STUDIES ON ENERGY EFFICIENT LIGHTING DESIGN OF INDUSTRIAL APPLICATION AREAS

A thesis towards partial fulfilment of dissertation of the requirements for the degree of

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Submitted By,

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CERTIFICATE OF RECOMMENDATION

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

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DECLARATION OF ORIGINALITY AND COMPLIANCE OF ACADEMIC ETHICS

I hereby declare that this thesis contains literature survey and original research work by the undersigned candidate, as part of his MTech. (Illumination Technology and Design) studies during academic session 2023-24

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

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

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This is to certify that Ms. Saswati Pramanick, 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 16th June, 2023 to 30th April, 2024.

The title of her thesis was "Studies on energy efficient Lighting Design of Industrial application areas" which was carried out under the guidance of Mr. Sumit Kar, DGM — Design. During the tenure of her internship with us, she has been sincere, hardworking, and diligent in carrying out the assignment entrusted to her.

We wish her all success in his future endeavour.

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LIST OF CONTENT

ABSTRACT

The key factors to consider in designing an industrial lighting space are discussed in this thesis work. When illuminating a spaces in-addition to task performance and visual comfort, perception of safety plays a significant role. To ensure worker safety and factory productivity, industrial facilities require high-quality illumination. In addition to being strong enough to resist adverse environmental factors including high temperatures, humidity, corrosive environments, soiled power, and vibration, lighting systems also need to adhere to relevant codes for materials, safety, and fire. Apart from these prerequisites, the luminaires must to be energy-efficient and require low maintenance. Advancements in light-emitting diode (LED) lighting technology provide a chance to assess the quality of light in industrial areas scientifically. The key considerations in designing an industrial lighting installation, summary of different lighting technologies, key factors to assess in selecting luminaires and recommended criteria to develop a specification are discussed in this work.

CHAPTER 1. INTRODUCTION

1.1 INTRODUCTION

The work in industrial plants carries numerous responsibilities, including properly adapting lighting to the industrial production conditions. This section introduces elements that a lighting specifier needs to consider when developing a specification for lighting purely from a visual performance, visual comfort, and well-being of users stand-point. This is the primary purpose served by illumination. An industrial plant's lighting design can be difficult as several different tasks must be completed precisely and frequently simultaneously. All factors that impact the amount and quality of light that reaches the work surface should be taken into account when choosing and installing lighting. Industrial lighting fixtures need to be built to last through locations that are exposed to high temperatures, vibrations, and water.

Industrial lighting is used in warehouses, factories, food processing, cold storage, heavy and light metal industries, etc. industrial lighting enables good visibility and visual comfort on all workplaces of this type.

This chapter establishes the framework for the research thesis, which analyses key aspects of industrial light system design. It will cover key elements of project work, goals, and how the project's overall plan is carried out.

1.1 LITERATURE SURVEY

Marc Elliott Member, IEEE Eaton Corp. 26850 SW Kinsman Rd Wilsonville, OR 97070, USA Asiri Jayawardena, Ph.D. Member, IEEE Eaton Corp. 1201 Wolf St Syracuse, NY 13208, USA The “Advancement of Industrial LED Lighting and Its Future Applications” IEEE 2022 [1]

This paper discusses key factors to consider in designing an industrial lighting space. Key lighting technologies used in industrial facilities with special focus on light emitting diode (LED) is discussed and compared. This paper discusses in detail attributes that needs to be considered in selecting a luminaire with emphasis on LED technology. How these attributes impact safety, sustainability, light pollution, and digitalization is discussed. A framework to consider when selecting luminaire is presented as a conclusion.

In environments such as cement, aggregate and sand, there are recent megatrends and ongoing challenges influencing our decisions in lighting. Sustainability is demonstrated in efforts to reduce emissions, greenhouse gas emissions and overall power consumption. Digitalization is the ability to connect facility assets to our people and software that translate that into actionable safety, maintenance, and operational insights.

While consistent increase in LED install base multiple factors needs to be considered when selecting a suitable luminaire has been seen. Recently lighting industry is pivoting towards offering digitally enabled products that can provide enhanced value with respect to sustainability, user experience, quality of light and operational efficiency. The paper also discusses key considerations in designing an industrial lighting installation, summary of

different lighting technologies, key factors to assess in selecting luminaires and recommended criteria to develop a specification. A framework to consider when selecting luminaire is presented as a conclusion.

Cletus Mullin Rene Koltes; Mick Walton; Jeff Krukowski "Industrial Lighting: A Holistic Approach Using Light-Emitting Diode Technology "IEEE Industry [2]

This paper discusses the effects of implementing a specialized holistic lighting design throughout a new industrial petroleum-processing facility using high mast lights and the latest light-fixture technology rather than conventional lighting design methods. Topics of engineering justification for design decisions, the final design outcomes, and the financial impacts of choosing the design approach are presented in a case study, and additional environmental and economic successes and failures of the design philosophy are explored.

