objects are summarized in Table II.

The recommended by CIE 115:2010 intensity of illumination [lx] of this park alley was achieved by using of 3 typical opal sphere lighting luminaries, which were placed on height of 4 m above park ground. The luminous flux of those park lamps (7300 lm) is typical for this kind of park luminaries. In this design park alley were modeled for given seasons. Crowns of trees are modeled using blocks consisting of more than 150 elementary surfaces with possibility for changing for each particular value of total reflection factor. The light transmission factor for all the crowns of the trees and the hedge was assumed as 10%. During the summer (Fig. 6a) the ground alleys park is whole covered by grass with total reflectance factor equal to 15%. The crowns of the trees are green with total reflectance factor equal to 20%. In winter (Fig. 6b), it was assumed that the entire surface of the alley park is covered by snow with reflectance factor equal to 90%. It was also assumed that the crowns of the trees are covered partially by snow - half of their surface is 100% transparent, and other half reflects light by a factor 90% with zero transmission.

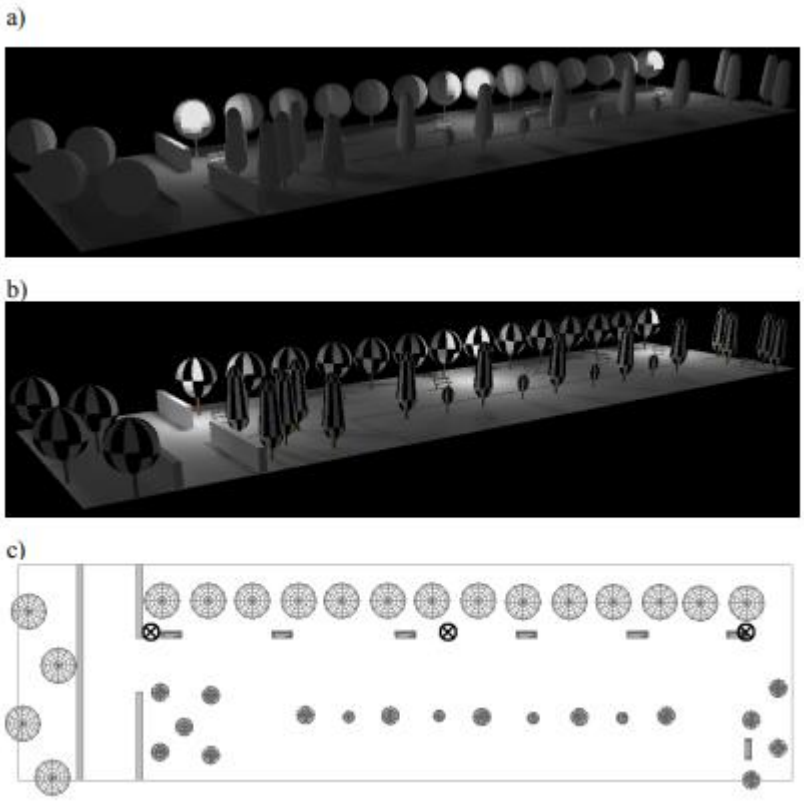


FIG.33: Park alley lighting computer simulation: a) summer season, b) winter season, c) map where location of objects is shown, where: : , , , - tree, Bench, Hedge, Lighting luminaries.

Object	Sign	Dimensions [m]			Properties				qty
		H [m]	B [m]	L [m]	ρ [%]		τ [%]		
					S	W	S	W	-
Tree 01		4.4	3.0	3.0	20	90	10	10	18
Tree 04		5.0	1.5	1.5	20	90	10	10	14
Tree 02		2.0	1.0	1.0	20	90	10	10	4
Hedge		1.5	0.5	*	20	90	10	10	3
H – height, B – width, L – length, ρ - reflection factor, τ - transmission factor, S – summer, W – winter, qty - quantity * there was used 3 types of hedges with varying length L (18, 7.4, 6.0) m									

TABLE-3: PARAMETERS WHICH ARE DESCRIBING PARK ALLEY GREENERY

4.8 RESULTS OVERVIEW

In order to illustrate the effect of the seasons on impact of light pollution, the calculations of illuminance above the park alley were performed on DIALux software. In agreement with publication "Outdoor site-lighting performance: A comprehensive and quantitative framework for assessing light pollution" by J.A. Brons, J.D. Bullough, and M.S. Rea, the computing grid was placed at a height of 10 m above the luminaries (in a parallel plane to the ground surface). The luminaries' luminous flux Φ was divided into two parts: upwards Φ_Λ and downwards Φ_V and to reflect the impact of the light reflected from the ground. Results given in Table III are calculated based on assumption that total light intensity E_m, taking into account the component of the direct $Em\Lambda$ (light intensity calculated on the grid where only the upper halfspace of luminous flux emitted by luminaries was taken into calculations) and E_{mV} (light intensity calculated on the grid where only the lower half space part of luminous flux emitted by luminaries, was taken into calculations). The value in Table III does not take into account the type of light source – its spectral power distribution. This is due to the specificity of DIALux.

Season of the year	$E_{m\wedge}$ [lx]	$E_{m\vee}$ [lx]	E_m [lx]	$\frac{E_{m\vee}}{E_m}$	$\frac{E_{m\wedge}}{E_m}$	$\frac{E_m}{E_{m(summer)}}$
summer	3.40	0.37	3.77	9.81%	90.19%	100%
winter	3.48	2.29	5.77	39.69%	60.31%	153%

TABLE-4: ILLUMINANCE LEVEL OF IILLUMINANCE GIVEN BY DIALUX, ON THE CALCULATION GRID PLACED 14 M ABOVE THE PARK GROUND

To comparing the relative amounts of scatter intensity from two different light sources, their SPDs must be first scaled into the same luminous flux by multiplying their wavelength intensity by the CIE (λ) photopic function. In order to determine the effect of the spectral characteristics of individual lamps the additional calculations were carried out, that also included (in determining the indirect component) reflective properties of the grass and snow (characterized by the spectral reflectance). The results of calculation, with assumption that Rayleigh scattering and lamp SPDs and luminous flux does not change with temperature, are presented in table IV. Due to the fact that the most popular light source used in outdoor luminaires is HPS lamp, data obtained in computer calculation were normalized to data obtained for HPS lamp in the summer. This allows to determine how lamp with different spectral characteristics installed in luminaires influences the effect of light pollution, depending on the season.

Light source	Season of the year	
	summer	winter
HPS	100%	166%
Super HPS	108%	175%
Metal Halide	112%	182%
LED Warm White	114%	185%
LED Cool White	120%	195%
Equienergy	122%	203%

TABLE-5: COMPARISON OF LIGHT POLLUTION CREATED IN SPECIFIED SEASON BY GIVEN LIGHT SOURCES IN RELATION TO VALUE FOR HPS LAMP

When lighting park alley by using MH, LED warm light and LED cool white lamp the factor describing light pollution is increased by 112%, 114% and 120% respectively compare to 100% for HPS lamp. Additionally the amount of light pollution created in the winter by high pressure sodium (HPS) lamp is 166% higher than in the summer.

CHAPTER-5

LIGHTING DESIGN

OVERVIEW OF STUDY AREA

5.1 LIGHTING DESIGN PROCESS

Light is a crucial component of vision, which is how we learn most of what is going on around us. A space's lighting configuration can produce particular conditions that can affect how we perceive things. The planning of our visual environment is known as lighting design. Aiming to provide us a sense of security and well-being while also enhancing the aesthetics of the surroundings, good lighting design strives to create conditions that can enable us to work effectively and orient ourselves safely in a space.

Both the qualitative and quantitative design elements are crucial for lighting design. Following a set of guidelines and standards created for the lighting design of diverse locations is how quantitative design is carried out. To provide optimal visual performance at reasonable operating costs, illuminance level, uniformity of light on a surface, glare, luminous color, and shadow quality are the primary issues here. A horizontal area is primarily illuminated uniformly in this type of design. Evidently, the quantitative lighting design standards for various areas vary, mostly based on the tasks carried out. The architectural integration of the area, optimal use of space, psychological needs of occupants, and color rendering are not given much consideration by quantitative design, despite the fact that it complies with approved standards. Here comes some high-quality lighting. It's not always true that more light is better light. Qualitative design takes into account brightness as its major criteria as opposed to illuminance, which merely characterizes the technical performance of a lighting installation. Brightness contrast ratios can be calculated for the entire area, whether they are used to compare the visual task to its circumstances, to specific items, or to the surroundings of an object in focus. Reflectance of surfaces, lighting setup, and material properties all need to be planned in tandem for luminance-based design. The necessary contrasts can be created not just by changing the lighting, but also by planning with the surrounding environment's color in mind. In order to keep the occupants' attention, it is important to design an atmosphere where the visual task or item of focus dominates the brightest area. While the luminance of the surrounding area is lower to prevent visual distraction, it nevertheless maintains a reasonable contrast level to allow the occupants' eyes to adjust to the brightness-contrast ratio.

In addition to taking into account the local architecture, good lighting also renders colors accurately; this is a crucial component of good design. When designing, the psychological needs of the occupants are taken into consideration, resulting in a more relaxing setting.

FIG.34: LAYOUT OF ECOLOGICAL PARK

- AUTOCAD LAYOUT:
  Obtaining and carefully studying the project's AutoCAD layout and elevation drawings in order to build regions with the proper proportions in the design software, which will allow suitable luminaires to be selected and placed in the best possible configuration. The floor layout and elevation plan of an apartment building are shown in the image below.

