DESIGN OF AIRPORT ILLUMINATION USING LED LIGHTING SYSTEM

A dissertation submitted in
partial fulfilment of the requirements for the degree of
Master of Technology in Illumination Technology and Design

Submitted By
KALLOL MUKHERJEE
Exam Roll No. M6ILT23008
Registration No. 154553 of 2020-2021

Under the guidance of
Prof. (Dr.) BISWANATH ROY
Professor of Illumination Engineering
Department of Electrical Engineering
Jadavpur University

Course affiliated to
Faculty Council of Engineering and Technology
Jadavpur University
Kolkata – 700032
India

2023

Jadavpur University
Faculty of Interdisciplinary Studies, Law and Management
School of Illumination Science, Engineering and Design

CERTIFICATE OF RECOMMENDATION

This is to certify that the thesis entitled "Design of Airport Illumination using LED Lighting System", is a bonafide work carried out by Kallol Mukherjee(M6ILT23008) under my supervision and guidance for partial fulfilment of the requirement of M.Tech (Illumination Technology and Design) in School of Illumination Science, Engineering and Design, during the academic session 2022 -2023.

(THESIS ADVISOR)
Prof. (Dr.) Biswanath Roy
Professor of Illumination Engineering
Department of Electrical Engineering
Jadavpur University
Kolkata-700 032

(DIRECTOR)
Prof. Parthasarathi Satvaya
School of Illumination Science, Engineering and Design
Jadavpur University
Kolkata-700 032

(DEAN - FISLM)
Prof. Tushar Jash
Jadavpur University
Kolkata-700 032

Jadavpur University
Faculty of Interdisciplinary Studies, Law and Management
School of Illumination Science, Engineering and Design

CERTIFICATE OF APPROVAL

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.

FINAL EXAMINATION FOR EVALUTION OF THESIS

Thesis Examiner 1

Thesis Examiner 2

BOARD OF EXAMINERS

DECLARATION OF ORIGINALITY AND COMPLIANCE OF ACADEMIC ETHICS

I hereby declare that this thesis contains literature survey and original research work by the undersigned candidate, as part of his M.Tech. (Illumination Technology and Design) studies during academic session 2022-2023.

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

I also declare that, as required by this rules and conduct, I have fully cited and referred all material and results that are not original to this work.

KALLOL MUKHERJEE
ROLL NUMBER: M6ILT23008

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Crompton Greaves Consumer Electricals Limited
Registered & Corporate Office: Tower 3, 1st Floor,
East Wing, Equinox Business Park, LBS Marg,
Kurla (West), Mumbai 400 070. India
Tel: +91 22 6167 8499 F: +91 22 6167 8383
W: www.crompton.co.in. CIN : L31900MH2015PLC262254

5th May 2023

SERVICE CERTIFICATE

This is to certify that Mr. Kallol Mukherjee, a student of M.Tech. in Illumination Tech & Design, School of Illumination Science, Engineering and Design Department, Jadavpur University, has worked as an Intern in the Lighting Advisory Bureau of Crompton Greaves Consumer Electricals Limited from 20th July, 2022 to 5th May, 2023.

The title of his thesis was "Design of Airport Illumination using LED Lighting System" which was carried out under the guidance of Mr. Sumit Kar, DGM – Design. During the tenure of his internship with us, he has been sincere, hardworking and diligent in carrying out the assignment entrusted to him.

We wish him all success in his future endeavour.

For **Crompton Greaves Consumer Electricals Limited**

Falguni Sharma
Manager Human Resources

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Chapter 1

FOREWARD

1.1 Introduction

Airports serve as critical transportation hubs connecting people and goods across the globe. Ensuring the safe and efficient operation of airports is of paramount importance, and one crucial aspect that contributes to this is effective illumination design. Proper lighting design in airports plays a significant role in enhancing visibility, promoting safety, and providing a pleasant experience for passengers and staff.

Airport illumination design refers to the deliberate planning and implementation of lighting systems in airports to meet specific requirements and standards. It encompasses various lighting aspects, including runway and taxiway lighting, signage illumination, terminal and apron area lighting, as well as interior and exterior architectural lighting.

Airport illumination design has witnessed significant advancements in recent years with the adoption of Light Emitting Diode (LED) lighting systems. LED lighting systems have several advantages over traditional lighting systems, such as incandescent or fluorescent bulbs. They are energy-efficient, have a longer lifespan, and require less maintenance.One significant advantage of LED lighting systems in airport illumination design is their flexibility and controllability. LED lights can be programmed to adjust their color temperature and intensity, depending on the time of day, weather conditions, or operational needs. They can also be easily integrated with other airport systems, such as the air traffic control system and the baggage handling system.

However, there are also some challenges associated with the adoption of LED lighting systems in airport illumination design. For example, LED lights require specific control systems and power supply, which can increase the cost of installation and maintenance. Moreover, the compatibility of LED lighting systems with existing airport infrastructure, such as the power grid and control systems, needs to be evaluated.

The adoption of LED lighting systems in airport illumination design offers several advantages, including energy efficiency, flexibility, and aesthetics. However, airport authorities and lighting designers need to carefully evaluate the compatibility and cost-effectiveness of LED lighting systems before adopting them. By considering these factors, airport illumination design using LED lighting systems can significantly enhance the safety, efficiency, and overall experience of the airport environment.

1.2 Motivation

The primary purpose of artificial lighting is to provide illumination in areas where natural light is insufficient or unavailable. It allows us to see and perform various tasks in both indoor and outdoor environments, regardless of the time of day or prevailing weather conditions. Adequate lighting levels are essential for creating optimal working or learning environments. Properly lit spaces enhance productivity, focus, and overall performance.

As we all agree to the fact that LEDs are the most energy efficient option for artificial lighting today and can help achieve in maximum energy savings over conventional lighting technologies. By consuming less energy, LED lighting contributes to a significant reduction in carbon dioxide (CO2) emissions. CO2 is a major greenhouse gas responsible for climate change. Switching to LED lighting in airports helps in mitigating climate change by reducing the overall carbon emissions associated with lighting operations.

According to the U.S. Department of Energy (DOE), replacing traditional lighting with LED lighting can save about 75 percent of the electricity used for lighting purposes. This translates into a corresponding reduction in CO2 emissions from electricity generation.To provide a general estimate, let's consider an example: If an airport switches its lighting systems to LED and achieves a 75 percent reduction in energy consumption for lighting, it can expect a proportional reduction in carbon dioxide emissions associated with lighting operations.For instance, if the airport's lighting systems initially emitted 100 metric tons of CO2 per year, the adoption of LED lighting could potentially reduce emissions to 25 metric tons per year, resulting in a 75 percent reduction.

LED lights provide bright and focused illumination, improving visibility and making it easier to see objects and details in the visual field. The high-quality light output of LEDs allows for accurate color rendering and better contrast, resulting in a clearer and more vibrant visual experience. LED lighting systems can be easily integrated with dimming controls and lighting management systems. This allows for adjustable lighting levels, enabling users to customize the lighting intensity according to their preferences or specific visual tasks. Dimming capabilities also contribute to energy savings by reducing lighting output when full brightness is not necessary.

1.3 Objectives

The objectives of the thesis are as follows:

- To study different areas in an Airport.
- Illumination design of different areas in an Airport using LED lighting system.

Chapter 2

Features of WLED Luminaires

WLED (White Light Emitting Diode) luminaires are lighting fixtures that utilize white LEDs (Light Emitting Diodes) as the light source. LEDs are semiconductor devices that emit light when an electrical current passes through them. WLED luminaires combine multiple colored LEDs, typically blue or ultraviolet LEDs, with a phosphor coating to produce white light. The phosphor coating converts the blue or ultraviolet light emitted by the LEDs into a broader spectrum of light, resulting in a white light output. The color temperature of the white light can be adjusted by varying the composition and thickness of the phosphor coating.

WLED luminaires have gained popularity in various lighting applications due to their numerous advantages. They are highly energy-efficient, consuming less electricity compared to traditional lighting sources. They also have a longer lifespan, reducing the need for frequent replacements and maintenance. WLED luminaires offer excellent color rendering, meaning they accurately represent the colors of objects illuminated by them. They provide a wide range of color temperatures, from warm to cool, allowing for customization to suit different environments and preferences.

2.1 Optical Features

2.1.1 LED Chip

A LED chip, also known as a light-emitting diode chip, is a semiconductor device that emits light when an electric current passes through it. It is the core component of an LED (light-emitting diode). LED chips are typically made from semiconducting materials such as gallium arsenide (GaAs) or gallium nitride (GaN).

LED chips are typically mounted on a substrate and enclosed within an epoxy resin or ceramic package to protect the chip and provide electrical connections. These packaged LED chips can then be integrated into various lighting fixtures and electronic devices for practical use. Led chips are basically of three types. They are:

- DIP Chip
- SMD LED Chip
- COB LED Chop

DIP Chip:

DIP (Dual In-line Package) LED chips refer to a specific type of LED chip packaging. DIP LEDs have a distinctive package design characterized by two parallel rows of pins or leads extending from the bottom of the chip. These pins are used for electrical connections and mechanical mounting.

DIP LED chips are typically larger in size compared to other LED chip packages, such as surface-mount device (SMD) LEDs. The larger size allows for easier handling and soldering, making them suitable for applications where simplicity and durability are important.

DIP LED chips are available in different colors, including red, green, blue, and yellow, allowing for versatile lighting and visual effects. Fig. 2.1 shows a typical picture of a DIP LED Chip.

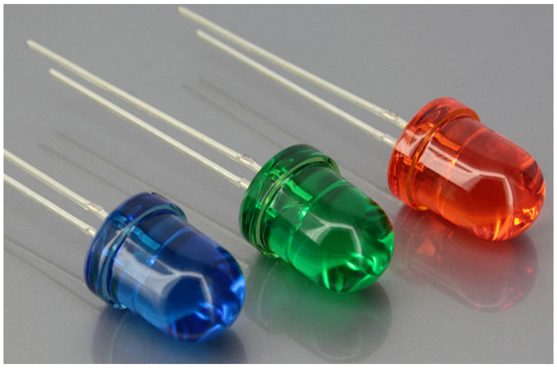


Figure 2.1: DIP LED Chip

SMD LED Chip:

SMD (Surface-Mount Device) LED chips are a popular type of LED chip packaging that has gained widespread usage in various applications. Unlike DIP LED chips, SMD LEDs do not have leads or pins extending from the bottom. Instead, they are mounted directly onto a printed circuit board (PCB) using surface-mount technology.

One of the key advantages of SMD LED chips is their versatility and ease of integration. They can be easily soldered onto PCBs using automated assembly processes, making them ideal for high-volume production.

SMD LED chips are smaller in size compared to DIP LEDs, which allows for compact and space-efficient designs. Fig. 2.2 shows a typical picture of a SMD LED Chip.

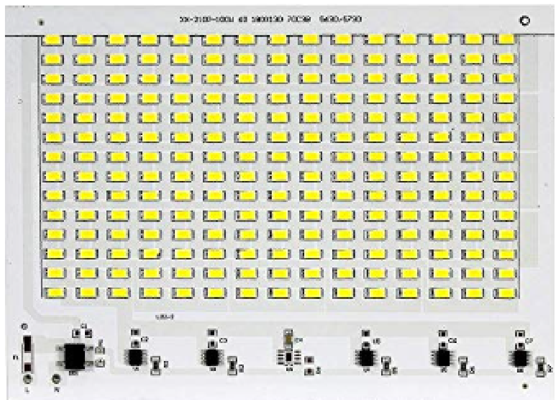


Figure 2.2: SMD LED Chip

COB LED Chip:

COB (Chip-on-Board) LED chips are a type of LED packaging that offers distinct advantages in terms of brightness, thermal management, and design flexibility. COB LEDs involve mounting multiple LED chips directly onto a substrate, forming a single module or array of closely packed LEDs. Fig. 2.3 shows a typical picture of a COB LED Chip.

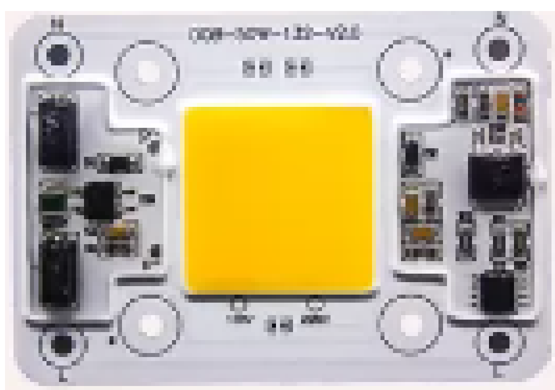


Figure 2.3: COB LED Chip

2.1.2 Optical Lens:

Optical lenses for LED luminaires are components used to control and manipulate the light emitted by LEDs. They help to shape and direct the light output, optimizing its distribution and achieving specific lighting effects.

Optical lenses for LED luminaires play a crucial role in controlling the direction, intensity, and distribution of light. They can shape the light beam by focusing or diffusing it, or by creating specific beam angles, such as narrow spot, wide flood, or even asymmetric distributions.

By using optical lenses, the efficiency of LED luminaires can be enhanced. Lenses help to collect and concentrate the light emitted by the LEDs, increasing the overall light output and reducing wasted light.

Lenses enable precise control over the beam angle and direction of the light. This allows for more effective lighting solutions, as the light can be directed exactly where it is needed, reducing light spillage and maximizing illumination in the desired areas.

Optical lenses are available in various sizes and configurations to match different LED packages and luminaire designs. It is important to select lenses that are compatible with the specific LED chips and luminaires to ensure optimal performance. Fig. 2.4 shows a typical picture of LED lens.

Figure 2.4: Different Types of LED Lens

2.2 Photometric Features

The photometric features of an LED luminaire refer to the characteristics of the light output and its distribution. These features are crucial in determining how the light is dispersed, its intensity, color, and overall performance.

2.2.1 Beam Angle

The beam angle of a LED luminaire refers to the angular extent of the light beam emitted by the luminaire. Technically, Beam Angle is an angle (in the plane through the beam axis) over which the luminous intensity drops to 50% of its peak intensity. Fig. 2.5 shows a typical repesentation of beam angle.

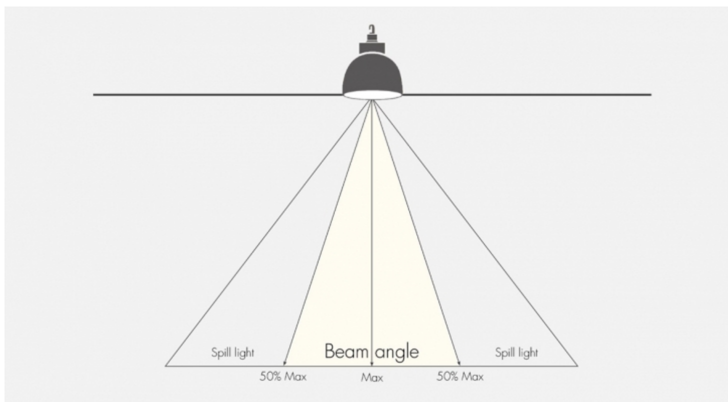


Figure 2.5: Typical Repesentation of Beam Angle

It's important to note that the specific beam angle required for a given application depends on factors such as the size of the space, the mounting height of the luminaire, the desired illumination levels, and the lighting design goals. Selecting the appropriate beam angle helps to achieve the desired lighting effect, uniformity, and functionality in the intended application. Fig. 2.6 shows different types of beam angle repesentation.

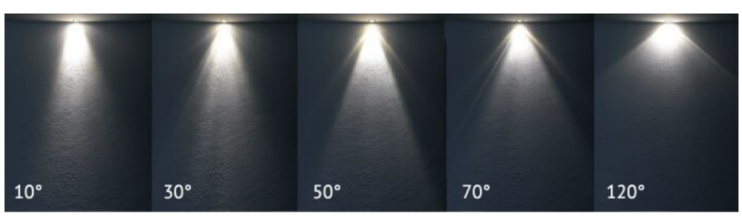


Figure 2.6: Different Types of Beam Angle Repesentation

2.2.2 Luminous Flux

The luminous flux of a LED luminaire refers to the total amount of visible light emitted by the luminaire in all directions. It is a measure of the overall brightness of the light output and is typically expressed in lumens (lm). Luminous flux quantifies the total radiant power emitted by the luminaire, weighted according to the sensitivity of the human eye to different wavelengths of light.

2.2.3 CCT

CCT (Correlated Color Temperature) of a LED luminaire refers to the color appearance of the light emitted by the luminaire. It is a measure of the perceived warmth or coolness of the light and is expressed in Kelvin (K). The CCT value indicates the color temperature of the light source and helps classify it into different categories. Fig. 2.7 shows some common CCT ranges for LED luminaires.

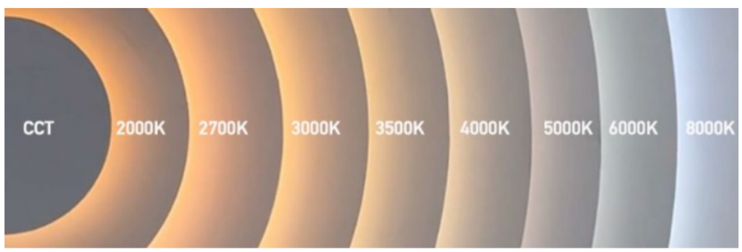


Figure 2.7: Common CCT Ranges for LED Luminaires

2.2.4 CRI

The CRI (Color Rendering Index) of a LED refers to its ability to accurately render colors compared to a reference light source. It is a numerical value on a scale from 0 to 100, with higher values indicating better color rendering capabilities.

The CRI is determined by comparing the appearance of a set of standard color samples under the LED light source with their appearance under a reference light source of the same color temperature. The CRI value is calculated based on the average color fidelity across these samples.

2.3 Electrical Features

The electrical features of a LED luminaire refer to the electrical characteristics and specifications of the luminaire, including parameters related to power supply, electrical efficiency, and control options.

2.3.1 Voltage and Power Supply

LED luminaires typically operate at low voltage, such as 12V or 24V DC, or high voltage, such as 120V or 240V AC. The voltage and power supply requirements of the luminaire should be compatible with the available electrical infrastructure and power source.

2.3.2 Power Consumption

LED luminaires are known for their energy efficiency. The power consumption of a luminaire is typically specified in watts (W) and indicates the electrical power required to operate the luminaire at its rated performance.

2.3.3 Power Factor (PF)

Power factor is a measure of how effectively a luminaire converts the incoming electrical power into useful work. It is a value between 0 and 1, with 1 representing ideal power factor. A higher power factor indicates better utilization of electrical power and is desirable to minimize power losses.

2.3.4 Surge Protection

LED luminaires may incorporate surge protection devices or circuitry to safeguard against voltage spikes or transient overvoltage events. Surge protection is important to ensure the longevity and reliability of the luminaire, especially in areas prone to power surges or electrical disturbances.

Understanding the electrical features of a LED luminaire is crucial for proper installation, compatibility with the electrical infrastructure, energy efficiency considerations, and ensuring compliance with electrical regulations.

2.4 Mechanical Features

The mechanical features of a LED luminaire refer to the physical characteristics and components that contribute to its structural integrity, installation, and overall functionality.

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

2.4.1 IK Rating

The IK (Impact Protection) rating of a luminaire indicates its resistance to mechanical impacts or shock. It measures the luminaire's ability to withstand external mechanical forces and protect its internal components. The IK rating is expressed as a numerical value ranging from IK00 to IK10, representing different levels of impact resistance.

Each IK rating corresponds to a specific energy level, which determines the luminaire's ability to withstand impact without compromising its functionality or safety. Here is a breakdown of the IK ratings and their corresponding energy levels:

• IK00: No impact protection. The luminaire offers no specific protection against mechanical impacts.

• IK01: Protection against impacts of 0.14 joules. This rating provides minimal protection against low-energy impacts, such as those caused by a small object accidentally hitting the luminaire.

• IK02: Protection against impacts of 0.2 joules. This rating offers slightly higher impact resistance compared to IK01.

• IK03: Protection against impacts of 0.35 joules. This rating provides moderate protection against medium-energy impacts.

• IK04: Protection against impacts of 0.5 joules. This rating offers increased impact resistance, suitable for environments where the luminaire may be exposed to stronger mechanical forces.

• IK05: Protection against impacts of 0.7 joules. This rating indicates a higher level of impact resistance, suitable for areas where there is a potential risk of stronger impacts or vandalism.

• IK06: Protection against impacts of 1 joule. This rating provides even higher resistance against strong impacts, making the luminaire more robust.

• IK07: Protection against impacts of 2 joules. This rating indicates a higher level of impact resistance, suitable for environments with a higher risk of mechanical impact.

• IK08: Protection against impacts of 5 joules. This rating offers significantly higher impact resistance, making the luminaire highly durable and suitable for demanding applications.

• IK09: Protection against impacts of 10 joules. This rating provides excellent impact resistance, suitable for areas with a high risk of mechanical damage.

• IK10: Protection against impacts of 20 joules. This is the highest IK rating and indicates an extremely high level of impact resistance. Luminaires with IK10 rating can withstand severe mechanical impacts.

2.4.2 IP Rating

The IP (Ingress Protection) rating of a luminaire indicates its level of protection against the ingress of solid particles and liquids. The IP rating consists of two numbers: the first digit represents the protection against solid particles, and the second digit represents the protection against liquids.

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

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

These vary from IP 00 (no protection against from foreign bodies) to IP 68 (complete dust proof and applicable for continuous immersion in specific pressurized liquid). IP Ratings are represented by combining the first and second digits as shown in the following Fig. 2.8 and Fig 2.9

First Characteristic numerical	Object size protected against	Effective against
0	____	No protection against contact and ingress of objects
1	>50 mm	Any large surface of the body, such as the back of a hand, but no protection against deliberate contact with a body part
2	>12.5 mm	Fingers or similar objects
3	>2.5 mm	Tools, thick wires, etc.
4	>1 mm	Most wires, slender screws, ants etc.
5	Dust protected	Ingress of dust is not entirely prevented, but it must not enter in sufficient quantity to interfere with the satisfactory operation of the equipment.
6	Dust tight	No ingress of dust; complete protection against contact (dust tight). A vacuum must be applied. Test duration of up to 8 hours based on air flow.

Figure 2.8: IP code according to protection against ingress of solid foreign bodies (IEC: 60529, 2001)

Second Characteristic Numerical	Protected against	Effective against
0	Not protected	——
1	Dripping water	Dripping water (vertically falling drops) shall have no harmful effect.
2	Dripping water when tilted up to 15°	Vertically dripping water shall have no harmful effect when the enclosure is tilted at an angle up to 15° from its normal position.
3	Spraying water	Water falling as a spray at any angle up to 60° from the vertical shall have no harmful effect.
4	Splashing of water	Water splashing against the enclosure from any direction shall have no harmful effect.
5	Water jets	Water projected by a nozzle (6.3 mm) against enclosure from any direction shall have no harmful effects.
6	Powerful water jets	Water projected in powerful jets (12.5 mm nozzle) against the enclosure from any direction shall have no harmful effects.
7	Immersion up to 1 m	Ingress of water in harmful quantity shall not be possible when the enclosure is immersed in water under defined conditions of pressure and time (up to 1 m of submersion).
8	Immersion 1 m or more	The equipment is suitable for continuous immersion in water under conditions which shall be specified by the manufacturer. However, with certain types of equipment, it can mean that water can enter but only in such a manner that it produces no harmful effects. The test depth and/or duration are expected to be greater than the requirements for IPx7.