Asiri Jayawardena; David Duffy; Joseph M. Manahan "Lighting Matters in Industrial Environments: A Framework Linking Workplace Safety to Lighting Quality Metrics" [3]

This paper says that Lighting affects human performance and, therefore, safety in industrial environments. Recent developments in light-emitting diode (LED) lighting technology offer an opportunity for a scientific evaluation of the quality of light in industrial spaces. For this article, the possibility of reducing the risk of key causes of occupational hazards through the effective application of lighting was evaluated. Vision science research was reviewed to identify mechanisms that could improve object detection, supra threshold visual performance, and response time. Metrics to quantify these mechanisms-i.e., small target visibility (STV), relative visual performance (RVP), mesopic luminance, and luminaire system application efficacy (LSAE)-were reviewed and applied in the context of industrial lighting installations. The results indicated the potential to harness new lighting technology to enhance visual task performance and thereby improve safety and productivity. Lighting is also related to the fatigue of industrial workers. It could influence fatigue by degrading the sleep quality of night-shift workers, causing visual discomfort and creating a negative perception of the environment. A review of research, simulations, and calculations led the authors to develop a framework that links occupational injury incidents to lighting quality metrics for industrial environments. This framework needs to be validated using field studies that are designed based on this research. In this period of technological transition, facility managers can use this study to benchmark lighting technologies and installations for safety. This article presents value propositions that a versatile and controllable source such as LEDs could offer to industries

1.2 PROBLEM DEFINATION

Lighting design of interior and exterior of different application of industrial areas using higher energy efficiency technology. To design on the basis of different lighting technologies, key factors to assess in selecting luminaires and recommended criteria to develop a specification. Also, considering various obstructions and objects during the design of the areas. Outdoor design challenges the decisions in lighting to achieve the desire result.

1.3 OBJECTIVES

The objectives of the thesis are as follows

1.To study the different application of industrial areas.

2.To study and apply illumination designing on different areas of industries using LED.

1.4 METHODOLOGY

1.Study of the area or the plan lay out in AutoCAD software.

2.consideration of all the design parameters, standards codes which will leads us to the result.

3.Simulation of the areas using DIAlux 4.13 software.

4.Comparison of the obtained results with the requirements data.

5.conclude and future scope of the project.

1.4 THESIS OUTLINE

This thesis contains six chapters:

1. The first chapter "**Introduction**" includes literature survey, objectives, problem definitions of the project.

2. The second chapter says the "**Background Theory**" about the topic which includes different industrial areas, general lighting, function of lighting are there.

3. The third chapter is "**lighting codes and standards**" includes different standards of industrial lighting and interior illumination ex IS 3646 Part 1 and 2, national lighting code.

4. The fourth chapter highlights the "**Methodology**" of this thesis, and the steps, tools, parameters of design, and key considerations and other factors are the primary points of concern.

5. The fifth chapter "**Designing of different Application of industrial areas**" are basically dealing with the actual task with proper methodology.

6. The last chapter "**Conclusion and Future Scope**" finalizes this thesis.

CHAPTER 2

BACKGROUND THEORY

INDUSTRIAL LIGHTING

fig 2.1 industry area

Industrial means anything related to industry, which is an economic sector that deals with the production and manufacturing of goods. Industries are grouped according to the goods and services they manufacture, making them major part of today's economy.

Industries play a crucial role in the economy, involving the production of goods, extraction of services, and provision of service

Manufacturing environments can be quite complex, involving significant infrastructure and multiple building systems for the same locations.

For factory productivity and worker safety, industrial facilities require high-quality illumination. In addition to having to meet appropriate fire, safety, and material requirements, lighting systems also need to be robust enough to endure extreme weather conditions including high temperatures, humidity, corrosive atmospheres, filthy power, and vibration. In addition to these specifications, the luminaires have to be energy-efficient and need little maintenance as shown as fig 2.1.[4]

Among the industrial sector's major uses are:

- Manufacturing and warehousing
- Food and beverage processing
- Heavy industries

2.1 FACTORS INFLUENCING GOOD INDUSTRIAL LIGHTING PRACTICE

- **A GOOD INDUSTRIAL LIGHTING INCLUDES:**

1. A good quantity of illumination.
2. A good quality of illumination.
3. To provide security and safety.
4. Enable the completion of visual tasks.

- QUANTITY OF ILLUMINATION:

Different light levels are needed for different visual tasks. taken into account while creating a design for an industry. A lighting system's utilitarian objective is to provide the best possible performance for a certain job. As a first step, the identification of link between lighting and performance, but other considerations including preventing tiredness, physiological and psychological consequences, and economics, among others, must be taken into account in the final suggestion. Ideal standards for figuring out how much light there is are:[5]

1. Adequacy for preventing occupational eye-strain and the risk of accidental injury due to bad visibility
2. Adequacy for creating an agreeable luminous environment.
3. Adequacy for different satisfactory levels of visual performance.

- QUALITY OF ILLUMINATION:

Quality of illumination refers to the distribution of brightness in the visual environment. The term is used in a positive sense and implies that all brightness should contribute favourably to visual performance, visual comfort, ease of seeing, safety and aesthetics for the specific visual task involved. The quality of industrial lighting is determined by the control extended on luminaire, visual test and room service luminance. If this luminance is not controlled, then disability, discomfort glare is produced and it reduces task visibility and visual comfort.

2.2 FUNCTIONS OF LIGHTING

-The lighting of an interior should fulfil three functions.

1. Ensure the safety of people in the interior,
2. Facilitate performance of visual tasks, and
3. aid the creation of an appropriate visual environment.

Safety is always important but the emphasis given to task performance and the appearance of the interior will depend on the nature of the interior. For example, the lighting considered suitable for a factory toolroom will place more emphasis on lighting the task than on the appearance of the room, but in a hotel lounge the priorities will be reversed. This variation in emphasis should not be taken to imply that either task performance or visual appearance can be completely neglected. In almost all situations the designer should give consideration to both these aspects of lighting.