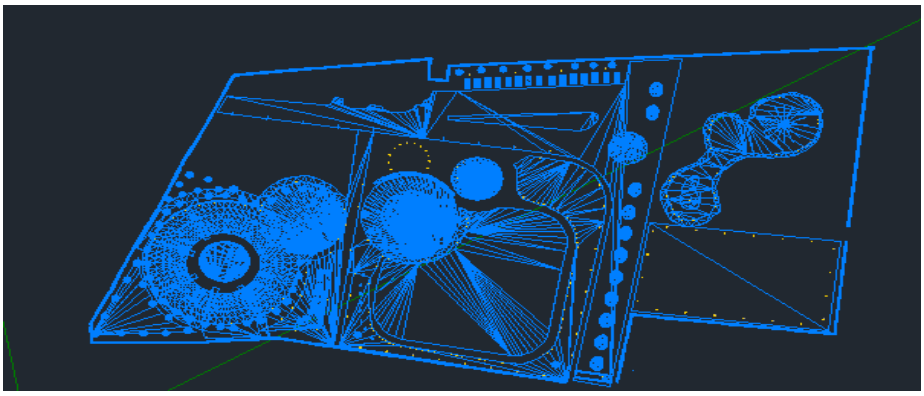


FIG.35: AUTOCAD LAYOUT OF AN AREA OF ECOLOGICAL PARK

- STUDY OF GUIDELINES:

  The study of pertinent codes and guidelines is crucial for producing an optimal design. This guarantees the proper level of design parameters as well as the visual comfort and safety of those who will be using those locations. For office lighting, for instance, IS3646: 1992 (Part 1 & Part 2) and Energy Conservation Building Code 2011 (ECBC) are adhered to. The recommended illumination level and homogeneity for the road surface are set forth in IS 1944 Parts 1 and 2 of 1970.

i. ENERGY CONSERVATION BUILDING CODE-2011(ECBC):

The Energy Conservation Building Code (ECBC) is a set of minimal standards for the design and construction of buildings and the systems inside of them. In India, the building industry uses roughly 33% of the nation's electricity, followed by the commercial and residential sectors at 8% and 25%, respectively. ECBC-compliant buildings are predicted to use 40 to 60 percent less energy than traditional structures, according to estimates based on computer simulation models. The mandated nationwide implementation of the ECBC is predicted to result in annual energy savings of roughly 1.7 billion kWh. Buildings or complexes of buildings with linked loads of 500 kW or more, or with contract demands of 600 KVA or more, are subject to the code. This category often includes structures or complexes with conditioned areas of 1000 m2 or more. ECBC provides two ways for calculating the power of interior lighting:

A. BUILDING AREA METHOD:

According to the kind of architecture, this approach outlines the process for calculating the total watts per square metre (Lighting Power Density) for the complete structure. To be in compliance, the total wattage of all lighting electricity for the building's various rooms cannot be higher. Finding the permitted power lighting density for the suitable building area types is the first step. Calculating the gross lit floor area types is the second stage. The allowable light power allowance is then calculated by multiplying the mentioned allowed watts per square metre for each building type by the corresponding lighted floor areas. The suggested Lighting Power Density (LPD) values by building area approach are shown in the table below.

Building Area Type	LPD (W/m^2)	Building Area Type	LPD (W/m^2)
Automotive Facility	9.7	Multifamily Residential	7.5
Convention Center	12.9	Museum	11.8
Dining: Bar Lounge/Leisure	14.0	Office	10.8
Dining: Cafeteria/Fast Food	15.1	Parking Garage	3.2
Dining: Family	17.2	Performing Arts Theater	17.2
Dormitory/Hostel	10.8	Police/Fire Station	10.8
Gymnasium	11.8	Post Office/Town Hall	11.8
Health care-Clinic	10.8	Religious Building	14.0
Hospital/Health Care	12.9	Retail/Mall	16.1
Hotel	10.8	School/University	12.9
Library	14.0	Sports Arena	11.8
Manufacturing Facility	14.0	Transportation	10.8
Motel	10.8	Warehouse	8.6
Motion Picture Theater	12.9	Workshop	15.1

TABLE- 6: LPD IN PARKING AREA

B. SPACE FUCTION METHOD:

Similar to the building area approach, the space function method's first step entails choosing the right building type and determining the permitted illumination power densities for that building type, which vary depending on the use of the space. The suggested values for LPD using the space function approach are shown in the table below.

C. LIGHTING SYSTEM STANDARDS FOR PARK DESIGN:

Plants are crucial to the garden landscape because they serve as its hair and create a gentle atmosphere. Plants are employed extensively and in a wide variety of plant species in urban landscape design. The vibrant colours and the symmetry of the plant landscape and sunlight can create some excellent aesthetic results. Many cities that use plants as the primary structural element to sculpt a three-dimensional landscape using light b right dots can be seen in the nighttime vertical terrain. A more detailed lighting landscape over the holidays to create cityscape characteristics. Lighting and lanterns decide on an LED lamp belt to encircle a plant as a model.

The design standard of landscape lighting for city parks and the standard for design of urban road lighting are:

Landscape lamp type		Lighting lamps			
		Power (W)	type	Height (M)	Spacing (M)
yard lamp	With masks	150	High pressure sodium lamp	3.5-4.5	18-20
	No mask	150	Sodium lamp and metal halide lamp	3.5-4.5	16
Lawn lamp		36 or 70	Sodium halide lamp	0.5-0.8	5-7
Floodlight		250	Metal halide lamp	-	-
Buried lamp		20	Sodium lamp	0.1-0.2	1.8-2

TABLE- 7: Design standard of landscape lighting for ecological parks

- Since each space is unique, each space also needs a particular kind of luminaire, mostly depending on its function. Naturally, the quantity is influenced by the work surface height and size.

level	Road type	Pavement luminance		Pavement illumination			Lamps and lanterns selection
		Average brightness (Cd/square meters)	Total uniformity	Longitudinal uniformity	Average illuminance	Evenness	
I	The main road (including the Yingbin Road, the main road leading to government offices and large public buildings, is located in the center of the city, behind the commercial center road)	1.5/2.0	0.4	0.7	20/30	0.4	Light cut or half light lamps and lanterns
II	Secondary roads	0.75/1.0	0.4	0.5	10/15	0.35	semi-cut-off lamps and lanterns
III	Access Rd	0.5/0.75	0.4	-	8/10	0.3	semi-cut-off lamps and lanterns

TABLE- 8: Standard for design of urban road lighting

- IMPORTANCE FOR LIGHTING DESIGN SOFTWARE:
  The software DIALux EVO and DIALux 4.12 are utilised for this project's illumination design. It's important to pay attention to the dimension unit in the AutoCAD drawing when importing the file into DIALux. The dimensions of an AutoCAD drawing are frequently different from what are stated in them because the drawing was not scaled properly. As a

result, an AutoCAD drawing needs to be examined to see if it is sized correctly, and if not, it needs to be scaled to the necessary dimensions.

5.2 DESIGN ON DIALux EVO:

Dialux Evo is a true special effects laboratory that allows for the experimental platform of real light effects and the associative use of the site, the building and its surroundings, and the isolated components. DIALux Evo is entirely intuitive, easy to use, and economical in contrast to many lighting software programmes.

The main benefit of DIALux Evo above its rivals is the cost savings, as it provides precise and thorough lighting studies in a professional manner and is totally free.

5.2.1 DESIGN PARAMETER IN CONSIDERATION:

- Deciding the category of area and task to be performed.
- Deciding the illuminance level and uniformity ratio required- Once the area type is decided, then by consulting IS 3646 and NLC and also IS1944 and keeping in mind the requirements of the client, required illuminance level and uniformity ratio for that area can be decided.

➢ Uniformity ratio - Uniformity of illuminance is measured as the ratio of minimum illuminance to the average illuminance over the task area. More the uniformity ratio, more uniformly is the light distributed over the surface without dark and light patches. A uniformity ratio of about 0.5 and above is usually acceptable.

- Finding out the dimension of the room. Once the dimensions are found out, then the type of lighting arrangement can be decided.
- Finding out the work plane height- An approximate work plane height of 0.76 is taken for some areas (usually ones involving table work), otherwise it is taken zero.
- Finding out the ceiling type- Depending on whether the ceiling is true ceiling or false ceiling, luminaires than can be used there is decided. Surface mounted or suspended luminaires are chosen for true ceiling. In case of false ceiling, recess mounted luminaires should be chosen.
- Selecting Maintenance Factor- Maintenance factor is chosen according to what is discussed with the client.

➢ Maintenance factor – Also known as **Light Loss Factor (LLF)**, it is the ratio of present illuminance for a given area to the value that would have occurred if the lamps had operated at their (initial) rated lumens and if no system variation or depreciation had

occurred. It is basically cumulative multiplication of some other factors like Lamp Lumen **Maintenance Factor (LLMF), Lamp survival Factor (LSF), Room Surface Maintenance Factor (RSMF) and Luminaire Maintenance Factor (LMF)**.

MF= LLMF * LSF * RSMF * LMF

Where,

- **RSMF (Room Surface Maintenance Factor)** takes account of the effect of dirt and dust accumulation and other degradation of the reflectivity of room surfaces. The main determining factor is the environment which can be classified on a scale of Very Clean to Dirty.
- **LMF (Luminaire Maintenance Factor)** takes account of the effect of dust and dirt accumulation on the luminaries. Luminaries are classified according to their degree of protection from dust and moisture, so dust accumulation on an open up light is more than on a sealed light.
- **LSF (Lamp Survival Factor)** takes account of the effect of the failure of light sources during the maintenance period.
- **LLMF (Lamp Lumen Maintenance Factor)** takes account of the effect of the lumen depreciation of the light sources during the maintenance period.

E maintained= E initial x Maintenance Factor

Where,

E maintained: maintained illuminance at working level

E initial: Initial lumen from luminaire.

I. Selecting the luminaire- According to the task to be performed, illumination level required, type of ceiling, and protection required from dust, moisture, heat, chemical, etc, the luminaire is chosen.

II. Finding out the number of luminaires required- The number of luminaires required to achieve the desired average illumination level for an interior is calculated by the Lumen method using the formula:

$$N = (L*B*E) / (n* \phi *MF*UF)$$

Where,

N= Number of luminaires

L= Length of area in m.

B= Width of area in m.

E= Average maintained horizontal illumination level in lux

n= Number of lamps per luminaire

ϕ= Lumen output of Lamp in Lumens

MF= Maintenance Factor

UF= Utilization Factor

- The Utilization factor or Coefficient of Utilization (COU) of a luminaire is the percentage of the light emitted by the light source, which contributes to illuminance on a surface. This factor takes into account the direct as well as indirect component of light, so it is dependent on the shape and size of the room, mounting height and also the reflection properties of the surroundings.