Figure 2.9: IP code according to protection against ingress of liquid (IEC: 60529, 2001)

Chapter 3

Applications of WLED Luminaires: Benefits and Challenges

WLED (White LED) luminaires are extensively used for general lighting in residential, commercial, and industrial spaces. WLED lighting systems have become increasingly popular in airport illumination design due to their superior lighting quality, color rendering, and reliability. LED lighting systems provide better visibility, which is essential for the safety of aircraft operations. They also contribute to the reduction of energy consumption and carbon footprint, which is critical for airport authorities seeking to adopt sustainable practices.

3.1 Benefits

A Techno-Commercial application is the key of choosing any particular system for applications which means that any particular system should not only be Technologically advanced or more suitable to a particular application but it also should be Economically viable to justify that technologically advanced system would be the best option to replace the existing technology. So, both Technological and Economical benefits are discussed below.

3.1.1 Technological Benefits

- **Long Life Span:**

Compared to the lifespan of your average incandescent bulb, the lifespan of a LED light is far superior. The average incandescent bulb lasts about a thousand hours. The lifespan of an average LED light is 50,000 hours. Depending on how you use it, its life may be as long as 100,000 hours. This means that an LED light can last anywhere from six to 12 years before you need to replace it. That is 40 times longer than an incandescent bulb

- **High Lumen Efficacy:**

Luminous efficacy is a measure of how well a light source produces visible light. It is the ratio of luminous flux to power, measured in lumens per watt (lm/w) in the International System of Units (SI). Currently, commercially available luminaires from quality suppliers typically have efficacy levels of 100 – 150 lm/W. However, with the efficacy levels of LEDs rapidly evolving, it is always recommended to consult with reliable manufacturers or industry representatives for the latest efficacy levels.

- **Extended Controllability:**

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

- **High Colour Rendering Index (CRI):**

CRI is a measurement of a light's ability to reveal the actual color of objects as compared to an ideal light source (natural light). High CRI is generally a desirable characteristic (although of course, it depends on the required application). LEDs generally have very high (good) ratings when it comes to CRI.

3.1.2 Economical Benefits

- **Lower Lifetime Cost:**

Due to its much longer lifetime the total cost of ownership (TCO) of an LED lighting system is lower by 50% or more. The TCO of a lighting system includes energy, lamp replacement, and labour and maintenance costs.

- **Lower Maintenance Cost:**

As LEDs are Solid State Devices, it is very robust and sturdy. So, the maintenance requirement in LEDs is also very less compared to other conventional sources.

- **Lower Energy Consumption:**

Having a higher efficacy helps LEDs consume very less energy to give same output which results economical to the consumers.

3.2 Challenges

LED's have some disadvantages as well, including the highly temperature-sensitive nature in both performance and reliability, poor light coupling through the LED surface which decreases external quantum efficiency, a highly directional external intensity distribution which ends up with light pollution. A number of design challenges and costs are associated with switching traditional lamps with LED lights. These design challenges include light production, thermal management, and manufacturing cost control.

- **Performance Consistency:**

For most applications it is hard for the user of the LEDs to set a tight specification on flux and color; generally, a range of a color is used. Challenges lie in the matter that LEDs, when manufactured, are produced in a distribution of colours (wavelengths or color corrected temperatures, CCT), light output (intensity or luminous flux), and efficacy (lumens per watt). Generating a matching color and light output in multiple fixtures is extremely important; it is critical both in the occasion of fixed or permanent installations. Color variations in LED arrays are a fundamental design consideration, particularly for applications such as wall washing, where disparities in adjacent LEDs can create unexpected color effects on the target surface.

- **Operating Temperature:**

LED performance predominantly relies on the ambient temperature of the operating environment. This criticality is especially noticeable in high power LED applications. In spite of the remarkable improvement in energy efficiency over currently established light sources, light sources employing light emitting diodes (LEDs) still convert between 20 to 50% of the power they are fed into heat. Heat can often lead to permanently damages to the LED, degrades LED performance by causing reduced light output, and ends up in a premature device failure. As a result, adequate heat-sinking or cooling essential to maintain a long lifetime for the LED, which is extremely important in applications where the LED must operate over a broad range of temperatures.

- **LED Driver Failure:**

LED system is consisting of some components which are: LED Chip, Lens, LED module, Driver Circuit, Luminaire Housing, Heat Sink and Mounting arrangement. Among them LED Driver Circuits are considered as the weakest link in the solid-state luminaire so LED driver can have life span less than that of LED itself. According to studies the life of LED driver is decided by Electrolytic capacitors at the output stage of LED driver and 50% SMPS failures are also caused by Electrolytic capacitors malfunction.

- **LED Driver Failure:**

LEDs unlike conventional light sources for example incandescent bulbs cannot effectively cool themselves. For this reason, additional heatsinking or cooling means are needed to prevent overheating. While high thermal conductivity materials are often used to propagate the heat out over a substantial area, these high thermal conductivity materials come with the addition of significant weight and cost. This raises the cost of not only the light sources as a result of shipping costs and materials costs but also the fixtures which use those light sources. Additionally, for driving an illumination system, the LED driver is commonly designed as general-purpose circuitry for use with a wide selection of LEDs. This further increases the overall cost.

Chapter 4

Overview of Different Areas in an Airport

An airport is a location where aircraft take off, land, and are parked. It is a transportation hub that serves as a gateway for air travel, connecting different cities, countries, and continents. Airports are designed to facilitate the movement of passengers, cargo, and aircraft in a safe and efficient manner.
Fig. 4.1 shows a typical layout of an airport.

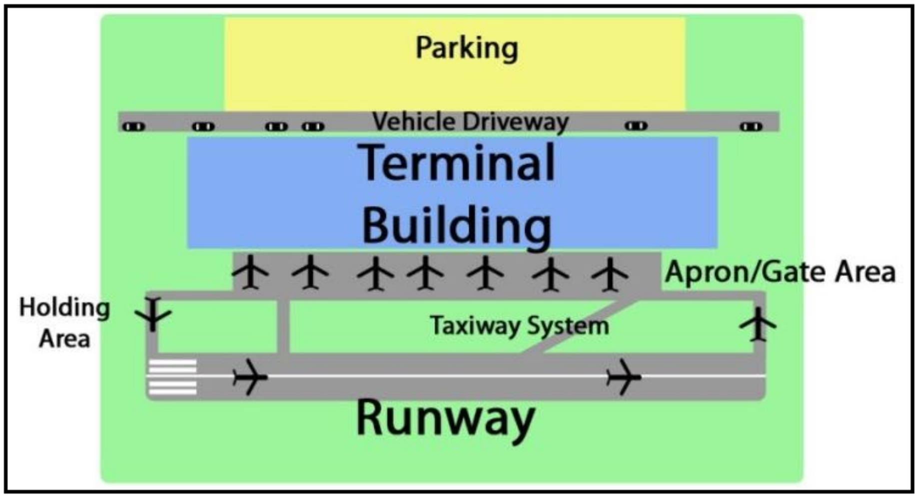


Figure 4.1: Typical Layout of an Airport

At its core, an airport consists of a runway or runways, which are long paved strips of land where aircraft take off and land. These runways are typically equipped with lighting and navigational aids to support operations in various weather conditions.

In addition to the runway, airports also have terminal buildings that house passenger facilities. These terminals include check-in counters, security checkpoints, boarding gates, baggage claim areas, retail shops, dining establishments, and other amenities. Terminals are designed to provide a comfortable and convenient experience for passengers, allowing them to easily navigate through the airport before and after their flights.

Airports also have aprons, which are areas adjacent to the terminal buildings where aircraft are parked, unloaded, and loaded. The apron provides aircraft parking stands, fueling facilities, and access to ground support equipment.

Airports are equipped with air traffic control towers, where air traffic controllers manage the movement of aircraft in the airport's airspace and on the ground. These controllers ensure safe separation between aircraft and provide instructions to pilots for takeoff, landing, and taxiing.

Ground transportation services are also available at airports, including taxi stands, rental car facilities, shuttle buses, and public transportation links, allowing passengers to travel to and from the airport and reach their final destinations.

Other facilities and services found at airports may include cargo terminals for the storage and processing of goods and shipments, maintenance hangars for aircraft repairs and maintenance, customs and immigration facilities for international travel, as well as amenities such as lounges, currency exchange, Wi-Fi access, and medical services.

Overall, airports play a vital role in connecting people, facilitating trade and tourism, and enabling efficient air travel around the world. They are complex infrastructures that require coordination and management to ensure the smooth and safe operation of flights and the comfort of passengers and cargo.

4.1 Land Side Area

The landside area of an airport refers to the section of the airport that is accessible to the public and is located before the security checkpoints. It encompasses various facilities and services that cater to the needs of passengers, visitors, and airport staff. The areas outside the terminal building, including parking lots, approach roads, drop-off/pick-up zones, walkways etc. are under landside area. Let us discuss the following areas which are mainly under a landside area.

4.1.1 Approach Road

The approach road typically extends from the main road or highway leading to the airport and provides a direct route for vehicles to reach the airport terminal or other key airport locations. It is designed to facilitate the smooth flow of traffic, ensuring convenient access for passengers, airport staff, and other individuals using ground transportation services.

The design and layout of the approach road are carefully planned to accommodate the anticipated traffic volume and ensure the safety and efficiency of the transportation process. Factors such as roadway width, lane markings, signage, traffic control devices, and lighting are considered during the design and construction of the approach road to enhance visibility, guide drivers, and ensure a seamless journey to and from the airport. Fig.4.2 shows a typical picture of an approach road.

Figure 4.2: Typical Airport Approach Road

4.1.2 Car Parking

Car parking at an airport is an essential component of the overall airport infrastructure, providing a convenient and secure location for passengers and visitors to park their vehicles while traveling.

Airports typically offer various types of parking options to cater to different needs and preferences. These may include short-term parking, long-term parking, premium or valet parking, economy parking, and sometimes even dedicated parking for specific groups such as disabled passengers or electric vehicles.

Airport parking facilities are designed to accommodate a large number of vehicles. They may consist of multi-level parking structures, surface parking lots, or a combination of both. These facilities often feature designated parking spaces, signage, and clear markings to guide drivers. Fig.4.3 shows a typical picture of a car parking area.

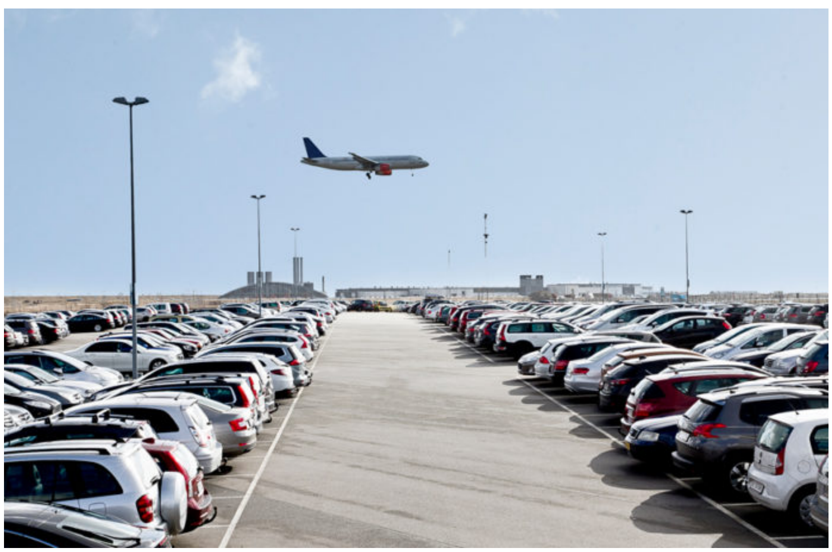


Figure 4.3: Typical Airport Car Parking Area

4.1.3 Bus Parking

Bus parking at an airport is an essential facility that accommodates buses used for various purposes, such as airport shuttle services, charter buses, tour buses, and ground transportation for passengers and airport staff.

Airports typically designate specific areas for bus parking to ensure organized and efficient operations. These areas are designed to accommodate buses of different sizes and provide sufficient space for maneuvering and parking.The bus parking area should be designed with clear markings, signage, and designated parking spaces to guide bus drivers and ensure proper alignment and positioning of the buses. The layout should consider the flow of traffic and allow easy access to and from the bus parking area.

The size of the bus parking area should be determined based on the expected number of buses and their sizes. It should have sufficient capacity to accommodate the peak demand while allowing for safe maneuvering and spacing between the buses. Bus parking areas should be easily accessible from the main roadways within the airport, allowing buses to enter and exit smoothly. The design should take into consideration the turning radius and dimensions of buses to ensure they can navigate the parking area comfortably. Fig.4.4 shows a typical picture of a bus parking area.

Figure 4.4: Typical Airport Bus Parking Area

4.1.4 Staff Vehicle Parking Area

The staff vehicle parking area in an airport serves as a dedicated parking space for airport employees, including airline staff, airport personnel, and other authorized personnel. The staff vehicle parking area should be conveniently located near the airport terminals or employee entrances to minimize commuting time for staff members. Easy access to the parking area from the main roadways within the airport is important to facilitate smooth traffic flow and efficient entry and exit for employees.

The size of the staff vehicle parking area should be determined based on the number of employees and their parking requirements. Sufficient capacity should be provided to accommodate the peak demand during different shifts, taking into account potential future growth and any specific needs such as dedicated spaces for disabled employees.

The parking area should be well-organized with clearly marked parking spaces, directional signage, and designated areas for specific employee categories or departments if required. The layout should facilitate easy navigation and parking while minimizing congestion and conflicts among vehicles. Fig.4.5 shows a typical picture of a staff vehicle parking area.

Figure 4.5: Typical Airport Staff Vehicle Parking Area

4.1.5 Entrance and Taxi Drop Area

The entrance area of an airport is the designated space where vehicles enter the airport premises. It is usually equipped with security measures, such as security checkpoints or gates, to ensure controlled access. The entrance area may include lanes or lanes divided for different types of vehicles, such as taxis, private cars, or commercial vehicles. It serves as the point of entry for passengers and visitors arriving at the airport.

The taxi drop area is a specific location within the airport where taxis can stop to drop off passengers. It is designed to provide a convenient and efficient area for taxi drivers to unload passengers and their luggage. The taxi drop area is typically located close to the terminal building or within easy walking distance for passengers.

The entrance and taxi drop area play a crucial role in facilitating the smooth flow of vehicles and passengers within the airport. They are designed to provide a safe and organized process for entering the airport premises and dropping off passengers, ensuring efficient traffic management and convenient access to the terminal building. Fig.4.6 shows a typical picture of entrance and taxi drop area.

Figure 4.6: Typical Airport Entrance and Taxi Drop Area

4.2 Terminal Side

An airport terminal refers to the building or section of the airport where passengers go through various processes related to their travel, including check-in, security screening, and boarding. It is the central point of activity for departing and arriving passengers.The terminal building is a crucial component of an airport as it serves as the main point of interaction between passengers and the airport facilities.Let us discuss the following areas which are mainly under a terminal side area.

4.2.1 Security Scan Checking

Security scan checking at airports is an essential part of the security measures in place to ensure the safety of passengers, aircraft, and airport facilities. These scans help to detect prohibited items and potential threats that could compromise aviation security.

X-ray machines are used to scan carry-on bags and other items that pass through the security checkpoint. The X-ray scan creates an image that allows security personnel to inspect the contents of the bag for any prohibited items or suspicious objects. Metal detectors are used to identify metal objects on passengers' bodies. Passengers are required to pass through the metal detector, which emits a low-level electromagnetic field. In certain cases, security personnel may use swabs or other devices to collect samples from passengers' hands, bags, or personal items. Fig.4.7 shows a typical picture of a security scanning area.

Figure 4.7: Typical Airport Security Scan Checking Area

4.2.2 Baggage Claim Areas

Baggage claim areas typically feature rotating carousels or conveyor belts that transport the checked luggage from the aircraft to the passengers. These carousels are numbered or labeled, indicating the flight numbers or origin of the arriving flights. Each carousel is assigned to a specific flight or group of flights.

Once the aircraft arrives and the baggage is unloaded, the luggage is transported to the respective baggage carousels. The bags are then placed on the carousels, allowing passengers to identify and retrieve their belongings. Digital screens or monitors are usually positioned near the baggage claim area, displaying flight numbers, originating cities, and carousel assignments. These displays help passengers locate the correct carousel for their flight. Passengers are typically given baggage claim tags or receipts when checking in their luggage. These tags contain unique identifiers that match the tags attached to their bags. It is important to keep these tags safe as they may be required for identification when claiming your luggage.

It's important to remember that the baggage claim area can get crowded, especially during peak travel times. Fig.4.8 shows a typical picture of a baggage claim area.

Figure 4.8: Typical Airport Baggage Claim Areas

4.2.3 Meeting Room

An airport meeting room is a designated space within an airport facility where individuals or groups can hold meetings, discussions, presentations, or conduct business activities. These meeting rooms are designed to provide a convenient and professional environment for travelers, airport staff, or business professionals who require a private space to collaborate or conduct meetings while at the airport.

Airport meeting rooms can vary in size and capacity, accommodating small groups or larger gatherings. They are designed to provide a comfortable and functional space for meetings of various sizes.

Meeting rooms in airports often come equipped with necessary facilities and amenities to support productive meetings. These may include tables, chairs, audio-visual equipment (projectors, screens), teleconferencing capabilities, whiteboards or flipcharts, and high-speed internet access.

Airport meeting rooms are equipped with modern technology and connectivity options to facilitate presentations, video conferences, and seamless communication. This includes high-speed internet access, audio-visual equipment, and teleconferencing capabilities to ensure smooth and efficient collaboration. Fig.4.9 shows a typical picture of a meeting room.

Figure 4.9: Typical Airport Meeting Room

4.2.4 Dining Area

A dining area in an airport is a designated space where passengers and visitors can enjoy meals, snacks, or beverages while they are at the airport. These dining areas are typically located within the terminal building and are designed to provide a comfortable and convenient environment for individuals to relax, dine, and recharge before or after their flights.

The dining area should have an ample number of seats and tables to accommodate various group sizes, from individuals to larger groups. The seating arrangement should be comfortable and spacious, allowing diners to sit and enjoy their meals without feeling crowded.

The design of the dining area should create a pleasant and inviting atmosphere. This can be achieved through a combination of lighting, decor, and sound control. Consider using warm lighting, comfortable seating, and visually appealing decor to create a relaxing and enjoyable dining experience. Sound-absorbing materials can be used to minimize noise levels and create a more peaceful environment.

Proper cleaning and maintenance protocols should be in place to ensure hygiene and cleanliness in the dining area. Regular cleaning, waste disposal, and upkeep of facilities are essential for maintaining a pleasant and sanitary environment. Fig.4.10 shows a typical picture of an airport dining area.

Figure 4.10: Typical Airport Dining Area

4.2.5 Cargo Storage Area

The airport cargo storage area, also known as the cargo terminal or cargo warehouse, is a dedicated facility within an airport where various types of cargo and freight are handled, stored, and processed. It serves as a crucial hub for the movement of goods, both domestically and internationally, through air transportation.

The cargo storage area should be designed with ample space to accommodate different types of cargo, including pallets, containers, and specialized handling equipment. The layout should be optimized for efficient movement of goods, with clearly designated storage zones, loading/unloading areas, and access routes for cargo handling equipment.

Given the valuable and often sensitive nature of the cargo being stored, security is of utmost importance. The cargo storage area should have appropriate security measures in place, including access control systems, surveillance cameras, and restricted entry for authorized personnel only. Additionally, secure storage areas or vaults may be required for high-value or perishable goods.

Adequate space and infrastructure should be provided for efficient loading and unloading operations. This includes dock doors, loading bays, and equipment such as forklifts, pallet jacks, or cargo handling machinery. The design should consider safe and smooth flow of cargo, minimizing congestion and ensuring compliance with occupational health and safety regulations. Fig.4.11 shows a typical picture of a typical cargo storage area.

Figure 4.11: Typical Airport Cargo Storage Area

4.2.6 Air Traffic Control Room

The Air Traffic Control (ATC) room is a critical facility within an airport where air traffic controllers monitor and manage the movement of aircraft in and around the airport's airspace. It serves as the nerve center for coordinating arrivals, departures, and movement of aircraft on the ground and in the air.

The ATC room should be designed to provide clear visibility of the airport's runways, taxiways, and airspace. The layout should allow air traffic controllers to have an unobstructed view of the entire airport and surrounding airspace, with minimal visual obstructions. This may involve the use of large windows, strategically positioned workstations, and appropriate seating arrangements.

The ATC room requires strict security measures to prevent unauthorized access and ensure the integrity of air traffic control operations. Access control systems, surveillance cameras, and restricted entry for authorized personnel only are critical for maintaining a secure environment.

Designing an effective Air Traffic Control room requires collaboration between architects, air traffic control experts, airport authorities, and regulatory bodies. The design should consider the specific needs, operational requirements, and safety considerations of the airport's air traffic control operations. Fig.4.12 shows a typical picture of a typical air traffic control room.

Figure 4.12: Typical Air Traffic Control Room

4.3 Air Side

The airside area of an airport refers to the secure zone beyond the security checkpoints where passengers, baggage, and aircraft have access. It is the area where the boarding gates, runways, taxiways, and aprons are located. Access to the airside area is restricted to passengers holding valid boarding passes, airport staff, and authorized personnel.

4.3.1 Apron Area

The airport apron area, also known as the ramp or tarmac, is the section of an airport where aircraft are parked, loaded, unloaded, fueled, and prepared for departure or after landing. It is the operational area located between the terminal building and the runway.

The apron area is specifically designated for aircraft operations and is typically a large, open space made of concrete or asphalt. It is where aircraft taxi to and from the runway, and where they are positioned for passenger boarding or cargo handling. The apron area is designed to accommodate multiple aircraft simultaneously and provides various services and facilities to support ground operations. Fig.4.13 shows a typical picture of an apron area.

Figure 4.13: Typical Airport Apron Area

4.3.2 Airport Hanger Area

The airport hangar area is a designated section of an airport where aircraft are stored, maintained, repaired, and sometimes assembled. Hangars are large enclosed structures that provide shelter and protection for aircraft from the elements, including weather conditions such as rain, snow, and extreme temperatures.

Hangars are primarily used for aircraft storage when they are not in use. They offer a secure and protected environment for aircraft, shielding them from adverse weather conditions, dust, and other potential hazards. Hangars are equipped with maintenance facilities and workshops where routine inspections, repairs, and servicing of aircraft are conducted. These areas may include equipment, tools, and personnel necessary for aircraft maintenance, avionics work, engine repairs, and other technical services.

Hangars come in various sizes and configurations to accommodate different types of aircraft, from small private planes to large commercial airliners. They are typically constructed with durable materials and may have features like climate control systems, lighting, and fire suppression systems to further protect the aircraft and facilitate maintenance operations. Fig.4.14 shows a typical picture of a hanger area.

Figure 4.14: Typical Airport Hanger Area

Chapter 5

Codes and Standards for Airport Illumination

The purpose of airport lighting is to ensure safe and efficient operations at airports, especially during periods of low visibility, such as at night or in adverse weather conditions. Airport lighting systems are designed to provide visual guidance to pilots, aircraft ground personnel, and drivers of vehicles on the airfield.

