# AN APPROACH TO DESIGN THERMAL POWER PLANT LIGHTING BY LED SYSTEM

A dissertation submitted in
partial fulfilment of the requirements for the degree of

**Master of Engineering in
Illumination Engineering**

*Submitted By,*

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## RECOMMENDATION CERTIFICATE

This is to certify that the thesis entitled **"An Approach to Design Thermal Power Plant Lighting by LED System "** submitted by **Pratik Kr Mohata**, (Exam Roll no. – M4ILN22018 and Registration No.–154041 of 2020–2021) of this university in partial fulfillment of requirements for the award degree of Master of Engineering in Illumination Engineering, Department of Electrical Engineering, is a bonafide record of the work carried out by him under my guidance and supervision.

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

## FINAL EXAMINATION FOR EVALUATION OF THESIS

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## 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 my Master of Engineering in Illumination Engineering studies.

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

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

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*PRATIK KR MOHATA*

Crompton

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**Internship Certificate**

This is to certify that **Mr Pratik Kr Mohata**, a student of M.E. in Illumination Engineering, Electrical Engineering Department, Jadavpur University, has worked as an Intern in the Lighting Advisory Bureau of Crompton Greaves Consumer Electricals Limited from 23rd August, 2021 to 22nd June, 2022.

The title of his thesis was **"An Approach to design Thermal Power Plant Lighting by LED system"** which was carried out under the guidance of Mr. Sumit Kar, DGM – Design. During the tenure of his internship with us, we found him very 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**

**Sanjay Biswas**
**Associate Vice President**
GREAVES CONSUMER ELECTRICALS LTD

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# Chapter 1

# FOREWARD

## 1.1 Introduction

Good lighting enables workers in industries to carry out their visual tasks easily, quickly and without fatigue and to move about in work areas safely. It also helps in cutting down wastage and rejects, in utilising floor space efficiently and in boosting morale and thus in improving the overall performance of the industry.

Industry encompasses seeing tasks, operating conditions and economic considerations of a wide range. Visual tasks may be very small or very large; dark or light; opaque, transparent or translucent; on specular or diffuse surfaces and may involve flat or contoured shapes. Lighting must be suitable for adequate visibility in developing raw materials into finished products. Physical hazards exist in manufacturing processes and therefore, lighting contributes to the safety factor in preventing accidents. The speed of operations may be such as to allow only minimum time for visual perception and, therefore, lighting must be a compensating factor to increase the speed of seeing.

The design of a lighting system and selection of equipment may be influenced by many economic and energy related factors. Economic decisions in regard to the lighting system should not only be based on the initial and operating costs of the lighting, but also on the relationship of lighting costs to other plant facilities and costs of labour. The lighting system should be a part of an overall planned environment.

Light should serve not only as a production tool and an aid to safety but should also contribute to the overall environment conditions of the work space. The lighting system should be a part of a planned environment contributing to the comfort and well-being of the users. So, the design of a lighting system and selection of equipment is influenced by many economic factors. The choice, however, should not only be based on the project and the running costs of the lighting but also on the relationship of total lighting cost to costs arising out of other plant producing facilities and labour.

Lighting accounts for around 19 % of global electricity consumption. The power consumption by the industrial lighting varies between 2 to 10 % of the total power depending on the type of industry. The urgency to replace old conventional lighting installations with more energy-efficient technologies should no longer be ignored.

As non-renewable or conventional sources of electricity generation requires fossil fuels which is very limited and decreasing day by day. So, this, coupled with the use of renewable energy sources, is essential to meet the expected increase in energy demand in an environmentally-sustainable manner. Light emitting diodes (LEDs) are proven to be the most efficient option for lighting today and can help achieve significant in energy savings over conventional lighting technologies such as metal halide, and high-pressure sodium lamps. There are now more examples of LEDs being successfully adopted in pilot trials and large-scale rollouts, delivering greenhouse gas (GHG) reductions by as much as 50% to 70% and generating significant budgetary savings. The quantity of light at a workplace depends upon the visual task so that the individual worker can see the task clearly, accurately and without eye strain. If the size of the critical detail of any visual task and its reflection characteristic are known, it is possible to state the appropriate value of illumination in lux (defined as lumens of flux per sqm of the surface of the task), which will enable the visual task to be performed satisfactorily.

## 1.2 Motivation

Any technology be it product based or service based can/should be considered or accepted not only for the modern, futuristic features but it also should solve some greater problems be it financial, environmental or physiological. As we all agree to the fact that LEDs are the most energy efficient option for road lighting today and can help achieve in maximum energy savings over conventional lighting technologies. In addition, the shift to LED based road lighting technologies would help reduce greenhouse gasses (GHG) emissions which results to overall growth of the environment.

We can significantly reduce GHG emissions by 670 MT annually and associated energy costs by 50-70% following a switch to LED based efficient lighting. The International Energy Agency (IEA) estimates that lighting accounts for 19% of global electricity consumption and about 1.9 billion tons of CO2 emissions annually. Thus, it offers an opportunity for quick wins and demonstrability that can lead others, especially private entities, to make the switch to efficient lighting system.

Taking into consideration the increasing industrial activities in India whereby a large number of people have to work on tasks and processes of increasing intricacy and detail with working hours extending into the night, need has been felt for well-planned and efficient industrial lighting which would create easier seeing conditions and agreeable atmosphere.

Be it any lighting system indoor, outdoor or industrial visual comfort is a subjective aspect related to lighting quality. If the degree of visual comfort is not good enough, the level of fatigue will increase to human eye and as a consequence, his visual performance and alertness will decrease. So, both visual comfort and visual performance are important for safety.

LEDs may sometimes have a special influence on visual comfort because they are available in a much wider range of spectra than are the conventional light sources. Their small light-emitting surfaces enable more pronounced beams to be produced, that in turn may influence visual comfort. The basis for any lighting installation is the quantity of light available for a specific visual task in a given situation. A comprehensive set of regulations exist for workplaces which define the optimum lighting conditions for specific visual tasks to ensure that visual tasks can be performed correctly and without causing fatigue. The standards only relate to establishing good working practice regarding working conditions.

## 1.3 Objectives

The objectives of the thesis are as follows:

- To study different structures of a thermal power plant  their cross sections.
- To study and illumination design implementation of a typical thermal power plant using modern energy efficient LED lighting system. .

# Chapter 2

# Technical Features of LED Luminaire

Power Plant lighting is the application of Industrial lighting systems for the purpose of improving safety by improving visibility and by reducing the effects of glare from other light sources in the visual environment. A suitable horizontal illuminance is required to make these clearly visible.

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

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

## 2.1 Optical Features

### LED:

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

Led chips are basically of three types. They area – 1. DIP Chip, 2. SMD and 3. COB.

1. **DIP Chip :**

   DIP (Dual In-Line Package) LEDs are the traditional LED lights. It is what most people think of when they picture LED lights. They look the most like a traditional light with the chip encased in hard plastic generally used with two straight parallel connecting pins. Figure 2.1 shows a DIP chip.

Figure 2.1: DIP LED Chip

2. **SMD :**

   SMD stands for Surface mounted diode and are much smaller and efficient LEDs than the previous DIP chips. They have become popular due to their versatility and are typically mounted and soldered onto a circuit board. SMD chips have become very important for the development of the LED industry as three diodes are able to be put on the same chip. As well as the brightness being significantly better, they have the capacity to change colour. Some of the chips are made small in order to be used in high end electronics such as laptop computer indicator lights. They are also standalone chips predominantly used LED strips or LED recessed downlights. Figure 2.2 shows a SMD LED downlighter chip.

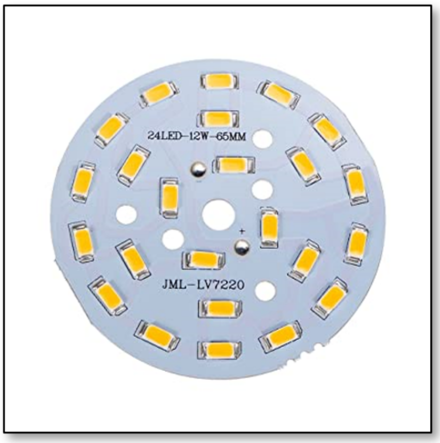



Figure 2.2: SMD LED Chip

3. **COB:**

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

Typically, in small devices such as cameras and Smartphone, this is due to a high amount of lumens created for a very small amount of energy. Figure shows a COB chip.

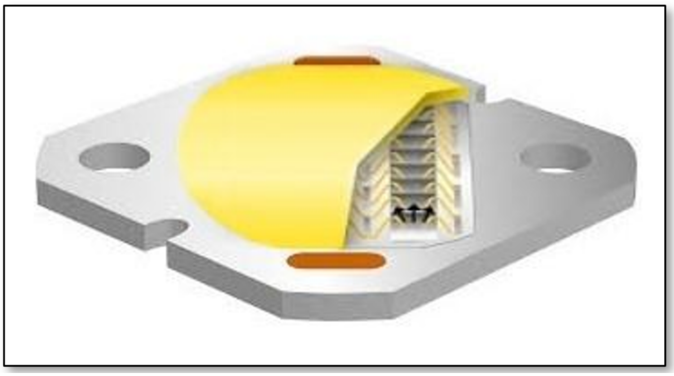


Figure 2.3: COB LED Chip

The top 10 global lighting manufacturers for LED chips are summarized in Table 1 below, ranked in descending order of LED technology quality.

| | **Company** | **Country** |
|---|---|---|
| **1** | CREE | USA |
| **2** | Nichia | Japan |
| **3** | Toyoda Gosei | Japan |
| **4** | OSRAM | Germany |
| **5** | Lumileds | San Jose |
| **6** | Seoul Semiconductor | South Korea |
| **7** | LG Innotek | South Korea |
| **8** | Edison Opto | Taiwan |
| **9** | EPISTAR | Taiwan |
| **10** | San ‘an Optoelectronics | China |

Figure 2.4: Top 10 Global LED Chip Manufacturers

## **Lens:**

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

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

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

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

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

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

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

Figure 2.5: (a) Single Lens; (b) Multi-Lens; (c) Street light lens; (d) Linear Lens; (e)High-bay Luminaire Lens

**Single Lens:** Single lenses are designed for single light source or LED clusters and can be clubbed easily into different layouts.

**Multi-Lens arrays:** Lens arrays in different shapes and sizes for faster installations and higher lumen output from compact areas.

**Street-Light Lens:** Modular single lenses and lens arrays are specially designed for street lighting to achieve bat-wing shape of photometry.

**Linear Lens:** Lenses designed for continuous row installations.

**High bay Luminaire Lens:** Modular single lenses and lens arrays specially designed for industrial and large indoor area lighting application.

KHATOD, LEDiL, OSRAM etc are very popular names of LED Lens Manufacturer.

## Beam Angle:

Beam Angle is a photometric feature of any 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. For Led Luminaire this beam angle range may start from 5 degrees to upto 150degrees.

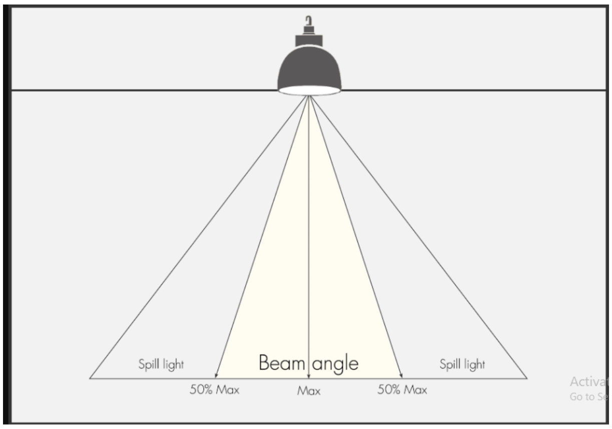



Figure 2.6: Beam angle

The selection of correct Beam Angle for any particular applications depends upon area/room dimensions, height, type of lighting environment required etc. It is preferred that higher the mounting height narrower should be the beam angle of the luminaire to get better uniformity, better energy efficiency and to avoid glare. For Industrial Lighting Application beam angle is an important parameter for the choice or selection of correct luminaire.

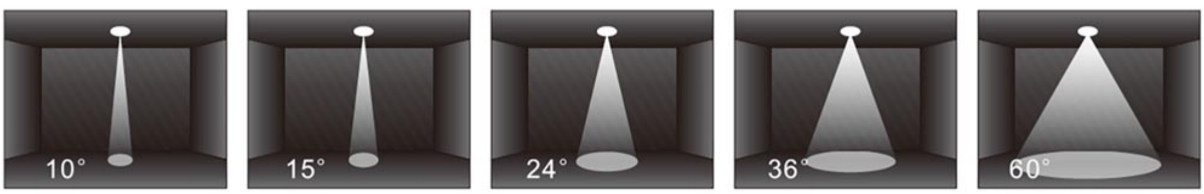



Figure 2.7: Effect of different beam angles

## 2.2 Electrical Features

The construction of a luminaire should be such that it guarantees safety to the person involved in its maintenance. The European Standard [BS EN IEC: 61140, 2001] classifies luminaires according to the degree of protection afforded against electrical shock. The material and the insulation should be such that it will be capable of withstanding the electrical load for the running time with a tolerance voltage spikes. In case of HID lamps, the cable insulation must be sufficient for the high ignition voltages, which may be far higher than the operating voltage. The degree of insulation against voltage spikes is described in figure as illustrated below –

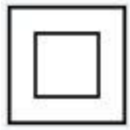
| SAFETY CLASS | PROTECTION | SYMBOL |
|---|---|---|
| I | Basic insulation with protective earth connector |  |
| II | Double or reinforced insulation without earthing |  |
| III | Extra-low-voltage circuits referred to as SELV (safety extra-low voltage) |  |

Figure 2.8: Electrical Insulation Class (BS EN: 61140, 2001)

## 2.3 Mechanical Features

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.

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

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

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

The IP rating normally has two numbers:

- Number 1 indicates Protection from solid objects or materials
- Number 2 indicates Protection from liquids (water)

| First Characteristic numerical | Object size protected against | Effective against |
|---|---|---|
| 0 | ______ | No protection against contact & ingress of object |
| 1 | >50 mm | Any large surface of the body, such as the back of 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 2.9: IP code according to protection against ingress of solid foreign bodies (IEC: 60529, 2001)

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

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

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

| **Second Numerical** | **Protected against** | **Effective against** |
|---|---|---|
| 0 | Not protected | ——— |
| 1 | Vertical condensation | Dripping water (vertically falling drops) shall have no harmful effect. |
| 2 | Dripping water when tilted up to 15° | Vertically dripping water shall have no harmful effect when 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 with discharge rate of 0.07ltr. /min for 10 minutes |
| 4 | Splashing of water from every direction | Water splashing against the enclosure from any direction with discharge rate of 0.07ltr. /min for 10 minutes |
| 5 | Low pressure Water jets | Jet water at all direction (*keeping distance 2.5 to 3m*) to object surface 1m2/min. for 3 minutes [*nozzle dia.=6.3mm & discharge rate = 12.5ltr./min*] |

| | | |
|---|---|---|
| 6 | High pressure Water jets | Jet water at all direction (keeping distance 2.5 to 3m) to object surface 1m2/min. for 3 minutes [nozzle dia.=12.5mm & discharge rate = 100ltr./min] |
| 7 | Immersion up to 1m in liquid | Ingress of water in harmful quantity shall not be possible when the enclosure is immersed in water under defined conditions of pressure and time (up to 1m of submersion). |
| 8 | Immersion 1m or more | The equipment is suitable for continuous immersion in water under conditions which shall be specified by the manufacturer. |

Figure 2.10: IP code according to protection against ingress of liquid (IEC: 60529, 2001)

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

In case of truss mounting luminaires, truss should be to carry and support the luminaires and should be properly spaced to get the optimal lighting. Obstructive structures like heavy machineries (conveyor belts, steam turbines, pumps etc) should also be taken into consideration in planning for the layout of lighting.

Smart Control Systems are infrastructure communication systems that allow instantaneous control of the lighting system. These can automatically adjust the level of lighting depending on the condition of the surroundings. Studies show that LED-based lighting coupled with smart control systems can maximize the lifespan of the luminaires, minimize maintenance costs.

Cables connect the luminaire to the energy source and to the smart control systems. It should match and be responsive to the energy demands of the lighting system.

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

| IK degree | Impact protection | Effective against |
|---|---|---|
| 00 | No protection | ______ |
| 01 | Against 0.14 Joule | Equivalent to impact of 0.25kg mass dropped from 56mm of impact surface |
| 02 | Against 0.20 Joule | Equivalent to impact of 0.25kg mass dropped from 80mm of impact surface |
| 03 | Against 0.35 Joule | Equivalent to impact of 0.25kg mass dropped from 140mm of impact surface |
| 04 | Against 0.50 Joule | Equivalent to impact of 0.25kg mass dropped from 200mm of impact surface |
| 05 | Against 0.70 Joule | Equivalent to impact of 0.25kg mass dropped from 280mm of impact surface |
| 06 | Against 1.0 Joule | Equivalent to impact of 0.25kg mass dropped from 400mm of impact surface |
| 07 | Against 2.0 Joule | Equivalent to impact of 0.50kg mass dropped from 400mm of impact surface |
| 08 | Against 5.0 Joule | Equivalent to impact of 1.7kg mass dropped from 300mm of impact surface |
| 09 | Against 10 Joule | Equivalent to impact of 5kg mass dropped from 200mm of impact surface |
| 10 | Against 20 Joule | Equivalent to impact of 5kg mass dropped from 400mm of impact surface |

Figure 2.11: Level of protection given by IK degree of luminaire (IEC:62262, 2002)

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

In Industrial Lighting, it is advised to used higher IP and IK rating products for better protection against Ingress and Impact respectively, as Industrial areas are generally less clean, less maintained and more dusty and more polluted. But higher IP, IK rating products are also expensive. So, considering the benefits and constraints mentioned above, the products selected in this project have the IP ratings of **IP65** and **IP66**; and IK ratings of **IK08**.

# Chapter 3

# Benefits and Challenges of LEDs in Industrial Lighting Applications

Solid State Lighting refers to a type of lighting making use of light-emitting diodes (LEDs) as sources of illumination instead of electrical filaments or gas. LEDs overcome a number of the disadvantages of traditional lighting owing to their significantly longer lifetime, superior spectral output with good color rendering ability, higher efficiency, and lower energy consumption. These attributes make them desirable for many lighting applications that had been previously the realm of incandescent or fluorescent lights. Nonetheless, 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.

## 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.

## Technological benefits:

- **High lumen efficacy:** Currently, commercially available luminaires from quality suppliers typically have efficacy levels of 100 – 150 lm/W. However, with the efficacy levels of LEDs rapidly evolving, it is always recommended to consult with reliable manufacturers or industry representatives for the latest efficacy levels.
- **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.
- **Long lifespan:** Laboratory testing and experience indicate that well-produced LED chips can last upto 50,000 hours, depending on usage. This compares favourably against the 5,000-to-15,000-hour lifetime of most conventional lamps.
- **High Colour Rendering Index (CRI):** Higher CRI is a virtue to LEDs as it has the ability to reveal the true colours to whatever they illuminate. LEDs have High CRI values than most of the other conventional light sources.

Technological benefits result rapid increase of applications of LED Lighting Systems in Industrial Lighting Systems, where high lumen efficacy is essential to deliver more lumen output with lesser energy consumption. The ability to dim luminaires is also very helpful for industries as when daylight is available then artificial luminaires can be dimmed to save not only energy but also increasing the life of the luminaires. Having high CRI values is also beneficial as the working personnel can be able to see the true colours of the machineries, meters, measuring instruments and many other objects which increases the visual performance of them.

## Economical benefits:

One of the main arguments for a switch to LED lighting in Industry is Economy. Industries like Power Plants, Factories, Warehouses etc are commercial hub . Economy is a key criteria for adopting any technology in these areas.

- **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.

The reason of wide acceptance of LEDs all over the industrial sectors is its economic benefits. For any Industry fixed cost and running cost are two very important matter of concern. Needless to say, that every industry tries to minimise its running cost to maximise its profit. LEDs plays a very important role in Industrial lighting system by saving the running energy consumption of luminaires every second. Similarly having longer life of LEDs help to save in fixed cost in Industrial Lighting applications.

## 3.2 Challenges:

In this practical world every technology or product or service have some challenges. Despite of its huge benefits LEDs also comes with some Challenges/ Constraints that are unavoidable. These challenges are discussed below.

- **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.

- **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.

- **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 is 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.

- **Product cost:** 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. Aside from that, white light LED costs are changing, pushing designers to use caution in specifying LEDs for specific lighting applications.

# Chapter 4

# Thermal Power Plant Lighting

## 4.1 Overview of Plant Areas:

Thermal energy is one of the major sources of power generation in India and all over the world as well. A thermal power station is a type of power station in which heat energy is converted to electrical energy. In a steam-generating cycle, known as Rankine cycle, heat is used to boil water in a large pressure vessel to produce high-pressure steam, which drives a steam turbine connected to an electrical generator or alternator, which generates electrical power and supply that power to grid.

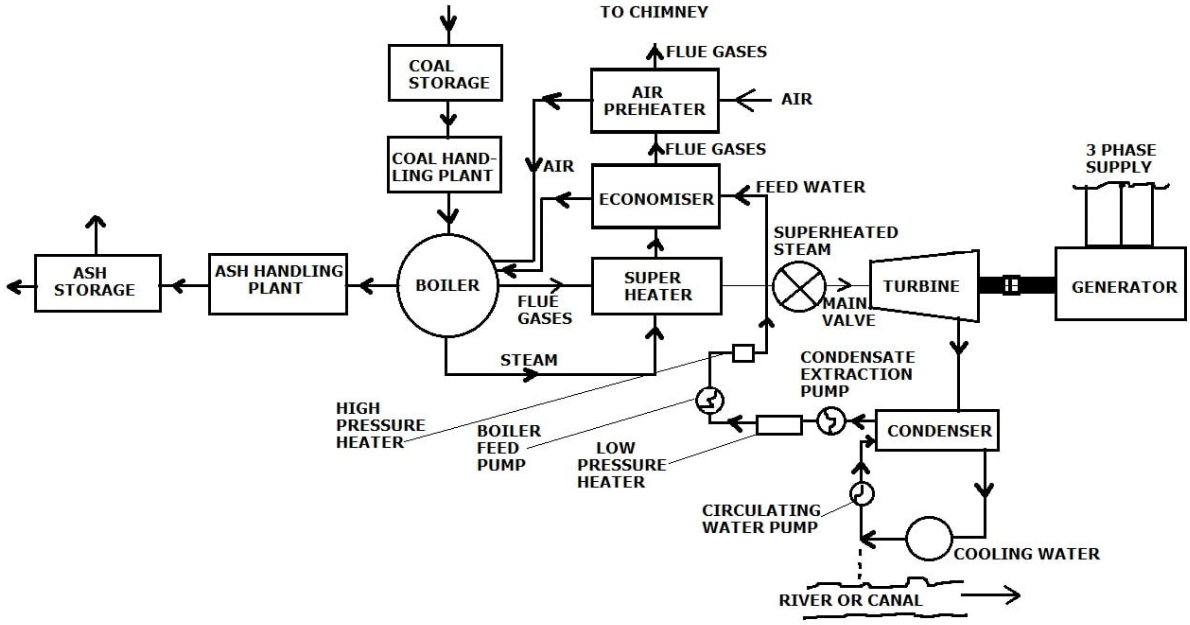



Figure 4.1: General Layout of Thermal Power Plant

Major areas of a Thermal Power Plant are: Boiler House, Turbine Hall, Coal Handling plant/ Crusher House , Ash handling plant , Ash Storage , Gypsum Storage, Gypsum Dewatering Building, Belt Conveyors , Transfer Houses/ Terminal Points, Wagon/Truck Tippler, FGD ( Flue Gas Desulphurisation), ESP (Electro-static Precipitator), Mill House , Switchgear Room, Control Room, Admin Building , Staff Quarters, Pump House , Wet Stack (Chimney), Cooling Tower, Silo Storage, Coal Stack Area, Outdoor Areas (Roads) within the boundary wall etc.

Due to limited Scope of the Project the some of the major areas are considered under case study for this project. They are - 1. Belt Conveyor, 2. Gypsum Storage Shed and Dewatering Building, 3. Turbine Hall, 4. Pump House, 5. Limestone Terminal Point, 6. Crusher House, 7. Storage Silo, 8. Wet Stack (Chimney), 9. Exterior Road.
These areas are breifly described below.

1. **Belt Conveyor:**

   Many power plants and utilities depend upon coal handling facilities. Belt Conveying Systems are a great way to transport a large amount of coal over very long distances. Belt conveyors equipment can cut the cost of operations because of its low power consumption. For coal handling, it is best to install the equipment up to an inclination up to 20 degrees to the horizontal. It is also important to take into account the tons/hr which we can handle up to 2,000 tons/hr and it can be easily transferred through very long distances.

Figure 4.2: Belt Conveyor

2. **Gypsum Storage Shed and Dewatering Building:**

   Finely grinded form of calcium sulphate / CuSO4.2H2O material industrially used for enhancing adhesive strength of the cement, called as gypsum. Gypsum Storage at large scale is needed since it is one of the prime resources in the cement industry. In purpose to improve cement's inherit qualities, performance and efficiency, a composite gypsum storage solution needs to be followed systematically.

   The resources like coal, petcock, limestone contain a significant amount of sulphur into them. In many large-scale power plants (where the resource is Coal, petcock, limestone etc), the problems arise from boiler or furnace where large volumes of So2 accumulation not only deteriorates air quality of environment but also highly corrosive for handling equipment like stacks, fans etc.

   In order to extract SO2 from flue gas, the mechanism of extraction employed is known as FGD or Flue Gas Desulphurization. In Flue Gas Desulphurization, the chemical Techniques are used to exclude sulphur di-oxide (SO2) in exhausted flue gasses from the Furnace/boiler. Some of the Chemical techniques used for FGD are 'Wet Scrubbing', 'Dry Scrubbing', 'SNOX FGD' etc. The output from flue gas desulphurization is synthetic gypsum. For cement manufacturing, this FGD storage product or synthetic gypsum is supplied in crushed form for further fine grinding with cement clinker and has many other commercial applications in cement industry, bricks manufacturing etc.

Figure 4.3: Gypsum Storage Shed


Figure 4.4: Gypsum Dewatering

3. **Turbine Hall**

A turbine hall/ building is a section in any thermal power plant which houses a number of components along with a steam turbine which essential for the generation of electricity from the steam that comes out of the boiler.

Figure 4.5: Turbine Hall

4. **Pump House:**

Pump House is an integral part of a thermal power plant which circulate necessary cooling water to the condenser to condensate. Raw sea/river water is used for this purpose. Inside the condenser phase conversion of saturated steam from LP turbine exit takes place. During this phase conversion lot of latent heat is released. This latent heat is absorbed by the cooling water supplied by CW pumps. After absorbing heat, cooling water is passed through Natural Draft Cooling Tower (NDCT) wherein it releases the heat naturally (due to shape of cooling tower). After cooling this cooling water is again used in the cycle by pumps.

Figure 4.6: Pump House

5. **Limestone Terminal Point:**

   Limestone is needed for operating FGD (Flue Gas Desulphurization) systems in Thermal Power Plant. Limestone powder is injected after the coal is burned, typically at the top of the boiler. The sulphur dioxide is formed when the sulphur contained in the coal (it is a contaminant in all coal) burns in the combustion chamber of the boiler. The sulphur dioxide bonds with the limestone to form a particulate; it believes that is CaSO3. The particulate is then trapped in the baghouse or electrostatic precipitator before it exists the stack. So, limestone enables capture of sulphur emissions.

Figure 4.7: Limestone Terminal Point

6. **Crusher House:**

   In the thermal power plants maximum requirements of fuel is a coal. The handling of this fuel is a great job. To handle the fuel, i.e., coal, each power station is equipped with a coal handling plant. Crusher House/Building is a part of this Coal handling plant, where fuel or coal crushed or pulverised from an irregular, large to a regular smaller size to increase the efficiency of the fuel.

Figure 4.8: Crusher House

**Silo Storage:**

Silos are the commonly used storage structures in production industries such as cement factories, power plant structures etc. When a Silo is used in the Thermal power plant structures it should be capable of storing ashes with high temperature.

Power production from thermal power plant structures is increasing day by day and producing huge number of wastes such as fly ash and wet ash. To store those ashes in power plant we need a good storage container say Silo which should satisfy the basic requirements of the power plant. Silos can be constructed as a single one or as group of two or more.

Figure 4.9: Silo Storage

7. **Exterior Road:**

Exterior Roads of a Thermal Power Plant are generally Peripheral roads which consist of the space surrounding the buildings of different sections of the plant. These roads help to connect one area of plant to another.

Figure 4.10: Exterior Road

8. **Wet Stack (Chimney):**

A flue-gas stack, also known as a wet stack, smoke stack, chimney stack or simply as a stack, is a type of chimney, a vertical pipe, channel or similar structure through which combustion product gases called flue gases are exhausted to the outside air. Flue gases are produced when coal, oil, natural gas, wood or any other fuel is combusted in an industrial furnace, a power plant's steam-generating boiler, or other large combustion device. Flue gas is usually composed of carbon dioxide (CO2) and water vapor as well as nitrogen and excess oxygen remaining from the intake combustion air. It also contains a small percentage of pollutants such as particulate matter, carbon monoxide, nitrogen oxides and sulphur. The flue gas stacks are often quite tall, up to 400 metres (1300 feet) or more, so as to disperse the exhaust pollutants over a greater area and thereby reduce the concentration of the pollutants to the levels required by governmental environmental policy and environmental regulation.

Figure 4.11: Wet stack (Chimney)

## 4.2 Lighting Recommendations and Standards:

The purpose of industrial lighting is to improve the visual performance and comfort to the working personnel. The lighting design of any industry should ensure that it not only meets the requirements of the workers, the required standards and codes, be energy and cost efficient, but also be easy to maintain in the long run, should be safe and appear comfortable.

The level and type of lighting adopted for a power plant is based mainly on its application. The system of lighting to be provided should take into account all the relevant factors, such as the reflectance properties of the surface, difficulty of the geometry of the heavy machineries, tools and of intersection density, quality of visual performance and comfort.

To meet that purpose there are lighting standards, guidelines available. They are discussed below.

### INTERNATIONAL STANDARDS:

1. **ISO 8995-1/CIE S 008:** *Lighting of Indoor work places*

   This CIE standard specifies lighting requirements for indoor work places and for people to perform the visual tasks efficiently, in comfort and safety throughout the whole work period.

| **16. Power stations** | | | | |
|---|---|---|---|---|
| Fuel supply plant | 50 | 28 | 20 | Safety colours shall be recognisable. |
| Boiler house | 100 | 28 | 40 | |
| Machine halls | 200 | 25 | 80 | For high-bay: see also clause 4.6.2. |
| Auxiliary rooms, e.g pump rooms, condenser rooms, switchboard, etc. | 200 | 25 | 60 | |
| Control rooms | 500 | 16 | 80 | 1. Control panels are often vertical.<br>2. Dimming may be required.<br>3. For VDT work see clause 4.10. |

Figure 4.12: ref of page no. 13 of **ISO 8995-1/CIE S 008**

2. **EN 12464-1:** *Light and lighting - Lighting of work places - Part 1: Indoor work places*

   This European Standard specifies lighting requirements for indoor work places, which meet the needs for visual comfort and performance.

| 2.15 | Power stations | | | | |
|---|---|---|---|---|---|
| Ref. no. | Type of interior, task or activity | $\bar{E}_m$ lx | $UGR_L$ - | $R_a$ - | Remarks |
| 2.15.1 | Fuel supply plant | 50 | - | 20 | Safety colours shall be recognisable. |
| 2.15.2 | Boiler house | 100 | 28 | 40 | |
| 2.15.3 | Machine halls | 200 | 25 | 80 | For high-bay: see 4.6.2. |
| 2.15.4 | Side rooms, e.g. pump rooms, condenser rooms etc.; switchboards (inside buildings) | 200 | 25 | 60 | |
| 2.15.5 | Control rooms | 500 | 16 | 80 | 1. Control panels are often vertical.<br>2. Dimming may be required.<br>3. For DSE-work see 4.11. |
| 2.15.6 | Outdoor switch gear | 20 | - | 20 | Safety colours shall be recognisable. |

Figure 4.13: ref of page no.21 of **EN 12464-1**

3. **ICAO:** *International Civil Aviation Organisation*

As all the standards values or guidelines for areas/sections of Power Plant were not found in the international standards; some national standards, tender documents have also been considered for better understanding and execution. They are mentioned as under.

## NATIONAL STANDARDS:

1. **IS 6665- 1972:** *Code of Practice for Industrial Lighting*
2. **IS 3646 (Part 1)-1992:** *Code of Practice for Interior Illumination*
3. **SP 72- 2010:** *National Lighting Code, 2010*
4. **SP 32 (1986):** *Handbook on Functional Requirements of Industrial Buildings (Lighting and Ventilation)*

## Tender Document:

### NTPC – Technical Specification, Section VI, Part B

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

# Chapter 5

# Lighting Design Methodology

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

## 5.1 Input:

### 5.1.1 Drawing of the area giving plan and elevation:

To initiate any lighting design for a(an) area/structure, 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.

### 5.1.2. 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.

### 5.1.3. 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., the NTPC [National Thermal Power Corporation] regulatory body here. Some of the requirements are certain maintained lux level values, uniformity ratio, design parameters, plan and profile of the project etc.

### 5.1.4. 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.

## 5.2 Method of Lighting:

During the actual lighting design phase of a lighting project, a lighting engineer has to perform lighting calculations in order to arrive at solutions that will satisfy the relevant lighting requirements. 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.

## 5.3 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

- 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

## 5.4 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.

## 5.5 Design Tools:

### 5.5.1. 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.

### 5.5.2. 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.

### 5.5.3. 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.

### 5.5.4. Luxmeter:

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

- **Post Installation Audit:** This is mainly required when the client wants to verify the simulated report with the practically achieved result. This is known as post installation audit.
- **Refurbishment:** When an existing installation needs to be replaced with a more efficient lighting scheme (i.e., LEDs).

## 5.6 Design Methodology:

### 5.6.1. 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.

### 5.6.2. 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.

### 5.6.3. Study of guidelines:

Now being a lighting designer, it is a responsibility to the study the relevant standard codes, guidelines in detail. For this particular project work relevant standards and guidelines which needs to be followed are mentioned in detail in chapter 4.

### 5.6.4 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.

### 5.6.5. Indoor area:

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

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

In the first step after having AutoCAD layout, we have to identify the 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.

But in industries there are many areas which are very prone to dust accumulation, not cleaned regularly for those areas maintenance factors are considered low than a clean area. In this project NTPC has mentioned some standard maintenance factor that has to be considered while designing. They are mentioned below-

- Office area (air conditioned): 0.8
- Office area (non-air conditioned) and other indoor area: 0.7
- Dust prone indoor and outdoor area: 0.6
- Coal Handling area and Conveyor /Transfer Points etc.: 0.5

***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 and floor are to be considered 70%, 50% and 20% respectively. For industry shed area reflectance factors for ceiling, walls and floor 50%, 30% and 10%. As we know Thermal Power Plant areas are quite dust prone; so, reflectance factors are to be considered as 30%, 30%, 10% respectively for ceiling, walls and floor.

***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.

### 5.6.6. 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

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

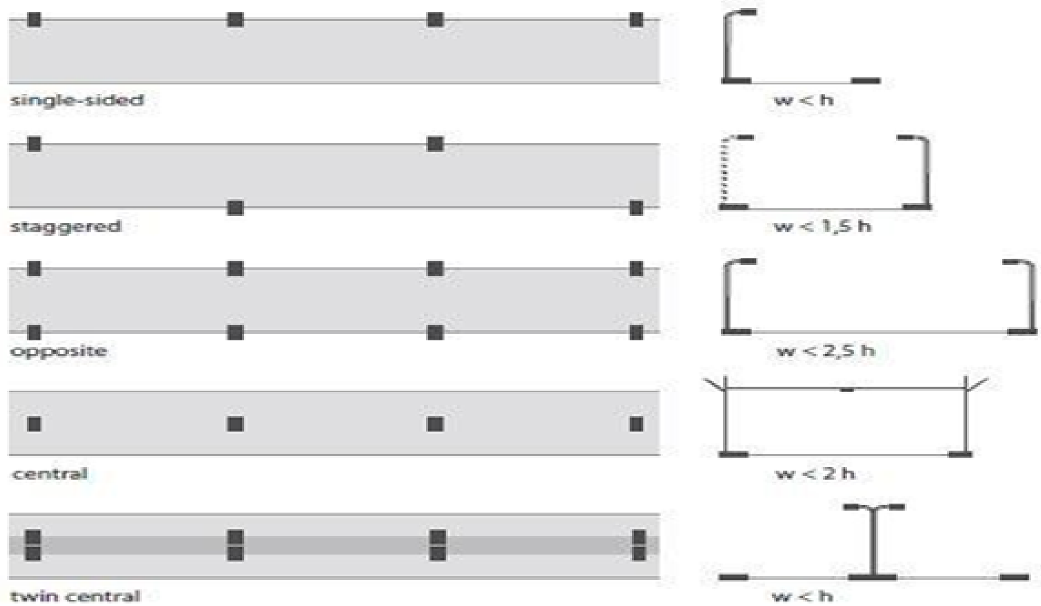



Figure 5.1: Pole Layout as per Road width

***STEP V- Street Arrangement***

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

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

Depending upon the width of the road, type of arrangement and geometry of road the mounting height required is decided. The mounting height should normally be equal to width of the road but should not exceed 10 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, MHL  HPSV 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.