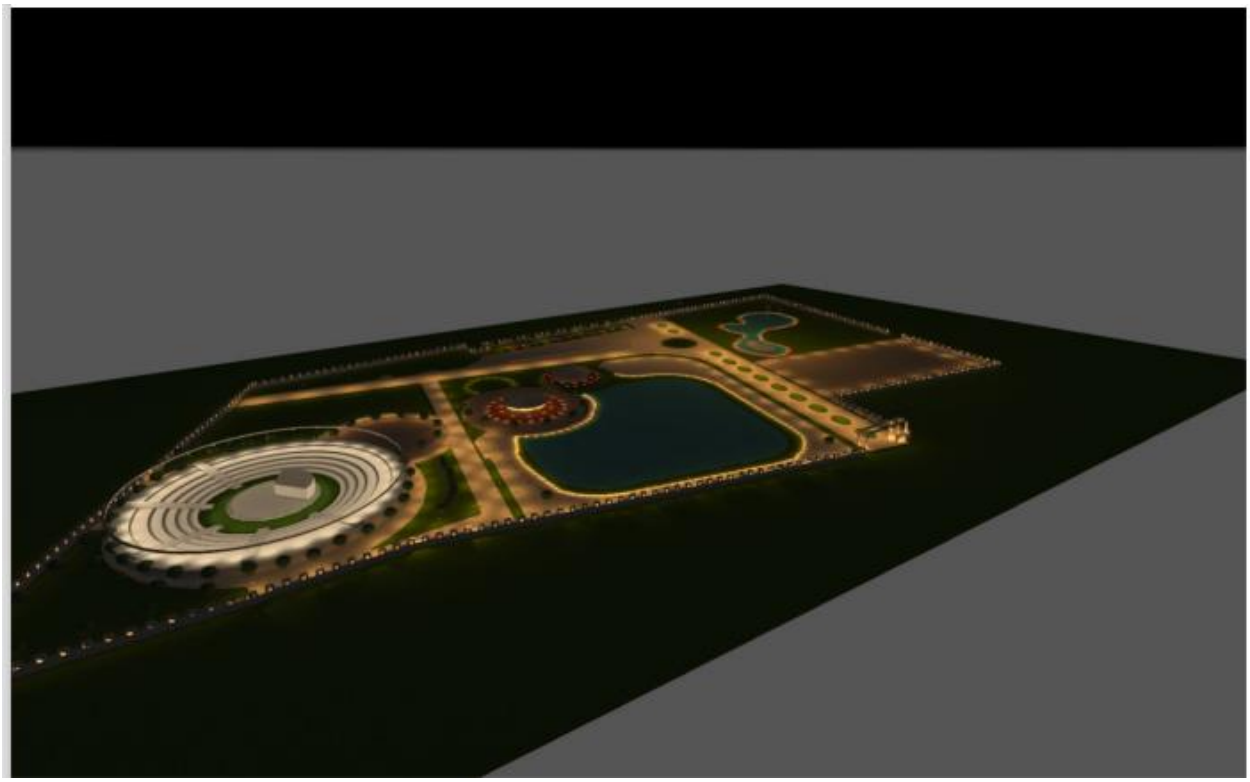


FIG.36: ILLUMINATION DESIGN OF AN AREA IN DIALux SOFTWARE

- ANALYSIS OF RESULT:
  The client receives the finished product. If the design does not meet the customer's needs and standards, or if the client requests any adjustments, a review is conducted and redesigning is carried out until the criteria are satisfied and the customer is satisfied.

CHAPTER-6

KOLKATA ECO PARK-

ISSUES AND PROBLEMS OF EXISTING LANDSCAPE LIGHTING

6.1 INTRODUCTION

A 42-hectare (100-acre) water feature with an island is part of the complex, which spans an area of 194 hectares (480 acres). The Biswa Bangla Convention Center, one of the biggest convention centres in the nation, has been constructed to the north of the site, which is located to the east of the Central Business District (CBD).

The Eco-master Park's plan was created with the goal of striking a balance between the park's requirement to help the surrounding area ameliorate some of the negative effects of urbanisation and its function as a city-level recreational open space. A robust, self-sustaining eco-system was created with the help of the Eco-Park.

6.1.1 VIEW OF ECO PARK

FIG.37: LAYOUT CAPTURE BY THE DROWN

FIG.38: FOUNTAIN SHOW VIEW

FIG.39: PATHWAY LIGHT VIEW

FIG.40: DIFFERENT LIGHT VIEW

6.2 VARIOUS ZONES OF ECO PARK

- BUTTER FLY GARDEN
- CHILDREN'S PARK
- ECO ISLAND
- FOOD COURT
- FLOWER GARDEN
- HERBAL GARDEN
- MASK GARDEN
- MUSICAL FOUNTAIN

- ROSE GARDEN
- SEVEN WONDERS
- SCULPTURE GARDEN
- HARINALAYA PARK
- PARKING AREA
- REST ROOM
- DIFFERENT SHOP STALL
- GRASSLANDS
- BAMBOO GARDEN

ETC.

6.3 LAYOUT OF THE ECO PARK

FIG.41: DIFFERENT AREAS OF ECO PARK LAYOUT

6.3.1 LOCATION OF ECO PARK:

The Eco Tourism Park is located in the Action Area- II of New Town along the Major Arterial Road, which is a part of Biswa Bangla Sarani. The park is situated at an approximate distance of 10km from Netaji Subhash Chandra Bose International Airport and is very well connected with VIP Road and EM Bypass.

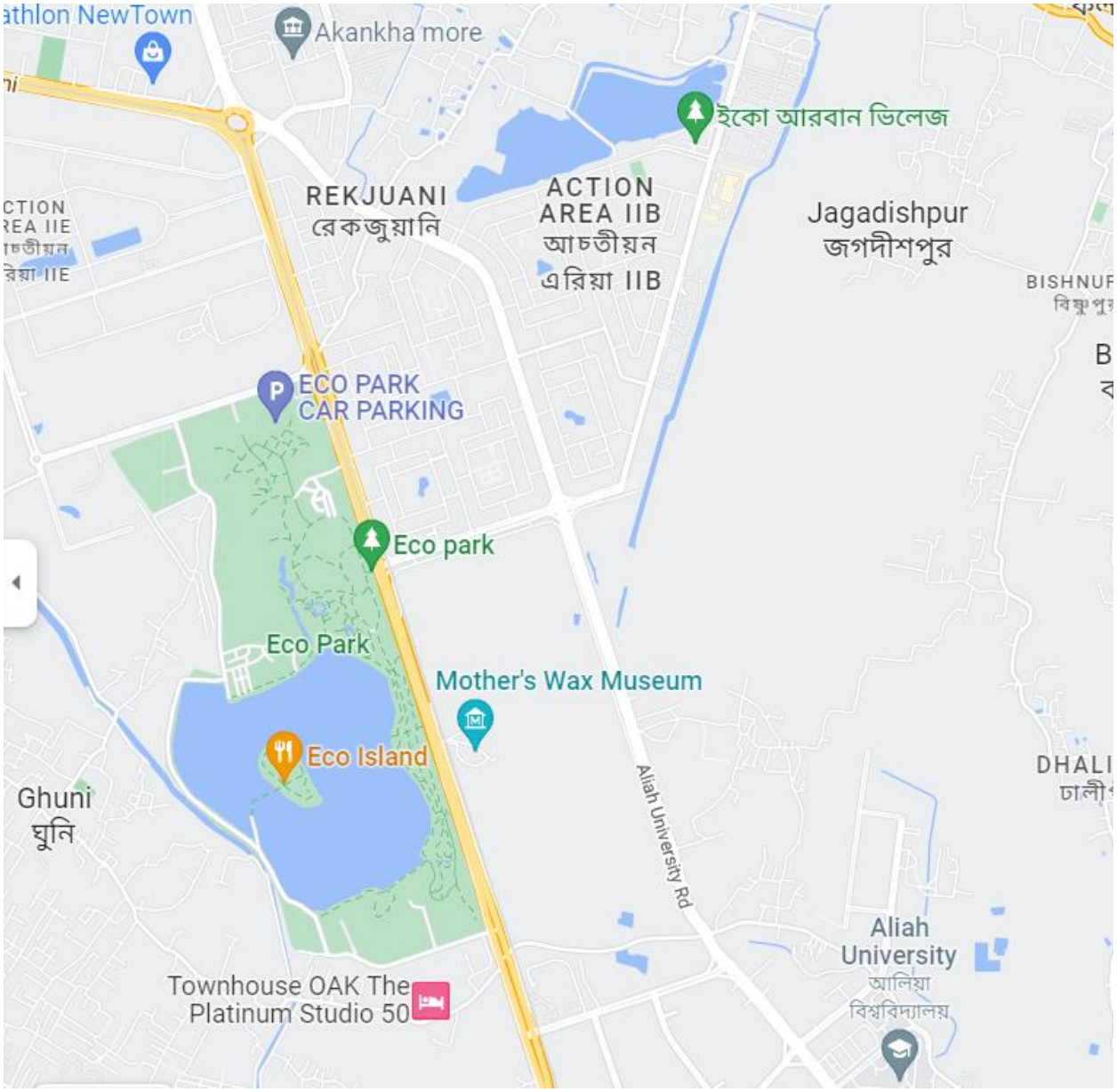


FIG.42: ECO PARK POSITION IN GOOGLE MAP

6.4 DIFFERENT ZONE OF LIGHTING ANALYSIS

In ECO PARK there are various zones. There are so many area can be considered, but some part of the park is in consideration.

1. Entrance plaza
2. Parking lot
3. Amphitheater
4. Visitor center
5. Pathway
6. Water garden

6.5 LIGHTING ISSUES IN ECO-PARK

6.5.1 Entrance plaza-

The park officials have chalked out an array of recreational activities that visitors can choose from depending on their requirements or interests. Lined by coconut trees all around, the lakefront promenade is a paved path used by the daily morning walkers.

Here bright high wattage light is installed, which occurs Light Pollution started becoming an issue just as recently. Increased sky glow is making it especially difficult for stargazers and professional astronomers to study our night sky. Though, steps have been taken to reduce our overall energy consumption, light pollution has increased globally and continues to be a problem.

In the Entrance Plaza there are so many lights installed there, which occurs light pollution,-

- Global light pollution is a problem. This was made abundantly clear when the World Atlas of Night Sky Brightness was published. Studies have shown that animal behaviors like migration patterns, wake-sleep schedules, and habitat development are all being impacted by light pollution
- Sea turtles and birds using the moonlight to guide them during migration become disoriented, lose their route, and frequently perish as a result of light pollution.
- Numerous insects, a major source of food for birds and other animals, are attracted to artificial lights and promptly killed upon coming into contact with them. This has an impact on birds as well, so several cities have implemented the "Lights Out" programmed to turn off building lights when birds are migrating.
- Excessive brightness, or glare, can be uncomfortable for the eyes (for example, when driving).

FIG.43: EXSISTING LIGHT OF ECO PARK ENTRANCE

6.5.2 PARKING LOT AREA

The outdoor lighting that is frequently put on poles and situated in parking lots and driveways is known as "parking lot lighting." The most common feature of this sort of outdoor lighting, which is used to provide illumination to areas for car and pedestrian use, is that the light fixtures are mounted to poles. Products with the FEMP designation include several types of external

luminaries, industrial high-bay luminaries, interior fluorescent luminaries, and ballasts. Parking lots are illuminated using FEMP-designated luminaries and other measures that balance energy savings and lighting quality. The first step in energy-efficient parking lot lighting is choosing energy-efficient equipment, such as FEMP-designated equipment.

In previous design lighting for parking lots poor lighting increases the risk of robberies, automobile break-ins, accidents, and injuries, Security cameras may not function as well in low light. Even if a business is operating late, a gloomy parking lot makes it appear closed. A friendly welcome is created for clients, crime is deterred, safety is enhanced, and potential lawsuits are avoided.

In the parking lot there are so many lights used there, which occurs excess light, makes light pollution-

- Maintaining a clear night sky is a top objective for the National Park Service (NPS). Approximately 100 parks have been monitored by the NPS Night Skies Team for night sky brightness, and nearly all of them revealed evidence of at least some light pollution.
- Manufacturers have developed and created high-efficiency light sources that save energy and lessen light pollution to control outdoor lighting.
- Sky glow is the brightening of the night sky, usually above urban areas, as a result of electric automobile lights.

