A Comprehensive Study on Industrial Lighting and a LED-Based Design Approach for a Coal Handling Plant

A THESIS
SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENT FOR THE DEGREE OF

MASTER OF TECHNOLOGYIN ILLUMINATION TECHNOLOGY AND DESIGN

SUBMITTED BY

SOUMYAJIT BANERJEE

Examination Roll no – M6ILT23001

Registration No: 154536 of 2020-21

UNDER THE SUPERVISION OF

Parthasarathi Satvaya

SCHOOL OF ILLUMINATION SCIENCE ENGINEERING AND DESIGN

Course affiliated to

Faculty Council of Engineering and Technology

JADAVPUR UNIVERSITY

KOLKATA – 700032

SEPTEMBER 2023

RECOMMENDATION CERTIFICATE

This is to certify that the thesis entitled **"A Comprehensive Study on Industrial Lighting and an LED-Based Design Approach for a Coal Handling Plant"** is a bonafide work carried out by **SOUMYAJIT BANERJEE**, Examination Roll No: **M6ILT23001 (Registration No.-154536 of 2020-21)** of this university under my supervision and guidance for partial fulfillment of the requirements for the award of degree of **M.Tech (Illumination Technology and Design) in School of illumination Science Engineering and Design, Jadavpur University,** during the academic session 2022-23.

(THESIS ADVISOR)

…………………………………………

Parthasarathi Satvaya
Assistant Professor
School of Illumination Science Engineering and Design,
Jadavpur University

..…………………………………………

Parthasarathi Satvaya
Director
School of Illumination Science
Engineering and Design,
Jadavpur University

……………………………………

Prof. Tushar Jash
Dean, FISLM
Jadavpur University

CERTIFICATE OF APPROVAL

This foregoing thesis is hereby approved as a creditable study in the area of Illumination Engineering, carried out and presented by **SOUMYAJIT BANERJEE**, 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 EVALUTION OF THESIS.

BOARD OF EXAMINERS

……………………………………….

………………………………………

..……………………………………..

(Signature of Examiners)

………………………………………

Date:

Crompton

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

5th May, 2023

SERVICE CERTIFICATE

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

The title of his thesis was "**A Comprehensive study on Industrial Lighting and an LED-Based Design Approach for a Coal Handling Plant.**" which was carried out under the guidance of Mr. Sumit Kar, DGM – Design. During the tenure of his internship with us, he has been sincere, hardworking and diligent in carrying out the assignment entrusted to him.

We wish him all success in his future endeavour.

For **Crompton Greaves Consumer Electricals Limited**

Falgun

Falguni Sharma
Manager Human Resources

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 Technology in Illumination Science Engineering and Design studies during academic session 2020-2023.

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 thesis rules and conduct, I have fully cited and referenced all material and results which are not original to this work.

- NAME: **SOUMYAJIT BANERJEE**
- ROLL NUMBER: **M6ILT23001**
- THESIS TITLE: **A COMPREHENSIVE STUDY ON INDUSTRIAL LIGHTING AND AN LED-BASED DESIGN APPROACH FOR A COAL HANDLING PLANT**

SIGNATURE WITH DATE

ACKNOWLEDGEMENT

A lot of inputs from various sources have gone into the making of this report and the analysis that has been carried out. I take this opportunity to express my deep sense of gratitude and indebtedness to my university guide **Parthasarathi Satvaya** of School of Illumination Science, Engineering and Design, Jadavpur University, for being thoughtful and understanding institutional guide for project and her constant guidance and supervision.

I would like to express my sincere gratitude to **Mrs. Uma Lanka**, Associate Vice President Lighting Division at Crompton Greaves Consumer Electricals Limited for her guidance and unconditional support.

I would also like to thank **Mr. Sumit Kar** (Deputy General Manager – Lighting), **Mr. Manash Bhattacharya** (Senior Manager- Application Design), **Mr. Sagar Bose** (Senior Manager- Application Design), **Mrs. Ujwala Prajapati** (Senior Manager- Application Design), **Mr. Phanendra Babu Rapelle** (Manager- Application Design), **Mr. Prasenjit Roy** (Associate Manager- Application Design),Crompton Greaves Consumer Electricals Limited for their valuable inputs and carrying out my project in Crompton Greaves Consumer Electricals Limited, Lighting Division, Mumbai (Head Office).

I am also very much thankful to **Crompton Greaves Team, Mumbai (Head Office)** for providing me their constant support during my internship which has helped in successful completion of the project. I would also like to express my sincere gratitude to **Management of Crompton Greaves Consumer Electricals Limited Lighting Division** for giving me an opportunity to carry out internship in their prestigious organization which has helped me in gaining valuable technical knowledge as well as industrial experience.

I would like to acknowledge my sincere thanks to **Parthasarathi Satvaya, Prof. (Dr.) Biswanath Roy, Asst. Prof. Mr. Suddhasatwa Chakraborty, Prof. (Dr.) Saswati Mazumdar, . Asst Prof. Mrs Sangita Sahana** from Department of Electrical Engineering, Jadavpur University for providing me the valuable suggestion and encouragement in carrying out this project work.

Again I would like to thank**, Mr. Pradip Pal and Mr. Gobinda Paul** from Electrical Engineering Dept. for their help to complete my project work. Last but not the least; I thank all of my friends who helped me directly in completing my thesis successfully.

Date - --

JADAVPUR UNIVERSITY **SOUMYAJIT BANERJEE**

Kolkata-700032 **Roll no- M6ILT23001**

Contents

CHAPTER-1

Foreword

1 FOREWORD

1.1 Motivation

Lighting serves as a vital element in our lives, offering numerous motivations for its importance and use. Lighting enables us to see and perceive the world around us. It provides the necessary illumination for our visual system to function optimally. By illuminating our surroundings, lighting allows us to recognize objects, colors, shapes, and depth, facilitating safe navigation and interaction with our environment. Adequate lighting is crucial for maintaining safety and security in various settings. Well-lit areas help prevent accidents, identify potential hazards, and minimize the risk of tripping, falling, or colliding with objects. In public spaces, effective lighting can deter criminal activity, improve surveillance, and create a sense of security. Lighting plays a significant role in supporting our ability to perform tasks effectively. Different activities require specific lighting conditions to ensure optimal visibility and accuracy. Whether it's reading, cooking, working, or engaging in hobbies, appropriate lighting helps reduce eye strain, enhances focus, and promotes efficient task completion. Lighting has a profound impact on our mood and emotional well-being. Different lighting levels, colors, and temperatures can evoke specific emotions and create varying atmospheres. Bright, cool-toned lighting can promote alertness and productivity, while warm, dim lighting can induce relaxation and a sense of comfort. Thoughtfully designed lighting can contribute to a positive and enjoyable environment. Lighting serves as a powerful tool for enhancing the aesthetics of spaces and objects. It can highlight architectural features, artwork, or decorative elements, creating focal points and visual interest. By manipulating light and shadow, different lighting techniques can add depth, texture, and drama to interiors, exteriors, and landscapes. With the growing emphasis on sustainability, energy-efficient lighting solutions have become increasingly important. LED (light-emitting diode) lighting, for instance, consumes significantly less energy compared to traditional incandescent bulbs, resulting in reduced energy costs and lower environmental impact. By adopting energy-efficient lighting practices, we can contribute to a greener and more sustainable future. Overall, lighting serves as a fundamental aspect of our daily lives, impacting our health, safety, productivity, emotions, and the aesthetics of our surroundings. By recognizing its importance and utilizing it effectively, we can create well-designed, functional, and visually pleasing environments.

1.2 Introduction

With the growing 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, a well-planned and efficient industrial lighting which would create easier seeing conditions and agreeable atmosphere. Good Industrial lighting plays a critical role in various industrial settings, such as factories, warehouses, manufacturing facilities, and construction sites. Safety is of paramount importance in industrial environments. Adequate lighting ensures that workers can see and navigate their surroundings safely, reducing the risk of accidents, injuries, and potential hazards. Properly illuminated work areas help identify potential dangers, machinery malfunctions, or spills, allowing for timely intervention and preventing accidents. Industrial activities often involve detailed and precise tasks that require good visibility. Effective lighting enhances visual acuity, enabling workers to perform their tasks accurately and efficiently. Whether it's assembly work, equipment operation, quality control, or maintenance, appropriate lighting levels and uniform illumination help minimize errors, improve productivity, and reduce downtime. Industrial work can be physically demanding, and proper lighting contributes to ergonomic considerations and employee well-being. Insufficient lighting can cause eye strain, fatigue, and discomfort, leading to decreased productivity and potential health issues. Well-designed lighting solutions that reduce glare, provide even illumination, and consider color rendering can enhance visual comfort and contribute to a healthier work environment. Industrial settings often require security measures to protect valuable assets, equipment, and inventory. Proper lighting can enhance surveillance systems by providing clear visibility, reducing blind spots, and enabling the identification of potential security threats or unauthorized access. Well-illuminated exterior areas also deter criminal activity and enhance the overall security of the premises. Industrial lighting systems typically consume a significant amount of energy due to the large spaces and long operational hours involved. Adopting energy-efficient lighting solutions, such as LED technology, can help reduce energy consumption, lower electricity costs, and decrease the environmental impact. Energy-efficient industrial lighting can lead to substantial long-term cost savings and contribute to sustainability initiatives. In this project typical coal handling plant indoor and outdoor important areas lighting design have been carried out with software simulation. Due to company norm & policy I couldn’t disclose the name of the plant designed by me.

1.3 Objective:

The objectives of this thesis

- To study the importance of industrial lighting.
- To study different areas of a typical coal handling plant and others industrial area
- Illumination design of a typical coal handling plant and others industrial area
  Using modern energy efficient LED lighting system.

CHAPTER-2

BACKGROUND THEORY

2 Background Theory

2.1 Details of Conventional light sources:

2.1.1 Incandescent Lamps:

Incandescent lamps operate based on the principle of incandescence.

- **Operational Features:** If an electric current is passed through a conductor, certain amount of energy is expended that appears as heat in the conductor. Heated body will give off a certain amount of light at temperatures over 525^{o} C (977 ^{o} F).A conductor heated above that temperature by an electric current will act as a light source.[5]
- **Types:** General Lighting Services – Lamp , i.e., Tungsten Filament Lamp
  Tungsten Halogen Lamp

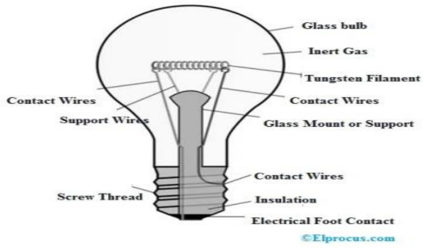


Fig 2.1: Incandescent Lamp

As shown in Fig 2.1 It is an incandescent lamp, commonly known as a light bulb, scientifically as Tungsten Filament lamp and Commercially as General Lighting Services (GLS) lamp. It is the simplest a form of electric light. Incandescent bulbs are so effective that they have been widely adopted around the world for all sorts of lighting applications.

2.1.2 Halogen Lamps:

A halogen lamp is a type of incandescent lamp that uses a halogen gas to increase its efficiency and lifespan compared to traditional incandescent lamps

- Operational Features: A halogen lamp is an incandescent lamp with a tungsten filament contained within an inert gas and a small amount of a halogen such as iodine or bromine. The combination of the halogen gas and the tungsten filament produces a chemical reaction known as a halogen cycle that increases the lifetime of the bulb and prevents its darkening by redepositing tungsten from the inside of the bulb back onto the filament.[5]

Fig 2.2: Halogen Lamp

2.1.3 **Fluorescent Lamps:**

Fluorescence lamp is an electric discharge source in which light is produced by the fluorescence of phosphors activated by Ultra Violet energy from a low pressure mercury arc. The efficiency of fluorescence lamp varies between 30 -100 Lumen /watt (excluding approximately 20% power loss at the Ballast which is required for starting and running of the lamp).

- Compact Fluorescent lamps (CFL): Miniature version of fluorescent lamps which is made to replace incandescent lamp. They are made of glass tubes filled with gas and a small amount of mercury. CFLs produce light when the mercury molecules are excited by electricity running between two electrodes in the base of the bulb. It can have integral ballast and can be retrofitted directly.[5]

2.1.4 **High-intensity discharge lamps:**

High Intensity Discharge (HID) lamps are electric discharge sources. The basic difference from Fluorescent lamp is that HID lamps operates at a much higher Arc Pressure. Spectral characteristics differ from those of Fluorescent lamps because the higher pressure arc exists a large portion of its visible light.HID lamp produce full light output only at full operating pressure usually several minutes after starting .Most HID lamps contain both an inner and a outer bulb. The inner bulb is made of quartz or poly crystalline aluminium , the outer bulb is generally of thermal shock resistant glass.HID lamps require current limiting devices which consume 10 – 20 % additional power . HID lamps include Mercury , Metal Halide , High Pressure Sodium and Low Pressure Sodium Vapour discharge lamps.[5]

- **Mercury Vapour Discharge Lamps:** A mercury-vapor lamp is a gas discharge lamp that uses mercury in an excited state to produce light. The arc discharge is generally confined to a small fused quartz arc tube mounted within a larger borosilicate glass bulb. The outer bulb may be clear or coated with a phosphor; in either case, the outer bulb provides thermal insulation, protection from ultraviolet radiation, and a convenient mounting for the fused quartz arc tube. Mercury vapor lamps (and their relatives) are often used because they are relatively efficient. Phosphor coated bulbs offer better color rendition than either high- or low-pressure sodium vapor lamps. Mercury vapor lamps also offer a very long lifetime, as well as intense lighting for several special purpose applications. All mercury vapor lamps has end of life Mercury hazard as well as UV radiation hazards during operation .Since efficiency is poor compared to Sodium vapour lamp et. It is going to be obsolete

- **Low-Pressure Mercury Lamps**: A low-pressure mercury lamp (LP Hg lamp) is a highly efficient UV light source of short wavelength. Classified as in the same group as fluorescent lamps or germicidal lamps, the main light emission is a 254nm line comprising an 185nm line of far shorter wavelength. Quite unlike LP mercury lamps, the high-pressure mercury lamps (HP Hg lamp) irradiate lights of many wavelengths including a visible light.

- **Metal Halide Lamps:** A metal-halide lamp is an electrical lamp that produces light by an electric arc through a gaseous mixture of vaporized mercury and metal halides (compounds of metals withbromine or iodine).

- **Low Pressure Sodium Vapour:** A Low-pressure sodium vapor lamps contains borosilicate glass gas discharge tube containing solid sodium, a small amount of neon, and argon gas in a Penning mixture to start the gas discharge. When the lamp is first started, it emits a dim red or pink light to warm the sodium metal; within a few minutes as the sodium metal vaporizes, the emission becomes the common bright yellow. This type of lamp uses sodium in presence of mercury in low pressure to emit monochromatic yellow light.

2.2 Details of Light Emitting Diode:

A light-emitting-diode lamp is a solid-state lamp free from Mercury, with instant switching capability, fully dimmable lamp is the upcoming source of lamp . LEDs providing over 200 lm/W (have been demonstrated in laboratory tests) , although average efficacy was still about 20-60 lm/W and expected lifetimes of around 50,000 hours are typical.Diodes use here are driven by direct current (DC) electrical power, so LED lamps must also include internal circuits to operate from standard AC voltage. LEDs are damaged by being run at higher temperatures, so LED lamps typically include heat management elements such as heat sinks and cooling fins. LED lamps offer long service life and high energy efficiency, but till time initial costs are much higher than those of fluorescent lamps.The color is characteristic of the energy bandgap of the semiconductor material used to make the LED. To emit white light from LEDs requires either mixing light from red, green, and blue LEDs, or using a phosphor to convert some of the light to other colors.The first method (RGB-LEDs) uses multiple LED chips each emitting a different wavelength in close proximity, to form the broad white light spectrum. The second method, phosphor converted LEDs (pcLEDs) uses one short wavelength LED (usually blue or ultraviolet) in combination with a phosphor, which absorbs a portion of the blue light and emits a broader spectrum of white light. (The mechanism is similar to the way a fluorescent lamp emits white light from a UV-illuminated phosphor.) The major advantage here is the low production cost, and high CRI, while the disadvantage is the inability to dynamically change the character of the light and the fact that phosphor conversion reduces the efficiency the device. The low cost and adequate performance makes it the most widely used technology for general lighting today.

- **Working Principle:** A P-N junction can convert absorbed light energy into a proportional electric current. The same process is reversed here (i.e. the P-N junction emits light when electrical energy is applied to it).This phenomenon is generally called electroluminescence, which can be defined as the emission of light from a semi-conductor under the influence of an electric field. The charge carriers recombine in a forward-biased P-N junction as the electrons cross from the N region and recombine with the holes existing in the P-region. Free electrons are in the conduction band of energy levels, while holes are in the valence energy band. Thus the energy level of the holes will be lesser than the energy levels of the electrons.

Some portion of the energy must be dissipated in order to recombine the electrons and the holes. This energy is emitted in the form of heat and light.

2.2.1 **Various technologies of led:**

- **Dual Inline Package (DIP):** 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. Fig 2.3 shows the a typical DIP chip.

Fig 2.3: DIP LED CHIP

- **Surface Mounted Diode(SMD):** Surface mounted device light emitting diodes (SMD LEDs) are the most common type of LED lights right now - these consist of a LED chip that is permanently fused to a printed circuit board, resulting in solid units that can be connected in a simple circuits to create various lighting configurations (including light bulbs and strip LED lights).Up to 3 diodes can be fused onto a single SMD chip - this gives SMD LEDs the ability to output a huge range of colors when a chip is built using blue, red and green diodes (while the old-style DIP LEDs are mono-colored).SMD LEDs are available in a range of dimensions - tuners might be familiar with the two most common sizes, SMD 3528 and SMD 5050; those are the two most common sizes used for 12V LED light strips.

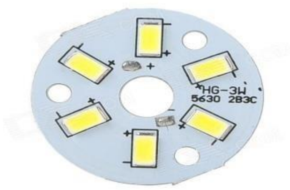


Fig 2.4: SMD LED CHIP

- **Chip On Board (COB):** Chip on board light emitting diodes, LEDs, are the newest type of LED lights to hit the market. Like SMD LEDs, COB LEDs consist of multiple diodes that are soldered directly onto a microchip, however, unlike SMDs, COBs typically use 9 or more diodes per chip - this produces a light that looks like a glowing panel (rather than a bunch of tiny little lights as with SMDs).COB LEDs are extremely ' heat efficient'; they produce very little heat, thanks in part to their cooling ceramic substrate. Unlike SMD LEDs, COB LEDs do not have the ability to emit different light colors, however, the light temperature (such as warm or cool) can be controlled.COB LEDs can produce a higher lumen-per-watt ratio in comparison to both SMD and DIP LEDs. COB LEDs use a single circuit and just two contacts, regardless of how many diodes are on each chip. Because they are relatively cheap to manufacture, consumers can look forward to lower prices on COB LEDs as production of this latest generation of LED lights ramps up.

Fig 2.5: COB LED CHIP

2.2.2 **Comparison between LED Chips:**

Table 2.1 Table explain the Comparison between Different Led Chips [5]

	SMD (Surface Mounted Diode) LED	**COB (Chip On Board) LED**
A	Low light intensity/ lumen efficiency (50-60 lm per watt)	High light intensity/ lumen efficiency (upto 120 lm per watt) **Nearly twice than SMD’s**
B	Are difficult to install & indulge high amount of labor & skilled man power in Manufacturing luminaries.	Are easy to install & hassle free in nature, thus require less labor & man power in Manufacturing luminaries.
C	require high amount of maintenance	are almost maintenance free
D	they can’t bear high junction temperature	they can bear high junction temperature
E	The slightest of power fluctuations can blow up the SMD’s	COB’s don’t fuse easily & can survive major power fluctuations
F	They get damaged easily & stop working	They work effectively even after rough handling
G	SMD’s radiate more heat as compared to COB’s	COB’s radiate less heat as compared to SMD’s
H	SMD’s are a very expensive source of lighting. Due to high amount of investment in labor & skilled manpower indulgence in manufacturing cost.	Compared to the SMD LED lights COB LED Lights are economic in nature. As they are easily manufactured, hence decrease manufacturing cost greatly. (approximately 15-20% cheaper than SMD LED’s)
I	Are usually laid down in circuit, even a single fault in line diffuses all the following LED’s in the fixture.	COB technology does not requires a circuit. Thus, it is unaffected & totally safe from this defect unlike the SMD’s.

J	Are not very much reliable, the damaged SMD's leave a spot or dead point in the whole layout fixture. Making it very awful to look.	Good reliability, the whole COB panel enlightens on receiving power thus no dead bulb and no spot caused unlike the SMD's.
K	SMD LED is fixed on small base PCB. Thus, radiates more heat which could not dissipate further easily increasing the junction temperature dangerously. Thus reducing the luminous efficiency and life span of LED fixture.	COB LED Lights use flat base aluminum COB packing technology: COB LED is fixed on aluminum layer of aluminum base PCB. The heat from chip is spread out through aluminum layer rapidly. Thus enabling to reduce LED Lights junction temperature, thus increasing the luminous efficiency and extend life.
L	SMD's emit unidirectional light in a single direction (in form of a straight beam) which makes them in-efficient for general lighting purposes as in flood lighting & street lights.	COB LED Lights emit out multi- directional light (i.e: uniform light in all directions) unlike the unidirectional lighting of SMD LED's. Which make them more efficient than the SMD lighting fixtures, .
M	Thermal resistances occurring in SMD's	Proper thermal management in COB's
N	Straight & Strong irradiancy (not safe)	Equable and soft irradiancy (safe)
O	Hard glaring and no eye Protection. SMD LED Lights proved that LED light source is too stimulating to the eye.	No glaring and proper eye Protection. COB LED Lights effectively solved the problem that LED light source is not too stimulating to the eye, paving the road area to large-scale application for road lighting.
P	Can't handle jarring & bumping	Can handle jarring & bumping
Q	Highly affected by rain & storm	Not affected by rain & storm
R	Generally IP 57 protection grading provided	Always above IP 65 protection grading provided
S	Not successful on Indian grounds.	Successful on Indian Grounds.

Table 2.1 explains the details comparison between SMD and COB based LED chip. If someone is looking for colour changeable interior exterior accent lighting SMD led is best option. If the requirement is maximum lumen per watt this feature available in COB led. SMD demands low maintenance cost COB have low productions cost but both these chips are energy efficient. In terms of heat emission COB produce better results compared to SMD led. Both this LED have a longer life span and can be used in different circumstances.

2.3 Ingress Protection (IP) Rating:

The degree of protection provided by the luminaries is classified according to the Ingress Protection code by the European Standard [BS EN IEC: 60529, 2001]. The IP system isaninternationally recognized method to indicate the degree of protection against the ingress of dust, solid objects and moisture into an enclosure.[12]

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 (explain in table 2.2)
- Number 2 indicates Protection from liquids (water) (explain in table 2.3)

Table 2.2 Values of first characteristic numerical and its protection level [12]

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

Table 2.3 Values of first second numerical and its protection level [12]

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

2.4 Correlated Colour Temperature And Colour Rendering Index:

- **Correlated Colour Temperature (CCT)**: The absolute temperature of a blackbody whose chromaticity most nearly resembles that of the light source is known as CCT of that light source. The correlated color temperature (CCT) is a specification of the color appearance of the light emitted by a lamp, relating its color to the color of light from a reference source when heated to a particular temperature, measured in degrees Kelvin (K). The CCT rating for a lamp is general "warmth" or "coolness" measure of its appearance.CCT of white light can be varied to get different appearance. As shown in fig 2.7 the visual understanding or difference between colour range as explain below.[7]

  - 2700-3500 K white light is termed as Warm White colour.
  - 4000 K white light is termed as —Natural White colour.
  - 5000 K white light is termed as —Daylight.
  - 6000-6500 K white light is termed as —Cool Daylight.

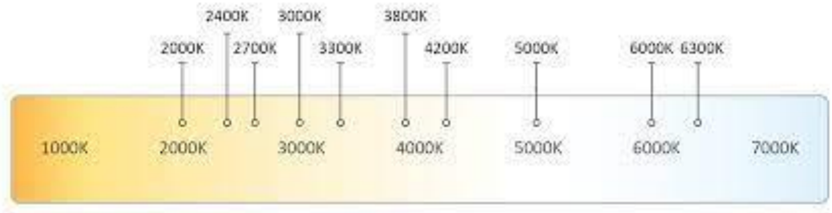


Fig 2.7: Understanding of CCT

- **Colour Rendering Index:** A measure of the degree to which the colour of surfaces illuminated by a given light source confirm to those of the same surfaces under a reference illuminant. Suitable allowance having been made for the state of chromatic adaptation.

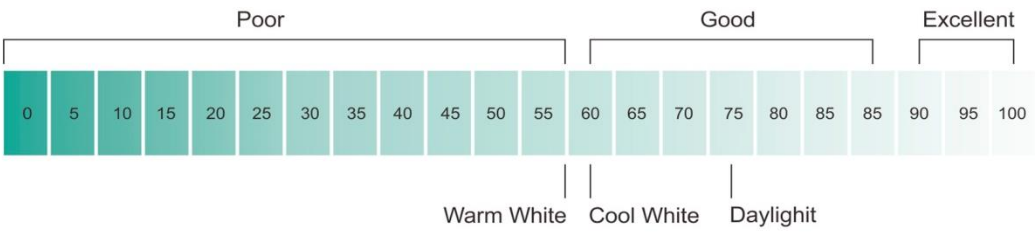


Fig 2.8: Understanding of CRI

Fig 2.8 shows the colour rendering index chart. As shown in this figure less than 55 cri is considered as poor CRI and 60-85 range considered as good CRI now a day's most of the LED available in this range of cri. Range of 90-100 considered as excellent CRI incandacent lamp has maximum CRI of 100

2.5 Maintenance Factor:

Ratio of the average illuminance on the working plane after a specified period of use of a lighting installation to the average illuminance obtained under the same conditions for a new installation.

RSMF (Room Surface Maintenance Factor): takes account of the effect of dirt and dust accumulation and other degradation of the reflectivity of the room surfaces. The main determining factor is the environment which can be classified on a sliding scale from Very Clean to Dirty.

LMF (Luminaire Maintenance Factor) : takes account of the effect of dust and dirt accumulation on the luminaire. Luminaires are classified according to their degree of sealing and their distribution, obviously dust accumulation on an open up light is far more onerous than on a sealed downlight.

LSF (Lamp Survival Factor): takes account of the effect of the failure of light sources during the maintenance period.

LLMF (Lamp Lumen Maintenance Factor): takes account of the effect of the lumen depreciation of the light sources during the maintenance period.

MF = LLMF x LSF x LMF x RSMF [13]

2.6 Utilization Factor:

Utilization Factor defined as the ratio of total lumens received on the working plane to the total lumens emitted by the light source.

Utilization factor = Lumens received on the working plane / Lumens emitted by the lamp

2.7 Lighting System:

Indoor commercial lighting can be divided by three domain explained in further studies.[2]

i. **General Lighting:** In general lighting scheme luminaries are provided by a regular array or following a pattern. In majority of installations general direct lighting is employed. It gives the required horizontal illumination level and uniformity in the entire areas. In such a system any place in office can be used as a workstation. The lighting arrangement need not be changed due to changes in office layout.

ii. **Localized General Lighting:** For this type of lighting luminaires are provided by an irregular pattern related to the working zones in offices. savings can be done by using localized general lighting. Localized- general lighting uses overhead fixtures in addition to ceiling fixtures to increase lighting levels for particular tasks. This type of illumination is used for those spaces or work areas that will require a high level of illumination, and it requires knowing the future location of each work station in advance of the design stage. The luminaries should be designed in such a way that it should give the recommended illumination level at workstation and correspondingly lower luminance in non-working areas/circulation areas. In circulation areas the lighting level can be reduced to 50% of level of illumination for visual task .Though this system can give substantial savings over general lighting. If the layout in working areas are changed then simultaneously luminaries arrangement need to be changed. This is one of the drawback for this type of lighting.

iii. **Local Lighting:** In this type of system lighting is provided by additional luminaries placed at a small distance from a visual task, which illuminate only a limited area. Say for example in office table for some specific task luminaire is provide from very small distance. One can turn and control the light as per their need

CHAPTER-3

LIGHTING DESIGN OBJECTIVE AND CRITERIA

3 Lighting Design objective and criteria

3.1 Introduction:

Lighting design objectives and criteria vary depending on the specific application and context.. In recent years, the lighting industry has struggled with two dominant forces: energy efficiency and light quality. With the advent of the lighting design profession, which places a high value on the quality of lighting, energy efficiency has also become a priority in building design. Initially, lighting designers faced a choice between attractive, well-lit spaces and low-energy spaces. These objectives and criteria provide a foundation for lighting designers to create well-designed lighting solutions that enhance the visual environment, support human needs, and align with the specific requirements of each project.

3.2 Lighting Design Objective:

3.2.1 Safety and Health:

Lighting design should prioritize safety by ensuring adequate visibility, especially in areas with potential hazards. Illumination should also contribute to the security of the space, deterring crime and providing a sense of safety.

3.2.2 Energy Efficiency:

Lighting design should aim to minimize energy consumption and reduce environmental impact. This can be achieved through the use of energy-efficient light sources, such as LED lighting, and implementing control systems to optimize lighting usage.

3.2.3 Visual Comfort:

Lighting should provide a visually comfortable environment, minimizing glare and excessive contrast. It should avoid causing visual fatigue or discomfort to occupants.

3.2.4 Adequate Illumination:

Lighting should provide sufficient light levels for the specific tasks or activities being performed in a space. This involves considering the appropriate illuminance levels and uniformity across the area.

3.2.5 Aesthetics and Mood:

Lighting can significantly influence the atmosphere and mood of a space. Designers consider the desired ambiance, architectural features, and the intended emotional response when selecting lighting fixtures and designing lighting schemes.

3.2.6 Cost Effectiveness:

Lighting design should balance the upfront and operational costs with the benefits gained. Evaluating the return on investment (ROI) of lighting solutions helps determine the most cost-effective options.

3.2.7 **Maintenance and Longevity:**

Lighting fixtures and systems should be designed for ease of maintenance, ensuring that lamps or luminaries can be replaced without significant disruption. Longevity and durability of components contribute to the overall lifecycle of the lighting system.

3.2.8 **Functionality and Flexibility:**

Lighting should support the functionality of the space and adapt to different activities or occasions. Incorporating adjustable or controllable lighting systems allows for flexibility in meeting different lighting needs.

3.2.9 **Sustainability:**

Consideration of sustainable lighting practices, such as using recyclable materials, reducing light pollution, and implementing daylight harvesting techniques, helps minimize the environmental impact of lighting systems.

3.2.10 **Compliance with Regulations and Standards:**

Lighting design must adhere to applicable building codes, safety regulations, and industry standards related to lighting quality, energy efficiency, and light pollution control.

In summary, lighting design is necessary to create visually comfortable, safe, aesthetically pleasing, and functional environments. It improves productivity, enhances experiences, and contributes to energy efficiency, sustainability, and human well-being.

3.3 Lighting Design Criteria:

3.3.1 **Average Illuminance (E_{avg}):**

The lighting of any work place should be both sufficient and suitable in terms of:

- Adequate quantity of light on the work tasks and surrounding area.
- The light should be such that it should not have any harmful effect on people's health and performance.

The code of practice for interior and industrial recommends illumination levels according to the tasks involved. They are mentioned in terms of the mean illumination levels throughout the maintenance cycle of lighting system and averaged over the relevant area. Relevant area may be the whole interior or just that occupied by tasks and immediate surroundings.[8]

3.3.2 **Overall Uniformity (U_O):**

As per code and standards uniformity of illuminance should be measured as the ratio between minimum illuminance to the average illuminance over the task area.

- An excessive variation in illuminance means that certain parts receive fewer illuminationsthan desired.

- Illuminance in the immediate surrounding can affect the visual performance and comfort.
- Uneven lighting can be termed as unsatisfactory lighting.

The code of practice for interior and industrial recommends overall Uniformity ratio should be greater than 0.6 and 0.4 respectively.

3.3.3 **Glare:**

Glare can be defined condition of vision in which there is discomfort or a reduction in the ability to see significant objects or both due to an unsuitable distribution or range of luminance or to extreme contrasts in space or time.[11]

Glare in the installation is defined by two different terms:

- Disability Glare: Disability Glare is the glare, which impairs the vision of objects without necessarily causingdiscomfort.

- Discomfort Glare: Discomfort Glare is the glare, which is distracting, annoying or uncomfortable but does significantly reduce the ability to perform visual tasks.