#### 5.6.7. 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 IX – Output***

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

***Conclusion:***

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 6

# Case Study of Different Areas of Thermal Power Plant

The objective of this chapter is to guide for designing and maintaining illumination standards followed by the National Thermal Power Corporation (NTPC). 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 different areas in a Thermal Power Plant. These are Belt Conveyor, Crusher House, Mill House, Turbine Hall, Pump House, Gypsum Dewatering, Gypsum Storage Shed, Limestone Terminal Point, Blower Shed, Wet stack (Chimney) . Different areas of Plant require different types of lighting. In this project a typical Thermal Power Plant is shown.

## 6.1 Belt Conveyor Gallery:

Belt conveyors help in the transportation of large volumes of coal/ limestone over long distances. Belt conveyors offer a low power consumption carrying system, with a low initial installation cost. Belt conveyors successfully carry loads on an inclination of up to 20 degrees to the horizon and can carry between 50 to 100 tonnes per hour.

**Design Aim:**

To provide uniform illumination over the Belt Conveyor and the walkway beside the conveyor area. The designed illumination level uniformity must meet the required value. The lighting installations must provide visual comfort and it should not create much glare.

- Required illuminance level: Average 100 Lux
- Overall uniformity: 0.40

**Layout and description of Belt Conveyor:**

Considering one of the Belt Conveyors for better understanding of lighting design, analysing software DIALux has been used for describing and achieving the recommended values as per NTPC standard. Typical plan layout of the Belt conveyor is shown in Fig. below.

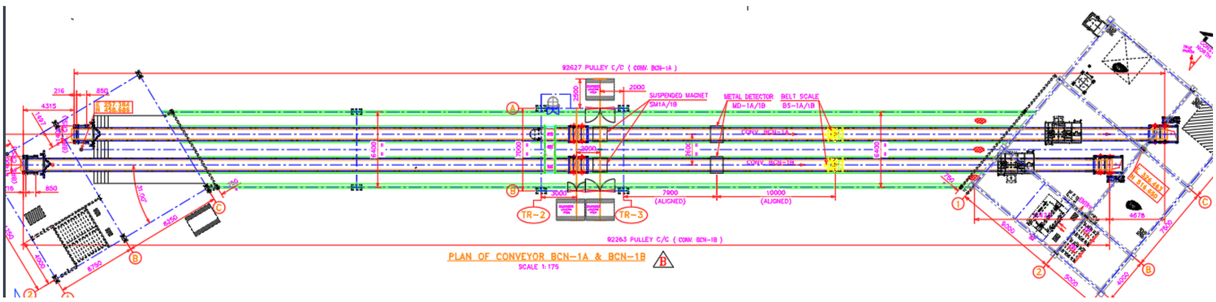



Figure 6.1: Plan layout of Belt Conveyor

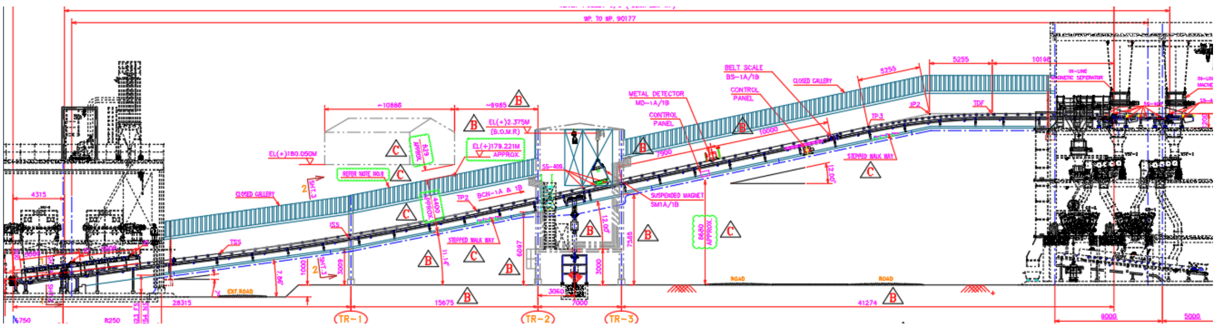



Figure 6.2: Elevation Details of Belt Conveyor

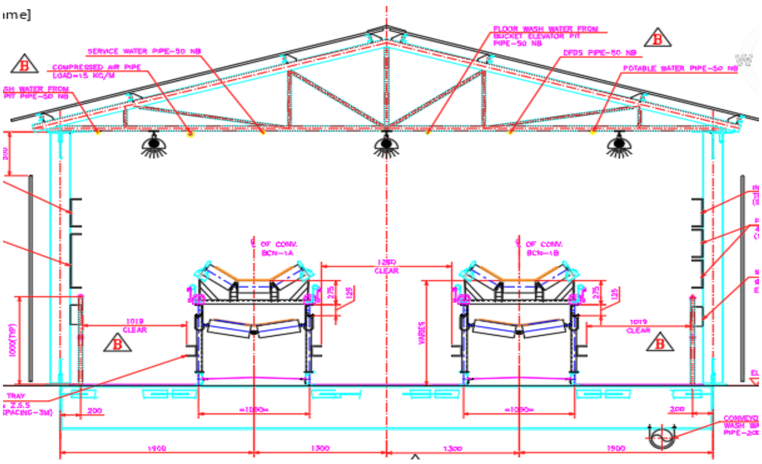


Figure 6.3: Luminaire mounting for Belt Conveyor

Simulation of Belt Conveyor as shown in Fig. is mainly on the calculation surfaces over the Belt Conveyor and walkway beside it. To illuminate this area staggered arrangement is considered beside the conveyors to mount the luminaires.

**Luminaire used:**

- Circular PDC Aluminium housing LED Well glass (as shown in fig.)
- Luminous flux: 3402 Lumen
- Wattage: 30 Watt
- System efficacy: 118 lm/W
- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected

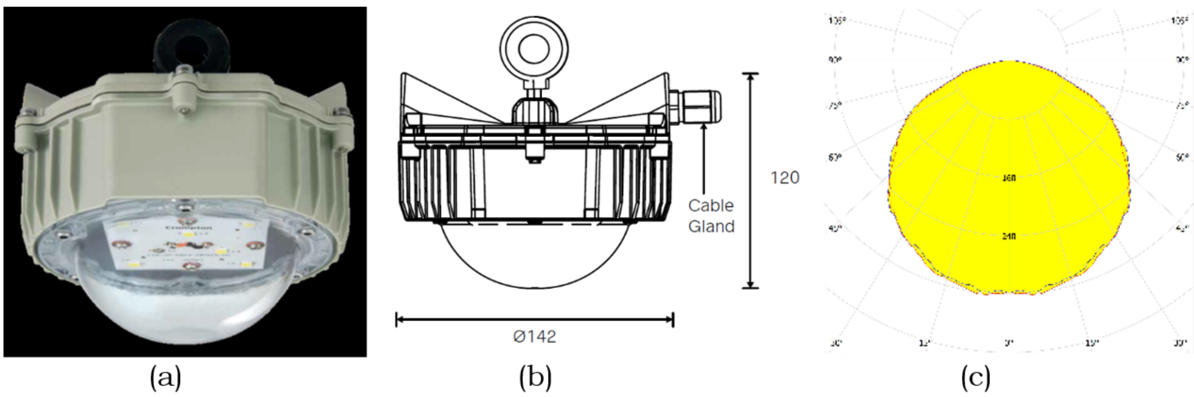



Figure 6.4: (a) Well Glass image (b) Well glass dimension (c) Polar curve

**Design Considerations for the lighting implementation:**

- Number of Luminaires: 42
- Mounting height: 3m from floor level
- Maintenance factor: 0.5

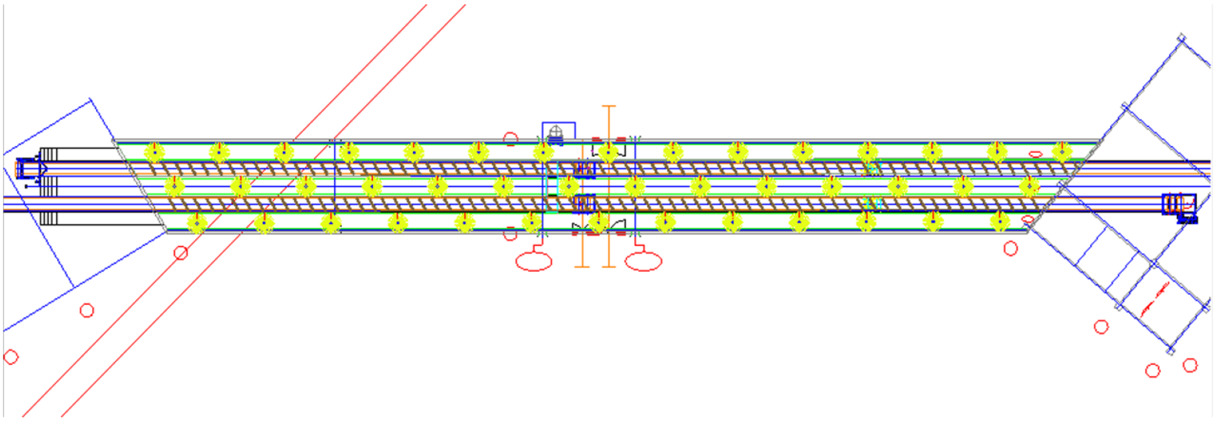
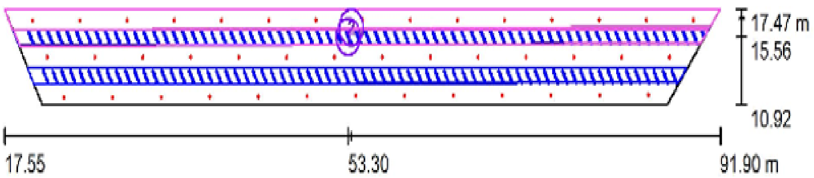


Figure 6.5: Simulated Layout of Belt Conveyor

## CONVEYOR BELT AREA / Calculation surfaces (results overview)




Scale 1 : 532

### Calculation Surface List

| No. | Designation | Type | Grid | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 | $E_{min}$ / $E_{max}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | CONVEYOR BELT | perpendicular | 64 x 8 | 126 | 85 | 161 | 0.676 | 0.528 |
| 2 | FLOOR LVL | perpendicular | 64 x 8 | 61 | 29 | 77 | 0.480 | 0.379 |

### Summary of Results

| Type | Quantity | Average [lx] | Min [lx] | Max [lx] | u0 | $E_{min}$ / $E_{max}$ |
|---|---|---|---|---|---|---|
| perpendicular | 2 | 61 | 29 | 161 | 0.48 | 0.18 |

Figure 6.6: Simulated output report of Belt Conveyor

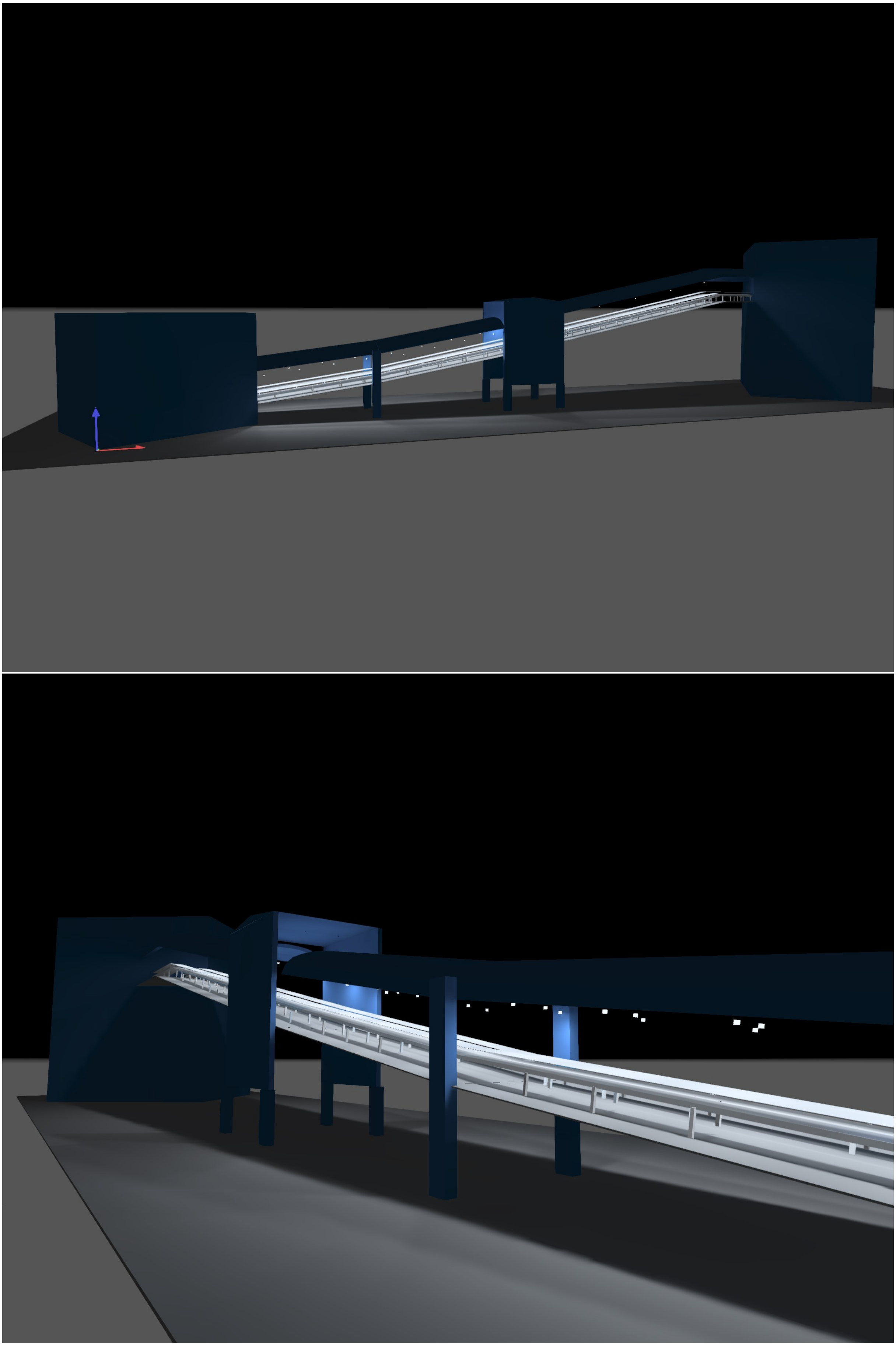


Figure 6.7: Simulated 3d Rendering of Belt Conveyor

## 6.2 Crusher House:

In the thermal power plants maximum requirements of fuel is a coal. The handling of this fuel is a great job. To handle the fuel, i.e., coal, each power station is equipped with a coal handling plant. Crusher House/Building is a part of this Coal handling plant, where fuel or coal crushed or pulverised from an irregular, large to a regular smaller size to increase the efficiency of the fuel.

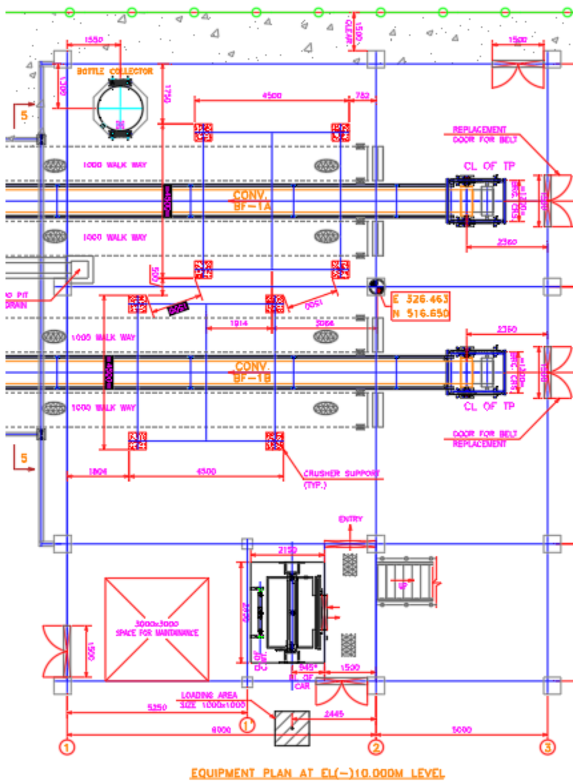
**Design Aim:**

To provide uniform illumination over the Crusher House and the walkway beside the conveyor belt. The designed illumination level uniformity must meet the required value. The lighting installations must provide visual comfort and it should not create much glare.

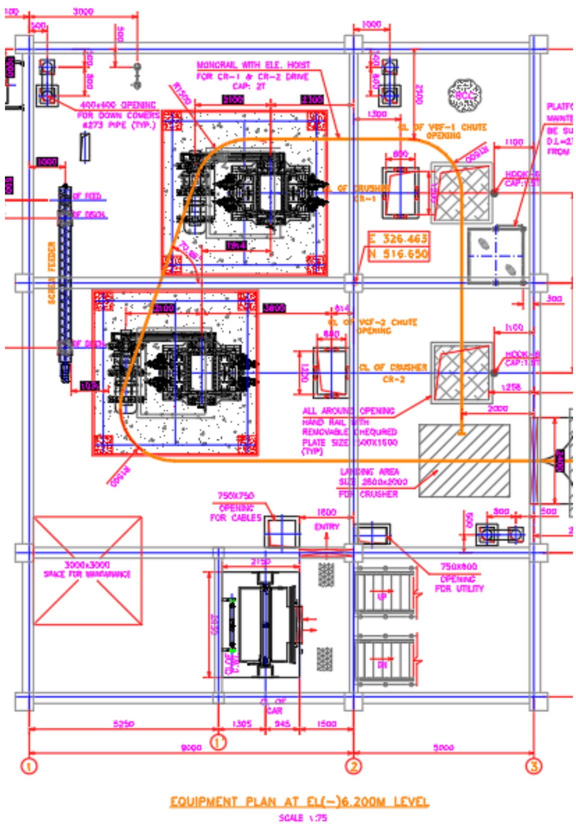
- Required illuminance level: Average 100 Lux
- Overall uniformity:0.40

**Layout and description of Crusher House:**

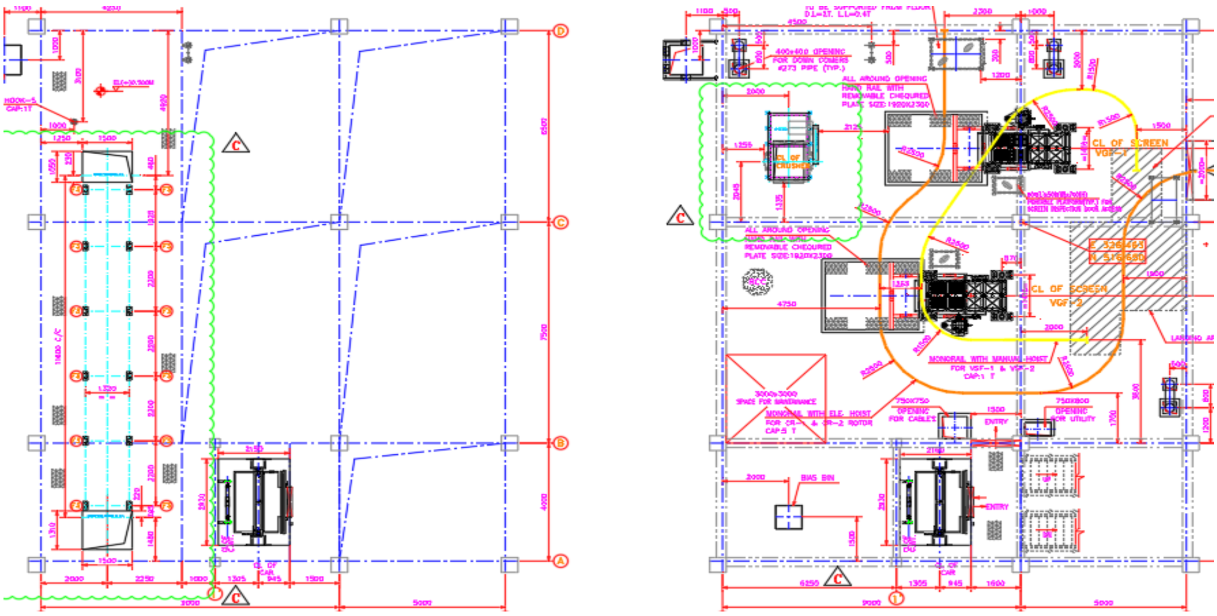
Considering one of the Crusher House for better understanding of lighting design, analysing software DIALux has been used for describing and achieving the recommended values as per NTPC standard. Typical plan layout of the Crusher House is shown in Fig. below.




(a)EL -10m




(b)EL -6.2m



(c) EL -1.5m

Figure 6.8: Plan Layout of Crusher House

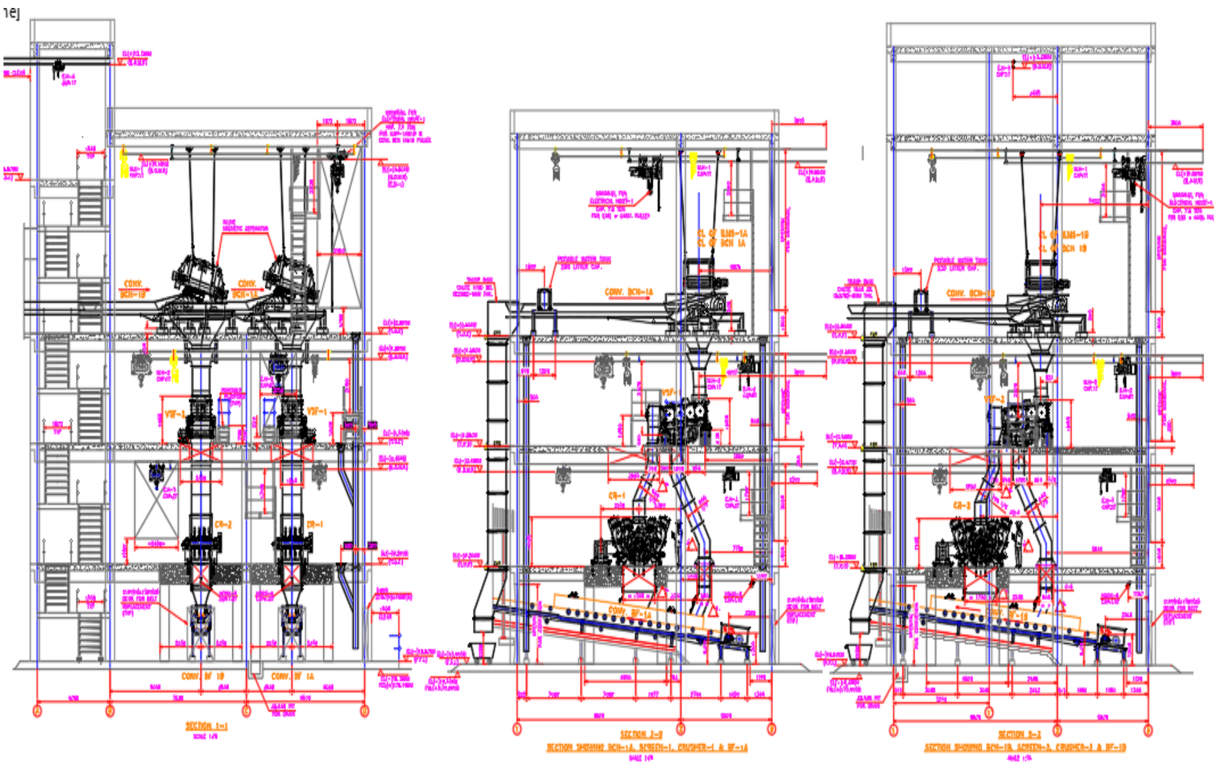


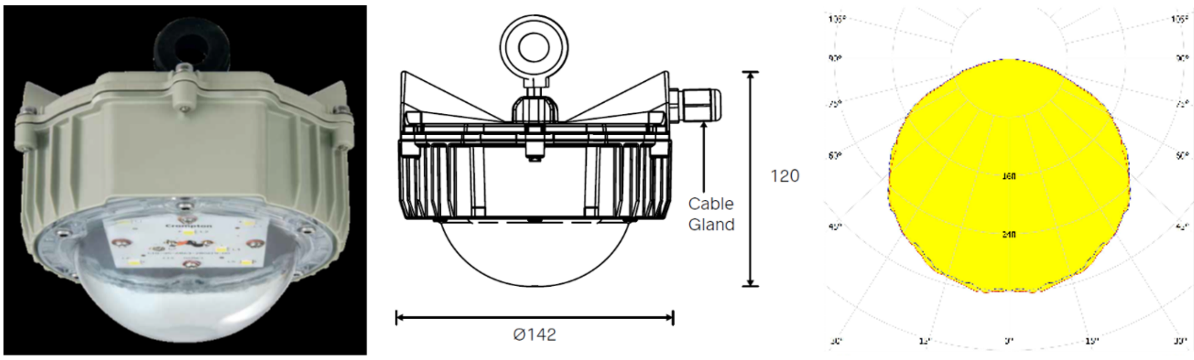
Figure 6.9: Elevation details of the Crusher House

Simulation of each level of Crusher House as shown in Fig. is mainly on the calculation surfaces as shown in the design report. To illuminate this area line arrangement is considered to mount the luminaires.

**For EL (-) 10m:**

**Luminaire used:**

- Circular PDC Aluminium housing LED Well glass (as shown in fig.)
- Luminous flux: 3402 Lumen
- Wattage: 30 Watt
- System efficacy: 118 lm/W
- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected




(a) (b) (c)

Figure 6.10: (a) Well Glass image (b) Well glass dimension (c) Polar curve

**Design Considerations for the lighting implementation:**

- Number of Luminaires: 25
- Mounting height: 3.5m from floor level
- Maintenance factor: 0.6
- Ceiling, Wall and Floor reflectance factor is considered 30%, 0%, 10% respectively

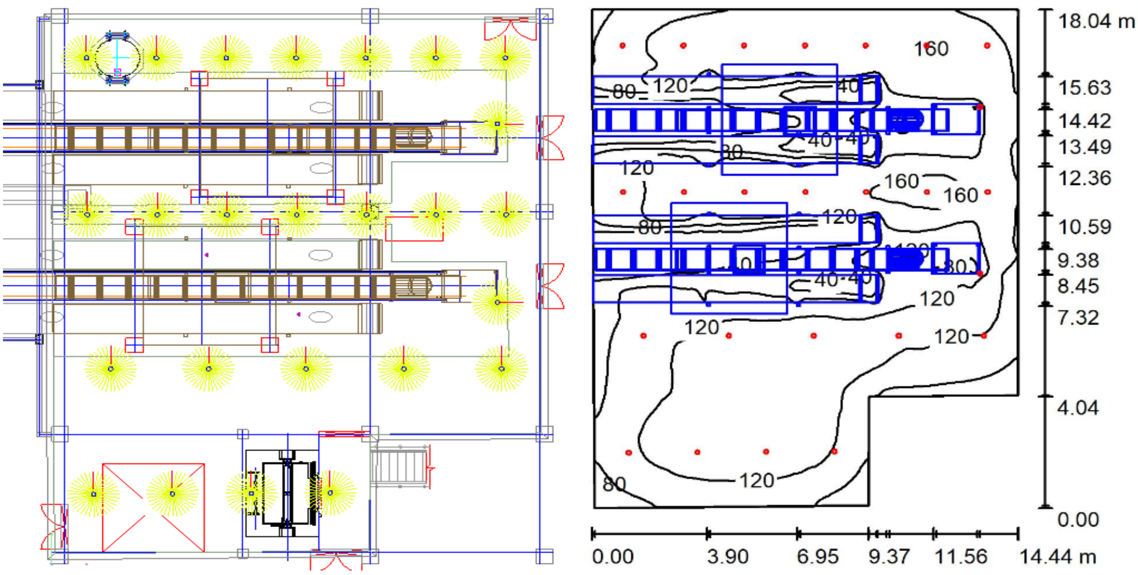
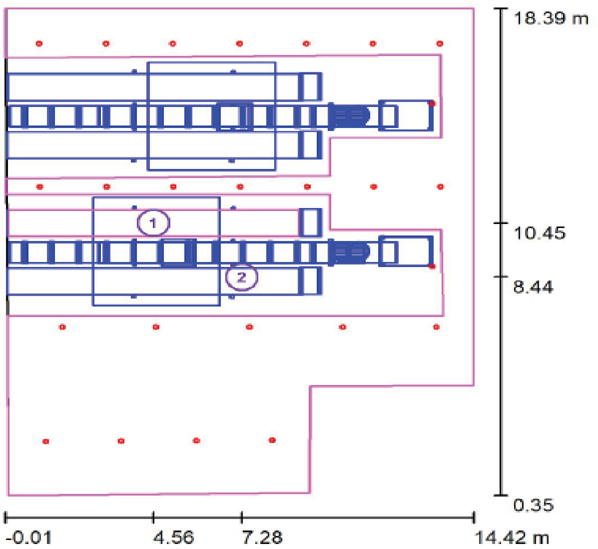



Figure 6.11: Simulated Layout of EL (-) 10m Design

**EL (-) 10.00 M LVL / Calculation surfaces (results overview)**

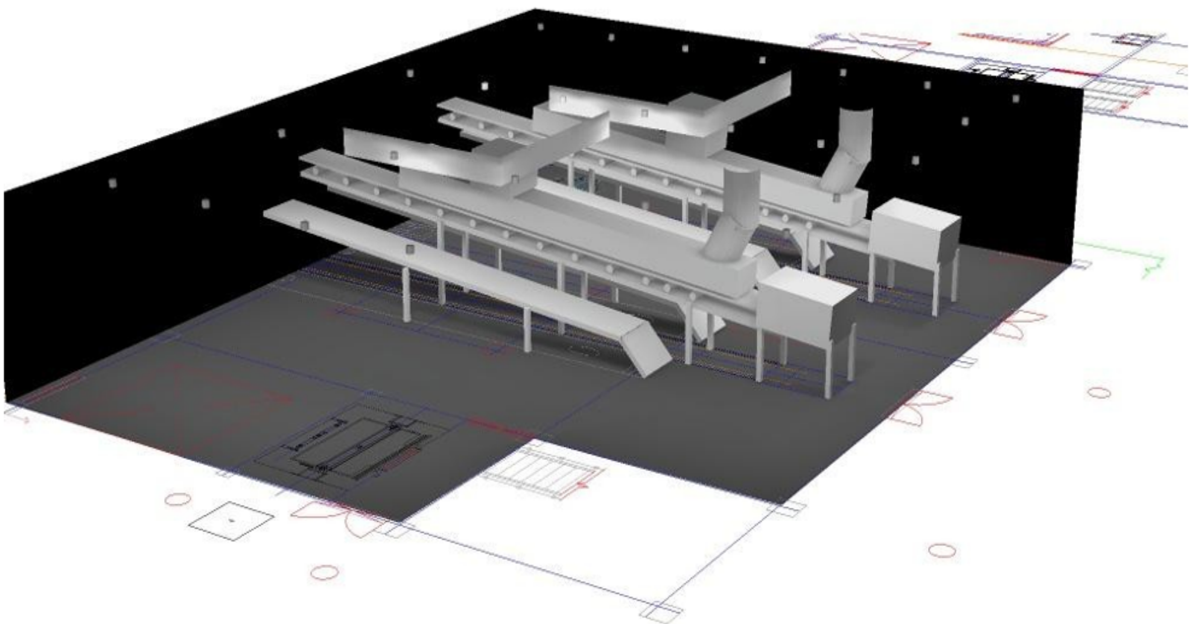



Scale 1 : 206

**Calculation Surface List**

| No. | Designation | Type | Grid | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 | $E_{min}$ / $E_{max}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | PLATFORM | perpendicular | 128 x 16 | 137 | 64 | 183 | 0.466 | 0.350 |
| 2 | Floor Level | horizontal | 128 x 128 | 123 | 51 | 170 | 0.416 | 0.301 |

Figure 6.12: Simulated report of EL (-) 10m Design



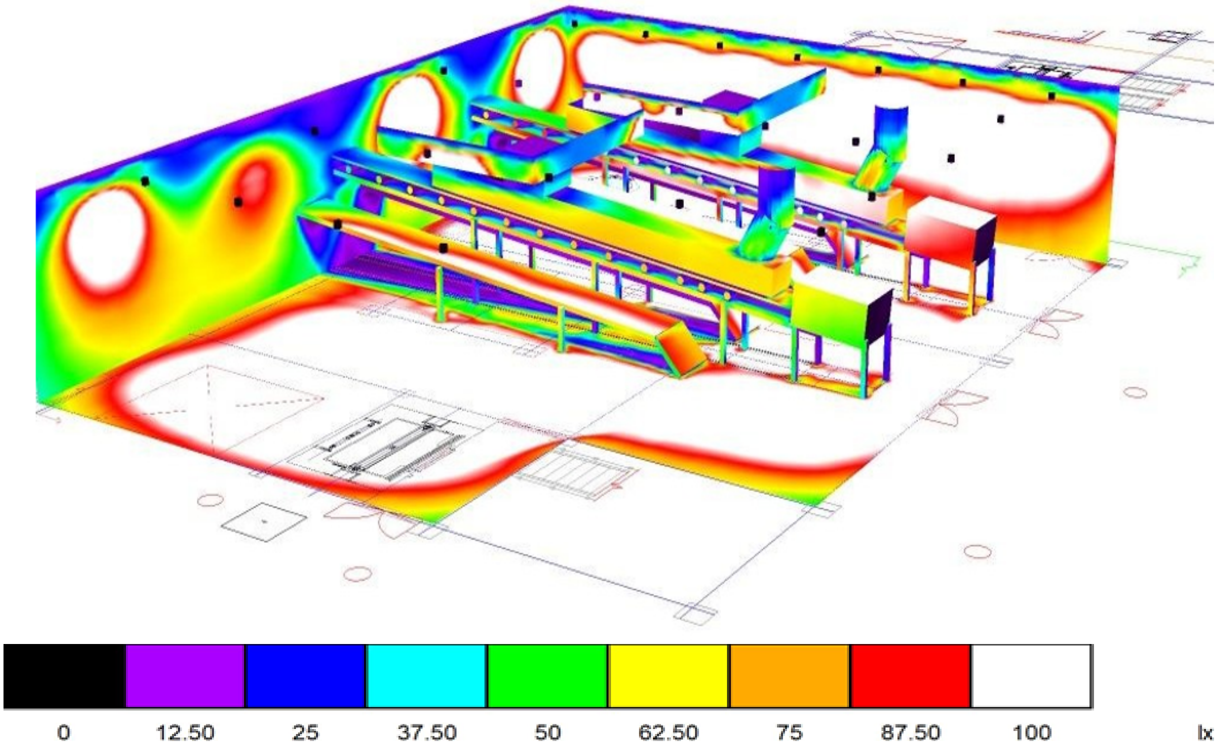
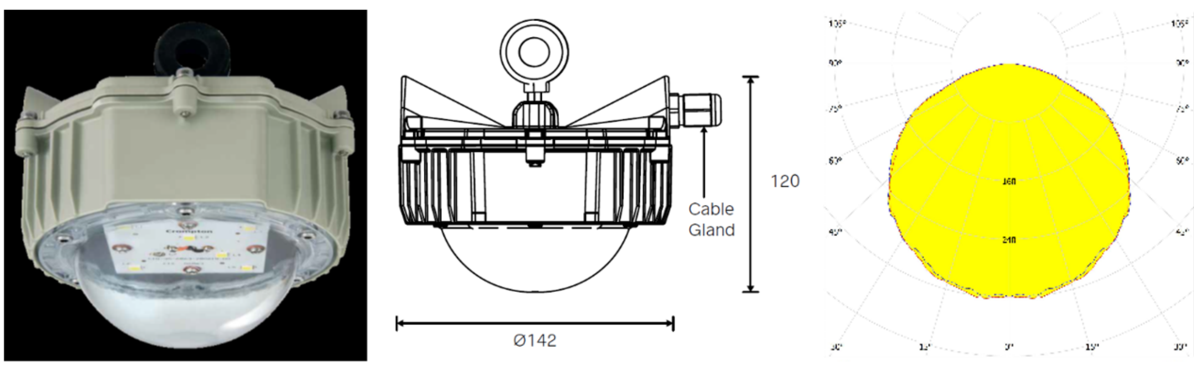