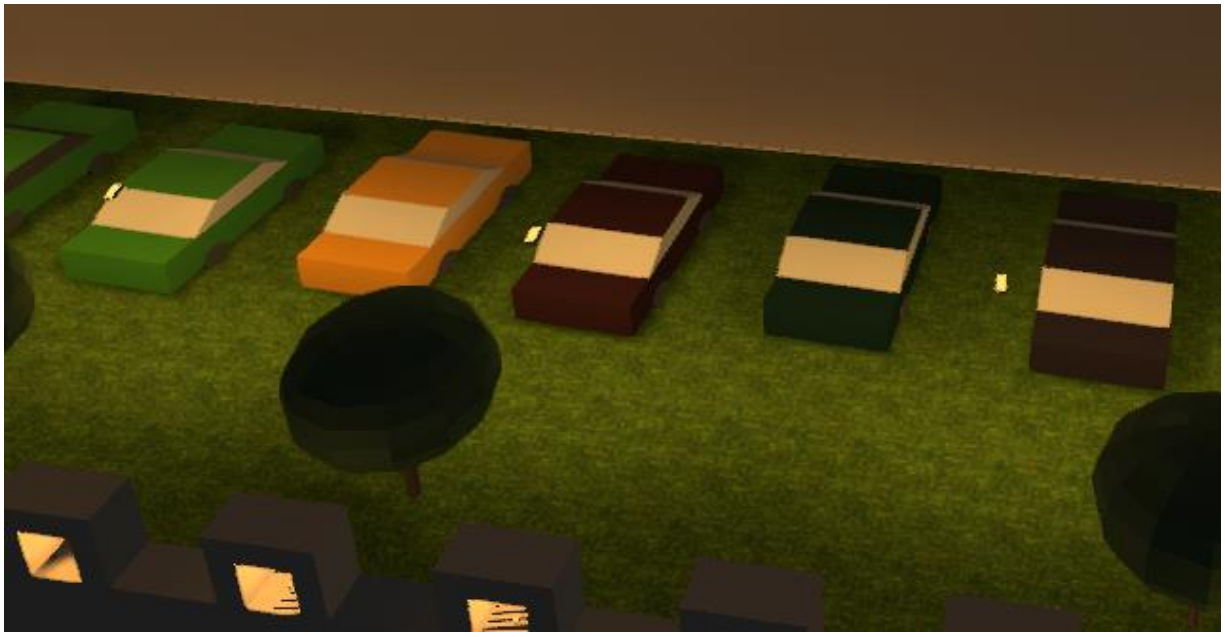


FIG.45: EXSISTING LIGHT OF ECO PARK PARKING LOT

6.5.3 AMPHITHEATRE

A vast open space encircled by upward-sloping rows of seats is known as an amphitheatre. During the Greek and Roman eras, plays were mostly performed in amphitheatres. A modern amphitheatre is a curving, semicircular, or circular performance area that is outside and has a lively acoustics. Modern amphitheatres frequently have standing objects called band shells, which can be curved or bowl-shaped and are placed both while behind stage and behind the audience. These band shells create an area that echoes or amplifies sound, making the amphitheatre perfect for musical or theatrical performances. Small-scale amphitheatres can be used to hold outdoor entertaining performances.

Up light creates the light pollution, which can have negative effects on our biological clock and can impede sleep cycles which can lead to sleep disorders, anxiety, and increased cranial pressure, such as what happens with migraines. Melatonin, which is the hormone that regulates sleep patterns, is seriously affected by light pollution. Not only that, but light pollution can be a direct contributor to environmental cycles in nature.

In the amphitheater or open theater there lights distribution are unevenly placed, which occurs un-uniform light, makes light pollution-

- Noticed that the lux level along the edge was low, while the lux level directly beneath the lights was extremely high (direct sunlight) (moonlit night).

- The significant variation in the measured lux levels shows that the installed lighting fixtures cannot produce lighting that is enough to assure safety throughout the podium.
- In addition, the close proximity of the sitting area to the high intensity LED lighting results in light disturbance, which has a negative impact on building occupants' health.
- Additionally, it obstructs views of the moon and stars in their natural habitats. When planning suitable lighting designs, uniformity ratios are just as crucial as lux levels.
- This has an impact on birds as well, so several cities have implemented the "Lights Out" programme to turn off building lights when birds are migrating.
- Spot lights make glare and Bright, jumbled, and overly numerous collections of light sources are clutter.

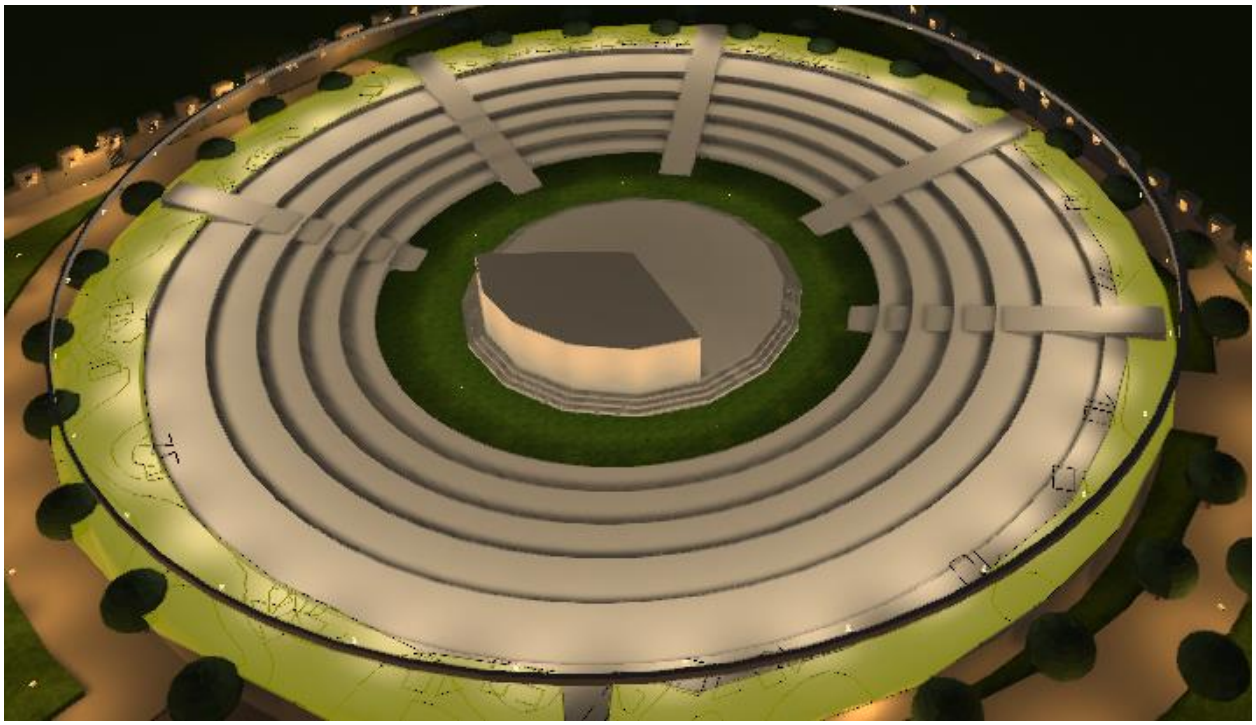


FIG.48: EXSISTING LIGHT OF ECO PARK AMPHITHEATRE

6.5.4 VISITOR CENTER

The Visitor center, which overlooks the flower lake, was constructed with the idea that people with creative tendencies needed a peaceful place to sit and produce the artwork of their choice. The rose garden, which is located behind the artists' home, creates a lovely aura that is ideal for a romantic setting. The Artists cottage that overlooks the lake and melodic fountains is directly

across from the Adda zone. As the name implies, there are benches arranged here where people can chat casually and engage in debates about many subjects.

In the visitor center there high wattage lights distribution are placed in downward, which occurs light pollution-

- People are advised to only use outdoor lighting when and where it is necessary, to make sure outdoor lights are properly protected and directing light downward rather than upward, and to close window blinds, shades, and curtains at night to keep light inside.
- About 100 parks were monitored by the Night Skies Team for the brightness of the night sky, and almost all of them had light pollution of some kind.
- LEDs are the kind of bulbs that have gained popularity for park and city lighting due to their low cost and high energy efficiency.
- The creation of animal habitats, migration patterns, and wake-sleep schedules are all impacted by light pollution.

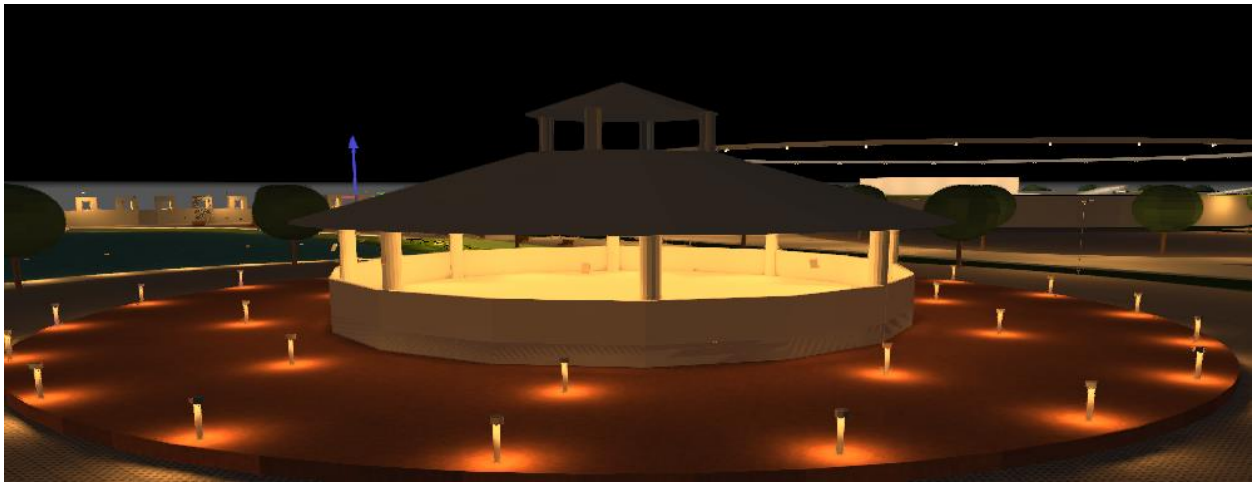


FIG.51: EXSISTING LIGHT OF ECO PARK VISITOR CENTER

6.5.5 PATHWAY

The landscape path lighting is to only be able to see the light's result, not the actual source of light. Path lighting is an exception because it's meant to be aesthetically pleasing and on display. Lighting at night has developed a unique status all its own. With the proper landscape lighting, gardens, backyards, or even more basic outdoor areas can look even lovelier at night, or they can appear darker and duller. With the proper outdoor LED lights and backyard lights put at these

locations, you not only ensure that your place is safe and secure but also that the illumination of outdoor spaces is attractive to the sight.