5.1 National Standards

- **IS :SP 72- 2010: National Lighting Code, 2010**

This code has been formulated for the purpose of setting out in a convenient form the requirements for responsible social, commercial and engineering conduct as designers, manufacturers and suppliers of lighting. Lighting technology plays a significant role in achieving basic social safety and environmental objectives. The intent of this code is to encourage good lighting practices and systems which would minimize light pollution, glare, light tresspass and conserve energy while maintaining safety, security, utility and productivity.

- **IS :11116 - 1984: Code of Practice for Lighting for Airport Aprons**

This Indian Standard was adopted by the Indian Standards Institution on 25 April 1984, after the draft finalized by the Illuminating Engineering and Luminaires Sectional Committee had been approved by the Electrotechnical Division Council.

- **IS.3646.1.1992 (Part 1): Code of Practice for Interior Illumination**

This code (Part I) covers -the principles and practice governing good lighting in buildings and relates chiefly to the lighting of working areas' in industrial, commercial and public buildings, hospitals and schools.

- **IS.3646.1.1992 (Part 2): Code of Practice for Interior Illumination**

This Indian Standard (Part II) was adopted by the Indian Standards Institution on 15 July 1966, .after the draft finalized by the Illuminating Engineering and Lifts Sectional Committee had been approved by the Electrotechnical Division Council.

5.2 International Standards

• **ICAO: International Civil Aviation Organisation**

The International Civil Aviation Organization (ICAO) creates regulations for aviation safety, security, efficiency and regularity and environmental protection. The organization also regulates operating practices and procedures covering the technical field of aviation.

• **EN 12464-1: Light and Lighting - Lighting of Work Places - Part 1: Indoor Work Places**

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 169. If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

• **EN 12464-2:2014: Light and Lighting - Lighting of Work Places - Part 2: Outdoor Work Places**

This European Standard specifies lighting requirements for outdoor work places, which meet the needs for visual comfort and performance. All usual visual tasks are considered. This European Standard does not specify lighting requirements with respect to the safety and health of workers at work and has not been prepared in the field of application of Article 153 of the EC treaty, although the lighting requirements, as specified in this standard, usually fulfil safety needs. Lighting requirements with respect to the safety and health of workers at work may be contained in Directives based on Article 153 of the EC treaty, in national legislation of member states implementing these directives or in other national legislation of member states.

5.3 Tender Document

AAI: AIRPORTS AUTHORITY OF INDIA

This is a Tender document specifically for the general description of design, manufacture and construction features supply, installation, testing and commissioning (SITC) of the Airport Lighting system equipment.

Summary of Standard of Designed Illumination Level for Different Activity Areas:

Name of the Area	Average Designed Illuminance in Lux	Overall Uniformity
Land Side Area		
Approach Road	40	0.4
Car Parking	20	0.25
Bus Parking	20	0.25
Staff Vehicle Parking Area	20	0.25
Entrance and Taxi Drop Area	150	0.25
Terminal Side Area		
Security Scan Checking	500	0.6
Baggage Claim Areas	500	0.6
Meeting Room	500	0.6
Dining Area	300	0.6
Cargo Storage Area	300	0.4
Air Traffic Control Room	500	0.6
Air Side Area		
Apron Area	20	0.25
Hanger Area	300	0.4

Chapter 6

Lighting Design Methodology

Lighting design methodology refers to the systematic approach and process followed by lighting designers to create effective and visually appealing lighting schemes for various spaces and applications. While different designers may have their own variations, here is a general outline of the steps involved in lighting design methodology:

6.1 Input Data

6.1.1 Drawing of the Area giving Plan and Elevation

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

6.1.2 Reflection Properties of Surroundings

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

6.1.3 Required Illumination Level

Another important criterion before designing is to know what the client wants for this space. Tender documents contain the requirements of the client, i.e., Airports Authority of India (AAI) here. Some of the requirements are certain maintained lux level values, uniformity ratio, design parameters, plan and profile of the project etc.

6.1.4 Layout and Heights of Machine and Tools

This will help in location of luminaires such that light is not obstructed by them and design becomes much more practical optimized. From AutoCAD layout we have idea of elevation. It also helps determining the work plane height considerations for any particular area.

6.2 Method of Lighting

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

6.3 Selecting the Lighting Equipment

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

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

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

Apart from these there are also some other factors which affect the luminaire choice. These are:

- Characteristics of light source and control gear
- Luminaire efficacy
- Light distribution
- Glare control
- Finish and appearance
- Size
- Accessibility of components for maintenance
- Ability to handle adverse operating conditions
- Aesthetics
- Thermal management

6.4 Choice of Luminaire

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

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

6.5 Design Tools

6.5.1 AutoCAD

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

6.5.2 DIALux:

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

6.5.3 AGi32

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

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

6.6 Design Methodology

6.6.1 Client Meet and Discussion

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

6.6.2 Obtaining the AutoCAD Layout

After client meeting, we need AutoCAD file of the project. AutoCAD layout provides us the exact length, width and height of particular area which helps in proper selection and arrangement of the luminaire. The more accurate/detailed the AutoCAD layout the more accurate will be the lighting design output.

6.6.3 Study of Guidelines

Now being a lighting designer, it is a responsibility to study the relevant standard codes, guidelines in detail. For this particular project work relevant standards and guidelines which needs to be followed in the previous chapter.

6.6.4 Design Simulation with the Site layout

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

6.6.5 Illumination Design for Indoor area

Indoor area design is done by DIALux. The following steps are involved in indoor illumination design:

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

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

STEP II – Deciding the illuminance level required

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

STEP III – Finding out the dimension of the room

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

STEP IV – Finding out the ceiling type

In this step we have to decide whether true ceiling or false ceiling is there. If it is true ceiling surface/ suspended mounted luminaires are chosen. In case of false ceiling recess mounted luminaire should be chosen.
In case of Industries, Plants, Factories most of the cases luminaires are mounted on the truss. So, we have to be careful while mounting the luminaires.

STEP V – Selecting the luminaire

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

STEP VI – Selecting Maintenance Factor

In any lighting design calculation, an appropriate maintenance factor has to be included to allow for depreciation. The magnitude of the maintenance factor significantly affects the number of luminaires needed to produce the specified illuminance. Maintenance factor is chosen as per design requirement otherwise mentioned by the client. Generally, for conventional light sources we consider maintenance factor 0.7 (for indoor) and for LED light sources 0.8.

STEP VII – Finding out the work plane height

Depending upon the application of task area work plane height is to be considered for office area we consider table height say 0.76 meter above the floor and for industrial shed area we consider null value, i.e., measurement to be performed at finished ground level.

STEP VIII – Selecting the reflectance factors

Depending upon the area we have to select the reflectance factors of the room. For office area reflectance factors for ceiling, walls nd floor are to be considered 70%, 50% and 20% respectively. For industry shed area reflectance factors for ceiling, walls and floor 50%, 30% and 10%.

STEP IX – Software simulation

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

STEP X – Output

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

6.6.6 Illumination Design for Street

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

STEP I – Deciding the type of road as per relevant code and guideline recommendation

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

STEP II – Deciding the illuminance level required

Once the road type is decided then as per recommendation illumination level and uniformity can be found out.

STEP III – Selecting Maintenance Factor

Maintenance factor is chosen as per design criteria or otherwise mentioned by the client. However, for normal use the maintenance factor normally varies from 0.60 to 0.85. Generally, for conventional light sources we consider maintenance factor 0.60 and for LED light sources 0.80.

STEP IV – Determining the Pole layout

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

- Mounting height [hm] = Road width → SINGLE SIDED
- 2 × Mounting height [hm] = Road width → OPPOSITE
- 1.5× Mounting height [hm] = Road width → STAGGERED
- 1.25 × Mounting height [hm] = Road width → CENTRAL VERGE

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

- Maintained horizontal illuminance level at road surface
- Road width
- Feasibility in laying of cabling tray
- Environmental restrictions
- Constraints in pole commissioning in practical site

STEP V- Street Arrangement

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

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

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

STEP VII– Selecting the light source

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

STEP VII – Deciding the spacing between luminaires

To achieve good uniformity standard, we have to decide spacing between two poles. Normally the spacing between poles is minimum three times to the pole height.

STEP VIII – Software simulation

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

STEP IX – Output

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

STEP X – Pole quantity

In DIALux there is default length of the street for simulation. To find out actual luminaire quantity we have to use following formula for a single sided arrangement.
Total no. of poles in chainage = (Total Length of road/Spacing Between poles) +1
In similar manner luminaire quantity can also be determined. If the arrangement is opposite or central verge then actual luminaire quantity should be multiplied by two.

6.6.7 Illumination Design for Exterior Area

To simulate the design of Exterior area, AGi32 software is used. Here grade separated exterior area e.g., major junction, toll plaza, amenity area has been done with software. The steps involved in lighting design are as under:

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

In the first step after having AutoCAD layout, we have to identify the type of work to be done.

STEP II – Finding out the dimension of the area

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

STEP III – Selecting Maintenance Factor

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

STEP IV – Selecting the luminaire

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

STEP V- Mounting height of luminaire

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

STEP VI – Aiming of Luminaires

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

STEP VII – Software simulation

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

STEP VIII – Output

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

6.6.8 Summary

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

Chapter 7

Case study of Different Areas of Airport Lighting

The objective of airport illumination design is to create a well-lit environment throughout the airport facility. In recent years, there has been an increased interest in sustainability and energy reduction in every sector. Whether driven by cost reduction targets or environmental concerns, a large shift towards sustainable design and operation is being adopted. Amid this rapid growth, lighting is one element that can support your goals for cost reduction, operational efficiency, safety, and sustainability, while at the same time delivering a memorable brand experience.

There are three different portions in an Airport Illumination design. These are Land Side, Terminal Side and Air Side, as shown in the Fig. 7.1

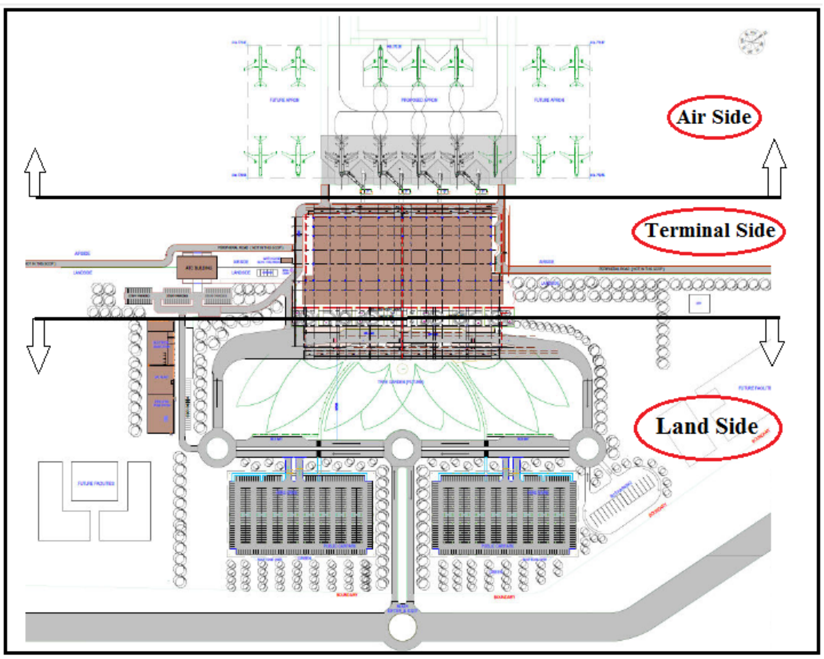


Figure 7.1: Different Zones in an Airport

These different parts of airport illumination design work together to create a safe, functional, and visually appealing environment for passengers, airport personnel, and aircraft operations throughout the airport premises.

7.1 Illumination Design of Land Side Area

Airport landside illumination design involves planning and implementing lighting systems for the areas outside the terminal building, including parking lots, approach roads, drop-off/pick-up zones, walkways, and other landside areas.

7.1.1 Approach Road

The approach road at an airport refers to the roadway that connects the main access points, such as the entrance or exit gates, with the airport terminal or other essential airport facilities. It is the route that vehicles, including cars, taxis, buses, and other ground transportation, use to access the airport terminal building or other designated areas.

The lighting design should provide sufficient illuminance levels to meet the specific requirements of the airport approach road. These levels are typically higher than those for regular roads to account for the critical nature of airport operations. Guidelines and standards set by aviation authorities or local regulations should be followed to determine the appropriate illuminance levels.

Uniform lighting distribution across the approach road is crucial to minimize the contrast between illuminated and dark areas, reducing the potential for driver discomfort or distraction. Uniformity helps ensure a consistent visual experience for drivers, allowing them to perceive hazards and roadway features accurately.

Design Aim:

The primary goal is to ensure clear visibility of the road, signage, and surrounding areas for drivers and pedestrians, particularly during nighttime or low-light conditions. Adequate lighting helps drivers navigate the approach road with confidence and reduces the risk of accidents.

- Required illuminance level: Average 40 Lux
- Overall uniformity: 0.4

Layout and description of Approach Road:

Considering one of the Approach Road for better understanding of lighting design, analyzing software AGi 32 has been used for describing and achieving the recommended values as per standard. Typical plan layout of the Approach Road (green coloured portion) is shown in Fig. 7.2 below.

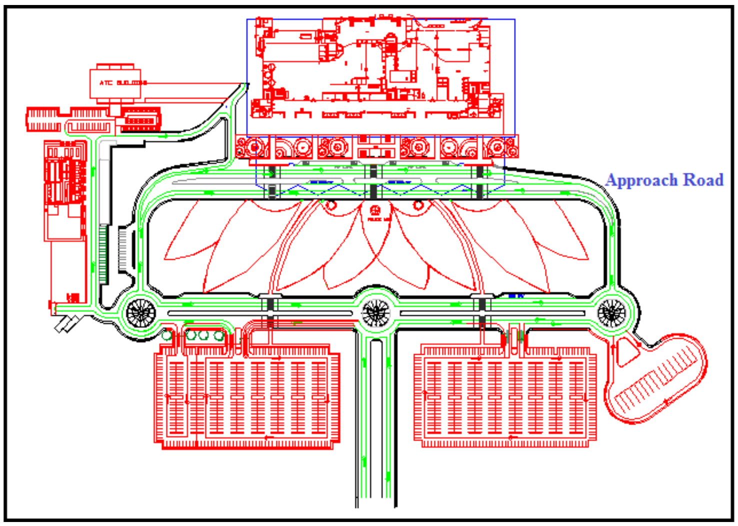


Figure 7.2: Typical Plan Layout of the Approach Road

Luminaire Used:

Luminaire Schedule				
Symbol	Qty	Label	LLF	Description
	69	A	0.850	CRP-414-200-57-HL2-GL-HR-NSG
	12	B	0.850	CFS-501-350-57-60D-HL2-GL-NGG

LED 200W Streetlight

Specification:

- Luminous flux: 24000 Lumen
- Wattage: 200 Watt
- Vo;tage Rating: 240V
- Current Rating: 0.877Amp
- System Efficacy: 120 lm/W
- CCT: 5700K
- CRI: 70
- IP 66 protected

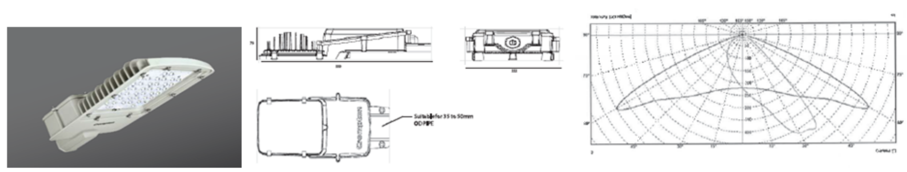


Figure 7.3: LED 200W Streetlight: Image, Dimension and Polar Curve

LED 350W Flood Light

Specifications:

- Luminous flux: 42000 Lumen
- Wattage: 350 Watt
- Vo;tage Rating: 240V
- Current Rating: 1.315Amp
- System Efficacy: 120 lm/W
- CCT: 5700K
- Beam Angle: 60 Deg
- CRI: 70
- IP 66 protected

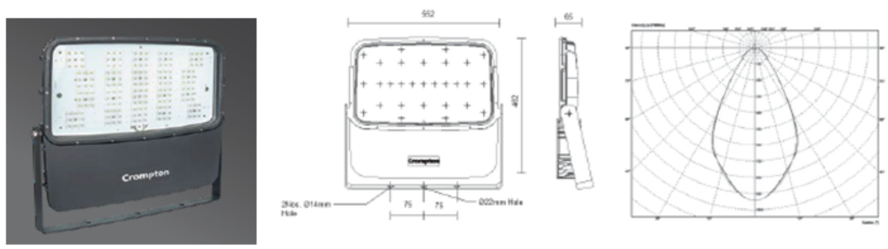


Figure 7.4: LED 350W Flood Light: Image, Dimension and Polar Curve

Design Considerations for the Lighting Implementation:

LED 200W Streetlight:

- Number of Luminaires: 69
- Pole height : 9m from Road Level
- Bracket : 2mtr
- Tilt : 15 deg.
- Spacing : 30mtr
- Maintenance factor: 0.85

LED 350W Flood Light:

- Number of Luminaires: 12
- Hightmast height : 20m from Road Level
- Hightmast Type : Symmetrical
- Tilt : 65 deg.
- Maintenance factor: 0.85

AGi 32 Simulation:

AGi 32 simulation of the Approach Road area is based on positioning the light fixture and aiming the luminaire in exact manner to achieve recommended illumination level on the calculation surface. The lighting level on this area must meet the value recommended by the authority. Fig. 7.5 shows the simulation view of Approach Road area.

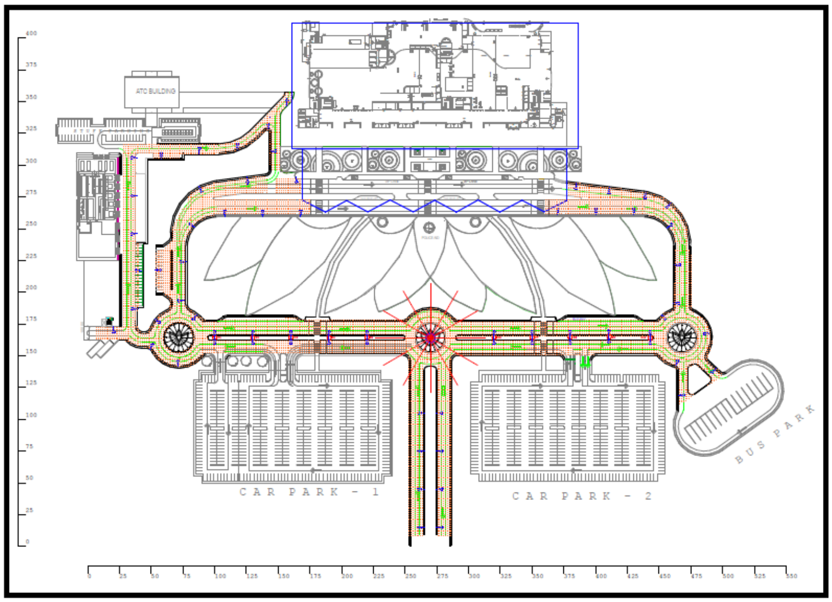


Figure 7.5: Approach Road Design in AGi 32 Software

Result Overview:

Calculation Summary						
Label	CalcType	Units	Avg	Max	Min	Min/Avg
Approach road	Illuminance	Lux	44.9	190	18	0.40

Here the value of average illumination level of 44.9 Lux and overall uniformity of 0.4 is achieved.

3D View of Approach Road Area :

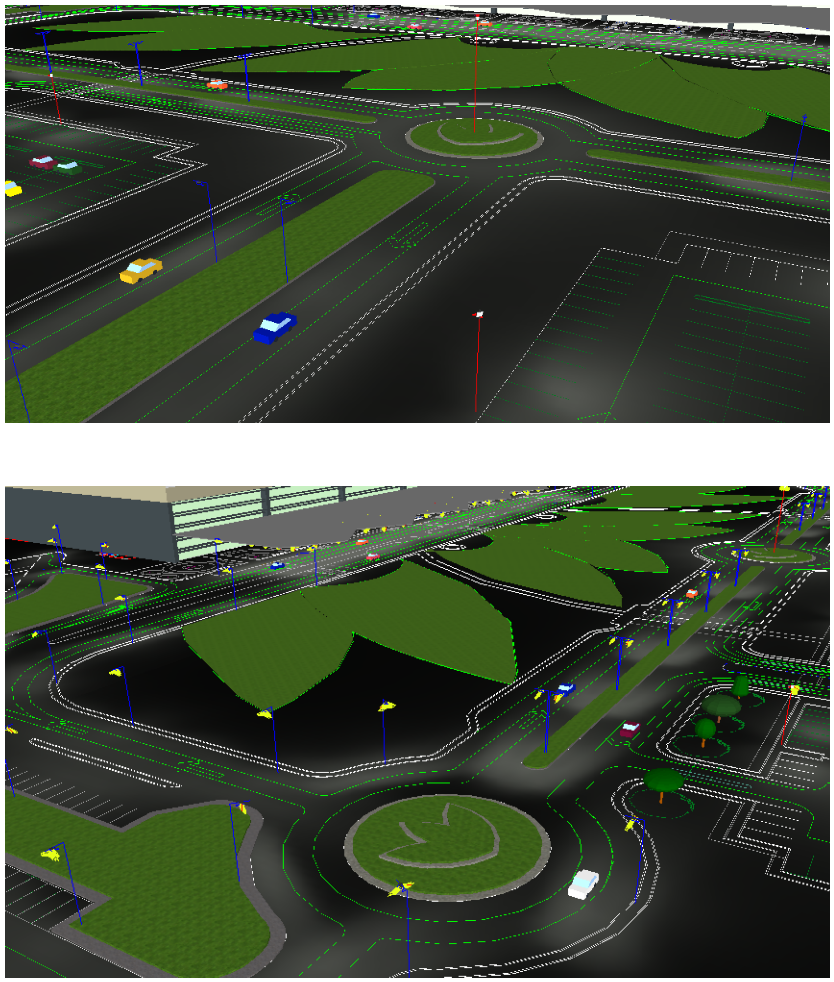


Figure 7.6: 3D View of Approach Road Area

7.1.2 Car Parking

Car parking at an airport is an essential component of the overall airport infrastructure, providing a convenient and secure location for passengers and visitors to park their vehicles while traveling.

Airport parking should be easily accessible from the main roadways leading to the airport terminals. Ideally, parking facilities are located in close proximity to the terminal buildings to minimize the time and effort required to reach the departure or arrival areas.

Adequate lighting levels should be provided to enhance visibility and ensure the safe movement of vehicles and pedestrians within the parking area.

Design Aim:

When designing the illumination for airport car parking areas, the primary goal is to ensure the safety and convenience of users.

Aim for uniform distribution of light throughout the parking area to minimize shadows and provide consistent illumination. Uniform lighting helps users navigate the parking lot more easily and reduces the risk of accidents or incidents.

It is crucial to comply with applicable lighting standards, regulations, and guidelines specific to the airport and local authorities when designing the illumination for airport car parking areas.

- Required illuminance level: Average 20 Lux
- Overall uniformity: 0.25

Layout and Description of Car Parking Area:

Considering the Car Parking for better understanding of lighting design, analyzing software AGi 32 has been used for describing and achieving the recommended values as per standard. Typical plan layout of the Car Parking (green coloured portion) is shown in Fig. 7.7 below.