Figure 6.13: Simulated 3d rendering of EL (-) 10m Design

**For EL (-) 6.2m:**

**Luminaire used:**

- Circular PDC Aluminium housing LED Well glass (as shown in fig.)
- Luminous flux: 3402 Lumen
- Wattage: 30 Watt
- System efficacy: 118 lm/W
- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected




(a) (b) (c)

Figure 6.14: (a) Well Glass image (b) Well glass dimension (c) Polar curve

**Design Considerations for the lighting implementation:**

- Number of Luminaires: 22
- Mounting height: 4.4m from floor level
- Maintenance factor: 0.6
- Ceiling, Wall and Floor reflectance factor is considered 30% , 0%, 10% respectively

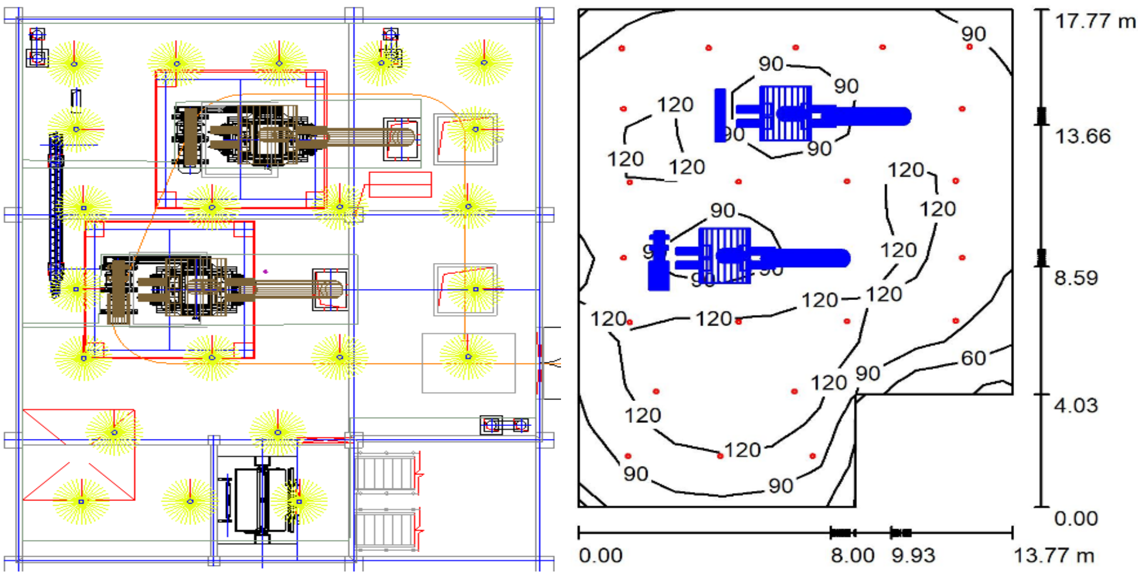
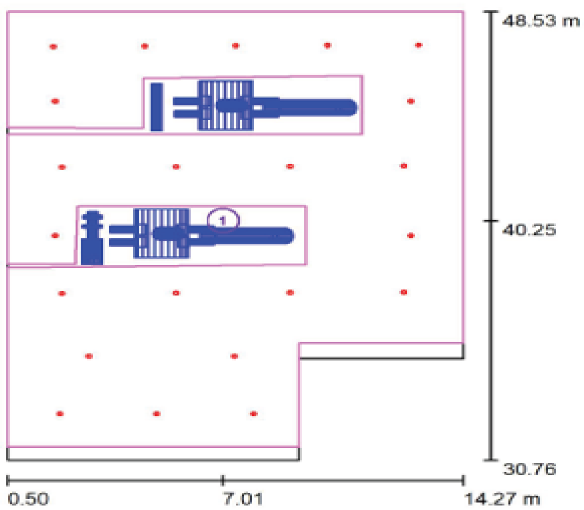



Figure 6.15: Simulated Layout of EL (-) 6.2m Design

**EL (-) 6.20 M LVL / Calculation surfaces (results overview)**




Scale 1 : 203

**Calculation Surface List**

| No. | Designation | Type | Grid | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 | $E_{min}$ / $E_{max}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | Floor Level | horizontal | 128 x 128 | 113 | 48 | 147 | 0.427 | 0.329 |

Figure 6.16: Simulated report of EL (-) 6.2m Design

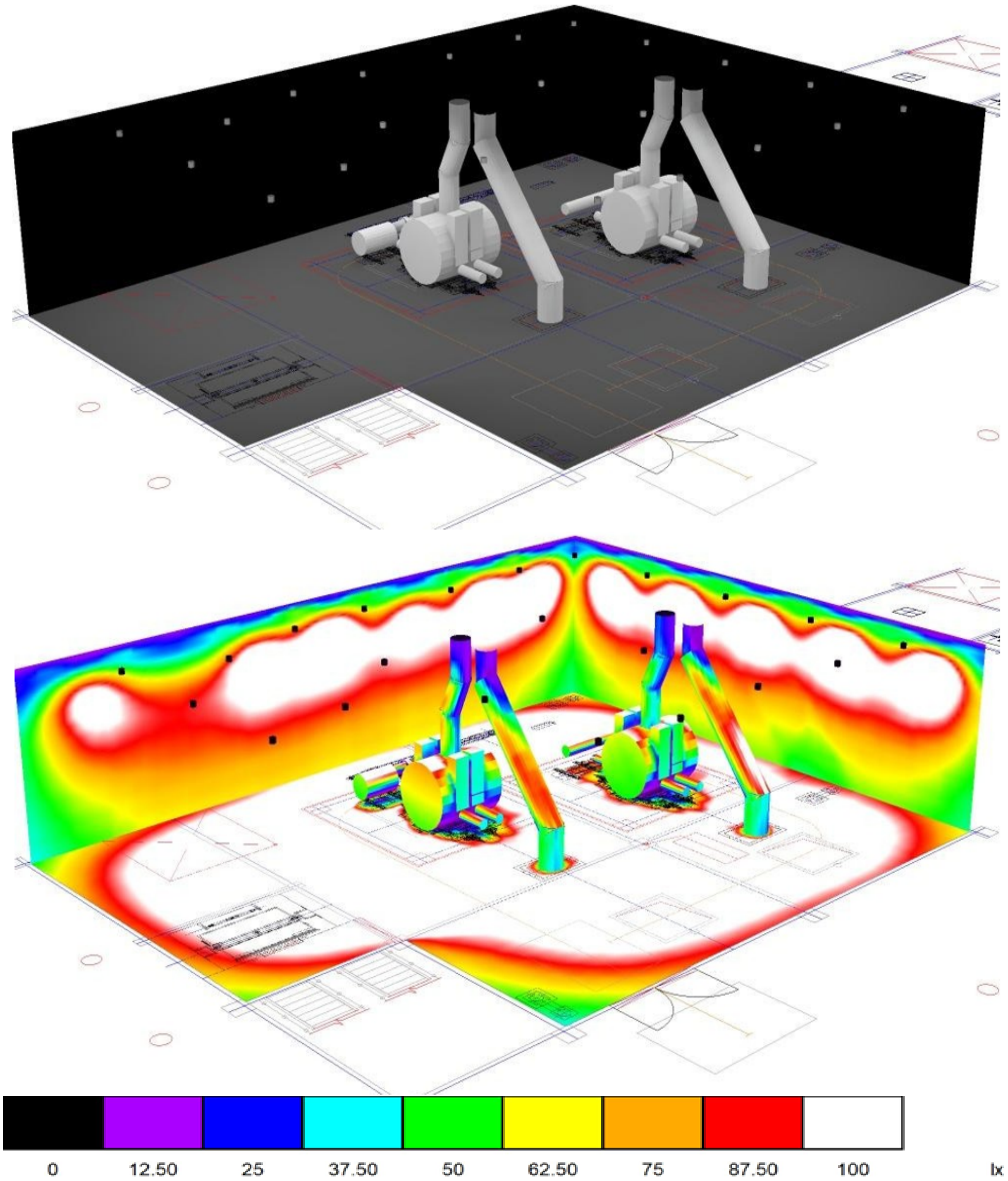
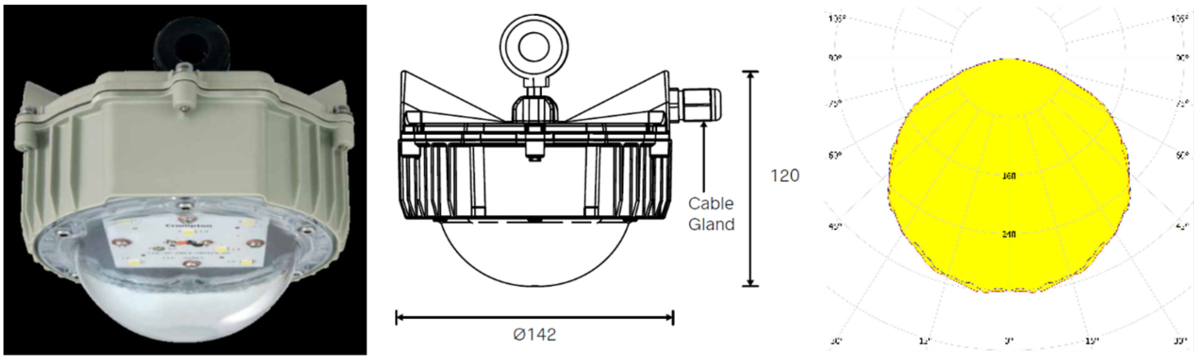



Figure 6.17: Simulated 3d rendering of EL (-) 6.2m Design

**For EL (-) 1.5 m:**

**Luminaire used:**

- Circular PDC Aluminium housing LED Well glass (as shown in fig.)
- Luminous flux: 3402 Lumen
- Wattage: 30 Watt
- System efficacy: 118 lm/W
- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected




(a) (b) (c)

Figure 6.18: (a) Well Glass image (b) Well glass dimension (c) Polar curve

**Design Considerations for the lighting implementation:**

- Number of Luminaires: 14
- Mounting height: 4m from floor level
- Maintenance factor: 0.6
- Ceiling, Wall and Floor reflectance factor is considered 30%, 0%, 10% respectively

**For Mezzanine Level:**

**Luminaire used:**

- Linear Weatherproof Integrated LED Batten (as shown in fig.)
- Luminous flux: 2323 Lumen
- Wattage: 20 Watt
- System efficacy: 115 lm/W
- Beam angle: 140 degrees (C0-C180); 100 degrees (C90-C270)
- CCT: 5700K
- CRI: 80
- IP 65 protected

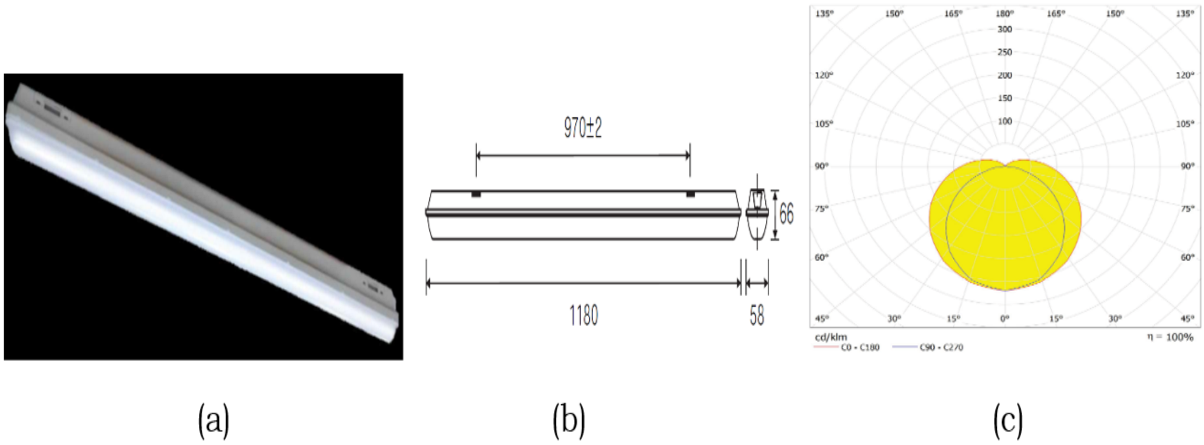



Figure 6.19: (a)Batten image (b)Batten dimension (c) Polar curve

**Design Considerations for the lighting implementation:**

- Number of Luminaires: 12 (6 above mezzanine and 6 below mezzanine level)
- Mounting height: 2m from respective floor level
- Maintenance factor: 0.6
- Ceiling, Wall and Floor reflectance factor is considered 30%, 0%, 10% respectively

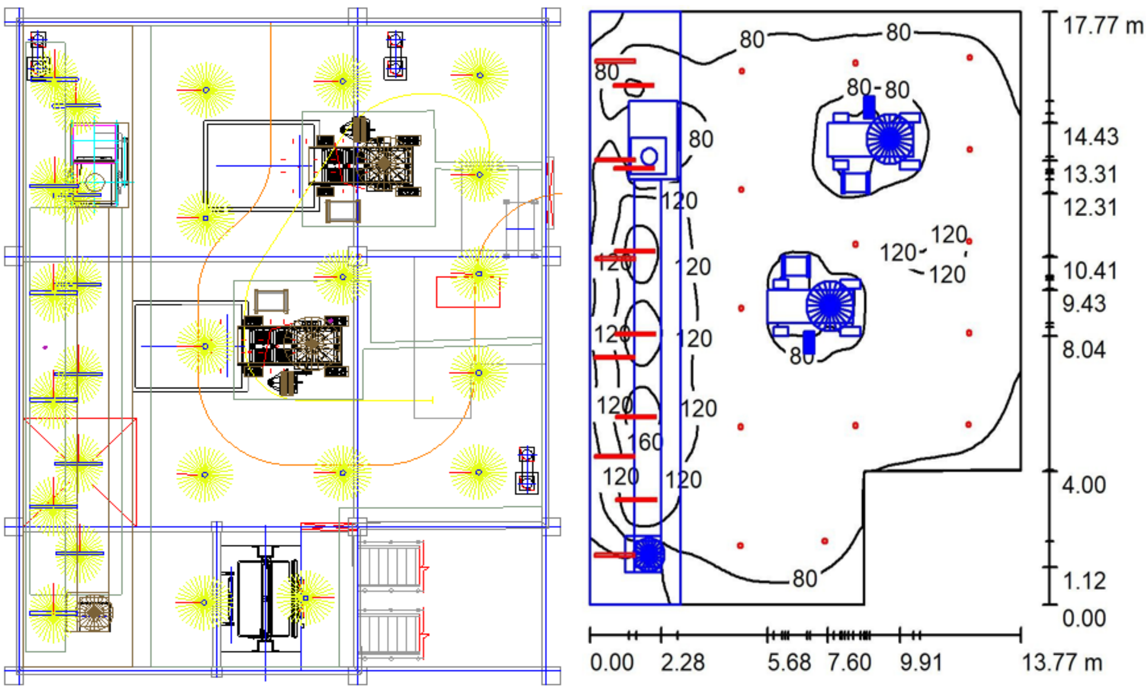
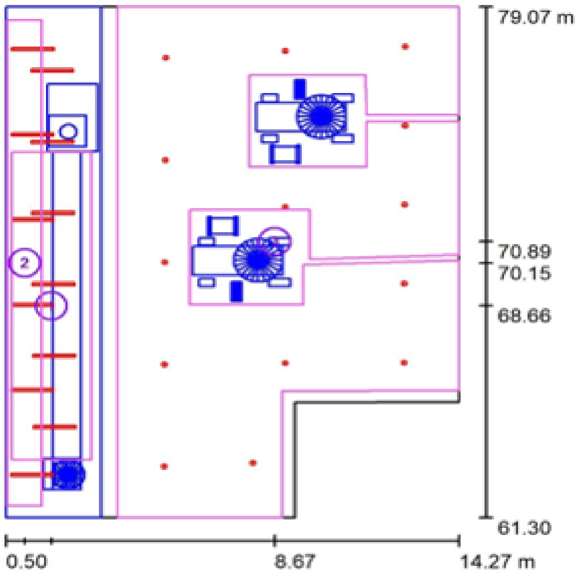



Figure 6.20: Simulated Layout of EL (-) 1.5m Design

**EL (-) 1.50 M LVL / Calculation surfaces (results overview)**

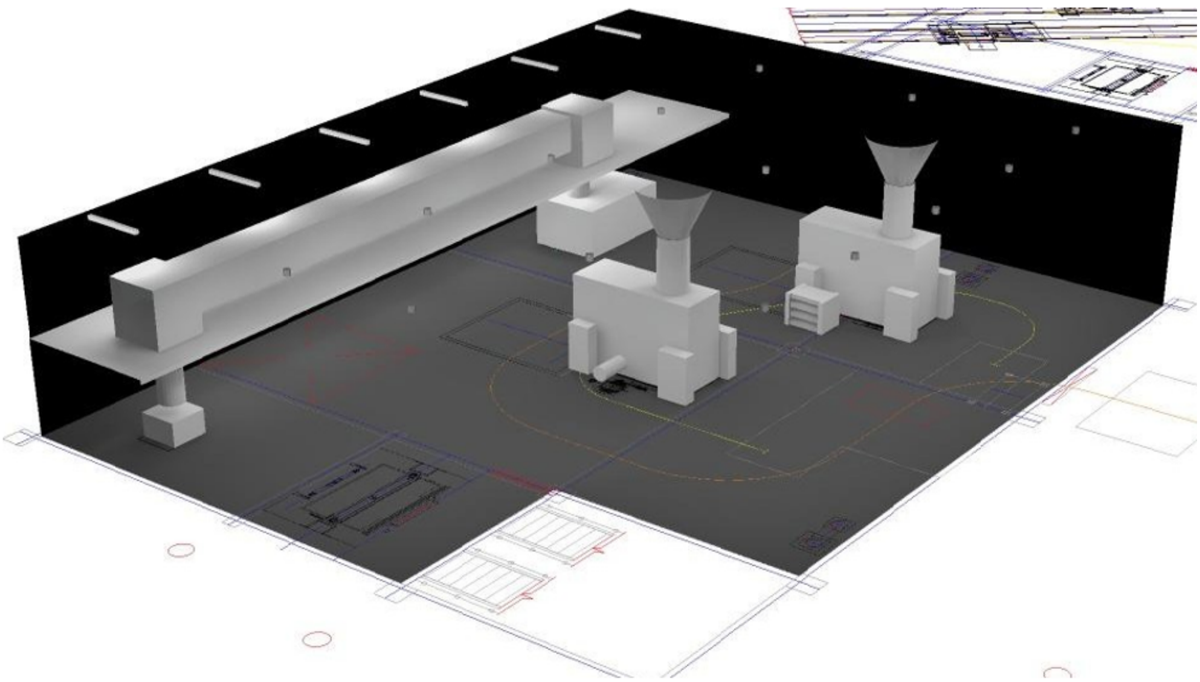



Scale 1: 203

**Calculation Surface List**

| No. | Designation | Type | Grid | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 | $E_{min}$ / $E_{max}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | Below MEZZ LVL | horizontal | 4 x 19 | 138 | 66 | 181 | 0.480 | 0.367 |
| 2 | BELT FEEDER | horizontal | 8 x 128 | 104 | 65 | 132 | 0.620 | 0.489 |
| 3 | Floor level | horizontal | 32 x 32 | 100 | 56 | 122 | 0.562 | 0.459 |

Figure 6.21: Simulated report of EL (-) 1.5m Design



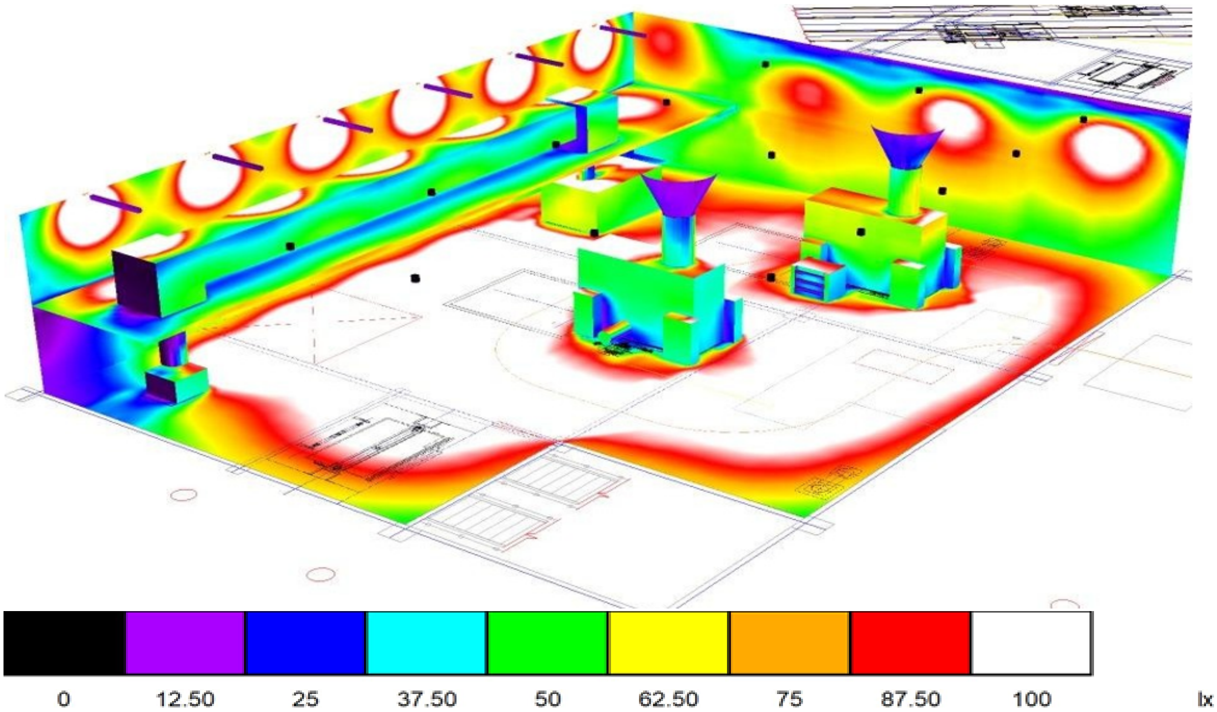
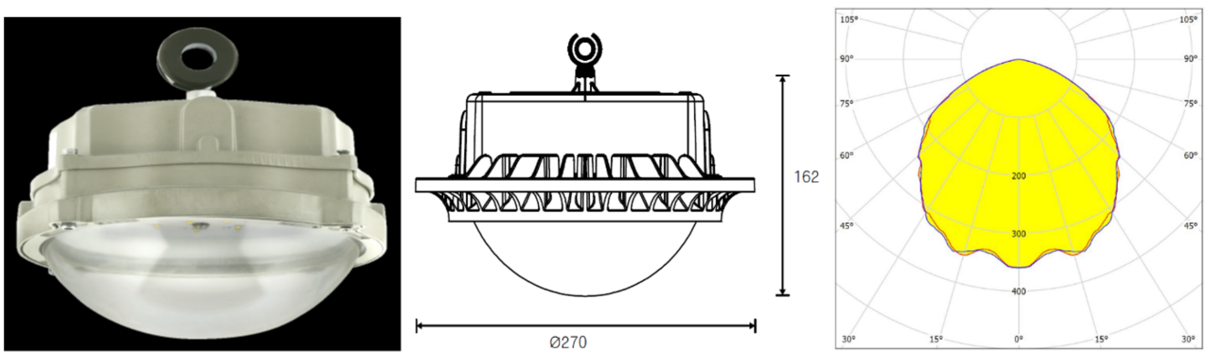



Figure 6.22: Simulated 3d rendering of EL (-) 1.5m Design

**For EL (+) 2.8 m:**

**Luminaire used:**

- Circular PDC Aluminium housing LED Well glass (as shown in fig.)
- Luminous flux: 7800 Lumen
- Wattage: 70 Watt
- System efficacy: 111 lm/W
- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected




(a) (b) (c)

Figure 6.23: (a) Well Glass image (b) Well glass dimension (c) Polar curve

**Design Considerations for the lighting implementation:**

- Number of Luminaires: 12
- Mounting height: 7.5m from floor level
- Maintenance factor: 0.6
- Ceiling, Wall and Floor reflectance factor is considered 30%, 0%, 10% respectively.

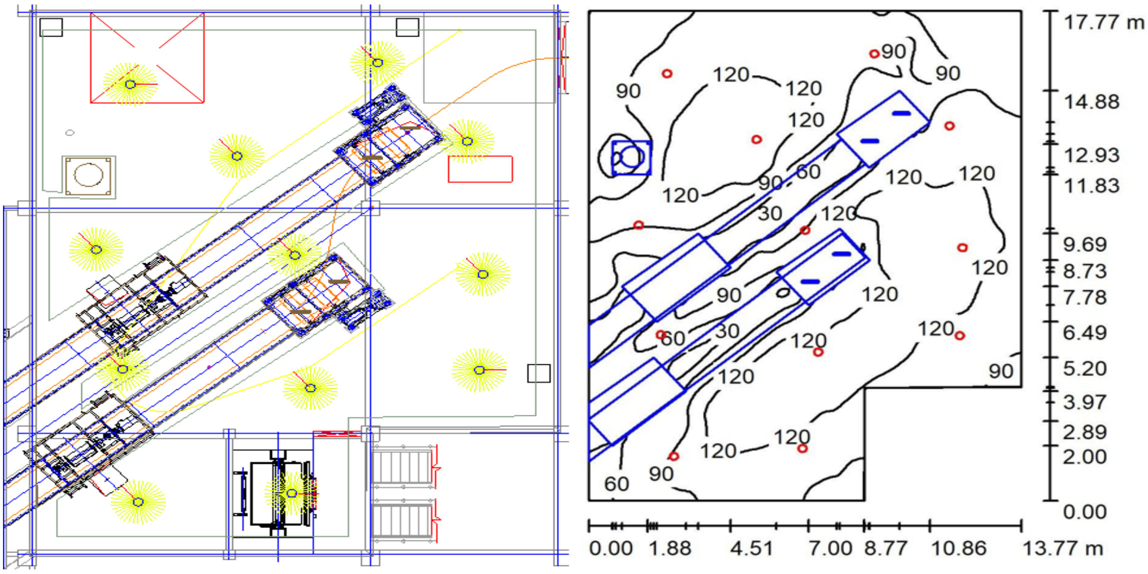
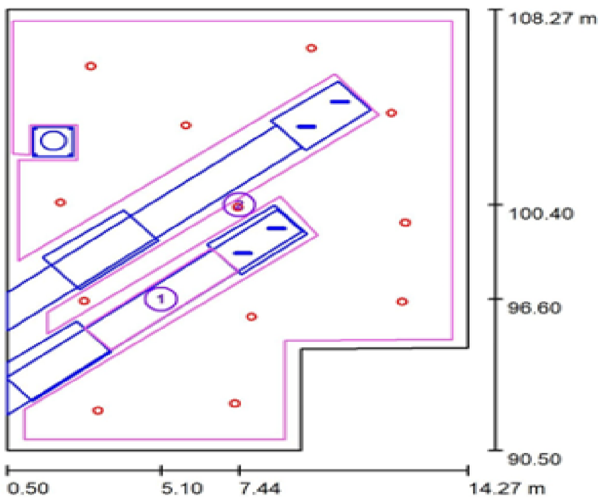



Figure 6.24: Simulated Layout of EL (+) 2.8m Design

**EL (+) 2.80 M LVL / Calculation surfaces (results overview)**




Scale 1: 203

**Calculation Surface List**

| No. | Designation | Type | Grid | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 | $E_{min}$ / $E_{max}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | CONVEYOR BELT | horizontal | 128 x 64 | 152 | 101 | 172 | 0.660 | 0.586 |
| 2 | Floor Level | horizontal | 32 x 32 | 111 | 50 | 149 | 0.449 | 0.334 |

Figure 6.25: Simulated report of EL (+) 2.8m Design

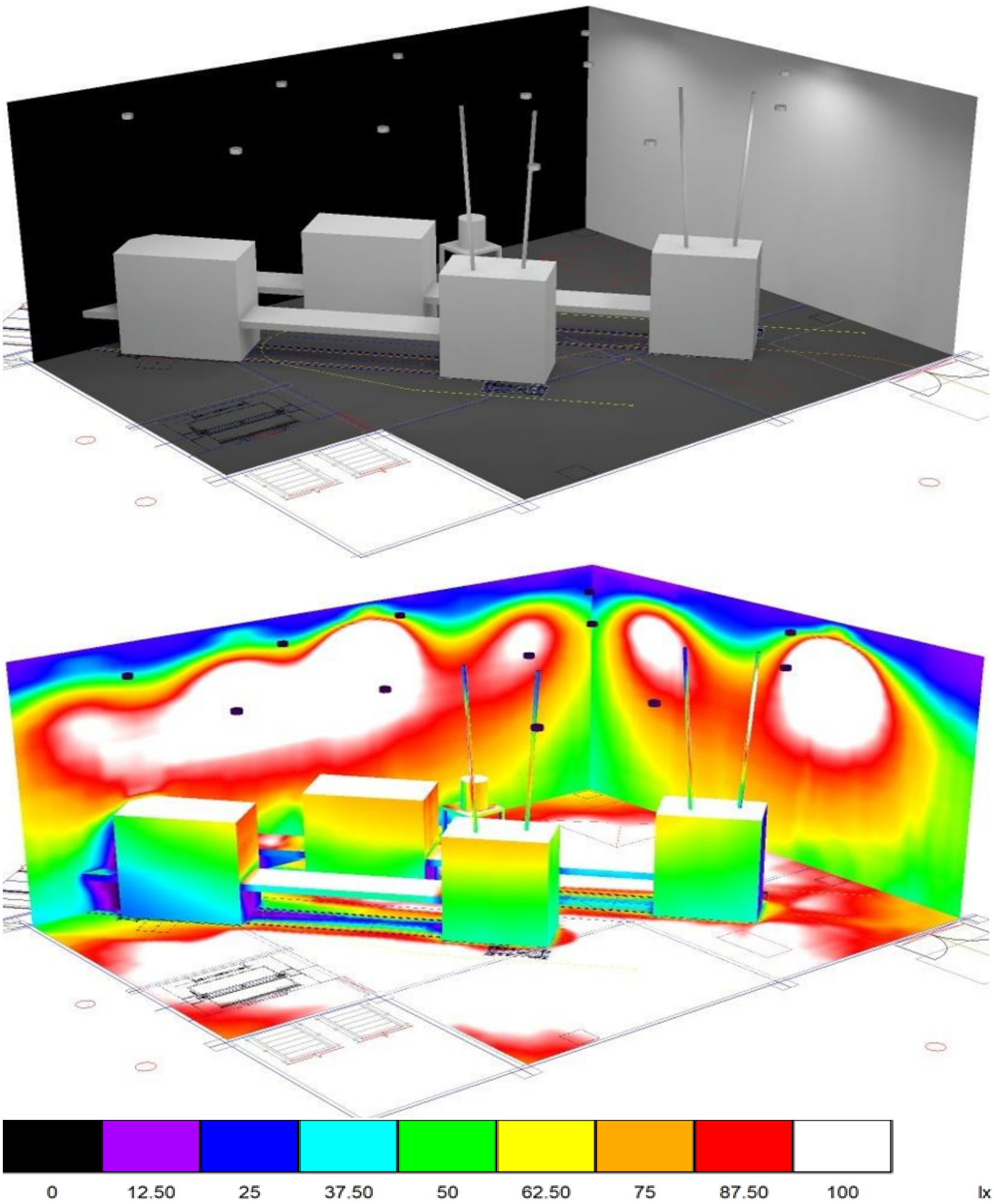



Figure 6.26: Simulated 3d rendering of EL (+) 2.8m Design

## 6.3 Mill Building with Silo Storage:

Elevated reinforced concrete Silos are playing important role in every production industry because of the demand for production. More particularly power production from thermal power plant structures is increasing day by day and producing huge number of wastes such as fly ash and bed ash. To store those ashes in power plant we need a good storage container say Silo which should satisfy the basic requirements of the power plant. Silos can be constructed as a single one or as group of two or more.

**Design Aim:**

To provide uniform illumination over the machinery and the floor. The designed illumination level and uniformity must meet the required value. The lighting installations must provide visual comfort and it should not create much glare.