So many different lights are used, which occur light pollution-

- One hundred parks were being monitored by the Night Skies Team for night sky brightness, and almost all of them showed evidence of light pollution.
- When light enters an area where it is not wanted or needed (such as a streetlight illuminating), this is known as light trespass. To prevent light trespass, make sure that lights are shielded properly, that light is directed downward rather than upward, and that window coverings—including blinds, shades, and curtains—are closed at night.
- So many lights are used here so high illuminance occurs, which means high power consumption. That's high lux will be generated. And somewhere non-uniform light gets in the pathway.

FIG.55: EXSISTING LIGHT OF ECO PARK PATHWAY

6.5.6 WATER GARDEN

The Formal Garden was created using a combination of inventiveness and cutting-edge concepts, and it is based on the idea of vertical growing in a flat landscape. Visitors can frequently learn a thing or two from here about how to plan their own backyard gardens. This garden is situated halfway between the visitor centre and a playground. Task, ambient, security, and feature lighting all have a role to play in effective outdoor lighting design when it comes to choose the ideal outdoor lights for your plan. Our outdoor places become more significant the more we use them.

Typically, lights are buried beneath ponds to cast light upward. They are ideal for highlighting any fish and help a pond come to life at night.

- Aquatic ecosystems are structured by natural light. Light intensity and spectral range both decrease with increasing water depth.
- Thus, light pollution modifies the regular exposures of aquatic creatures to intensities, colors, and frequency.
- Additionally, the amount of light has an impact on the survival of many aquatic species. Feeding, schooling, and migratory in radiated fin fish are dependent on particular light intensities.

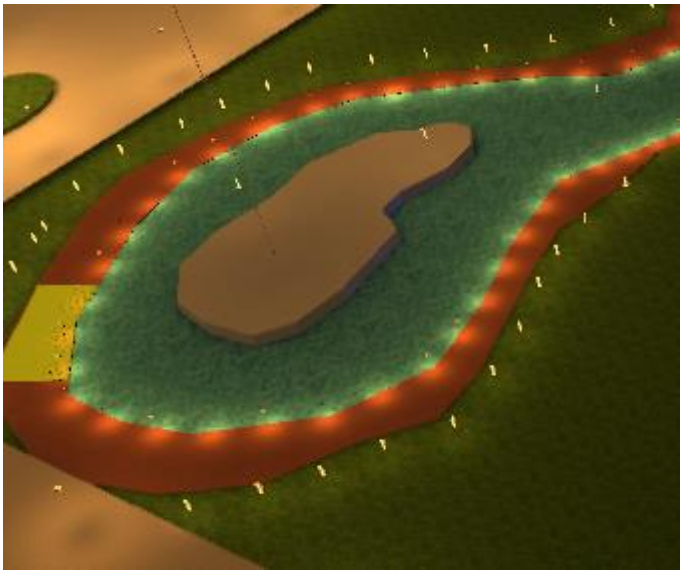


FIG.59: EXSISTING LIGHT OF ECO PARK WATER GARDEN

CHAPTER-7

KOLKATA ECO PARK-

ISSUES AND PROBLEMS OF EXISTING LANDSCAPE LIGHTING

7.1 DESIGN DETAILS & ITS COMPARISONS

Outdoor lighting can give your business or home that aesthetic appeal that is not only impressive, but also allows for well lit, secure property. However, there is concern when it comes to how bright landscape lighting should be. Due to their otherwise hectic schedules, people come to places like Eco Tourism Park as a respite from the usual mundane, which they find rather peaceful and relaxing.

1. Entrance plaza
2. Parking lot
3. Amphitheater
4. Visitor center
5. Pathway
6. Water garden

7.1.1 Entrance plaza-

The park officials have chalked out an array of recreational activities that visitors can choose from depending on their requirements or interests. Lined by coconut trees all around, the lakefront promenade is a paved path used by the daily morning walkers.

PROPOSED LIGHT- In past there is too much light in the entrance part, Brightness that is too much or too unpredictable, specifically for those with neurological conditions, can be incapacitating or uncomfortable and Clusters of lights that are too many and could distract cars and aircraft, which could lead to accidents. Because spotlights can invade neighbor's privacy and comfort when they beam through windows or over a fence, this specific sort of light pollution can be a serious issue with landscape lighting, An inappropriate placement or use of lighting, such as that found with flashing spotlights, floodlights, motion detectors, and electronic billboards. A cityscape that exudes an excessive amount of light overall. So, we have to set the design where we have to propose the light has to be fewer glares, less illuminant, less light cutter and sky glow. Not only that, but light pollution can be a direct contributor to environmental cycles in nature.

FIG.44: PROPOSED LIGHT OF ECO PARK ENTRANCE

7.1.2 PARKING LOT AREA

The outdoor lighting that is frequently put on poles and situated in parking lots and driveways is known as parking lot lighting. The most common feature of this sort of outdoor lighting, which is used to provide illumination to areas for car and pedestrian use, is that the light fixtures are mounted to poles. Products with the FEMP designation include several types of external luminaries, industrial high-bay luminaries, interior fluorescent luminaries, and ballasts. Parking lots are illuminated using FEMP-designated luminaries and other measures that balance energy savings and lighting quality. The first step in energy-efficient parking lot lighting is choosing energy-efficient equipment, such as FEMP-designated equipment.

PROPOSED LIGHTING-

To get a proper lighting in parking lot, some things needs to be in consideration—

- Dark spaces make you look thinner.
- Your sunglasses look even cooler in low light.
- Creepy shadows help you hide from the paparazzi

Common (HID) lamp wattages used for parking lot and area light fixtures range from 100 watts to 1000 watts. The higher the wattage, the higher the light output. Maintenance costs are often a big

concern for outdoor lighting applications such as parking and area light fixtures. In addition to the potential lamp lifetime concerns, parking and area lights often require the use of a bucket truck or lift to change out a lamp or ballast because they are often on poles in excess of 15 feet high. Choosing smarter lights can lower your energy consumption by up to 90%. Lamps can degrade as much as 40% over just a few years, which make them operate less effectively. So, it's important to upgrade them regularly.

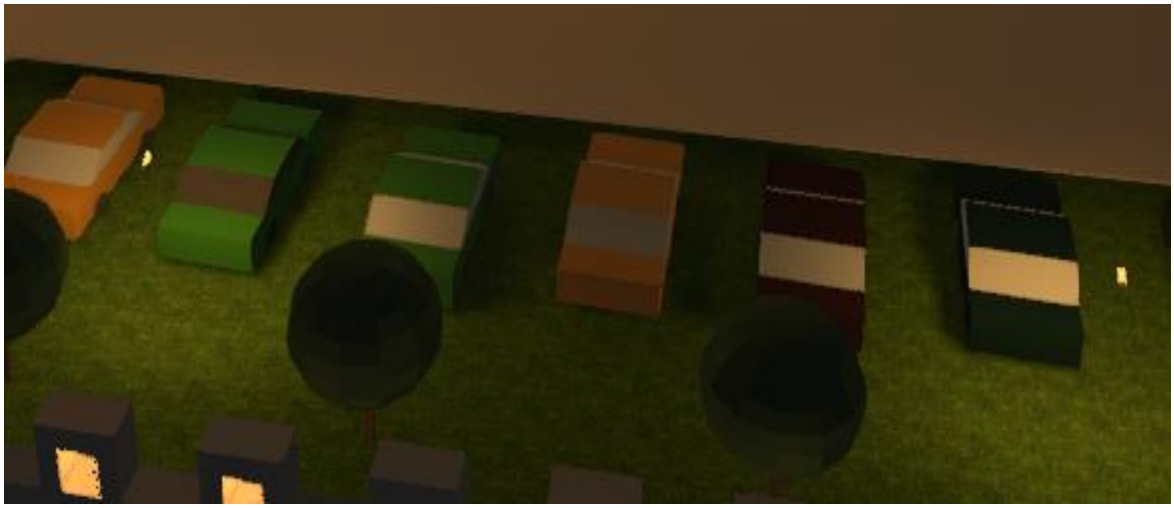
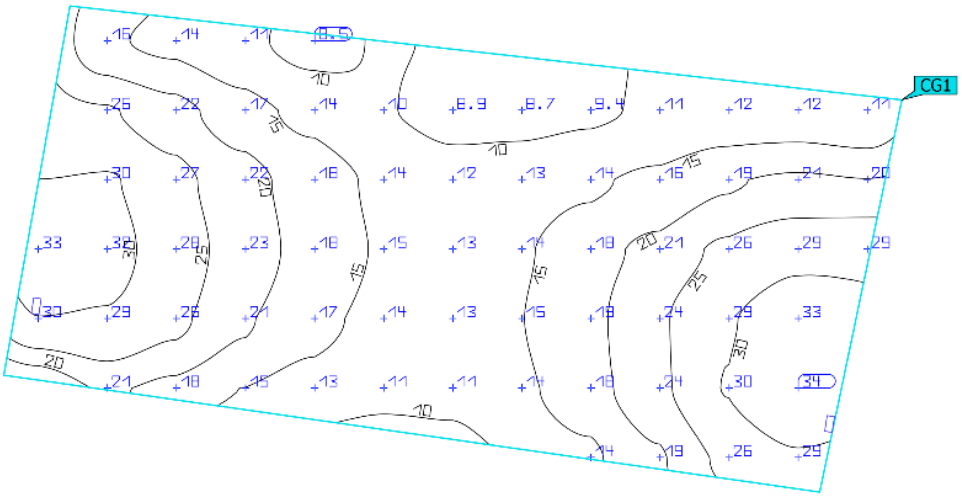


FIG.46: PROPOSED LIGHT OF ECO PARK PARKING LOT



Properties	Ē	E_{min}	E_{max}	g_1	g_2	Index
STREET AREA Perpendicular illuminance Height: 0.600 m	19.1 lx	8.45 lx	33.9 lx	0.44	0.25	CG1

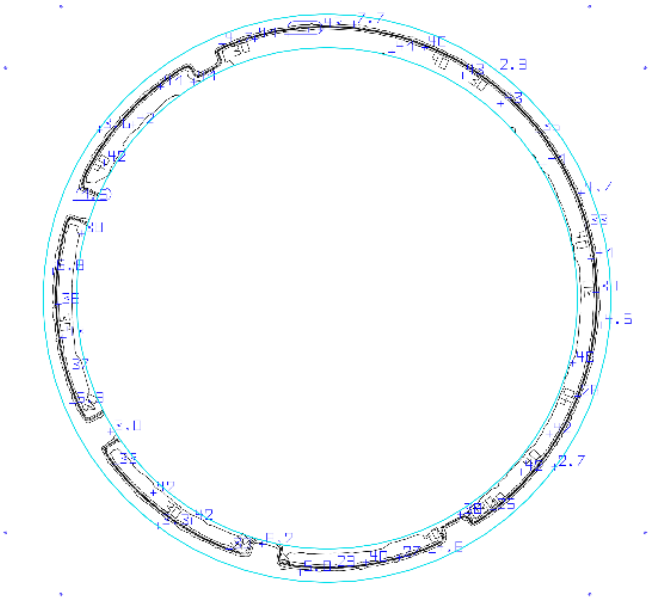
FIG.47: ISOLINE CURVE OF ECO PARK PARKING LOT

7.1.3 AMPHITHEATRE

A vast open space encircled by upward-sloping rows of seats is known as an amphitheatre. During the Greek and Roman eras, plays were mostly performed in amphitheatres. A modern amphitheatre is a curving, semicircular, or circular performance area that is outside and has a lively acoustics. Modern amphitheatres frequently have standing objects called band shells, which can be curved or bowl-shaped and are placed both while behind stage and behind the audience. These band shells create an area that echoes or amplifies sound, making the amphitheatre perfect for musical or theatrical performances.