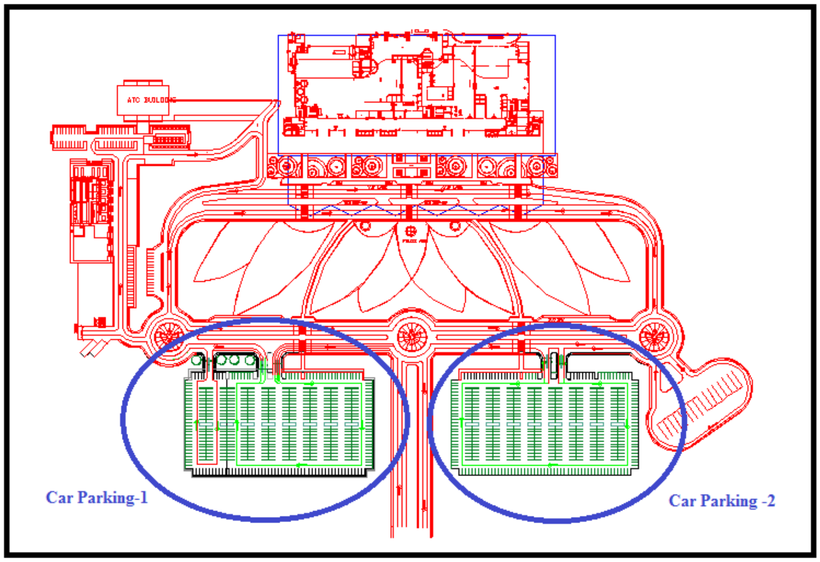


Figure 7.7: Typical Plan Layout of Car Parking Area

Luminaire Used:

Luminaire Schedule				
Symbol	Qty	Label	LLF	Description
	32	B	0.850	CFS-501-350-57-60D-HL2-GL-NGG

LED 350W Floodlight

Specifications:

- Luminous flux: 42000 Lumen
- Wattage: 350 Watt
- Vo;tage Rating: 240V
- Current Rating: 1.315Amp
- System Efficacy: 120 lm/W
- CCT: 5700K
- CRI: 70
- IP 66 protected

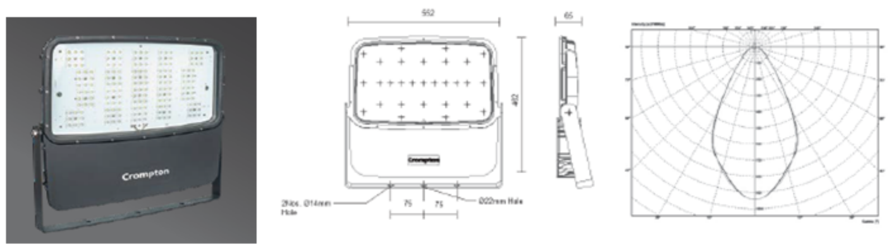


Figure 7.8: LED 350W Flood Light: Image, Dimension and Polar Curve

Design Considerations for the Lighting Implementation:

LED 350W Flood Light:

- Number of Luminaires: 32
- Pole height : 9m from Road Level
- Tilt : 67.5 deg.
- Maintenance factor: 0.85

AGi 32 Simulation:

AGi 32 simulation of the Car Parking area is based on positioning the light-fixture and aiming the luminaire in exact manner to achieve recommended illumination level on the calculation surface. The lighting level on this area must meet the value recommended by the authority. Fig. 7.9 shows the simulation view of Car Parking area.

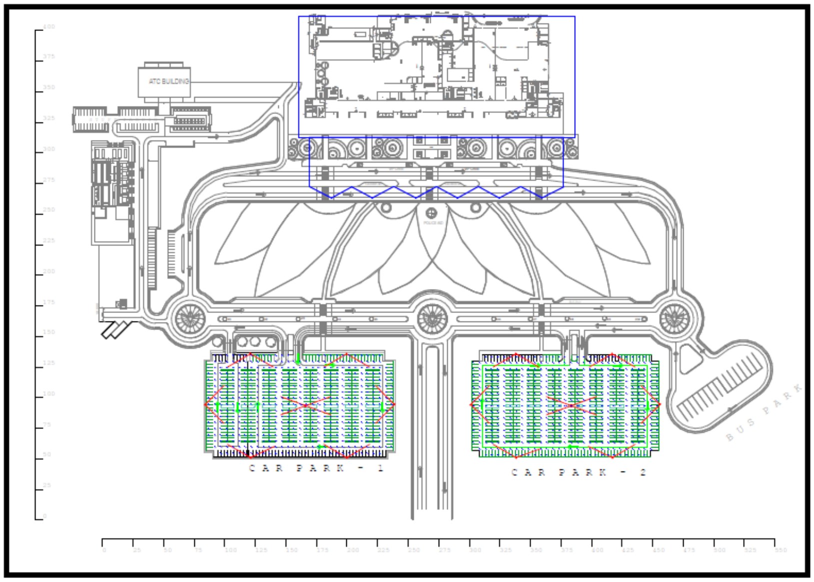


Figure 7.9: Car Parking Area Design in AGi 32 Software

Result Overview:

Calculation Summary						
Label	CalcType	Units	Avg	Max	Min	Min/Avg
Car Park 1 area	Illuminance	Lux	29.9	150	8	0.27
Car Park 2 area	Illuminance	Lux	29.7	155	8	0.27

Here for car parking 1 the value of average illumination level of 29.9 Lux and overall uniformity of 0.27 is achieved. For car parking 2 the value of average illumination level of 29.7 Lux and overall uniformity of 0.27 is achieved.

3D View of Car Parking Area :

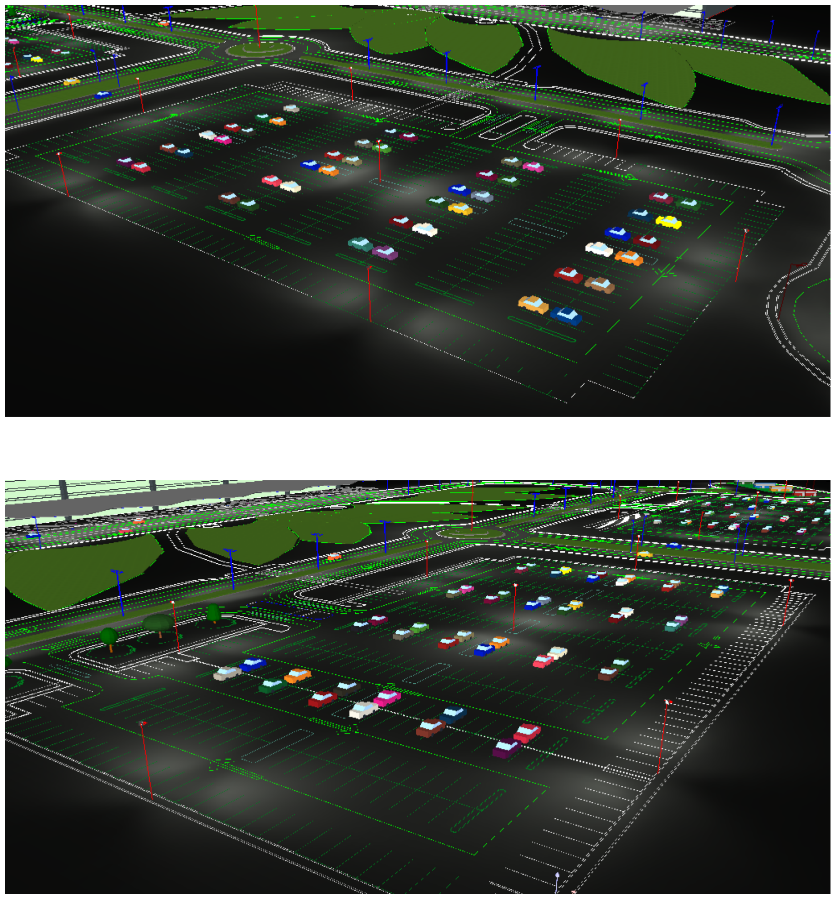


Figure 7.10: 3D View of Car Parking Area

7.1.3 Bus Parking

Bus parking at an airport is an essential facility that accommodates buses used for various purposes, such as airport shuttle services, charter buses, tour buses, and ground transportation for passengers and airport staff.

Safety is of utmost importance in bus parking areas. Adequate lighting, clear signage, and well-marked pedestrian pathways should be provided to ensure the safety of passengers and pedestrians in and around the bus parking area. Additionally, traffic flow within the parking area should be carefully planned to prevent congestion and facilitate smooth operations.

Design Aim:

When designing the illumination for an airport bus parking area, the primary objectives are to ensure safety, visibility, and security for buses, drivers, passengers, and pedestrians.

Determine the required illuminance levels for the bus parking area based on local regulations and safety standards. Adequate lighting should be provided to ensure clear visibility for drivers maneuvering buses and passengers boarding or disembarking.

Aim for uniform lighting distribution across the entire bus parking area to minimize shadows and provide consistent illumination. Uniform lighting helps drivers assess the surroundings and enhances safety for passengers and pedestrians moving within the area.

- Required illuminance level: Average 20 Lux
- Overall uniformity: 0.25

Layout and Description of Bus Parking Area:

Considering the Bus Parking for better understanding of lighting design, analyzing software AGi 32 has been used for describing and achieving the recommended values as per standard. Typical plan layout of the Bus Parking (green coloured portion) is shown in Fig. 7.11 below.

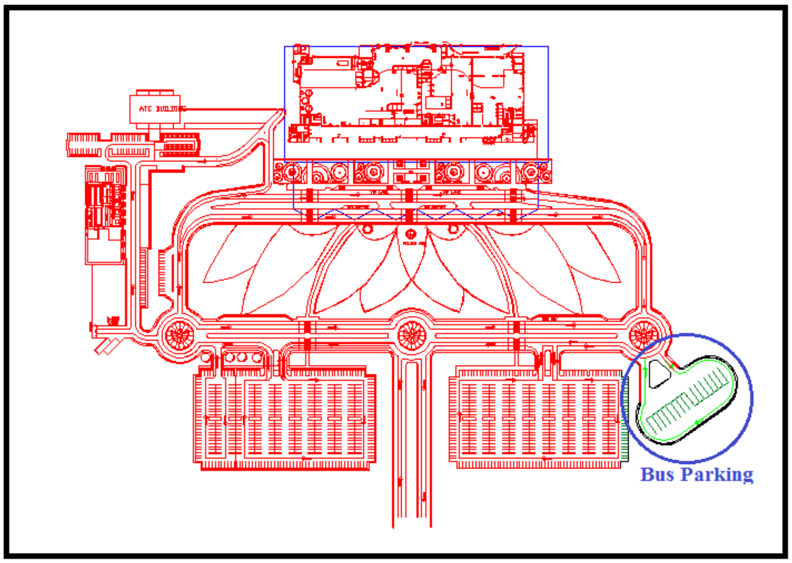


Figure 7.11: Typical Plan Layout of Bus Parking Area

Luminaire Used:

Luminaire Schedule				
Symbol	**Qty**	**Label**	**LLF**	**Description**
	6	C	0.850	CRP-414-180-57-HL2-GL-HR-NSG

LED 180W Streetlight

Specifications:

- Luminous flux: 21600 Lumen
- Wattage: 180 Watt
- Vo;tage Rating: 240V
- Current Rating: 0.789Amp
- System Efficacy: 120 lm/W
- CCT: 5700K
- CRI: 70
- IP 66 protected

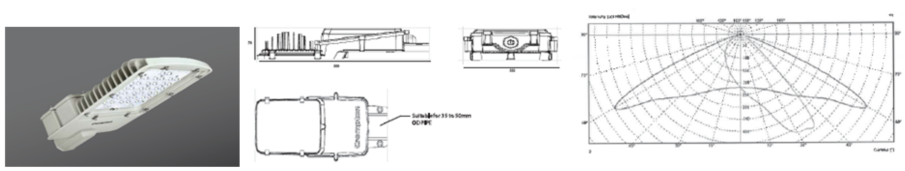


Figure 7.12: LED 180W Streetlight: Image, Dimension and Polar Curve

Design Considerations for the Lighting Implementation:

LED 180W Streetlight:

- Number of Luminaires: 6
- Pole height : 9m from Road Level
- Bracket : 2mtr
- Tilt : 20 deg.
- Spacing : 30mtr
- Maintenance factor: 0.85

AGi 32 Simulation:

AGi 32 simulation of the Bus Parking area is based on positioning the light-fixture and aiming the luminaire in exact manner to achieve recommended illumination level on the calculation surface. The lighting level on this area must meet the value recommended by the authority. Fig. 7.13 shows the simulation view of Bus Parking area.

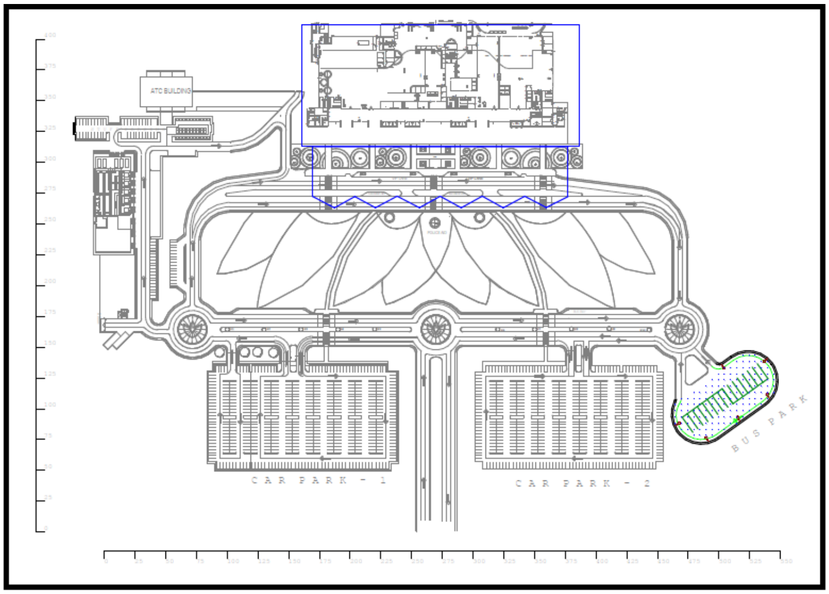


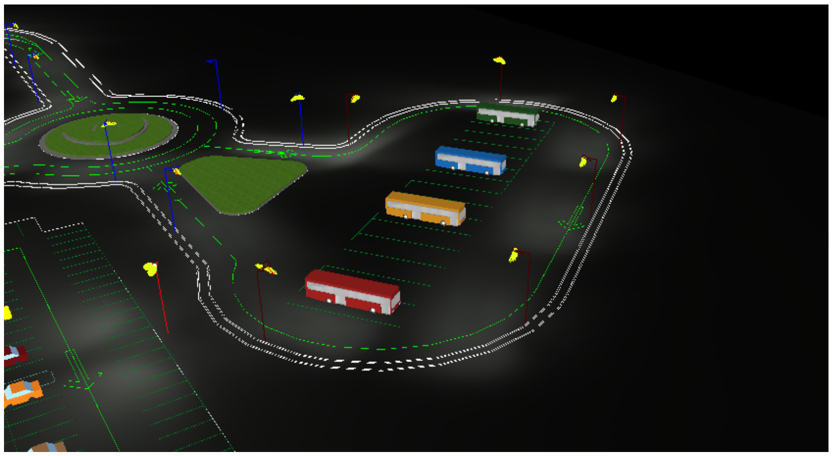
Figure 7.13: Bus Parking Area Design in AGi 32 Software

Result Overview:

Calculation Summary						
Label	**CalcType**	**Units**	**Avg**	**Max**	**Min**	**Min/Avg**
Bus Park area	Illuminance	Lux	28.4	59	8	0.28

Here for bus parking the value of average illumination level of 28.4 Lux and overall uniformity of 0.28 is achieved.

3D View of Bus Parking Area :



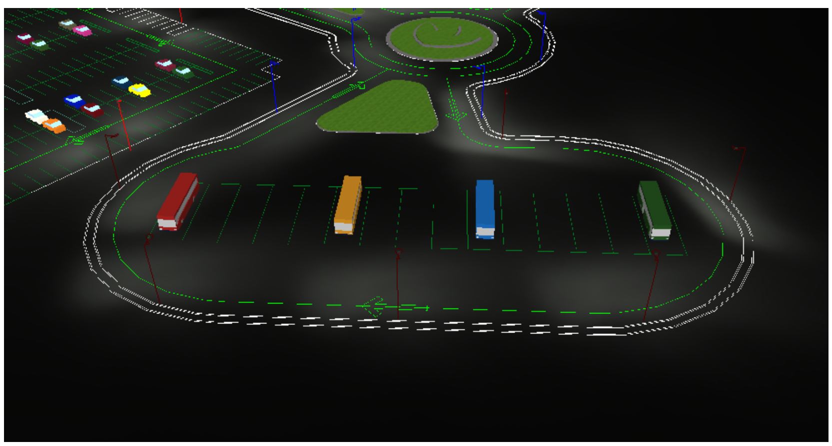


Figure 7.14: 3D View of Bus Parking Area

7.1.4 Staff Vehicle Parking Area

The staff vehicle parking area in an airport serves as a dedicated parking space for airport employees, including airline staff, airport personnel, and other authorized personnel.Adequate security measures should be implemented in the staff parking area to ensure the safety of employees and their vehicles. This may include surveillance cameras, well-lit areas, controlled access points, and security patrols to deter theft, vandalism, or unauthorized access.

Proper illumination is crucial for staff vehicle parking areas, particularly during early morning, late-night, or low-light conditions.

Design Aim:

When designing the illumination for the staff vehicle parking area in an airport, the primary objectives are to ensure safety, visibility, and security for employees.Ensure that the lighting design enhances security measures in the staff parking area. Well-lit parking areas discourage criminal activities and assist security personnel in monitoring and surveilling the area effectively. Coordinated efforts between lighting and security teams can help create a safe environment.

Determine the required illuminance levels for the staff vehicle parking area based on local regulations and safety standards. Adequate lighting should be provided to ensure clear visibility for employees walking to and from their vehicles, as well as within the parking area itself.

Aim for uniform lighting distribution across the entire staff vehicle parking area to minimize shadows and provide consistent illumination. Uniform lighting helps employees assess their surroundings, locate their vehicles, and navigate the parking lot safely.

- Required illuminance level: Average 20 Lux
- Overall uniformity: 0.25

Layout and Description of Staff Vehicle Parking Area:

Considering the Staff Vehicle Parking Area for better understanding of lighting design, analyzing software AGi 32 has been used for describing and achieving the recommended values as per standard. Typical plan layout of the Staff Vehicle Parking Area (green coloured portion) is shown in Fig. 7.15 below.

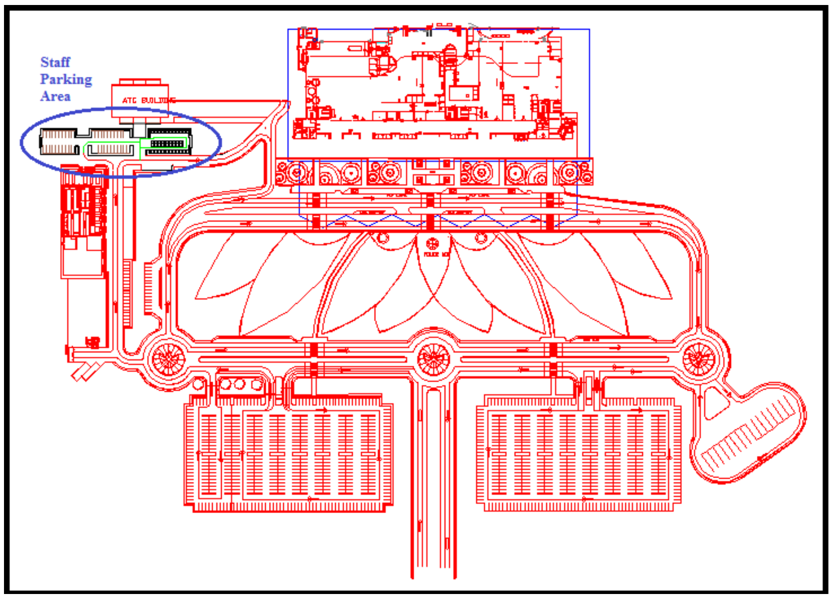


Figure 7.15: Typical Plan Layout of Staff Vehicle Parking Area

Luminaire Used:

Luminaire Schedule				
Symbol	Qty	Label	LLF	Description
	3	C	0.850	CRP-414-180-57-HL2-GL-HR-NSG

LED 180W Streetlight

Specifications:

- Luminous flux: 21600 Lumen
- Wattage: 180 Watt
- Vo;tage Rating: 240V
- Current Rating: 0.789Amp
- System Efficacy: 120 lm/W
- CCT: 5700K
- CRI: 70
- IP 66 protected

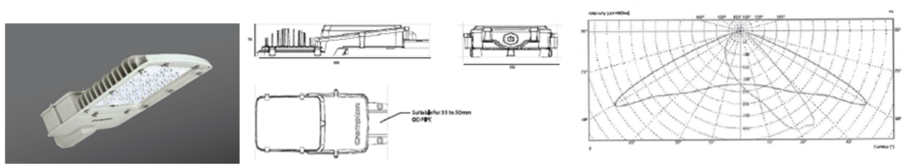


Figure 7.16: LED 180W Streetlight: Image, Dimension and Polar Curve

Design Considerations for the Lighting Implementation:

LED 180W Streetlight:

- Number of Luminaires: 3
- Pole height : 9m from Road Level
- Bracket : 2mtr
- Tilt : 20 deg.
- Maintenance factor: 0.85

AGi 32 Simulation:

AGi 32 simulation of the Staff Vehicle Parking Area is based on positioning the lightfixture and aiming the luminaire in exact manner to achieve recommended illumination level on the calculation surface. The lighting level on this area must meet the value recommended by the authority. Fig. 7.17 shows the simulation view of Staff Vehicle Parking Area.

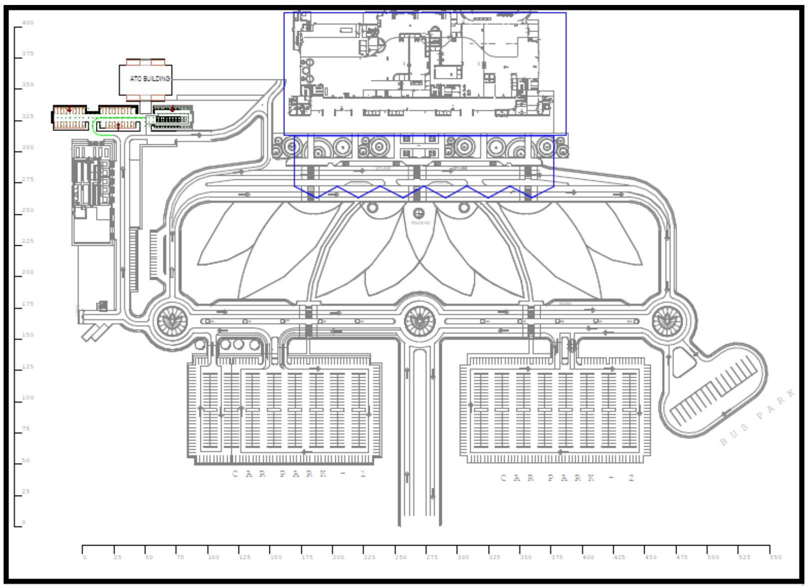


Figure 7.17: Staff Vehicle Parking Area Design in AGi 32 Software

Result Overview:

Calculation Summary						
Label	CalcType	Units	Avg	Max	Min	Min/Avg
Stuff Park area	Illuminance	Lux	25.8	60	7	0.27

Here for Staff Vehicle Parking Area the value of average illumination level of 25.8 Lux and overall uniformity of 0.27 is achieved.