Degree of glare is measured in indoor application by **Unified Glare Ratio (UGR)**. It is expressed by the formula [9]:

$$UGR= 8\log (0.25/L_b)\ \Sigma_n (L^2\ \omega / P^2)$$

Where,

L_b: Luminance in the field of view (cd /m2) (not including luminaire luminance).
L: Luminance of a luminaire in the direction of an observer.
ω: Solid angle of a luminaire subtended to the observer.
P: Position index of a luminaire.
Degree of glare is measured in outdoor application by **Glare Rating (GR)**. It is expressed by the formula [9]:

$$GR =27 +24 \log [L_{vl} / (L_{ve})^{0.9}]$$

Where,

L_{vl}: The veiling luminance produced by the luminaires.
L_{ve}: The veiling luminance produced by the environment.

CHAPTER-4

LIGHTING DESIGN METHODOLOGY

4 Lighting Design Methodology

4.1 Introduction:

To achieve the best overall outcome in a lighting installation, it is important to avoid the tendency of rushing straight into luminaries 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 in the successful completion of the project. The assumptions made, the luminaries specifications and the tools used have also been mentioned in this chapter.

4.2 Input:

4.2.1 Drawing of the area given Plan and Elevation:

To initiate any lighting design it is essential to design the structure on software, and that structure should be 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.

4.2.2 Reflection property of given area:

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. For clean environment generally designer take higher reflection value in case of dusty area reflection value is on lower side.

4.2.3 Required Illumination Level:

This will help in deciding the illumination level for the particular type of application from Indian standards. Other than Indian standards some tender documents provided by the client they has their own specific requirement design parameter.

4.2.4 Layout and Height of obstruction:

This will help in to place luminaires in such a way that light is not obstructed by them and design becomes much more practical optimized. From AutoCAD layout we can get the height of machine or obstruction. It also helps determining the work plane height considerations for any particular area.

4.3 Method of Lighting:

A lighting engineer has to perform lighting calculations in order to give solutions that will satisfy the relevant lighting requirements. Lighting simulation software are being used for calculation and virtual rendering purpose. 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.

4.4 Selecting the Lighting Equipment:

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

The following parameter 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
- ❖ Aesthetic
- ❖ Size
- ❖ IP rating
- ❖ Thermal Management

4.5 Choice of Luminaries:

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

- ❖ Efficient 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 andancillary equipment.
- ❖ High light output ratio with the appropriate light distribution.
- ❖ Ease of installation, cleaning and maintenance.

4.6 Design Tools:

I. **DIALux:** DIALux is 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 4.13 enables us to enjoy complete freedom for designing, whether it is an Indoor Area, or an Industrial Shed or an Exterior area.

II. **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 aswell.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.

III. **AGI-32:** 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 arerequired 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 wellto 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.

IV. **Luxmeter:** It is an instrument used to measure the illumination level at different points in working area. A proper calibrated lux meter was used for carrying out the lighting audit. Lux meter is required for the post installation audit when client want to verify the design lux level with actual site value.

4.7 Design Methodology:

4.7.1 Site Survey and Discussion:

For any lighting designer, the first 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 space would serve for, and hence to have an idea about what needs to be done.

4.7.2 Obtaining and study 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 help in proper selection and arrangement of the luminaire.

4.7.3 Study of guidelines:

Study the relevant codes, guide lines in detail. For indoor lighting design IS3646.1992 (Part I & Part II), National lighting code IS.SP.72.2010, Road lighting design IS1944, Industrial lighting design IS: 6665-1972, Airport apron lighting design IS:11116-1984 are referred. For LPD calculation ECBC 2009 is referred.

4.7.4 Design as per Autocad 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.

4.7.5 Selection of Luminaires:

Being a lighting designer the most important part is to choose the luminaire as per the design need. Costing of luminaire should consider during choice of luminaire. By this selective choice design can be cost effective. The choice of luminaire vary from application to application.

4.7.6 Analysis of result:

If the simulation does not comply with the standards, or if the client asks for a specific requirement, a review is done on that and redesigning is done until the standards are met, and the client is satisfied.

4.8 Design Process:

4.8.1 Design Process for Indoor Area:

- **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 e.t.c.

- **Deciding the illuminance level required:**Once the area type and task to be performed decided then as per IS 3646 recommendation illuminance level required can be found out.

- **Find the dimension of the room:** After import 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.

- **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.

- **Selecting the Maintaince Factor:** Maintenance factor is chosen as discussed earlier otherwise mentioned by the client. Generally for conventional light sources we consider maintenance factor 0.7 and for LED light sources 0.8.

- **Selecting the Reflection Factors:** Depending upon the area we have to select the reflectance factors of the room. For office area or for clean 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% respectively.

- **Deciding The Workplane Height:** Depending upon the task to be performed 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.

- **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.

- **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.

- **Output Analysis:** 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.

4.8.2 Design Process for Street Lighting:

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 as it is.Incase of street lighting instead of finding out the number of luminaires as in case of indoor or exterior lighting, the spacing between the luminaires is calculated. Once the spacing is known them 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 4.13 are as under.[10]

- **Deciding the type of road as per standrad:** Based on the road location and type of traffic, whether the road belongs to Group A or Group B is decided.
- **Deciding the illuminance level required:** Once the road type is decided then as per IS 1944 recommendation illumination level and uniformity can be found out
- **Find the width of the road:** From the drawing of the road the width of road can be decided. Once the road is found out, then the type of lighting arrangement can be decided.
- **Selecting the Maintaince Factor:** Maintenance factor is chosen as discussed earlier otherwise mentioned by the client. Generally for conventional light sources we consider maintenance factor 0.7 and for LED light sources 0.8.
- **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.
- **Deciding The Pole Height:** 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
- **Selecting The luminaire:** There is no hard and fast rule for selecting the luminaires . Depending on the customers liking this is selected. Now a days the LED luminaires are the common light sources for street lighting.
- **Deciding the pole arrangement:** Followed by the above steps we have to decide the pole arrangement i.e. whether it is single sided, opposite, staggered or central verge. For doing this in DIALux we have to select street light arrangement option. For central verge arrangement we have select luminaires per pole quantity two unlike other arrangement and pole will be on median.

- **Deciding 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 meter. Normally the angle of tilt should be 0, 10 and 15 degree 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.

- **Deciding the spacing between luminaires:** To achieve good uniformity as per IS 1944 standard we have to decide spacing between two poles. Normally the spacing between poles is minimum three times to the mounting height but this is not the hard and fast rule to be followed by the designer.

- **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.

- **Output Analysis:** 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 uniformity for the specific road.

- **Finding the 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.

4.8.3 Design Process for Exterior Area:

Exterior area design is done by AGi32 software. Here airport exterior area e.g. apron, car parking, entrance, area lighting, sports lighting has been done with software. The steps involved in exterior area lighting are as under.

- **Deciding the task specific area:** In the first step after having AutoCAD layout we have to identify the type of work to be done e.g. whether it is apron area or car parking area e.t.c.

- **Find 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.

- **Selecting the Maintaince Factor:** Maintenance factor is chosen as discussed earlier otherwise mentioned by the client. Generally for conventional light sources we consider maintenance factor 0.7 and for LED light sources 0.8 and sometime 0.85

- **Selecting The luminaire:** Luminaire is chosen based upon the task performed in the area, area type illumination level required. Generally in outdoor area we use flood light. Depending upon illuminance required we have to select suitable wattage of the lamps. Depending upon the area dimension beam angle of luminaire is selected. To select the luminaire we have to select luminaire from luminaire selection option in the software.

- **Deciding the Mounting Height:** Depending upon illuminance required high mast height should be selected. High mast height should be 12,16,20,25,30m as per industry standard. One mast can cover area 2.5 times of mounting height.

- **Aiming of luminaire:** 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). So giving tilt and orient is very much important

- **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.

- **Output Analysis:** Unlike DIALux in AGi32 software we can view simultaneously result in case of any change in high mast location, height or change of luminaries tilt. To view output we have select statistics window. There we can find average illuminance, uniformity.

CHAPTER-5

OVERVIEW OF INDUSTIAL LIGHTING CONCEPT

5 Overview of Industrial Lighting Concept

5.1 Introduction

Industrial area lighting refers to the lighting systems used in industrial facilities, such as manufacturing plants, warehouses, factories, and other large-scale industrial complexes. Proper lighting in industrial areas is crucial for ensuring a safe and productive working environment.

5.2 General Features in Industrial Area

- **Lighting levels:** Industrial areas typically require higher lighting levels compared to other environments due to the nature of the work being carried out. The lighting should provide sufficient illumination for workers to perform their tasks safely and effectively. Lighting levels are often measured in lux.

- **Energy efficiency:** Industrial area lighting should aim to be energy-efficient to reduce operational costs and environmental impact. This can be achieved through the use of energy-efficient lighting technologies such as LED (light-emitting diode) lighting. LED lights have longer lifespans, consume less energy, and provide better quality lighting compared to traditional lighting options like fluorescent or high-intensity discharge (HID) lamps.

- **Uniformity and glare control:** Lighting should be designed to provide uniform illumination across the entire industrial area, minimizing areas of high contrast and shadows. Glare control is also essential to prevent discomfort and visual impairment for workers. Properly designed fixtures, shields, and diffusers can help minimize glare.

- **Durability and ruggedness:** Industrial environments are often harsh, with high levels of dust, vibrations, and potential exposure to chemicals or moisture. Lighting fixtures should be durable and designed to withstand such conditions. Look for fixtures with appropriate IP (Ingress Protection) ratings to ensure they are suitable for the specific environment.

- **Safety considerations**: Safety is a crucial aspect of industrial area lighting. Emergency lighting should be in place to provide illumination in case of power failures or emergencies. Additionally, proper lighting should be provided for areas with potential hazards, such as staircases, ramps, walkways, and areas with heavy machinery.

- **Lighting controls**: Implementing lighting controls, such as occupancy sensors or daylight sensors, can help optimize energy usage and reduce unnecessary lighting when areas are not in use. Dimming controls can also be employed to adjust lighting levels based on specific tasks or time of day.

- **Maintenance and reliability:** Industrial area lighting systems should be designed for easy maintenance and repair. Accessible fixtures, replaceable components, and reliable wiring systems can help minimize downtime and maintenance costs.

5.3 Lighting Related to Structure of industrial Premises

A. **High bay Halls:** Generally high roofing is provided in factory interiors where sufficient clearance for large workpieces handled in the particular factory is required or where overhead travelling crane is provided or where fumes and smoke have to be carried off. The artificial lighting has to be located at a greater height in the roof structure to allow unobstructed manipulation of crane.While for low and medium mounting height mid bay or low bay lighting is an immediate choice, for highbay lighting it may sometimes be more advantageous to use less number of high lumen LED luminaries. Due to high mounting the horizontal illumination is much more than the vertical illumination. To improved the lighting sometimes additional fittings like flood light is used at lower height from column or sheer wall.[2]

FIG 5.1: High bay hall In Industry

B. **Closed Ceiling:** In this type of construction there is very little dependence on day lighting which is mainly from side windows and is inadequate. The artificial lighting has to be designed purely on the needs of the nature of work, layout of machinery, etc. Where false ceiling is provided, the lighting fittings may be recessed in the false ceiling giving a more streamlined appearance to the whole installation. Generally a continuous mounting of the fittings is to be preferred. Tube fitting is preferred in closed ceiling to achieve better vertical luminance. It is generally desired from the user's point of view that the fittings should, as far as possible, be fixed to the existing members in the roof structure like the bottom members of the trusses or longitudinal tie members, etc. The fittings have to be oriented according to the layout of the machinery to obtain most satisfactory seeing conditions. The trunking system which is essentially metal channels with cover plates at the bottom, of standard lengths joined together, is run across the hall with suspensions at necessary intervals. Incidentally, this minimizes the number of suspension points compared to individually mounted fittings each with two suspension pipes. The wiring is run through the trunking itself and the fittings are attached to the trunking at the required locations

FIG 5.2: Closed Hall In Industry

C. **<u>Factory Spaces With Skylights:</u>** Day lighting is given due consideration in the design of a building, the shape of the building is primarily determined by this requirement. The working area is also planned on the basis of day lighting. While planning the artificial lighting the layout of the lighting fittings has to be related to the layout of the working area so as to obtain the most favorable lighting effect for comfortable working. Where the lighting can be integrated with natural shape and structure of the building while still meeting the requirements of lighting effect on the working place, a better result can be achieved. The trend is noticeable in our country in many industrial buildings where instead of the artificial lighting building has rectangular or circular cutout or other designs like shelled roofing, etc, have been adopted.

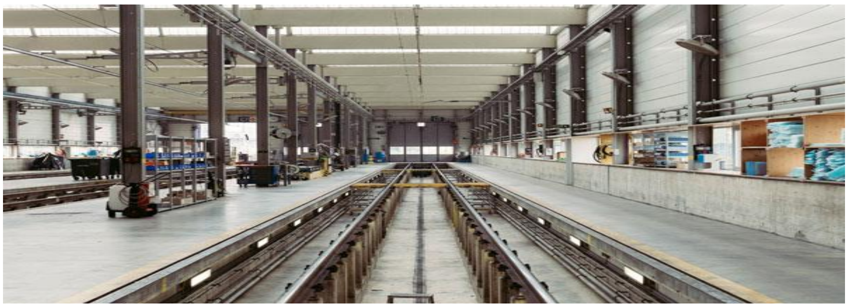


FIG 5.3: Daylight Integrated in Industry

Day lighting is given due consideration in the design oa building, the shape of the building is primarily determined by this requirement. The working area is also planned on the basis of day lighting. While planning the artificial lighting the layout of the lighting fittings has to be related to the layout of the working area so as to obtain the most favorable lighting effect for comfortable working. Where the lighting can be integrated with natural shape and structure of the building while still meeting the requirements of lighting effect on the working place, a better result can be achieved. The trend is noticeable in our country in many industrial buildings where instead of the artificial lighting building has rectangular or circular cutout or other designs like shelled roofing, etc, have been adopted.

5.4 Luminaries For Industrial Lighting:

When it comes to selecting luminaries for industrial lighting, several factors need to be considered, including the specific requirements of the industrial area, lighting levels, energy efficiency, durability, and safety. Here are some common types of luminaries used for industrial lighting.

- **High-Bay Luminaires:** High-bay luminaires are designed for illuminating large open spaces with high ceilings, such as warehouses or manufacturing facilities. They provide powerful, uniform illumination from a higher mounting position. High-bay luminaires are typically equipped with high-intensity discharge (HID) lamps or LED modules to deliver high lumen output and energy efficiency.

FIG 5.4: High-bay Luminaire

- **Low-Bay Luminaires:** Low-Bay Luminaires: Low-bay luminaires are suitable for areas with lower ceiling heights, such as assembly lines or smaller workshops. They provide efficient and evenly distributed lighting for tasks performed at lower heights. These luminaires can be surface-mounted or suspended, depending on the ceiling height and layout.

FIG 5.5: Well Glass

- **Floodlights:** Floodlights are used to illuminate outdoor industrial areas, such as loading docks, storage yards, or parking lots. They are designed to provide wide-angle lighting with high lumen output to cover large areas effectively. Floodlights are available with various lamp types, including metal halide, high-pressure sodium, or LED.

FIG 5.6:Floodlight

- **Linear Luminaires:** Linear luminaires, such as strip lights or linear LED fixtures, are commonly used in industrial areas that require continuous lighting along workbenches, production lines, or conveyor belts. These luminaires offer versatility, can be easily mounted, and provide focused illumination for specific tasks.

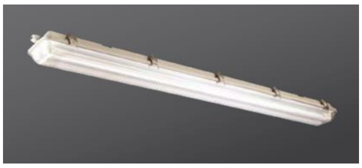


FIG 5.7:Industrial Batten

- **Flameproof Luminaires:** In hazardous industrial environments where there is a risk of flammable gases or dust, explosion-proof luminaires are essential. These luminaires are designed with robust enclosures and specially engineered seals to prevent the ignition of hazardous substances. They are typically used in oil refineries, chemical plants, or mining operations.

FIG 5.8:Flameproof Floodlight

- **Street Luminaires:** In external area or in internal street where security is an important aspect and moving of truck or other vehicle is necessary street light luminaire is mounted on pole.pole height must be on higher side to avoid obstruction of moving vechile.

FIG 5.8:Street Light

5.5 Benefit and challenges of LED in industrial lighting:

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.

5.5.1 Technical 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. 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.

5.5.2 Economical Benefit:

- **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.

For any Industry capital expenditure (cap-ex) and operational expenditure (op-ex) are two very important factor. Every industry tries to minimize the operational cost for profit. So here LED 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.

CHAPTER-6

Illumination design of Coal handling plant

6 Illumination design of Coal handling Plant

6.1 Overview of Coal Handling Plant:

In a coal based thermal power plant, the initial process in the power generation is "Coal Handling". Coal requirements per day of a large thermal plant are very large. A 600 MW power plant handles about 7200 tons of coal per day. Therefore, one of the major requirements of a power plant is to reduce the cost of handling of coal from the point of its origin up to the furnace of boiler where it is burnt. So proper handling of coal is very much important for a smooth generation of electricity. Various steps involved in a coal handling system as shown in block diagram.[1]

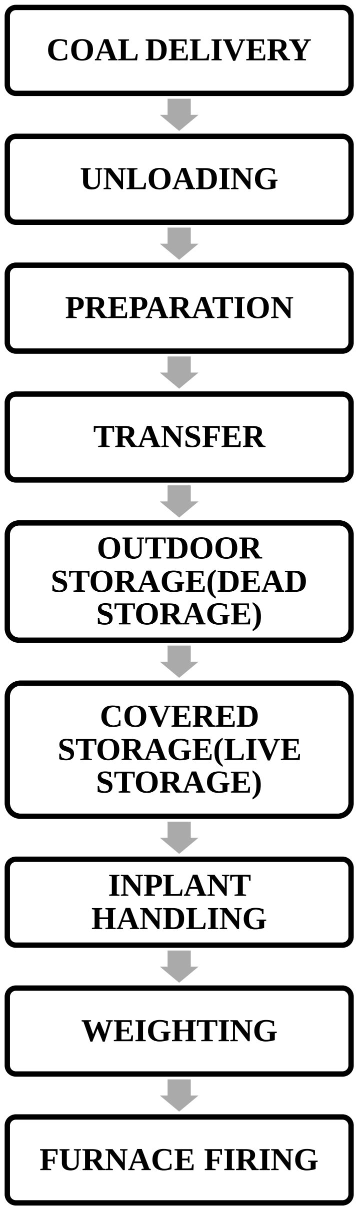


Figure 6.1: Block Diagram of a Coal Handling Plant [1]

6.2 Process of Coal Handling:

- **Coal Delivery:** The coal from mines is transported by ships or boats or by rail transport depending on the location of power plant and the cost of transport involved. In certain cases the transport of coal by trucks is also used where the rail facilities are not available. Transport of coal by rope ways is also used if the distance between the mines and power station is less than 10 km. Below Fig 6.2 Explain the process of Coal Delivery technique

Figure 6.2: Coal Delivery by road and railway [1]

- **Coal Unloading:** Unloading of coal at site depends on the mode of transport used for transportation of coal to power plants.
  In case of coal is brought by railway wagons the equipments used are car shakes, rotary car dumpers for unloading from closed wagons, cranes, grab buckets and coal accelerators.
  If the coal is delivered by trucks, there is no need of unloading device as the trucks may dump the coal to the outdoor storage. As shown in below fig 6.3 it explain how coal is unloaded with the help of wagon tipper and truck with scoop

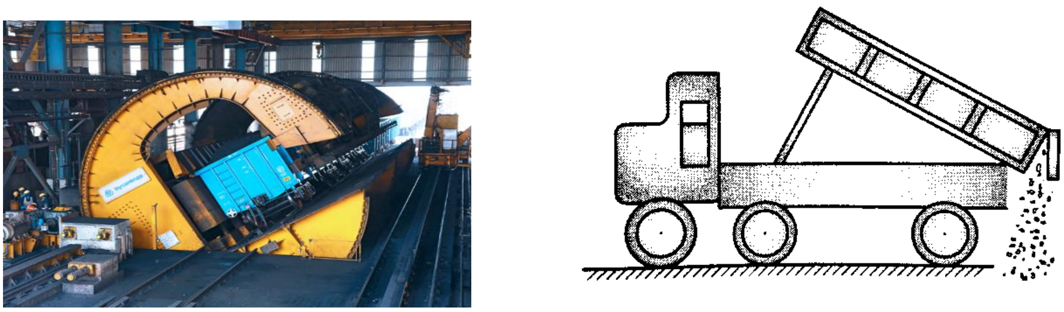


Figure 6.3: Coal Unloading by Wagon tipper and Scoop Truck [1]

- **Preparation of Coal:** If the coal received from mines is of different sizes then it is not suitable for feeding into furnace of the boiler. In such a case, the coal is prepared into required size by crushers. The crushed coal is passed through sizers which removes the coal of bigger size than required. The process known as coal crushing. Crushers and pulverizes are commonly used for this purpose. Coal screens are used to separate coal particles of different sizes. By this process the plant can ensure that only the desired size of coal is sent for further processing, while the oversized or undersized particles are redirected for re-crushing or removal. In some cases, coal washing or beneficiation processes are employed to remove impurities from the coal, such as sulfur, ash, and rock debris. This helps improve the quality of the coal and its combustion efficiency.

- **Transfer of Coal:** After preparation of coal, it is transferred from the site of preparation of coal to dead storage by means of various equipments like belt conveyors, screw conveyors, grab bucket conveyors, bucket elevators. These conveyors help in maintaining a continuous flow of coal during the handling process.

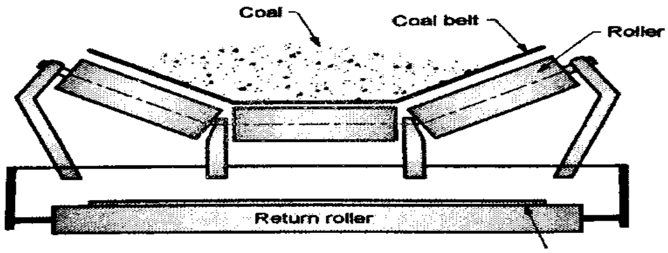


Figure 6.4: Typical Belt Conveyor [1]

- **Coal Storage:** Coal is often delivered to the plant by rail or truck and stored in stockpiles or silos. This allows for a continuous supply of coal, even during transportation interruptions.
  The purpose of coal storage is-
  To store the coal for a period of 30 to 80 days so that the plant is never required to be shut-down due to failure of supplies of coal from the place of origin or due to transport problems.

  Method of coal storage is-

➢ **Outdoor coal storage:** In the outdoor storage or dead storage, the coal is usually kept on ground in the form of a pile exposed to outside weather. The coal is required to be protected from deterioration and weathering.

➢ **Closed or live storage:** In the closed or live storage the coal is stored for one or two day's requirement of the power plant. This storage is used for the purpose of supplying the coal to the combustion equipment with negligible handling. The coal is usually stored in the

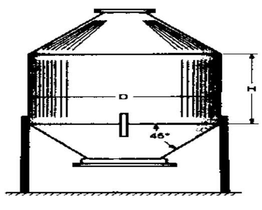


Figure 6.5: Coal Bunker

vertical cylinder bunkers or coal bins. Coal from bunkers is transferred to the boiler combustion chamber.

6.3 Detail case Study of Different areas in Coal Handling Plant

➢ Objective

- Ensure safety and security inside the area.
- Proper utilization of light on the working plane and walking areas, so that every single detail is properly visible.
- Depending upon the application, parameters like illuminance level, uniformity must meet the criteria

Due to limited Scope of the Project the some of the major areas are considered under case study for this project. These are: Unloading Areas, Storage Area, Belt Conveyor, Junction House , Crushers House, Transfer Points, Exterior Road

6.3.1 **BELT CONVEYOR:**

Belt conveyors help in the transportation of large volumes of coal over long distances.

Design Aim:

To illuminate one of the conveyor belts and walkways around the conveyor. The uniformity of the designed light level must have the desired value. Lighting will provide comfort to the eyes and not create too much glare.

- Required Average illuminance level: Average 50 Lux [11]

Typical Design of Belt conveyor:

Considering one of the belt conveyor for better understanding. DIALux software is used for the simulation purpose:

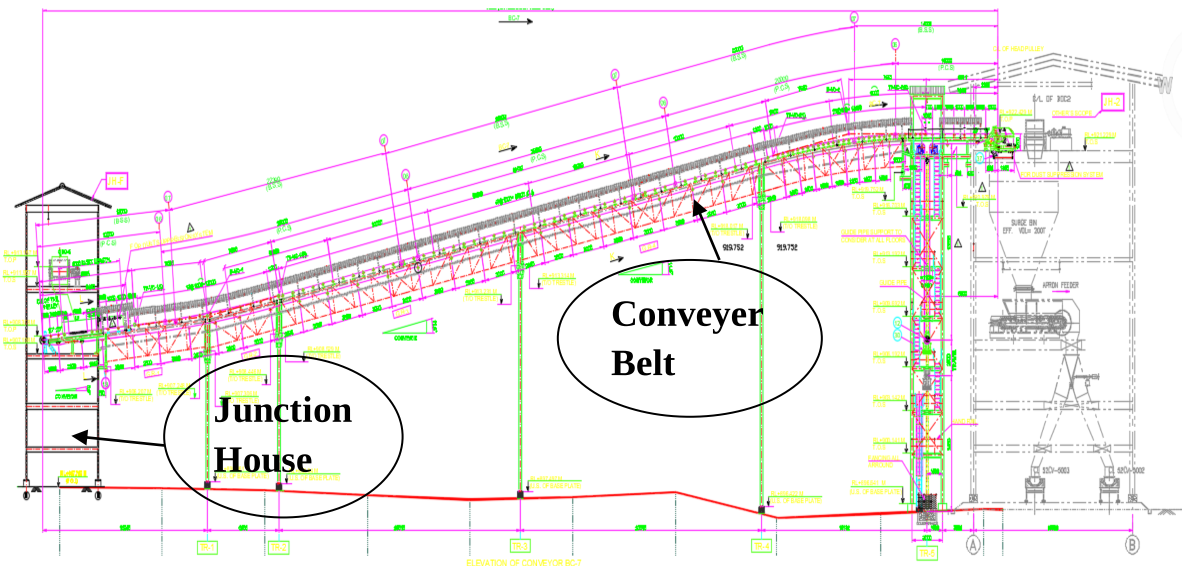


Figure 6.6: Elevation of Belt Conveyor

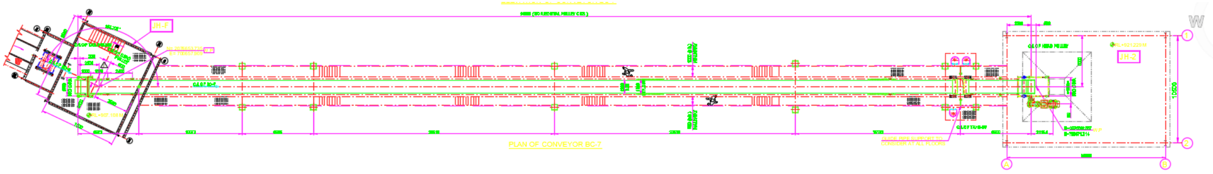


Figure 6.7: Plan of Belt Conveyor

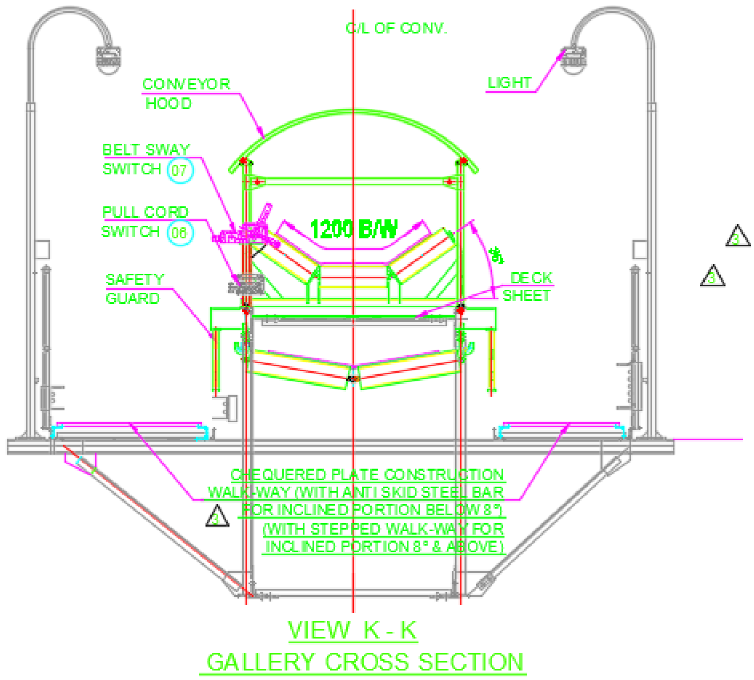


Figure 6.8: Cross Section view of a belt conveyor

Above Fig 6.6 shows the elevation details of a typical belt conveyor. It shows the how the belt conveyor is elevated along with junction house on both side. The plan view is shown on fig 6.7 and cross section details shows in figure 6.8 from section view one can get the mounting height of luminaire.

Luminaire used:

- Circular Pressure Die Cast Aluminum housing LED Well glass
- Luminous flux: 4400 Lumen
- Wattage: 40 Watt
- System efficacy: 110 lm/W

- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected

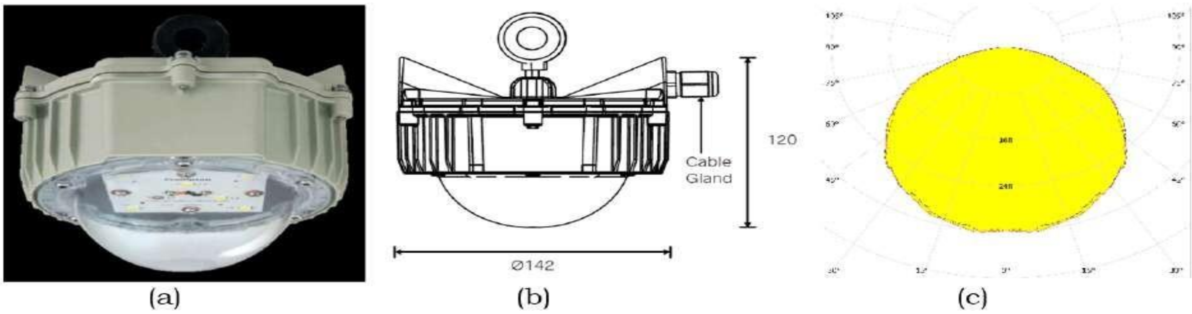


Figure 6.9: (a) Well Glass image (b) Well glass dimension (c) Polar curve

Figure 6.9 shows a typical well glass type luminaire made of PDC housing and its intensity distribution whose beam angle is 120 degree.

Design Consideration:

- Number of Luminaries: 10
- Mounting height: 3m from floor level
- Maintenance factor: 0.6
- Reflectance Factor(ceiling/wall/floor) Respectively: 0/0/10

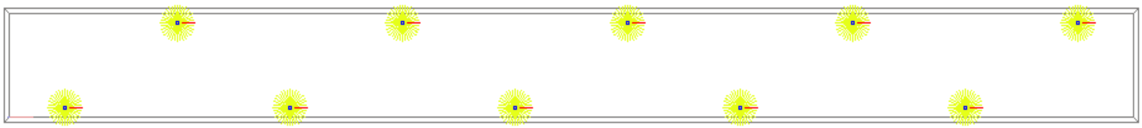


Figure 6.9: DIALux simulation of a typical conveyor belt

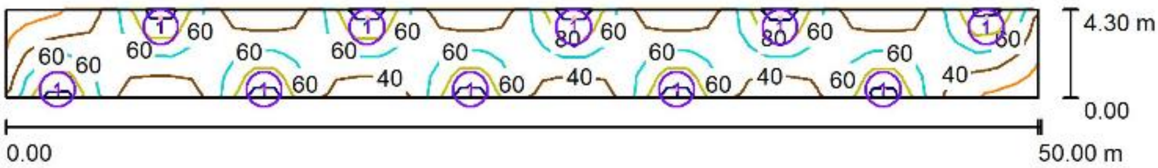


Figure 6.10: Isolines and value chart of a typical conveyor belt

Result Overview:

Table 6.1: Simulated output report of Belt Conveyor

E_{av}[Lx)	E_{min}[Lx]	E_{max}[Lx]	U_0
56	16	109	0.276

DIALux simulation of the belt conveyor area is based on positioning the light fixture in a staggered arrangement to achieve recommended illumination level. Table 6.1 shows the simulation report of Typical Belt conveyor area.

6.3.2 **CRUSHER HOUSE:**

The crusher house in a thermal power plant is responsible for crushing raw coal into a fine powder to increase the efficiency of the coal which is then transported to the boiler and burned to generate steam and electricity.