PROPOSED- As up light creates light clutter and light trespass, which means light pollution can be a real problem with landscape lighting because it interferes with neighbors' privacy and comfort when spotlights shine through windows or over a fence. And sky glow occurs which causes the problem for person and audience. With down lighting and minimizing up lighting only in our designs, we believe we are taking steps to be Dark Sky Friendly.

FIG.49: PROPOSED LIGHT OF ECO PARK AMPHITHEATRE



Properties	Ē	E_{min}	E_{max}	g_1	g_2	Index
Surface result object 10 (Furniture) Perpendicular illuminance (adaptive) Height: 2.315 m	24.3 lx	0.61 lx	45.6 lx	0.025	0.013	RS10

FIG.50: ISOLINE CURVE OF ECO PARK AMPHITHEATRE

7.1.4 VISITOR CENTER

The Visitor center, which overlooks the flower lake, was constructed with the idea that people with creative tendencies needed a peaceful place to sit and produce the artwork of their choice. The rose garden, which is located behind the artists' home, creates a lovely aura that is ideal for a romantic setting. The Artists cottage that overlooks the lake and melodic fountains is directly across from the Adda zone.

PROPOSED- Here vast of direct light is used before, so this occurs large number of problem in human as well as in animal, direct light occurs glare, which is excessive and uncontrolled brightness that can be disabling or uncomfortable especially for people with neurological disorders. The illumination of exteriors gives outdoor areas and façades vitality. Exterior lights can alter how you perceive and comprehend a structure or walkway, whether they are used for security, landscape, or dramatic effect. Although external lighting may be the domain of a landscape architect, it's critical for all types of architects to comprehend how outdoor lights can complement a building and its wider location. Inspiring and intriguing places can be made by architects by utilizing contrast and shadows and an awareness of the interaction between light

and dark. Establishing the primary design goal—to define essential elements, add drama to surfaces that don't often stand out, or simply to create a clear path—is the best place to start when thinking about external lighting. So as proposal comfort illuminate indirect light is use to reduce neurological disorder, also it occurs good ambience for the people.

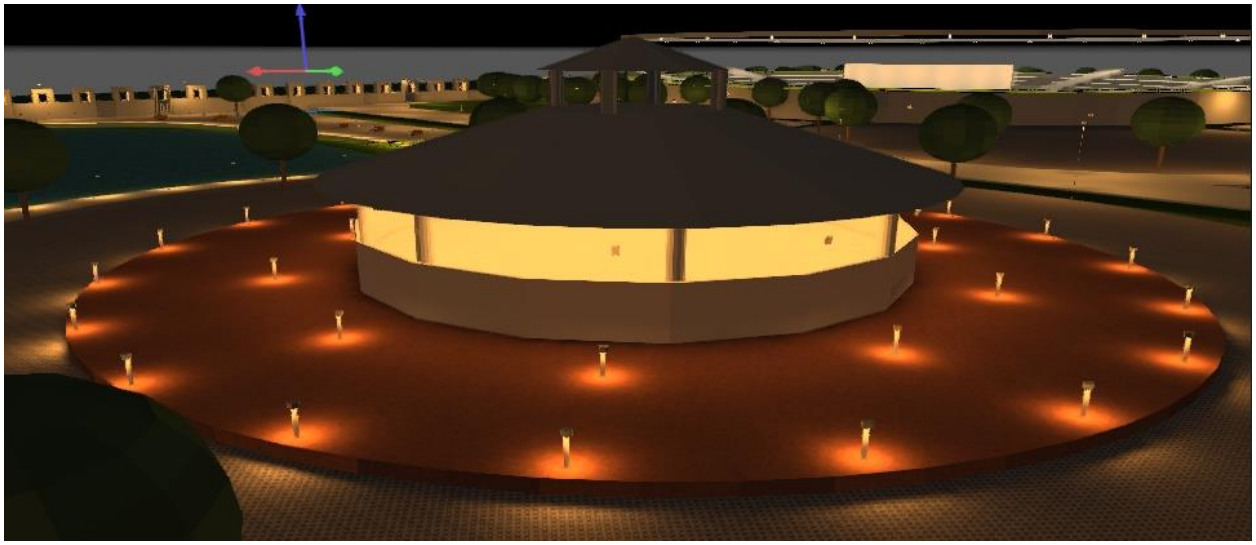
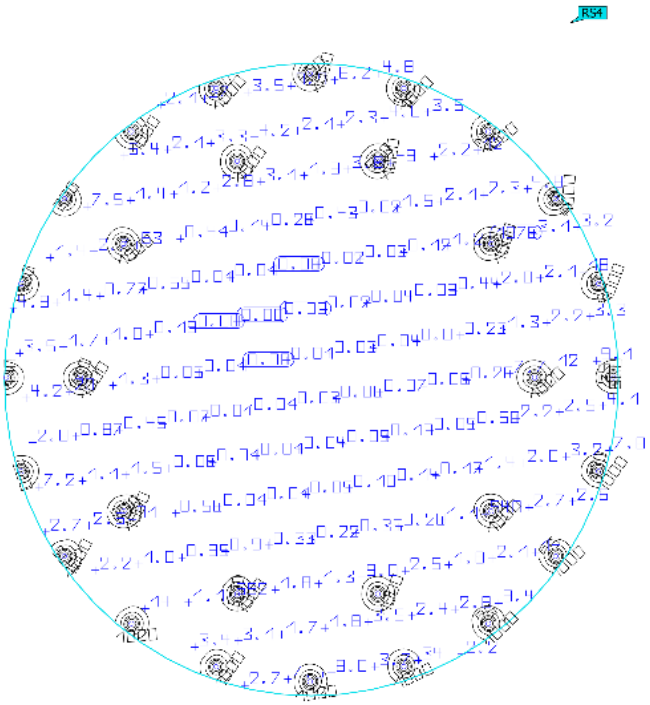
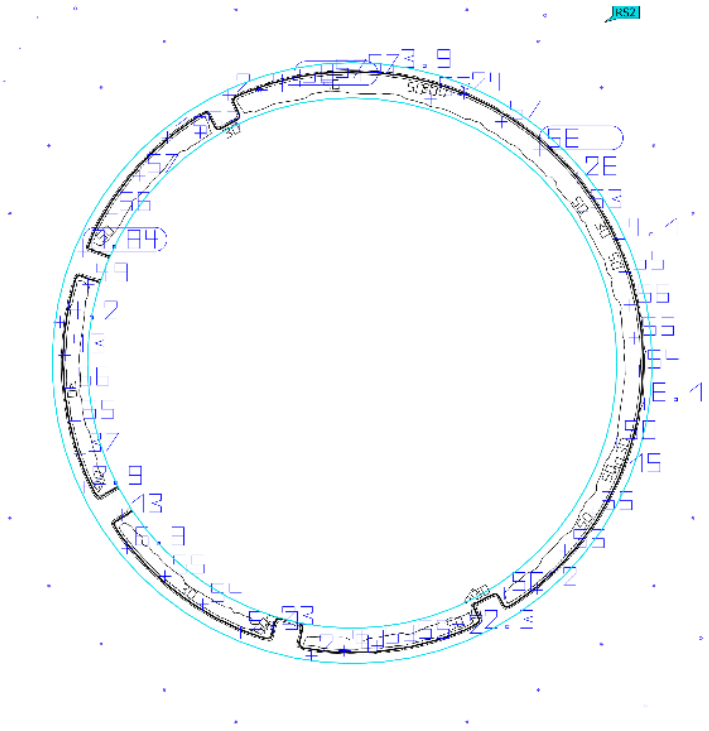


FIG.52: PROPOSED LIGHT OF ECO PARK VISITOR CENTER



Properties	Ē	E_{min}	E_{max}	g_1	g_2	Index
Surface result object 4 (Furniture) Perpendicular illuminance (adaptive) Height: 1.115 m	23.0 lx	0.003 lx	2195 lx	0.000	0.000	RS4

FIG.53: ISOLINE CURVE OF ECO PARK VISITOR CENTER SITTING DOWN VIEW



Properties	Ē	E_{min}	E_{max}	g_1	g_2	Index
Surface result object 2 (Furniture) Perpendicular illuminance (adaptive) Height: 2.815 m	34.5 lx	0.21 lx	59.8 lx	0.006	0.004	RS2

FIG.54: ISOLINE CURVE OF ECO PARK VISITOR CENTER SITTING UP VIEW

7.1.5 PATHWAY

The landscape path lighting is to only be able to see the light's result, not the actual source of light. Path lighting is an exception because it's meant to be aesthetically pleasing and on display. Lighting at night has developed a unique status all its own.

PROPOSED-- Even basic guiding lights can greatly enhance the exterior of your property, whether you have a side corridor going to a gate or a route leading to the end of your garden. They not only look fantastic, but they also give you a secure path through your yard. Gardens with fewer plants can use feature lights to draw attention to their furniture. With the appropriate lighting, even the most basic design elements may appear amazing. Path lights are not only for use on paths; they may also be utilised to improve the appearance of your landscape. While path lights are frequently used to draw attention to walks, they can also cast a soft glow around tiny plants and pebbles.

The amount of wattage needed to illuminate a particular outdoor space largely relies on its size and the object you're illuminating. High wattages, starting at 80 watts and upwards, can be utilised to flood a big lawn with light. It is advised to use lighting fixtures between 40 and 80 watts to illuminate a small or medium-sized garden in mild to moderate light. However, choosing lighting fixtures that are under 40 Watts can help you save energy and minimize light pollution. Not all landscape lighting can achieve this, but walkways can be well illuminated with a series of 20-watt lamps. A home's landscape lighting design creates a cozy atmosphere, highlights structural details, and adds an added layer of security. A well-lit driveway and walkway might also catch the eye of prospective buyers.