3D View of Staff Vehicle Parking Area :

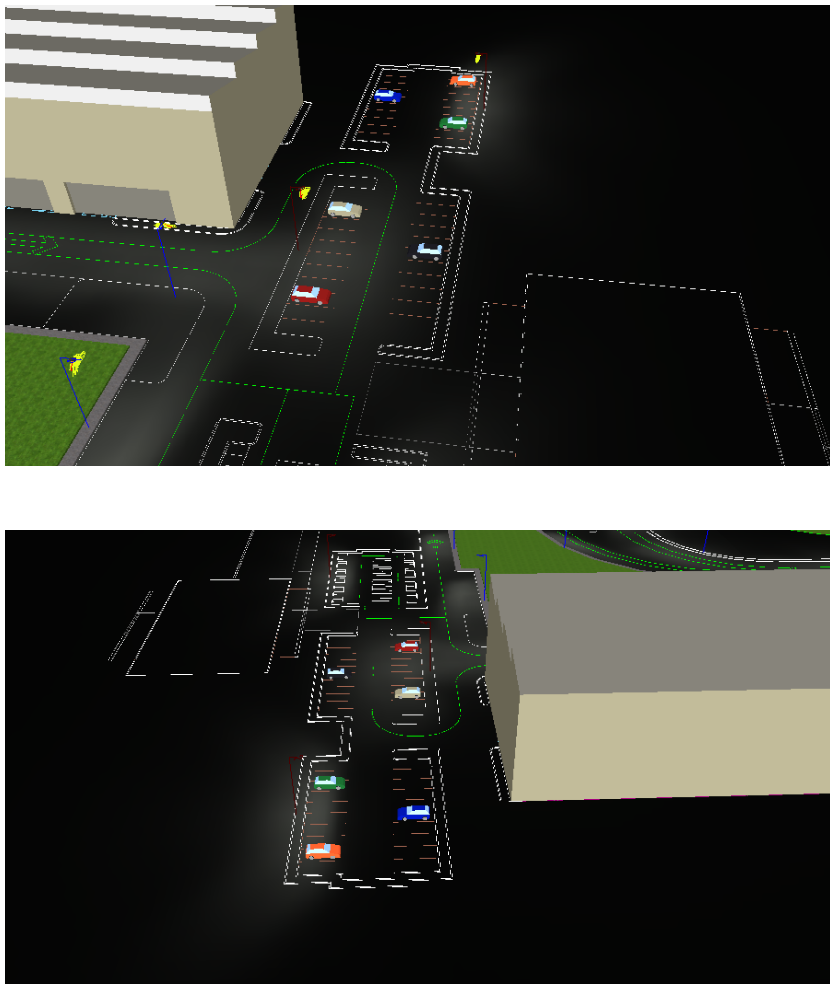


Figure 7.18: 3D View of Staff Vehicle Parking Area

7.1.5 Entrance and Taxi Drop Area

The entrance and taxi drop area in an airport are specific locations where vehicles, such as taxis and private cars, can enter the airport premises and drop off passengers. These areas are typically located near the main terminal building or designated entrance points.

Design Aim:

Differentiate lighting zones within the entrance and taxi drop area to address specific needs. For example, consider separate lighting for passenger drop-off and pick-up points, pedestrian walkways, signage, and waiting areas.

Pay special attention to lighting in vehicle movement areas, such as the lanes where taxis drop off and pick up passengers. Ensure adequate lighting is provided to assist drivers in maneuvering safely and efficiently.

- Required illuminance level: Average 150 Lux
- Overall uniformity: 0.25

Layout and Description of Entrance and Taxi Drop Area:

Considering the Entrance and Taxi Drop Area for better understanding of lighting design, analyzing software AGi 32 has been used for describing and achieving the recommended values as per standard. Typical plan layout of the Entrance and Taxi Drop Area (green coloured portion) is shown in Fig. 7.19 below.

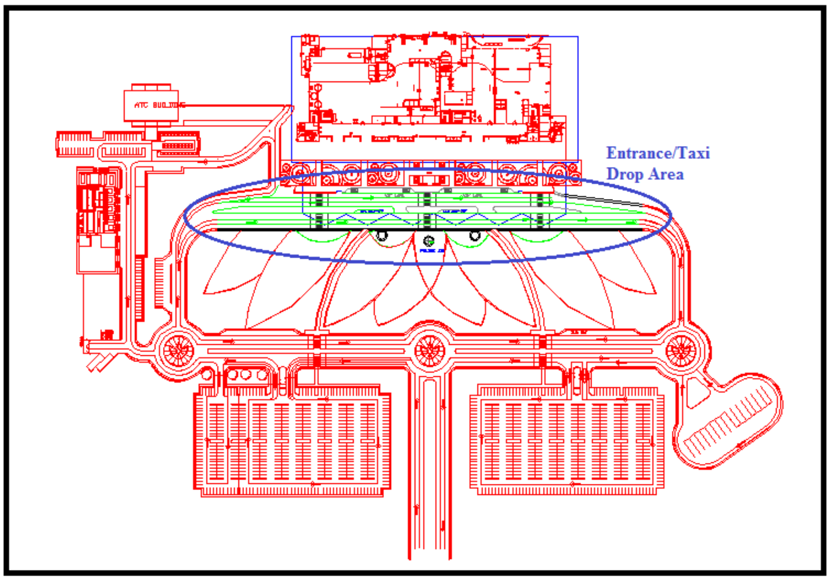


Figure 7.19: Typical Plan Layout of Entrance and Taxi Drop Area

Luminaire Used:

Luminaire Schedule				
Symbol	Qty	Label	LLF	Description
	156	D	0.850	CIR-328-80-65-SL-DP-NWH

LED 80W Linear Under Canopy Light

Specifications:

- Luminous flux: 8195.5 Lumen
- Wattage: 80 Watt
- Vo;tage Rating: 240V
- Current Rating:
- System Efficacy: 100 lm/W
- CCT: 6500K
- CRI: 70
- IP 66 protected

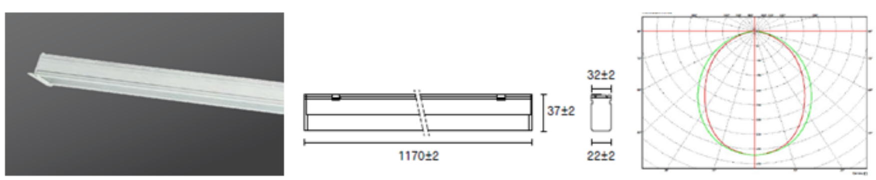


Figure 7.20: LED 80W Linear Under Canopy Light: Image, Dimension and Polar Curve

Design Considerations for the Lighting Implementation:

LED 80W Linear Under Canopy Light:

- Number of Luminaires: 156
- Mounting Height : 8m from Road Level
- Maintenance factor: 0.85

AGi 32 Simulation:

AGi 32 simulation of the Entrance and Taxi Drop Area is based on positioning the lightfixture and aiming the luminaire in exact manner to achieve recommended illumination level on the calculation surface. The lighting level on this area must meet the value recommended by the authority. Fig. 7.21 shows the simulation view of Entrance and Taxi Drop Area.

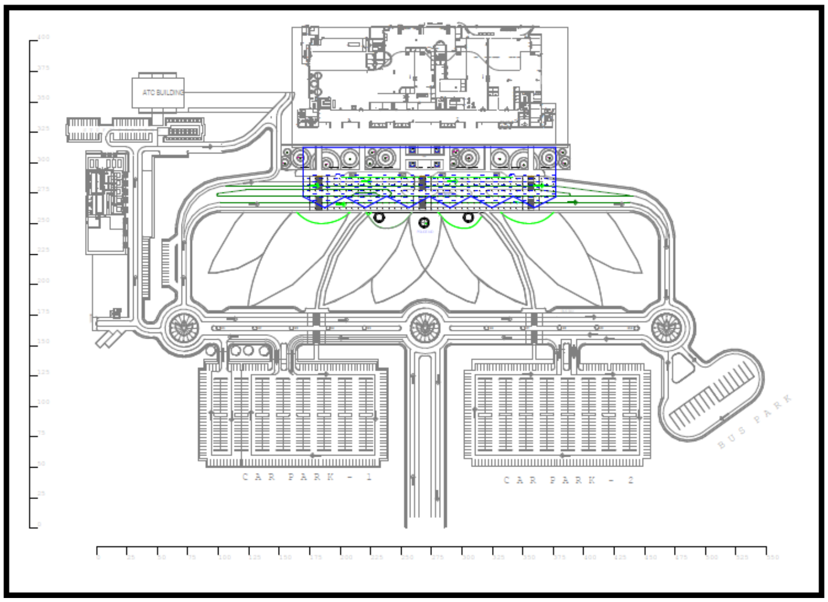


Figure 7.21: Entrance and Taxi Drop Area Design in AGi 32 Software

Result Overview:

Calculation Summary						
Label	**CalcType**	**Units**	**Avg**	**Max**	**Min**	**Min/Avg**
TAXI DROP AREA	Illuminance	Lux	158.3	220.9	40.2	0.25

Here for Entrance and Taxi Drop Area the value of average illumination level of 158.3 Lux and overall uniformity of 0.25 is achieved.

3D View of Entrance and Taxi Drop Area :

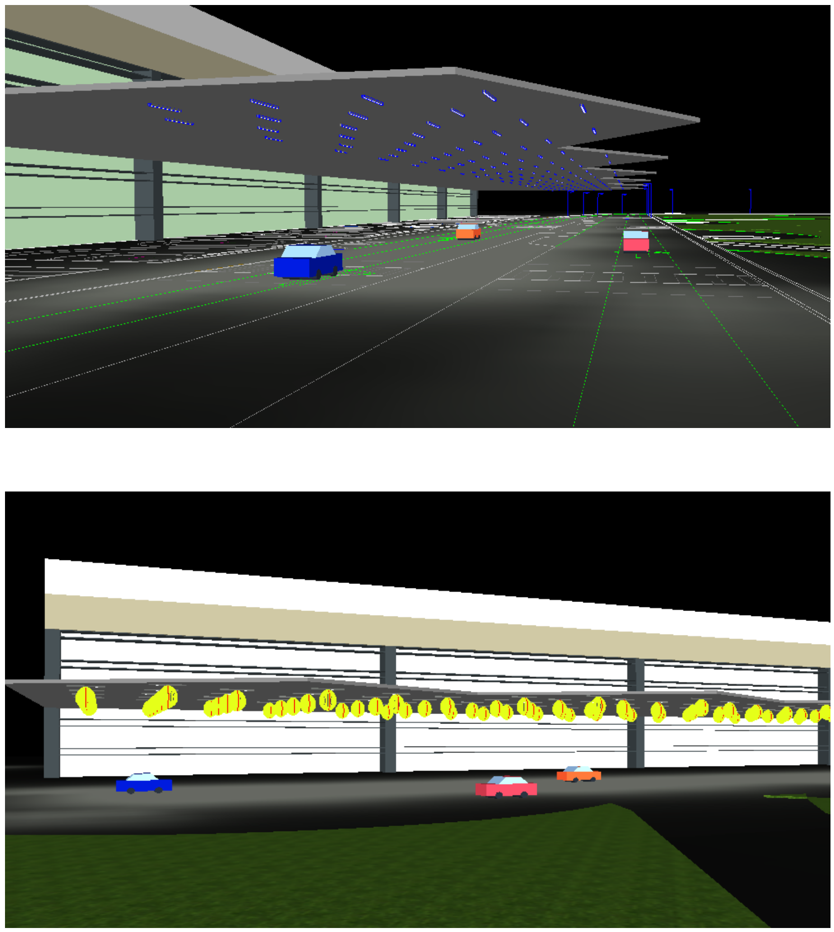


Figure 7.22: 3D View of Entrance and Taxi Drop Area

3D View of Overall Landside Area :

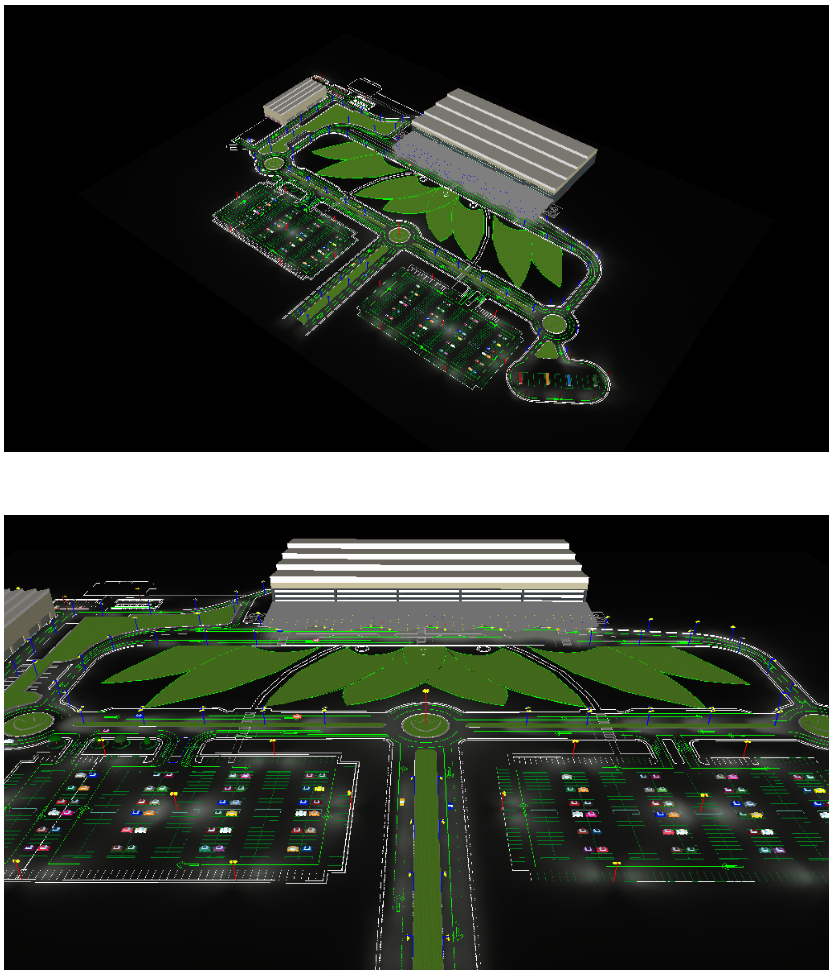


Figure 7.23: 3D View of Overall Landside Area

7.2 Illumination Design of Terminal Side Area

The terminal side of an airport refers to the area where passenger facilities, including the terminal building, gates, check-in counters, security checkpoints, baggage claim areas, and passenger amenities are located. Designing the illumination for the terminal side is crucial for creating a welcoming, safe, and efficient environment for passengers and airport staff.

7.2.1 Security Scan Checking

Security scan checking in an airport refers to the process of screening passengers and their belongings to detect prohibited items, weapons, or potential security threats before they board an aircraft. The illumination design for security scan checking areas is crucial to ensure effective screening, maintain safety, and create a comfortable environment for passengers and security personnel.

Create a balanced lighting environment by providing even illumination throughout the security scan checking area. This helps eliminate shadows and ensures consistent visibility across all areas, including screening machines, conveyors, and walk-through metal detectors.

Design Aim:

The illumination design for airport security scan checking areas is crucial to ensure effective and accurate screening of passengers and their belongings while maintaining a safe and comfortable environment.

Provide sufficient lighting levels to enable security personnel to accurately inspect and identify objects on the screening monitors. Adequate illuminance enhances visibility and facilitates the detection of prohibited items or potential threats. Recommended lux levels may vary depending on local regulations and specific requirements.

Ensure uniform lighting throughout the security scan checking area to eliminate shadows and provide consistent visibility across all inspection points. Uniform lighting helps maintain accuracy during screening procedures and prevents any areas from being excessively bright or dim.

- Required illuminance level: Average 500 Lux
- Overall uniformity: 0.6

Layout and Description of Security Scan Checking:

Considering the Security Scan Checking area for better understanding of lighting design, analyzing software DIALux 4.13 has been used for describing and achieving the recommended values as per standard. Typical plan layout of the Security Scan Checking area is shown in Fig. 7.24 below.

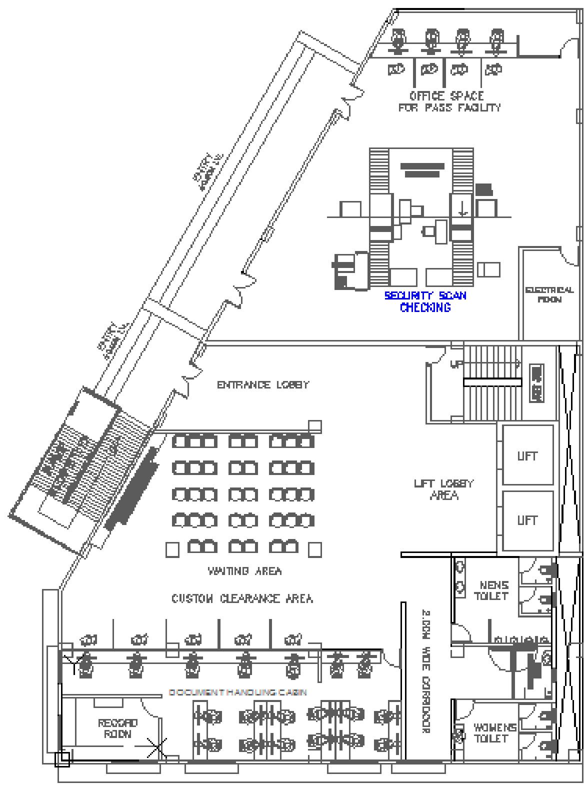


Figure 7.24: Typical plan Layout of Security Scan Checking Area

Number of Luminaires Calculation using Lumen Method Formula:

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

E= (n*N* Q* UF*MF)/A
Where,

E = Average illuminance over the horizontal working plane = 500 Lux
n = Number of lamps in each luminaire = 1
N = Number of luminaire = ?
Q = Initial bare lamp luminious flux = 1983 Lumen
UF = Utilisation factor for the horizontal working plane = 1
MF = Maintenance factor = 0.8
A = Area of the horizontal working plane = 192.27 sq m

So,
N = 60

Thus the number of luminaires can be found using this formula and is carried out for the rest of the design.

Luminaire Used:

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	62	Crompton Greaves Consumer Electricals Ltd 01 CDR-206-18-57-SL-NWH (1.000)	1983	2005	18.4
			Total: 122975	Total: 124285	1140.8

LED 18W Downlighter

Specifications:

• Luminous flux: 1983 Lumen
• Wattage: 18 Watt
• Vo;tage Rating: 240V
• Current Rating: 0.078Amp
• System Efficacy: 110 lm/W
• CCT: 5700K
• CRI: 80
• IP 20 protected

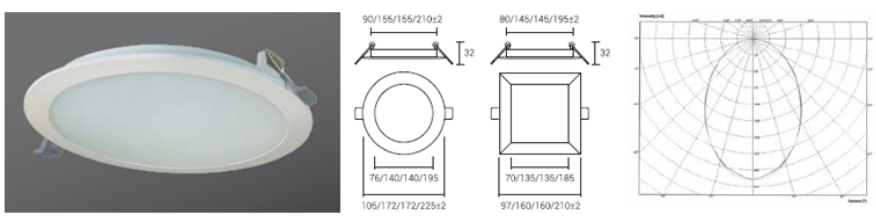


Figure 7.25: LED 18W Downlighter: Image, Dimension and Polar Curve

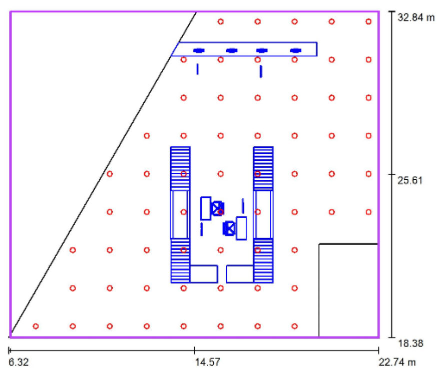
Design Considerations for the Lighting Implementation:

LED 18W Downlighter:

• Number of Luminaires: 62
• Mounting height: 4m from floor level
• Maintenance factor: 0.8
• Ceiling, Wall and Floor reflectance factor is considered (70-50-20) percent respectively

DIALux Simulation:

DIALux 4.13 simulation of the Security Scan Checking is based on positioning the light fixture and aiming the luminaire in exact manner to achieve recommended illumination level on the calculation surface. The lighting level on this area must meet the value recommended by the authority. Fig. 7.26 shows the simulation view of Security Scan Checking.



Scale 1 : 145

Position: (14.570 m, 25.610 m, 0.760 m)
Size: (16.339 m, 14.463 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: User defined, Quantity Points: 66

Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\,m}/E_m$	H [m]	Camera
1	perpendicular	529	395	601	0.75	0.66	/	0.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

Figure 7.26: Security Scan Checking Area Design in DIALux Software

Here for Security Scan Checking Area the value of average illumination level of 529 Lux and overall uniformity of 0.75 is achieved.

3D View of Security Scan Checking Area :

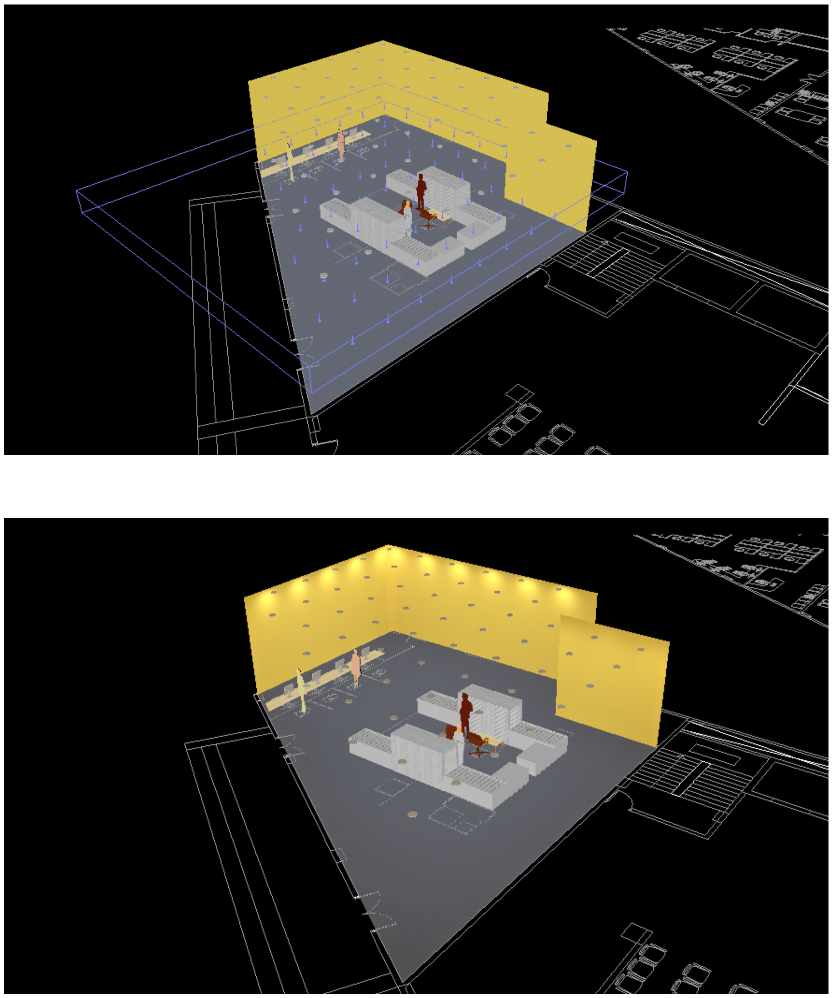


Figure 7.27: 3D View of Security Scan Checking Area

7.2.2 Baggage Claim Areas

The baggage claim area in an airport is the designated space where arriving passengers retrieve their checked-in luggage or baggage. After passengers disembark from the aircraft and proceed through immigration and customs procedures, they proceed to the baggage claim area to collect their belongings before exiting the airport. The baggage claim area is typically located within the terminal building, often near the arrivals hall or in a separate section specifically dedicated to baggage handling.