Design Aim:

To provide illumination on walkways around the conveyor and crusher house .The uniformity of the designed light level must have the desired value. Lighting will provide comfort to the eyes and not create too much glare.

- Required illuminance level: Average 150 Lux [11]

Typical Design of Crusher House:

Considering one of the Crusher house for better understanding. DIALux software is used for the simulation purpose.

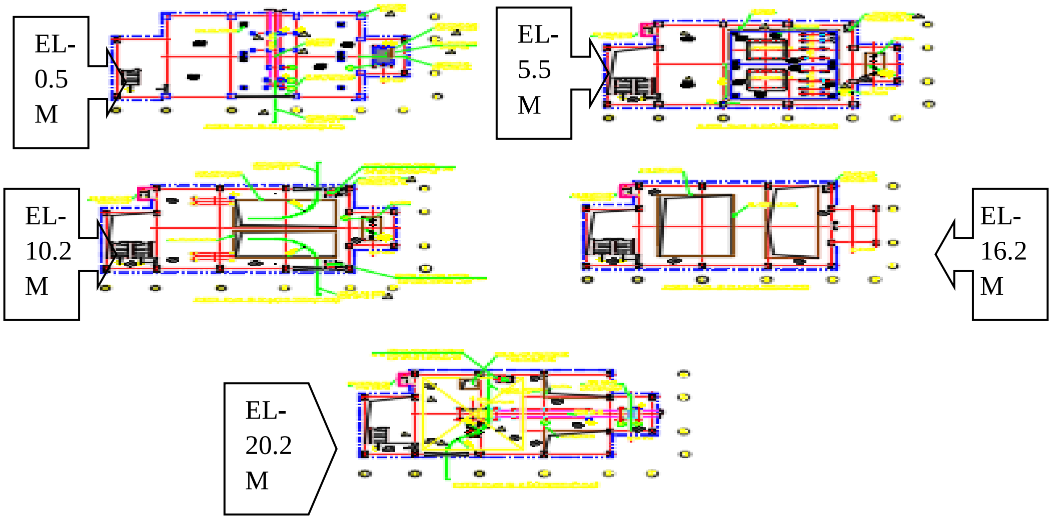


Figure 6.11: Plan details of Crusher House

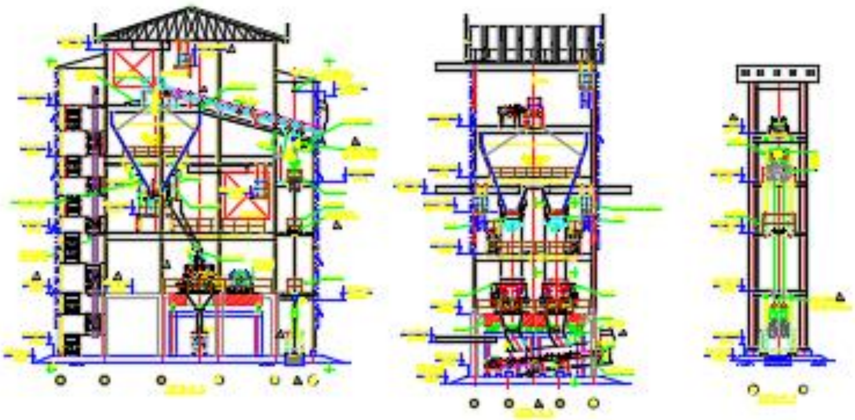


Figure 6.12: Elevation details of Crusher House

As shown in fig 6.11 crusher building has five levels, each level design procedure is described further. From Fig 6.12 one can get the elevation details or say mounting height of the luminaire. Each level is illuminated as per NTPC Standard, obstruction are taking into consideration for simulation purpose.

For Elevation (+) 0.500M:

Luminaries used:

- Circular PDC Aluminum housing LED Well glass
- Luminous flux: 4400 Lumen
- Wattage: 40 Watt
- System efficacy: 110 lm/W
- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected

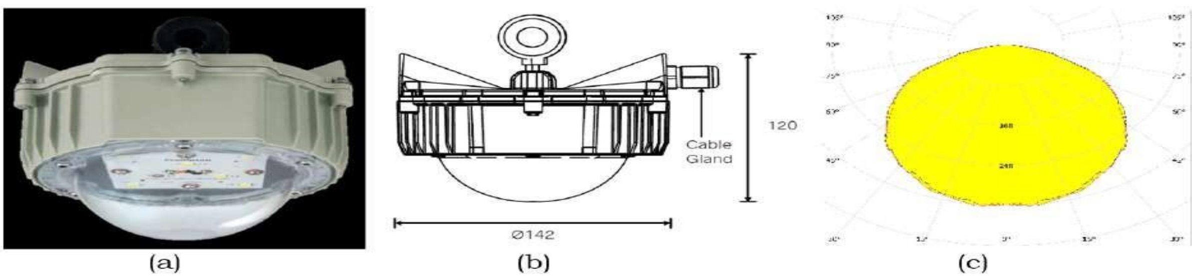


Figure 6.13: (a) Well Glass image (b) Well glass dimension (c) Polar curve

Figure 6.13 shows a typical well glass type luminaire made of PDC housing and its intensity distribution whose beam angle is 120 degree.

Design Consideration:

- Number of Luminaries: 20
- Mounting height: 4.6m from floor level
- Maintenance factor: 0.5
- Reflectance Factor(ceiling/wall/floor) Respectively: 30/30/10

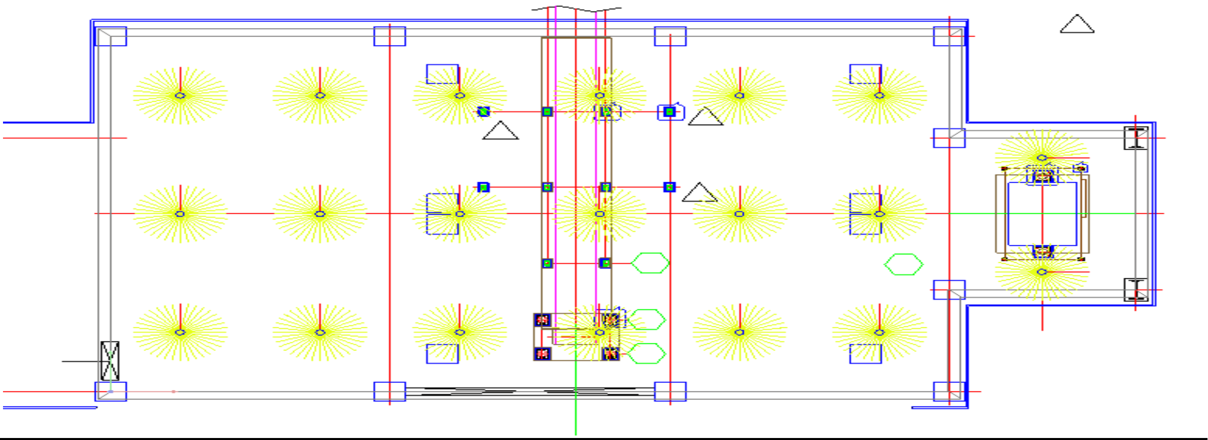


Figure 6.14: Simulated Layout of Crusher House EL (+)0.500M

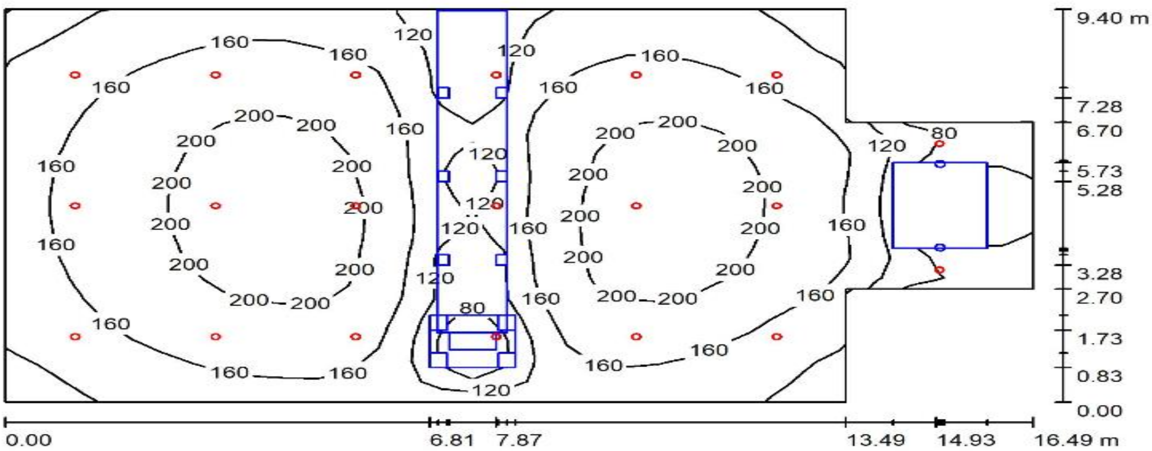


Figure 6.15: Isolines and value chart of a Crusher House EL (+)0.500M

Result Overview:

Table 6.2: Simulated output report of of a Crusher House EL (+)0.500M

E_{av}[Lx)	E_{min}[Lx]	E_{max}[Lx]	U_0
158	25	218	0.160

As shown in fig 6.14 DIALux simulation of Elevation 0.5m is based on positioning the light fixture in a uniform arrangement to achieve recommended illumination level. Fig 6.15 shows the values in workplane .Table 6.2 shows the simulation report of Level 0.500 m . 3D simulation view and false colour rendering is shown in fig 6.16.

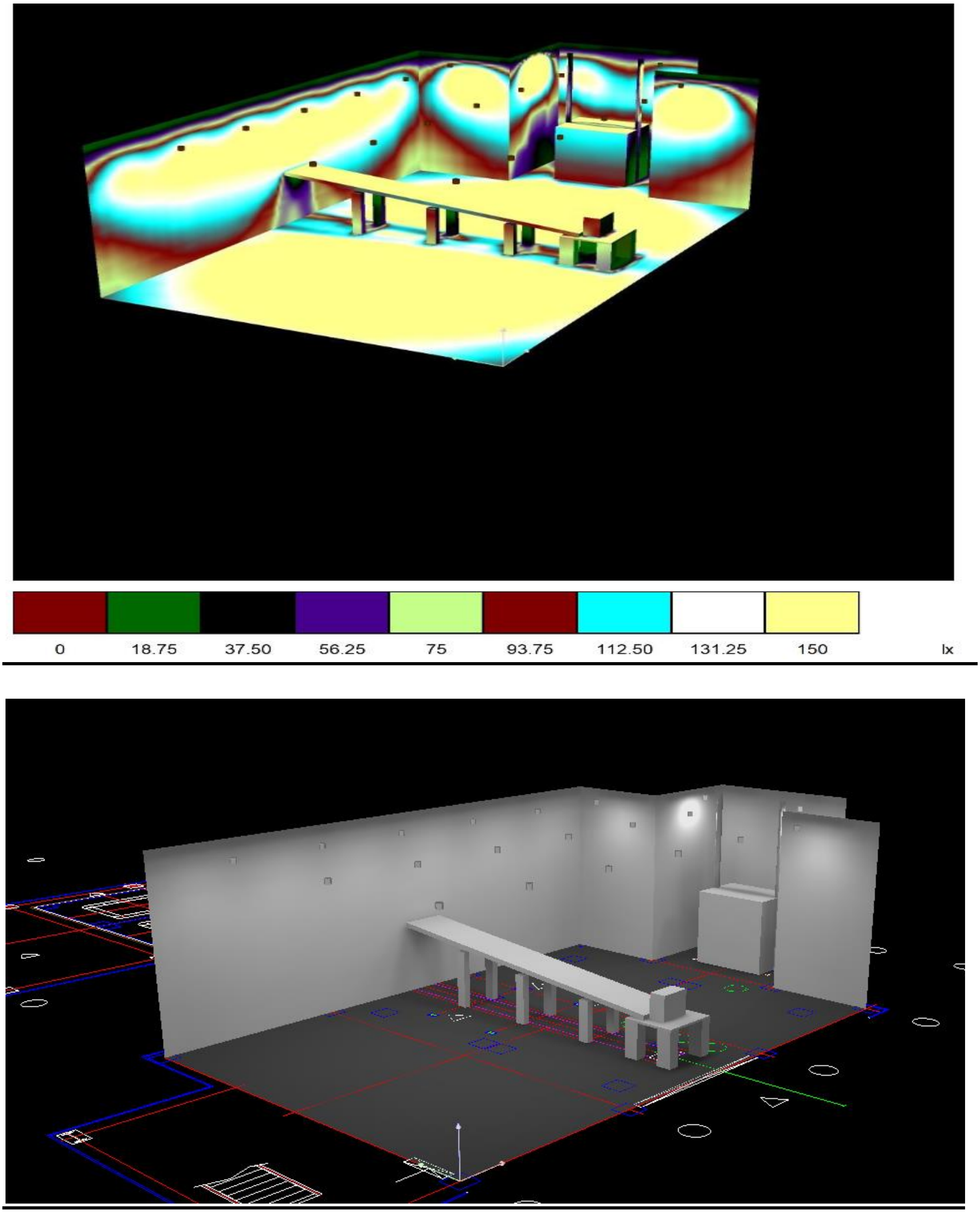


Figure 6.16: Simulated 3D view of Crusher House EL (+)0.500M

For Elevation (+)5.500M:

Luminaries used:

- Circular PDC Aluminum housing LED Well glass (as shown in fig.)
- Luminous flux: 3850 Lumen
- Wattage: 35 Watt
- System efficacy: 110 lm/W
- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected

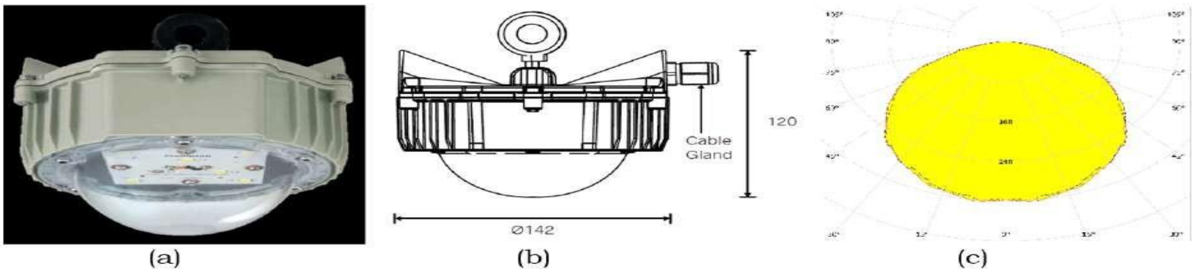


Figure 6.17: (a) Well Glass image (b) Well glass dimension (c) Polar curve

Figure 6.17 shows a typical well glass type luminaire made of PDC housing and its intensity distribution whose beam angle is 120 degree.

Design Consideration:

- Number of Luminaries: 24
- Mounting height: 4.2m from floor level
- Maintenance factor: 0.5
- Reflectance Factor(ceiling/wall/floor) Respectively: 30/30/10

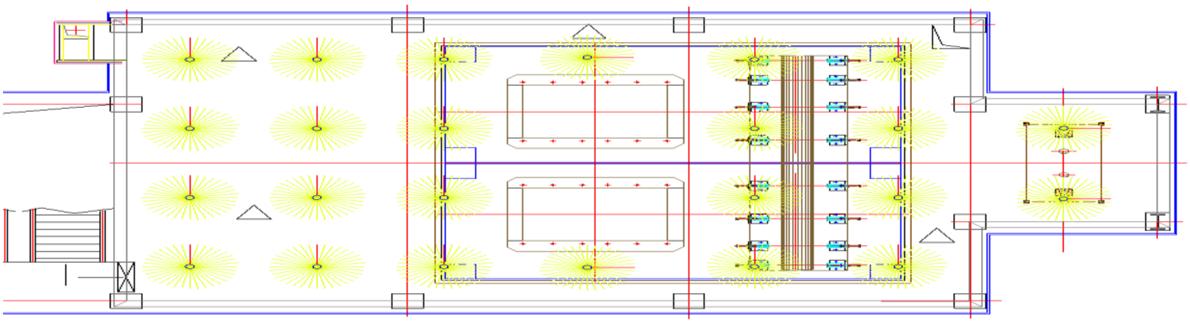


Figure 6.18: Simulated Layout of Crusher House EL (+) 5.500M

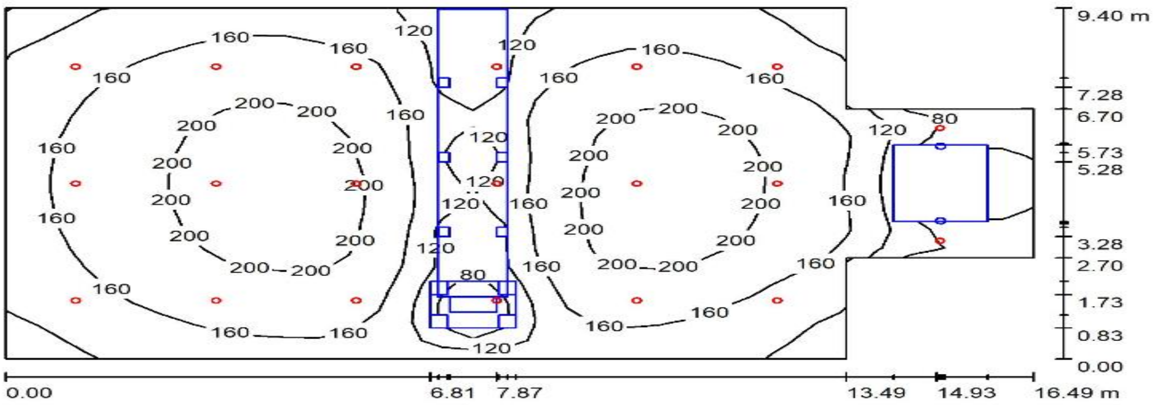


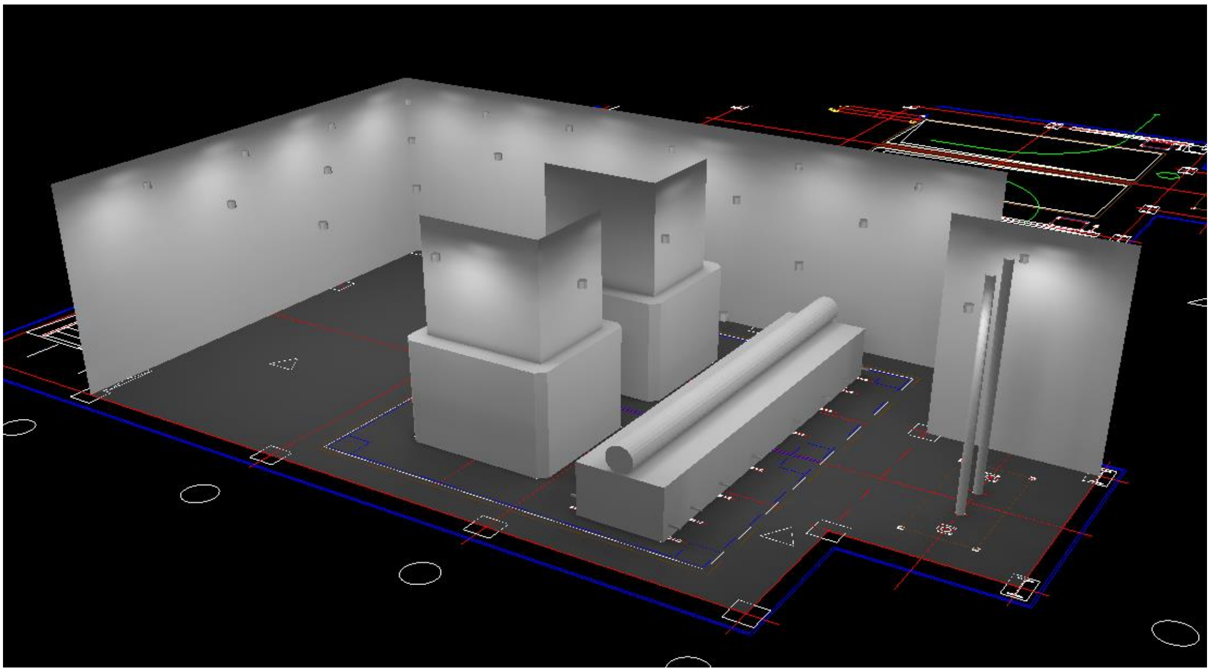
Figure 6.19: Isolines and value chart of a Crusher House EL (+) 5.500M

Result Overview:

Table 6.3: Simulated output report of of a Crusher House EL (+)5.500M

E_{av}[Lx)	E_{min}[Lx]	E_{max}[Lx]	U_0
163	86	245	0.524

As shown in fig 6.18 DIALux simulation of Elevation 5.5m is based on positioning the light fixture in a uniform arrangement to achieve recommended illumination level. Fig 6.19 shows the values in workplane .Table 6.3 shows the simulation report of Level 5.500 m . 3D simulation view and false colour rendering is shown in fig 6.20.



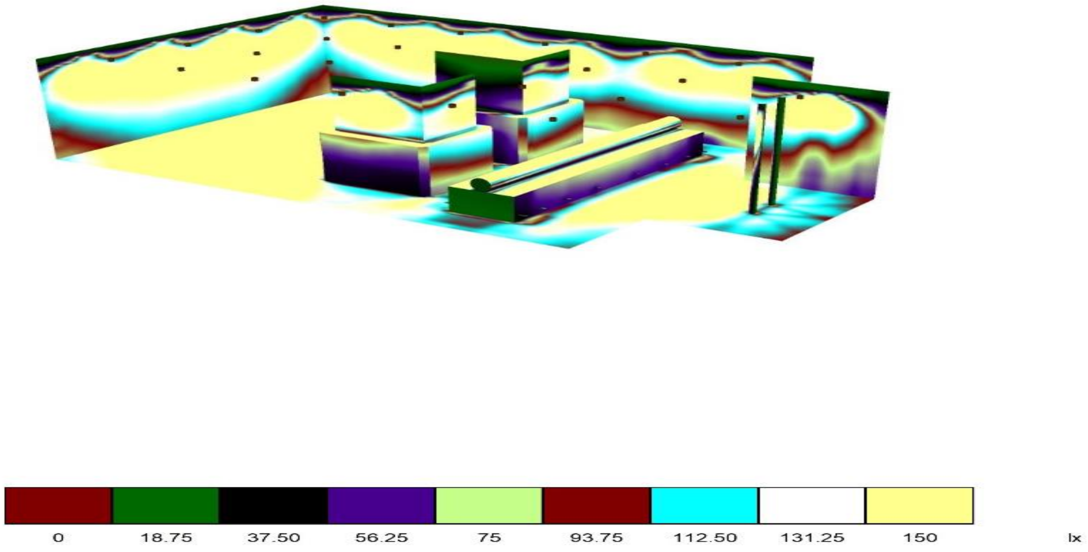


Figure 6.20: Simulated 3D view of Crusher House EL (+)5.500M

For Elevation (+)10.200M:

Luminaries used:

- Circular PDC Aluminum housing LED Well glass (as shown in fig.6.21)
- Luminous flux: 3402 Lumen
- Wattage: 30 Watt
- System efficacy: 110 lm/W
- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70
- IP 66 Protected

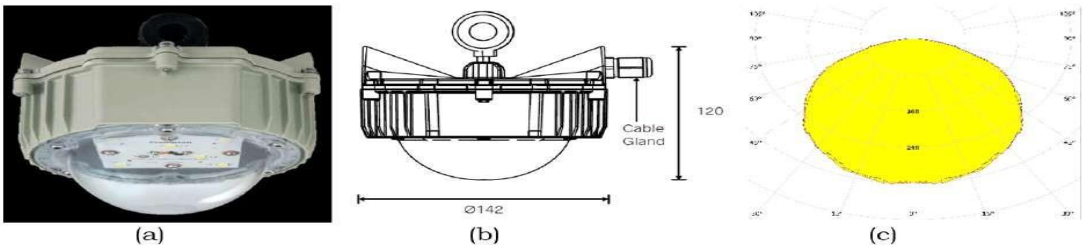


Figure 6.21: (a) Well Glass image (b) Well glass dimension (c) Polar curve

- Circular PDC Aluminum housing LED Well glass (as shown in fig.6.22)
- Luminous flux: 7800 Lumen
- Wattage: 70 Watt
- System efficacy: 110 lm/W
- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected

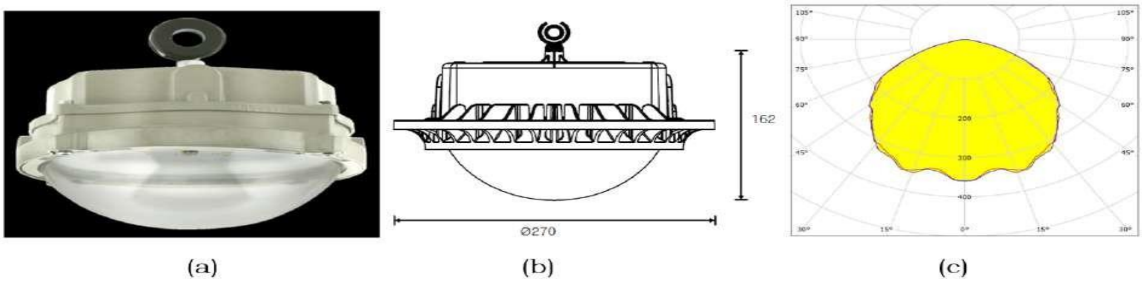


Figure 6.22: (a) Well Glass image (b) Well glass dimension (c) Polar curve

Design Consideration:

- Number of Luminaries: 2 (30 WATT)+12(70WATT)
- Mounting height: 5.4m from floor level
- Maintenance factor: 0.5
- Reflectance Factor(ceiling/wall/floor) Respectively: 30/30/10

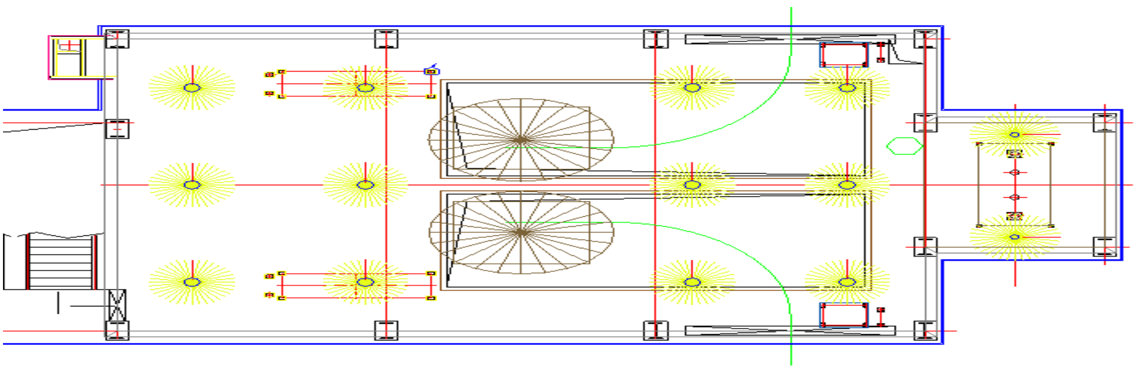


Figure 6.23: Simulated Layout of Crusher House EL (+) 10.20M

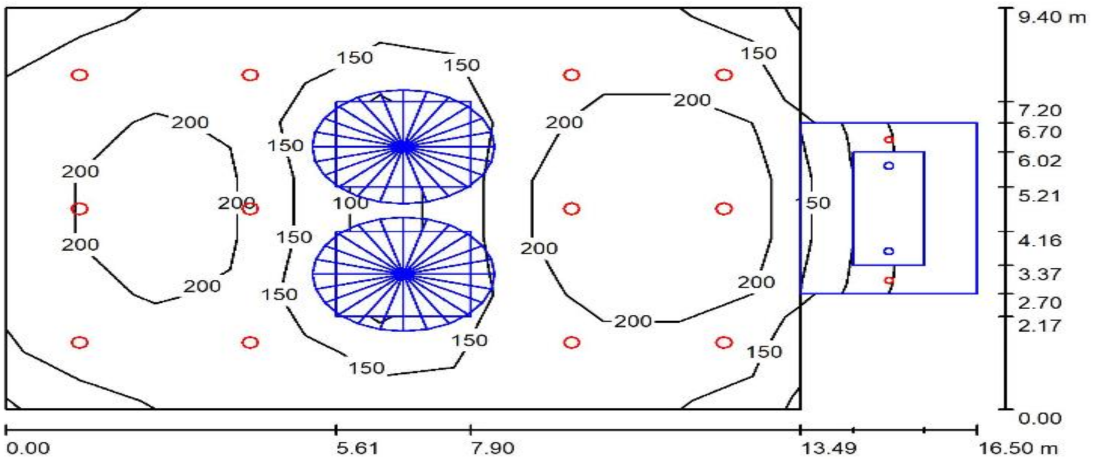


Figure 6.24: Isolines and value chart of a Crusher House EL (+)10.200M

Result Overview:

Table 6.4: Simulated output report of of a Crusher House EL (+)10.

E_{av}[Lx)	E_{min}[Lx]	E_{max}[Lx]	U_0
173	13	230	0.076

So, it can be stated from the result that using 70 watt well glass at a height 5.4 m from ground level and 30 watt well glass at a height of 3m from ground level the recommended result over 150 Lux on wokplane with considering the obstruction of coal hopper as shown in table 6.4. 3D simulation view and false colour rendering is shown in fig 6.25.

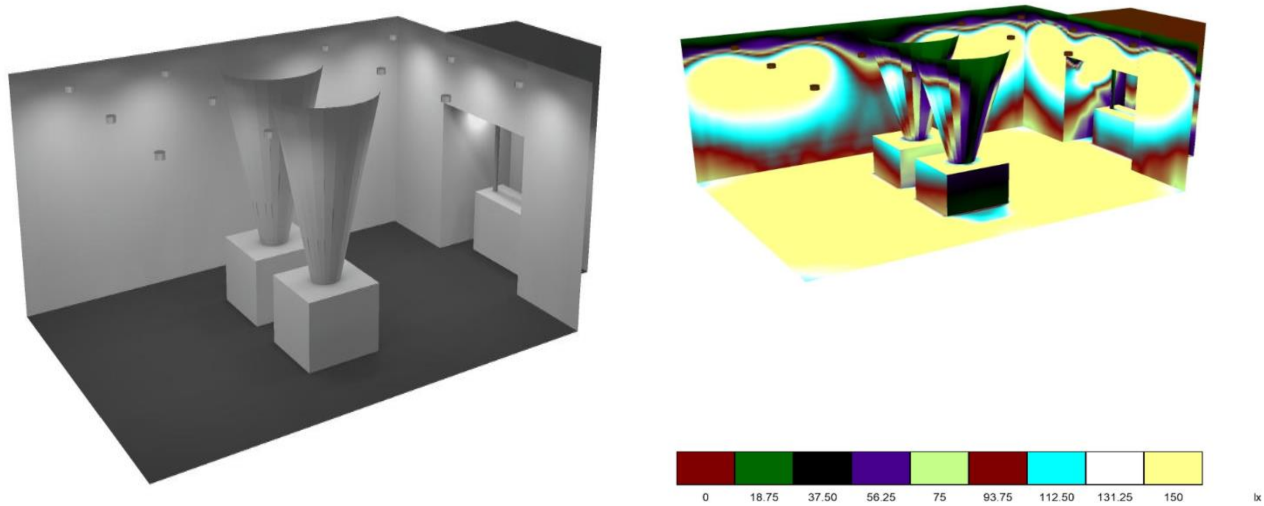
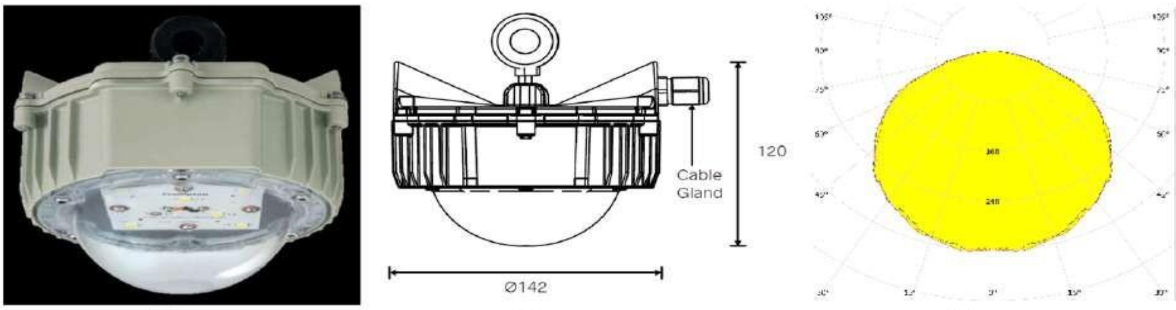


Figure 6.25: Simulated 3D view of Crusher House EL (+)10.20M

<u>For Elevation (+)16.200M:</u>

Luminaries used:

- Circular PDC Aluminum housing LED Well glass (as shown in fig.)
- Luminous flux: 4400 Lumen
- Wattage: 40 Watt
- System efficacy: 110 lm/W
- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected



(a) (b) (c)

Figure 6.26: (a) Well Glass image (b) Well glass dimension (c) Polar curve

Figure 6.26 shows a typical well glass type luminaire made of PDC housing and its intensity distribution whose beam angle is 120 degree.