Lighting affects safety, task performance and the visual environment by changing the extent to and the manner in which different elements of the interior are revealed. Safety is ensured by making any hazards visible. Task performance is facilitated by making the relevant details of the task easy to see. Different visual environments can be created by changing the relative emphasis given to the various objects and surfaces in an interior. Different aspects of lighting influence the appearance of the elements in an interior in different ways. However. it should always be remembered that lighting design involves integrating the various aspects of lighting into a unity appropriate to the design objectives.[6]

2.3 GENERAL CONSIDERATIONS OF DESIGN FOR LIGHTING INDUSTRIAL AREAS

The designer of an industrial lighting system should consider the following factors as the first and important requirement of good planning:

1. Determine the quantity and quality of illumination & desirable for the manufacturing processes involved.
2. Select lighting equipment that will provide the quantity and quality requirements by examining photometric characteristics, and mechanical performance that meet installation, operating and actual maintenance conditions. [6]

3. Select and arrange equipment so that it will be easy and practical to maintain; and Balance all the economic factors including initial, operating and maintenance costs, versus the quantity and quality requirements for optimum visual performance.

2.4 LIGHTING RELATED TO STRUCTURE OF INDUSTRIAL PREMISES

1. Factory Spaces with Skylights –

Where daylighting 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 on daylighting. 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 as shown as fig 2.2. [6]

Fig 2.2 factory space with skylight

2.Closed ceiling

In this type of construction there is very little dependence on daylighting which is mainly from side windows and is inadequate and consequently the work layout is organized on considerations other than daylighting requirements. 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.

To provide the best viewing circumstances, the fittings must be aligned in accordance with the machinery configuration. A design chosen with this kind of care could not work with the current structural components, and extra members might need to be made especially to mount the lighting fixtures as shown below in fig 2.3.

Fig 2.3 factory with closed ceiling

3.High Bay lighting

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, etc as shown in fig 2.4.

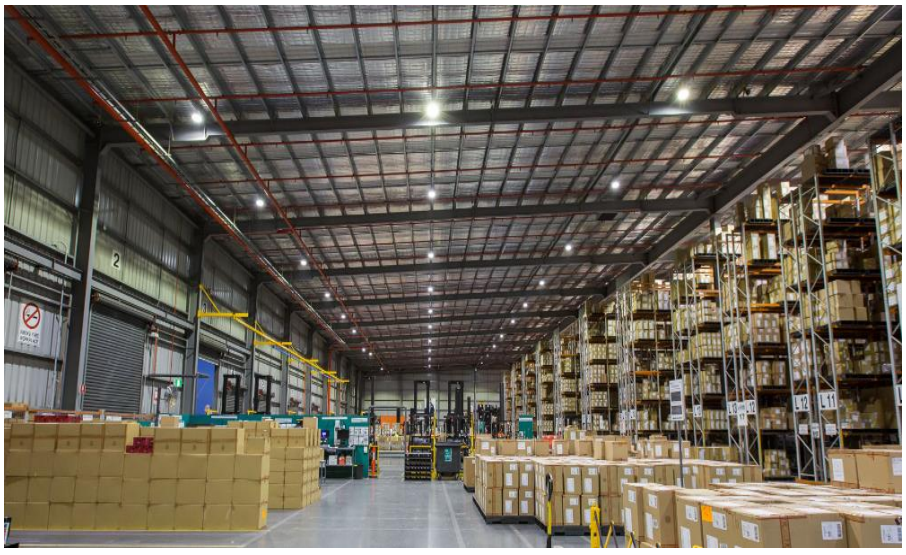


Fig 2.4 factory with high bay lighting

2.5 OVERVIEW OF DIFFERENT INDUSTRIAL AREAS

1. WAREHOUSE

An Industrial Warehouse is defined as an economical solution for housing and storing heavy machinery like mining plants.

Such facilities include features like open sides, tilt panels, and concrete flooring to ensure that your machinery is not only safe and shielded from the weather, giving it a long time. As an industrial shed builder, we understand the way people use a shed differs, looking at their industry, needs, and storage requirements. Not every industrial shed is the same. Thus, they are used for many alternative purposes as shown in fig 2.5. [8]

Fig 2.5 Warehouse

2. WAREHOUSE WITH MEZZANINE FLOOR

A warehouse mezzanine is a partial floor or elevated floor/platform that is installed between the main floor and ceiling of the warehouse. It is semi-permanent structure that serves as an intermediate floor within a warehouse or industrial facility, creating additional usable space without the need to expand the shed's footprint. Mezzanine floors can be used for a variety of purposes, including additional storage, work areas, and office/recreational space as shown in fig 2.6. [9]

Fig 2.6 Warehouse with mezzanine

3. WAREHOUSE WITH RACK

Pallet or warehouse racking is a type of material handling system that may be used for large-scale product storage. Adapting a racking system is the first step to warehouse automation. This is achieved by integrating smart conveyor systems and cranes. This can lead to significant savings in terms of manpower costs and can streamline the business process especially for large distribution centres as shown in fig 2.7.

Warehouse racking is designed to take advantage of storage space, arrange products efficiently, and provide a system making it easier to pick required items. Safety measures are a necessary part of the efficiency of a warehouse and are an integral part of racking system design. Included as safety measures are sensors and alarms, guard rails, rack end protectors, rack guards, and column guards.[10]

Fig 2.7 Warehouse with racks

4. PETROL PUMP CANOPY

A structure called a "petrol pump canopy" is used to shade gasoline dispensers at gas stations as shown in fig 2.8. It is a crucial safety component that shields the machinery and users from outside factors including the sun, rain, and debris. The following are important features of gas station canopies: [11]

- They are built to be sturdy and withstand various weather conditions.
- Canopies are constructed to endure potential hazards and accidents.
- High-quality materials are used to ensure long-term use.
- If damaged, they can be dismantled and replaced easily.
- They offer shade and reduce the risk of overheating at the pumps.