In airport baggage claim areas, proper illumination is crucial to facilitate the efficient and secure retrieval of passengers' luggage. The recommended lux levels for baggage claim areas in an airport may vary depending on specific requirements and regulations.

Design Aim:

Provide a balanced and uniform general illumination throughout the baggage claim area. This level of illumination ensures passengers can easily locate their luggage and navigate safely. The areas around the conveyor belts where passengers collect their luggage require higher illumination levels.

- Required illuminance level: Average 500 Lux
- Overall uniformity: 0.6

Layout and Description of Baggage Claim Areas:

Considering the Baggage Claim area for better understanding of lighting design, analyzing software DIALux 4.13 has been used for describing and achieving the recommended values as per standard. Typical plan layout of the Baggage Claim area is shown (crossed mark portion) in Fig. 7.28 below.

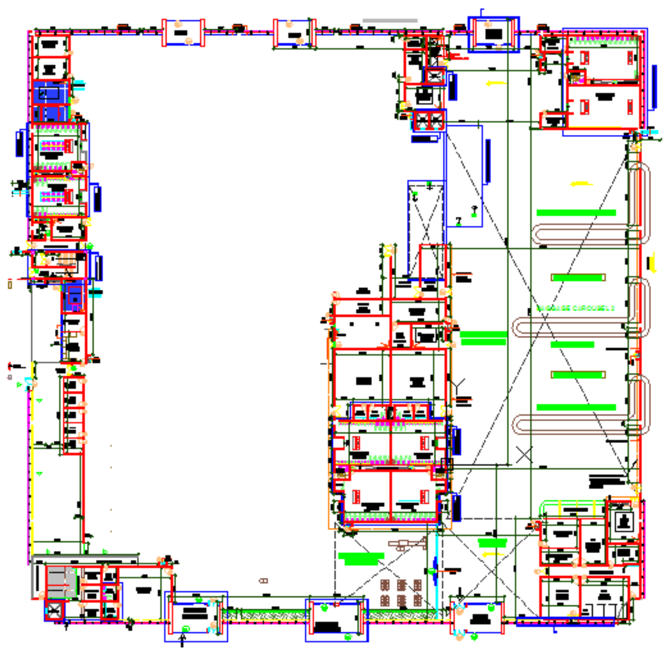


Figure 7.28: Typical plan Layout of Baggage Claim Areas

Luminaire Used:

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	439	Crompton Greaves Consumer Electricals Ltd 05 LCTLRNE-36-FO-CDL (1.000)	3906	3946	34.2
			Total: 1714594	Total: 1732206	15013.8

LED 36W Recessed Mounted (2ftx2ft) Tiles

Specifications:

- Luminous flux: 3906 Lumen
- Wattage: 36 Watt
- Vo;tage Rating: 240V
- Current Rating: 0.17Amp
- System Efficacy: 110 lm/W
- CCT: 5700K
- CRI: 80
- IP 20 protected

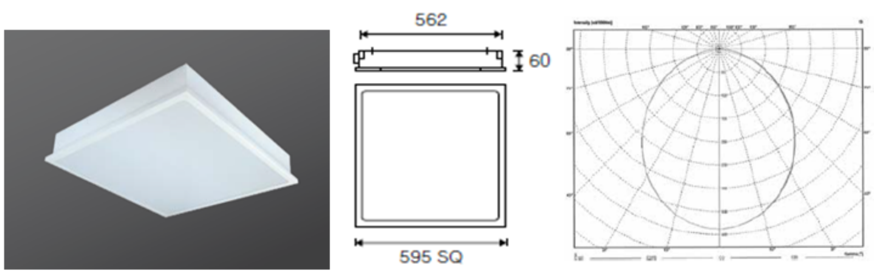


Figure 7.29: LED 36W Recessed Mounted (2ftx2ft) Tiles: Image, Dimension and Polar Curve

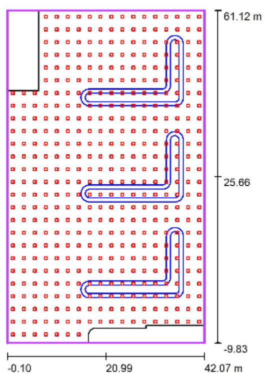
Design Considerations for the Lighting Implementation:

LED 36W Recessed Mounted (2ftx2ft) Tiles

- Number of Luminaires: 439
- Mounting height: 3.5m from floor level
- Maintenance factor: 0.8
- Ceiling, Wall and Floor reflectance factor is considered (70-50-20) percent respectively

DIALux Simulation:

DIALux 4.13 simulation of the Baggage Claim area is based on positioning the light fixture and aiming the luminaire in exact manner to achieve recommended illumination level on the calculation surface. The lighting level on this area must meet the value recommended by the authority. Fig. 7.30 shows the simulation view of Baggage Claim area.



Scale 1 : 711

Position: (20.987 m, 25.658 m, 0.760 m)
Size: (42.172 m, 70.916 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: User defined, Quantity Points: 192

Results overview

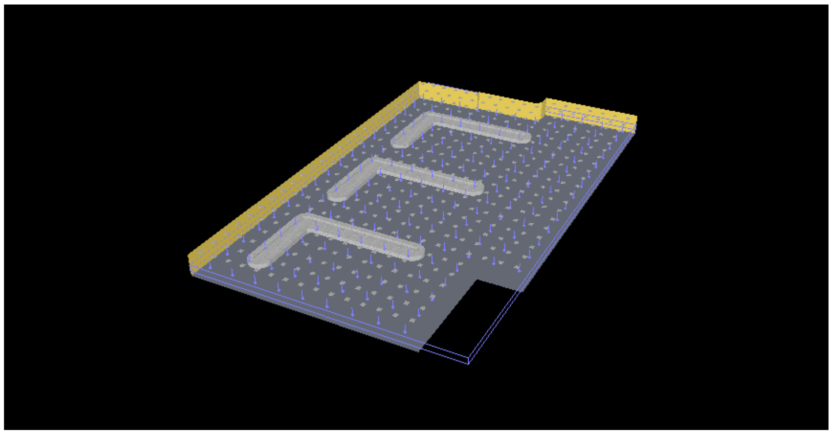
No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\,m}/E_m$	H [m]	Camera
1	perpendicular	523	413	553	0.79	0.75	/	0.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

Figure 7.30: Baggage Claim Area Design in DIALux Software

Here for Security Baggage Claim Area the value of average illumination level of 523 Lux and overall uniformity of 0.79 is achieved.

3D View of Baggage Claim Area :



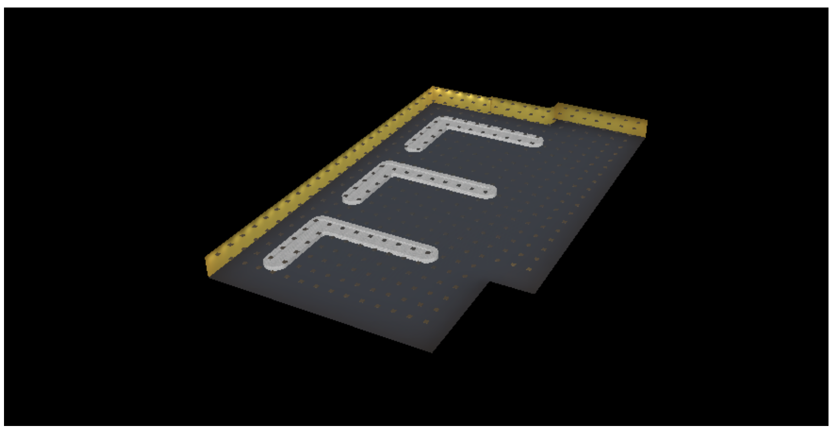


Figure 7.31: 3D View of Baggage Claim Area

7.2.3 Meeting Room

An airport Meeting Room is a designated space within an airport facility where individuals or groups can hold meetings, discussions, presentations, or conduct business activities. These meeting rooms are designed to provide a convenient and professional environment for travelers, airport staff, or business professionals who require a private space to collaborate or conduct meetings while at the airport.

Design Aim:

The illumination design for airport meeting rooms is essential to create a conducive and professional environment for productive meetings.

Aim for a balanced and uniform distribution of light throughout the meeting room. Avoid excessive contrast or shadows that can cause visual discomfort or difficulty in reading materials. Uniform lighting ensures that participants can see each other, presentation materials, and other visual aids clearly from all areas of the room.

- Required illuminance level: Average 500 Lux
- Overall uniformity: 0.6

Layout and Description of Meeting Room:

Considering the Meeting Room for better understanding of lighting design, analyzing software DIALux 4.13 has been used for describing and achieving the recommended values as per standard. Typical plan layout of the Meeting Room is shown in Fig. 7.32 below.

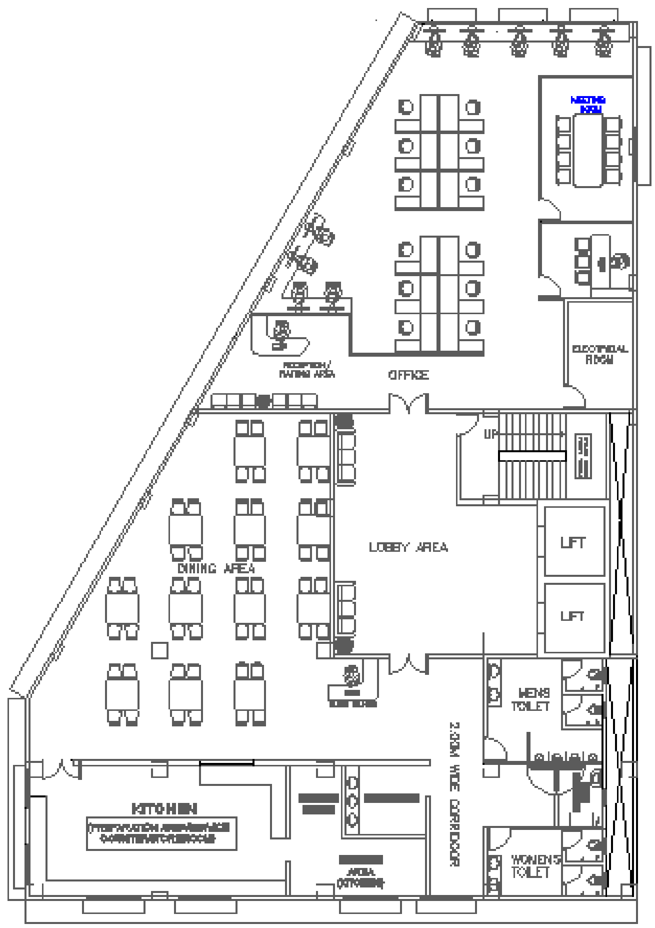


Figure 7.32: Typical Plan Layout of Meeting Room

Luminaire Used:

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	6	Crompton Greaves Consumer Electricals Ltd 01 CDR-206-18-57-SL-NWH (1.000)	1983	2005	18.4
2	2	Crompton Greaves Consumer Electricals Ltd 05 LCTLRNE-36-FO-CDL (1.000)	3906	3946	34.2
			Total: 19712	Total: 19919	178.8

LED 36W Recessed Mounted (2ftx2ft) Tiles

Specification:

- Luminous flux: 3906 Lumen
- Wattage: 36 Watt
- Vo;tage Rating: 240V
- Current Rating: 0.17Amp
- System Efficacy: 110 lm/W
- CCT: 5700K
- CRI: 80
- IP 20 protected

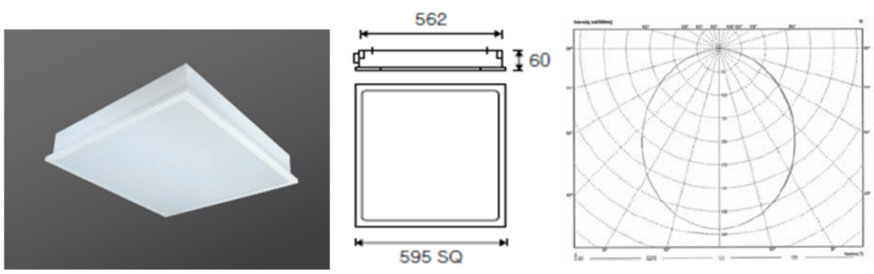


Figure 7.33: LED 36W Recessed Mounted (2ftx2ft) Tiles: Image, Dimension and Polar Curve

LED 18W Downlighter

Specifications:

- Luminous flux: 1983 Lumen
- Wattage: 18 Watt
- Vo;tage Rating: 240V
- Current Rating: 0.078Amp
- System Efficacy: 110 lm/W
- CCT: 5700K
- CRI: 80
- IP 20 protected

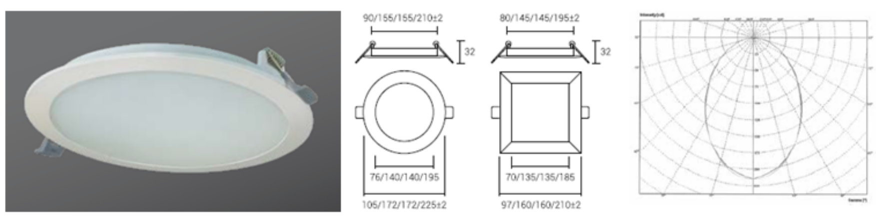


Figure 7.34: LED 18W Downlighter: Image, Dimension and Polar Curve

Design Considerations for the Lighting Implementation:

LED 36W Recessed Mounted (2ftx2ft) Tiles:

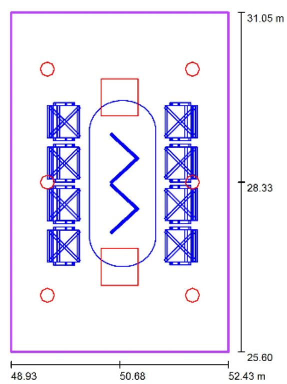
- Number of Luminaires: 2
- Mounting height: 3.0m from floor level
- Maintenance factor: 0.8
- Ceiling, Wall and Floor reflectance factor is considered (70-50-20) percent respectively

LED 18W Downlighter:

- Number of Luminaires: 6
- Mounting height: 3.0m from floor level
- Maintenance factor: 0.8
- Ceiling, Wall and Floor reflectance factor is considered (70-50-20) percent respectively

DIALux Simulation:

DIALux 4.13 simulation of the Meeting Room is based on positioning the light fixture and aiming the luminaire in exact manner to achieve recommended illumination level on the calculation surface. The lighting level on this area must meet the value recommended by the authority. Fig. 7.35 shows the simulation view of Meeting Room.



Scale 1 : 52

Position: (50.678 m, 28.330 m, 0.760 m)
Size: (3.499 m, 5.450 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 5 x 9 Points

Results overview

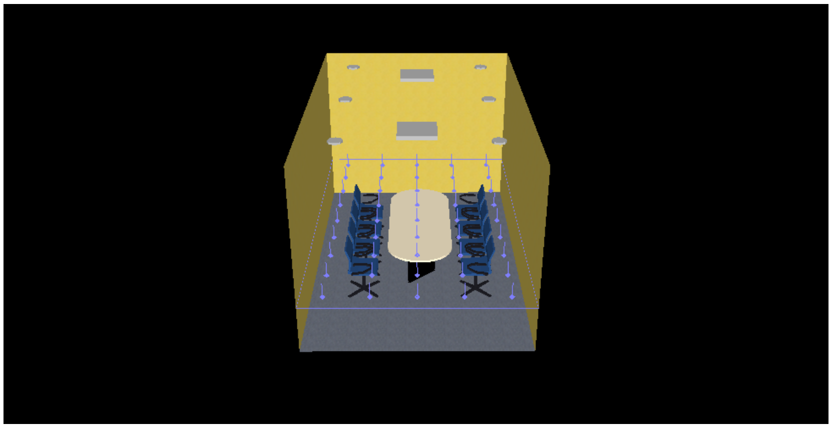
No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\,m}/E_m$	H [m]	Camera
1	perpendicular	532	392	645	0.74	0.61	/	0.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

Figure 7.35: Meeting Room Design in DIALux Software

Here for Meeting Room the value of average illumination level of 532 Lux and overall uniformity of 0.74 is achieved.

3D View of Meeting Room :



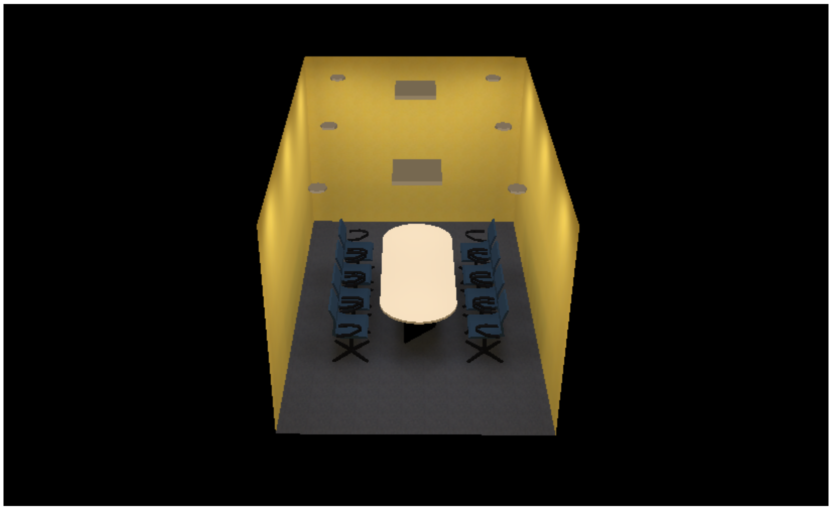


Figure 7.36: 3D View of Meeting Room

7.2.4 Dining Area

A Dining Area in an airport is a designated space where passengers and visitors can enjoy meals, snacks, or beverages while they are at the airport. These dining areas are typically located within the terminal building and are designed to provide a comfortable and convenient environment for individuals to relax, dine, and recharge before or after their flights.

The illumination design for an airport dining area is essential to create a welcoming and comfortable environment for passengers and visitors to enjoy their meals.

Design Aim:

Provide balanced lighting levels that allow diners to see their food and surroundings comfortably. Ensure uniform lighting distribution throughout the dining area to minimize shadows and provide consistent illumination across tables and seating areas. This helps to create a visually balanced and comfortable dining experience for all patrons. Avoid extreme contrasts or excessively bright or dim areas.

- Required illuminance level: Average 300 Lux
- Overall uniformity: 0.6

Layout and Description of Dining Area:

Considering the Dining Area for better understanding of lighting design, analyzing software DIALux 4.13 has been used for describing and achieving the recommended values as per standard. Typical plan layout of the Dining Area is shown in Fig. 7.37 below.

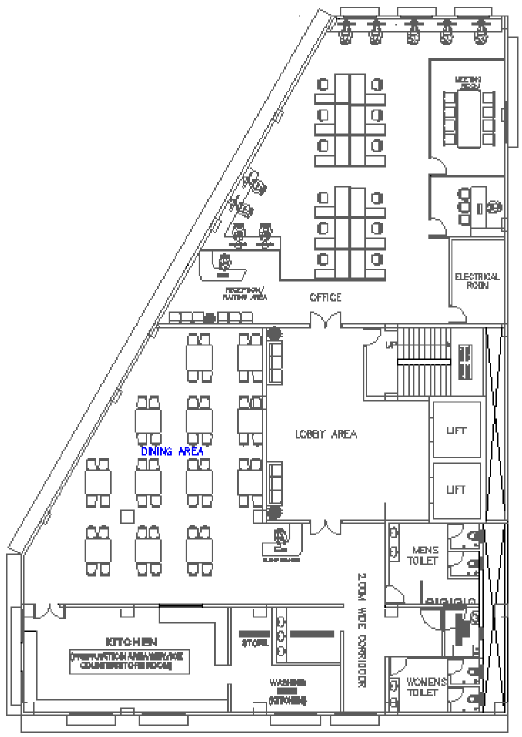


Figure 7.37: Typical Plan Layout of Dining Area

Luminaire Used:

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	38	Crompton Greaves Consumer Electricals Ltd 01 CDR-206-15-57-SL-NWH (1.000)	1657	1674	15.7
			Total: 62964	Total: 63612	598.1

LED 15W Downlighter

Specifications:

- Luminous flux: 1657 Lumen
- Wattage: 15 Watt
- Vo;tage Rating: 240V
- Current Rating: 0.0627Amp
- System Efficacy: 110 lm/W
- CCT: 5700K
- CRI: 80
- IP 20 protected

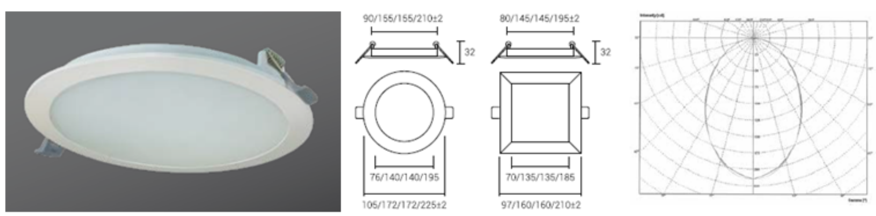


Figure 7.38: LED 18W Downlighter: Image, Dimension and Polar Curve

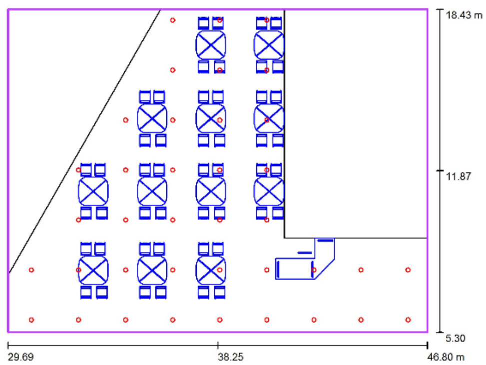
Design Considerations for the Lighting Implementation:

LED 18W Downlighter:

- Number of Luminaires: 38
- Mounting height: 3.0m from floor level
- Maintenance factor: 0.8
- Ceiling, Wall and Floor reflectance factor is considered (70-50-20) percent respectively

DIALux Simulation:

DIALux 4.13 simulation of the Dining Area is based on positioning the light fixture and aiming the luminaire in exact manner to achieve recommended illumination level on the calculation surface. The lighting level on this area must meet the value recommended by the authority. Fig. 7.39 shows the simulation view of Dining Area.