Design Consideration:

- Number of Luminaries: 9
- Mounting height: 3.52m from floor level
- Maintenance factor: 0.5
- Reflectance Factor(ceiling/wall/floor) Respectively: 30/30/10

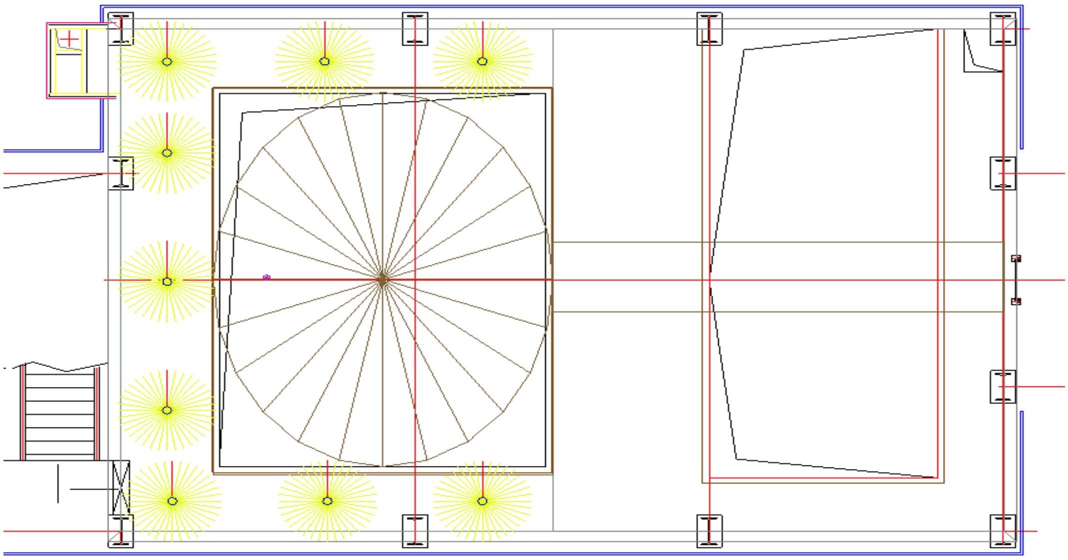
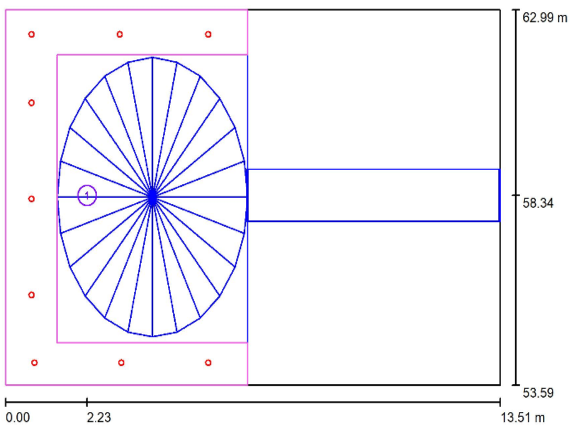


Figure 6.27: Simulated Layout of Crusher House EL (+) 16.20M



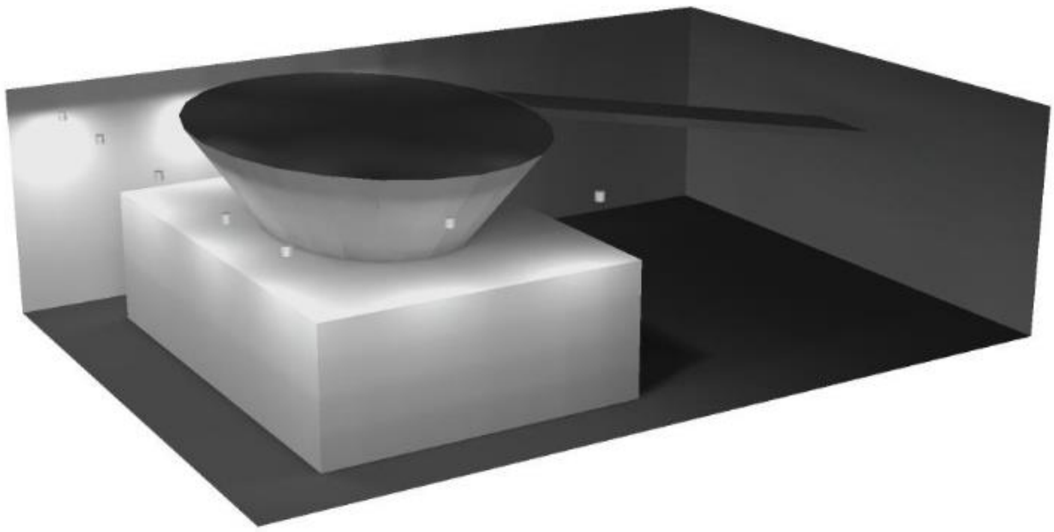
Scale 1 : 107

Calculation Surface List

No.	Designation	Type	Grid	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1	GRID A-C @ 16.200 M	perpendicular	64 x 64	160	88	210	0.551	0.421

Figure 6.28: Simulated Report of Crusher House EL (+) 16.20M

As shown in fig 6.27 DIALux simulation of Elevation 16.2m is based on positioning the light fixture in a uniform arrangement in the movement area to achieve recommended illumination level for safety purpose. Fig 6.28 shows the values in workplane .3D simulation view and false colour rendering is shown in fig 6.29.



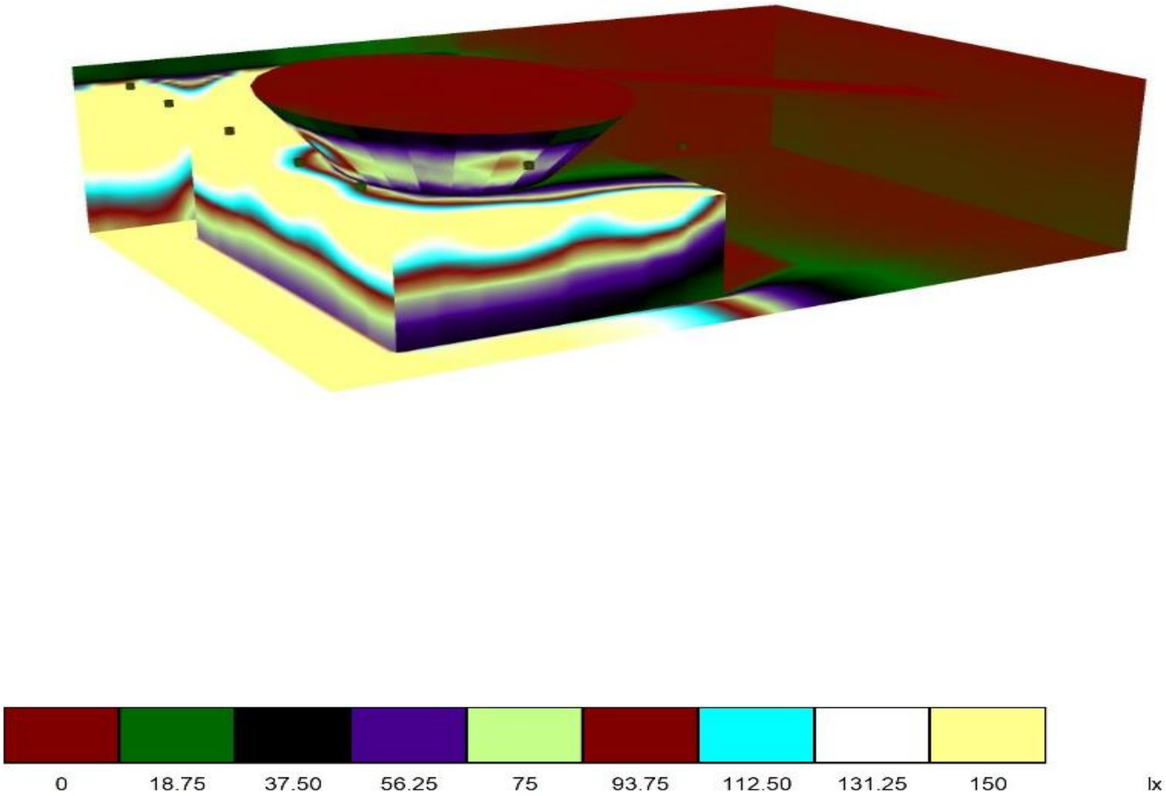
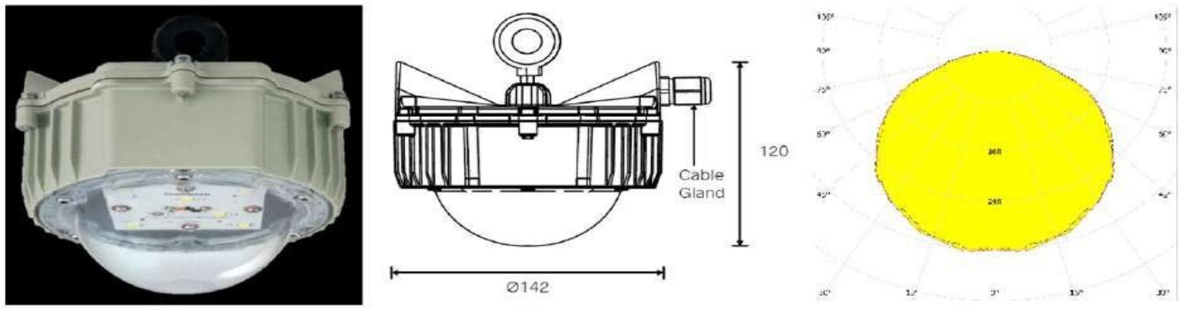


Figure 6.29: Simulated 3D view of Crusher House EL (+)16.20M

For Elevation (+)20.200M:

Luminaries used:

- Circular PDC Aluminum housing LED Well glass (as shown in fig.6.29)
- Luminous flux: 4400 Lumen
- Wattage: 40 Watt
- System efficacy: 110 lm/W
- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected



(a) (b) (c)

Figure 6.30: (a) Well Glass image (b) Well glass dimension (c) Polar curve

Luminaries used:

- Circular PDC Aluminium housing LED Highbay (as shown in fig.6.30)
- Luminous flux: 10998 Lumen
- Wattage: 100 Watt
- System efficacy: 110 lm/W
- Beam angle: 60 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected

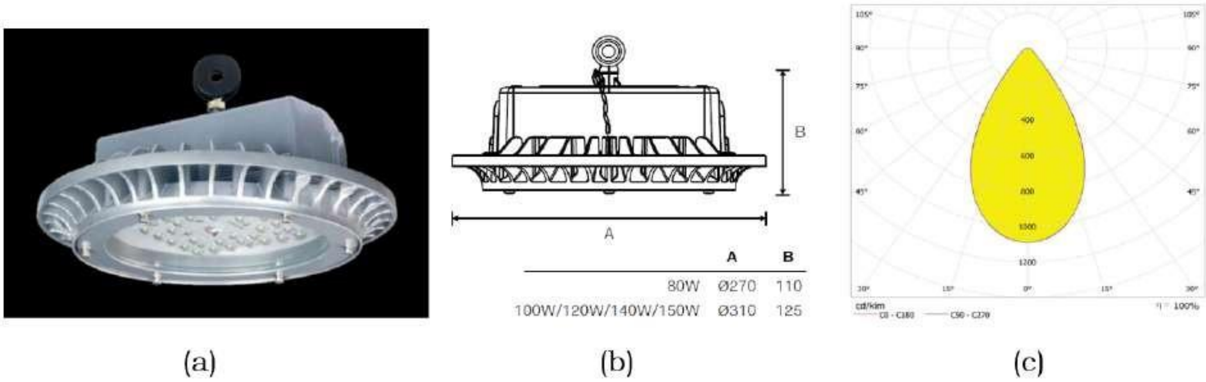


Figure 6.31: (a) Highbay image (b) Highbay dimension (c) Polar curve

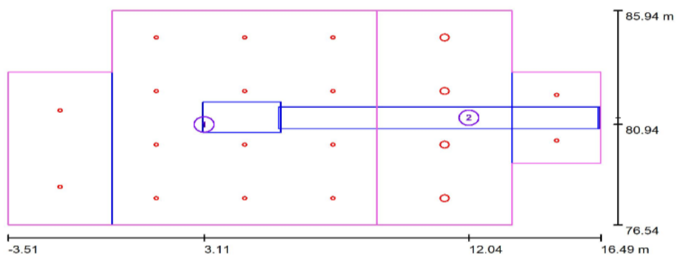
Figure 6.30 shows a typical well glass type luminaire made of PDC housing and its intensity distribution whose beam angle is 120 degree and Figure 6.31 shows a typical highbay type luminaire of PDC housing suitable for industrial application and its has internal surge protection of 10KV. Beam angle of this highbay is 60 degree.

Design Consideration:

- Number of Luminaries: 4 (100 watt highbay)
- Mounting height: 9m from floor level
- Maintenance factor: 0.5
- Reflectance Factor(ceiling/wall/floor) Respectively: 30/30/10

For Mezzanine Level(@5m height)

- Number of Luminaries: 16 (40 watt well glass)
- Mounting height: 9m from floor level(Effective Height 5m)
- Maintenance factor: 0.5
- Reflectance Factor(ceiling/wall/floor) Respectively: 30/30/10



Scale 1 : 143

Calculation Surface List

No.	Designation	Type	Grid	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1	CALCULATION @ 24.200 M GRID A'B-C	perpendicular	128 x 128	175	50	286	0.284	0.174
2	CALCULATION @ 20.200 M	perpendicular	64 x 64	150	58	233	0.388	0.250

Figure 6.32: Simulated Report of Crusher House EL (+) 20.20M

So, it can be stated from the result that using 40 watt well glass at a height 9 m from ground level effective height 4m recommended result over 150 Lux on wokplane with considering the obstruction of coal hopper and conveyor as shown in table 6.32.Four number of highbay luminaire is used to illuminate the area without mezzanine. 3D simulation view and false colour rendering is shown in fig 6.33.

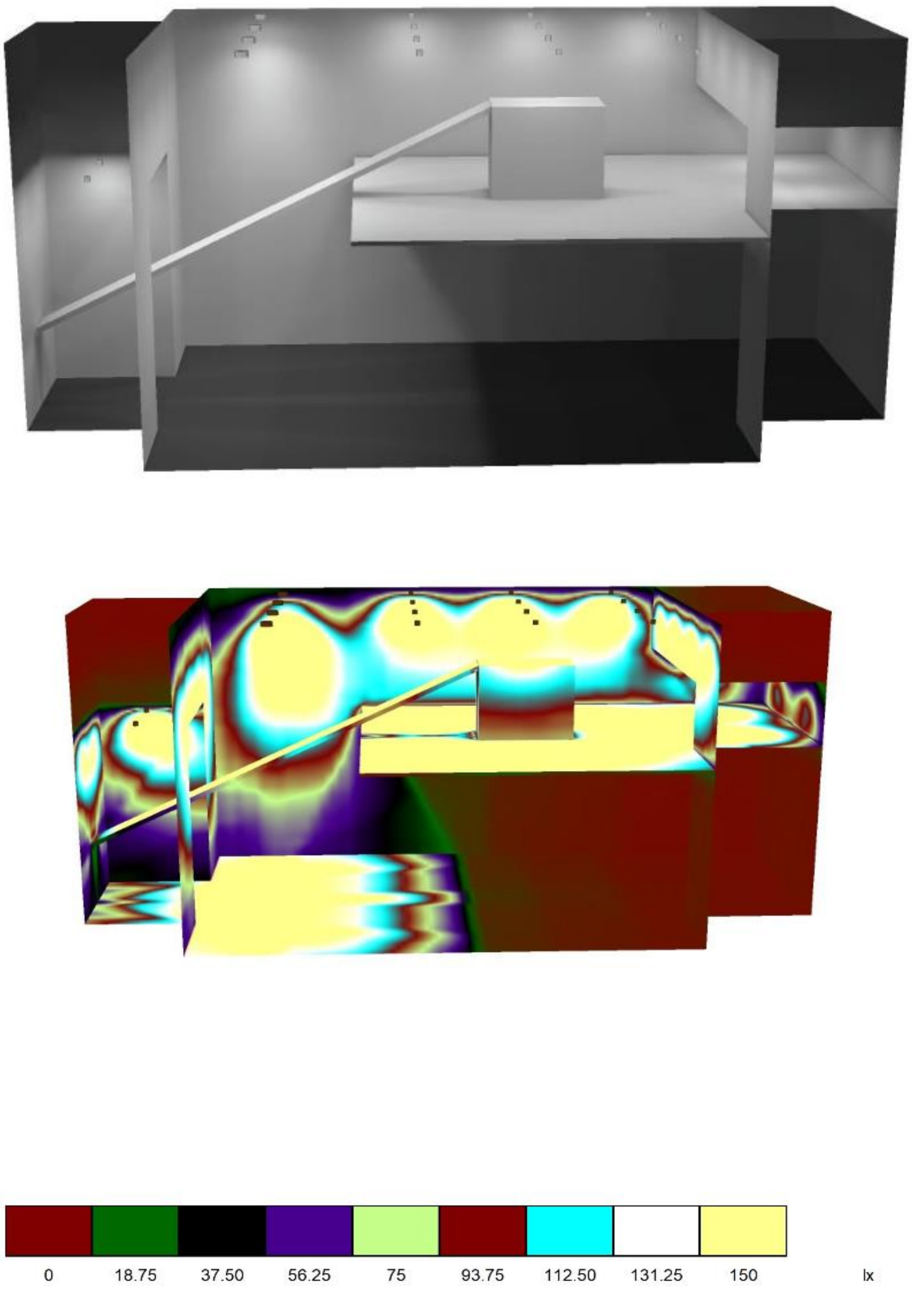


Figure 6.33: Simulated 3D view of Crusher House EL (+)20.20M

6.3.3 COKE SCREEN HOUSE:

Coke, which is derived from coal, is a vital ingredient in the production of steel.During the coke screening process, the coke is typically fed into a series of vibrating screens or sieves. These screens have different mesh sizes, allowing smaller particles to pass through while larger particles are retained. By separating the coke particles based on size, the desired coke size fractions can be obtained for specific applications in steelmaking.

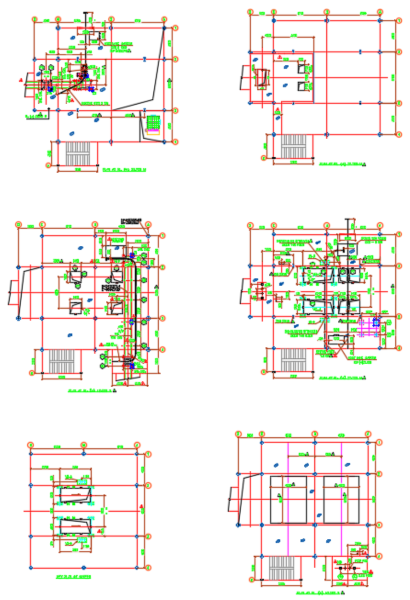
Design Aim:

To provide illumination on walkways around the conveyor and screening house area close to vibrating screener .The uniformity of the designed light level must have the desired value. Lighting will provide comfort to the eyes and not create too much glare.

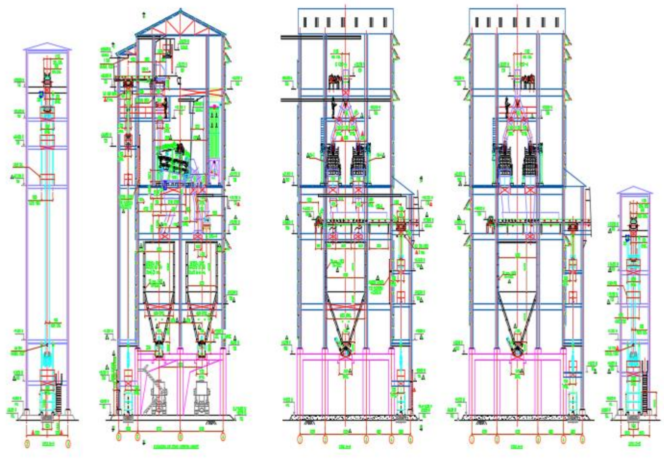
- Required illuminance level: Average 100/150 Lux as per different area [11]

Typical Design of Coke Screen House:

Considering one of the Coke screen house for better understanding. DIALux software is used for the simulation purpose. Result analysis as per the NTPC standard.



(a)



(b)

Figure 6.34: (a) Plan Details (b) Elevation Details of a crusher house

Figure 6.34 (a) shows the plan details of coke screen house it has six level out of which five level design is discussed below. Sectional details is shown in Figure 6.34 (b) coke screen building is illuminated as per NTPC Standard, obstruction are taking into consideration for simulation purpose.

<u>For Elevation (+)0.5M:</u>

Luminaries used:

- Circular PDC Aluminum housing LED Well glass
- Luminous flux: 4400 Lumen
- Wattage: 40 Watt
- System efficacy: 110 lm/W
- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected

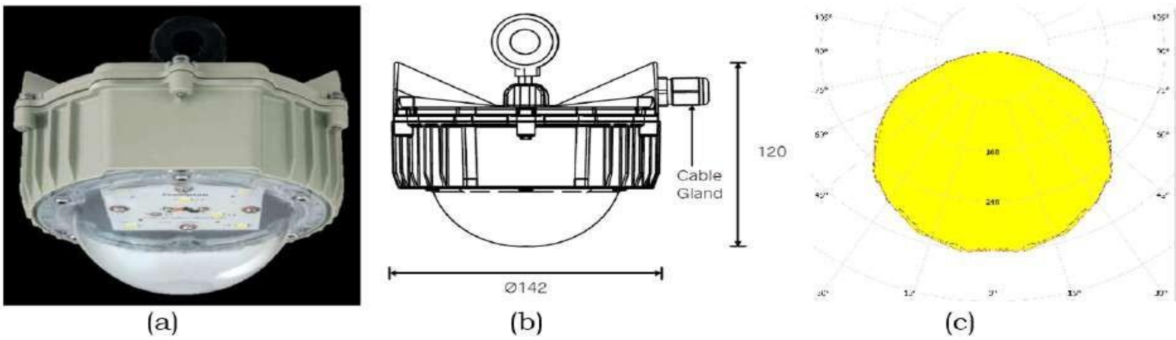


Figure 6.35: (a) Well glass image (b) Well Glass dimension (c) Polar curve

Figure 6.35 shows a typical well glass type luminaire made of PDC housing and its intensity distribution whose beam angle is 120 degree.

Design Consideration:

- Number of Luminaries: 25
- Mounting height: 4.9 m from floor level
- Maintenance factor: 0.5
- Reflectance Factor(ceiling/wall/floor) Respectively: 30/30/10

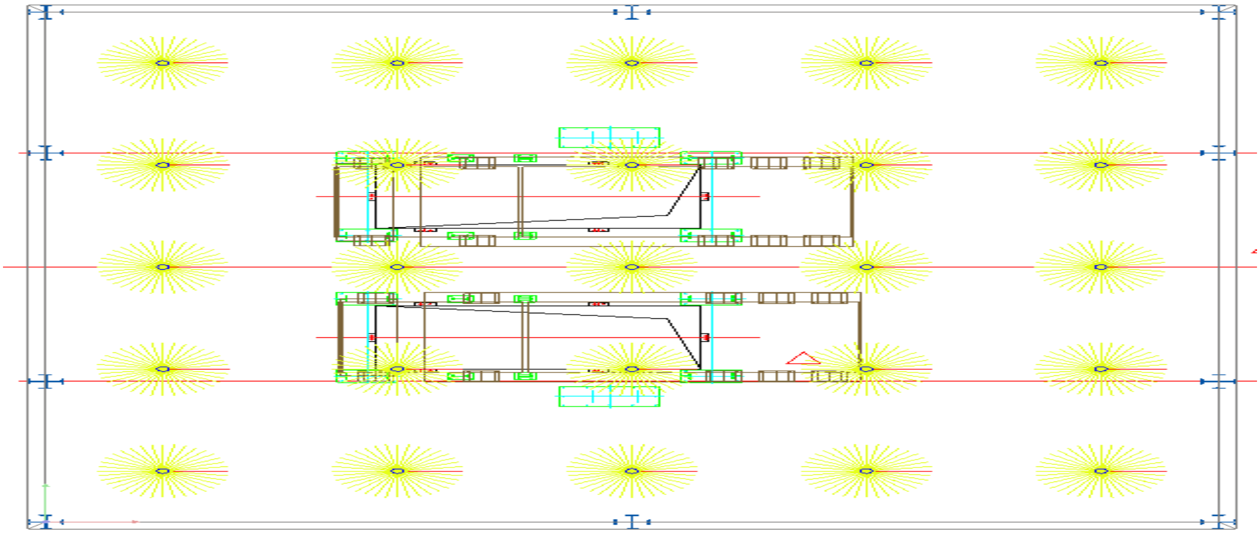


Figure 6.36: Simulated Layout of Coke Screen House EL (+) 0.500M

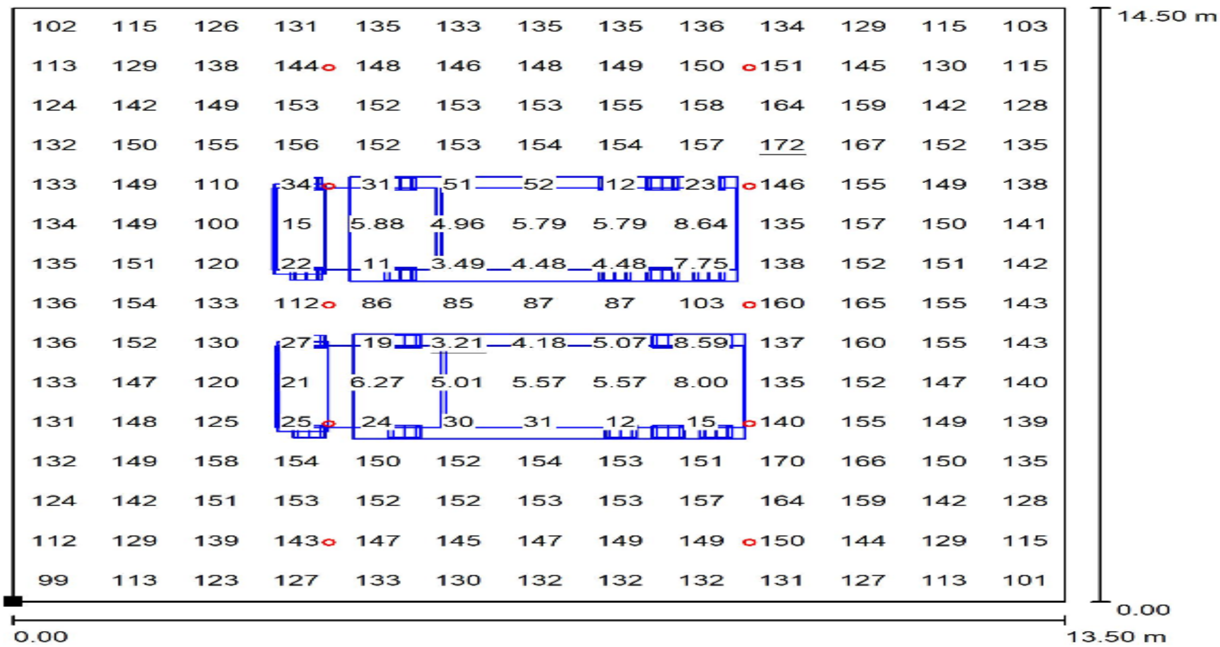


Figure 6.37: value chart of a Coke Screen House EL (+)0.500M

So, it can be stated from the result that using 40 watt well glass at a height 4.9 m from ground level recommended result over 100 Lux on wokplane is achieved for unloading area. Table 6.5 shows the lux level chart. Figure 6.36 shows the Luminaire arrangement and 6.37 shows the value chart on workplane.3d rendering and false color rendering shows in figure 6.38.

Result Overview:

Table 6.5: Simulated output report of of a Coke Screen House EL (+)0.500M

E_{av}[Lx)	E_{min}[Lx]	E_{max}[Lx]	U_0
117	46.8	172	0.41

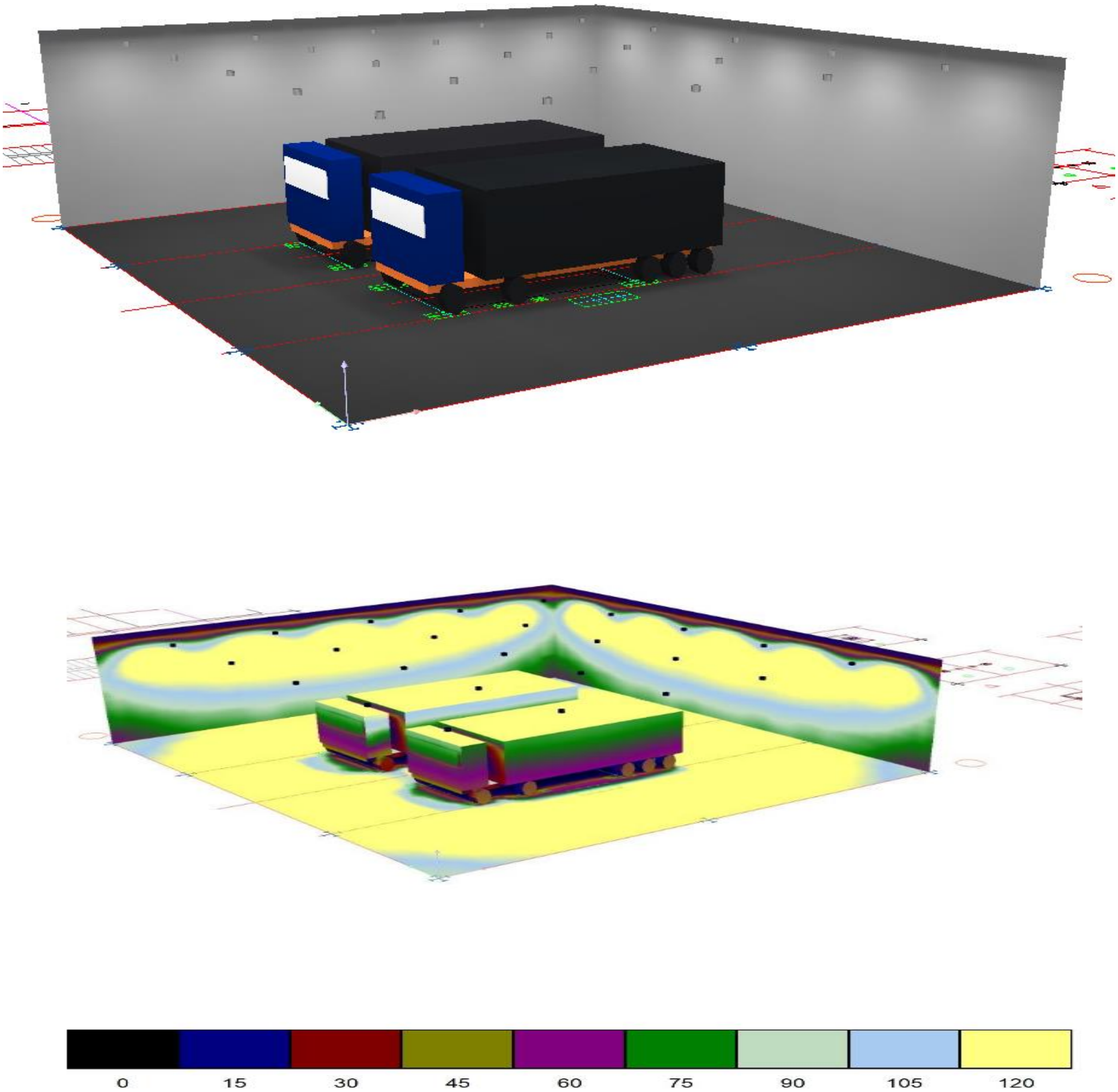


Figure 6.38: Simulated 3D view of Coke Screen House EL (+)0.500M

For Elevation (+)10.5M:

Luminaries used:

- Circular PDC Aluminum housing LED Well glass
- Luminous flux: 7800 Lumen
- Wattage: 70 Watt
- System efficacy: 110 lm/W
- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected

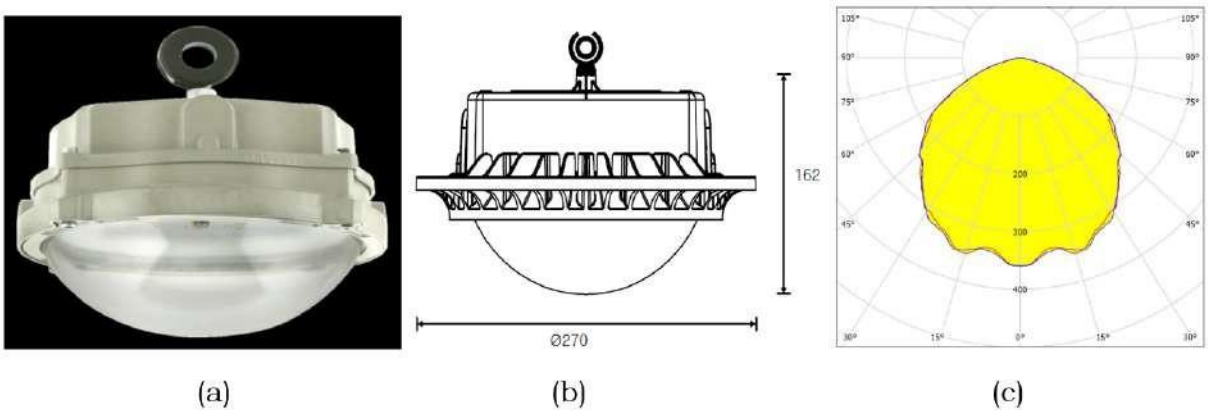


Figure 6.39: (a) Well Glasss image (b) Well Glass dimension (c) Polar curve

Figure 6.39 shows a typical well glass type luminaire made of PDC housing and its intensity distribution whose beam angle is 120 degree.