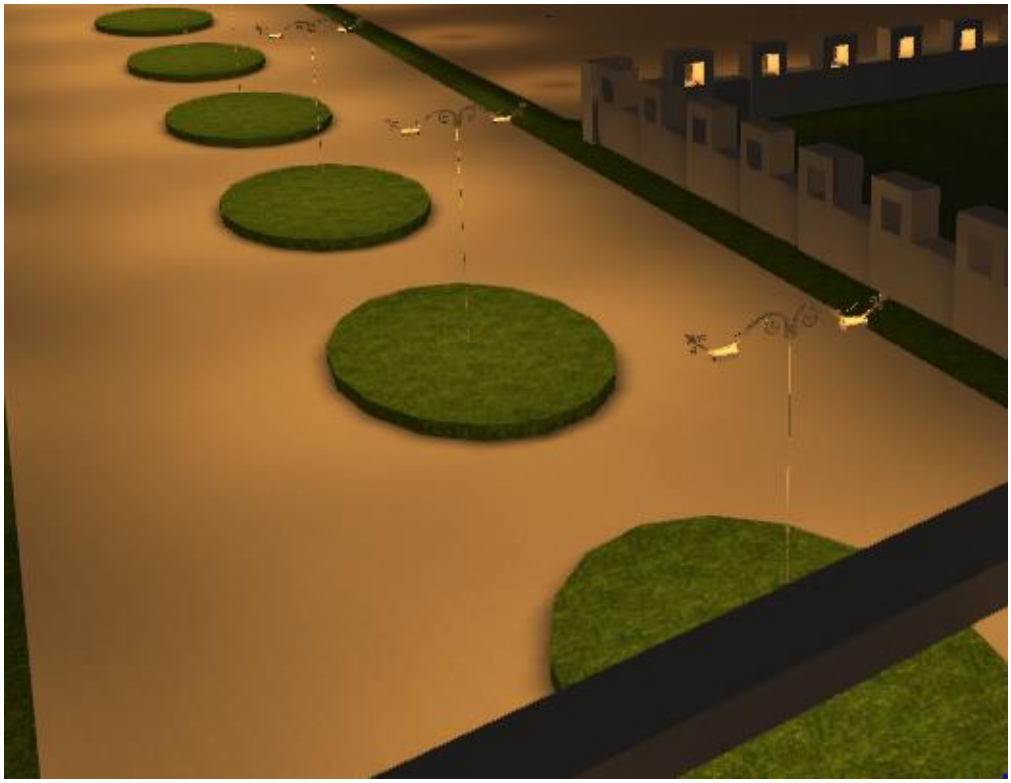
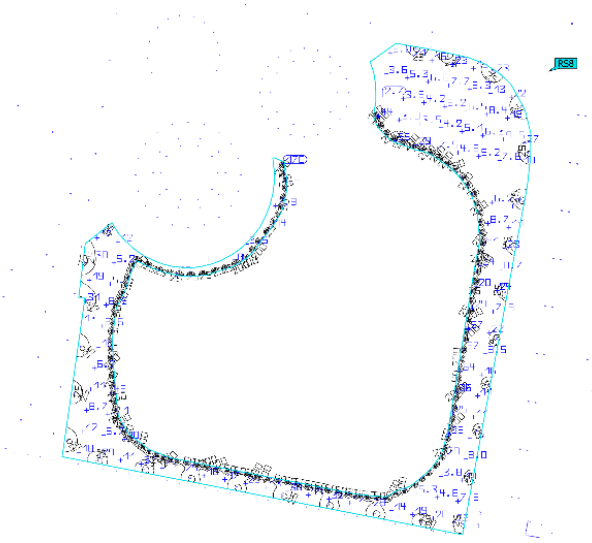
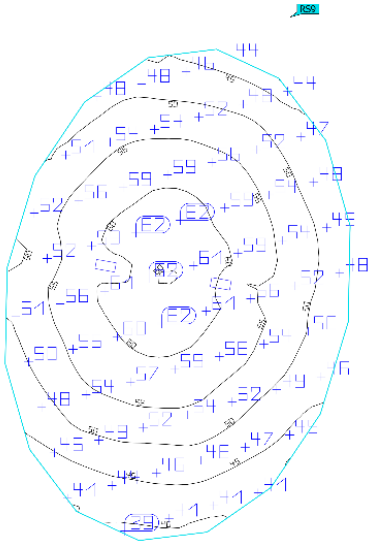


FIG.56: PROPOSED LIGHT OF ECO PARK PATHWAY



Properties	Ē	E_{min}	E_{max}	g_1	g_2	Index
Surface result object 8 (Furniture) Perpendicular illuminance (adaptive) Height: 0.300 m	19.0 lx	1.47 lx	222 lx	0.077	0.007	RS8

FIG.57: ISOLINE CURVE OF ECO PARK PATHWAY



Properties	Ē	E_{min}	E_{max}	g_1	g_2	Index
Surface result object 9 (Furniture) Perpendicular illuminance (adaptive) Height: 1.000 m	52.4 lx	39.3 lx	62.8 lx	0.75	0.63	RS9

FIG.58: PROPOSED LIGHT OF ECO PARK PATHWAY UNDER LIGHT

7.1.6 WATER GARDEN

The Formal Garden was created using a combination of inventiveness and cutting-edge concepts, and it is based on the idea of vertical growing in a flat landscape. Visitors can frequently learn a thing or two from here about how to plan their own backyard gardens. This garden is situated halfway between the visitor centre and a playground. Task, ambient, security, and feature lighting all have a role to play in effective outdoor lighting design when it comes to choose the ideal outdoor lights for your plan. Our outdoor places become more significant the more we use them. Typically, lights are buried beneath ponds to cast light upward. They are ideal for highlighting any fish and help a pond come to life at night.

- Aquatic ecosystems are structured by natural light. Light intensity and spectral range both decrease with increasing water depth.
- Thus, light pollution modifies the regular exposures of aquatic creatures to intensities, colors, and frequency.
- Additionally, the amount of light has an impact on the survival of many aquatic species. Feeding, schooling, and migratory in radiated fin fish are dependent on particular light intensities.

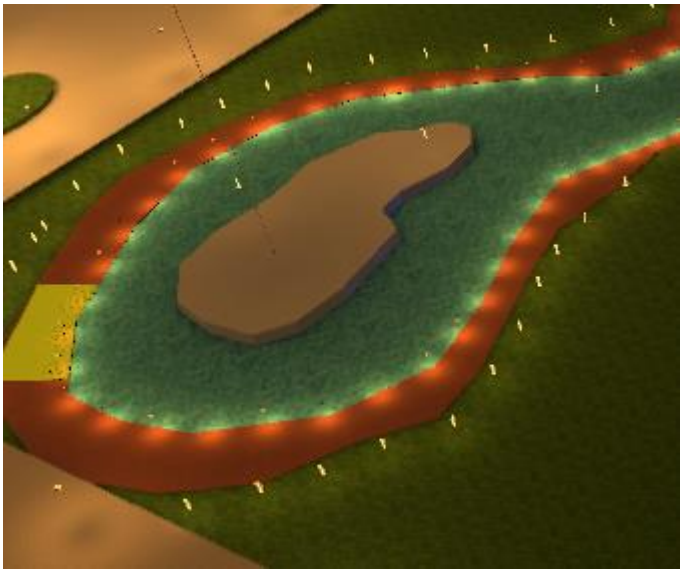
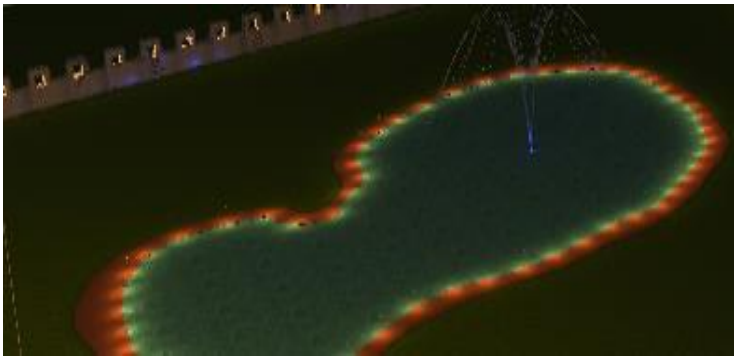


FIG.59: EXSISTING LIGHT OF ECO PARK WATER GARDEN

PROPOSED-The water Garden at Kolkata's Eco Tourism Park contains a sizable number of WATER-BEARING, FLOWERING trees. The majority of the plantations are made up of the various kinds and variations of that can be found all throughout Bengal. It is a fantastic location for nature lovers to visit and discover more about the diverse species. The American Society of Landscape Architects (ASLA) conducted a study of homeowners, and external lights came out on top. at the very least in terms of outdoor living amenities. According to the poll, 96.2% of respondents evaluated outdoor lights as a common technique to enhance the exterior aspects of their homes. Pool lights are designed specifically for placement underwater. It may stay in deep waters for an extended period of time. The locations of these lights can be along the internal walls of the fountain or the floor area, similar to swimming pools. To protect them, these lights are housed in watertight housing.



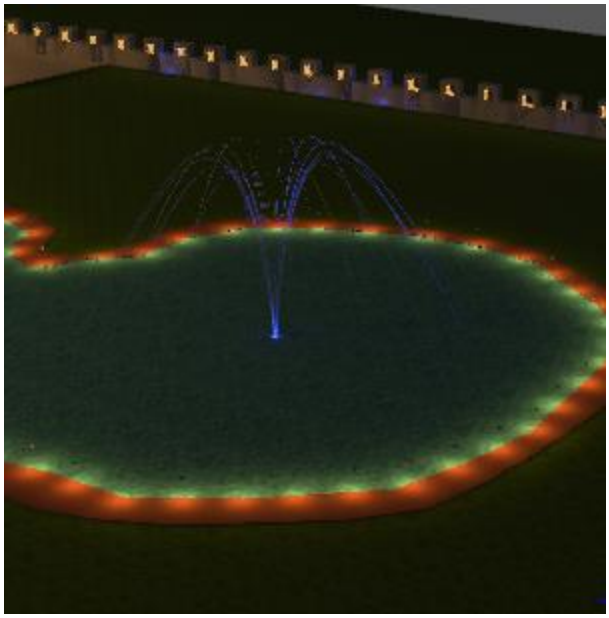
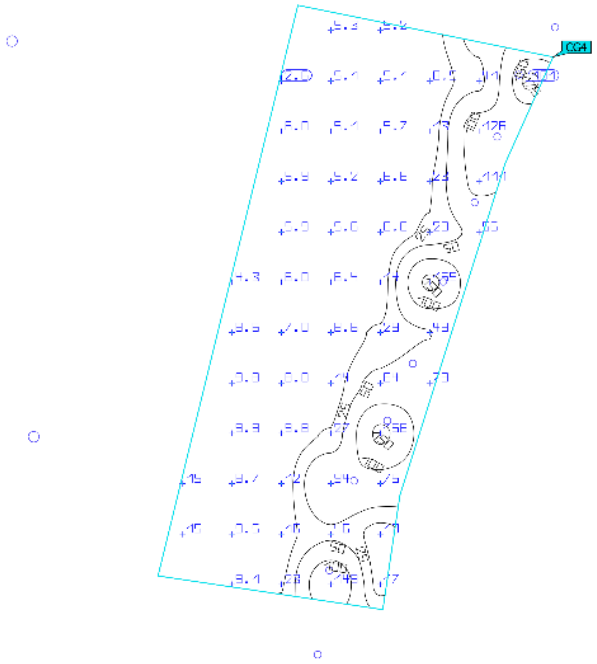