Fig 2.8 Petrol pump canopy

5. BULK TANK STORAGE INDUSTRIAL

Fig 2.9 large storage tanks

Industrial storage tanks designed for holding different kinds of liquids and gases in an industrial environment. They are made to meet the storage requirements of a variety of sectors, including water treatment, chemical manufacture, oil and gas, and more. They come in a variety of sizes and forms. Depending on the material they are meant to retain and the circumstances they must endure, these tanks might be constructed of concrete, stone, fiberglass, steel, or plastic as shown in fig 2.9. [12]

Typical industrial storage tank types include the following:

1.**Tanks for storing fuels:** These are used to store petroleum products such as gasoline and diesel. They may be underground or above ground.

2.Tanks for storing chemicals: These containers may have unique linings to stop corrosion and are made to hold a variety of chemicals.

3.Oil Storage Tanks: Include tanks with floating roofs to minimize evaporation, and fixed roof tanks for stable storage.

4.Water and Liquid Storage Tanks: These can hold waste liquids or water for use in industrial processes. Open-top, poly, and fiberglass tanks are among the varieties. Gas storage tanks are used to store gases under pressure, such natural gas or propane.

6. EXTERIOR ROAD AREA

A huge storage tank's outside roadways are often peripheral roads that are encircled by the various storage area buildings. One tank area and another tank region are connected by these routes.

Fig 2.10 internal factory roads

2.6 KEY FEATURES OF LED LIGHTS

Out of many lighting technologies available in market, one technology gaining traction and acceptance is LED (Light Emitting Diodes). Numerous lighting technologies, such as high intensity discharge (HID), fluorescent, and light emitting diode (LED) technologies, have been created since Thomas Edison invented the incandescent lamp in 1879. Installing LED products has grown across all applications between 2016 and 2018, nearly doubling to 2,325 million units, bringing LED penetration to 30.0% of all general illumination lights. According to the US Department of Energy (DOE), in 2015, 6% of all industrial luminaire installations were LED light fixtures.[13]

light-emitting diode (LED) is a semiconductor device that emits light when an electric current flows through it. When current passes through an LED, the electrons recombine with holes emitting light in the process. LEDs allow the current to flow in the forward direction and blocks the current in the reverse direction.

LEDs like any electrical component are represented in electrical drawings by a symbol. The symbol is shown below fig 2.10

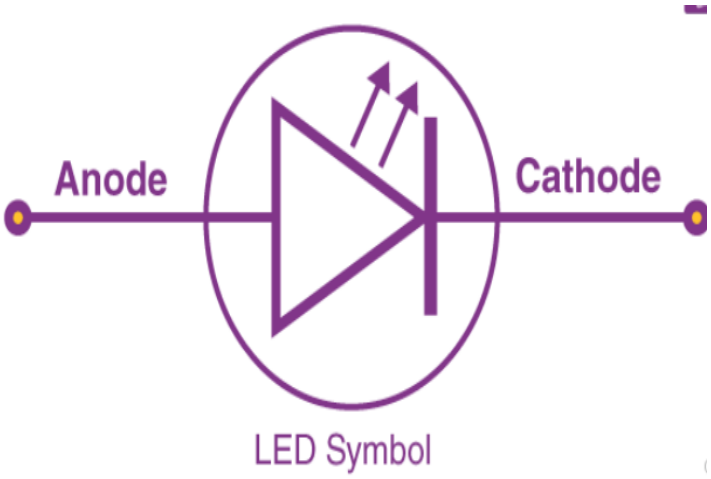


Fig 2.10 Light-emitting diode symbol

There are various kinds of LEDs which we design through the use of semiconductors. They include:

- Miniature LEDs
- Bi and Tri-Colour
- High-Power LEDs
- Flash LED
- Red Green Blue LEDs
- Lighting LED

Some advantages of LEDs over Incandescent Power Lamps are:

- LEDs demand a low operating voltage and use less power.
- There is no need for LEDs to warm up.
- They are hardy and have a long lifespan.

Why LEDs are suitable for industrial lighting

ENERGY EFFICIECY

LEDs are incredibly energy-efficient; they produce light from around 80% of the electrical energy they need. By contrast, only around 20% of the energy used by incandescent bulbs is converted to light; the remaining energy is lost as heat. Reduced greenhouse gas emissions and huge energy savings result from this greater efficiency.

Longevity

LEDs, on average, endure 25,000 to 100,000 hours, which is an outstanding longevity. This is far longer than the typical 1,000-hour life of a regular incandescent lightbulb and the 8,000-hour life of a compact fluorescent lightbulb. LEDs thus require less replacement, which lowers waste and maintenance expenses.

Environmentally friendly

LEDs are an eco-friendly lighting option due to their low energy consumption and long lifespan. Additionally, they do not contain hazardous materials such as mercury, which is found in compact fluorescent bulbs. This makes LED disposal simpler and safer for the environment.

The Future of LED Technology

LED technology is continuously evolving, with researchers and manufacturers striving to improve its efficiency, colour quality, and affordability. Future advancements in LED technology may include:

- **Increased Energy Efficiency:** Ongoing research aims to develop LEDs with even higher energy efficiency, which will further reduce energy consumption and associated greenhouse gas emissions.
- **Improved Colour Quality:** Researchers are working on enhancing the colour rendering index (CRI) of LEDs, which will improve the quality of light and provide more accurate colour representation.
- **Smart Lighting Solutions:** The integration of LED lighting with smart home and building automation systems will enable advanced control, monitoring, and energy management capabilities.
- **Flexible and Stretchable LEDs:** The development of flexible and stretchable LED materials will enable new applications in wearables, medical devices, and other innovative areas.