Design Consideration:

- Number of Luminaries: 16
- Mounting height: 5.7 m from floor level
- Maintenance factor: 0.5
- Reflectance Factor(ceiling/wall/floor) Respectively: 30/30/10

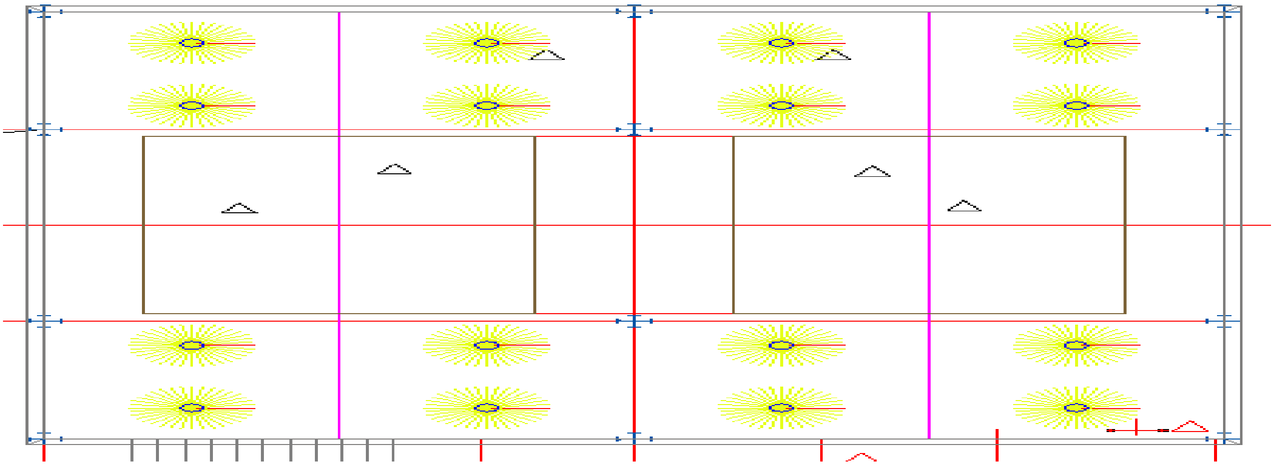


Figure 6.40: Simulated Layout of Coke Screen House EL (+) 10.500M

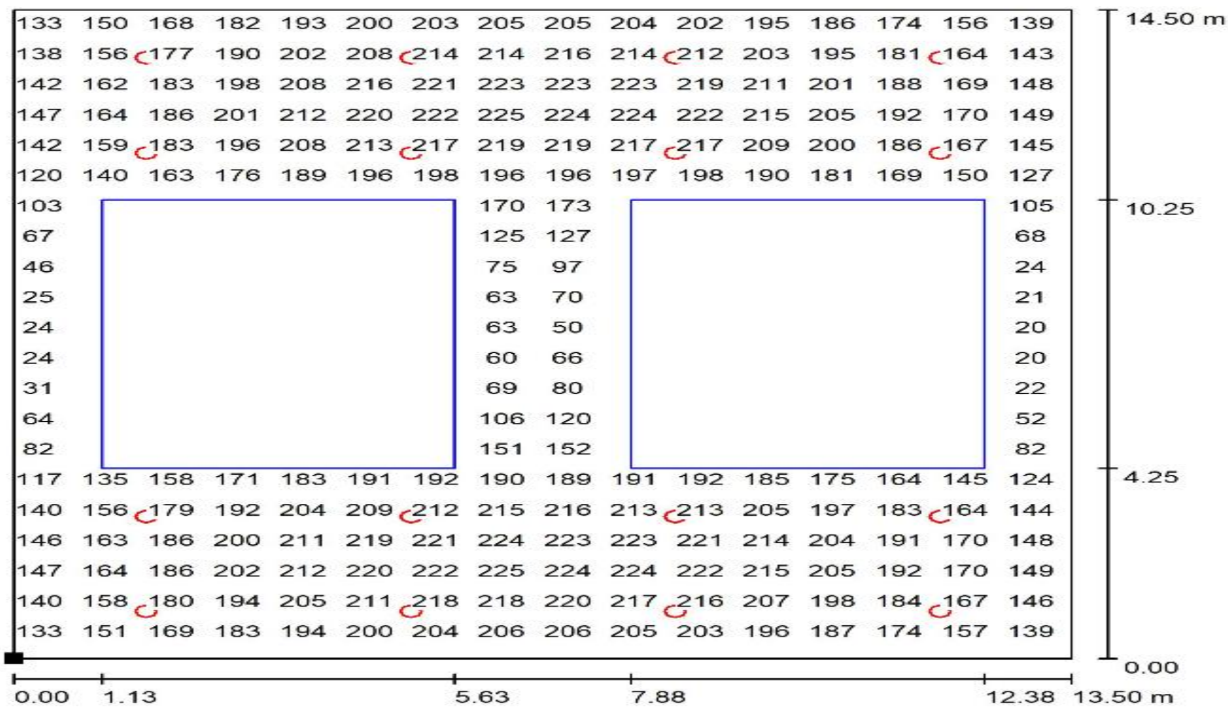


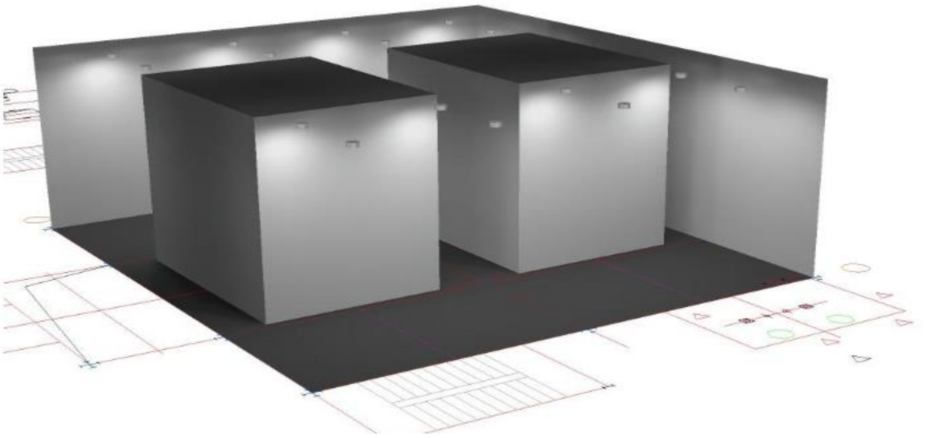
Figure 6.41: value chart of a Coke Screen House EL (+) 10.500M

Result Overview:

Table 6.6: Simulated output report of of a Coke Screen House EL (+)10.500M

E_{av}[Lx)	E_{min}[Lx]	E_{max}[Lx]	U_0
166	68.06	226	0.41

So, it can be stated from the result that using 70 watt well glass at a height 5.7 m from ground level recommended result over 150 Lux on wokplane is achieved. Table 6.6 shows the lux level chart. Figure 6.40 shows the Luminaire arrangement and 6.41 shows the value chart on workplane.3d rendering and false color rendering shows in figure 6.42.



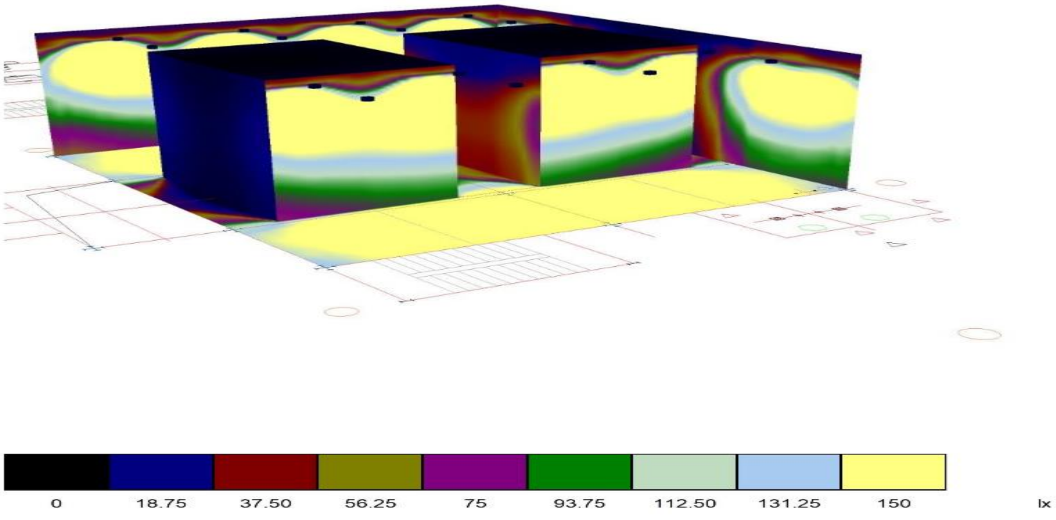
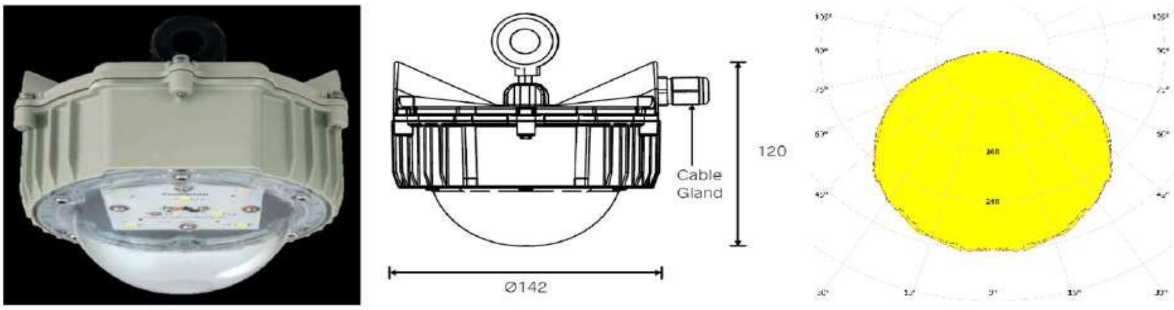


Figure 6.42: Simulated 3D view of Coke Screen House EL (+) 10.500M

For Elevation (+)16.8M:

Luminaries used:

- Circular PDC Aluminum housing LED Well glass
- Luminous flux: 4400 Lumen
- Wattage: 40 Watt
- System efficacy: 110 lm/W
- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected



(a) (b) (c)

Figure 6.43: (a) Well glass image (b) Well Glass dimension (c) Polar curve

Figure 6.43 shows a typical well glass type luminaire made of PDC housing and its intensity distribution whose beam angle is 120 degree.

Design Consideration:

- Number of Luminaries: 26
- Mounting height: 4 m from floor level
- Maintenance factor: 0.5
- Reflectance Factor(ceiling/wall/floor) Respectively: 30/30/10

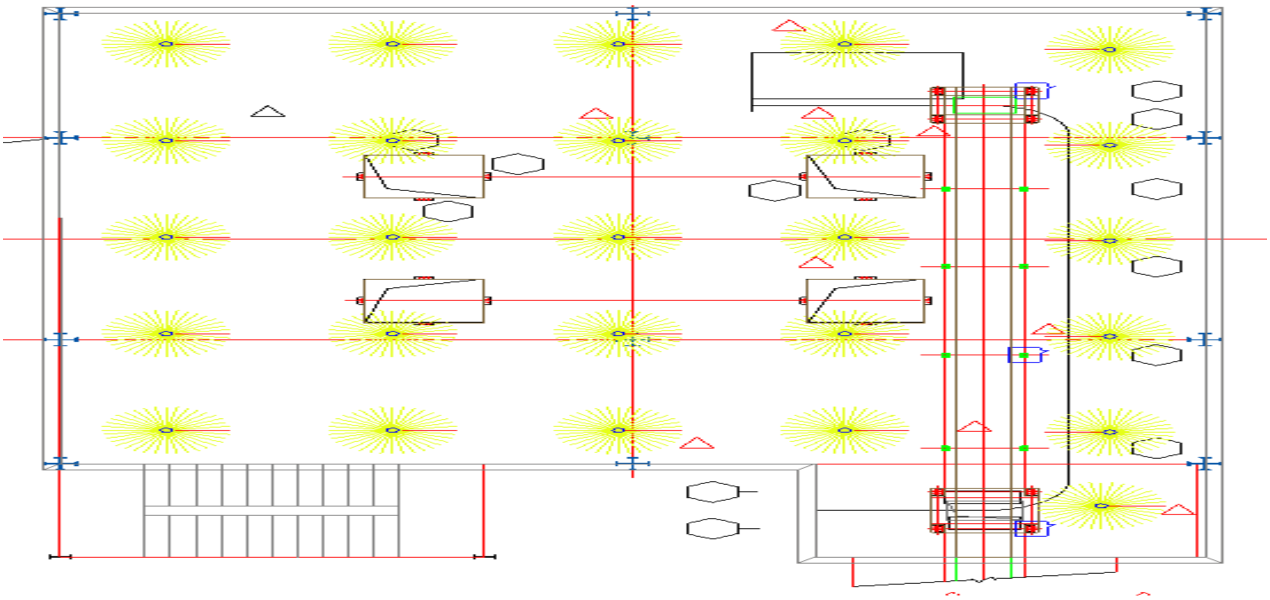


Figure 6.44: Simulated Layout of Coke Screen House EL (+) 16.80M

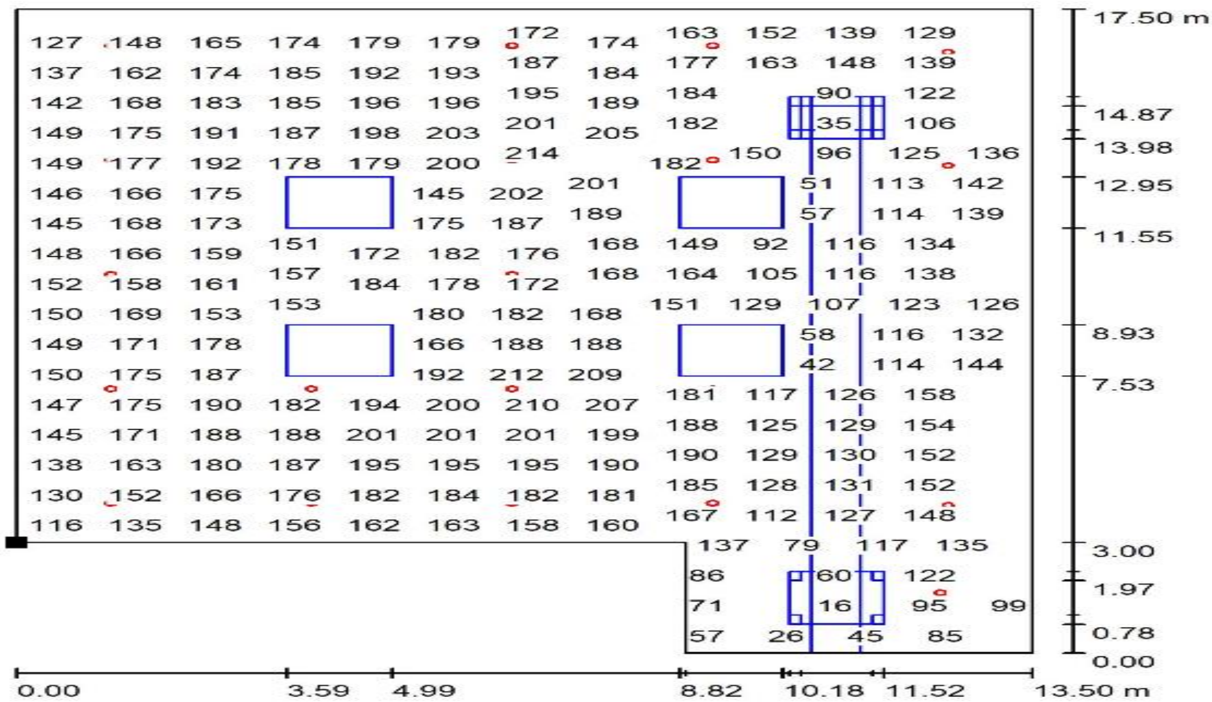


Figure 6.45: value chart of a Coke Screen House EL (+)16.80M

Result Overview:

Table 6.7: Simulated output report of of a Coke Screen House EL (+)16.80M

E_{av}[Lx)	E_{min}[Lx]	E_{max}[Lx]	U_0
152	60.8	216	0.41

So, it can be stated from the result that using 40 watt well glass at a height 4 m from ground level recommended result over 150 Lux on wokplane is achieved. Table 6.7 shows the lux level chart. Figure 6.44 shows the Luminaire arrangement and 6.45 shows the value chart on workplane.3d rendering and false color rendering shows in figure 6.46.

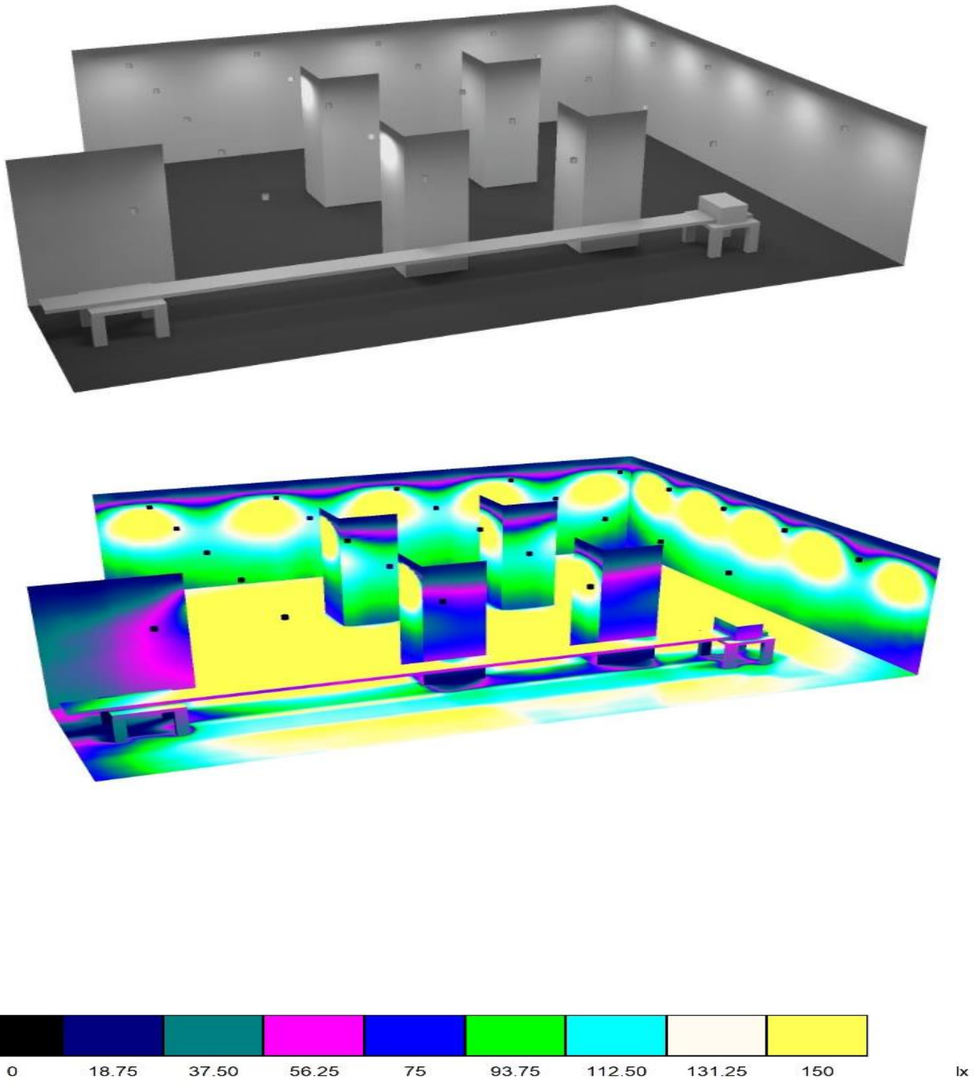


Figure 6.46: Simulated 3D view of Coke Screen House EL (+)16.80M

For Elevation (+)21.0M:

Luminaries used:

- Circular PDC Aluminum housing LED Well glass (as shown in fig.6.47)
- Luminous flux: 3402 Lumen
- Wattage: 30 Watt
- System efficacy: 110 lm/W
- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected

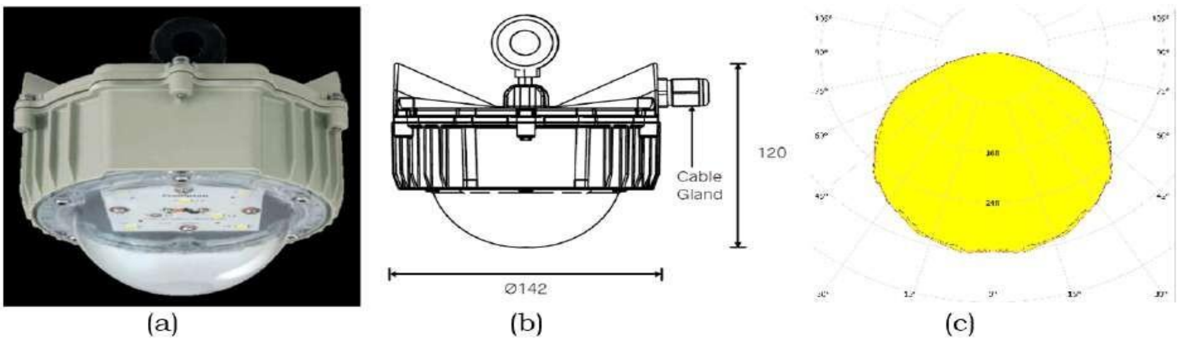
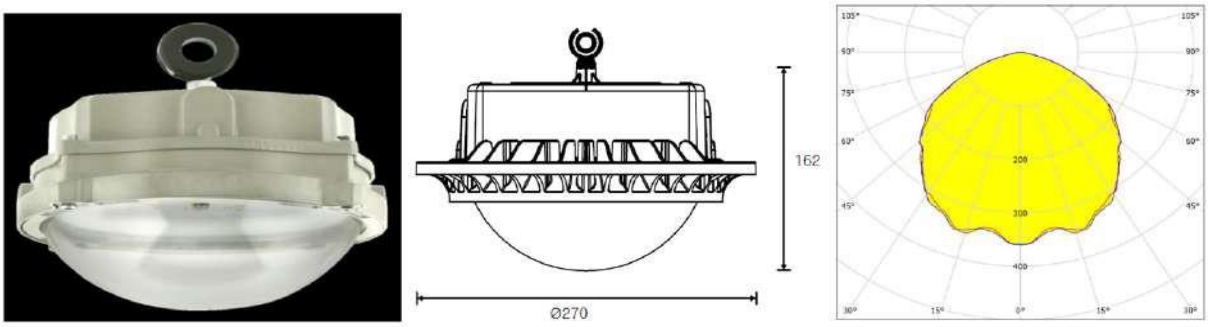


Figure 6.47: (a) Well glass image (b) Well Glass dimension (c) Polar curve

Luminaries used:

- Circular PDC Aluminum housing LED Well glass (as shown in fig.6.48)
- Luminous flux: 7800 Lumen
- Wattage: 70 Watt
- System efficacy: 110 lm/W
- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70

- IP 66 protected



(a) (b) (c)

Figure 6.48: (a) Well glass image (b) Well Glass dimension (c) Polar curve

Design Consideration:

For 7.8m Height

- Number of Luminaries: 18 (70 watt Well Glass)
- Mounting height: 7.8 m from floor level
- Maintenance factor: 0.5
- Reflectance Factor(ceiling/wall/floor) Respectively: 30/30/10

For 5.75m Height

- Number of Luminaries: 9
- Mounting height: 5.75 m from floor level
- Maintenance factor: 0.5
- Reflectance Factor(ceiling/wall/floor) Respectively: 30/30/10

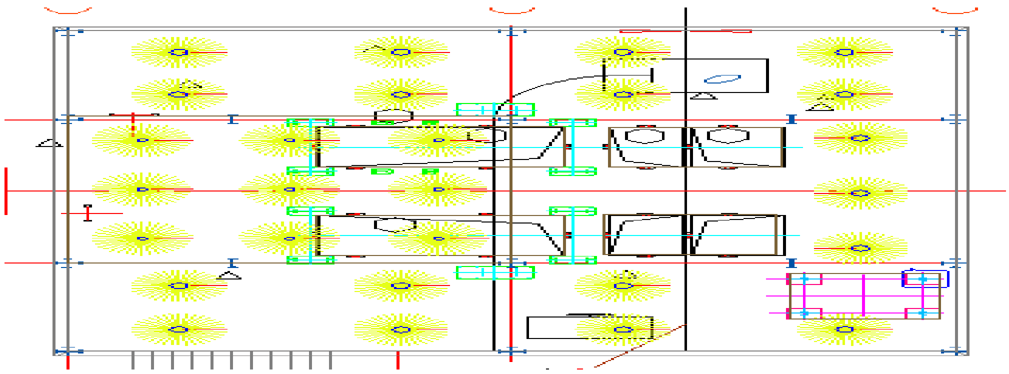


Figure 6.49: Simulated Layout of Coke Screen House EL (+) 21.00M

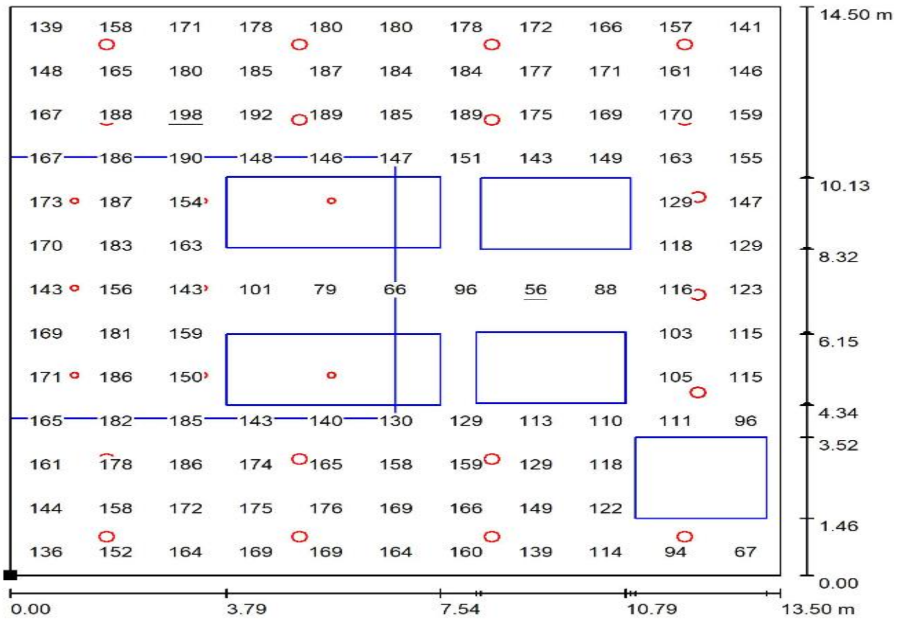


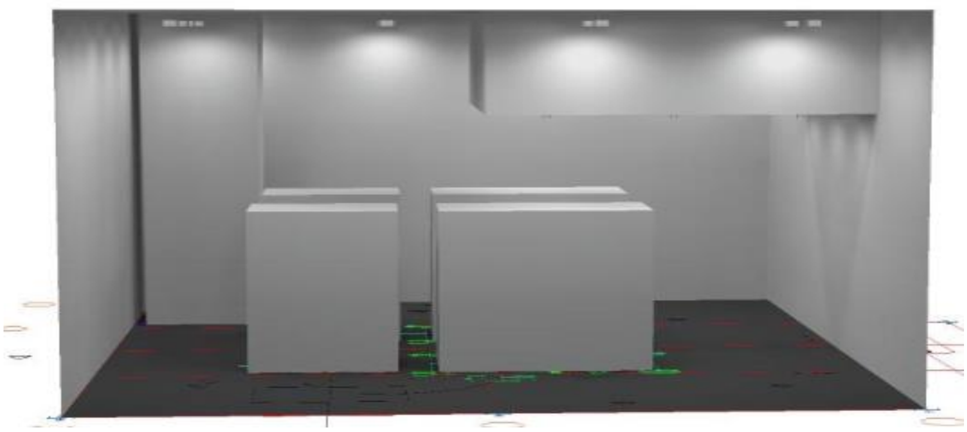
Figure 6.50: value chart of a Coke Screen House EL (+)21.00M

Result Overview:

Table 6.8: Simulated output report of of a Coke Screen House EL (+)21.00M

E_{av}[Lx)	E_{min}[Lx]	E_{max}[Lx]	U_0
150	56	198	0.372

So, it can be stated from the result that using 30 watt well glass at a height 5.75m from ground level & 70 watt well glass at a height 7.8m recommended result over 150 Lux on wokplane is achieved considering the conveyor and hooper obstruction. Table 6.8 shows the lux level chart. Figure 6.49 shows the Luminaire arrangement and 6.50 shows the value chart on workplane.3d rendering and false color rendering shows in figure 6.51.