- Required illuminance level: Average 100 Lux
- Overall uniformity: 0.40

**Layout and description of Mill Building with Silo Storage:**

Considering one of the Mill Building with Silo Storage for better understanding of lighting design, analysing software DIALux has been used for describing and achieving the recommended values as per NTPC standard. Typical plan layout of the Mill Building with Silo Storage is shown in Fig. below

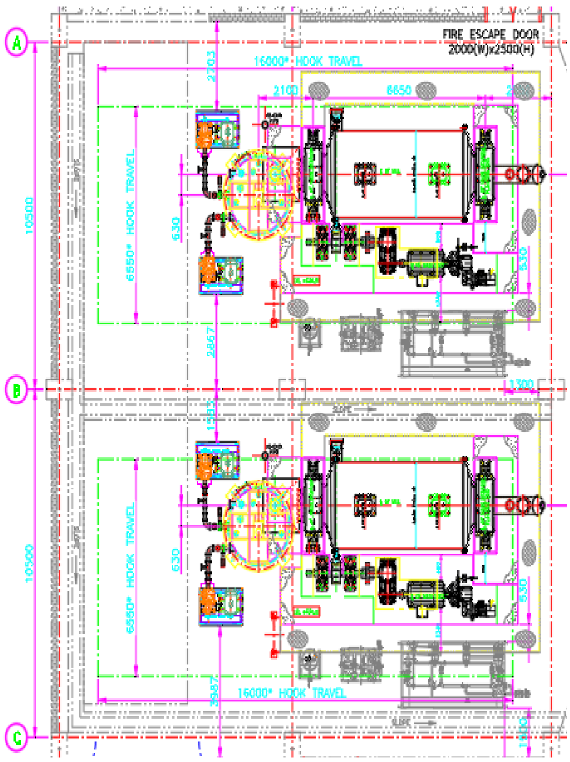



Figure 6.27: Plan Layout of El (-) 10m

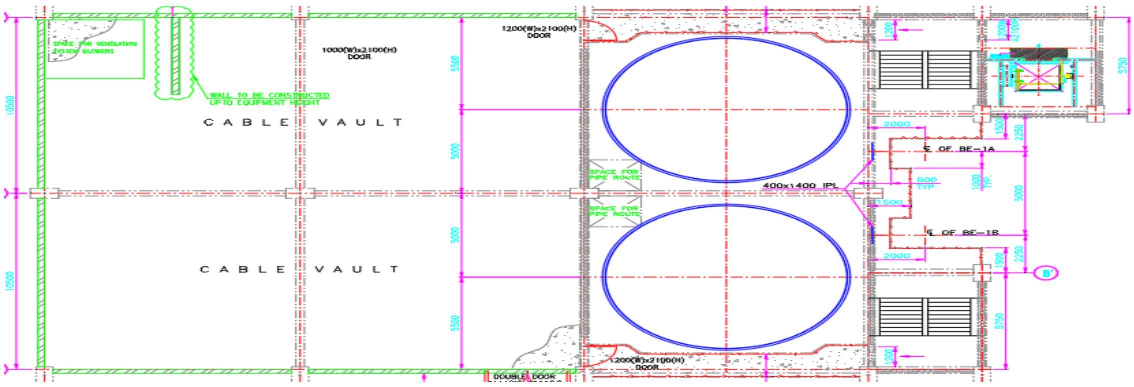



Figure 6.28: Plan Layout of El (+) 5.2m

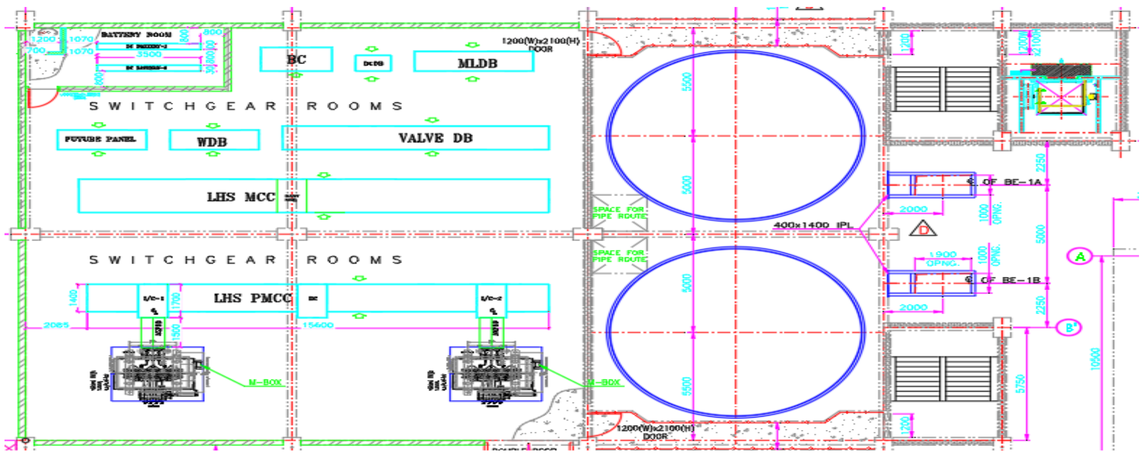



Figure 6.29: Plan layout of EL (+) 9.7m Switchgear room

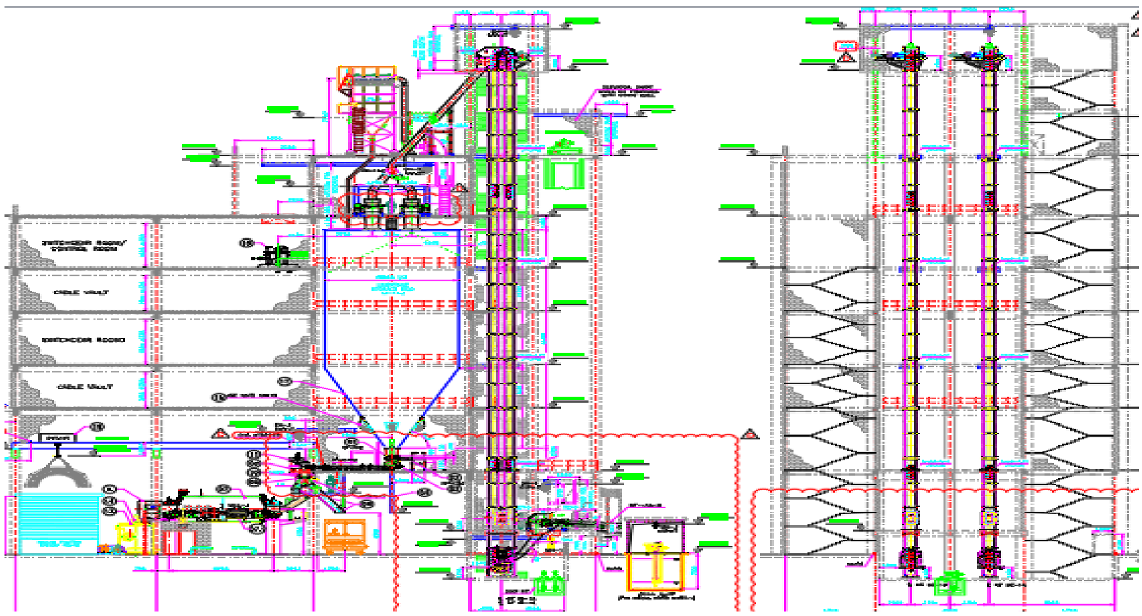
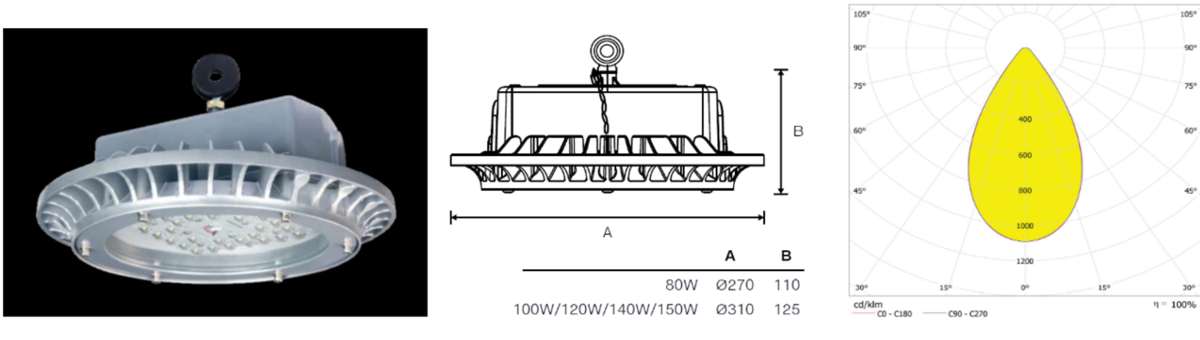


Figure 6.30: Elevation Details of Mill Building with Silo Storage

**For EL (-) 10m:**

**Luminaire used:**

- Circular PDC Aluminium housing LED Highbay (as shown in fig.)
- Luminous flux: 21000 Lumen
- Wattage: 150 Watt
- System efficacy: 140 lm/W
- Beam angle: 60 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected




(a) (b) (c)

Figure 6.31: (a) Highbay image (b)Highbay dimension (c) Polar curve

**Design Considerations for the lighting implementation:**

- Number of Luminaires: 6
- Mounting height: 15m from floor level
- Maintenance factor: 0.6
- Ceiling, Wall and Floor reflectance factor is considered 30%, 30%, 10% respectively.

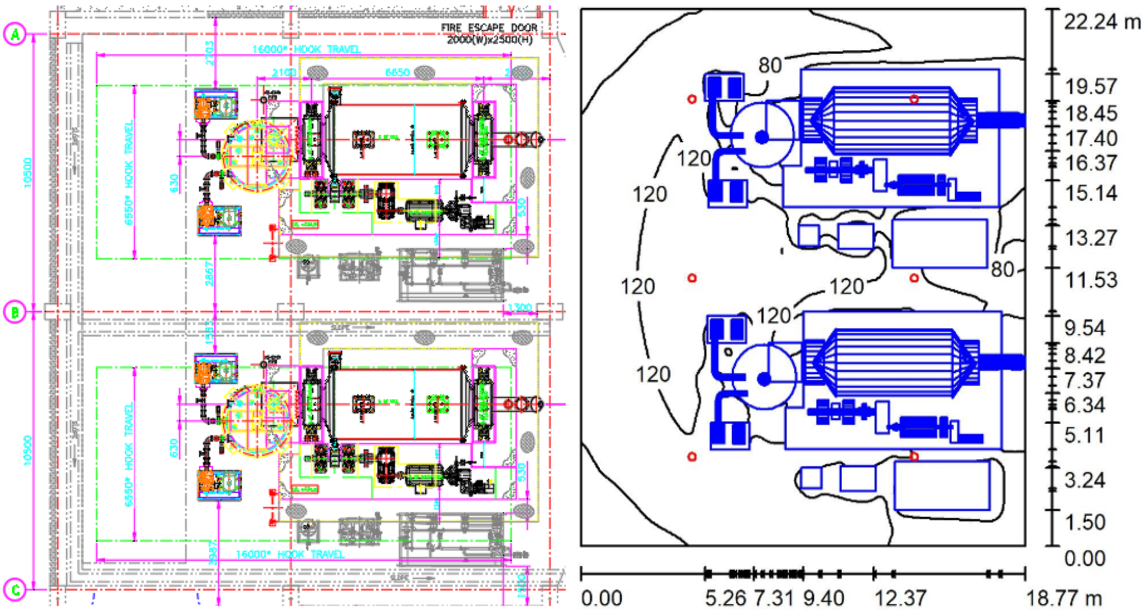
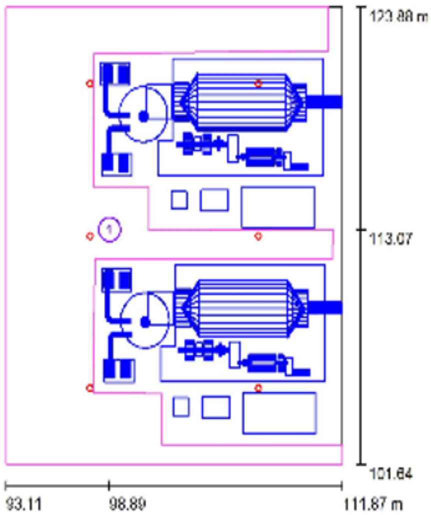



Figure 6.32: Simulated Layout of EL (-)10m Design

EL (-)10M_1 / Calculation surfaces (results overview)

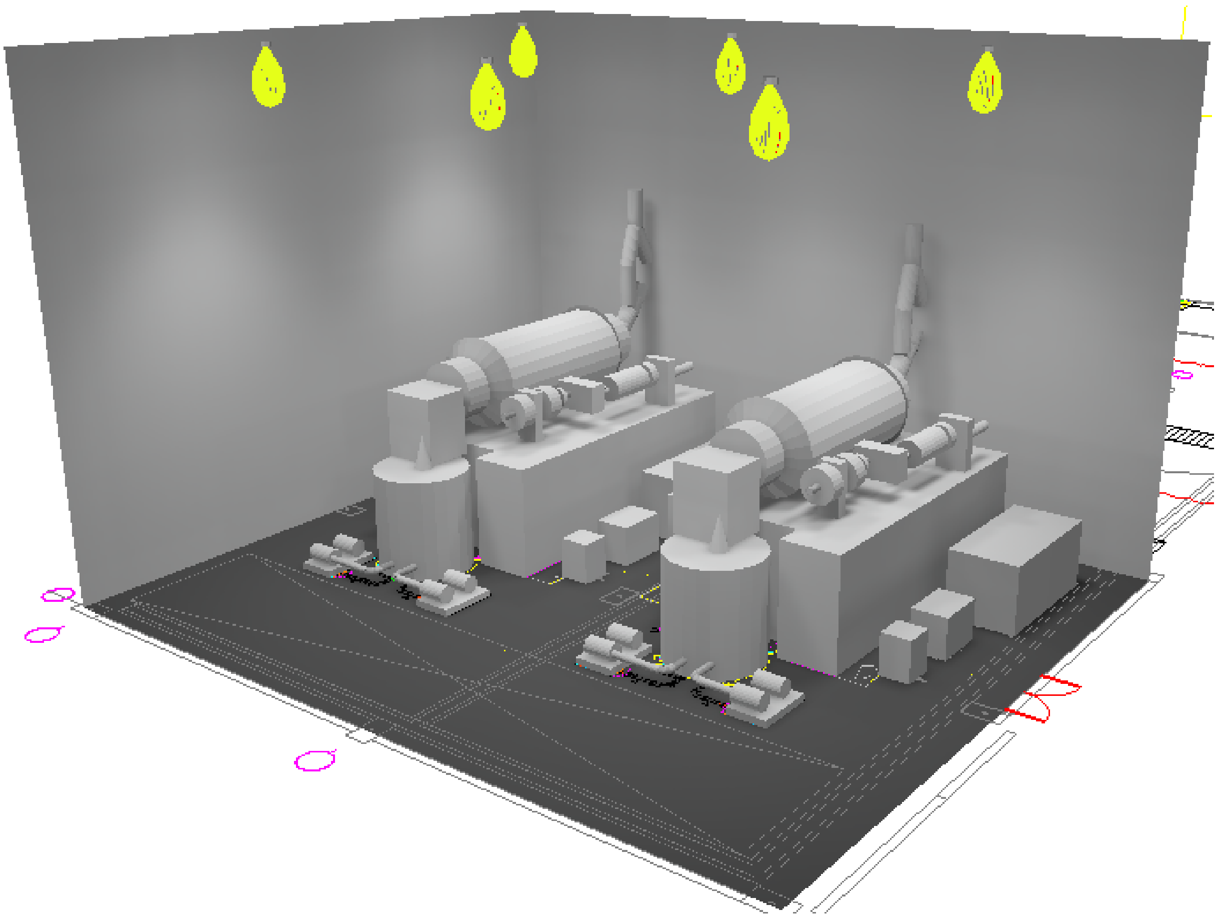



Scale 1 : 254

**Calculation Surface List**

| No. | Designation | Type | Grid | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 | $E_{min}$ / $E_{max}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | Floor Level | horizontal | 32 x 32 | 102 | 51 | 158 | 0.505 | 0.326 |

Figure 6.33: Simulated report of EL (-)10m Design



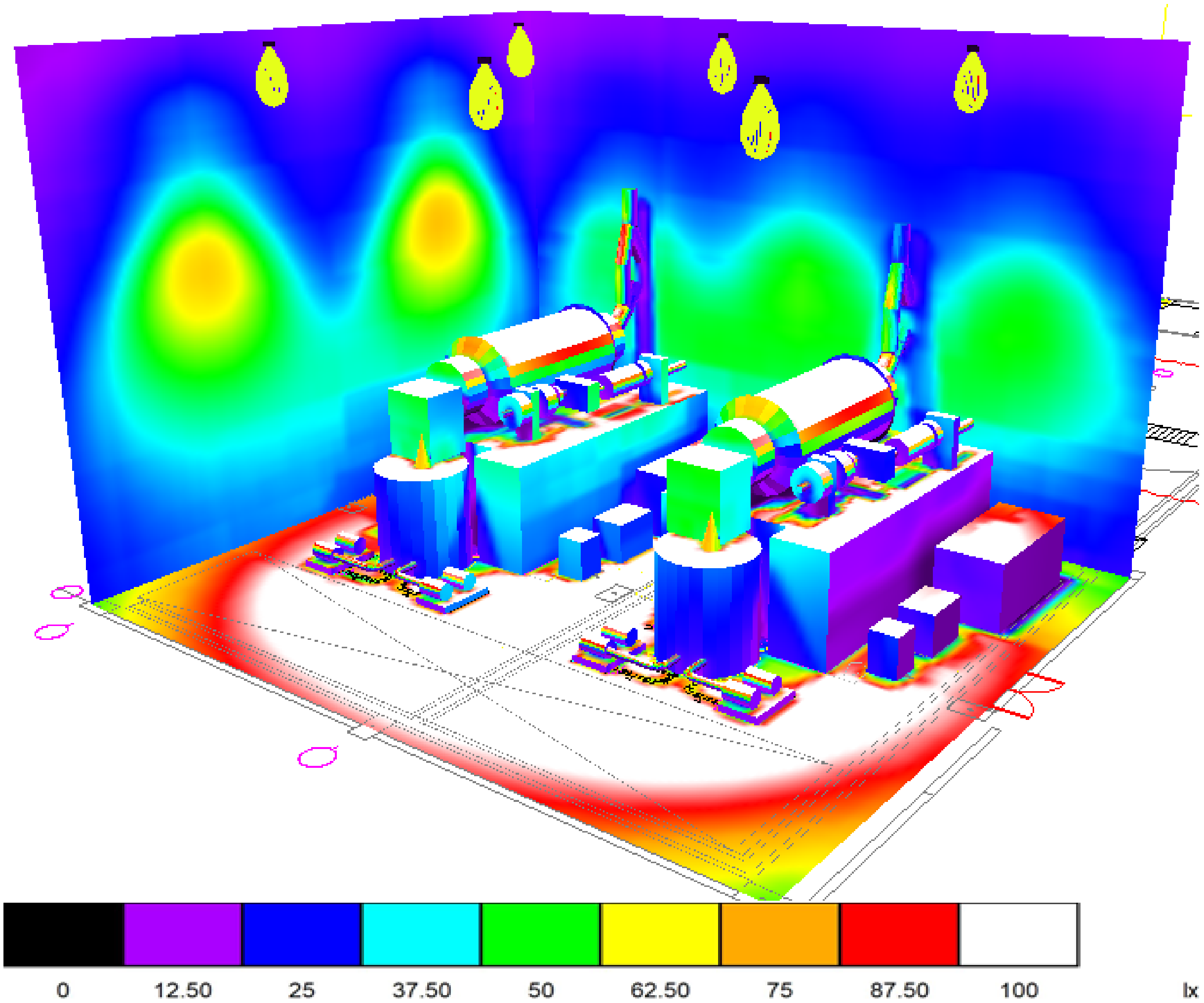



Figure 6.34: Simulated 3d rendering of EL (-)10m Design

**For EL (+)5.2 m Cable Vault:**

**Luminaire used:**

- Linear Weatherproof Integrated LED Batten (as shown in fig.)
- Luminous flux: 4342 Lumen
- Wattage: 40 Watt
- System efficacy: 110 lm/W
- Beam angle: 140 degrees (C0-C180); 100 degrees (C90-C270)
- CCT: 5700K
- CRI: 80
- IP 65 protected

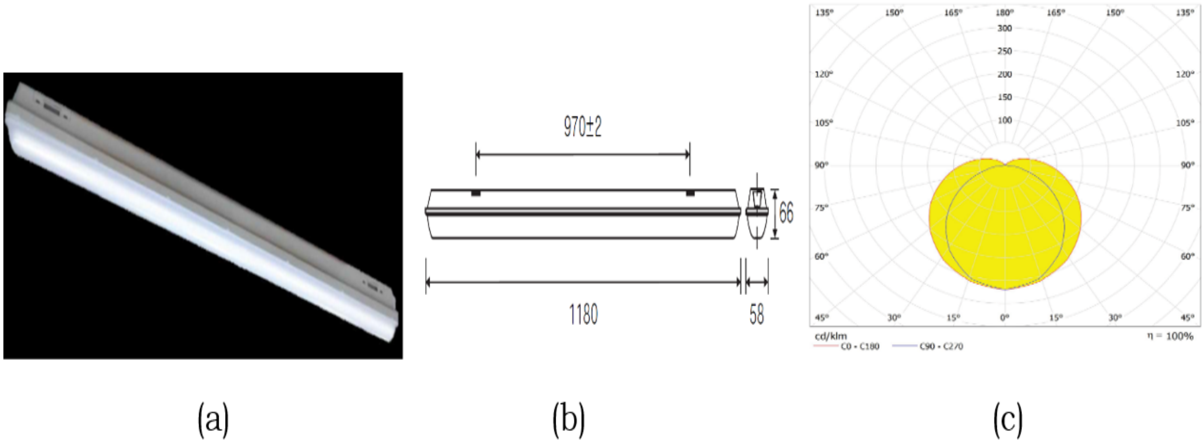



Figure 6.35: (a)Batten image (b)Batten dimension (c) Polar curve

**Deign Aim:**

- Required illuminance level: Average 50 Lux
- Overall uniformity: 0.40

**Design Considerations for the lighting implementation:**

- Number of Luminaires: 12
- Mounting height: 3.5m from respective floor level
- Maintenance factor: 0.6
- Ceiling, Wall and Floor reflectance factor is considered 30%, 30%, 10% respectively

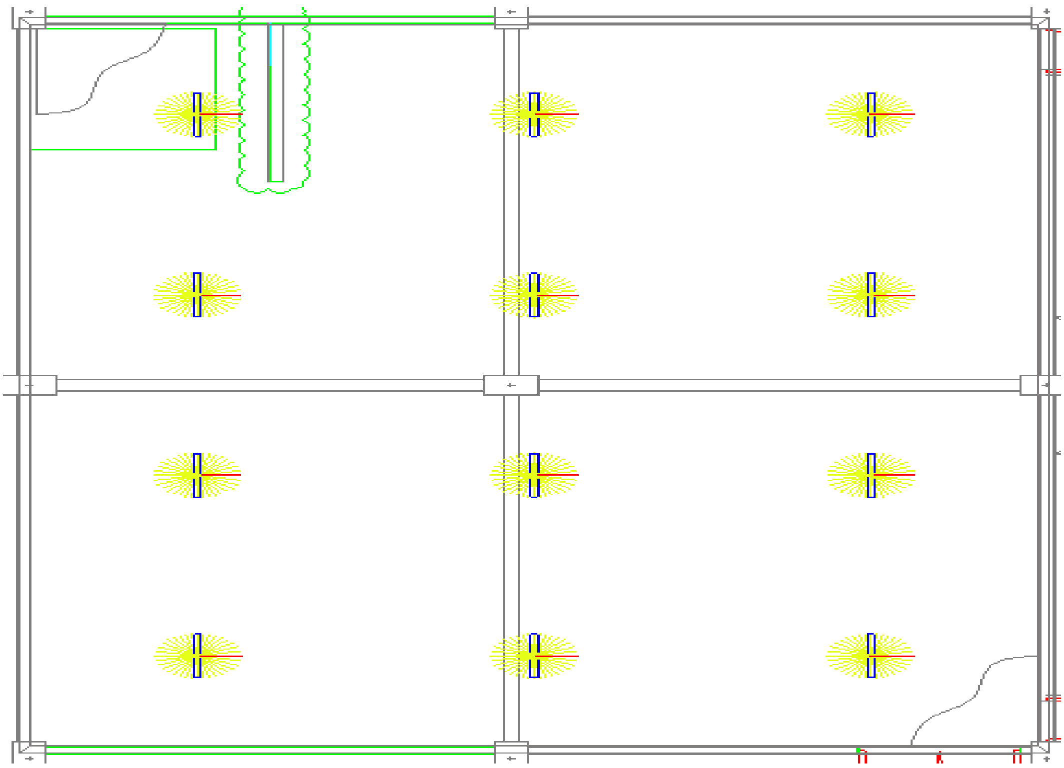
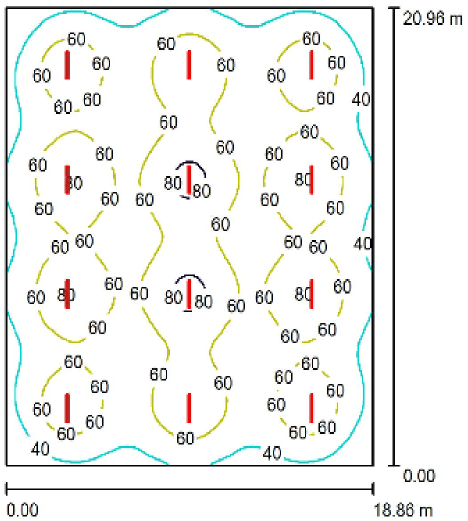


Figure 6.36: Simulated Layout of EL (+)5.2m Cable Vault Design

EL (+)5.2M_CABLE VAULT / **Summary**




Height of Room: 3.500 m, Mounting Height: 3.500 m, Light loss factor: 0.60

Values in Lux, Scale 1:270

| Surface | ρ [%] | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 |
|---|---|---|---|---|---|
| Workplane | / | 57 | 25 | 85 | 0.444 |
| Floor | 10 | 57 | 24 | 85 | 0.427 |
| Ceiling | 30 | 15 | 6.55 | 417 | 0.427 |
| Walls (4) | 30 | 35 | 12 | 50 | / |

Figure 6.37: Simulated report of EL (+)5.2m Cable Vault Design

## For (+) 5.2m Silo Storage:

### Design Aim:

To provide uniform illumination over the side walkway area. To illuminate the walkway areas luminaires are mounted on inverted J-shape pole, which are placed on the railings. There are identical walkways on every level of silo storage so only one typical area has been shown here. The designed illumination level and uniformity must meet the required value. The lighting installations must provide visual comfort and it should not create much glare.

- Required illuminance level: Average 50 Lux
- Overall uniformity: 0.4

### Luminaire used:

- Circular PDC Aluminium housing LED Well glass (as shown in fig.)
- Luminous flux: 3402 Lumen
- Wattage: 30 Watt
- System efficacy: 118 lm/W
- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected

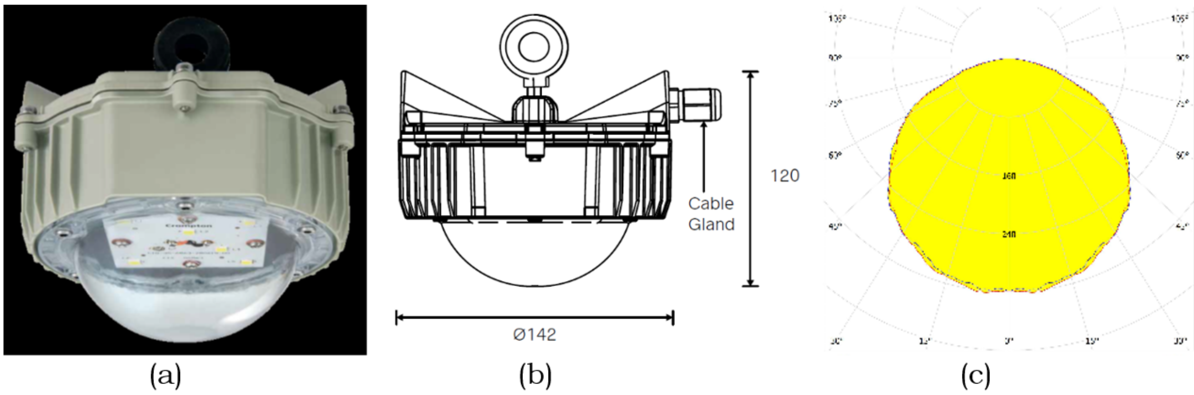



Figure 6.38: (a) Well Glass image (b) Well glass dimension (c) Polar curve

**Design Considerations for the lighting implementation:**

- Number of Luminaires: 2 (each side)
- Mounting height: 3m from floor level
- Maintenance factor: 0.6

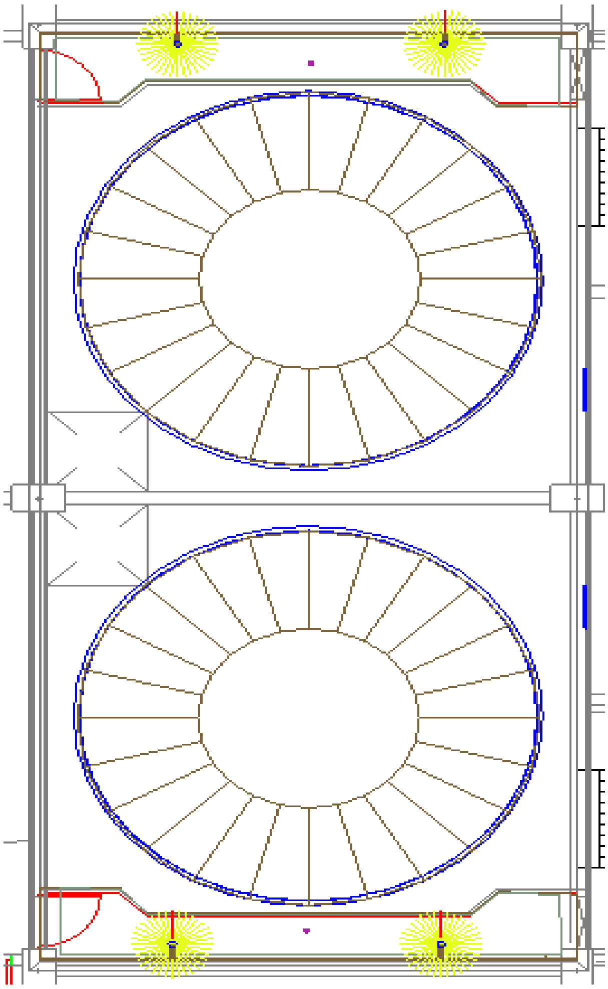
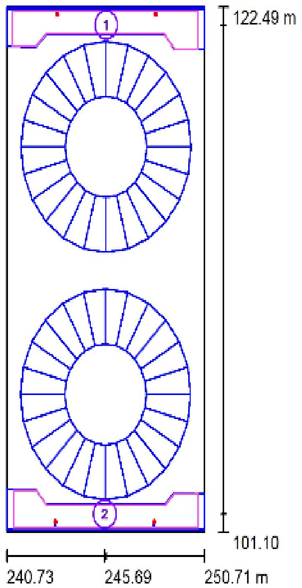


Figure 6.39: Simulated Layout of EL (+)5.2m Silo Storage Design

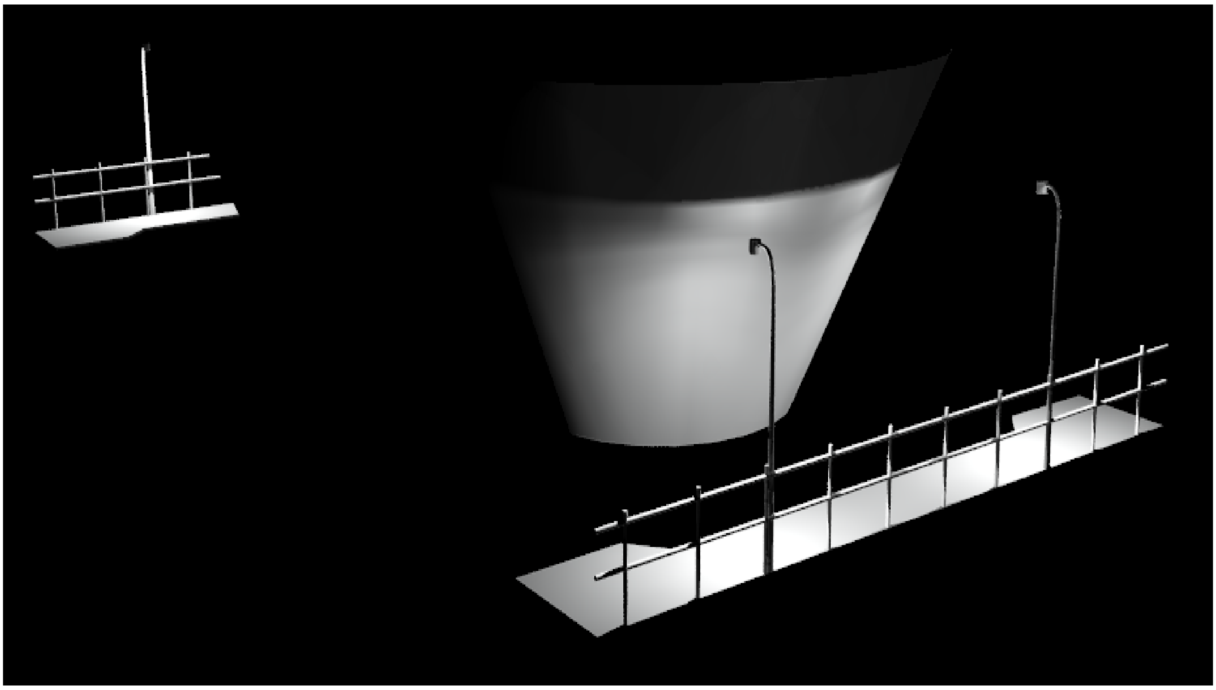



Scale 1 : 244

Calculation Surface List

| No. | Designation | Type | Grid | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 | $E_{min}$ / $E_{max}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | WALKWAY_1 | horizontal | 128 x 32 | 62 | 27 | 87 | 0.436 | 0.308 |
| 2 | WALKWAY_2 | horizontal | 128 x 128 | 63 | 29 | 87 | 0.463 | 0.335 |

Figure 6.40: Simulated Report of EL (+)5.2m Silo Storage Design



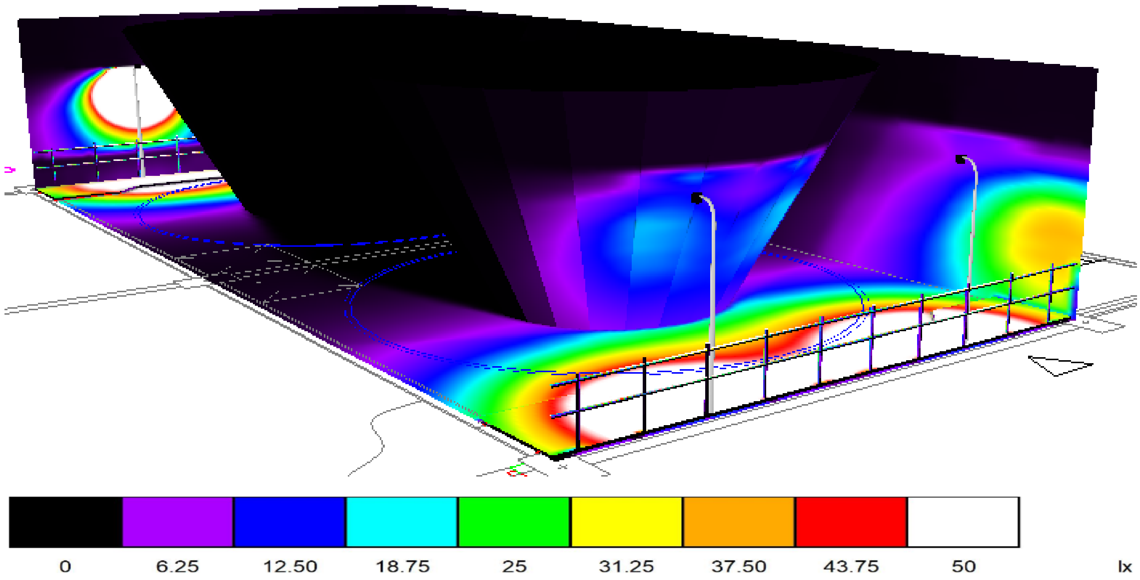



Figure 6.41: Simulated 3d rendering of EL (-)5.2m Design

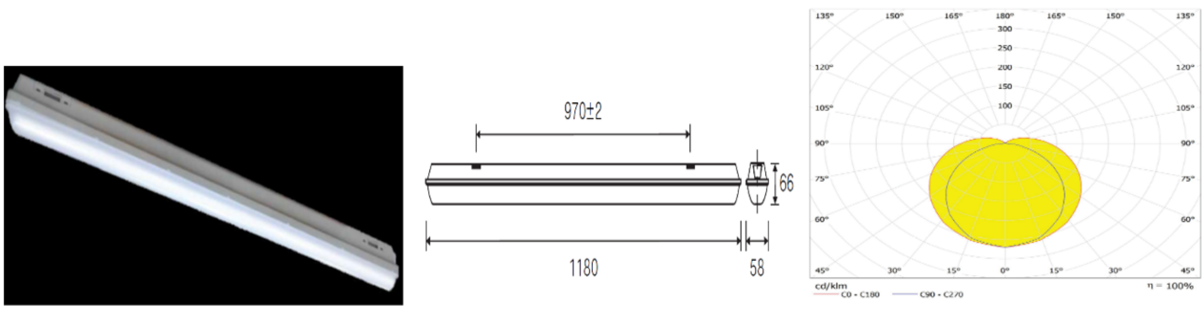
**For EL (+) 9.7m Switchgear room:**

**Design Aim:**
To provide uniform illumination over the aisle area between the panels. The designed illumination level and uniformity must meet the required value. The lighting installations must provide visual comfort and it should not create much glare.