CHAPTER 3.

LIGHTING DESIGN CODES AND STANDARDS

LIGHTING STANDARDS UNDER RECONSIDERATIONS

Industrial lighting refers to the sight of tasks, operating conditions and economic conditions. The visual tasks may be classified as small or very large; dark or light; opaque, transposing surfaces; flat or contoured shapes. In the manufacturing process, physical hazards exist and, therefore, lighting should play a leading role in preventing accidents.

Light should not only be a safety component and a tool for production, but it should also enhance the general atmosphere of the workplace. Lighting needs to be a deliberate component of a space that encourages people' comfort and general well-being. The design of a lighting system is done under some standards and codes which is discussed below.

3.1 lighting standards under considerations

This chapter aims to provide a quick overview of the criteria that must be followed when presenting any industrial design. The primary object of this code is to indicate the factors which should be taken into account to achieve good lighting.

STANDARDS FOLLOWED

1. IS 3646 Code of practice for interior illumination (Part I ,1992) (Part 2, 1996)

This deals with the general lighting requirements and recommendations for working interiors. This Indian Standard (Part I and II) was adopted by the Bureau of Indian Standards, after the draft finalized by the Illuminating Engineering and Luminaires Sectional Committee had been approved by the Electrotechnical Division Council. The primary object of this code is to indicate the factors that should be taken into account to achieve good lighting. Lighting is good only when it is suitable in both quality and quantity for two purposes; for creating good environmental brightness which is at the same time agreeable and beneficial to the user, and for permitting a high degree of efficiency in seeing whatever is of special interest or importance.[5]

1.1 RECOMMENED ILLUMINATION AS IS 3646 PART 1

AREA	ILLUMINANCE RANGE(LUX)
Warehouses and Bulk Stores	
•Storage of goods where identification requires only limited preparation of detail.	50-100-150
•Storage of goods where identification requires perception of detail	100-150-200
•Automatic high bay rack stores	
- Gangway	20
- Control Station	150-200-300
- Packing and dispatch	200-300-500
- Loading bays	100-150-200

1.2 RECOMMENED ILLUMINATION AS IS 3646 PART 2

AREA	ILLUMINANCE RANGE(LUX)
•Factory Outdoor Areas	
- Stockyards, main entrances and exit roads, car parks, internal factory roads	20
•Electricity Generating Station: Outdoor Location	
- Oil storage tanks	50
- Coal unloading areas	20
- Coal storage areas	20

2. IS 6665 – 1972 CODE OF PRACTICE FOR INDUSTRIAL LIGHTING

This Indian Standard was adopted by the Indian Standards Institution on 8 August 1972, after the draft finalized by the Illuminating Engineering Sectional Committee had been approved by the Electrotechnical Division Council. Taking into consideration the increasing industrial activities in India thereby a large number of people have to work on tasks and processes of Increasing intricacy and detail with working hours extending into the night, would has been felt for well planned and efficient industrial lighting which would create easier seeing conditions and agreeable atmosphere. This has led to the publication of this code of practice.[6]

3. SP-72-2010 NATIONAL LIGHTING CODE

The NATIONAL LIGHTING CODE (NLC) covers the following:

1) Guidance on illuminating engineering practices to be followed by various types of occupancies;

2) Guidance on good engineering practices to be followed in the design, selection, installation and maintenance of lighting systems for indoor and outdoor areas;

3) Matters related to the science of illumination such as physics of light, electric light sources, luminaires and photometry;

4) Coordination aspects to be considered while designing the lighting systems such as daylighting; and

5) Aspects relating to energy management and energy conservation in lighting installations including guidelines for design and good practices to be adopted for effective and efficient use of light sources.

This code has been formulated for the purpose of setting out in a convenient form the requirements for responsible social, commercial and engineering conduct as designers, manufacturers and suppliers of lighting. Lighting technology plays a significant role in achieving basic social safety and environmental objectives. The intent of this code is to encourage good lighting practices and systems which would minimize light pollution, glare, light trespass and conserve energy while maintaining safety, security, utility and productivity.[7]

CHAPTER 4

DESIGN METHODOLOGY

This chapters consists of all the design consideration, design parameters, methodology to achieve the desire requirements

4.1 DESIGN PARAMETERS

Average Illuminance (E_{avg}):

The quantity of luminous flux falling on the work plane per unit area of the light receiving surface. Typically, the work plane height is set at 0.76 meters above the ground.

E_{avg} = Amount of light falling on the work plane (in lumens)/ area (in M^2).

Overall Uniformity U_0 :

Code of practice recommends that the uniformity of illuminance should be measured as the ratio of minimum illuminance to the average illuminance over the task area, which may be the whole interior or specific task areas. The ratio usually applies to values on the working plane over the working area. The overall uniformity is different for different cases for examples for interiors like offices , hospital the U0 is maintained as U0 ≥ 0.7 and for any critical task area like Designing or skilled drawing which requires very high lux levels, the overall uniformity for the entire surroundings is maintained at U0 ≥ 0.8 or ≥0.9 depends.

It is mathematically described as: $U= E_{min}/E_{avg}$

Where: **E_{min}** = minimum value of illuminance over the task area (in lux or fc)

E_{avg} = average value of illuminance over task area (in lux or fc)

Unified Glare Rating (UGR):

Glare in the installation is defined in two different terms:

1. Disability glare: Disability glare is the glare, which reduces the ability to perceive visual information needed for task performance. This is because too much light gets scattered in the eye.

2. Discomfort glare: Discomfort glare, is the glare that causes discomfort without necessarily impairing the vision of objects and task area.