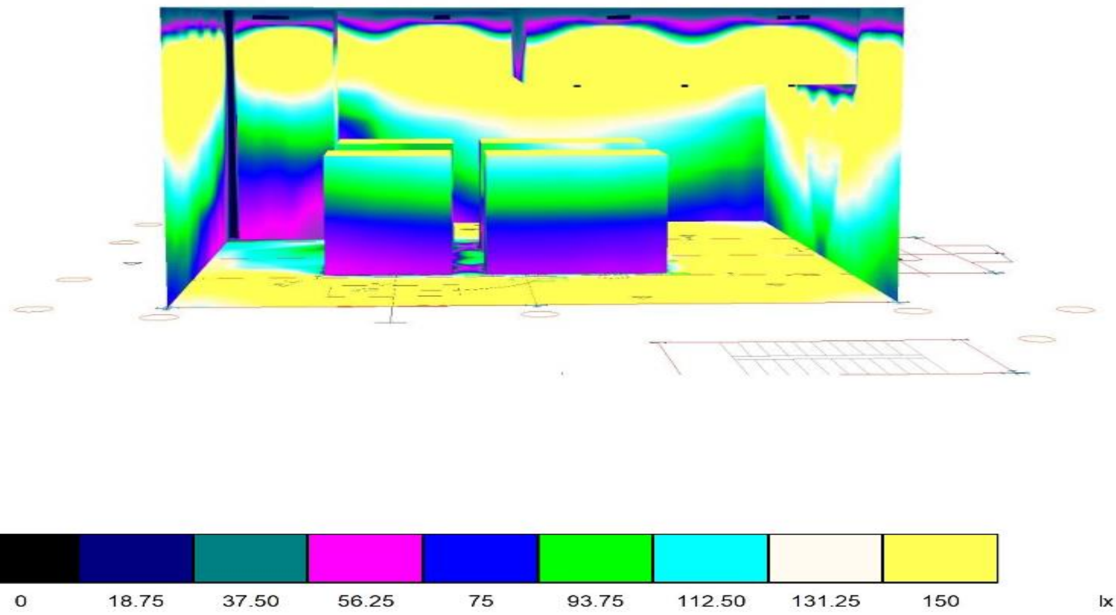


Figure 6.51: Simulated 3D view of Coke Screen House EL (+)21.00M

For Elevation (+)29.7M:

Luminaries used:

- Circular PDC Aluminum housing LED Well glass (as shown in fig.6.52)
- Luminous flux: 4400 Lumen
- Wattage: 40 Watt
- System efficacy: 110 lm/W
- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected

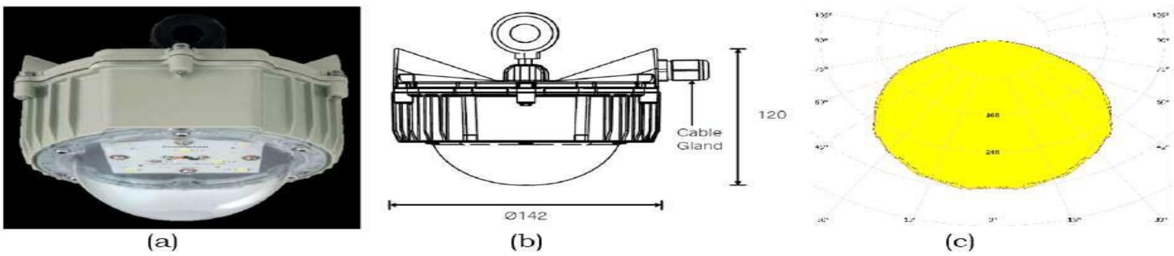


Figure 6.52: (a) Well glass image (b) Well Glass dimension (c) Polar curve

Design Consideration:

- Number of Luminaries: 27
- Mounting height: 4.9 m from floor level
- Maintenance factor: 0.5
- Reflectance Factor(ceiling/wall/floor) Respectively: 30/30/10

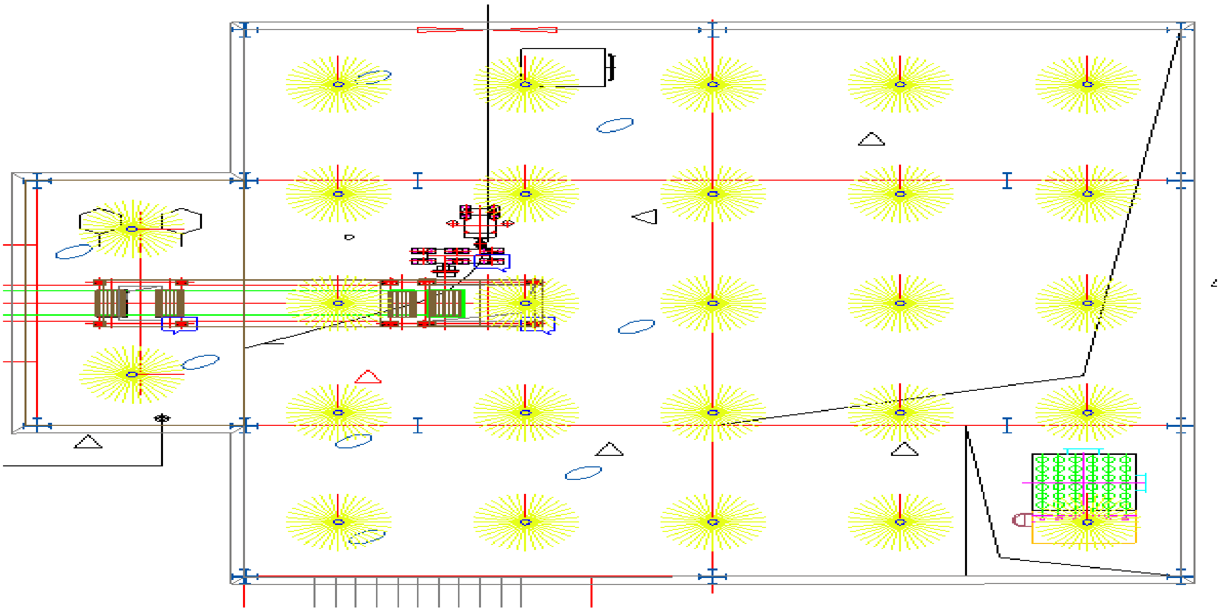


Figure 6.53: Simulated Layout of Coke Screen House EL (+) 29.70M

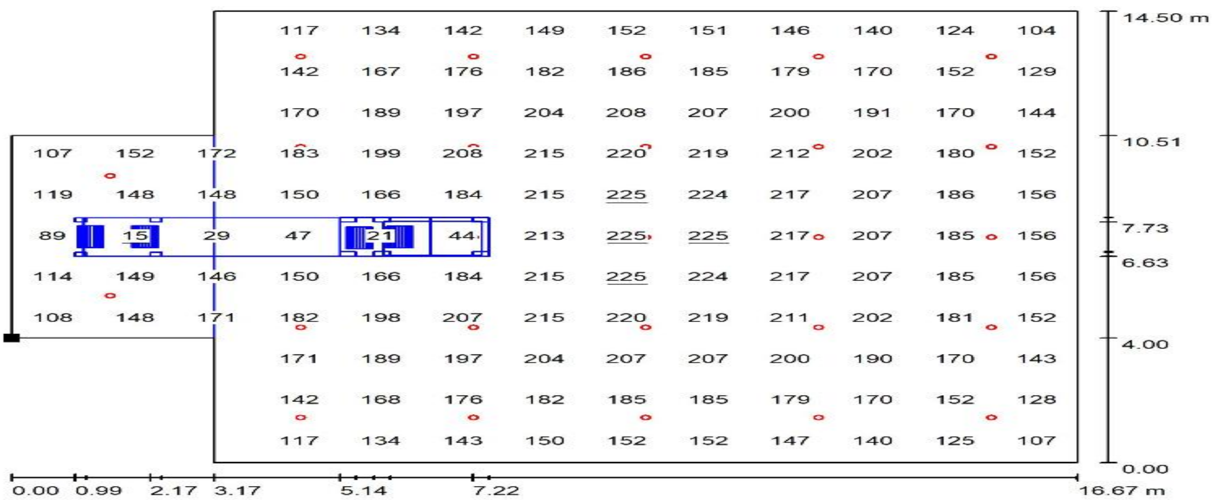


Figure 6.54: value chart of a Coke Screen House EL (+)29.70M

Result Overview:

Table 6.9: Simulated output report of a Coke Screen House EL (+)29.70M

E_{av}[Lx)	E_{min}[Lx]	E_{max}[Lx]	U_0
166	63.8	225	0.38

So, it can be stated from the result that using 40 watt well glass at a height 4.9m from ground level recommended result over 150 Lux on wokplane is achieved .Luminaire is placed considering the obstruction. Table 6.9 shows the lux level chart. Figure 6.53 shows the Luminaire arrangement and 6.54 shows the value chart on workplane.3d rendering and false color rendering shows in figure 6.55.

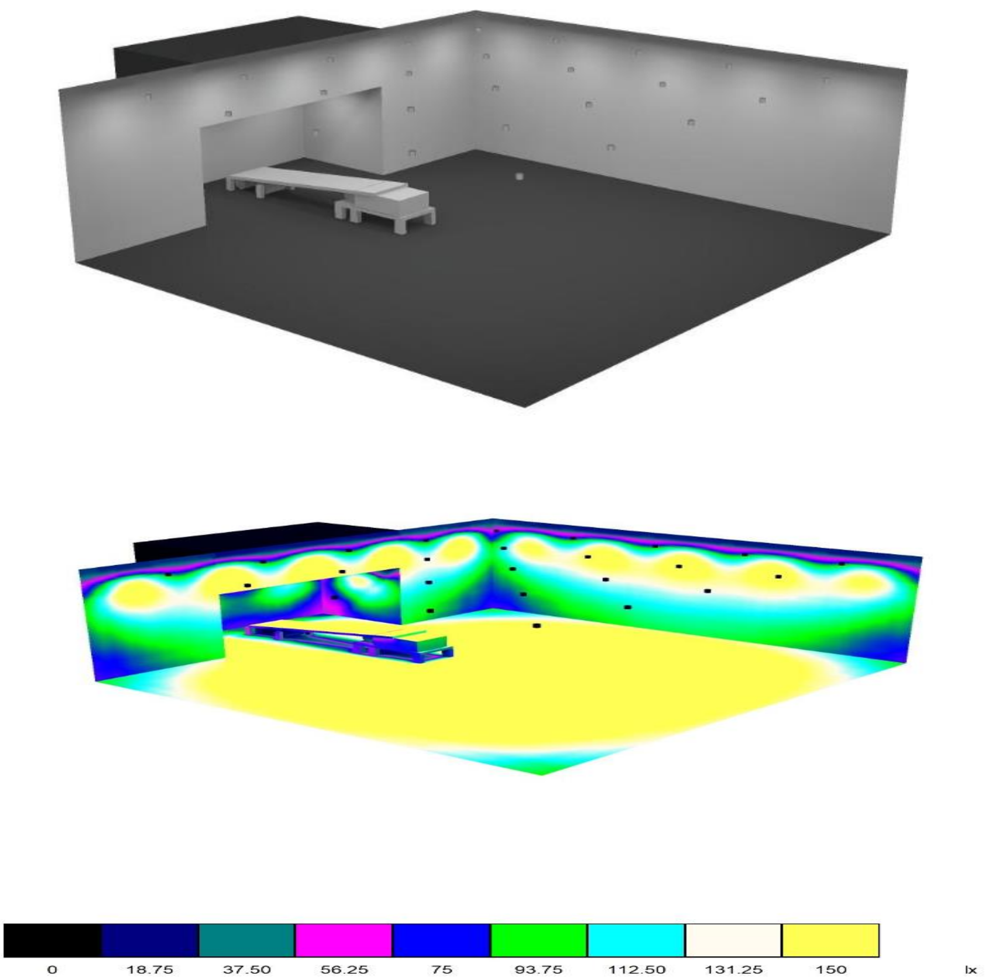


Figure 6.55: Simulated 3D view of Coke Screen House EL (+)29.70M

6.3.4 **Pump House/Motor House:**

Pump House is an integral part of a thermal power plant which circulate necessary cooling water to the condenser to condensate.

Design Aim:

To provide uniform illumination on walkways around the pump house area and also at the oprating box near the pump. The uniformity of the designed light level must have the desired value. Lighting will provide comfort to the eyes and not create too much glare.

- Required illuminance level: Average 150 Lux as per different area [11]

Typical Design of Pump House:

Considering one of the Pump house for better understanding. DIALux software is used for the simulation purpose and DIALux evo is used for rendering purpose. Result analysis as per the NTPC standard.

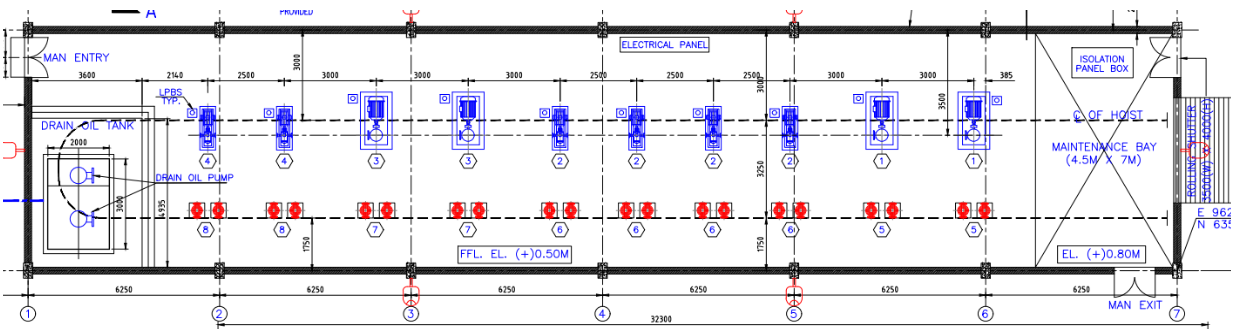


Figure 6.56: Plan view of a Pump house

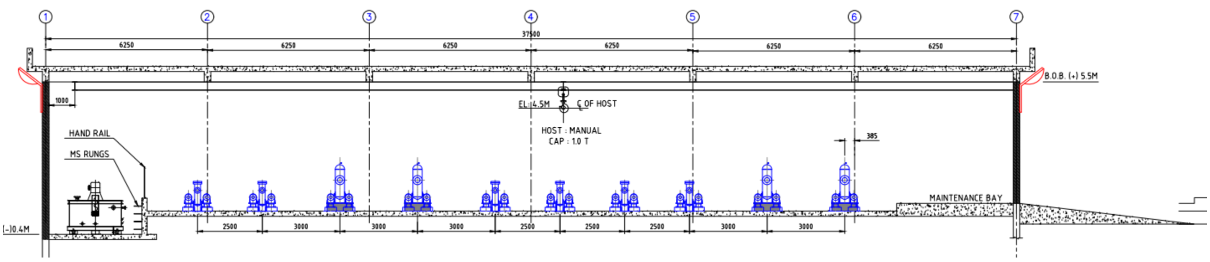


Figure 6.57: Elevation view of a Pump house

As shown in fig 6.56 it shows a typical floor plan of an pump house .From Fig 6.57 one can get the elevation details or say mounting height of the luminaire and height of the pump.

Luminaries used:

- Circular PDC Aluminium housing LED Highbay
- Luminous flux: 10150 Lumen
- Wattage: 80 Watt
- System efficacy: 125 lm/W
- Beam angle: 90 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected

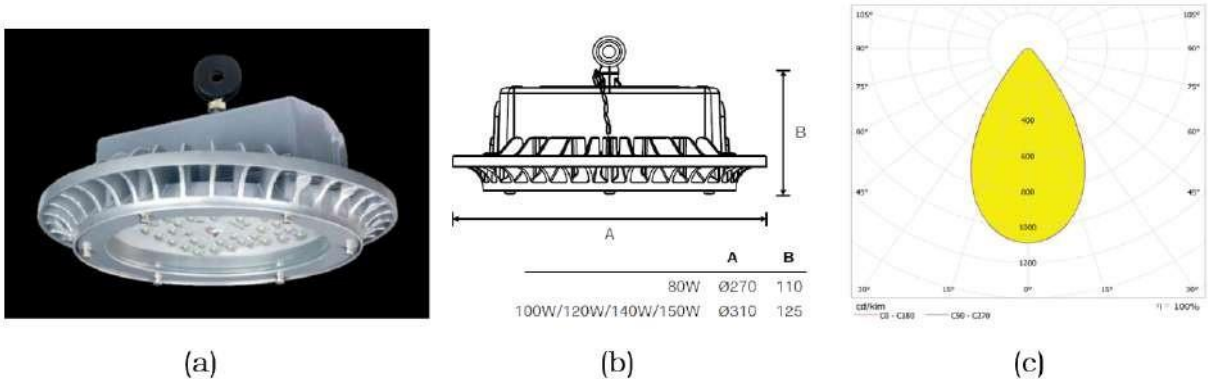


Figure 6.58: (a) Highbay image (b) Highbay dimension (c) Polar curve

Figure 6.58 shows a typical highbay type luminaire made of PDC housing and its intensity distribution whose beam angle is 90 degree.

Design Consideration:

- Number of Luminaries: 14
- Mounting height: 5.5 m from floor level
- Maintenance factor: 0.5
- Reflectance Factor(ceiling/wall/floor) Respectively: 30/30/10

In this Pump house design 80 watt high bay of 90 degree beam angle is used to avoid spot on ground level. In case of 60 degree beam angle it will create bright spot on ground but in case of 90 degree beam angle light is distributed uniformly

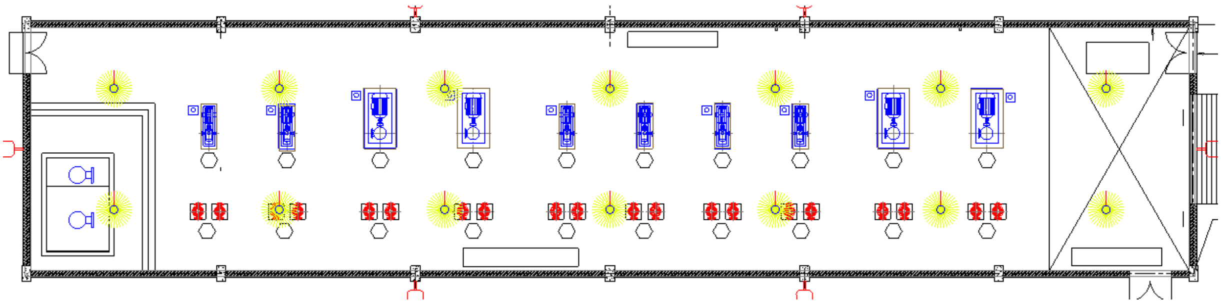


Figure 6.59: Simulated Layout of Pump House

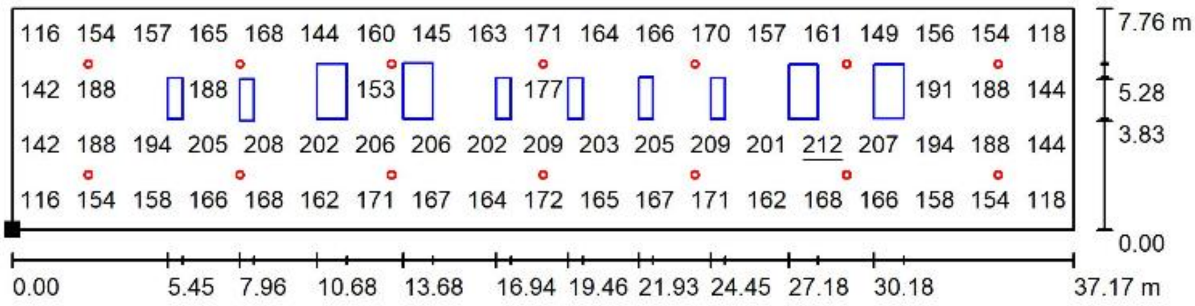


Figure 6.60: value chart of a Pump House

Result Overview:

Table 6.10: Simulated output report of a Pump House

E_{av}[Lx)	E_{min}[Lx]	E_{max}[Lx]	U_0
166	63.8	225	0.38

So, it can be stated from the result that using 80 watt Highbay at a height 5.5 m from ground level recommended result over 150 Lux on wokplane is achieved .Luminaire is placed considering the pump obstruction. Table 6.10 shows the lux level chart.Figure 6.59 shows the Luminaire arrangement and 6.60 shows the value chart on workplane.3d rendering and false color rendering shows in figure 6.61.

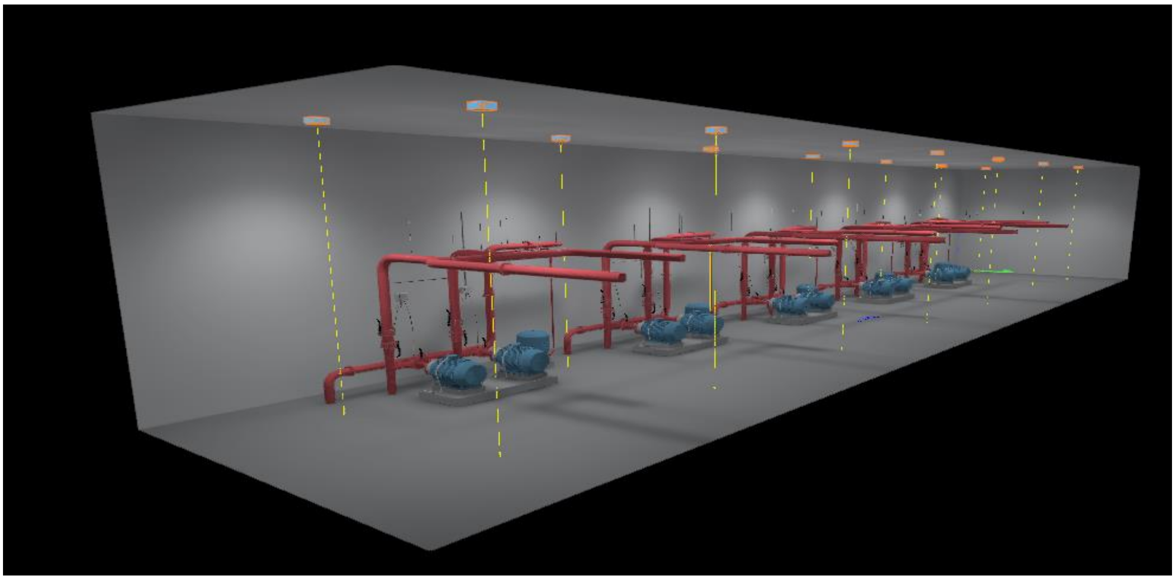


Figure 6.61: Simulated 3D view of a Pump House

6.3.5 **Junction House:**

Junction house sometime called as junction towers are the major component of coal handling system. These are supporting structures for the conveyor system to transfer materials from one location to other location. All junction towers would be of structural steel with chequered plate covered floors.

Design Aim:

To provide uniform illumination on walkways around the conveyor area and also at the oprating area near the conveyor. The uniformity of the designed light level must have the desired value. Lighting will provide comfort to the eyes and not create too much glare.

- Required illuminance level: Average 150 Lux as per different area [11]

Typical Design of Junction House:

Considering one of the Junction house for better understanding. DIALux software is used for the simulation purpos. Result analysis as per the NTPC standard. In this design the junction house has three level. Each level of crusher building is illuminated as per NTPC Standard, obstruction are taking into consideration for simulation purpose.

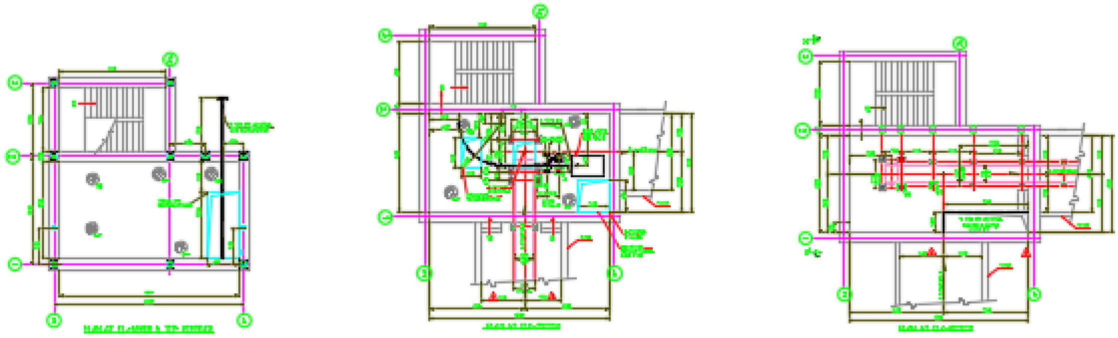


Figure 6.62: Plan view of a Junction house

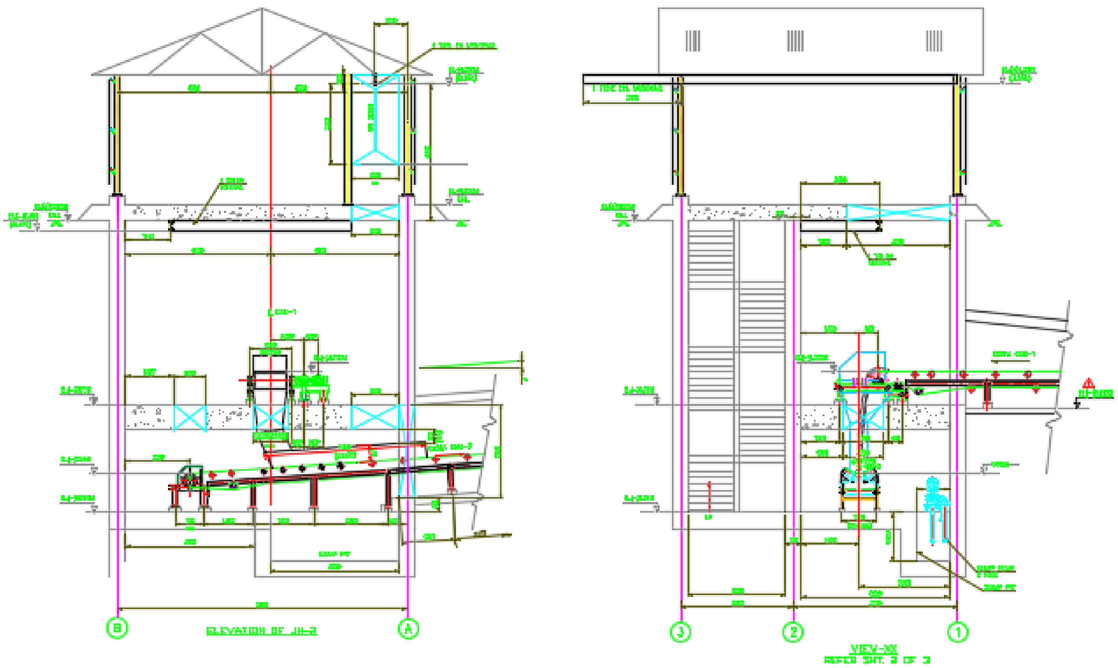


Figure 6.63: Elevation view of a Junction house

As shown in fig 6.62 junction house has three levels, each level design procedure is described further.From Fig 6.63 the elevation details or say mounting height of the luminaire is taken. Each level is illuminated as per NTPC Standard, obstruction are taking into consideration for simulation purpose.

For Elevation (+)0.50M:

Luminaries used:

- Circular PDC Aluminum housing LED Well glass
- Luminous flux: 4400 Lumen
- Wattage: 40 Watt
- System efficacy: 110 lm/W
- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected

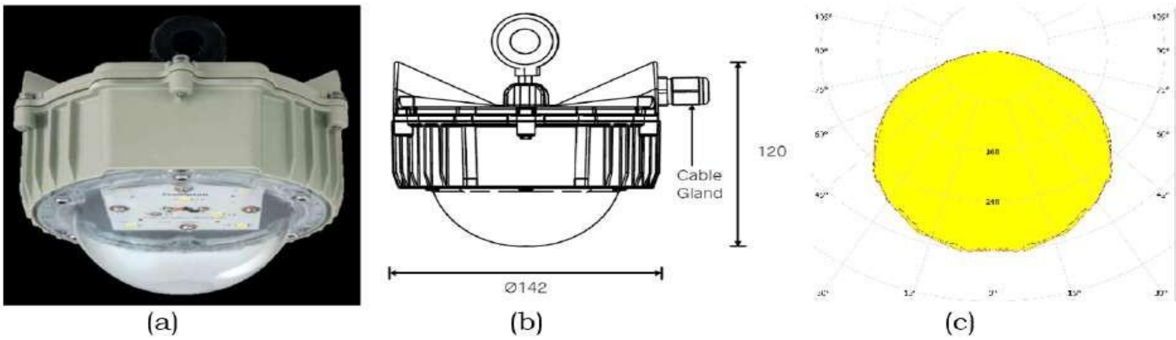


Figure 6.64: (a) Well glass image (b) Well Glass dimension (c) Polar curve

Figure 6.64 shows a typical well glass type luminaire made of PDC housing and its intensity distribution whose beam angle is 120 degree.

Design Consideration:

- Number of Luminaries: 6
- Mounting height: 4.0 m from floor level
- Maintenance factor: 0.5
- Reflectance Factor(ceiling/wall/floor) Respectively: 30/30/10

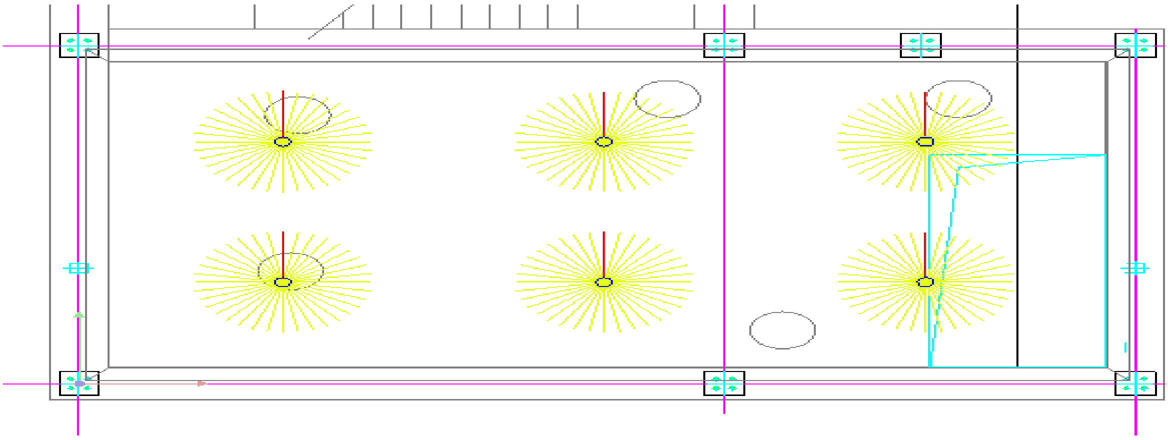


Figure 6.65: Simulated Layout of Juncttion House EL (+) 0.500M

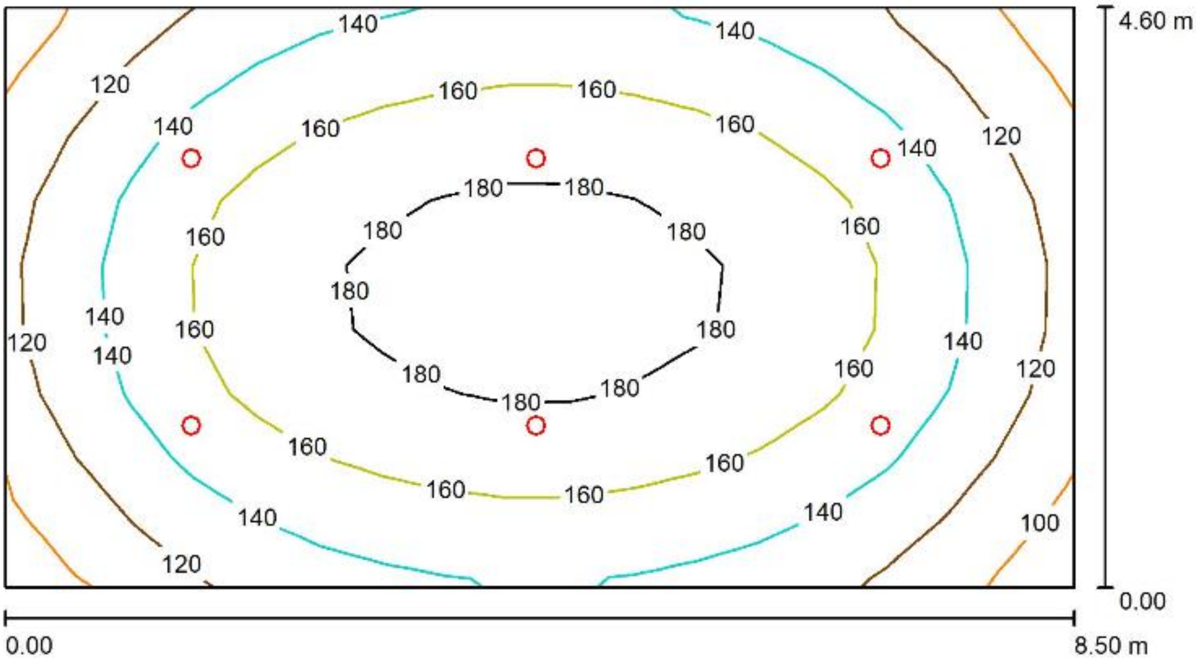
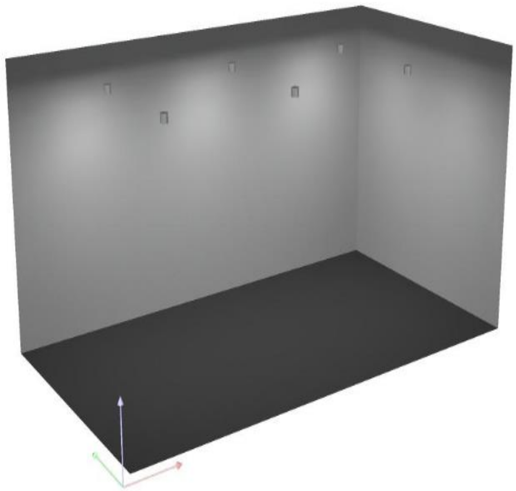


Figure 6.66: Value chart and Isolines of a Junction House EL (+)0.500M

Result Overview:

Table 6.11: Simulated output report of a Junction House EL (+)0.500M

E_{av}[Lx)	E_{min}[Lx]	E_{max}[Lx]	U_0
150	95	190	0.634



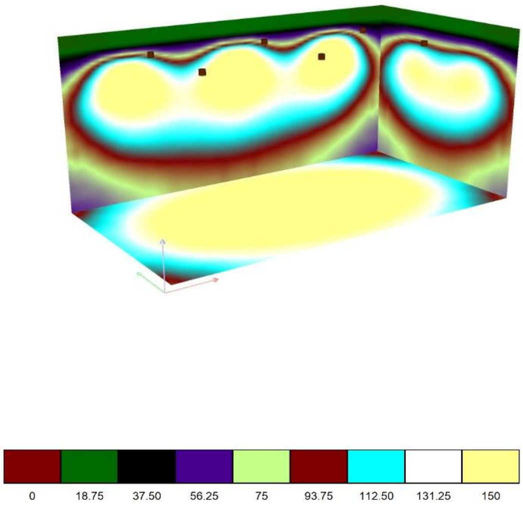


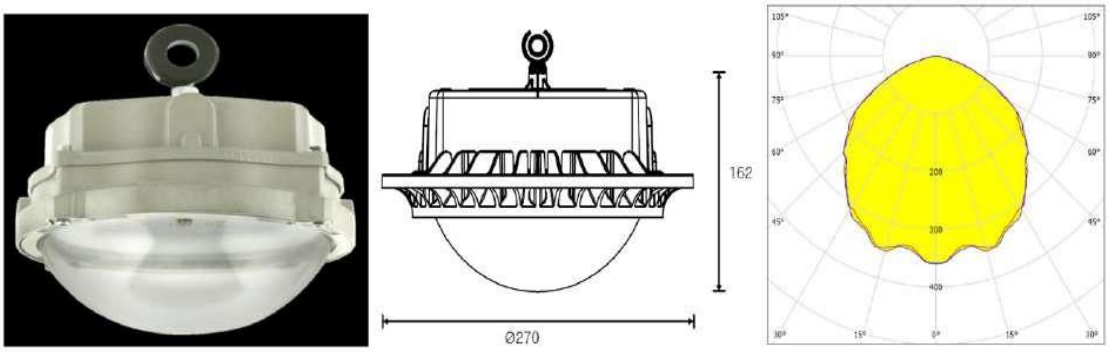
Figure 6.67: Simulated 3D view of a Junction House EL (+)0.500M

So, it can be stated from the result that using 40 watt well glass at a height 4 m from ground level recommended result over 150 Lux on wokplane is achieved .Table 6.11 shows the lux level chart.Figure 6.65 shows the Luminaire arrangement and 6.66 shows the value chart on workplane.3d rendering and false color rendering shows in figure 6.67.