- Required illuminance level: Average 200 Lux
- Overall uniformity: 0.4

**Luminaire used:**

- Linear Weatherproof Integrated LED Batten (as shown in fig.)
- Luminous flux: 4342 Lumen
- Wattage: 40 Watt
- System efficacy: 110 lm/W
- Beam angle: 140 degrees (C0-C180); 100 degrees (C90-C270)
- CCT: 5700K
- CRI: 80
- IP 65 protected




(a) (b) (c)

Figure 6.42: (a)Batten image (b)Batten dimension (c) Polar curve

**Design Considerations for the lighting implementation:**

- Number of Luminaires: 45
- Mounting height: 3.5m from respective floor level
- Maintenance factor: 0.8
- Ceiling, Wall and Floor reflectance factor is considered 50%, 30%, 10% respectively

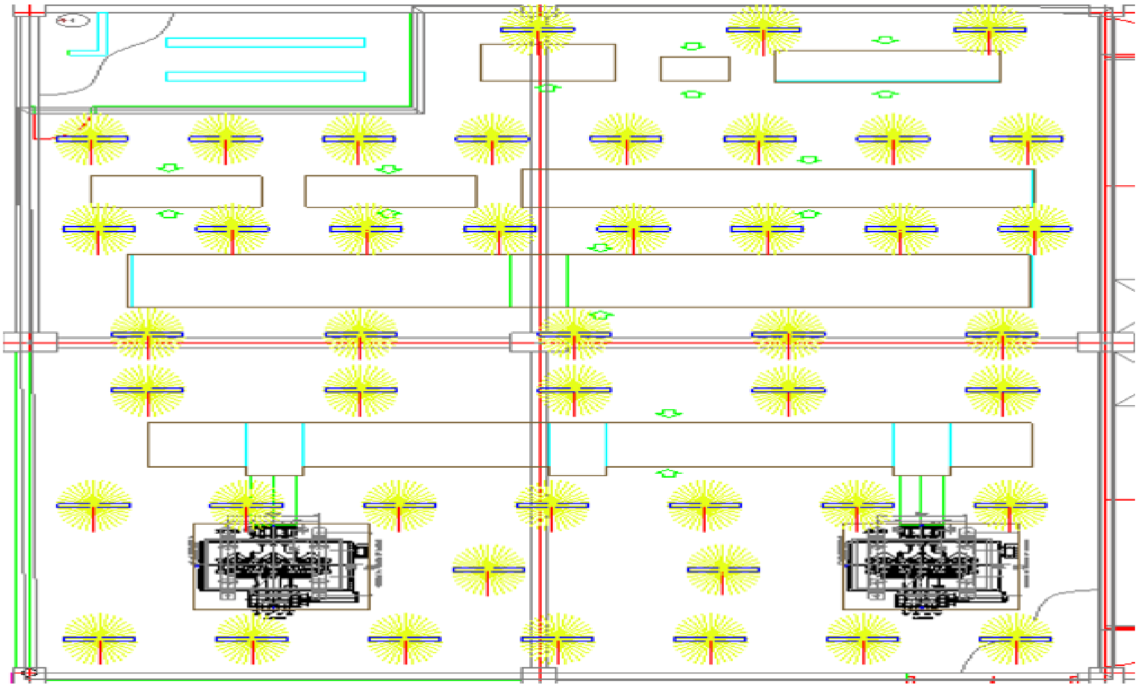
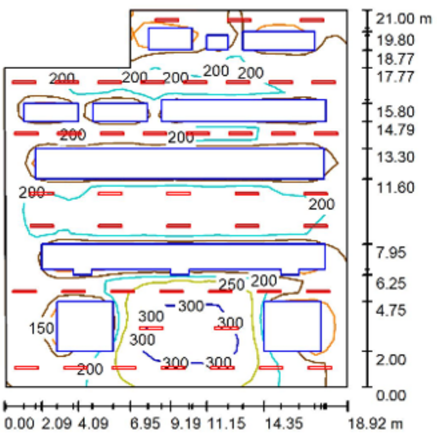


Figure 6.43: Simulated Layout EL (+) 9.7m Switchgear room

EL (+)9.7M _SWITCHGEAR ROOMS / **Summary**




Height of Room: 3.500 m, Mounting Height: 3.500 m, Light loss factor: 0.80

Values in Lux, Scale 1:270

| Surface | ρ [%] | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 |
|---|---|---|---|---|---|
| Workplane | / | 203 | 86 | 325 | 0.424 |
| Floor | 10 | 152 | 8.13 | 328 | 0.053 |
| Ceiling | 50 | 95 | 37 | 634 | 0.394 |
| Walls (6) | 30 | 194 | 40 | 1004 | / |

Figure 6.44: Simulated report EL (+) 9.7m Switchgear room

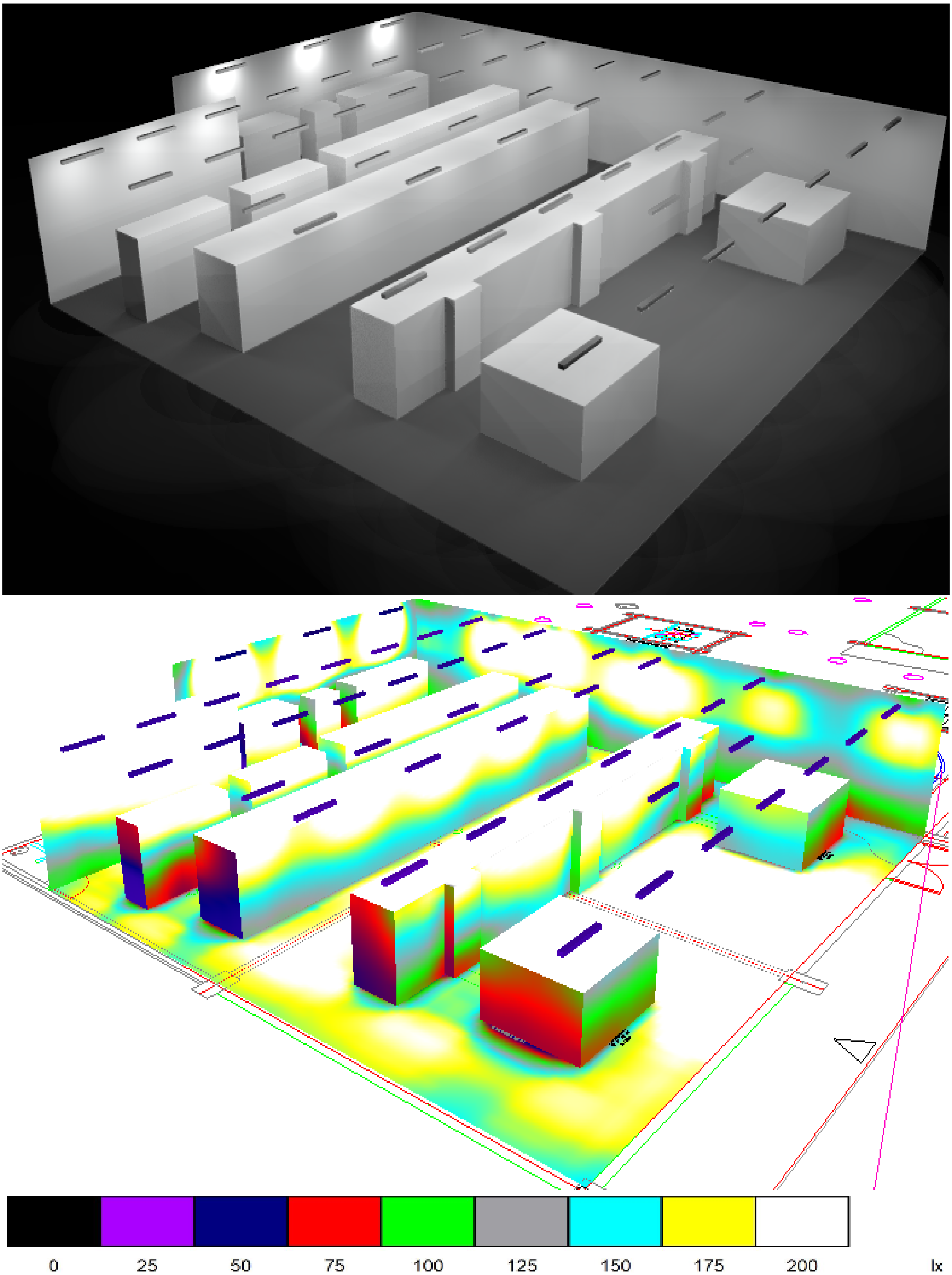



Figure 6.45: Simulated 3d rendering of EL (+) 2.8m Design

## 6.4 Turbine Hall:

The Turbine Hall is that part of the Thermal Power Plant where a number of vital components are kept which are required to generate electricity. Among those components Turbine is one of the most important components which extracts thermal energy from steam and converts it into mechanical work on a rotating magnetic shaft.

**Design Aim:**

To provide uniform illumination to the overall area. The designed illumination level and uniformity must meet the required value. The lighting installations must provide visual comfort and it should not create much glare.

- Required illuminance level: Average 200 Lux
- Overall uniformity: 0.4

**Layout and description of Turbine Hall:**

Considering one of the turbine halls for better understanding of lighting design, analysing software DIALux has been used for describing and achieving the recommended values as per NTPC standard. Typical plan layout of the Turbine Hall is shown in Fig. below

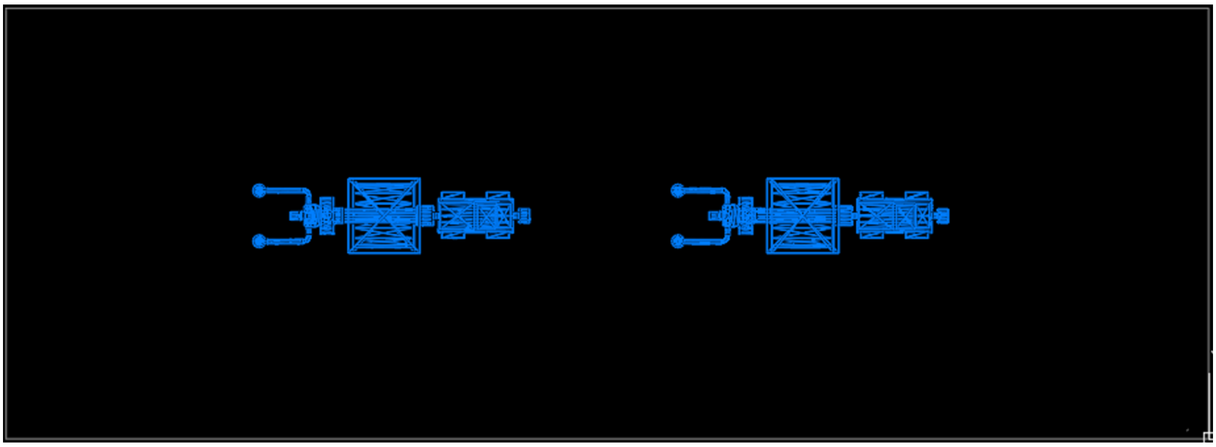
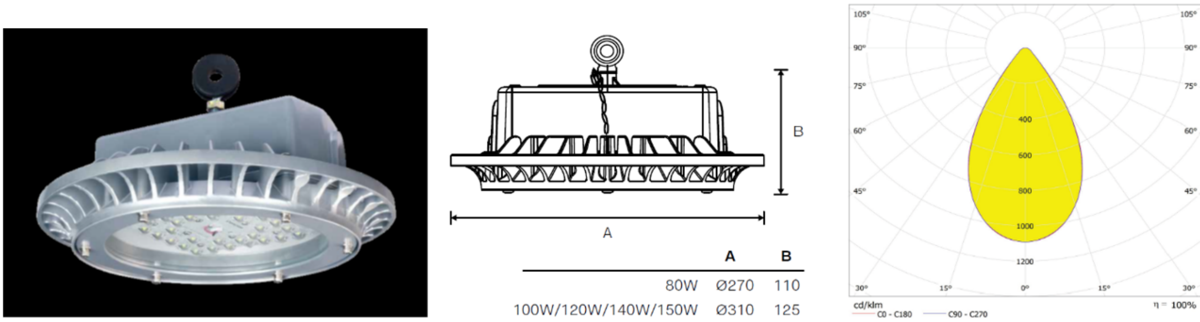


Figure 6.46: Plan Layout of Turbine Hall

**Luminaire used:**

- Circular PDC Aluminium housing LED Highbay (as shown in fig.)
- Luminous flux: 21000 Lumen
- Wattage: 150 Watt
- System efficacy: 140 lm/W
- Beam angle: 60 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected




(a) (b) (c)

Figure 6.47: (a) Highbay image (b)Highbay dimension (c) Polar curve

**Design Considerations for the lighting implementation:**

- Number of Luminaires: 70
- Mounting height: 15m from floor level
- Maintenance factor: 0.7
- Ceiling, Wall and Floor reflectance factor is considered 50%, 30%, 20% respectively.

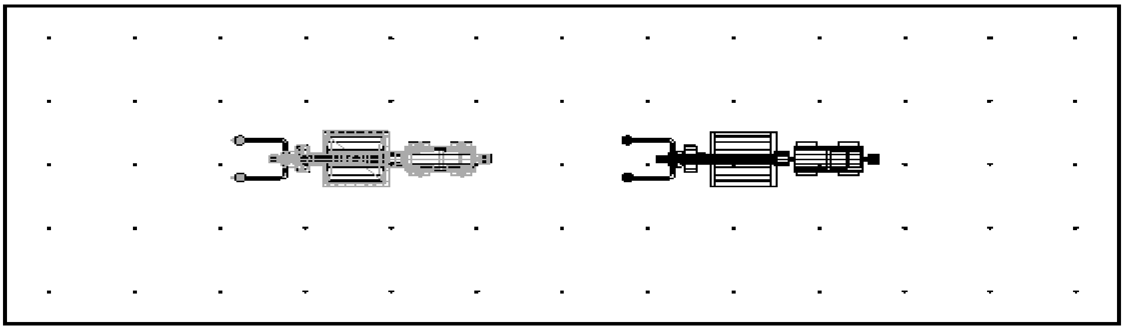
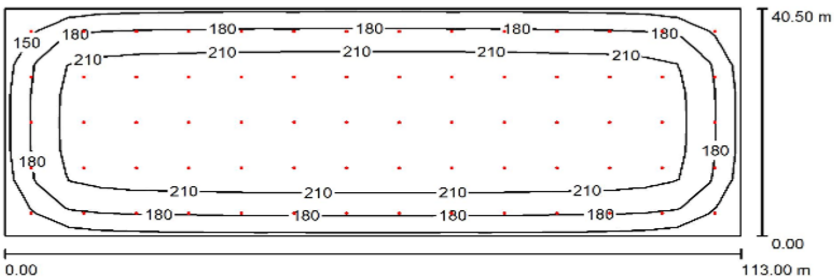


Figure 6.48: Simulated Layout of Turbine Hall

**TURBINE HALL / Summary**




Height of Room: 15.000 m, Mounting Height: 15.000 m, Light loss factor: 0.70 — Values in Lux, Scale 1:808

| Surface | ρ [%] | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 |
|---|---|---|---|---|---|
| Workplane | / | 206 | 121 | 232 | 0.586 |
| Floor | 20 | 204 | 83 | 235 | 0.407 |
| Ceiling | 50 | 33 | 21 | 38 | 0.657 |
| Walls (4) | 30 | 64 | 29 | 95 | / |

Figure 6.49: Simulated Report of Turbine Hall

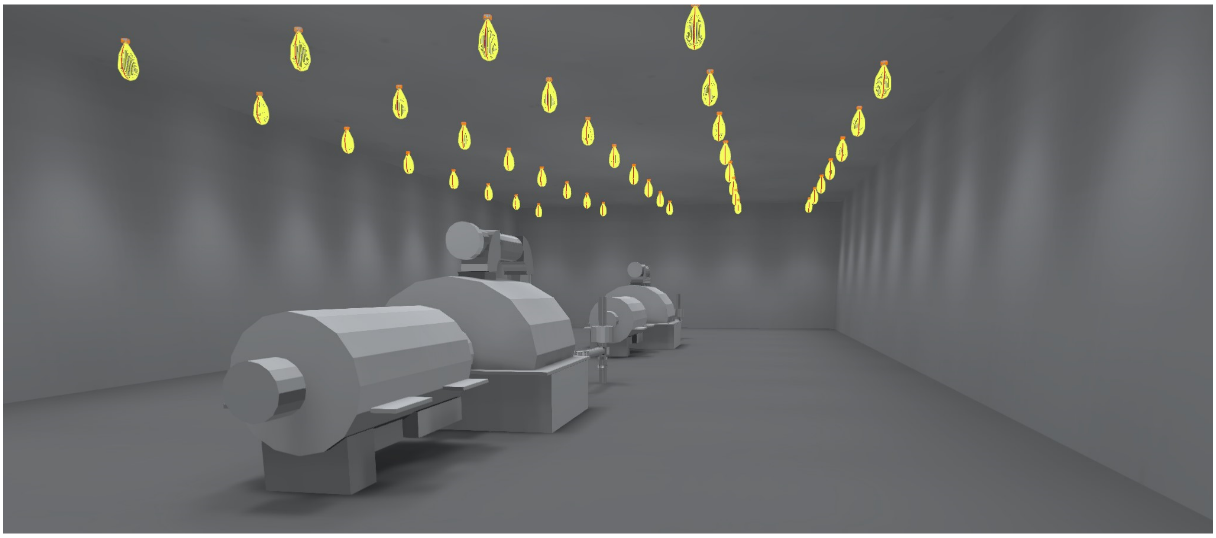


Figure 6.50: Simulated 3d rendering of Turbine Hall

## 6.5 Pump House:

Pump House is an integral part of a thermal power plant which circulate necessary cooling water to the condenser to condensate. Raw sea/river water is used for this purpose. Inside the condenser phase conversion of saturated steam from LP turbine exit takes place. During this phase conversion lot of latent heat is released. This latent heat is absorbed by the cooling water supplied by CW pumps. After absorbing heat, cooling water is passed through Natural Draft Cooling Tower (NDCT) wherein it releases the heat naturally (due to shape of cooling tower). After cooling this cooling water is again used in the cycle by pumps.

### Layout and description of Pump House:

Considering one of the Pump houses for better understanding of lighting design, analysing software DIALux has been used for describing and achieving the recommended values as per NTPC standard. Typical plan layout of the Pump house is shown in Fig. below

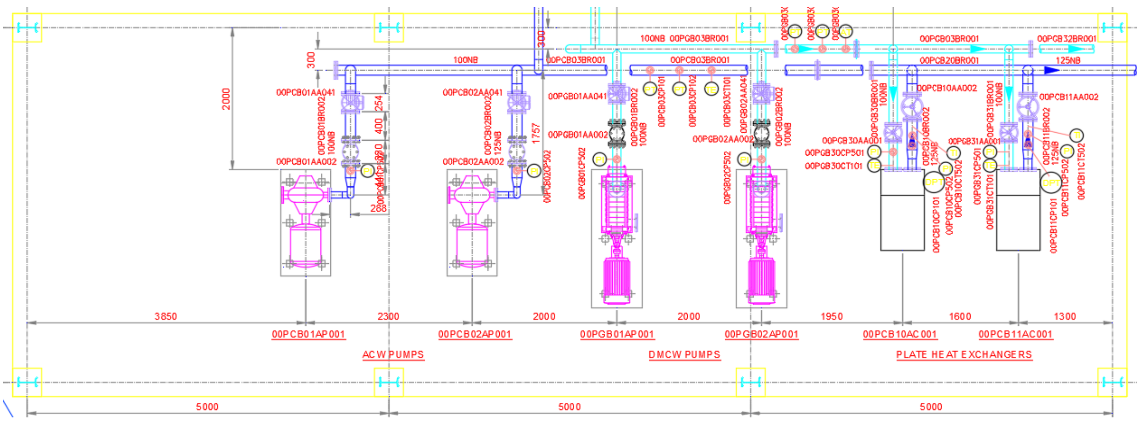



Figure 6.51: Plan Layout of Pump House

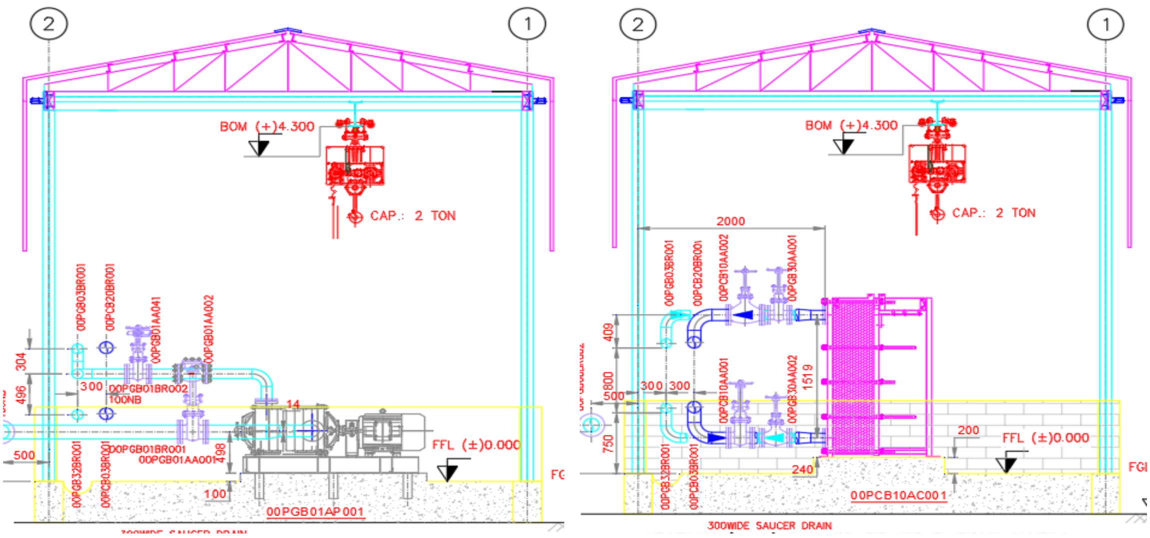



Figure 6.52: Elevation details of Pump House

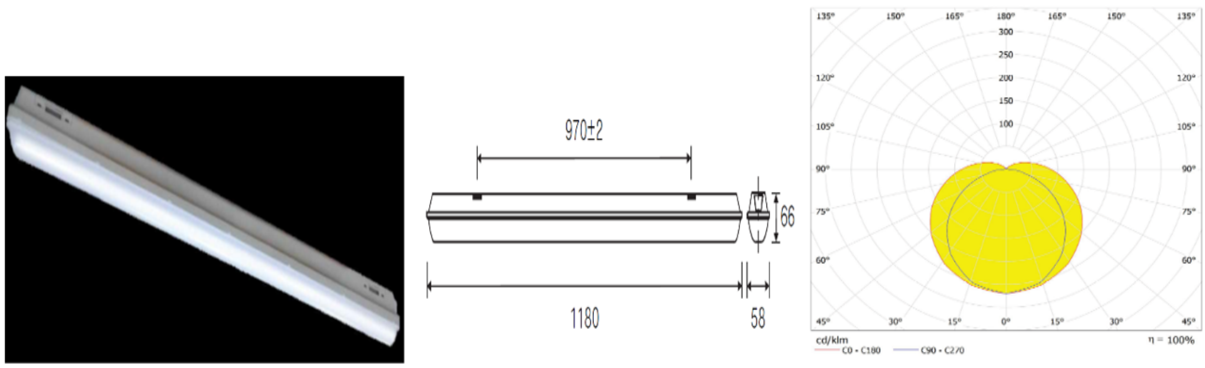
**Design Aim:**

To provide uniform illumination to the overall area. The designed illumination level and uniformity must meet the required value. The lighting installations must provide visual comfort and it should not create much glare.

- Required illuminance level: Average 150 Lux
- Overall uniformity: 0.4

**Luminaire used:**

- Linear Weatherproof Integrated LED Batten (as shown in fig.)
- Luminous flux: 4342 Lumen
- Wattage: 40 Watt
- System efficacy: 110 lm/W
- Beam angle: 140 degrees (C0-C180); 100 degrees (C90-C270)
- CCT: 5700K
- CRI: 80
- IP 65 protected




(a) (b) (c)

Figure 6.53: (a)Batten image (b)Batten dimension (c) Polar curve

**Design Considerations for the lighting implementation:**

- Number of Luminaires: 12
- Mounting height: 4.5m from respective floor level
- Maintenance factor: 0.7
- Ceiling, Wall and Floor reflectance factor is considered 50%, 30%, 10% respectively

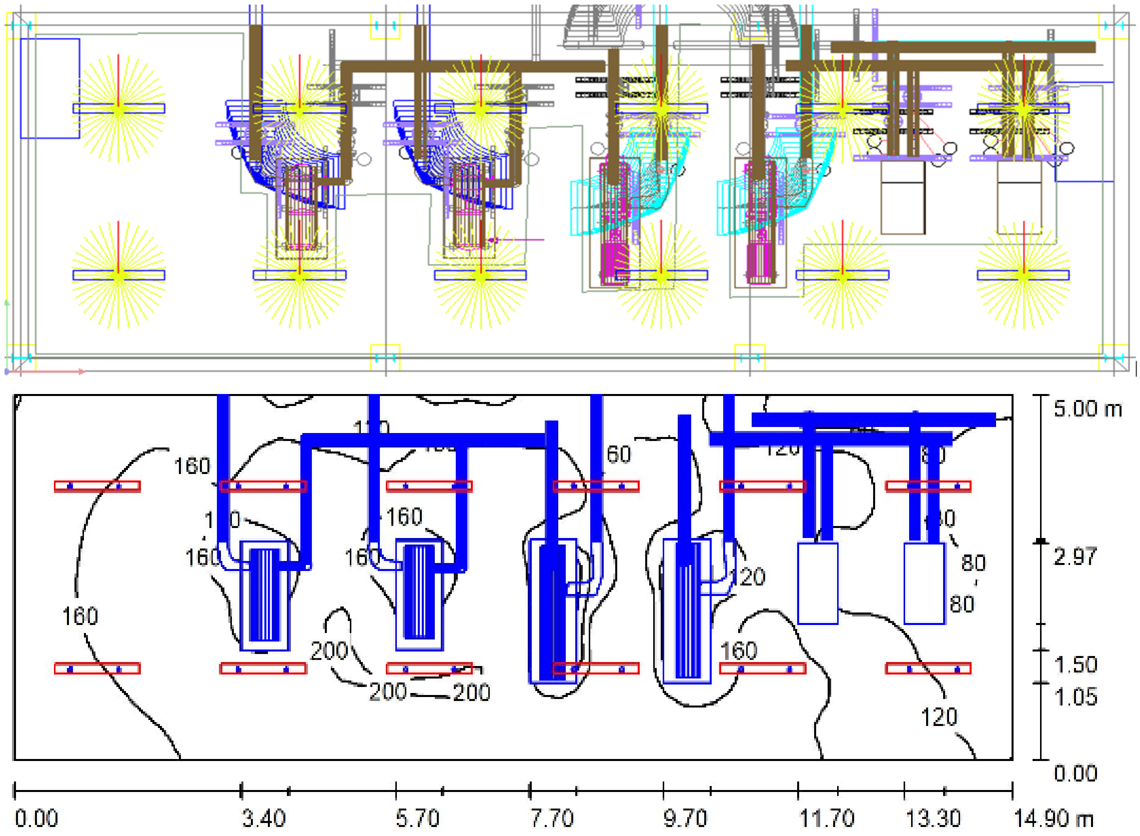
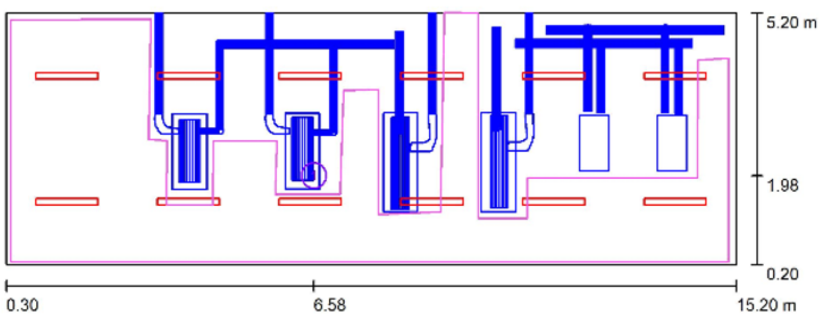



Figure 6.54: Simulated layout of the Pump House

**PUMP HOUSE / Calculation surfaces (results overview)**




Scale 1 : 107

**Calculation Surface List**

| No. | Designation | Type | Grid | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 | $E_{min}$ / $E_{max}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | Floor Level | horizontal | 64 x 32 | 165 | 70 | 208 | 0.425 | 0.337 |

Figure 6.55: Simulated report of Pump house

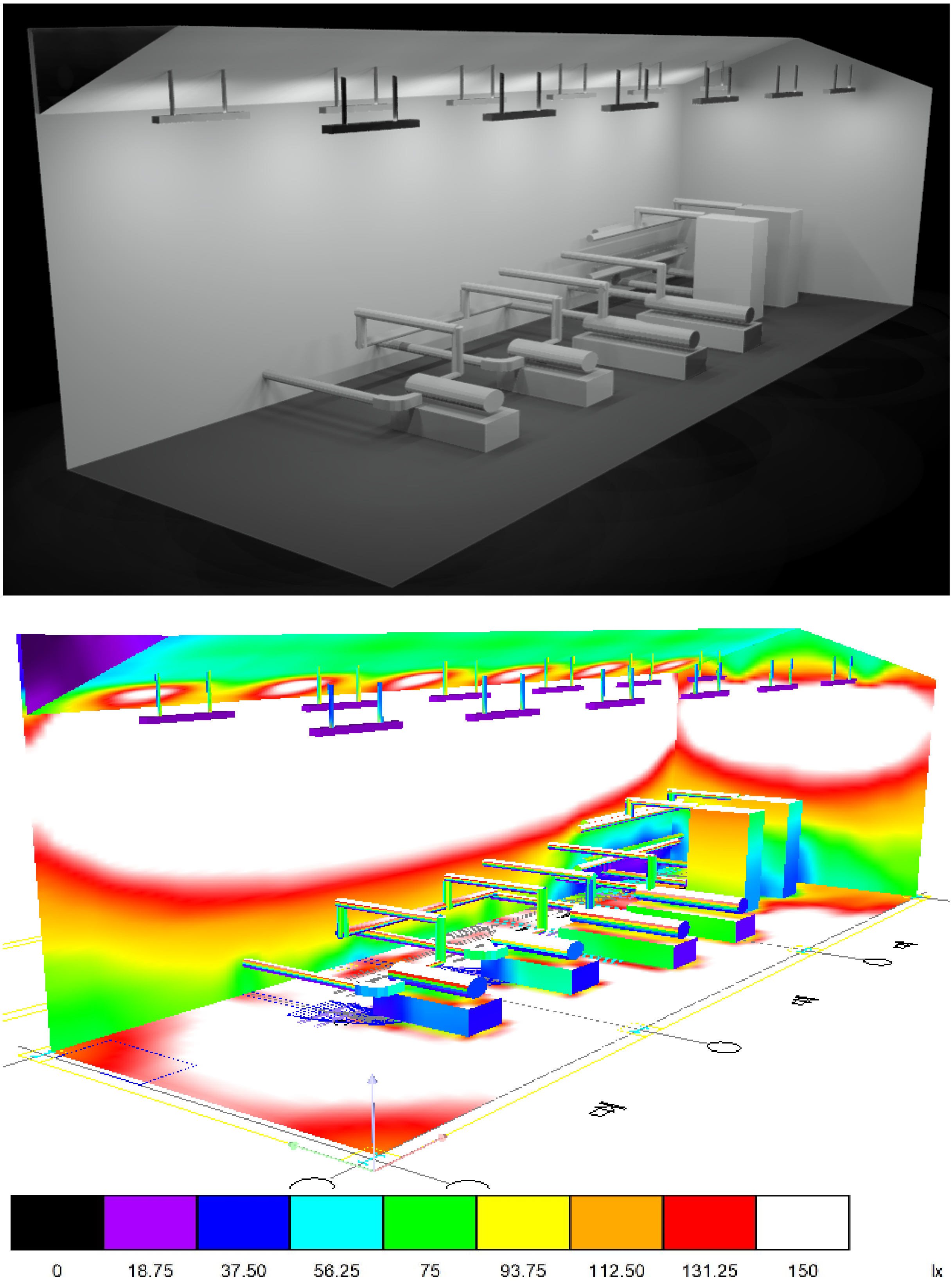



Figure 6.56: Simulated 3d rendering of Pump house

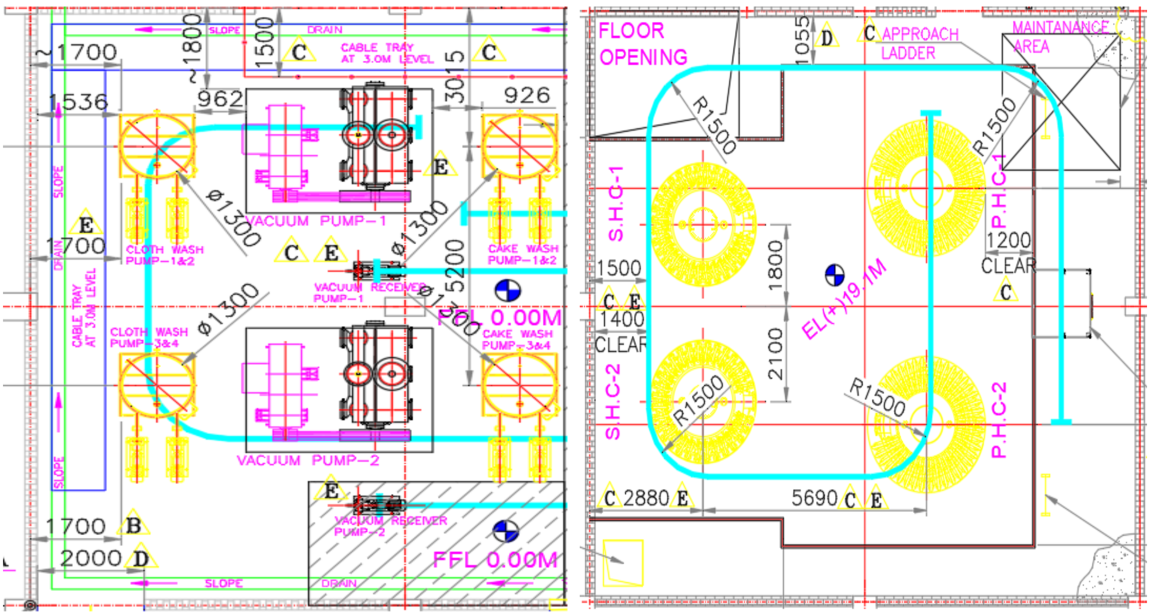
## 6.6 Gypsum Dewatering Building:

Gypsum Dewatering and storage buildings are important structures for Flue Gas Desulfurization (FGD) process. The resources like coal, petcock, limestone contain a significant amount of sulphur into them. In many large-scale power plants (where the resource is Coal, petcock, limestone etc), the problems arise from boiler or furnace where large volumes of So2 accumulation not only deteriorates air quality of environment but also highly corrosive for handling equipment like stacks, fans etc.

In order to extract So2 from flue gas, the mechanism of extraction employed is known as FGD or Flue Gas Desulphurization. In Flue Gas Desulphurization, the chemical Techniques are used to exclude sulphur di-oxide (So2) in exhausted flue gasses from the Furnace/boiler. Some of the Chemical techniques used for FGD are 'Wet Scrubbing', 'Dry Scrubbing', 'SNOX FGD' etc. The output from flue gas desulphurization is synthetic gypsum. For cement manufacturing, this FGD storage product or synthetic gypsum is supplied in crushed form for further fine grinding with cement clinker and has many other commercial applications in cement industry, bricks manufacturing etc.

**Layout and description of Gypsum Dewatering Building:**

Considering one of the Gypsum Dewatering Building for better understanding of lighting design, analysing software DIALux has been used for describing and achieving the recommended values as per NTPC standard. Typical plan layout of the Gypsum Dewatering Building is shown in Fig. below




(a) (b)

Figure 6.57: Plan Layout (a) Vacuum Pump Area; (b) EL (+) 17.6m

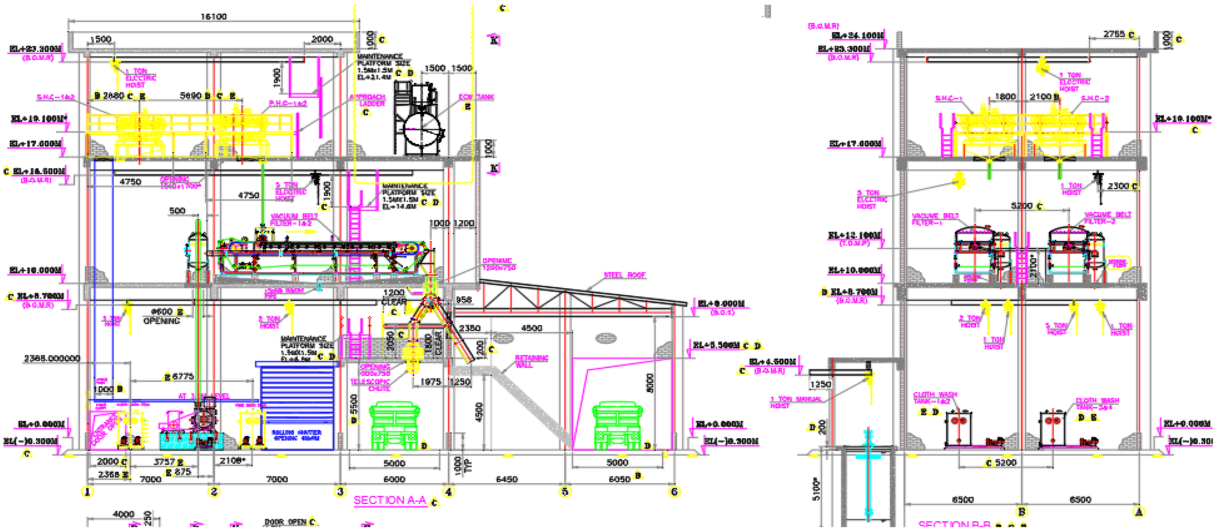


Figure 6.58: Elevation Details of Gypsum Dewatering building

**Design Aim:**

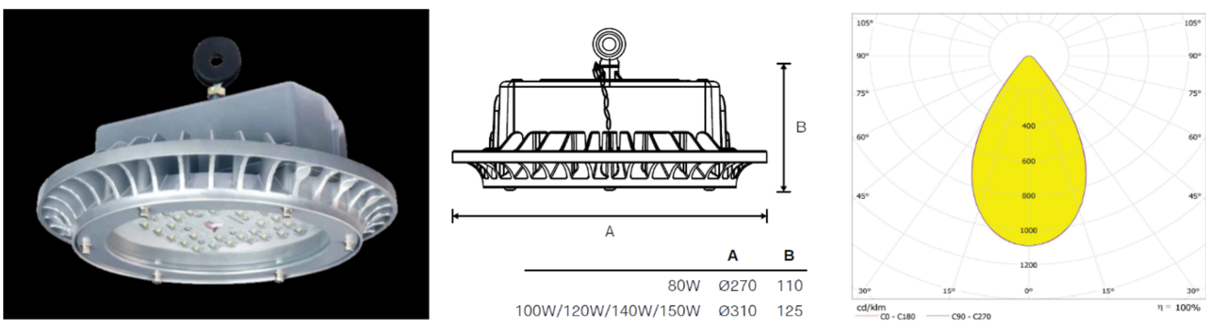
To provide uniform illumination to the overall area. The designed illumination level and uniformity must meet the required value. The lighting installations must provide visual comfort and it should not create much glare.