Scale 1 : 132

Position: (38.250 m, 11.867 m, 0.760 m)
Size: (17.100 m, 13.121 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: User defined, Quantity Points: 59

Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\ m}/E_m$	H [m]	Camera
1	perpendicular	333	206	385	0.62	0.54	/	0.000	/

$E_{h\ m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

Figure 7.39: Dining Area Design in DIALux Software

Here for Dining Area the value of average illumination level of 333 Lux and overall uniformity of 0.62 is achieved.

3D View of Dining Area :

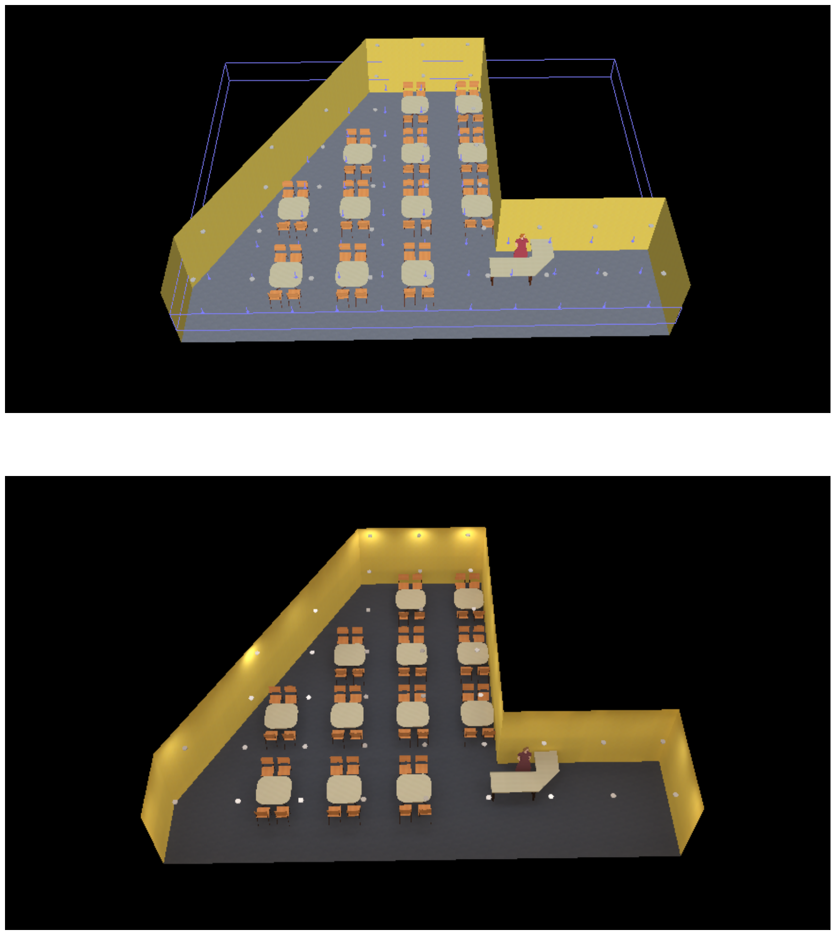


Figure 7.40: 3D View of Dining Area

7.2.5 Cargo Storage Area

The airport cargo storage area, also known as the cargo terminal or cargo warehouse, is a dedicated facility within an airport where various types of cargo and freight are handled, stored, and processed. It serves as a crucial hub for the movement of goods, both domestically and internationally, through air transportation.

Sufficient and properly distributed lighting is crucial in the cargo storage area to ensure safe and efficient operations. High-intensity lighting fixtures should be used to provide uniform illumination, enabling workers to identify, sort, and handle cargo effectively. Lighting design should consider the height and layout of storage racks, equipment positioning, and potential shadows or obstructions.

Design Aim:

The illumination design for an airport cargo storage area is crucial for ensuring a safe and efficient working environment. Provide sufficient lighting levels to ensure good visibility and safe working conditions. Ensure uniform lighting distribution throughout the cargo storage area to minimize shadows and provide consistent illumination across all areas. This helps workers navigate the space safely and perform tasks effectively. Avoid extreme contrasts or excessively bright or dim areas.

- Required illuminance level: Average 300 Lux
- Overall uniformity: 0.4

Layout and Description of Cargo Storage Area:

Considering the Cargo Storage Area for better understanding of lighting design, analyzing software DIALux 4.13 has been used for describing and achieving the recommended values as per standard. Typical plan layout of the Cargo Storage Area is shown in Fig. 7.41 below.

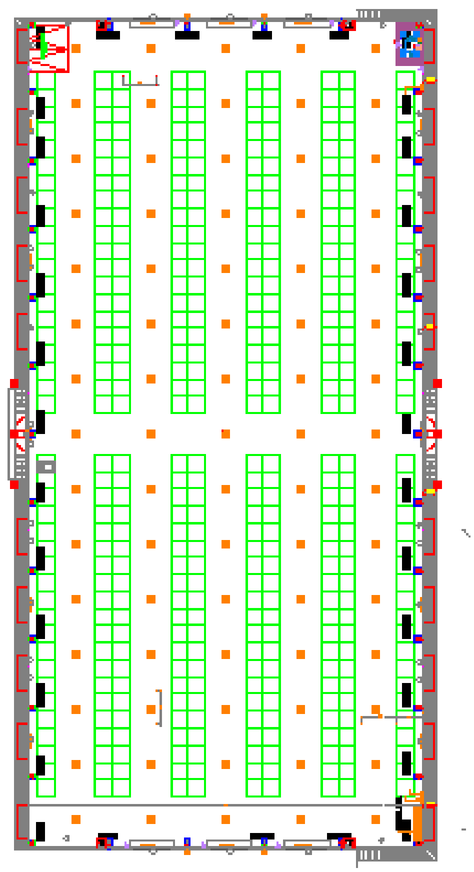


Figure 7.41: Typical Plan Layout of Cargo Storage Area

Luminaire Used:

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]		Φ (Lamps) [lm]	P [W]
1	75	Crompton Greaves Consumer Electricals Ltd 01 CIP-327-100-57-60D-HL2-LM-NSG (1.000)	12498		12500	103.8
			Total: 937357	Total:	937500	7785.8

LED 100W Highbay Luminaire

Specifications:

- Luminous flux: 12498 Lumen
- Wattage: 100 Watt
- Vo;tage Rating: 240V
- Current Rating: 0.45Amp
- System Efficacy: 120 lm/W
- CCT: 5700K
- Beam Angle: 60 Deg
- CRI: 70
- IP 66 protected

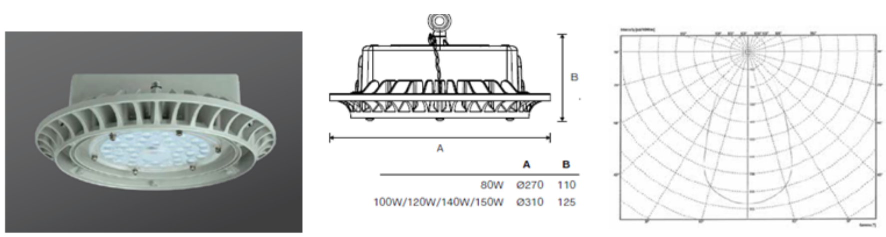


Figure 7.42: LED 100W Highbay Luminaire: Image, Dimension and Polar Curve

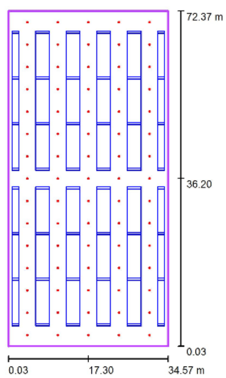
Design Considerations for the Lighting Implementation:

LED 100W Highbay Luminaire:

- Number of Luminaires: 75
- Mounting height: 10m from floor level
- Maintenance factor: 0.8
- Ceiling, Wall and Floor reflectance factor is considered (50-30-20) percent respectively

DIALux Simulation:

DIALux 4.13 simulation of the Cargo Storage Area is based on positioning the light fixture and aiming the luminaire in exact manner to achieve recommended illumination level on the calculation surface. The lighting level on this area must meet the value recommended by the authority. Fig. 7.43 shows the simulation view of Cargo Storage Area.



Scale 1 : 690

Position: (17.300 m, 36.200 m, 0.000 m)
Size: (34.540 m, 72.340 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 9 x 19 Points

Results overview

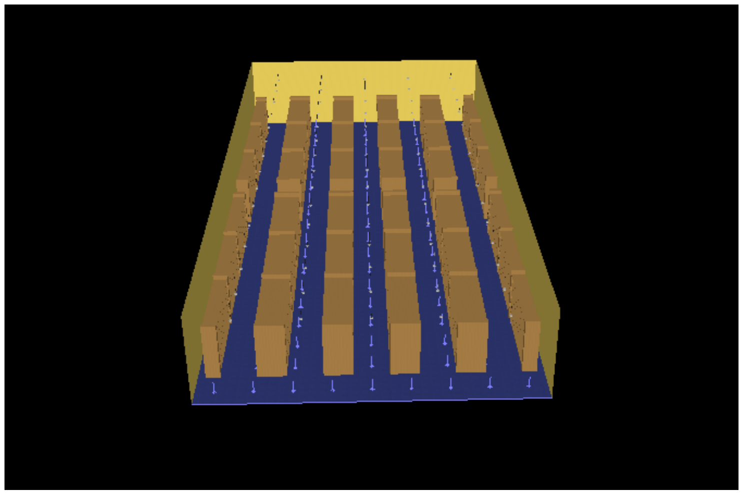
No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\,m}/E_m$	H [m]	Camera
1	perpendicular	308	193	352	0.63	0.55	/	0.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

Figure 7.43: Cargo Storage Area Design in DIALux Software

Here for Cargo Storage Area the value of average illumination level of 308 Lux and overall uniformity of 0.63 is achieved.

3D View of Cargo Storage Area :



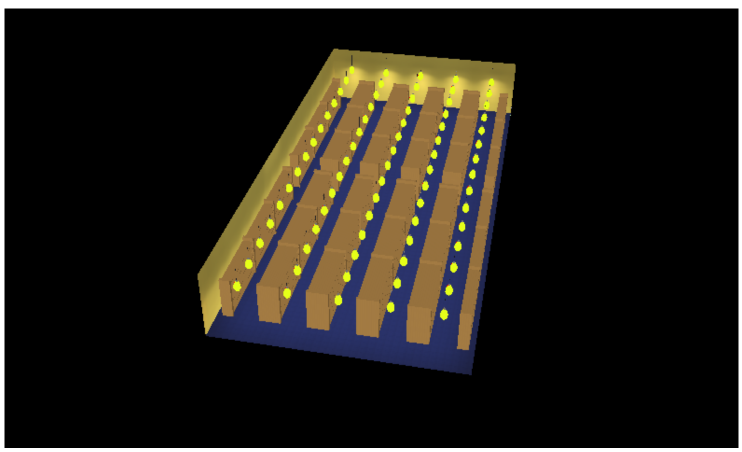


Figure 7.44: 3D View of Cargo Storage Area

7.2.6 Air Traffic Control Room

The Air Traffic Control (ATC) room is a critical facility within an airport where air traffic controllers monitor and manage the movement of aircraft in and around the airport's airspace. It serves as the nerve center for coordinating arrivals, departures, and movement of aircraft on the ground and in the air.

Adequate lighting is crucial in the ATC room to provide clear visibility of control panels, screens, and other equipment. The lighting should be uniform, glare-free, and adjustable to individual preferences. Dimmable lighting systems can help create an optimal working environment, allowing air traffic controllers to adjust lighting levels based on their needs and external lighting conditions.

Design Aim:

The illumination design for an Air Traffic Control (ATC) room in an airport is crucial for creating a well-lit and visually comfortable environment for air traffic controllers. Provide sufficient lighting levels to ensure clear visibility of control panels, monitors, displays, and other equipment. Adequate lighting helps maintain focus, reduces eye strain, and ensures accurate interpretation of visual information. Ensure uniform lighting distribution throughout the ATC room to minimize shadows and maintain consistent illumination levels across workstations and control areas. This helps air traffic controllers perceive information accurately and reduces the risk of errors due to uneven lighting conditions.

- Required illuminance level: Average 500 Lux
- Overall uniformity: 0.6

Layout and Description of Air Traffic Control Room:

Considering the Air Traffic Control Room for better understanding of lighting design, analyzing software DIALux 4.13 has been used for describing and achieving the recommended values as per standard. Typical plan layout of the Air Traffic Control Room is shown in Fig. 7.45 below.

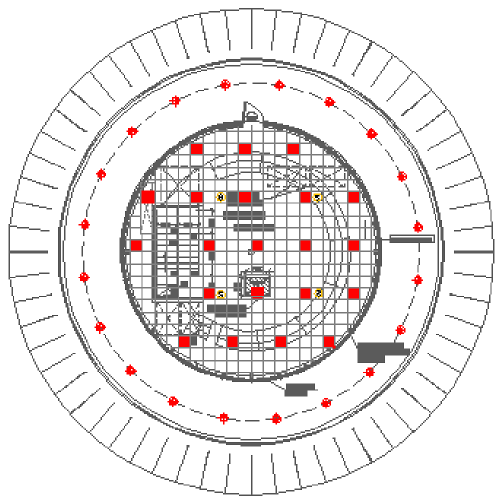


Figure 7.45: Typical Plan Layout of Air Traffic Control Room

Luminaire Used:

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)		Φ (Luminaire) [lm]		Φ (Lamps) [lm]	P [W]
1	51	Crompton Greaves Consumer Electricals Ltd 01 CDR-206-18-57-SL-NWH (1.000)		1983		2005	18.4
			Total:	101157	Total:	102235	938.4

LED 18W Downlighter

Specifications:

- Luminous flux: 1983 Lumen
- Wattage: 18 Watt
- Vo;tage Rating: 240V
- Current Rating: 0.078Amp
- System Efficacy: 110 lm/W
- CCT: 5700K
- CRI: 80
- IP 20 protected

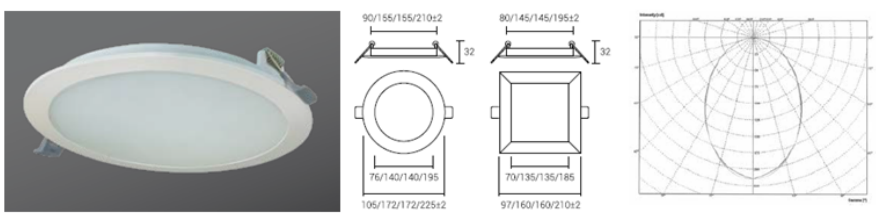


Figure 7.46: LED 18W Downlighter: Image, Dimension and Polar Curve

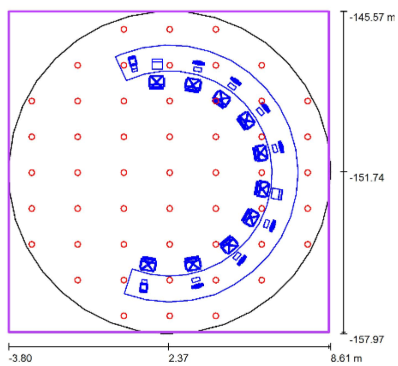
Design Considerations for the Lighting Implementation:

LED 18W Downlighter:

- Number of Luminaires: 51
- Mounting height: 3m from floor level
- Maintenance factor: 0.8
- Ceiling, Wall and Floor reflectance factor is considered (70-50-20) percent respectively

DIALux Simulation:

DIALux 4.13 simulation of the Air Traffic Control Room is based on positioning the light fixture and aiming the luminaire in exact manner to achieve recommended illumination level on the calculation surface. The lighting level on this area must meet the value recommended by the authority. Fig. 7.47 shows the simulation view of Air Traffic Control Room.



Scale 1 : 125

Position: (2.370 m, -151.743 m, 0.760 m)
Size: (12.345 m, 12.340 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: User defined, Quantity Points: 97

Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\ m}$/E_m	H [m]	Camera
1	perpendicular	551	358	668	0.65	0.54	/	0.000	/

$E_{h\ m}$/E_m = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

Figure 7.47: Air Traffic Control Room Design in DIALux Software

Here for Air Traffic Control Room the value of average illumination level of 551 Lux and overall uniformity of 0.65 is achieved.

3D View of Air Traffic Control Room :

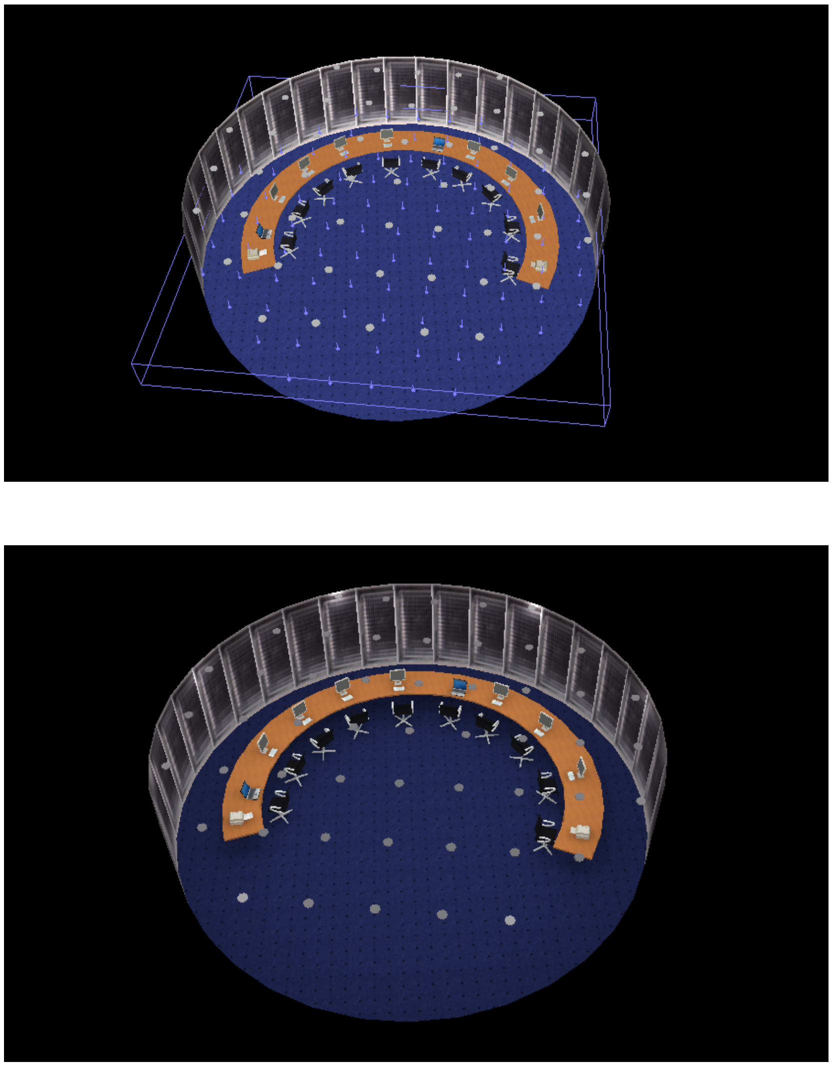


Figure 7.48: 3D View of Air Traffic Control Room

7.3 Illumination Design of Air Side Area

The airside of an airport refers to the area that is restricted to authorized personnel and aircraft operations. It includes runways, taxiways, aprons, and other facilities directly related to aircraft movement and operations. Designing the illumination for the airside area is critical for ensuring safe and efficient aircraft operations during various lighting conditions.

7.3.1 Apron Area:

An apron is a defined area on a land aerodrome intended to accommodate aircraft for the purpose of embarkation and disembarkation of passengers, loading and unloading of mail or cargo, refuelling and parking or maintenance. Aircraft would normally be expected to move (into these areas under their own power or by towing and adequate lighting is necessary to enable these tasks to be performed safely and efficiently at night. It is an important operational space that requires appropriate illumination for various activities and to ensure the safety of personnel and aircraft.

Design Aim:

Determine the required illuminance levels for the apron area based on local regulations and safety standards. Adequate lighting should be provided to ensure clear visibility for ground personnel, pilots, and maintenance crews performing various tasks on and around the aircraft. Aim for uniform lighting distribution across the entire apron area to minimize shadows and provide consistent illumination. This helps ensure that all areas are well-lit, allowing personnel to perform their duties efficiently and safely.

Position light fixtures to direct light downward and avoid glare or light pollution. Proper shielding and positioning of luminaires should be employed to control the direction of light and prevent glare from obstructing visibility or affecting safety.

Apron floodlights are commonly used to provide general illumination for the apron area. These floodlights are typically mounted on poles or lighting masts at suitable heights to ensure wide coverage and proper illumination. They should be positioned to minimize shadows and provide consistent lighting across the apron surface.

- Horizontal Illumination level required (Eh): 20Lux
- Horizontal Overall Uniformity : 0.25
- Vertical Lux level required (Ev): 20Lux (at a height 2m above the apron)

Layout and Description of Apron Area:

Considering the Apron Area for better understanding of lighting design, analyzing software AGi 32 has been used for describing and achieving the recommended values as per standard. Typical plan layout of the Apron Area is shown in Fig. 7.49 below.