For Elevation (-) 5.700M:

Luminaries used:

- Circular PDC Aluminum housing LED Well glass
- Luminous flux: 7800 Lumen
- Wattage: 70 Watt
- System efficacy: 110 lm/W
- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70
- IP 66 Protected



(a) (b) (c)

Figure 6.68: (a) Well glass image (b) Well Glass dimension (c) Polar curve

Figure 6.68 shows a typical well glass type luminaire made of PDC housing and its intensity distribution whose beam angle is 120 degree.

Design Consideration:

- Number of Luminaries: 6
- Mounting height: 5.7 m from floor level
- Maintenance factor: 0.5
- Reflectance Factor(ceiling/wall/floor) Respectively: 30/30/10

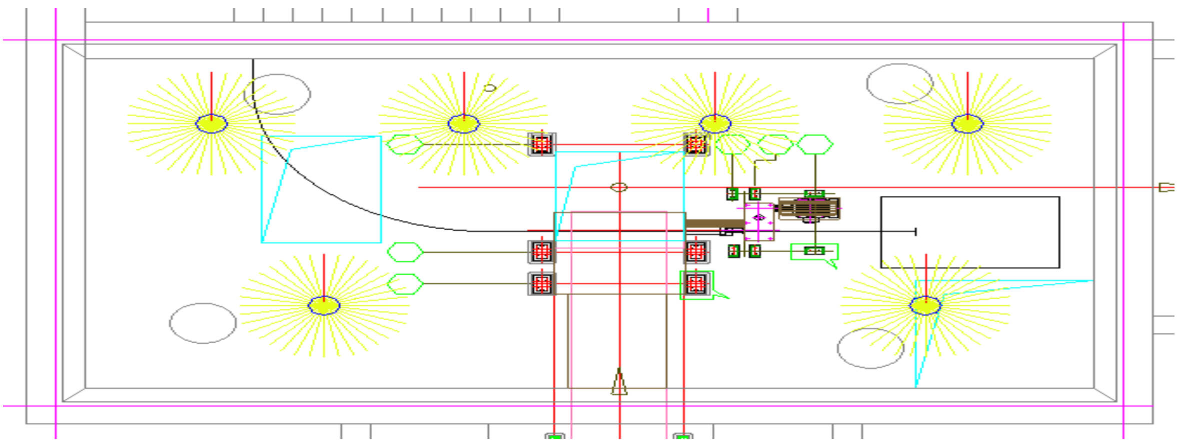


Figure 6.69: Simulated Layout of Juncttion House EL (-) 5.700M

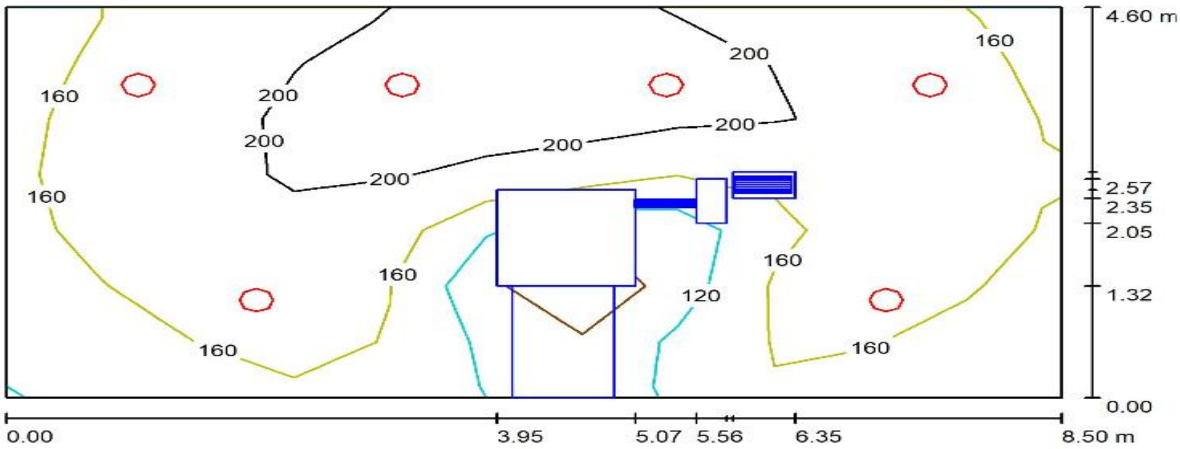


Figure 6.70: Value chart and Isolines of a Junction House EL (-) 5.700M

Result Overview:

Table 6.12: Simulated output report of a Junction House EL (-)5.700M

E_{av}[Lx)	E_{min}[Lx]	E_{max}[Lx]	U_0
172	66	217	0.383

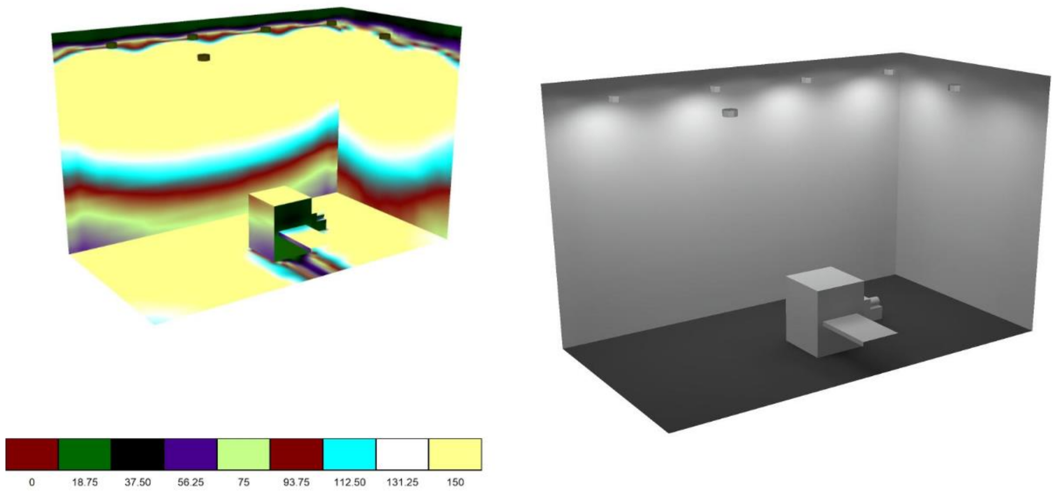


Figure 6.71: Simulated 3D view of a Junction House EL (-) 5.700M

So, it can be stated from the result that using 70 watt well glass at a height 5.7 m from ground level recommended result over 150 Lux on wokplane is achieved .Table 6.12 shows the lux level chart. Figure 6.69 shows the Luminaire arrangement and 6.70 shows the value chart on workplane.3d rendering and false color rendering shows in figure 6.71.

For Elevation (-)9.20M:

Luminaries used:

- Circular PDC Aluminum housing LED Well glass
- Luminous flux: 4400 Lumen
- Wattage: 40 Watt
- System efficacy: 110 lm/W
- Beam angle: 120 degrees
- CCT: 5700K
- CRI: 70
- IP 66 protected

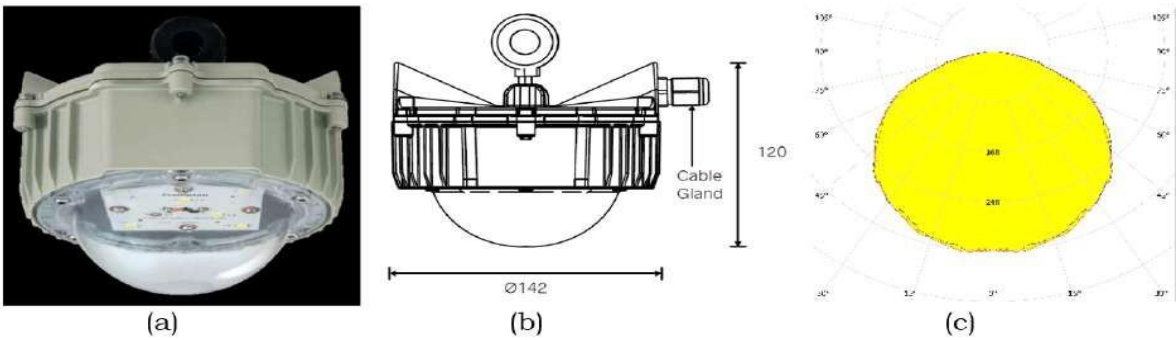


Figure 6.72: (a) Well glass image (b) Well Glass dimension (c) Polar curve

Figure 6.72 shows a typical well glass type luminaire made of PDC housing and its intensity distribution whose beam angle is 120 degree.

Design Consideration:

- Number of Luminaries: 6
- Mounting height: 2.56 m from floor level
- Maintenance factor: 0.5
- Reflectance Factor(ceiling/wall/floor) Respectively: 30/30/10

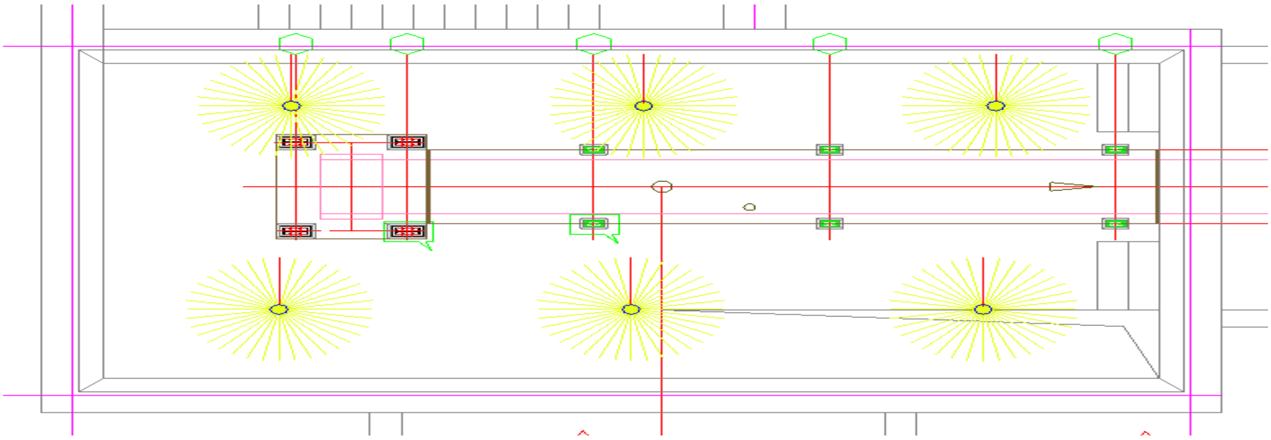


Figure 6.73: Simulated Layout of Juncttion House EL (-) 9.200M

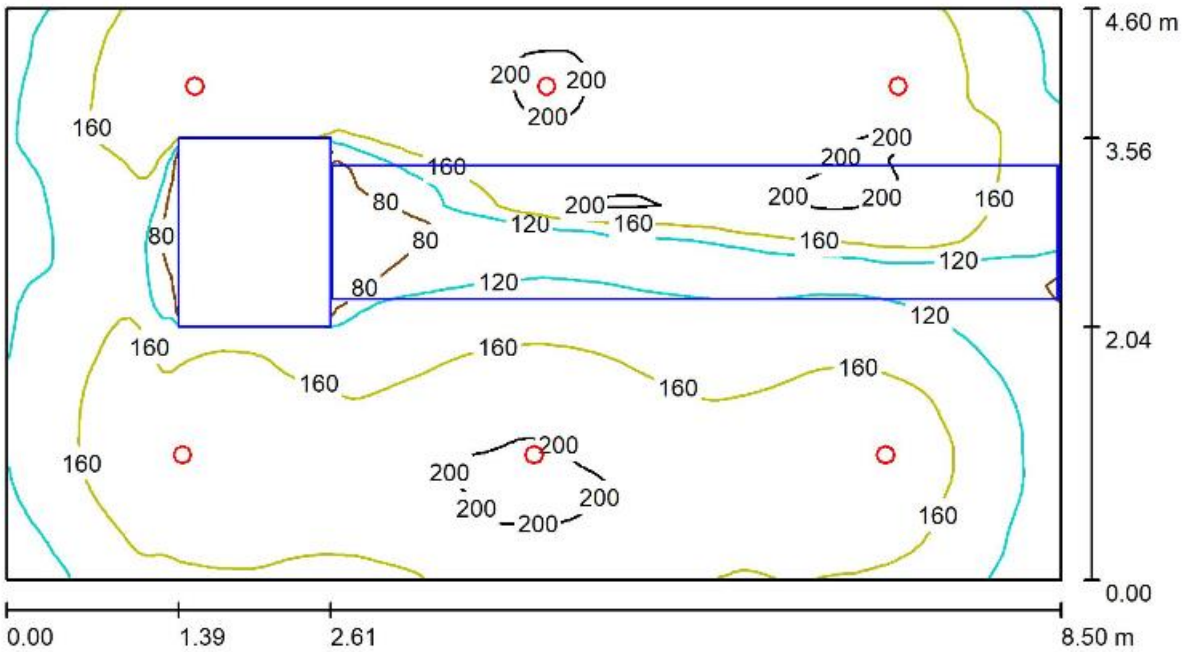


Figure 6.74: Value chart and Isolines of a Junction House EL (-) 9.200M

Result Overview:

Table 6.13: Simulated output report of a Junction House EL (-) 9.200M

E_{av}[Lx)	E_{min}[Lx]	E_{max}[Lx]	U_0
158	37	216	0.234

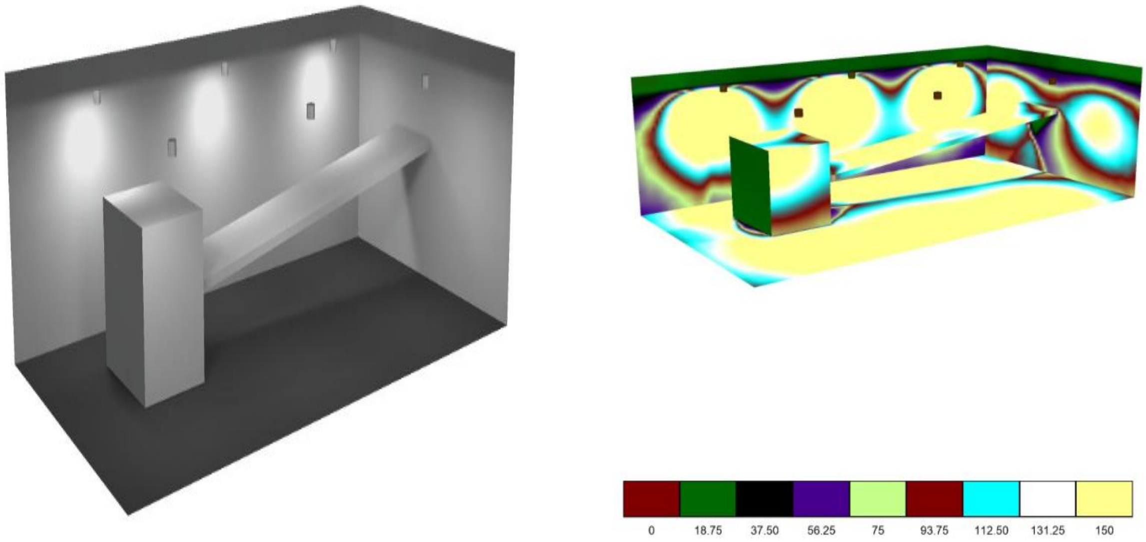


Figure 6.75: Simulated 3D view of a Junction House EL (-) 9.200M

So, it can be stated from the result that using 40 watt well glass at a height 2.56 m from ground level recommended result over 150 Lux on wokplane is achieved .Table 6.13 shows the lux level chart. Figure 6.73 shows the Luminaire arrangement and 6.74 shows the value chart on workplane.3d rendering and false color rendering shows in figure 6.75.

6.3.6 **Exterior Street:**

Exterior Roads of any Thermal Power Plant are generally Peripheral areas consist of the space surrounding the buildings of different sections of the plant. This type of road is interconnected through all over the area inside the plant. This road is used for truck moving purpose and material transportation purpose.

Design Aim:

To provide uniform illumination over the street for safely movement of truck and other transportation purpose. 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 Illumination Level: Average 20 Lux [8]
- Overall Uniformity(min/avg): Greater than 0.33[8]

Layout and Description of a Typical Exterior Road:

Considering one of 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.

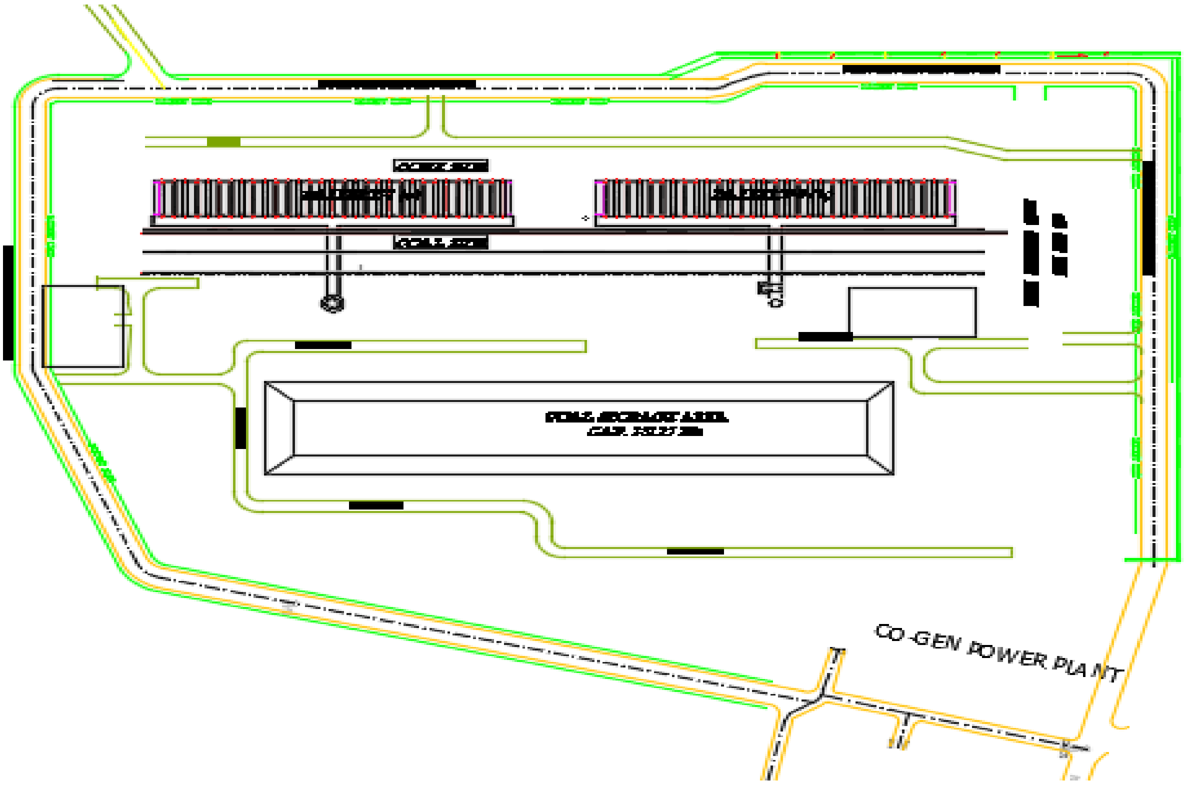
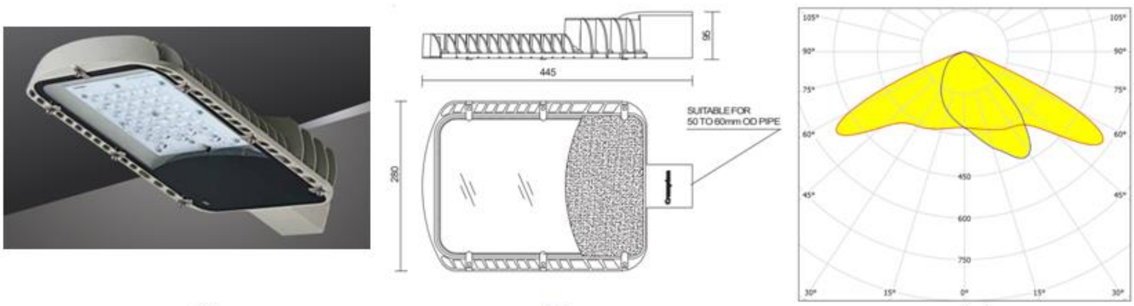


Figure 6.76: Plan Layout a Exterior Road

As shown in figure 6.76 it is a plan view of coal yard. Internal street is mark in green colour. This internal road is connected throughout the plant for material transportation. So proper illumination is required for safe transportation.

Luminaries Used:

- Aerodynamically designed PDC Aluminum housing LED streetlight
- Luminous flux: 13200 Lumen
- Wattage: 120 Watt
- System efficacy: 110 lm/W
- CCT: 5700K
- CRI: 80
- IP 66 protected



(a) (b) (c)

Figure 6.77: (a) Street Light image (b) Street Light dimension (c) Polar curve

In this Exterior Road the width of road is 7m. For this Design 120 W luminaire is used at a height of 11m at a spacing of 30m aprox. Maximum Pole height is taken for safe movement of truck without create any obstruction. Here three 30M high mast is also used for area lighting and the design is optimized by reducing the number of pole quantity and street light. Agi-32 software is used for the simulation purpose. Horizontal Calculation grid considered at ground level without obstruction. The colour of the grid is orange.

Design Consideration:

- Maintenance Factor: 0.5
- Number of Street Light Luminaires:21
- No of Poles:21
- Pole Height:11m from G/L
- Bracket Arm Length:1m
- Tilt:5 degree
- Arrangement: Single Sided
- Spacing :30 M approx

Result Overview:

Table 6.14: Simulated output report of a Exterior Road

E_{av}[Lx)	E_{min}[Lx]	E_{max}[Lx]	U_0	$E_{min/}$ E_{av}
23	10	40	0.43	0.25

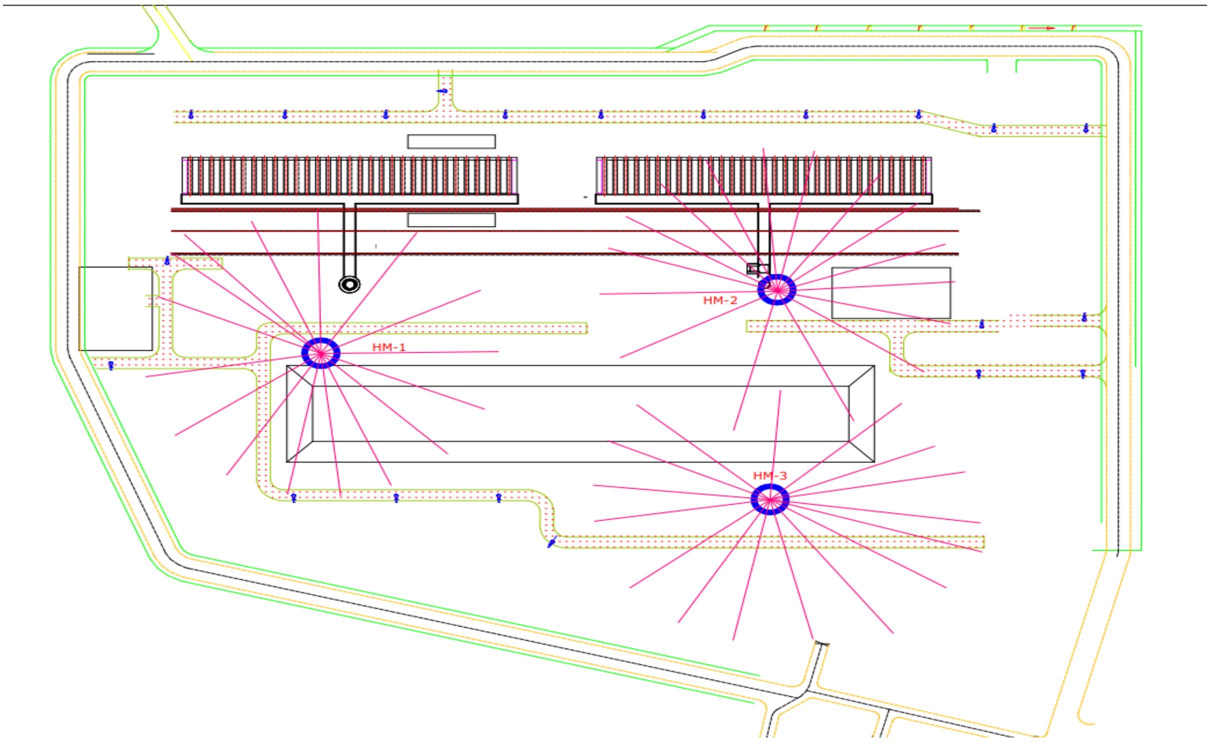


Figure 6.78: Simulated Layout of Road using Agi-32

So it can be stated that after using 21 number of street light luminaries and 16 nos of 500 watt floodlight on each mast required lux level (20 Lux) is achived with required uniformity in all over the exterior road. Table 6.14 shows the lux level chart.

6.3.7 **Exterior Area Lighting of a Coal Storage:**

Coal is often delivered to the plant by rail or truck and stored in stockpiles or silos. This allows for a continuous supply of coal, even during transportation interruptions. So storage of coal for a 5-10 days or more is important.

Design Aim:

To provide uniform illumination over the area associated with the storage shed for safely movement of truck and unloading purpose and other transportation purpose. Boundary or peripheral area need to be illuminated.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 Illumination Level: Average 20 Lux [2]
- Overall Uniformity(min/avg): Greater than 0.33[2]

Layout and Description of a Typical Exterior Area:

Considering one of Exterior area for better understanding of lighting design, analyzing software AGi32 has been used for describing and achieving the recommended values as per NTPC standard.

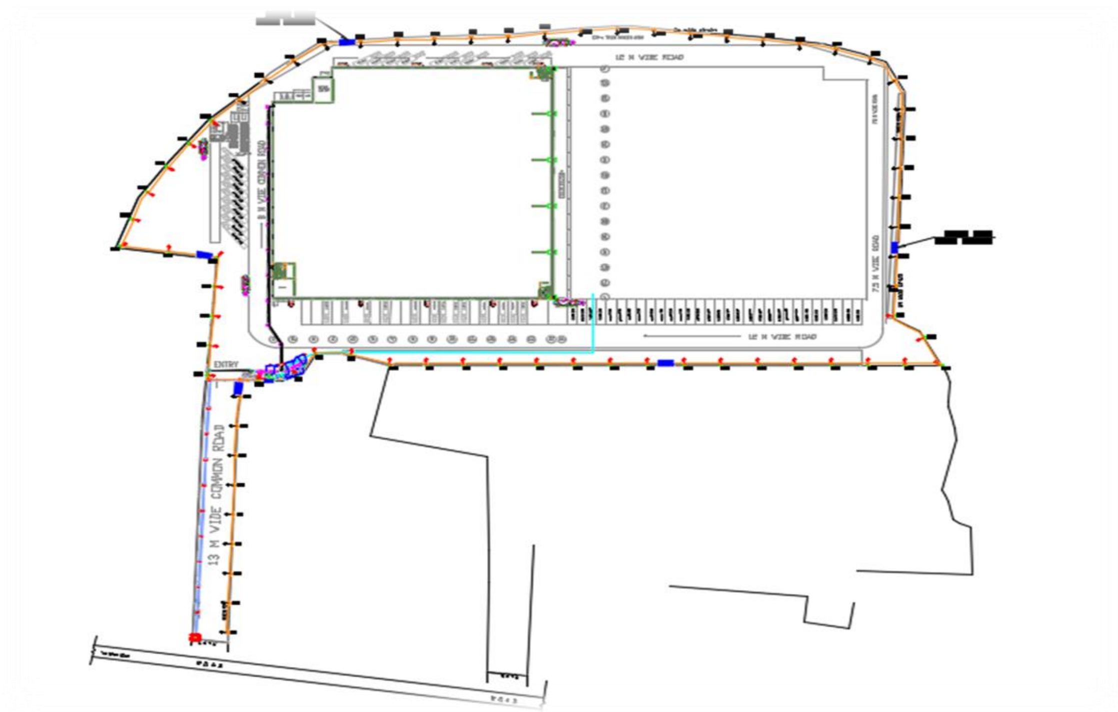


Figure 6.79: Plan Layout a Exterior Area

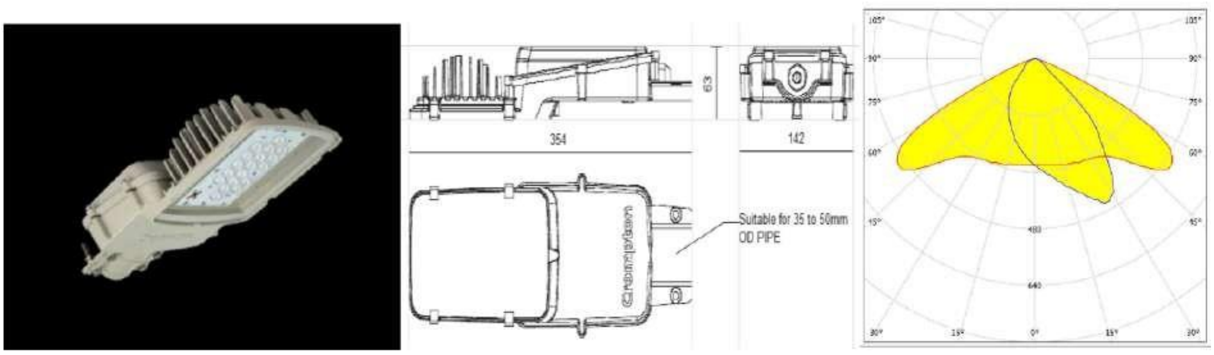
This Exterior area lighting divided into three part the under canopy and peripheral lighting along with the entry road. The width of entry road is 11m. For this Design 120 W luminaire is used at a height of 7m at a spacing of 25m aprox. Maximum Pole height is taken for safe movement of truck without creates any obstruction. The grid colour of entry road in blue.