- Required illuminance level: Average 150 Lux
- Overall uniformity: 0.4

**For Vacuum Pump Area:**

**Luminaire used:**

- Circular PDC Aluminium housing LED High Bay Luminaire (as shown in fig.)
- Luminous flux: 13688 Lumen
- Wattage: 100 Watt
- System efficacy: 136 lm/W
- Beam angle: 60 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected




(a) (b) (c)

Figure 6.59: (a) Highbay image (b) Highbay dimension (c) Polar curve

**Design Considerations for the lighting implementation:**

- Number of Luminaires: 4
- Mounting height: 9m from floor level
- Maintenance factor: 0.6
- Ceiling, Wall and Floor reflectance factor is considered 30%, 30%, 10% respectively

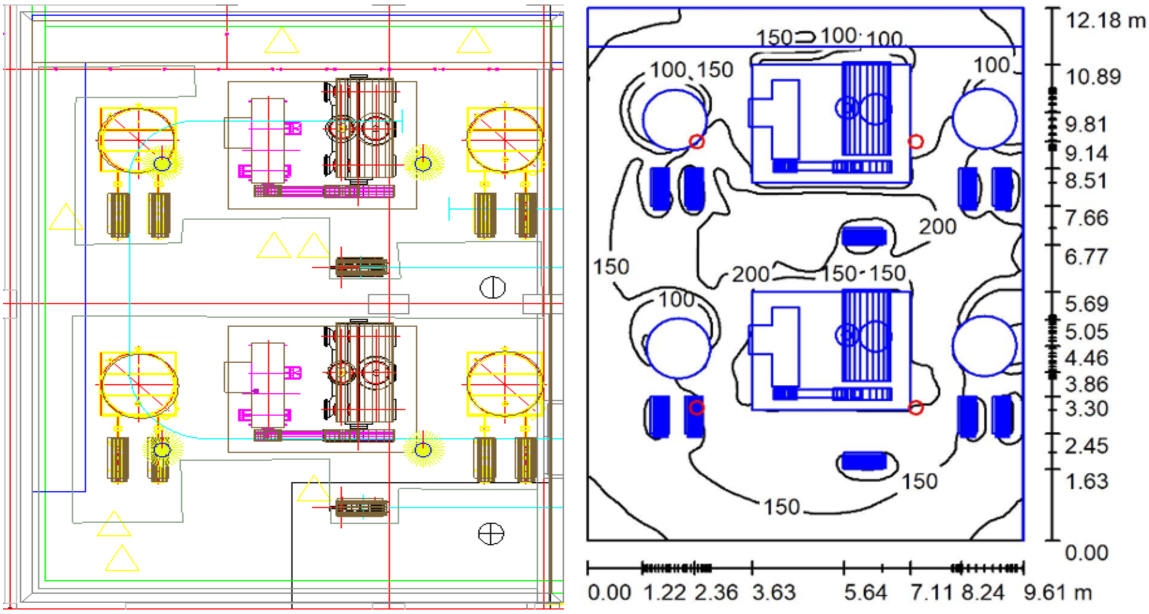
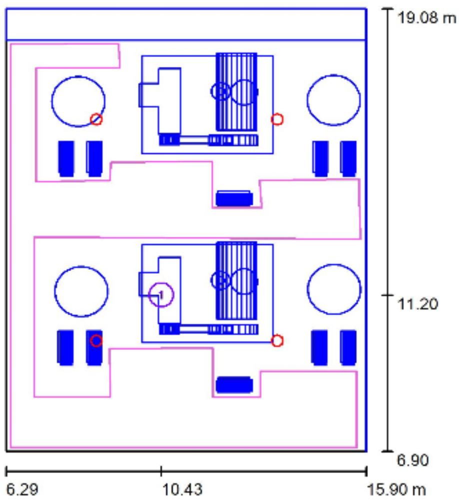



Figure 6.60: Simulated layout of Vacuum pump area

EL 0M_VACCUM PUMP AREA / **Calculation surfaces (results overview)**




Scale 1 : 139

**Calculation Surface List**

| No. | Designation | Type | Grid | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 | $E_{min}$ / $E_{max}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | Floor Level | horizontal | 16 x 16 | 158 | 94 | 246 | 0.592 | 0.381 |

Figure 6.61: Simulated report of Vacuum pump area

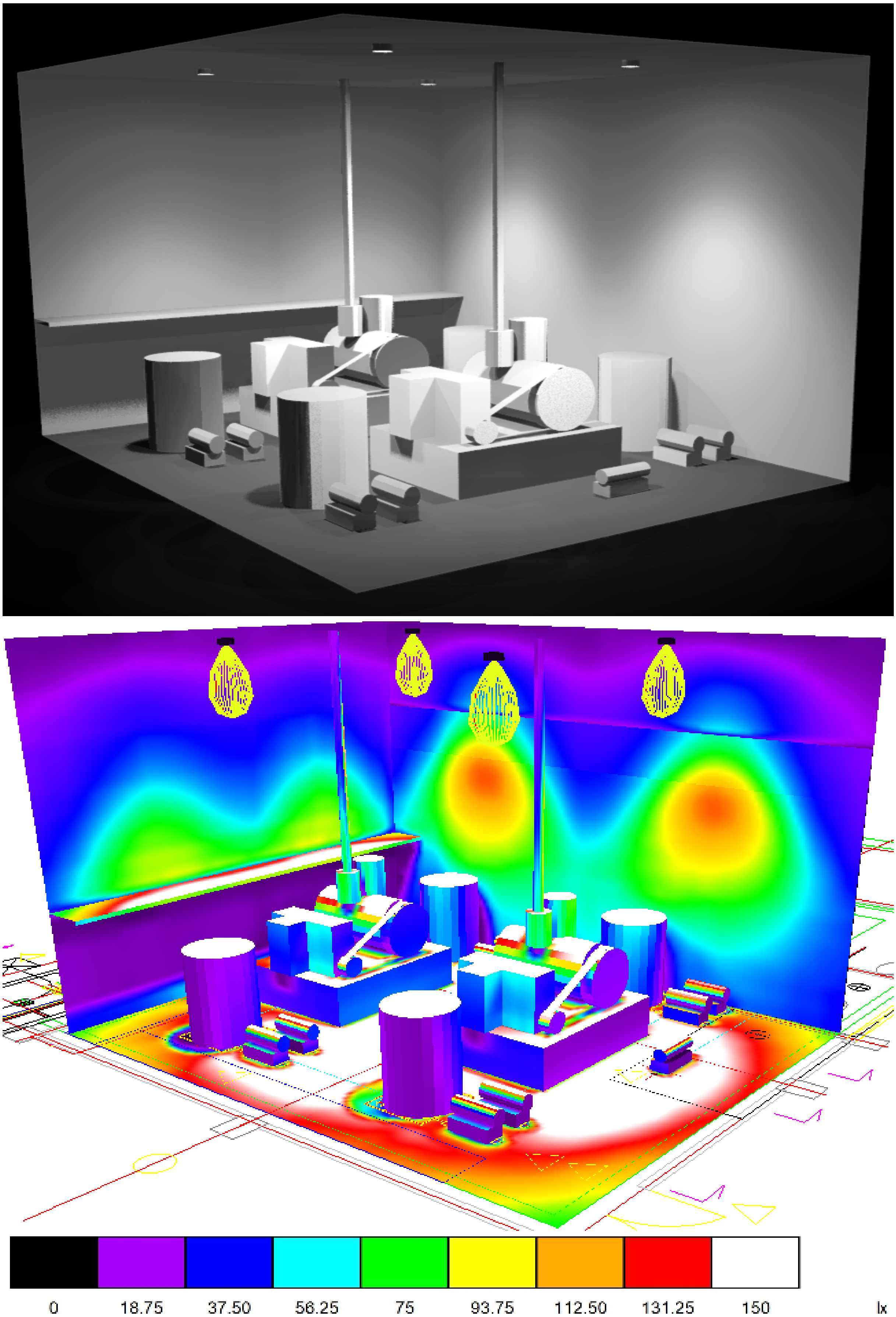
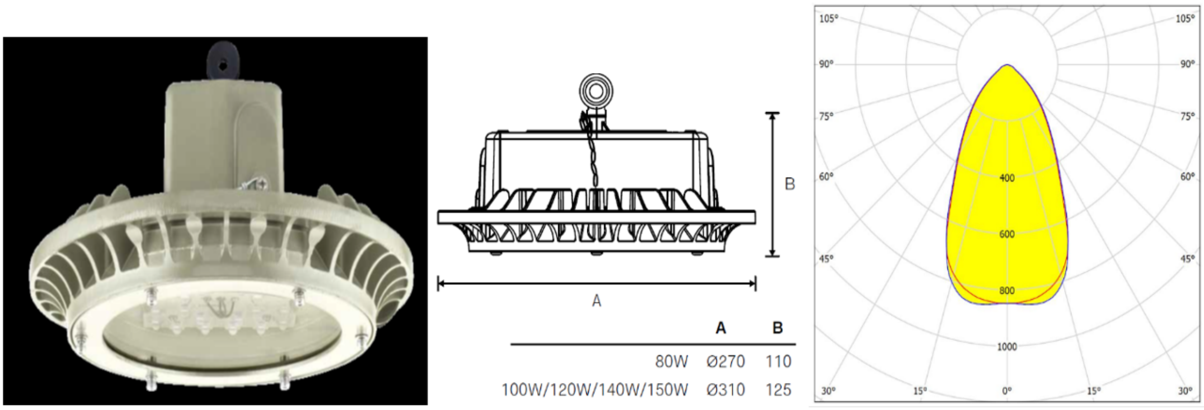



Figure 6.62: Simulated 3d rendering of Vaccum Pump Area

**For El (+)17.6m:**

**Luminaire used:**

- Circular PDC Aluminium housing LED High Bay Luminaire (as shown in fig.)
- Luminous flux: 8800 Lumen
- Wattage: 80 Watt
- System efficacy: 110 lm/W
- Beam angle: 60 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected



(a) (b) (c)

Figure 6.63: (a) Highbay image (b) Highbay dimension (c) Polar curve

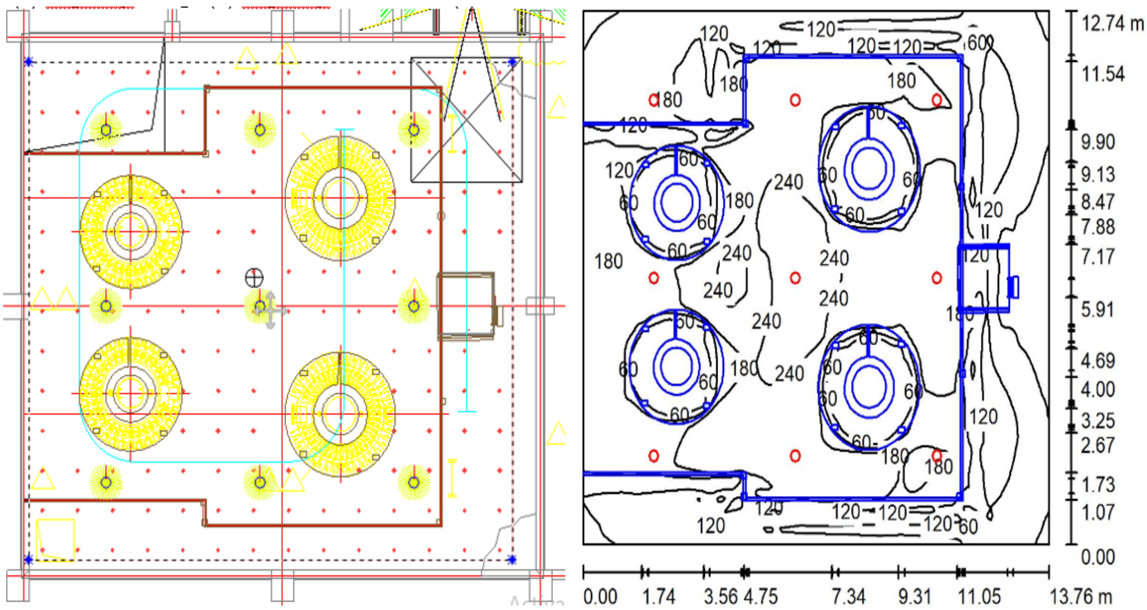
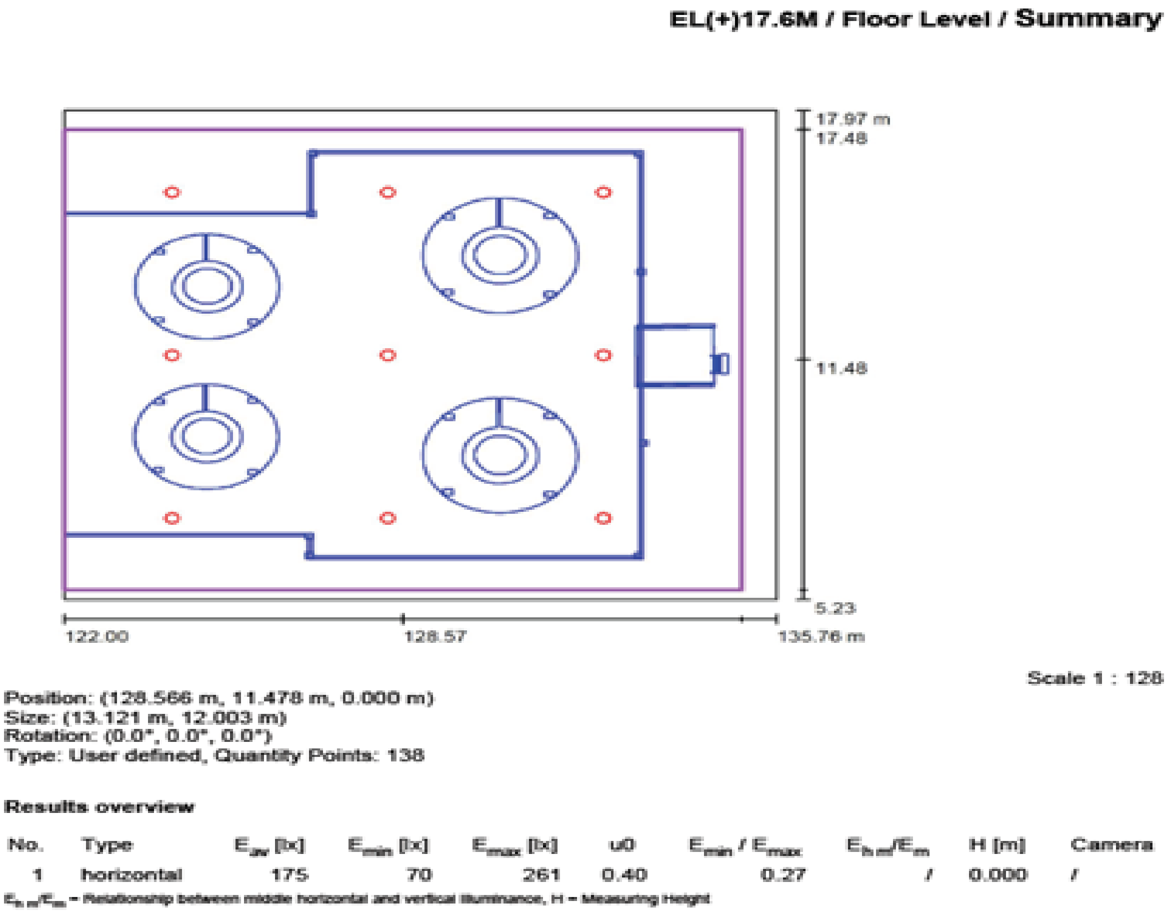



Figure 6.64: Simulated layout of (+) EL 17.6m


EL(+)17.6M / Floor Level / Summary



Scale 1 : 128

Position: (128.566 m, 11.478 m, 0.000 m)
Size: (13.121 m, 12.003 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: User defined, Quantity Points: 138

**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 | horizontal | 175 | 70 | 261 | 0.40 | 0.27 | / | 0.000 | / |

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

Figure 6.65: Simulated report of (+) EL 17.6m

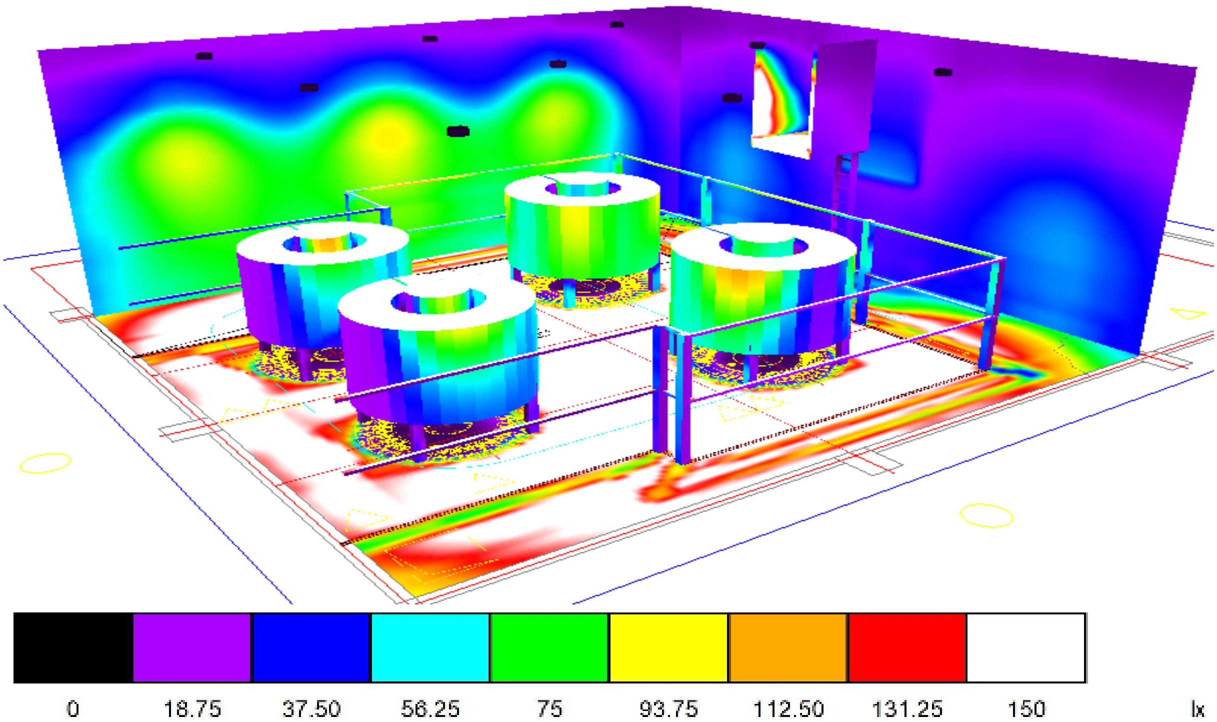



Figure 6.66: Simulated 3d rendering of (+) EL 17.6m

## 6.7 Gypsum Storage Shed:

Being an important component Gypsum for Flue Gas Desulphurization (FGD), Storage of this gypsum is also necessary in the power plant. Typically, 5 to 10 days of gypsum storage is necessary as per the capacity of the Thermal power plant.

**Layout and description of Gypsum Dewatering Building:**

Considering one of the Gypsum Storage Shed for better understanding of lighting design, analysing software DIALux has been used for describing and achieving the recommended values as per NTPC standard. Typical plan layout of the Gypsum Storage Shed is shown in Fig. below.

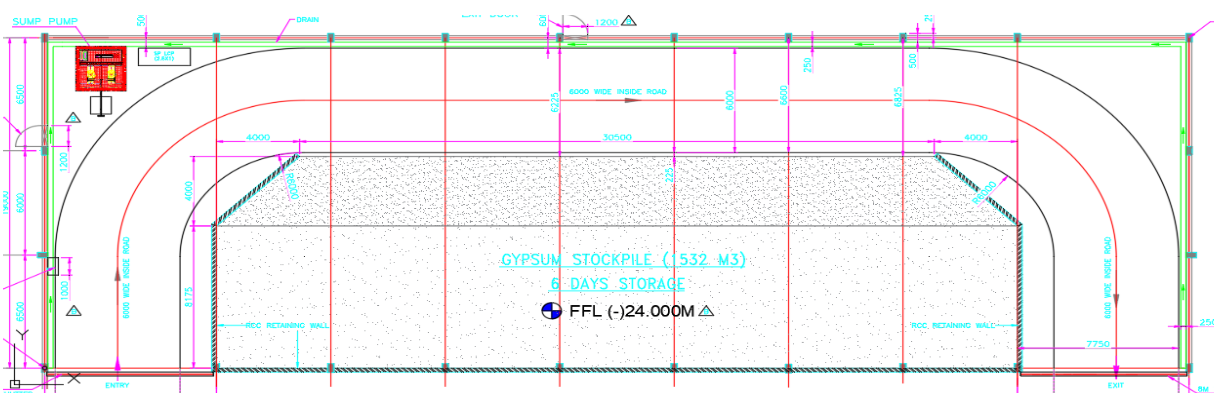



Figure 6.67: Plant layout of Gypsum Storage Shed

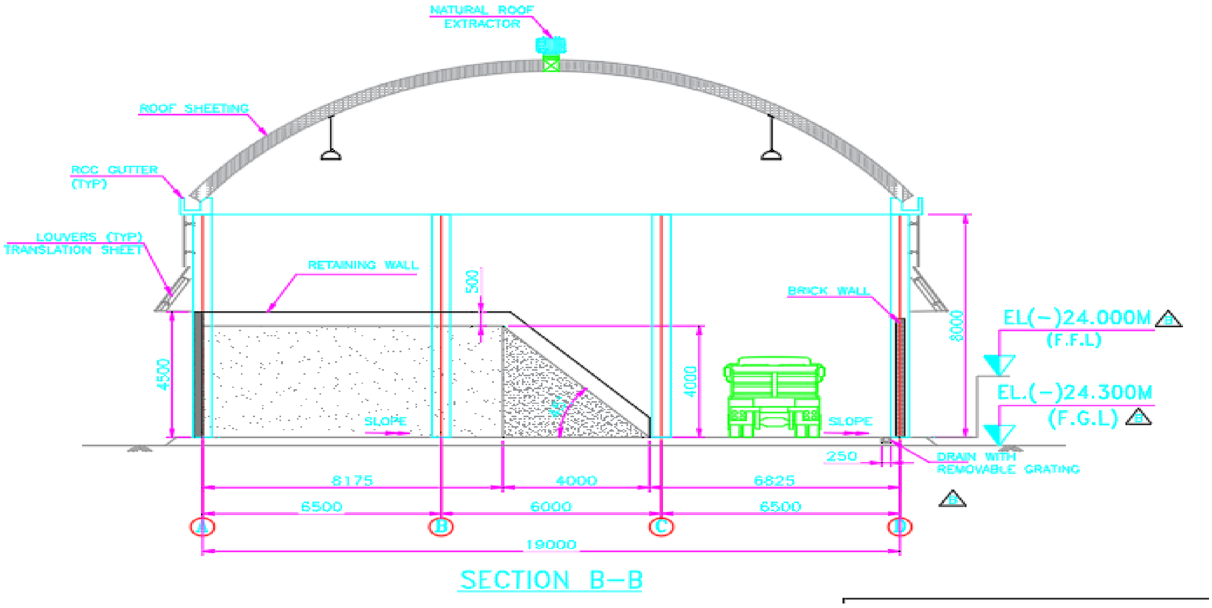



Figure 6.68: Elevation Details of Gypsum Storage Shed

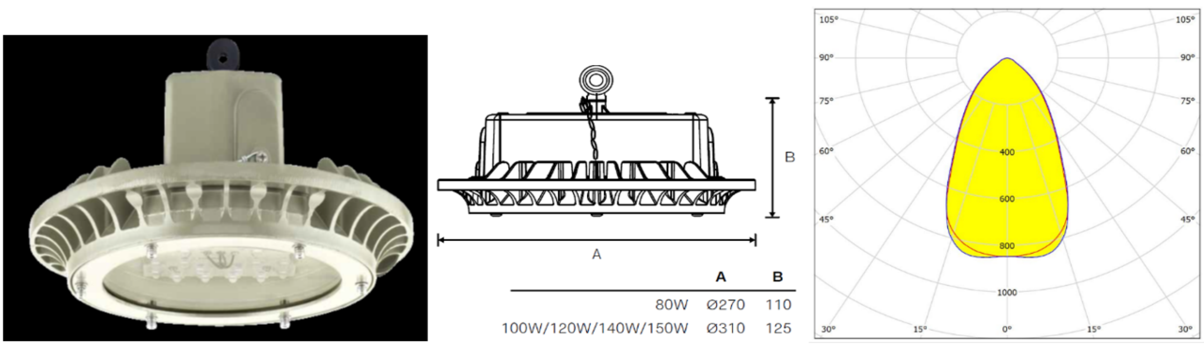
**Design Aim:**

To provide uniform illumination to the overall area. The designed illumination level and uniformity must meet the required value. The lighting installations must provide visual comfort and it should not create much glare.

- Required illuminance level: Average 100 Lux
- Overall uniformity: 0.4

**Luminaire used:**

- Circular PDC Aluminium housing LED High Bay Luminaire (as shown in fig.)
- Luminous flux: 11000 Lumen
- Wattage: 100 Watt
- System efficacy: 110 lm/W
- Beam angle: 60 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected




(a) (b) (c)

Figure 6.69: (a) Highbay image (b) Highbay dimension (c) Polar curve

**Design Considerations for the lighting implementation:**

- Number of Luminaires: 20
- Mounting height: 10m from floor level
- Maintenance factor: 0.6
- Ceiling, Wall and Floor reflectance factor is considered 30%, 30%, 10% respectively

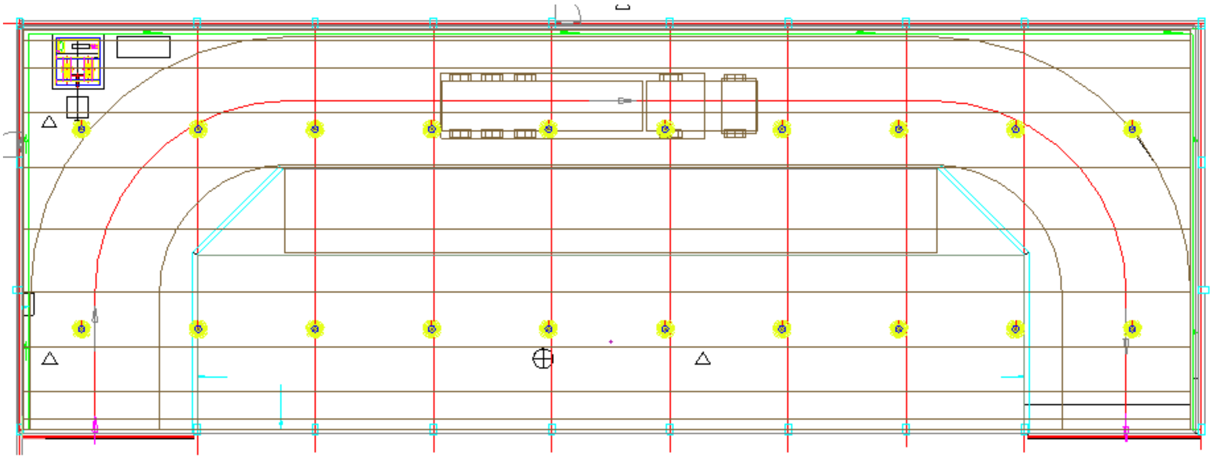
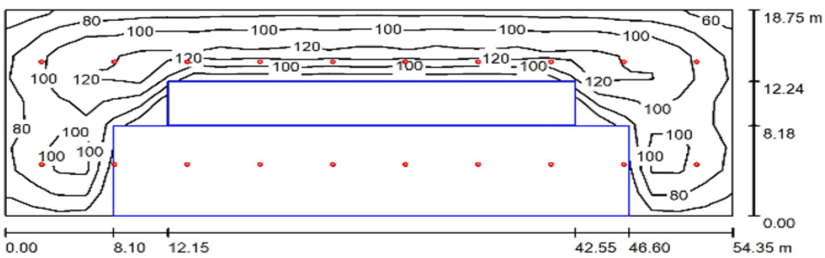


Figure 6.70: Simulated layout of Gypsum Storage shed

**GYPSUM STORAGE SHED / Summary**

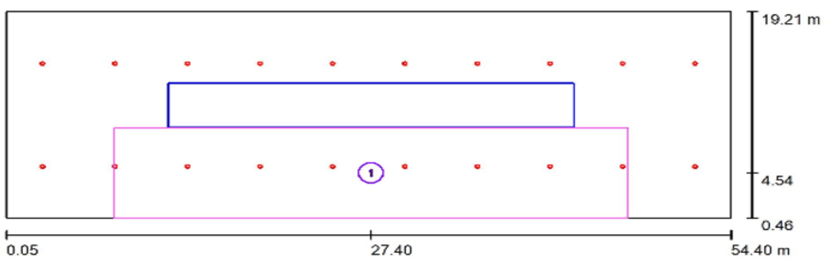



Height of Room: 13.000 m, Mounting Height: 10.000 m, Light loss factor: 0.60

Values in Lux, Scale 1:389

| Surface | ρ [%] | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 |
|---|---|---|---|---|---|
| Workplane | / | 101 | 53 | 141 | 0.528 |
| Floor | 10 | 57 | 0.17 | 139 | 0.003 |
| Ceilings (14) | 48 | 6.55 | 0.04 | 32 | / |
| Walls (5) | 30 | 23 | 0.31 | 68 | / |

**GYPSUM STORAGE SHED / Calculation surfaces (results overview)**




Scale 1 : 389

**Calculation Surface List**

| No. | Designation | Type | Grid | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 | $E_{min}$ / $E_{max}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | PLATFORM | horizontal | 32 x 8 | 139 | 56 | 210 | 0.401 | 0.267 |

Figure 6.71: Simulated report of Gypsum Storage shed

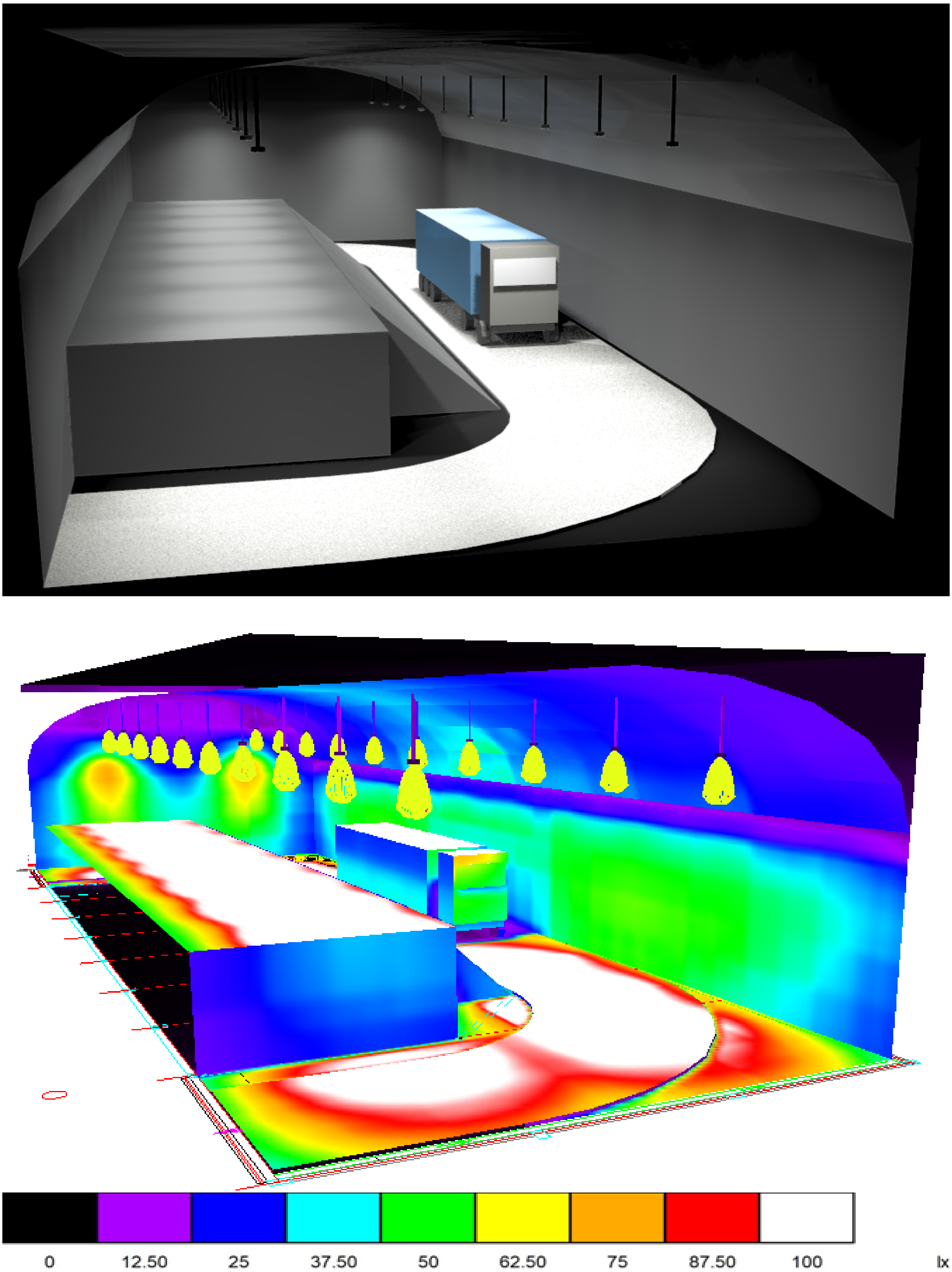


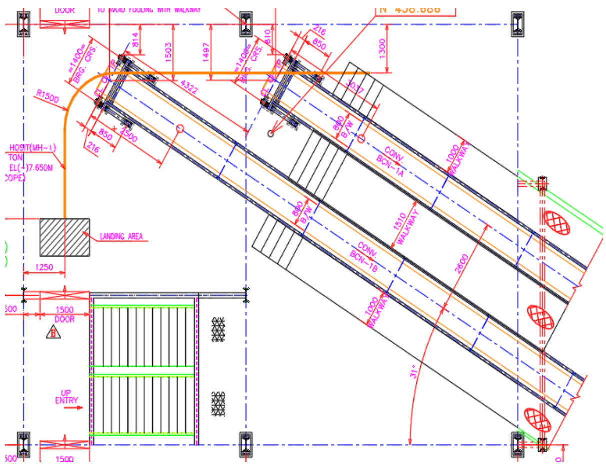

Figure 6.72: Simulated 3d rendering of Gypsum Storage shed

## 6.8 Limestone Terminal Point:

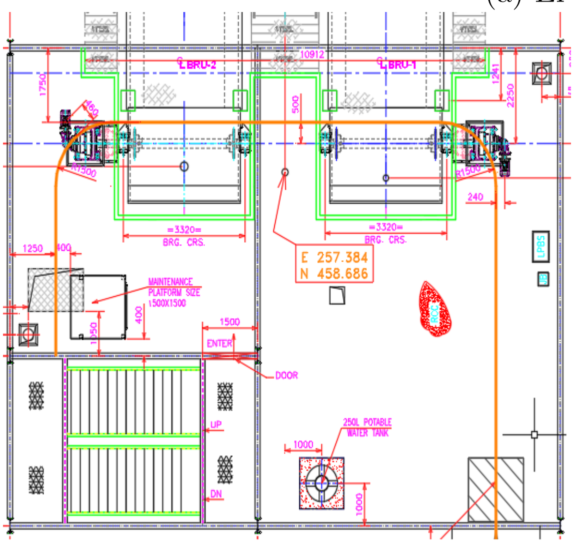
Limestone is needed for operating FGD (Flue Gas Desulphurization) systems in Thermal Power Plant. Limestone powder is injected after the coal is burned, typically at the top of the boiler. The sulphur dioxide is formed when the sulphur contained in the coal (it is a contaminant in all coal) burns in the combustion chamber of the boiler. The sulphur dioxide bonds with the limestone to form a particulate; it believes that is CaSO3. The particulate is then trapped in the baghouse or electrostatic precipitator before it exists the stack. So, limestone enables capture of sulphur emissions.