4.2 DESIGN CONSIDERATIONS:

1. REFLECTANCE SURFACES

This indicates the percentage of light that enters the work plane after reflecting off of the floors, walls, and ceilings. The brighter the walls reflect more light and darker walls absorb more light.

Depending on the environment condition or specified by the client we decide the reflectance factor.

For example:

The ceiling, wall and floor reflectance of offices or school have been considered as 70%, 50% and 20% respectively, as these areas are expected to have false ceilings with proper maintenance.

For other industrial areas like Stores, Warehouse, coal plant etc, the ceiling, wall and floor reflectance are considered as 30%, 20% and 10% respectively. It is expected that these areas are not so well maintained and dirty, are assumed to have lower reflectance values.

2. ILLUMINANCE LEVEL

Illuminance of the area or building are always decided as per as standard.

IS 3646 Code of practice for interior illumination (Part I AND II)

IS 6665 – 1972 CODE OF PRACTICE FOR INDUSTRIAL LIGHTING

3. MAINTENANCE FACTOR:

also called as **light loss factor (LLF)**. The maintenance factor is important in lighting design as it helps ensure that the lighting system can provide the required level of illumination throughout its lifespan.

For example, if the needed lighting level of a project over a lifetime is about 500 lumens, where the MF is set to 80 percent (or 0.8), then an initial 625 lumens need to be installed in that area. This is important for maintaining the required lighting level over the entire span of its lifetime.

It estimates the effect on the illuminance provided by the installation of the fall in the lamp luminous flux with hours of use and the depreciation caused by dirt deposited on luminaires and room surfaces. Light loss factor is, therefore, product of three other factors.

Light-loss factor = Lamp lumen maintenance factor x Luminaire maintenance factor x Room surface maintenance factor

- Room surface maintenance factor:

RSMF is the ratio of the reflectance of the room surfaces before and after cleaning. It depends on the environment, cleaning frequency, and the impact of room surfaces on the lighting level. The RSMF is influenced by the surface material and the maintenance schedule.

- Lamp lumen maintenance factor:

The LLMF is the ratio of the lamp lumens at a specific time to the initial values. It depends on the lamp type, the operating conditions, and the quality of the lamp.

-Luminaire maintenance factor:

LMF is the ratio of the light output of a clean luminaire to that of a dirty one. It depends on the type and quality of the lamp and luminaire, as well as the amount of dirt and dust that can accumulate on them.

As a designer, you should ensure that occupants get at least the minimum illuminance requirement for the duration of their stay by designing a lighting system to supply the necessary light level even after the system has reached its worst stage of degeneration. Concerning the lighting setup.

It is, therefore, recommended that in interiors with fairly clean atmosphere, for example, offices, air-conditioned factory interiors, etc, a light loss factor of 0.8, in interiors, which are prone to accumulate dust faster, for example, most industrial interiors, an **LLF** of 0.7.

4.3 DESIGNING TOOLS USED

1. DIAlux 4.13:

DIAlux is one of the leading software on lighting design, used to calculate, and visualize indoor/outdoor lights, which is a time-saving software when compared to the manual calculation. It also gives information on the total power consumption by the lighting load for the given area.

2. Auto CAD 2015:

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 place the lighting layout as well.

4.4 DESIGN PROCESS:

Step 1:

For any designer, the very first step is to have a formal discussion with the client or other members of the design team, to get the information. To gain an understanding of the purpose of the space and to determine what needs to be done.

Step 2:

To get the AutoCAD file of the project and having an attentive study of the drawing or plan layout.

Step 3:

Being a lighting designer it is very important to go through the project, analyse the dimensions of the rooms. If any information is missing get it from the client.

Step 4:

To study the relevant codes and guidelines to that particular area in detail.

Step 5:

Go through the different possible lamps and luminaires which could be used for lighting up the given area.

Step 6:

Importing the AUTOCAD files in the lighting design software e.g.: DIALux version.

4.5 DESIGN SIMULATION WITH PLAN LAYOUT IN SOFTWARE DIAlux 4.13 VERSION

4.5.1. INPUT DATA

Step 1: IMPORTED CORRECTLY

The first step after importing the AutoCAD to make sure that all the dimensions and the areas in which we are going to work with are imported properly.

Step 2: SELECTING REFLECTANCE SURFACES

This indicates the percentage the ceiling, wall (ρw), floor (ρf) and ceiling (ρc). It is expected that these areas are not so well maintained and dirty, are assumed to have lower reflectance values. Areas that are clean have high reflectances.

Examples:

- **Area with clean atmosphere: Offices, Hospitals**

Wall reflectance (ρ_w): 70%

Ceiling reflectance(ρ_c) : 50%

Floor reflectance(ρ_f) : 20%

- Area with dusty atmosphere: Factories, Garage

Wall reflectance (ρ_w): 50%

Ceiling reflectance (ρ_c) : 30%

Floor reflectance (ρ_f) : 20%

- Thermal/coal plant area:

Wall reflectance (ρ_w): 30%

Ceiling reflectance (ρ_c): 10%

Floor reflectance (ρ_f) : 10%

- step 3: SELECTING MAINTENANCE FACTOR:

We usually considered maintenance as factor 0.8 and if it's a dust area then it could be 0.7 or 0.6

-Step 4: FINDING OUT THE WORK PLANE HEIGHT:

Work plane height is always depended upon the application of task, for Office the work plane height is to be considered as 0.76m from the ground level. As for the application in industries without equipment it is considered to be 0 that is the ground level.

-Step 5: FINDING OUT THE CEILING TYPE:

Before proceeding into areas we need to know whether the ceiling type is false ceiling or true ceiling**.**

- In case of false ceiling recessed mounted luminaires should be used.