Here three 150 watt flood light is used at a height of 7.5m and 9m from building parapet wall with wall mounted bracket .For Illuminate the peripheral area this area is also used for truck parking. A 5m x 5m calculation grid is taken on ground level. Colour of grid is green.

For under canopy where unloading process takes place 70 watt well glass light is used at a height of 7.5m .For Illuminate the canopy under the area. A 5m x 5m calculation grid is taken on ground level. Colour of grid is pink. For better understanding the grid colour is distinguished.

Luminaries Used:

- Aerodynamically designed PDC Aluminum housing LED streetlight (as shown in fig 6.80)
- Luminous flux: 13200 Lumen
- Wattage: 120 Watt
- System efficacy: 110 lm/W
- CCT: 5700K
- CRI: 80
- IP 66 protected

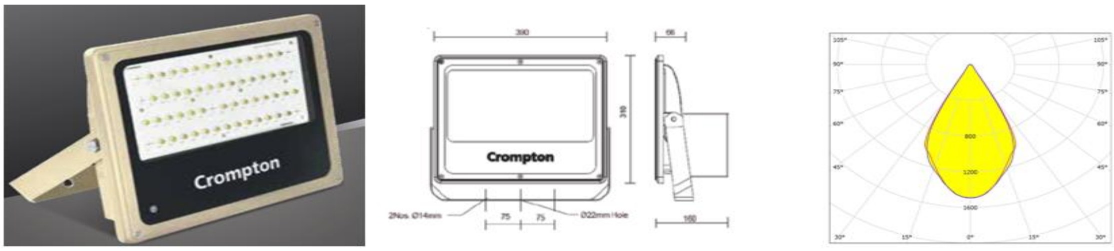


(a) (b) (c)

Figure 6.80: (a) Street Light image (b) Street Light dimension (c) Polar curve

Luminaries Used:

- Die cast powder coated white housing rectangular flood light (as shown in fig 6.81)
- Luminous flux: 16500 Lumen
- Wattage: 150 Watt
- System efficacy: 110 lm/W
- Beam Angle: 60 Degree
- CCT: 5700K
- CRI: 80
- IP 66 protected

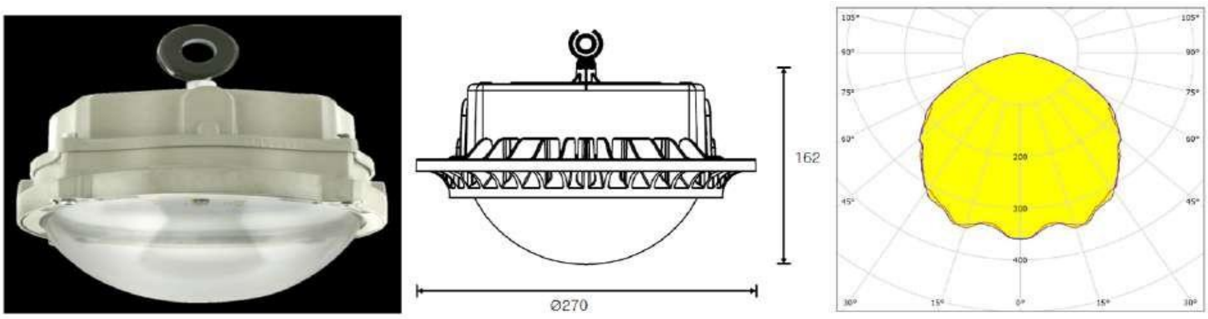


(a) (b) (c)

Figure 6.81: (a) Flood Light image (b) Flood Light dimension (c) Polar curve

Luminaries Used:

- Circular PDC Aluminum housing LED Well glass (as shown in fig 6.82)
- Luminous flux: 7800 Lumen
- Wattage: 70 Watt
- System efficacy: 110 lm/W
- Beam angle: 120 Degree
- CCT: 5700K
- CRI: 80
- IP 66 protected



(a) (b) (c)

Figure 6.82: (a) Well Glass image (b) Well Glass dimension (c) Polar curve

Design Consideration for Entry Road

- Maintenance Factor: 0.5
- Number of Street Light Luminaires:15
- No of Poles:15
- Pole Height:7m from G/L
- Bracket Arm Length:1m
- Tilt:15 degree
- Arrangement: Single Sided
- Spacing :25 M approx

Result Overview:

Table 6.15: Simulated output report of a Entry Road

E_{av}[Lx)	E_{min}[Lx]	E_{max}[Lx]	U_0	$E_{min/}$ E_{av}
21	10	40	0.47	0.25

Design Consideration for Peripheral Lighting

- Maintenance Factor: 0.5
- Number of Flood Light Luminaires:38
- Height:7.5m from building wall using bracket

Result Overview:

Table 6.16: Simulated output report of a Peripheral Area

E_{av}[Lx)	E_{min}[Lx]	E_{max}[Lx]	U_0	$E_{min/}$ E_{av}
54	13	103	0.24	0.13

Design Consideration for Under Canopy Lighting:

- Maintenance Factor: 0.5
- Number of Well glass Luminaires:38
- Height:7.5m from canopy

Result Overview:

Table 6.17: Simulated output report of a Peripheral Area

E_{av}[Lx)	E_{min}[Lx]	E_{max}[Lx]	U_0	$E_{min/}$ E_{av}
61	48	72	0.79	0.67

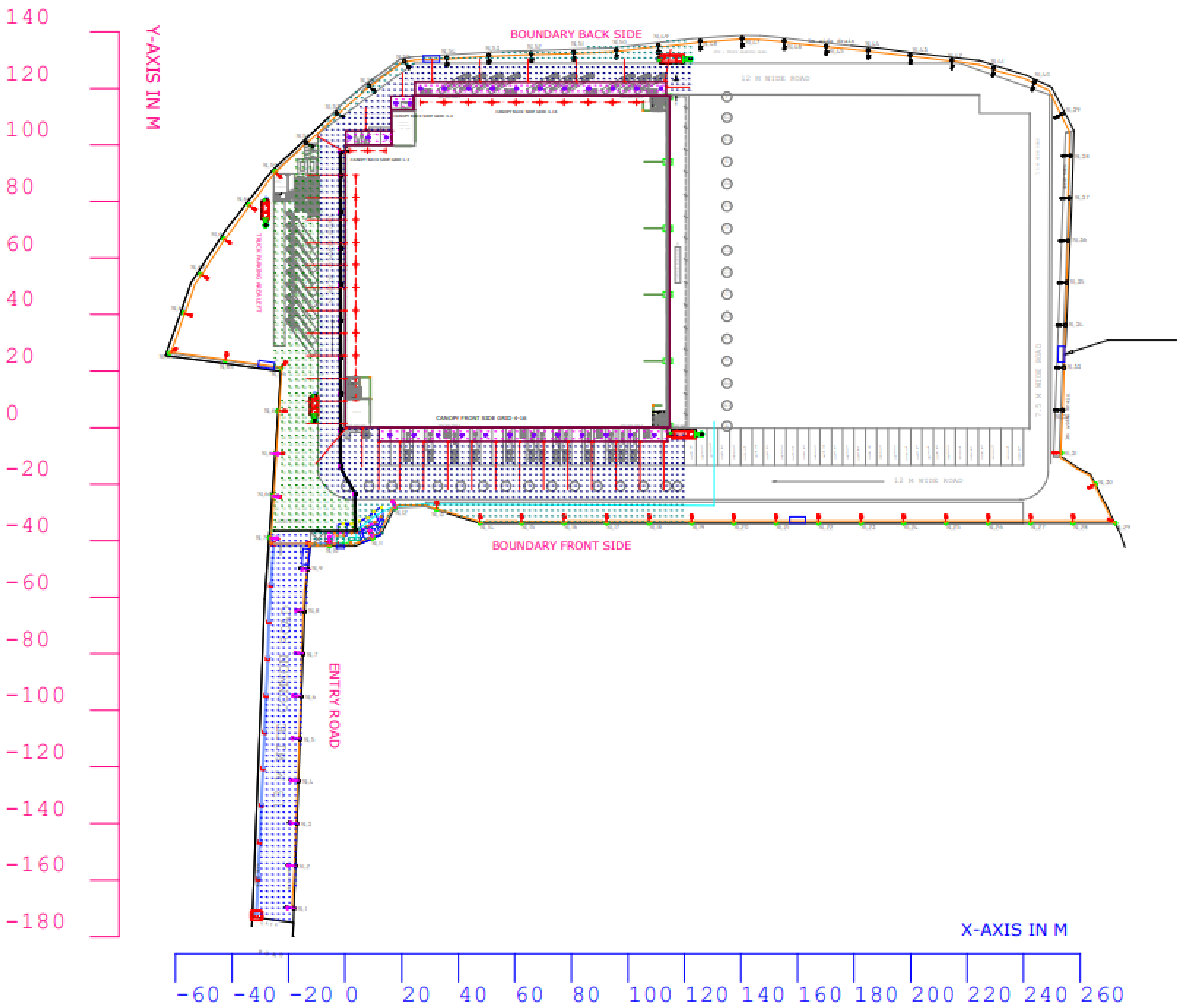


Figure 6.83: Simulated Layout of Total Area Agi-32

6.3.8 **Switchyard External Lighting:**

Every coal handling plant better to say a thermal plant have its own substation and external switchyard area for better voltage regulation. Switchyard is a necessary area to distribute the electricity generate from the plant.

Design Aim:

To provide uniform illumination over the equipment area and ground level of the switchyard to ensure safety and security. The lighting installations must provide visual comfort and it should not create much glare.

- Required Illumination Level: Average 50 Lux on equipment Level [8]
  Average 30 Lux on Ground Level [8]
- Overall Uniformity(min/avg): Greater than 0.3 [8]

Layout and Description of a Typical Switchyard External Area:

Considering one of External switchyard area for better understanding of lighting design, analyzing software DIALux has been used for describing and achieving the recommended values as per the specification.

Figure 6.84: Plan and Elevation of Switchyard Area

As shown in figure 6.84 this switchyard design the area is divided into two parts. One is High Voltage side (400kv side) others is Low Voltage side (200Kv side). So for the design purpose first step is to find the gantry height and equipment level height from elevation drawing. After place the calculation grid for equipment level and ground level. After placing the grid luminaries are placed in a manner that satisfies both quality of illumination and arrangement is done that its reduced glare and pole cost.

Luminaries Used:

- Aerodynamically designed PDC Aluminum housing LED streetlight (as shown in figure 6.85)
- Luminous flux: 4950 Lumen
- Wattage: 45 Watt
- System efficacy: 110 lm/W
- CCT: 5700K
- CRI: 80
- IP 66 protected

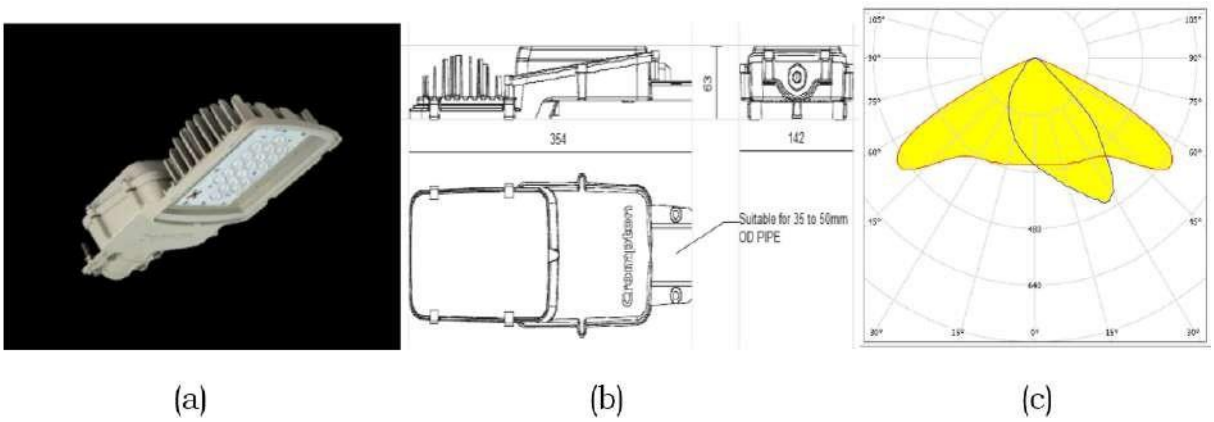


Figure 6.85: (a) Street Light image (b) Street Light dimension (c) Polar curve

Luminaries Used:

- Die cast powder coated white housing rectangular flood light (as shown in figure 6.86)
- Luminous flux: 16500 Lumen

- Wattage: 150 Watt
- System efficacy: 110 lm/W
- Beam Angle: 60 Degree
- CCT: 5700K
- CRI: 80
- IP 66 protected

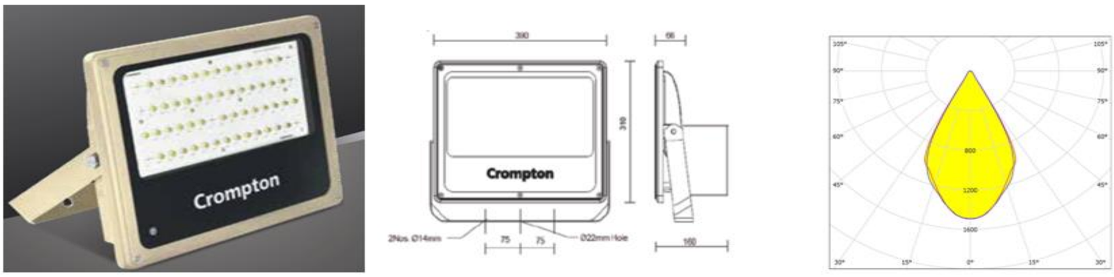
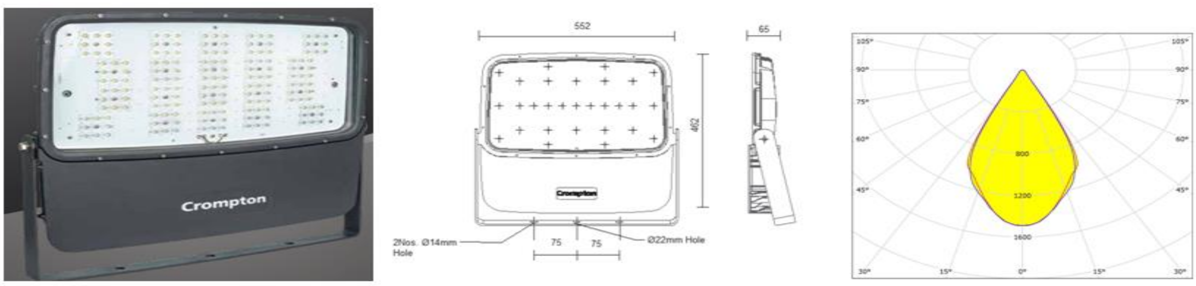


Figure 6.86: (a) Flood Light image (b) Flood Light dimension (c) Polar curve

Luminaries Used:

- Die cast powder coated white housing rectangular flood light (as shown in figure 6.87)
- Luminous flux: 27500 Lumen
- Wattage: 250 Watt
- System efficacy: 110 lm/W
- Beam Angle: 60 Degree
- CCT: 5700K
- CRI: 80
- IP 66 protected



(a) (b) (c)

Figure 6.87: (a) Flood Light image (b) Flood Light dimension (c) Polar curve

Design Consideration for Internal Street

- Maintenance Factor: 0.5
- Number of Street Light Luminaires:11
- No of Poles:1
- Pole Height:8m from G/L
- Bracket Arm Length:1m
- Tilt:5 degree
- Arrangement: Single Sided
- Spacing :25 M approx

Result Overview:

Table 6.18: Simulated output report of a Internal Road

E_{av}[Lx)	E_{min}[Lx]	E_{max}[Lx]	U_0	$E_{min/}$ E_{av}
21	10	44	0.437	0.212

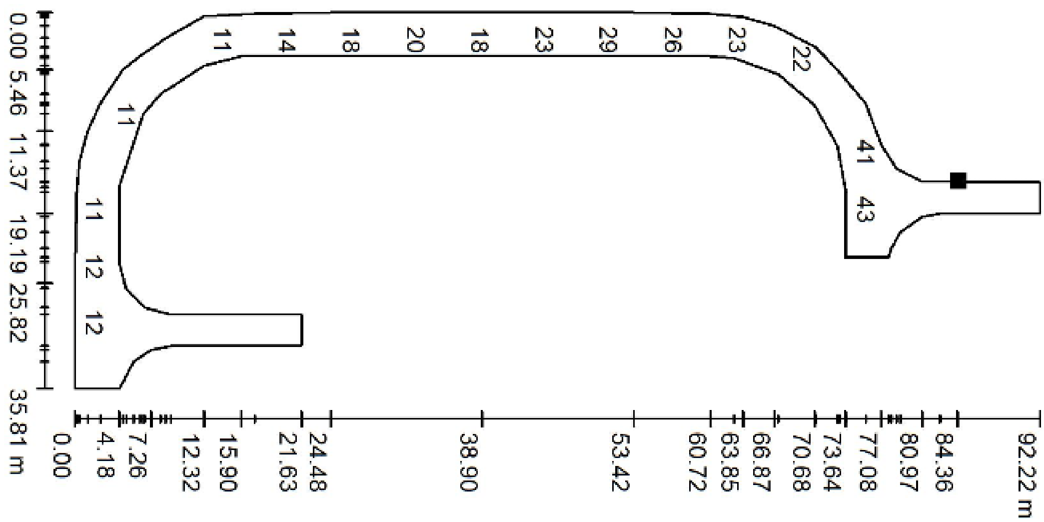


Figure 6.88: Value Chart of a Internal Road

As shown in table 6.18 it can be stated that after using 11 Nos of street light luminaires at spacing of 25 m the required lux level is achived. Contribution of flood light is also taken to reduce pole quantity. Figure 6.88 shows the value chart of the internal road.

Design Consideration for Switchyard Area

- Maintenance Factor: 0.5
- Number of Flood Light Luminaries for Low voltage side:15 Nos 150 watt flood
- Number of Flood Light Luminaries for High voltage side:21 Nos 250 watt flood light

Result Overview for High Voltage Side:

Table 6.19: Simulated output report for High Voltage Side equipment level

E_{av}[Lx)	E_{min}[Lx]	E_{max}[Lx]	U_0	E_{min}/ E_{av}
51	15	234	0.3	0.06

So it can be stated that after using 21 Nos of 250 watt LED flood light luminaries at gantry (height taken from elevation) and calculation grid at a height of 8m the required lux level is achieved. Table 6.19 shows the Lux level chart. Figure 6.89 shows the value chart for a high voltage side.

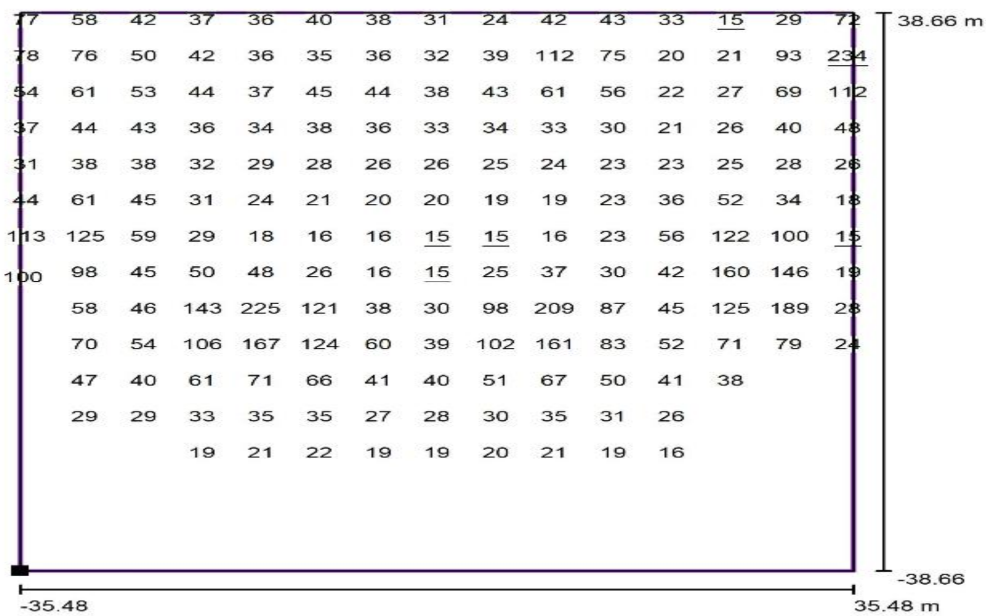


Figure 6.89: Value Chart for High Voltage side equipment level of a Switchyard

Result Overview for Low Voltage Side:

Table 6.20: Simulated output report for Low Voltage Side Equipment level

E_{av}[Lx)	E_{min}[Lx]	E_{max}[Lx]	U_0	$E_{min/}$ E_{av}
60	24	152	0.4	0.16

So it can be stated that after using 15 Nos of 150 Watt LED flood light luminaries at gantry (height taken from elevation) and calculation grid at a height of 5.9m the required lux level is achieved. Table 6.20 shows the Lux level chart. Figure 6.90 shows the value chart for a low voltage side.

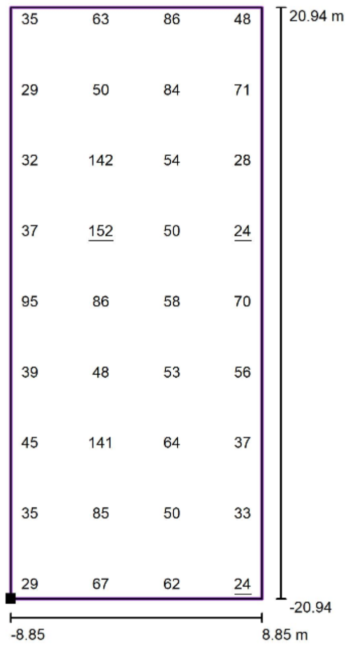


Figure 6.90: Value Chart for Low Voltage side equipment level of a Switchyard

Result Overview for Overall Ground Area:

Table 6.21: Simulated output report for Ground Level

E_{av}[Lx)	E_{min}[Lx]	E_{max}[Lx]	U_0	$E_{min/}$ E_{av}
29	9.75	69	0.33	0.14

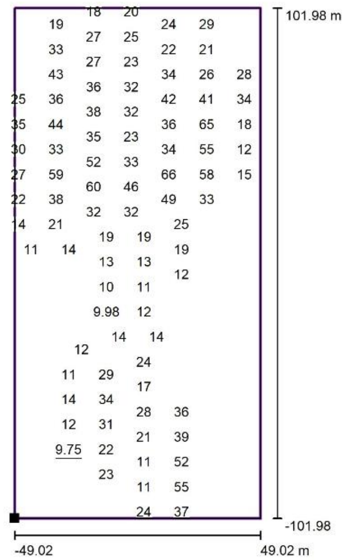


Figure 6.91: Value Chart for Ground level of a Switchyard

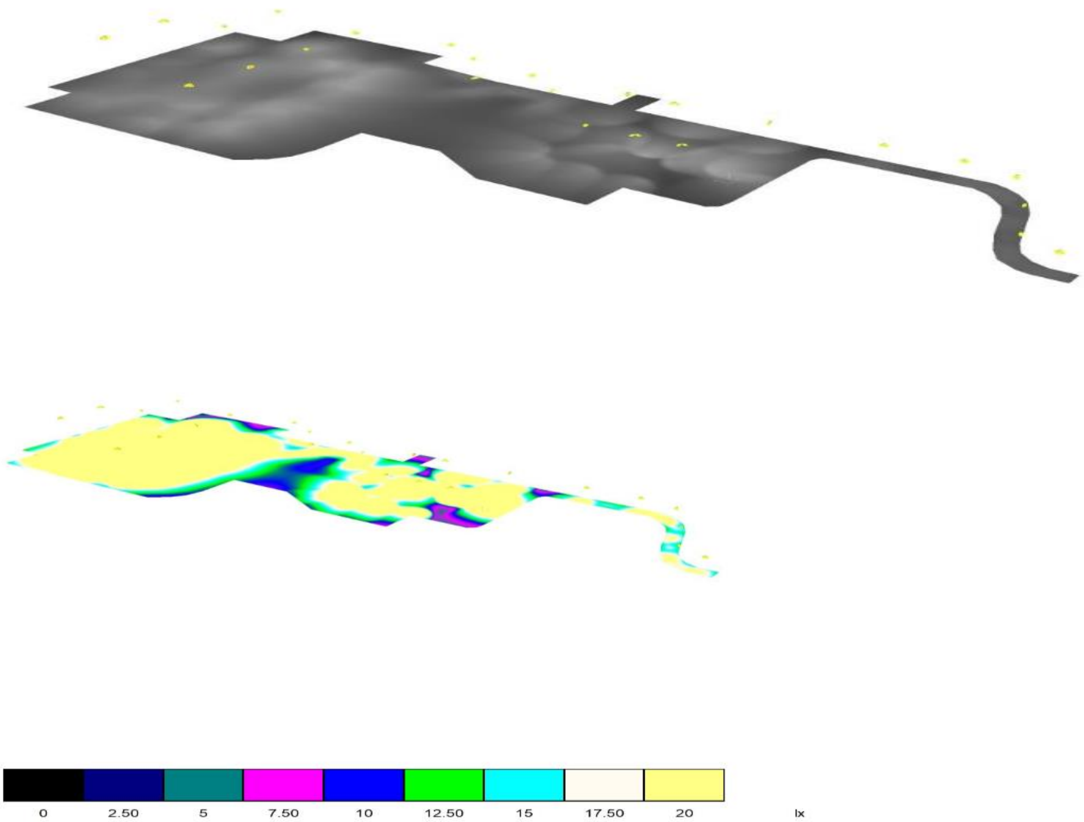


Figure 6.92: Simulated 3D view of a Switchyard

CHAPTER-7

Conclusion and Future Scope

7 Conclusion and Future Scope:

7.1 Conclusion:

This project is dealt with analyzing the processes and activities in various areas of Coal handling Plant, so as to provide lighting design approach of various areas 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.

After reviewing the entire document, to conclude the industrial lighting design techniques, the illustration has been made in three segments i.e., Product Specification ,Design Methodology, Practical Installation

7.1.1 Product Specification:

In last 10 years, it is quite visible that LED has replaced the conventional light source as it has advantages over conventional light source i.e.

- LED gives more lumen output for a particular wattage than the conventional light source, i.e., LED has better efficacy (lumen/watt) than conventional light source.
- LED does not contain any toxic material inside it, while conventional light source contains toxic materials like mercury. And for some cases this is one of the most vital factor for choosing LED over conventional light source. E.g., If conventional light source is used inside a biscuit factory and somehow if the luminaries breaks then the toxic material may fall on the food products.
- Controlling a LED is very easy than the conventional light source.
- The life span of LED is very impressive than the conventional light source, in general LED has a life span of 50000 hours, while conventional light source has a life span of 10000-15000 hours. Thus using LED over a conventional light source will decrease the maintenance cost, so it will be more economical option to use.

The enclosure of the Luminaries has to be in such a way that it's IP rating has to be more than or equal to IP- 65 in most of the cases for industrial application, and IK rating has to be more than or equal to 07 in most of the cases. And for the high bay luminaries the beam angle is restricted to the 60 deg to 90 deg. And for outdoor area the flood lights are used of beam angle 60 deg to 30 deg. In some cases, product should be designed in such a way that it can easily withstand fire.

7.1.2 Design:

During DIALux simulation of an industry illumination project some parameters has to be taken properly to match the luminance in the actual site i.e

- Maintenance factor for indoor areas is to be considered, 0.7 to 0.8, but not more than that, in some cases like coal mine areas it is safe to consider the maintenance factor as 0.6, while using LED luminaries. And for outdoor areas it is safe to consider the maintenance factor as 0.6-0.7 to match the atmosphere of the actual site.

- Room reflectance is another important parameter. In general, for general electrical apparatus room, it is advisable, to consider the room reflectance for ceiling, wall and floor are 50%, 30% and 10% respectively. For comparatively darker room it is safe to consider the room reflectance for ceiling, wall and floor are 30%,30% and 10% respectively.
- For the selection of the distance between to grid points for an outdoor area, it is convenient to consider 1 to 5 meters depending upon the area.
- For the selection of grid points for indoor areas should follow the given formula mentioned in the standard EN-12464,

$$\mathbf{p = 0.2 \times 5 \log d} \ \textbf{[8]}$$

Where:
d:Longer dimension area in meter(m)
The value of P should be less than <=10

7.1.3 **Installation:**

- In shed areas the luminaries are advisable to install the luminaries on the truss to minimize the installation cost.
- The luminaries should be arranged in such a way that the emission of light does not fall on the obstructions, instead they should be mounted in such a way that the working plane and paths are properly visible.
- For outdoor areas, to reduce the installation cost we must find the scope that the luminaries can be mounting on the building wall.

7.2 Challenges Faced:

To compare LED sources with conventional in a particular area in terms of energy efficiency the lux level values obtained should be close enough. It is only possible when the lumen packages and the photometric distribution of the luminaries are nearly same. But it is really difficult to have a LED and Conventional luminaries which matches exactly. Although now-a days LEDs are available which can replace different CFL/ FTL fixtures piece to piece without altering the quantity but in some cases the quantity may differ in two designs to match illuminance level properly, which leads to re-arrangement of total electrical layout.

7.3 Future Scope of Work:

7.3.1 Daylight Integration:

Day light integration with artificial light is the future of lighting design in near future, as it brings some added advantages inside the factory or industrial area.

- It reduces the electric lighting loading, i.e. LPD will be under control during day time.
- It brings improved lighting conditions, i.e. colour rendition, CCT etc.
- It is scientifically proved that, under daylight workers feel more active, so production rate will increase while damage is less.
- It reduces maintenance and operation cost.

7.3.2 Lighting Control:

Controlled light inside the factory is very much desirable as it brings some added advantages inside the factory and exterior area.

- **Energy Savings** – lights can be automatically dimmed or turned off according to occupancy or available daylight.
- **Extend Bulb Life** – the amount of life a bulb has is increased due to less use, particularly with incandescent and halogen lights.
- **Adjust Light Levels Relative to Tasks** – lower levels can be used for ambiance; higher levels can be used for tasks that require it.
- **Security** – outdoor lights will automatically turn on between dusk and dawn, security alarms can also trigger at both indoor and outdoor lights to turn on.

So it can be stated that after conducting several simulations using different LED fixtures, LED fixtures resulted in lower power consumption compared to all other fixtures, keeping all other standards intact. That being said, currently LED fixtures have higher prices compared to conventional fixtures, which may result in higher payback periods. Hence, owing to the capital investment involved, all clients may not prefer LED fixtures; in that case FTL/ CFL and MHL fixtures can be proposed.

CHAPTER-8

Reference

8 Reference

[1] IS 6665 (1972): Code of practice for industrial lighting [ETD 24: Illumination Engineering and Luminaries]

[2] IS 3646-1 (1992): Code of practice for interior illumination, Part 1: General requirements and recommendations for welding interiors [ETD 24: Illumination Engineering and Luminaries]

[3] Energy Conservation Building Code-2017

[4] IS 1944-1 and 2 (1970): Code of Practice for Lighting of Public Thoroughfare. Part 1 and 2 For main and secondary roads (Group A and B) [ETD 24: Illumination Engineering and Luminaries]

[5] SP 72 (2010): National Lighting Code 2010 [ETD 24: Illumination Engineering and Luminaries]

[6] "Road Lighting Fundamentals, Technology and Application", Van Bommel, Wout, 1981.

[7] "Lighting-engineering-applied-calculations",RH Simons and AR BAEAN,2001

[8] EN 12464-1: Light and Lighting - Lighting of Work Places - Part 1: Indoor Work Places

[9] EN 12464-2:2014: Light and Lighting - Lighting of Work Places - Part 2: Outdoor Work Places

[10] Crompton Professional Lighting Product Catalogue.

[11] Natioanl Thermal Power Corporation Document Part B Subsection III-B-09-Illumination

[12] IS 10322-1 (1982):Specification of Luminaires Part-1 General Requirements.

[13] CIE 97, 2005 Technical Report Guide on Maintaince of Indoor Electric Lightting Systems

[1] https://www.deepakkumaryadav.in/2021/09/coal-handling-in-thermal-power-plant.html

[2] https://www.stouchlighting.com/blog/everything-need-to-know-high-bay-lighting-industrial-led-lighting

[3] https://stock.adobe.com/in/search?k=%22spinning+mill%22