**Layout and description of Limestone Terminal Point:**

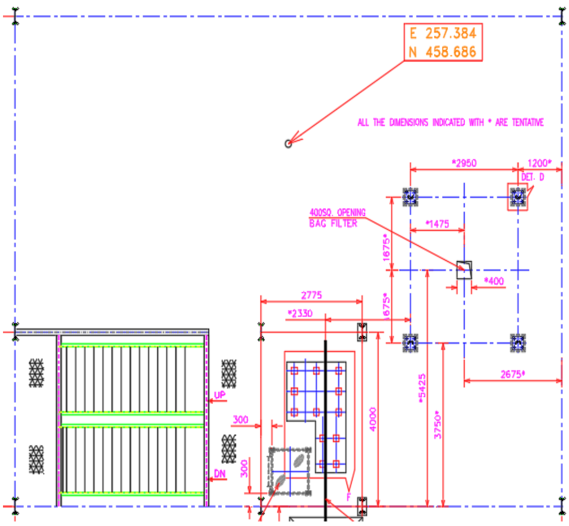
Considering one of the Limestone Terminal Point for better understanding of lighting design, analysing software DIALux has been used for describing and achieving the recommended values as per NTPC standard. Typical plan layout of the Limestone Terminal Point is shown in Fig. below.




(a) El (-)11m




(b) EL(-) 6.6m




(c) El (-)0.15m

Figure 6.73: Plan Layout of Limestone Terminal Point

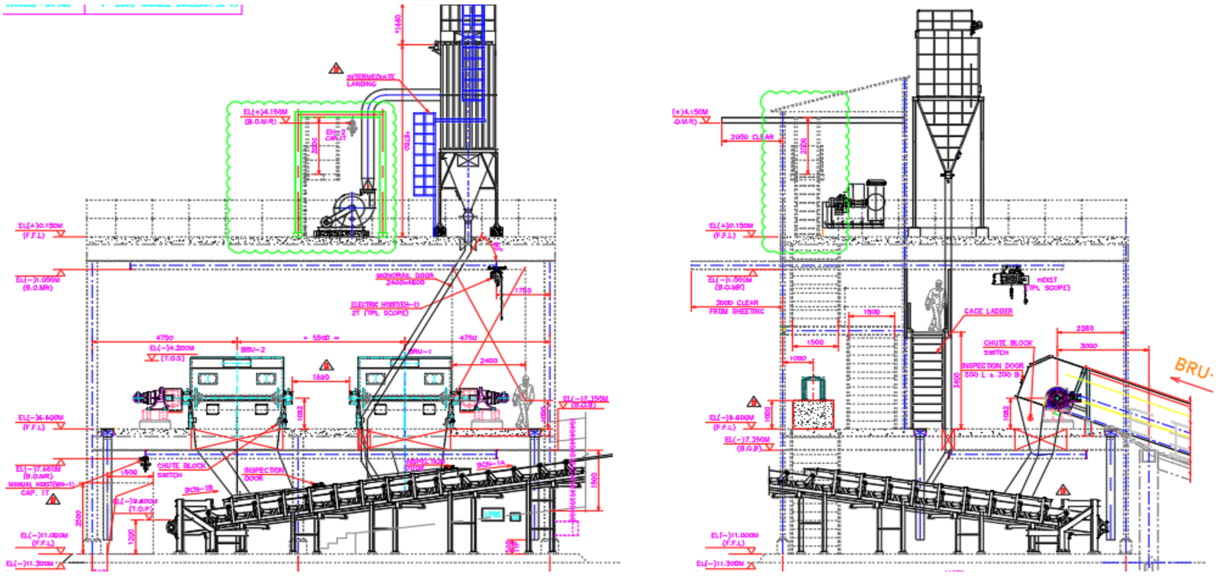


Figure 6.74: Elevation details of Limestone Terminal point

**Design Aim:**

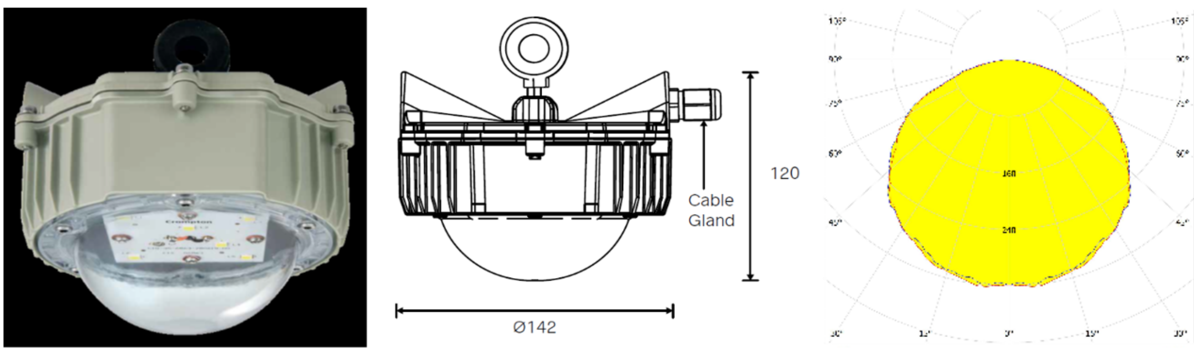
To provide uniform illumination to the overall area. The designed illumination level and uniformity must meet the required value. The lighting installations must provide visual comfort and it should not create much glare.

- Required illuminance level: Average 100 Lux
- Overall uniformity: 0.4

**For EL (-)11m:**

**Luminaire used:**

- Circular PDC Aluminium housing LED Well glass (as shown in fig.)
- Luminous flux: 3402 Lumen
- Wattage: 30 Watt
- System efficacy: 118 lm/W
- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected




(a) (b) (c)

Figure 6.75: (a) Well Glass image (b) Well glass dimension (c) Polar curve

**Design Considerations for the lighting implementation:**

- Number of Luminaires: 15
- Mounting height: 4m from floor level
- Maintenance factor: 0.6
- Ceiling, Wall and Floor reflectance factor is considered 30%, 30%, 10% respectively

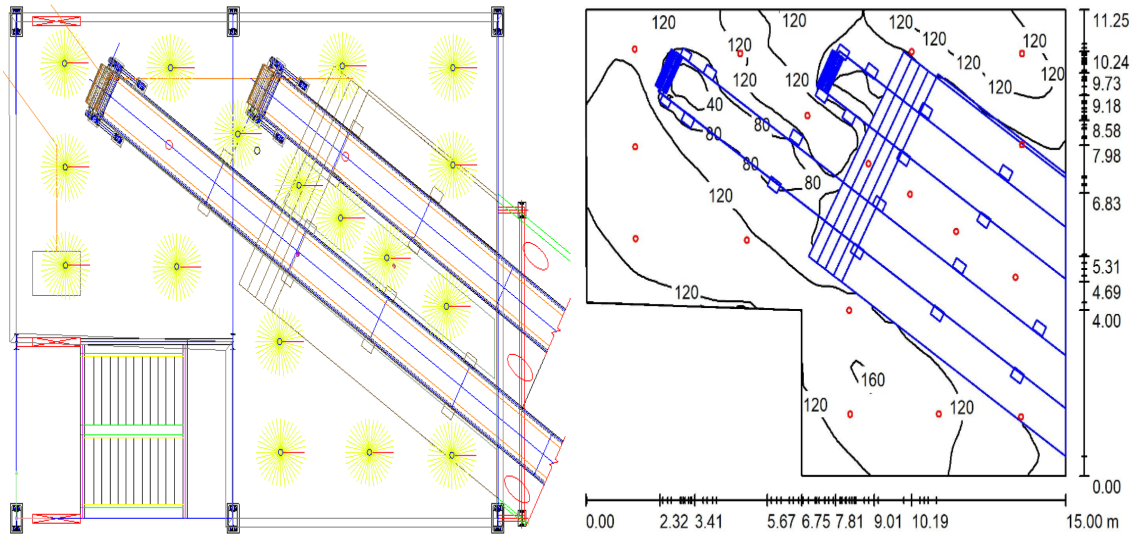
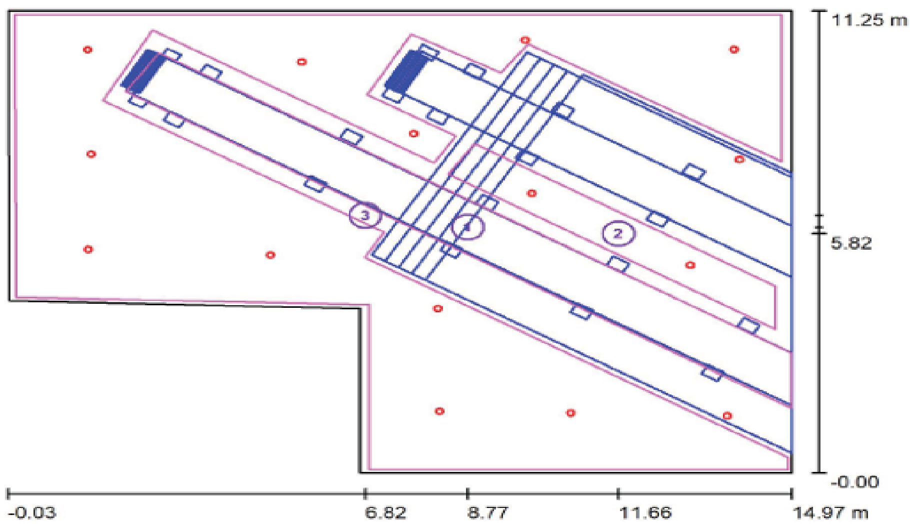



Figure 6.76: Simulated layout of EL (-)11m

**EL (-)11.00 M LVL / Calculation surfaces (results overview)**




Scale 1 : 129

**Calculation Surface List**

| No. | Designation | Type | Grid | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 | $E_{min}$ / $E_{max}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | CONVEYER BELT | perpendicular | 128 x 64 | 140 | 63 | 241 | 0.450 | 0.260 |
| 2 | PLATFORM | perpendicular | 64 x 8 | 116 | 53 | 139 | 0.461 | 0.385 |
| 3 | Floor Level | horizontal | 64 x 64 | 102 | 53 | 134 | 0.519 | 0.396 |

Figure 6.77: Simulated report of EL (-)11m

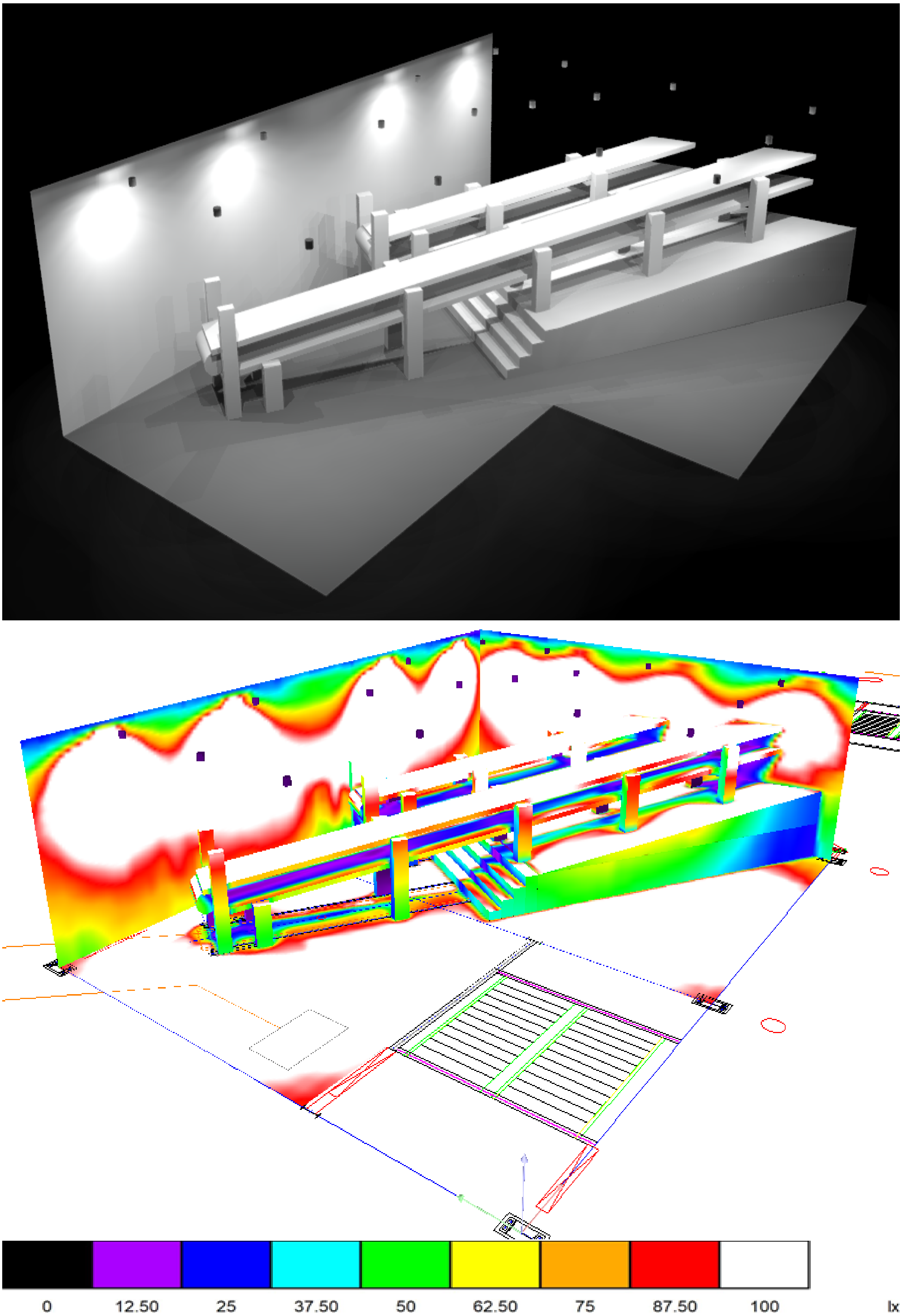
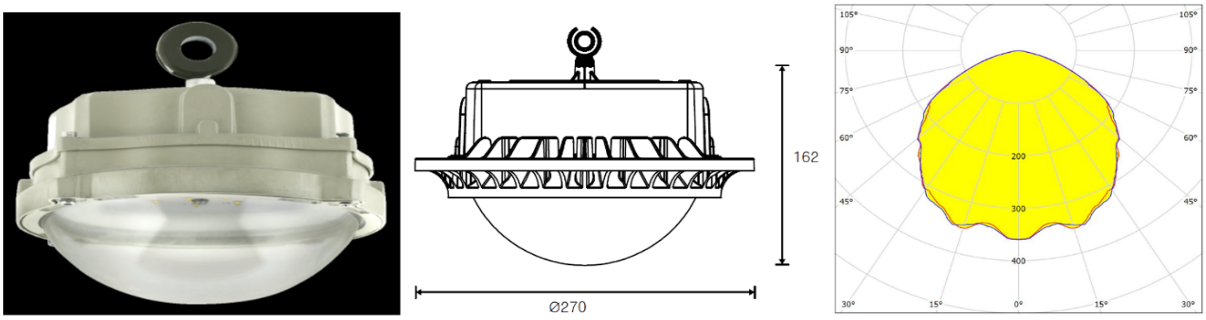



Figure 6.78: Simulated 3d rendering of EL (-)11m

**For EL (-)6.6m:**

**Luminaire used:**

- Circular PDC Aluminium housing LED Well glass (as shown in fig.)
- Luminous flux: 7800 Lumen
- Wattage: 70 Watt
- System efficacy: 111 lm/W
- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected




(a) (b) (c)

Figure 6.79: (a) Well Glass image (b) Well glass dimension (c) Polar curve

**Design Considerations for the lighting implementation:**

- Number of Luminaires: 8
- Mounting height: 5.6m from floor level
- Maintenance factor: 0.6
- Ceiling, Wall and Floor reflectance factor is considered 30%, 0%, 10% respectively.

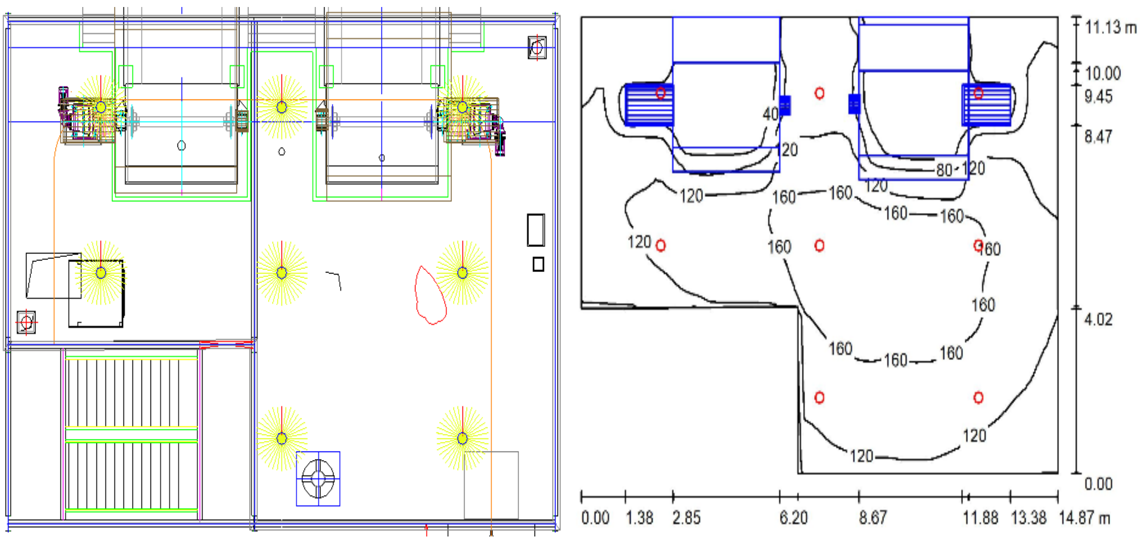
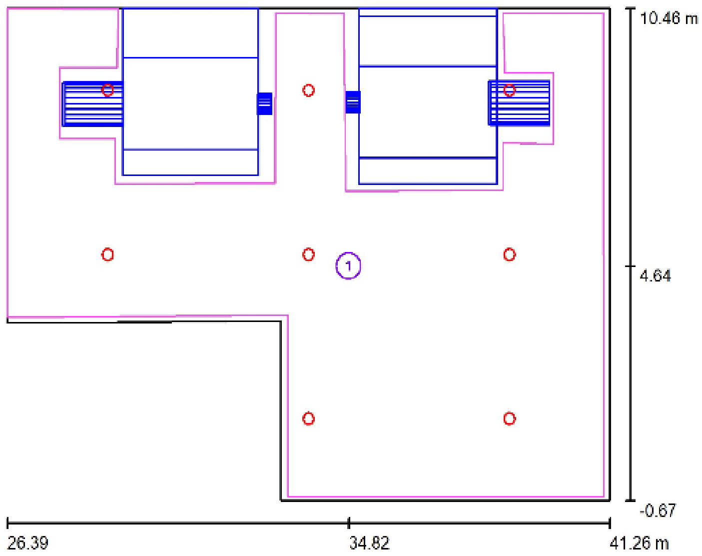



Figure 6.80: Simulated layout of EL (-)6.6m

**EL (-)6.6 M LVL / Calculation surfaces (results overview)**




Scale 1 : 127

**Calculation Surface List**

| No. | Designation | Type | Grid | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 | $E_{min}$ / $E_{max}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | Floor Level | horizontal | 16 x 16 | 135 | 62 | 188 | 0.463 | 0.330 |

Figure 6.81: Simulated report of EL (-)6.6m

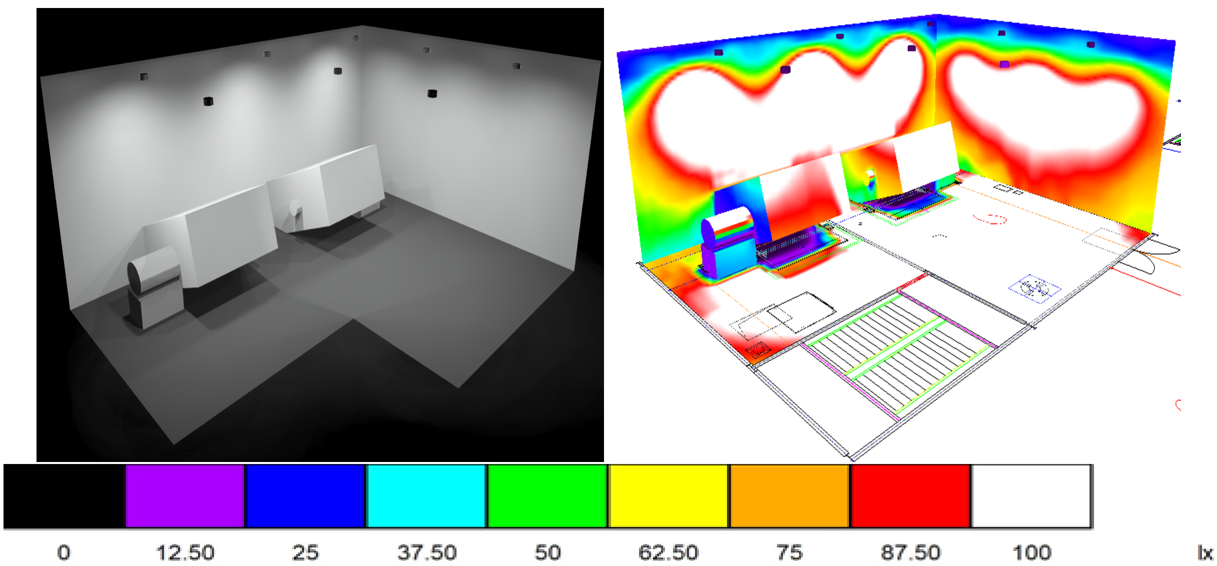



Figure 6.82: Simulated 3d rendering of EL (-)6.6m

**For EL (-)0.15m:**

**Design Aim:**

To provide uniform illumination over the area. To illuminate the areas luminaires are mounted on inverted J-shape pole, which are placed on the railings. The designed illumination level and uniformity must meet the required value. The lighting installations must provide visual comfort and it should not create much glare.

- Required illuminance level: Average 50 Lux
- Overall uniformity: 0.25

**Luminaire used:**

- Circular PDC Aluminium housing LED Well glass (as shown in fig.)
- Luminous flux: 3402 Lumen
- Wattage: 30 Watt
- System efficacy: 118 lm/W
- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected

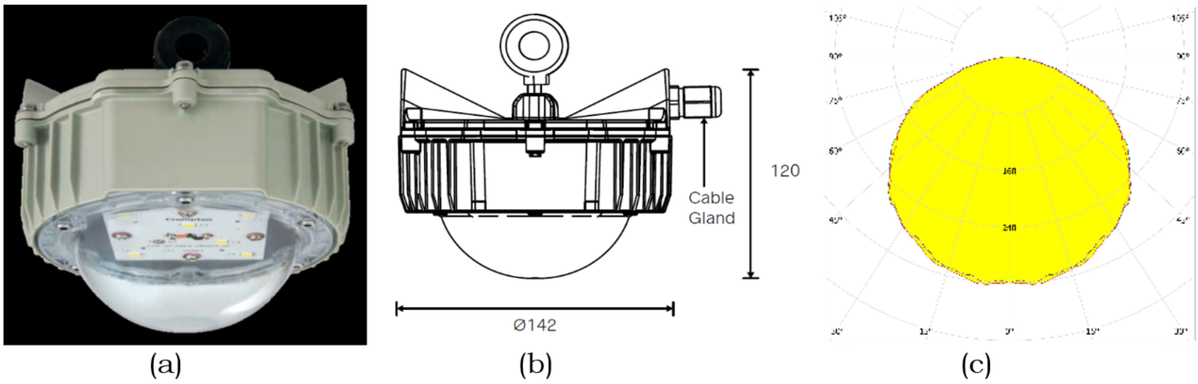



Figure 6.83: (a) Well Glass image (b) Well glass dimension (c) Polar curve

**Design Considerations for the lighting implementation:**

- Number of Luminaires: 15
- Mounting height: 3m from floor level
- Pole Spacing: 4m
- Maintenance factor: 0.6

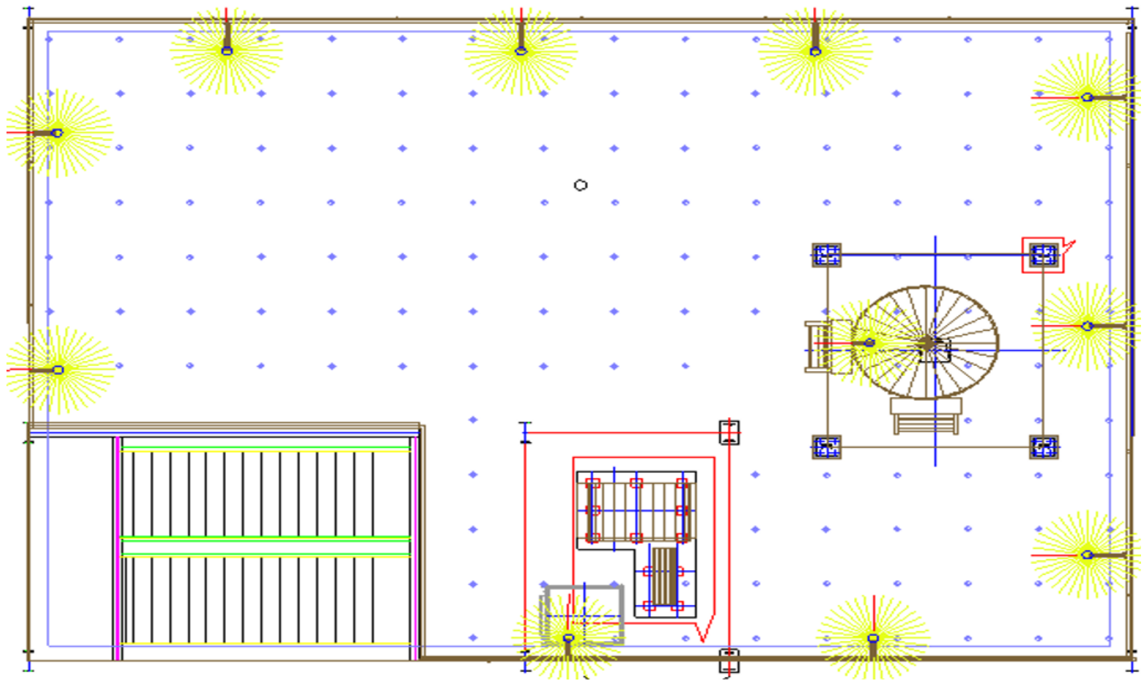
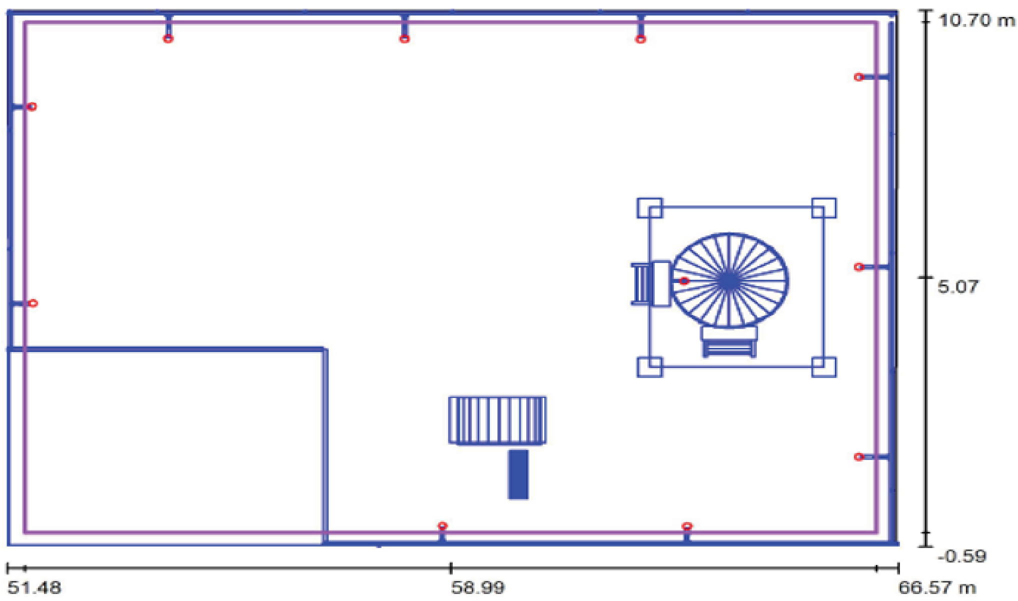


Figure 6.84: (Simulated Layout of EL(-) 0.15m




Scale 1 : 115

Position: (58.989 m, 5.073 m, 0.010 m)
Size: (14.422 m, 10.745 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: User defined, Quantity Points: 146

**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 | horizontal | 72 | 18 | 119 | 0.25 | 0.15 | / | 0.000 | / |

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

Figure 6.85: Simulated report of EL(-) 0.15m

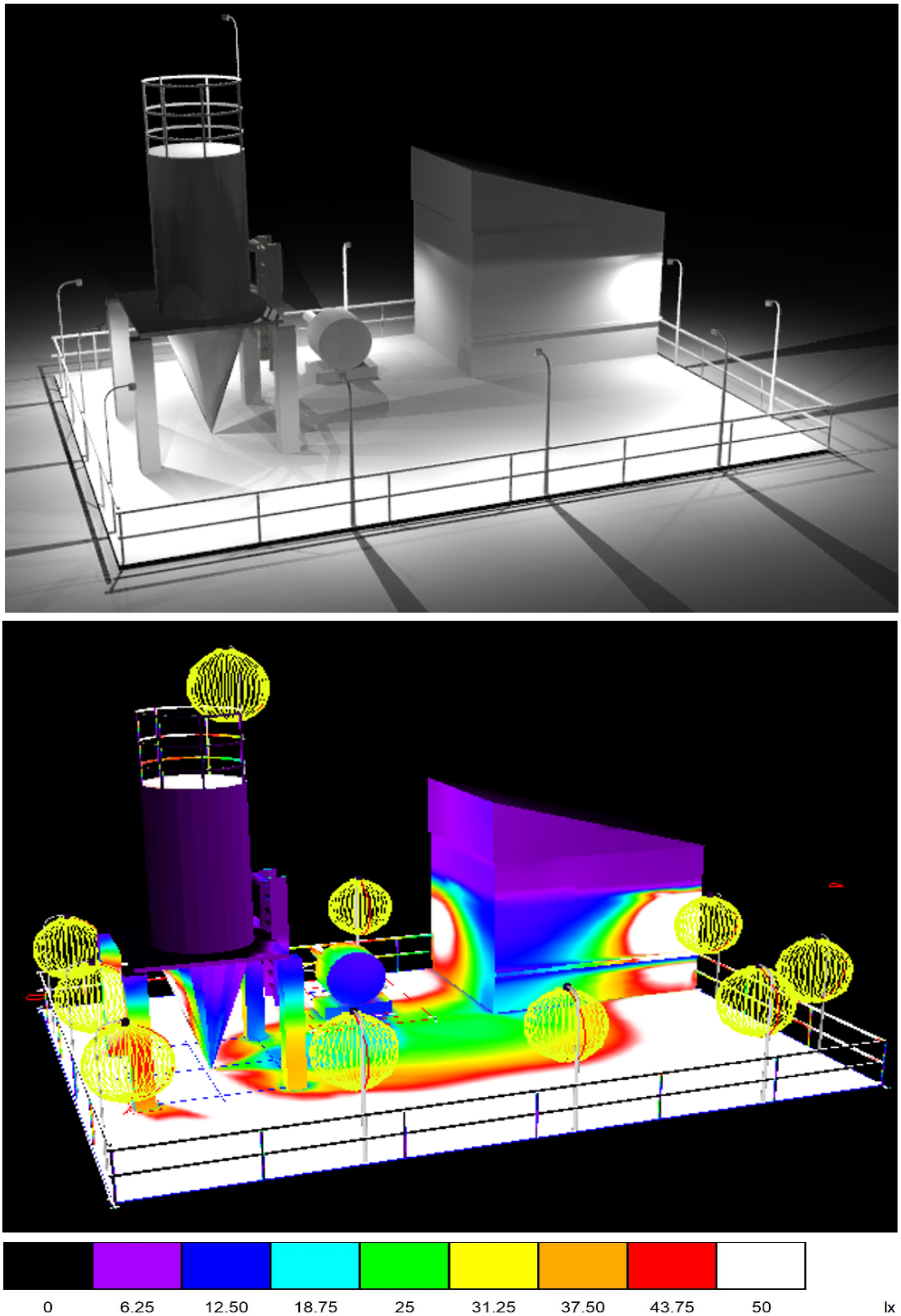



Figure 6.86: Simulated 3d rending of EL(-)0.15m

## 6.9 Exterior Road:

Exterior Roads of any Thermal Power Plant are generally Peripheral areas consist of the space surrounding the buildings of different sections of the plant. Hence, 20lux level streetlights are recommended.