FIG.60: PROPOSED LIGHT OF ECO PARK WATER GARDEN



Properties	Ē	E_{min}	E_{max}	g_1	g_2	Index
SITTING AREA Perpendicular illuminance Height: 0.300 m	32.9 lx	2.57 lx	181 lx	0.078	0.014	CG4

FIG.61: PROPOSED LIGHT OF ECO PARK WATER GARDEN

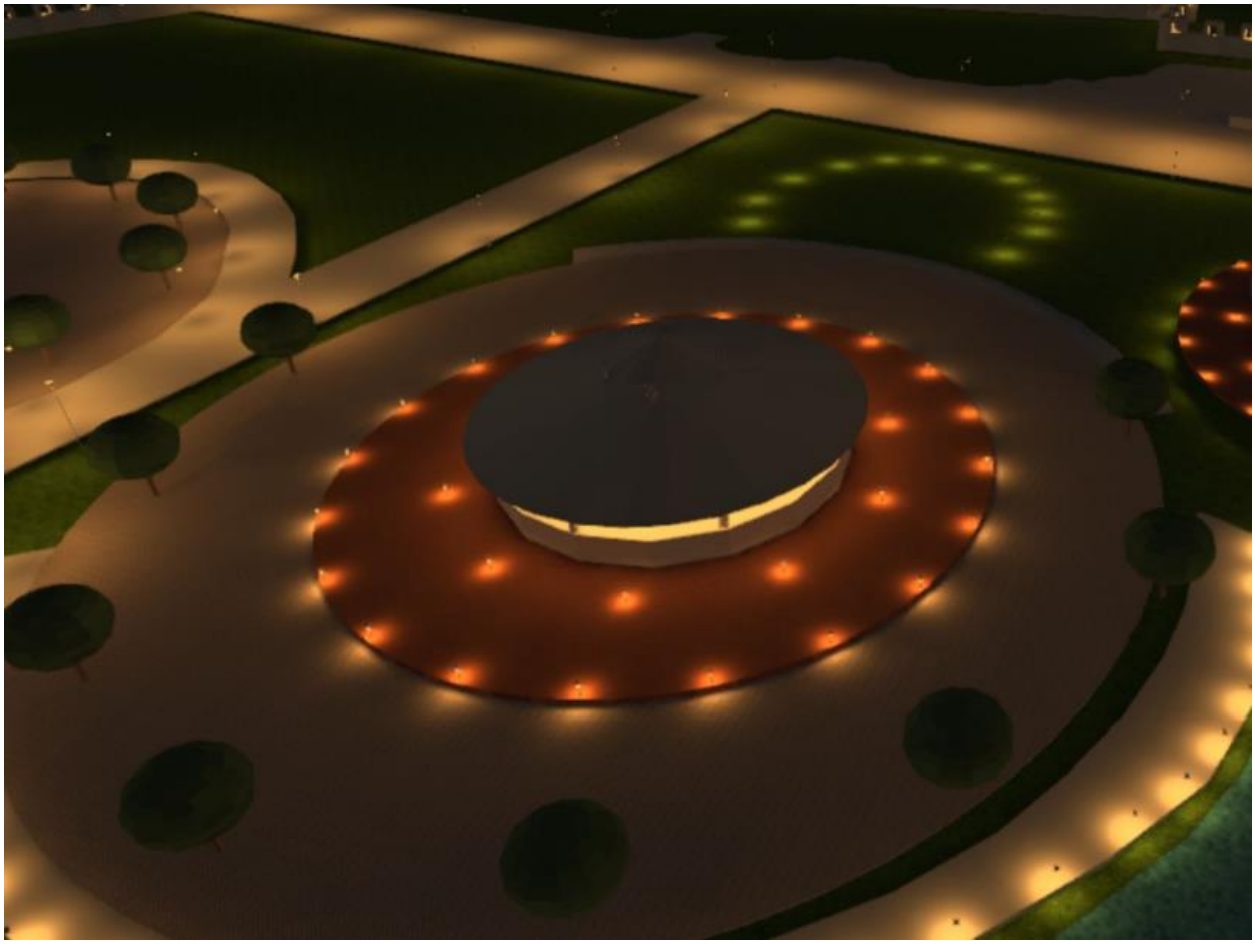
7.2 LUMINARIES DETAILS exist

SL NO.	AREA	PRODUCT EXSISTING DETAILS	PRODUCT PROPOSED DETAILS	REMARKS
1	ENTRANCE PLAZA	ASTRA FLOOD LIGHT, 100W, 5700K	OREON SURFACE LIGHT, 10W, 4000K	EXIST- • High wattage luminary used • Light pollution occurs PROPOSED- • Low wattage luminary used • Light pollution solved
		OREON SURFACE LIGHT, 10W, 4000K	WALL WASHER, 30W, 3000K	
		WALL WASHER, 30W, 3000K		
2	PARKING LOT	CLEO STREET LIGHT, 60W, 5700K	CLEO STREET LIGHT, 60W, 5700K	EXIST- • No. of luminaries increase • Light pollution occurs PROPOSED- • Less No. of luminaries used • Light pollution solved
		ELAVA GROUND UP-LIGHT, 9W, 3000K	ELAVA GROUND UP-LIGHT, 9W, 3000K	
3	AMPHITHEATRE	ASTRA FLOOD LIGHT, 100W, 5700K	ASTRA FLOOD LIGHT, 100W, 5700K	EXIST- • luminaries direction is wrong, spot created • Light pollution occurs • High wattage luminary used PROPOSED- • Light pollution solved • luminaries set in right direction
		OGEE POST, 36W, 4000K	OGEE POST, 36W, 4000K	
		PICTOR SPIKE LIGHT, 10W, 4000K		

4	VISITOR CENTER	POLO POST-TOP ,15W, 3000K	POLO POST-TOP ,15W, 3000K	EXIST- • No. of luminaries increase • Light pollution occurs PROPOSED- • Less No. of luminaries used • Light pollution solved
		ASTRA FLOOD LIGHT , 50W, 5700K, IN DOWN WARD	ASTRA FLOOD LIGHT , 50W, 5700K, IN UP WARD	
5	PATHWAY	CLEO STREET LIGHT, 60W, 5700K	CLEO STREET LIGHT, 60W, 5700K	EXSIST- • No. of luminaries increase • High wattage luminary used • Light pollution occurs PROPOSED- • Less No. of luminaries used • Low wattage luminary used • Light pollution solved
		OGEE POST, 36W, 4000K	OGEE POST, 36W, 4000K	
		FERN BOLLARD, 10W, 3000K		
		ASTRA FLOOD LIGHT, 300W, 5700K	ASTRA FLOOD LIGHT, 200W, 5700K	
6	WATER GARDEN	FERN BOLLARD, 10W, 3000K	FERN BOLLARD, 10W, 3000K	EXIST- • No. of luminaries increase • High wattage luminary used • Light pollution occurs PROPOSED- • Less No. of luminaries used • Low wattage luminary used • Light pollution solved
		ELAVA GROUND UP-LIGHT, 18W, 3000K	ELAVA GROUND UP-LIGHT, 18W, 3000K	
		POLO POST-TOP ,15W, 3000K	POLO POST-TOP ,15W, 3000K	
		ELAVA GROUND UP-LIGHT ,9W, 3000K		

CHAPTER-8

CONCLUSION & FUTURE SCOPE



8.1 CONCLUSION

We can conclude that we should install lights which don’t effect on animals natural life cycle. Also keep in mind about light intensity, wattage, CCT values. We should focus on lighting pollution and also keep in mind to install minimum light for safety and security purposes.

There are mainly four purpose of Zoological lighting design. Such as-

- Visibility - The first order of business is to ensure that hosted animal and human life is made as visible as possible to guests and spectators in managed situations. Reflections, glare, uniform shading or illumination can destroy the best educational and recreational moments in a facility. If the audience can't see human collection, it's not doing its job and it's not aiding conservation initiatives one whit.
- Animal Welfare - The nutritional and enrichment aspects of light for hosted animal species are crucial for institutional success. Daylight quality and intensity vary widely from ecosystem to ecosystem, and animal welfare depends on the luminous environment. Measurement is crucial to exhibit design success. Knowing what light is reaching your collection, and what light quality is necessary, allows a ecological park to create the best conditions possible.
- Ecologically Sensitive Lighting - Light is something to celebrate, but like fine cuisine the issue is not one of quantity but quality. Natural luminous regimes have played the most consistent role in the evolution of species. Inappropriate artificial lighting interrupts these regimes, and causes a host of deleterious effects upon animal life and in turn, the human environment. Insensitive lighting contributes directly to population declines and extinctions. Lighting in a zoo therefore has to be executed in a manner cognizant of ecological effects just as it must pursue carbon neutrality. Global warming and ocean acidification are relevant to conservation initiatives, and better lighting can begin to address these massive concerns.
- Carbon Reduction and Energy Efficiency - Lighting design can replace wasteful strategies with effective ones. Day-lighting leads any sustainable lighting program, followed by sensitivity to the nocturnal landscape, and finally supplementation with artificial lights and reflectors. Efficient lighting does not simply mean replacing low efficiency lamps with high efficiency lamps, or one technology with a new one. In many cases, no lamps might do well if other strategies are deployed to improve the overall visual environment. Proper attention to these issues leads to reduced operating costs, lower first costs, richer variations in exhibit lighting and a cleaner look for a facility in general.

8.2 FUTURE SCOPE

- In further if it is possible to study that how can we control the intensity of light as requirement and analysis with DIALux simulation Install Low intensity boundary light for the security of the ecological park.
- Install a motion sensing light in the park ways for the visitor's safety o Because of animals kept there so some post light in every animal's area.
- Small bollard light should be installing in park area for pleasant aesthetic view o Install smart led lights in the area where dangers animals are present which can detect animals present.
- Also we can install Human Centric Light.
- Need to control the light pollution as for reduce the economical problem.
- If we convert the eco-park to a night that increase our heritage of the country.
- Use controller to control the lights in the night time.
- Set this as a Govt. sponsored project as using controller, power consumption is low, and make efficient light.

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