- In case of true ceiling surface mounted luminaires is being used.

Step 6: SELECTING LUMINAIRES:

Luminaires are selected depending upon the nature of task also the ceiling type, level of protection requires for the specific area.

Step 7: PLACING OF LUMINARES:

If client gave the AutoCAD file along luminaires layout then the placing of luminaires should be according to the layout both for indoor and outdoor. otherwise it should be done as per standard depending required lux level in specific task area.

Step 7: SOFTWARE SIMULATION

After giving every input data and completion of drawing we will run the DIAlux to give the output.

Step 8: OUTPUT

After software simulation done, we get the result where we check all the required parameters e.g. average illuminance, overall uniformity, luminaires quantities.

4.6 DESIGN DECISIONS

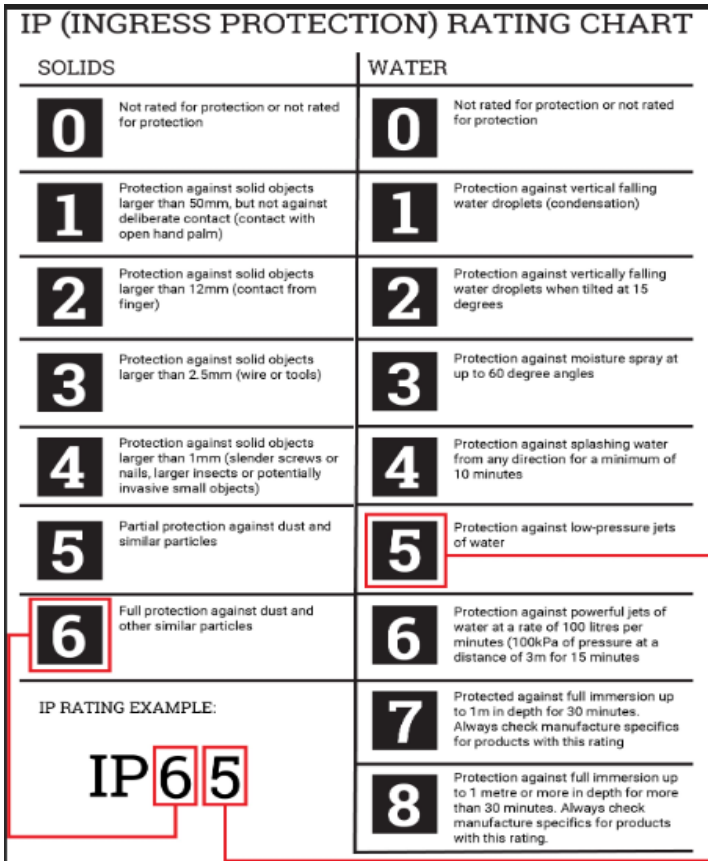
Once the general requirements of the lighting installation and the room to be lighted are known. an analysis of the visual task may lead to more special requirements for the illumination of the interior. This will determine the choice of lighting system to be used and the location and arrangement of the luminaires.

These decisions are normally taken by the designer

1.Choice of luminaires

- In the choice of luminaire, the designer can exercise a combination of professional judgement, personal preference and economic analysis. Luminaires may have to withstand a variety of physical conditions, such as vibration moisture, dust, ambient temperature. The lamps must also have satisfactory colour rendering properties.

- In certain instances, the luminaires also improve the interior's attractiveness. The right IP-rated luminaires must be chosen when they must endure the harsh environmental conditions that are fairly expected when designing for an industrial. The distribution of light should guide the luminaire selection. An overview of IP is provided by the chart below as shown in fig 4.1.below.


IP (INGRESS PROTECTION) RATING CHART
SOLIDS
0 Not rated for protection or not rated for protection
1 Protection against solid objects larger than 50mm, but not against deliberate contact (contact with open hand palm)
2 Protection against solid objects larger than 12mm (contact from finger)
3 Protection against solid objects larger than 2.5mm (wire or tools)
4 Protection against solid objects larger than 1mm (slender screws or nails, larger insects or potentially invasive small objects)
5 Partial protection against dust and similar particles
6 Full protection against dust and other similar particles
IP RATING EXAMPLE:
IP65
WATER
0 Not rated for protection or not rated for protection
1 Protection against vertical falling water droplets (condensation)
2 Protection against vertically falling water droplets when tilted at 15 degrees
3 Protection against moisture spray at up to 60 degree angles
4 Protection against splashing water from any direction for a minimum of 10 minutes
5 Protection against low-pressure jets of water
6 Protection against powerful jets of water at a rate of 100 litres per minutes (100kPa of pressure at a distance of 3m for 15 minutes
7 Protected against full immersion up to 1m in depth for 30 minutes. Always check manufacture specifics for products with this rating
8 Protection against full immersion up to 1 metre or more in depth for more than 30 minutes. Always check manufacture specifics for products with this rating.