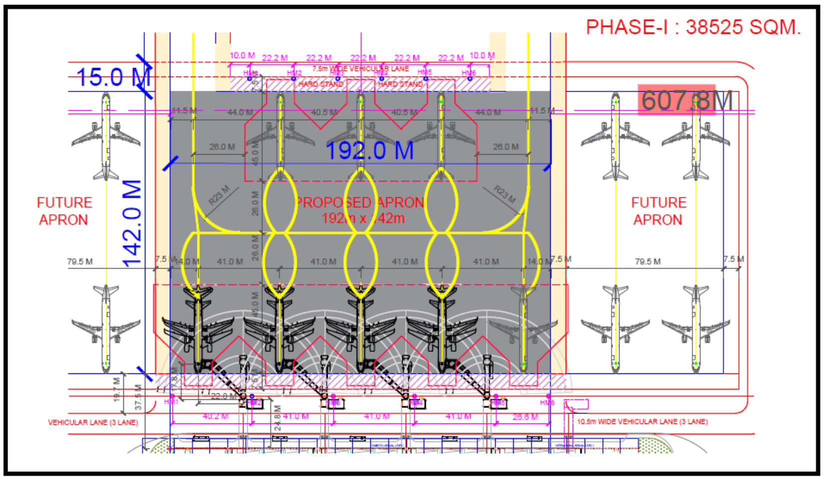


Figure 7.49: Typical Plan Layout of Apron Area

Luminaire Used:

Luminaire Schedule					
Symbol	Qty	Label	LLF	Description	Lumens/Lamp
	20	CFS-501-300-57-60D-SL-GL-NGG	0.800	300 W LED FLOOD LIGHT	33000
	22	CFS-501-350-57-60D-SL-GL-NGG	0.800	350 W LED FLOOD LIGHT	38500

LED 300W Flood Light

Specification:

- Luminous flux: 33000 Lumen
- Wattage: 300 Watt
- Vo;tage Rating: 240V
- Current Rating: 1.315Amp
- System Efficacy: 110 lm/W
- CCT: 5700K
- Beam Angle: 60 Deg
- CRI: 70
- IP 66 protected

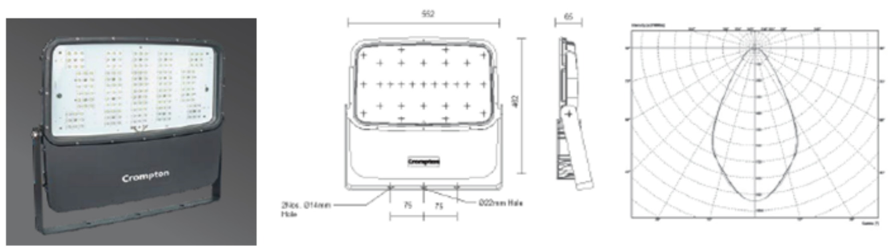


Figure 7.50: LED 300W Flood Light: Image, Dimension and Polar Curve

LED 350W Flood Light

Specification:

- Luminous flux: 38500 Lumen
- Wattage: 350 Watt
- Vo;tage Rating: 240V
- Current Rating: 1.535Amp
- System Efficacy: 110 lm/W
- CCT: 5700K
- Beam Angle: 60 Deg
- CRI: 70
- IP 66 protected

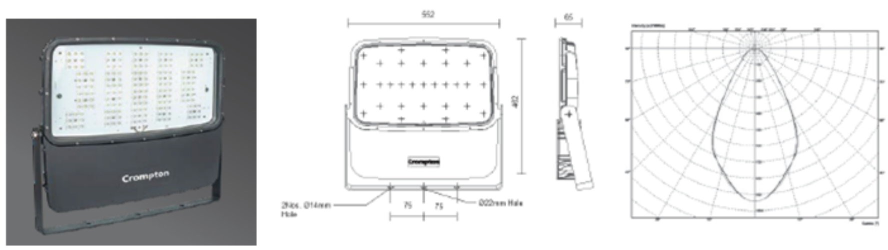


Figure 7.51: LED 350W Flood Light: Image, Dimension and Polar Curve

Design Considerations for the Lighting Implementation:

LED 300W Flood Light:

- Number of Luminaires: 20
- Mast height : 12m from Ground Level
- Maintenance factor: 0.80

LED 350W Flood Light:

- Number of Luminaires: 22
- Mast height : 16m from Road Level
- Maintenance factor: 0.80

AGi 32 Simulation for Horizontal Overall Illuminance Calculation:

AGi 32 simulation of the Apron Area is based on positioning the light fixture and aiming the luminaire in exact manner to achieve recommended illumination level on the calculation surface. The lighting level on this area must meet the value recommended by the authority. Fig. 7.52 shows the simulation view of Apron Area.

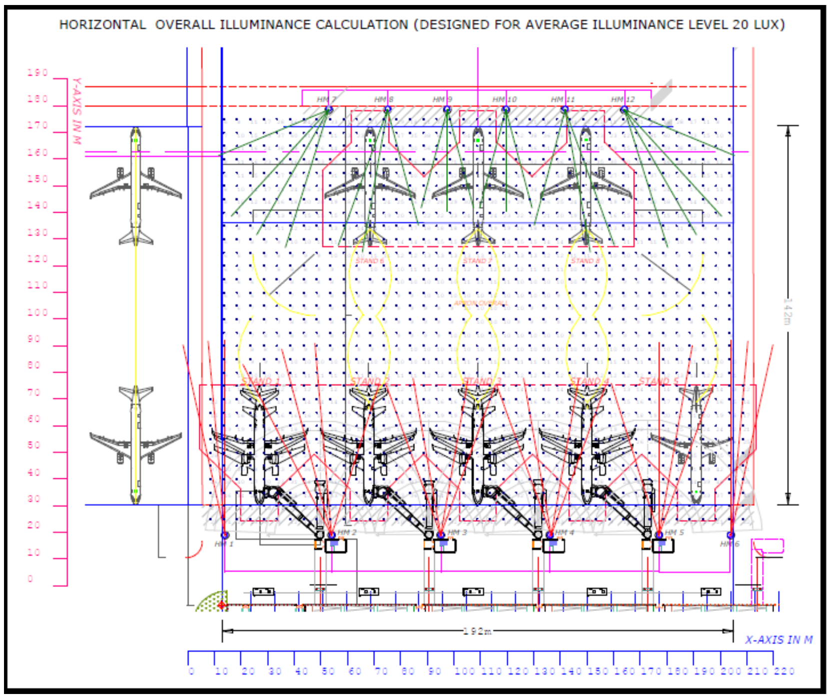


Figure 7.52: Hoz Overall Illumination Calculation in AGi 32 Software

Result Overview:

Calculation Summary							
Label	**CalcType**	**Units**	**Avg**	**Max**	**Min**	**Min/Avg**	**Min/Max**
APRON OVERALL _HOZ	Illuminance	Lux	22	100	6	0.28	0.06

Here average horizontal overall illumination level of 22 Lux and overall uniformity of 0.28 is achieved.

AGi 32 Simulation for Horizontal Standwise Illuminance Calculation:

AGi 32 simulation of the Apron Area is based on positioning the light fixture and aiming the luminaire in exact manner to achieve recommended illumination level on the calculation surface. The lighting level on this area must meet the value recommended by the authority. Fig. 7.53 shows the simulation view of Apron Area.

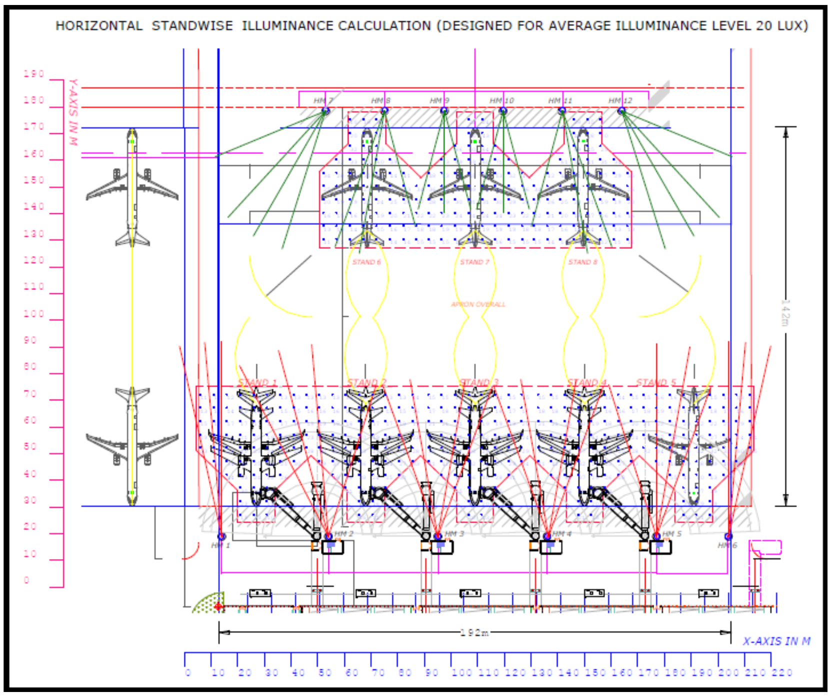


Figure 7.53: Horizontal Standwise Illumination Calculation in AGi 32 Software

Result Overview:

Calculation Summary							
Label	**CalcType**	**Units**	**Avg**	**Max**	**Min**	**Min/Avg**	**Min/Max**
APRON STAND 1_HOZ	Illuminance	Lux	20	44	10	0.50	0.23
APRON STAND 2_HOZ	Illuminance	Lux	22	48	11	0.50	0.23
APRON STAND 3_HOZ	Illuminance	Lux	25	56	13	0.52	0.23
APRON STAND 4_HOZ	Illuminance	Lux	25	56	13	0.52	0.23
APRON STAND 5_HOZ	Illuminance	Lux	27	55	12	0.44	0.22
APRON STAND 6_HOZ	Illuminance	Lux	26	73	10	0.39	0.14
APRON STAND 7_HOZ	Illuminance	Lux	36	93	15	0.41	0.16
APRON STAND 8_HOZ	Illuminance	Lux	25	69	9	0.36	0.13

Here average horizontal Standwise illumination level and overall uniformity is achieved as shown in the fig above.

AGi 32 Simulation for Vertical Standwise Illuminance Calculation:

AGi 32 simulation of the Apron Area is based on positioning the light fixture and aiming the luminaire in exact manner to achieve recommended illumination level on the calculation surface. The lighting level on this area must meet the value recommended by the authority. Fig. 7.54 shows the simulation view of Apron Area.

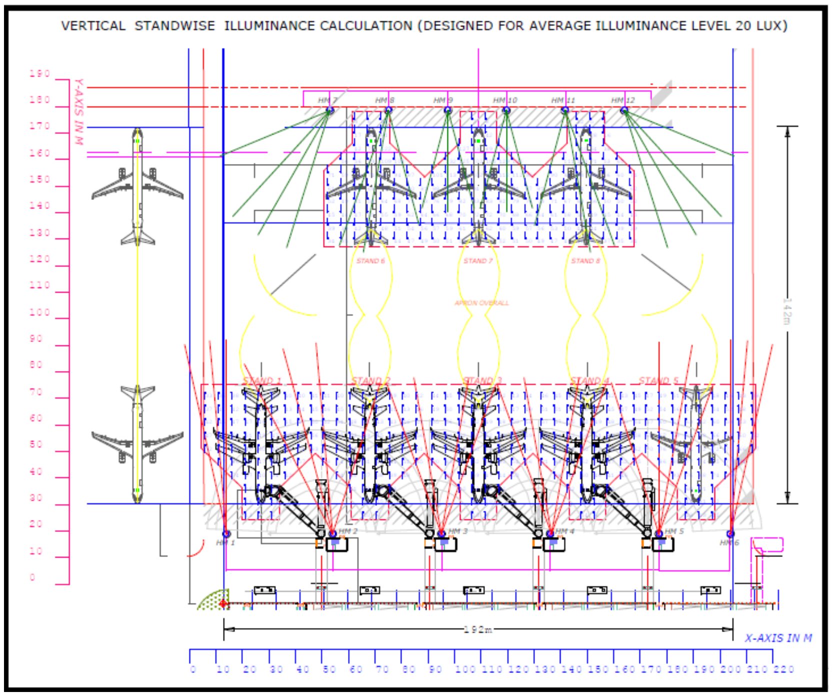


Figure 7.54: Vertical Standwise Illumination Calculation in AGi 32 Software

Result Overview:

Calculation Summary							
Label	**CalcType**	**Units**	**Avg**	**Max**	**Min**	**Min/Avg**	**Min/Max**
APRON STAND 1_VERT	Illuminance	Lux	44	74	6	0.14	0.08
APRON STAND 2_VERT	Illuminance	Lux	47	84	6	0.13	0.07
APRON STAND 3_VERT	Illuminance	Lux	53	95	8	0.15	0.08
APRON STAND 4_VERT	Illuminance	Lux	53	96	8	0.15	0.08
APRON STAND 5_VERT	Illuminance	Lux	59	93	13	0.22	0.14
APRON STAND 6_VERT	Illuminance	Lux	57	122	3	0.05	0.02
APRON STAND 7_VERT	Illuminance	Lux	80	138	7	0.09	0.05
APRON STAND 8_VERT	Illuminance	Lux	56	111	3	0.05	0.03

Here average vertical Standwise illumination level and overall uniformity is achieved as shown in the fig above.

7.3.2 Airport Hanger Area

An airport hangar area is a designated section of an airport where aircraft hangars are located. It is a space specifically designed and allocated for the storage, maintenance, and servicing of aircraft. The hangar area typically includes one or more hangar buildings, which are large enclosed structures used to house aircraft. These buildings provide protection for aircraft from the elements, such as rain, snow, and direct sunlight, and also serve as a secure storage space.

The hangar area may include additional facilities and infrastructure to support aircraft operations and maintenance. This can include workshops, fueling stations, aircraft wash areas, offices, storage facilities, and sometimes even amenities for crew members or passengers.

Design Aim:

Airport hangar illumination design involves the planning and implementation of lighting systems within hangar facilities to ensure adequate and appropriate lighting levels for various activities.

Determine the required lighting levels based on the specific tasks and activities conducted within the hangar. Different areas may have different lighting requirements, such as aircraft inspection, maintenance, storage, or administrative areas.

Aim for uniform lighting distribution throughout the hangar to minimize shadows and ensure consistent visibility across the space. This is important for safety and productivity, as well as for maintaining an even lighting environment.

- Required illuminance level: Average 300 Lux
- Overall uniformity: 0.4

Layout and Description of Airport Hanger Area:

Considering the Airport Hanger Area for better understanding of lighting design, analyzing software AGi 32 has been used for describing and achieving the recommended values as per standard. Typical plan layout of the Airport Hanger Area is shown in Fig. 7.55 below.

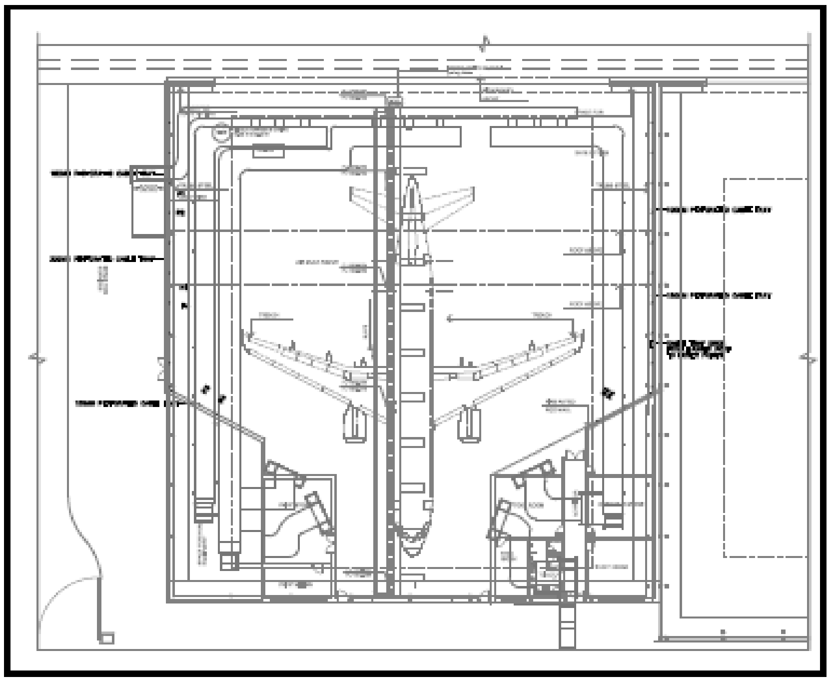


Figure 7.55: Typical Plan Layout of Airport Hanger Area

Luminaire Used:

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]		Φ (Lamps) [lm]	P [W]
1	104	Crompton Greaves Consumer Electricals Ltd 01 FFL1315-300-CDL/60-HB-M (1.000)	29996		30000	294.6
		Total:	3119549	Total:	3120000	30638.4

LED 300W Flameproof Luminaire

Specifications:

- Luminous flux: 30000 Lumen
- Wattage: 300 Watt
- Vo;tage Rating: 240V
- Current Rating: 1.278Amp
- System Efficacy: 100 lm/W
- CCT: 5700K
- CRI: 70
- IP 66 protected

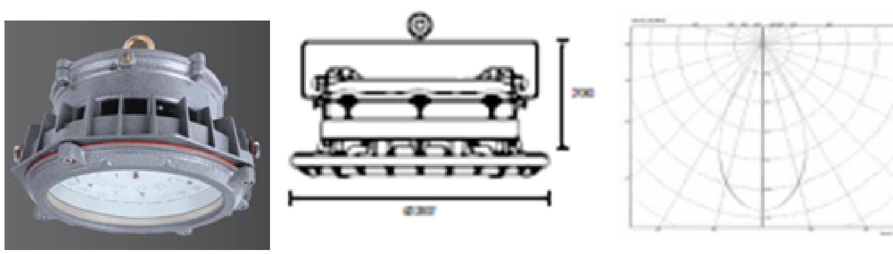


Figure 7.56: LED 300W Flameproof Luminaire: Image, Dimension and Polar Curve

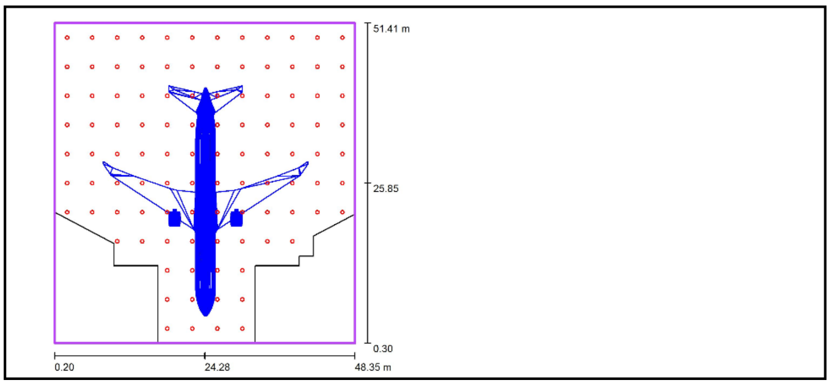
Design Considerations for the Lighting Implementation:

LED 18W Downlighter:

- Number of Luminaires: 104
- Mounting height: 35m from floor level
- Maintenance factor: 0.8
- Ceiling, Wall and Floor reflectance factor is considered (50-30-20) percent respectively

DIALux Simulation:

DIALux 4.13 simulation of the Airport Hanger Area is based on positioning the light fixture and aiming the luminaire in exact manner to achieve recommended illumination level on the calculation surface. The lighting level on this area must meet the value recommended by the authority. Fig. 7.57 shows the simulation view of Airport Hanger Area.



Scale 1 : 512

Position: (24.276 m, 25.853 m, 0.000 m)
Size: (48.152 m, 51.106 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: User defined, Quantity Points: 228

Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\,m}/E_m$	H [m]	Camera
1	perpendicular	1054	475	1312	0.45	0.36	/	0.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

Figure 7.57: Airport Hanger Area Design in DIALux Software

Here for Airport Hanger Area the value of average illumination level of 1046 Lux and overall uniformity of 0.412 is achieved. Though the recomended illumination level (as per standered) is 300 Lux, but here the designed illumination level is 1000 Lux due to client requirement.

3D View of Airport Hanger Area :

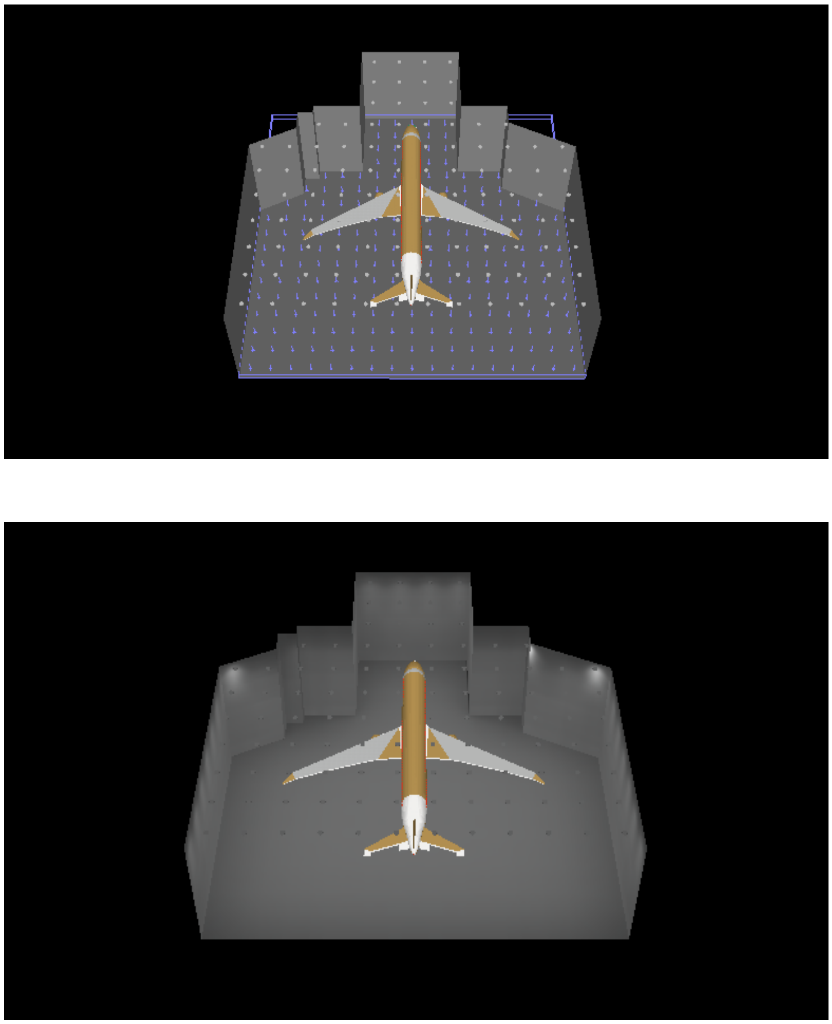


Figure 7.58: 3D View of Airport Hanger Area

Chapter 8

Conclusion and Future Scope

Light plays a crucial role in design and visual perception. It has the power to transform and enhance our perception of spaces, objects, and colors. Proper lighting design can enhance spatial perception and create a sense of depth in a room. By using various lighting techniques like uplighting, downlighting, and wall washing, designers can manipulate shadows and highlights to add dimensionality to a space, making it appear larger, more dynamic, or more intimate.

One of the primary challenges is achieving adequate illumination throughout a space. Designers must ensure that light levels are sufficient for the intended activities, whether it's reading, working, or performing specific tasks. Balancing the lighting requirements with energy efficiency considerations can be a complex task.

Achieving uniform lighting distribution can be challenging, especially in larger spaces. Uneven lighting levels or abrupt changes in illumination can lead to visual discomfort and difficulties in perceiving the environment. Designers must consider factors like the height and spacing of light fixtures, the reflective properties of surfaces, and the specific lighting requirements of each area to achieve a consistent and uniform lighting design.

Improperly placed light fixtures or fixtures with high glare can create discomfort for occupants and hinder visual tasks. Glare occurs when there is excessive brightness or contrast, making it difficult to see clearly. Designers need to consider glare control techniques such as shielding, diffusing, or using appropriate light levels to minimize glare. Conversely, achieving the right balance of light and shadows can add depth and visual interest to a space.

Designers face the challenge of balancing energy efficiency and sustainability goals with the desired lighting quality. Selecting energy-efficient lighting technologies, implementing lighting controls, and optimizing lighting layouts are necessary to reduce energy consumption. However, designers must ensure that energy-saving measures do not compromise visual comfort or the intended design concept.

8.1 Overall Conclusion

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

A practice-oriented design concept must therefore first describe how the desired lighting effects can be realized within the basic conditions and restrictions inherent to the project. The design concept may be required to correspond to specific standards, and it must keep within the budget with regard to both the investment costs and the operating costs. Lighting defines economic efficiency, safety and security. The lighting design should be designed in such a way that the energy consumption for particular area has to be optimized and light pollution problems have to be minimized. Hence the lighting concept must also be coordinated with other engineering work to be affected on the project.

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

8.2 Future Scope of Work

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

LED Lights consumes very less energy and control for the light output can be done very easily. With Pulse Width Modulation (PWM) Technology LEDs can be dimmed accurately makes it easy to integrate with daylight sensors. We know about the various advantages of smart lighting soutions, the extra benefits we are getting from smart applications. If the availability of Daylight is there, then the artificial luminaires can be dimmed to save more energy.

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

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