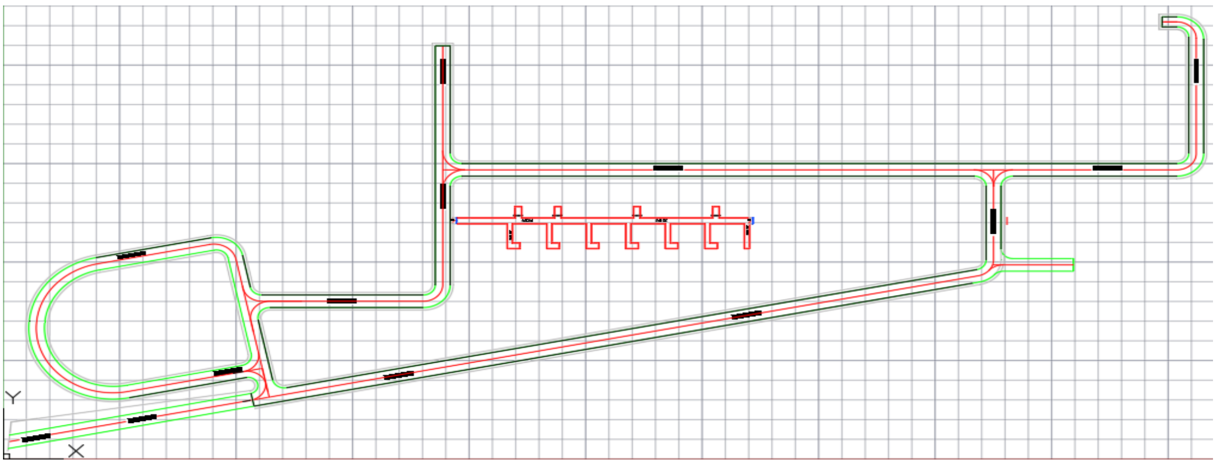
**Design Aim:**

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

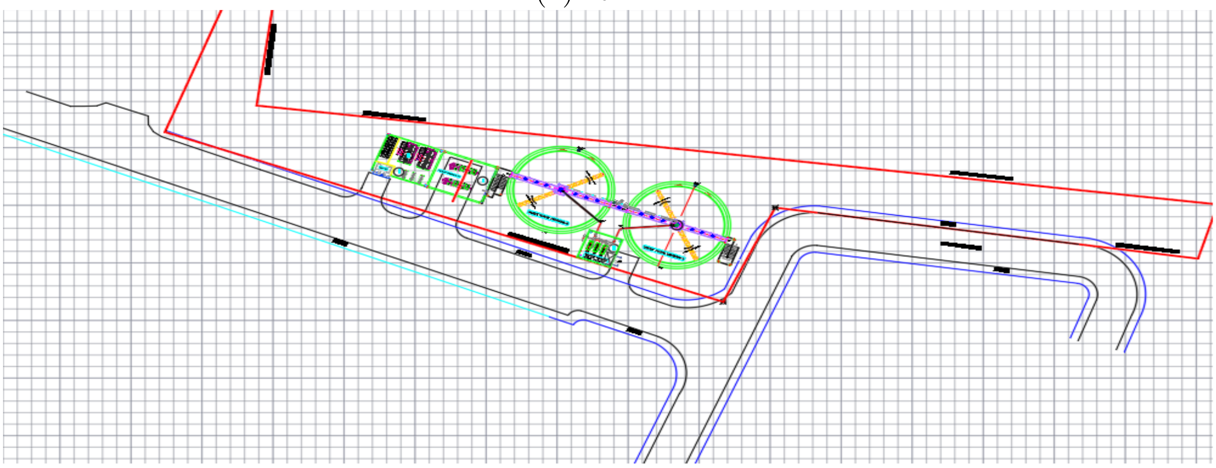
- Required illuminance level: Average 20 Lux
- Overall uniformity: 0.40
- Overall min./max. ratio: 0.25

**Layout and description of Exterior Road:**

Considering Exterior Roads for better understanding of lighting design, analysing software AGi32 has been used for describing and achieving the recommended values as per NTPC standard. Typical plan layout of the Exterior Roads is shown in Fig. below



(a) Road 1

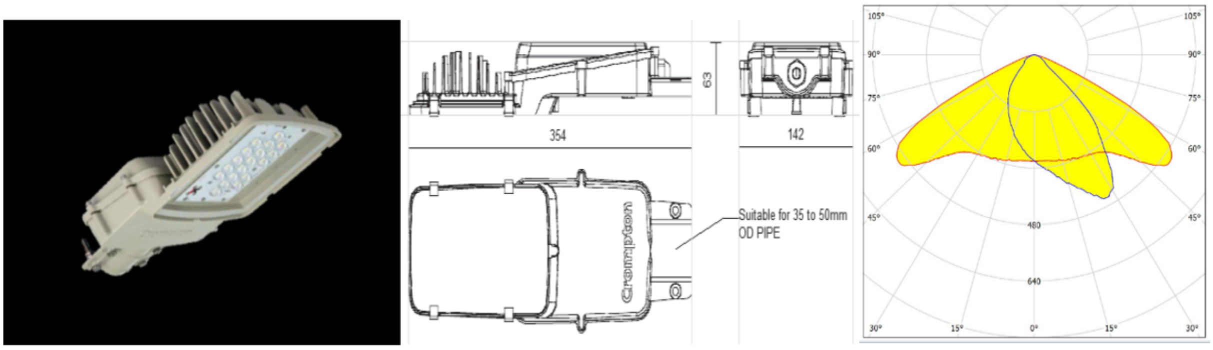


(b) Road 2

Figure 6.87: Plan layout of Exterior Road

**Luminaire used:**

- Aerodynamically designed PDC Aluminium housing LED streetlight (as shown in fig)
- Luminous flux: 7700 Lumen
- Wattage: 70 Watt
- System efficacy: 110 lm/W
- Photometry type: Cut-off
- CCT: 5700K
- CRI: 80
- IP 66 protected




(a) (b) (c)

Figure 6.88: (a) Streetlight image (b) Streetlight dimension (c) Polar curve

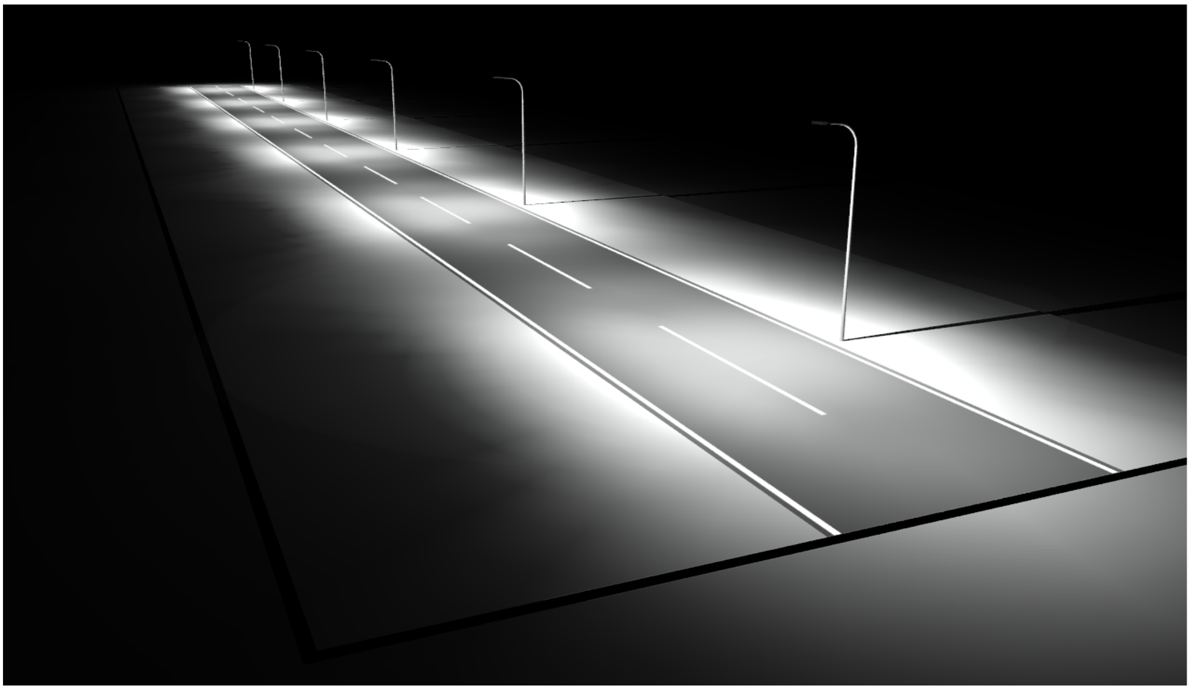


Figure 6.89: Simulated 3d Rendering of the Exterior Road

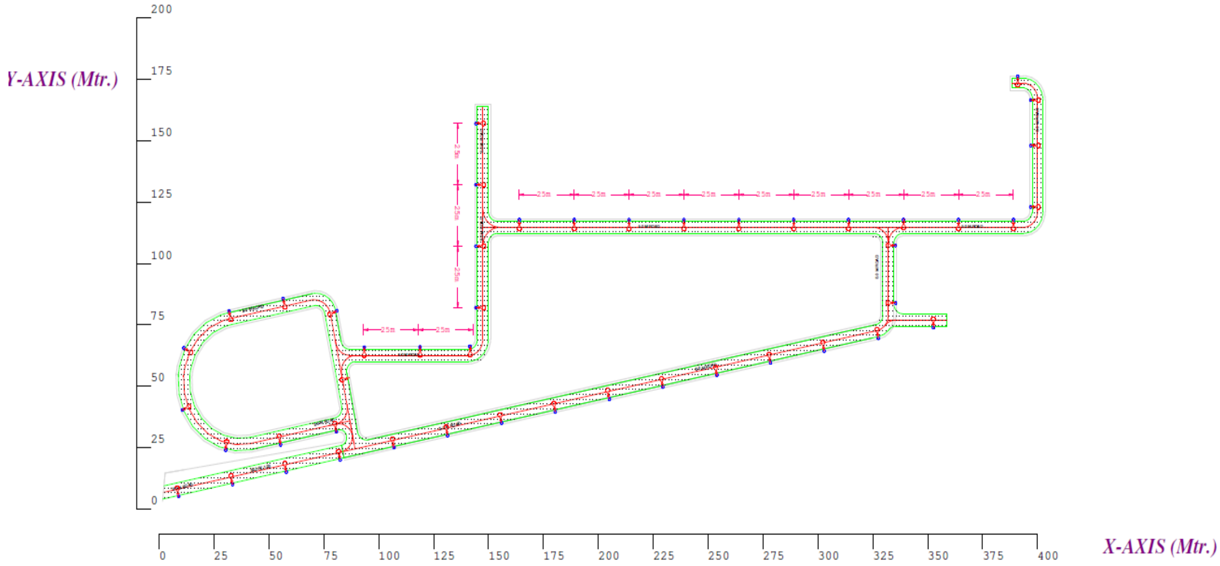



Figure 6.90: Simulated Layout of Road 1 using Agi32

**Design Considerations :**

**No of poles : 47 nos.**
**Pole height : 7 mtr. from road level**
**Bracket arm length : 1.0 mtr.**
**Luminaire tilt : 5 degree**
**Arrangement : Single-sided**
**Spacing : 25 meters**
**Luminaire Used : LED 70 watt street light**

**Horizontal lighting calculation grid is considered at road level**

| **Luminaire Schedule** | | | | |
|---|---|---|---|---|
| **Symbol** | **Qty** | **Label** | **LLF** | **Description** |
| | 47 | CRP-409-70-57-SL-GL-NSG | 0.800 | 70 WATT LED STREET LIGHT |

| **Calculation Summary** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Label** | **CalcType** | **Units** | **Avg** | **Max** | **Min** | **Min/Avg** | **Min/Max** |
| 5 Mtr Road | Illuminance | Lux | 23.8 | 47.6 | 11.9 | 0.45 | 0.25 |

**** NOTE ****

**HORIZONTAL CALCULATION GRID IS CONSIDERED AT E/L 0 mtr.**
**FROM ROAD LEVEL WITHOUT CONSIDERING OBSTRUCTIONS.**

Figure 6.91: Simulated report of Road 1 using AGi32

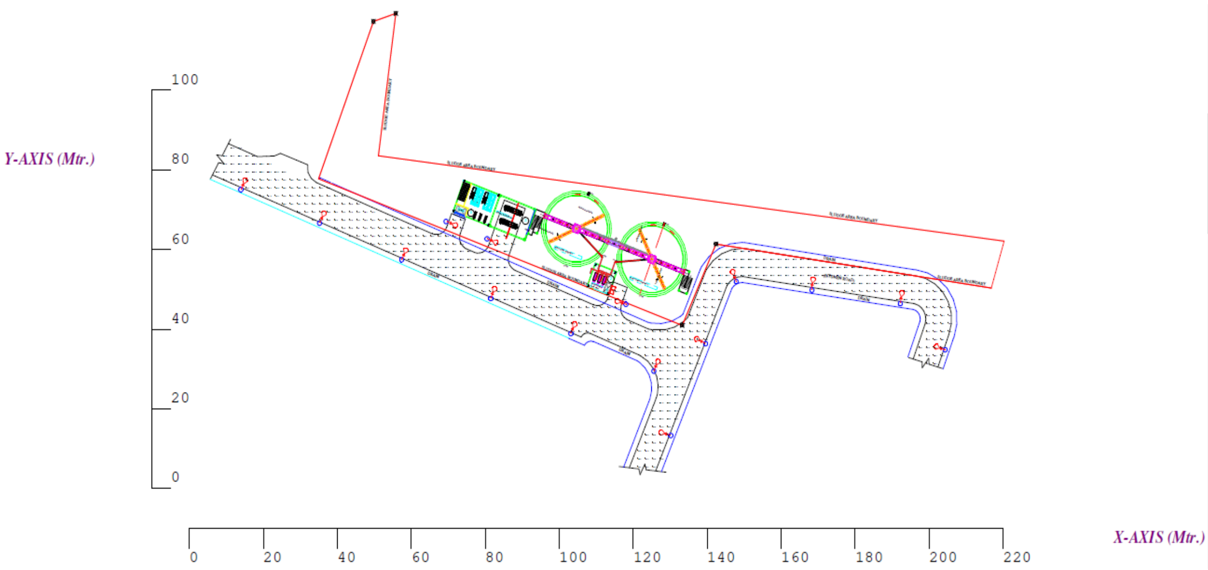



Figure 6.92: Simulated Layout of Road 2 using Agi32

**Design Considerations :**

**No of poles : 15 nos.**
**Pole height : 7 mtr. from road level**
**Bracket arm length : 1.0 mtr.**
**Luminaire tilt : 15 degree**
**Arrangement : Single-sided**
**Spacing : 25 meters (Approx.)**
**Luminaire Used : LED 70 watt street light**

**Horizontal lighting calculation grid is considered at road level**

| **Luminaire Schedule** | | | | |
|---|---|---|---|---|
| **Symbol** | **Qty** | **Label** | **LLF** | **Description** |
| (symbol) | 15 | CRP-409-70-57-SL-GL-NSG | 0.800 | 70 WATT LED STREET LIGHT |

| **Calculation Summary** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Label** | **CalcType** | **Units** | **Avg** | **Max** | **Min** | **Min/Avg** | **Min/Max** |
| Road | Illuminance | Lux | 23.7 | 43.6 | 11.0 | 0.46 | 0.25 |

**** NOTE ****

**HORIZONTAL CALCULATION GRID IS CONSIDERED AT E/L 0 mtr.**
**FROM ROAD LEVEL WITHOUT CONSIDERING OBSTRUCTIONS.**

Figure 6.93: Simulated report of Road 2 using AGi32

## 6.10 Wet Stack (Chimney):

A chimney is a typical cylindrical and vertical structure that provides ventilation for hot flue gases or smoke from a boiler, stove, furnace or fireplace to the outside atmosphere.

In the special case of chimneys, cooling towers, and flare stacks lights may be displayed as low as 20 feet (6-m) below the top to avoid the obscuring effect of deposits and heat generally emitted.

# Basic Rules of Aviation Lighting:

- The number of light levels recommended depends on the height of the structure;
- The number and arrangement of light units at each level should be placed so the lighting is visible from every angle in azimuth;
- Lights are applied to display the general definition of an object or a group of buildings;
- The top obstruction lights should be placed sufficiently below the top so as to minimize contamination by smoke, etc
- The diameter of the structure determines the number of obstruction lights installed at the top and at each light level.

# Required Luminaire Specifications:

The International Civil Aviation Organization (ICAO) specifies the mandatory use of aviation obstruction lights as per the following nomenclature for installation on structures of different heights.

- Low intensity (A minimum Luminous Intensity of 10 candela in red) lights should be used for structure with $H < 45$ m during night time, if those are considered inadequate, then medium – high intensity lights should be used.
- Medium intensity (A minimum directional light intensity of 1600cd, in flashing red) lights type should be used for structure with $45 \text{ m} < H < 150$ m.
- High intensity (Either: White light of 200,000cd for daytime visibility, white light of 20,000cd for twilight, and red light of 2000cd for night -all flashing at 20 to 60 flashes per minute), should be used to indicate the presence of an object if its $H > 150$ m and an aeronautical study indicates such lights to be essential for the recognition of the object by day.

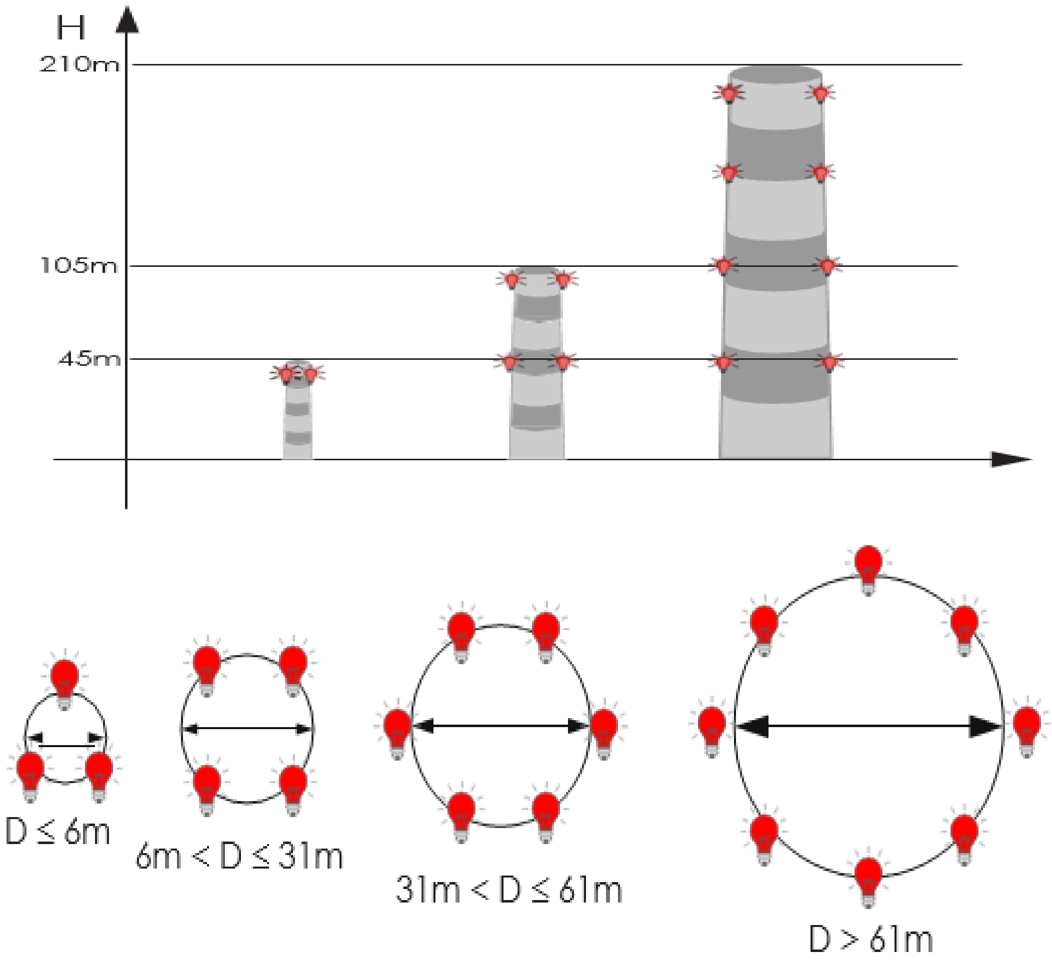



Figure 6.94: Aviation Obstruction Luminaire Arrangement

**Aviation obstruction light markings:**

There are 3 options for lighting a chimney with aviation obstruction light systems.
1. If the chimney is to be lighted only at night with red light

- If the authorities state that there is no need to light the day
- If the chimney marked with paint (white-red strip)

2. If the chimney is to be lighted day and night with white light

3. If the chimney is to be lighted with white light at daytime and with red light at night time

- If the authorities state that white light is too much discomfortable at night

In this Project Option 1 has been considered.

**Layout and description of Chimney:**

Considering one of the Chimneys for better understanding of lighting design, analysing software DIALux has been used for describing the area and designing as per the rules mentioned earlier. Typical plan layout of the Chimney is shown in Fig which has a height of 130m from ground level.

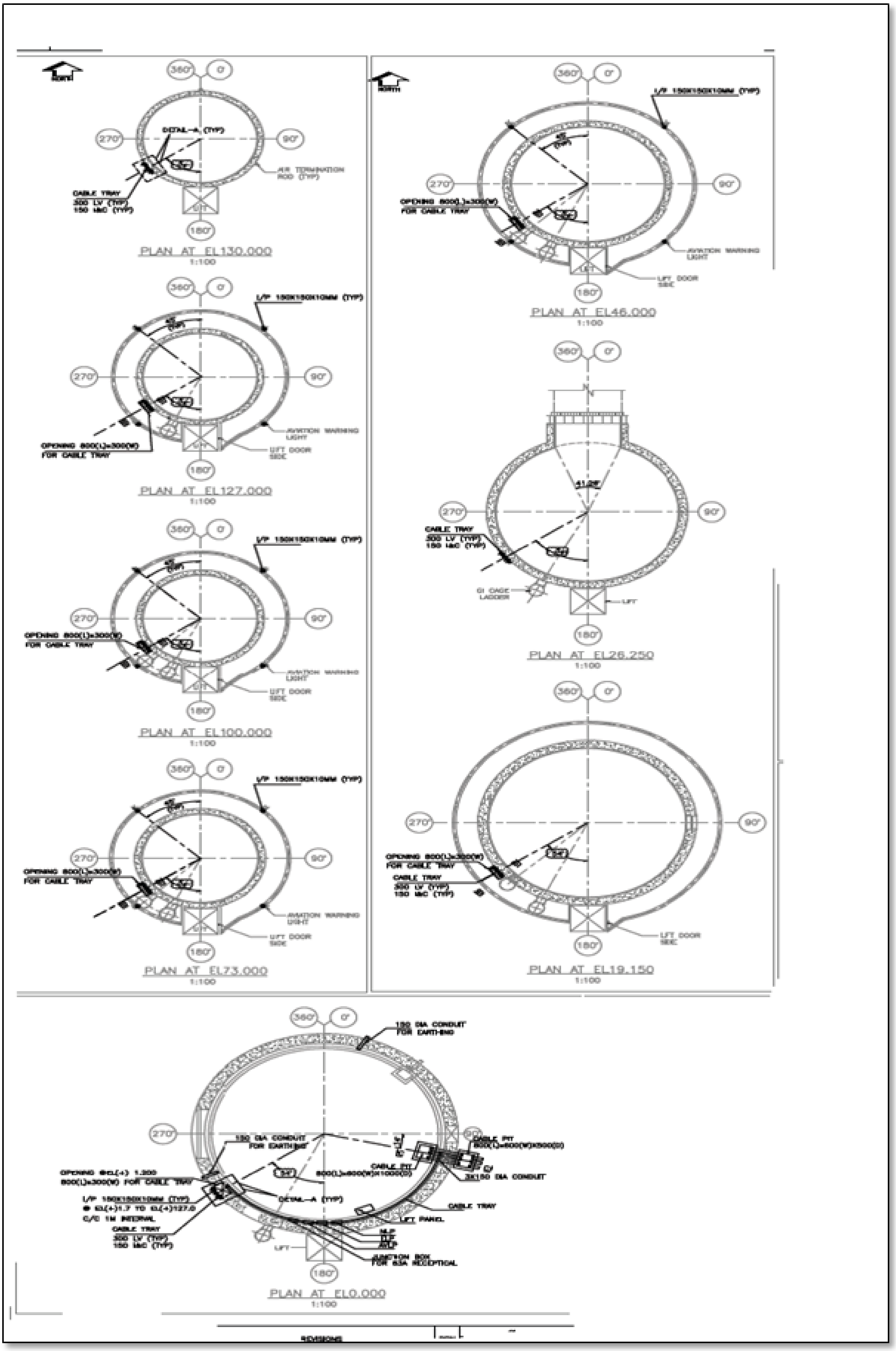



Figure 6.95: Plan layout of Chimney

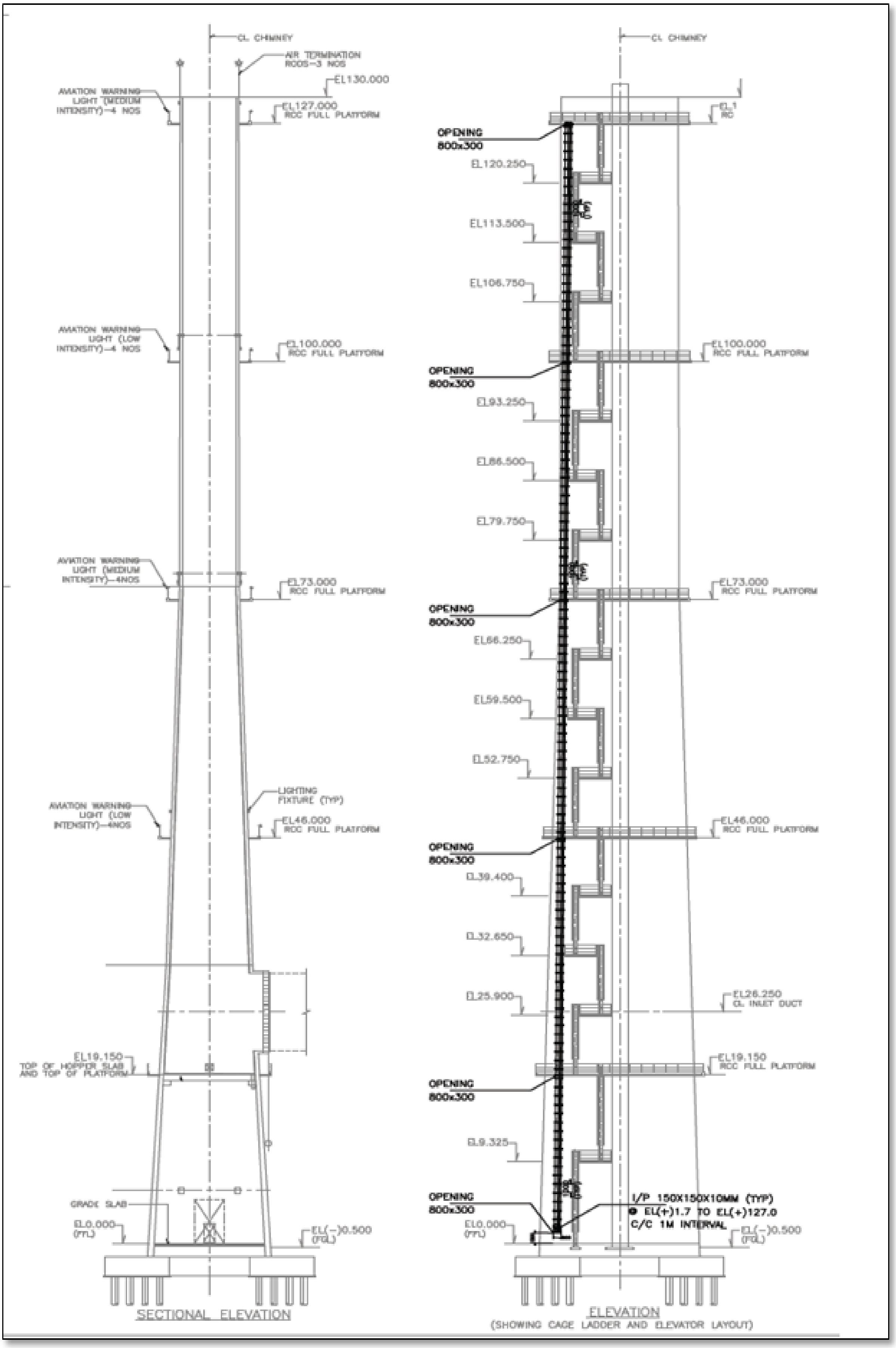



Figure 6.96: Elevation details of chimney

The Chimney has 6 levels elevation levels as shown in the layout. They are at 19m, 46m, 73m, 100m and 127m respectively. So as per the rules from starting from 46m Aviation Lighting has to be implemented.

**Design Considerations for aviation lighting:**

- Number of Luminaires: 4 per level
- Mounting height: 3m as shown in elevation
- Luminous Intensity: 1600candela

**Luminaire used:**

- Medium Intensity Twin Type Aviation Obstruction Lamp (as shown in fig.)
- Wattage: < 65 Watt
- Luminous Intensity: > 1600 Candela
- Horizontal radiation pattern: 360°
- Vertical radiation pattern: + 05° to - 05°
- Colour: Red (wavelength: 615-650nm)
- IP65 Protected
- 20-40 Flashes per minute

Figure 6.97: AOL Image

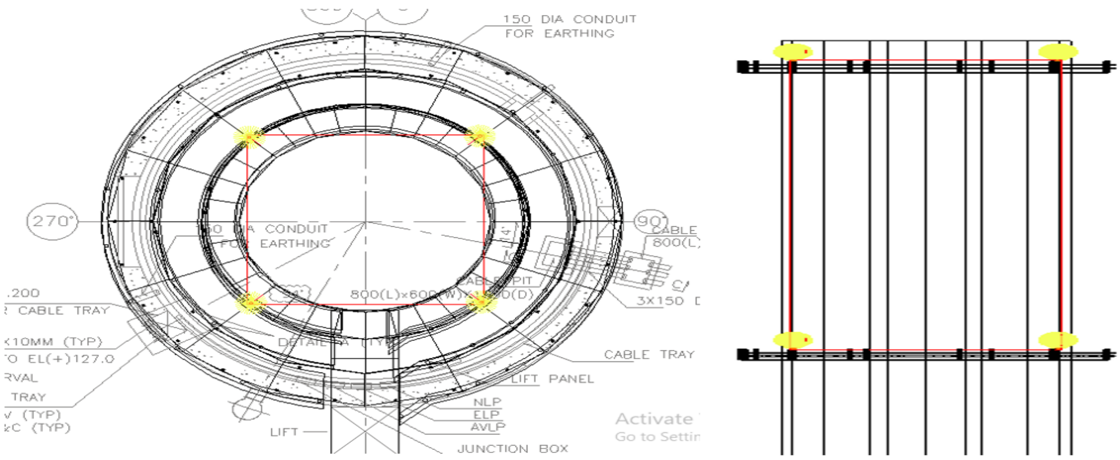



Figure 6.98: Simulated Layout for Aviation Lighting

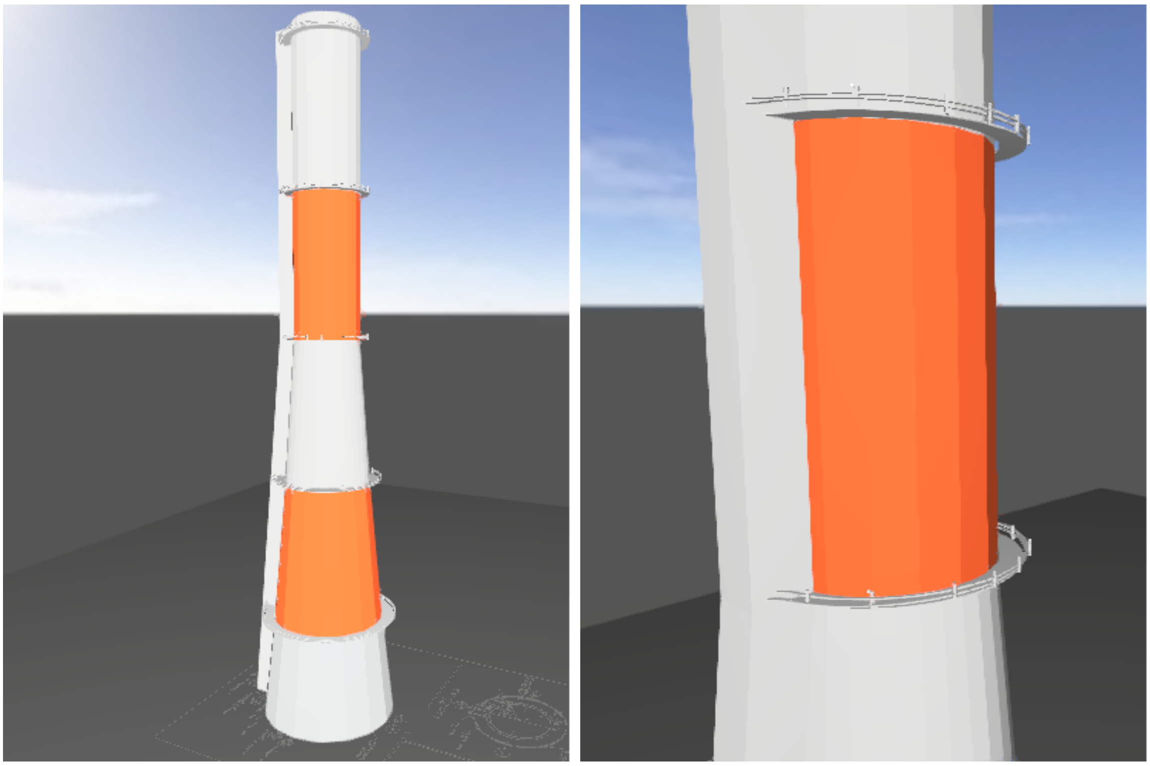


Figure 6.99: 3d Rendering of the Chimney

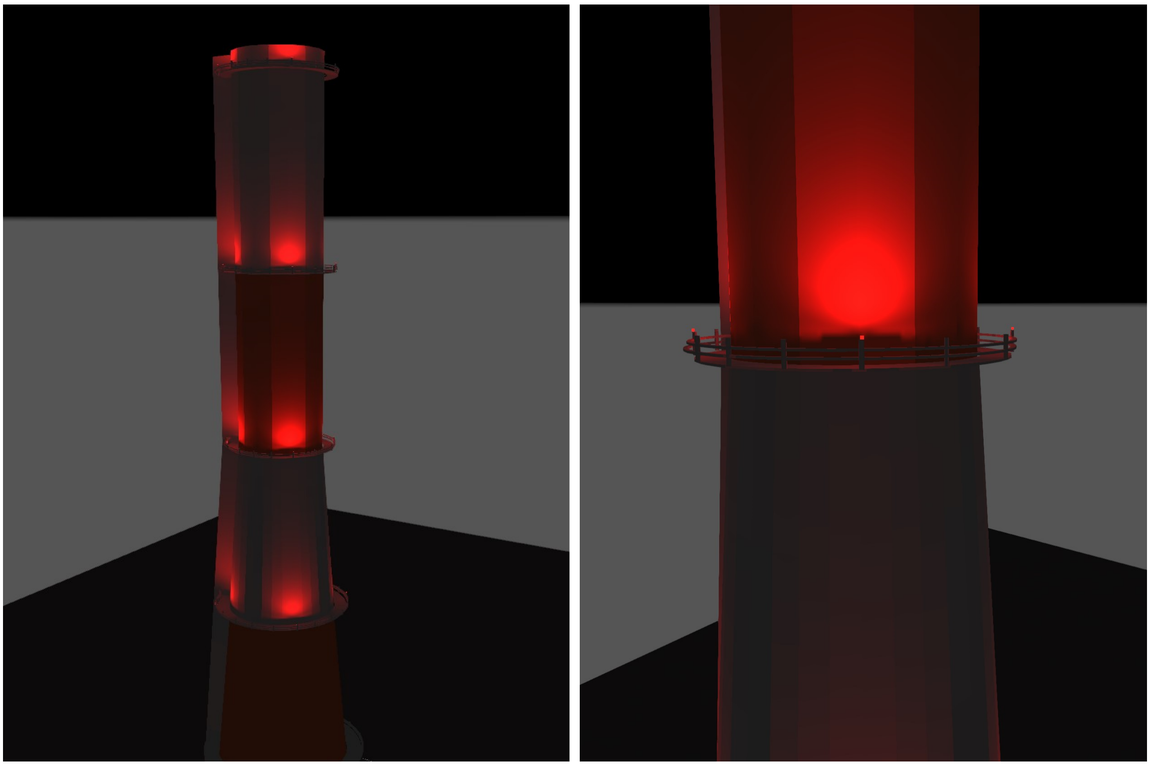


Figure 6.100: Simulated 3d Rendering of the Chimney

# Chapter 7

# Result Analysis

## 7.1 Introduction

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

Today people are much more aware of their requirements and they believe in personalizing their surroundings and lighting plays a major role in that. Making of their own style statement, would demand a unique and compatible lighting solution. This "humanization" of lighting has taken the lighting designer's attention from "light bulb", the incandescent sources to the "visual emotion" through perfect lighting experience.The energy-efficient lighting solutions save monetary expenditures, as well as the environment.

Being the lighting engineers, our aim is to inspire people to live a greener life. The greener life means a life under the essence of nature accompanied by the sustainable development of technology and in the context of Lighting science and Engineering. The greener life aliases to the LED technology. Now a days, the benefits of LED lighting is well known to us specially to the engineers and technocrats working in this field.

## 7.2 Design Challenges

The real challenge behind qualitative lighting design lies in the development of a concept that is able to fulfil a wide range of requirements by means of a lighting installation that is both technically and aesthetically consistent. In contrast to quantitative concepts, which derive one general set of lighting qualities from the given profile of requirements for a project, which almost inevitably leads to a uniform and thereby standard design using light and luminaires, qualitative lighting design must come to terms with complex patterns of required lighting qualities.

From a technical, economical and design point of view the aim of lighting design should be to find a solution that does not go for a confusing and distracting muddle of lighting fixtures designed to cover a narrow set of lighting requirements, but a concept that produces a clearly structured distribution of lighting qualities by means of a consistent lighting scheme by addressing wide range of design specifications.

## 7.3 Conclusion

This project is dealt with analysing the processes and activities in various areas of Thermal Power Plant, 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 thermal power plant 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.

## 7.4 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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