4.1 IP CHART

4.7 TECHNICAL FEATURES AND SPECIFICATIONS OF LUMINAIRES USED

LUMINAIRES NAME	SPECIFICATIONS	IMAGE
LED RECTANGULAR HIGHBAY JUPITAR NEO (80W/100W/120W/140W/150W/180W/200W)	**1. 4KV+10KV INTERNAL SURGE PROTECTION** **2. 110 LUMENS/W LUMINAIRE EFFICACY** **3. IP66 INGRESS PROTECTION**[12]	
LED T8 Lamp ECO-I High efficacy integrated LED Batten to create a sustainable lighting environment with surface/suspended mounting.	**1. HIGHLY ROBUST FOR MULTIDIMENTIONAL CONDITION** **2.HIGH GRADE ENGINEERING PLASTIC END CAPS** **3. IP66 INGRESS PROTECTION**	

TECHNICAL FEATURES AND SPECIFICATIONS OF LUMINAIRES USED

LUMINAIRES NAME	SPECIFICATIONS	IMAGE
LED Under Canopy **NEPTUNE NEO-II** **80** PDC aluminium constructed recessed mounted under canopy luminaire with superior aesthetic finish and high reliability making it an ideal solution for petrol pumps. It has 10KV SPD & ingress protection of IP66. Available in 600x600 mm frame.[13]	**1. 4KV+10KV INTERNAL SURGE PROTECTION** **2. 110 LUMENS/W LUMINAIRE EFFICACY** **3. IP66 INGRESS PROTECTION**	
LED Streetlight **RAPTOR PRO-I & II** **45W/60W/70W/90W/120W** Street lights are aerodynamically designed for all weather conditions with excellent thermal management, made up of pressure die cast housing with toughened glass and high power LED's with secondary optics and IP66 protection.	**1.PRESSURE DIE CAST HOUSING WITH TOUGHENED GLASS** **2.100/125/135/W LUMENS/W LUMINAIRE EFFICACY** **3. IP66 INGRESS PROTECTION**	

TECHNICAL FEATURES AND SPECIFICATIONS OF LUMINAIRES USED

LUMINAIRE TYPE	SPECIFICATIONS	IMAGE
FLOGA FLAMEPROOF FLOODLIGHT Flameproof fixtures are designed to ensure that internal ignition within a flammable atmosphere will not transmit outside the protective enclosure.	1.**DIE CASTING ALUMINIUM HOUSING HAMMER TONE FINISH** **2. IP65 INGRESS PROTECTION** **3. ZONE 1 & 2**	
LED HIGHBAYS PARABOLA ULTRA 180W/200	**1. 4KV+10KV INTERNAL SURGE PROTECTION** **2. 120, 130 & 140 LUMENS/W LUMINAIRE EFFICACY** **3. IP66 INGRESS PROTECTION**[12]	

LUMINAIRE TYPE	SPECIFICATIONS	IMAGE
PLUTO PRO PLUS **LED FLOOD LIGHT** **300 W**	**1. 4KV+10KV INTERNAL SURGE PROTECTION** **2. 110 LUMENS/W LUMINAIRE EFFICACY** **3. IP66 INGRESS PROTECTION**	

CHAPTER 5. DESIGNING OF DIFFERENT APPLICATION OF INDUSTRIES

DESIGNING OF DIFFERENT APPLICATION OF INDUSTRIES

5.1 LIGHTING DESIGN OF CAPTAIN STEEL ASANSOL (WAREHOUSE)

1.DESIGN AIM

According to IS Standard (IS 3646 Part I and II) and National Lighting Code (NLC), 2010 the maintained average illuminance and overall uniformity all over the area.

-Maintained Average Illuminance (in lux) = 150 lx
-Overall Uniformity (U0) = 0.4

2.LAYOUT AND DESCRIPTION OF THE WAREHOUSE

Generally, we get the AutoCAD layout of the project but sometimes for shed area client gave only the dimensions or sometimes rough drawing of the area with dimensions, luminaires positions etc. In this layout a warehouse of 52m*72m is given, where the required lux level is 150 lux and high bay luminaires is used to meet the parameters as shown in fig 5.1. Detailed luminaires description is given below.

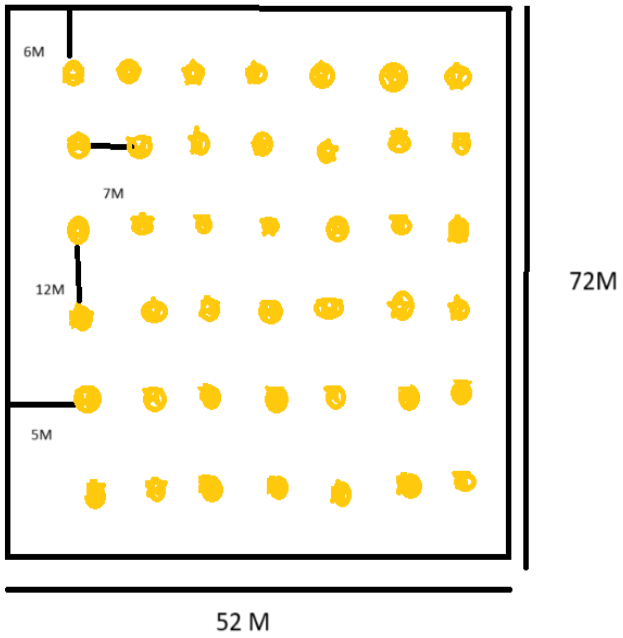


Fig 5.1 rough plan of the warehouse

3.LUMINAIRE USED

- LED RECTANGULAR HIGHBAY JUPITAR NEO

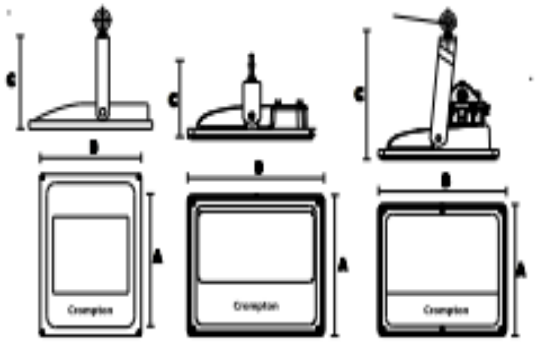
- LUMINAIRE LUMIOUS FLUX (IN LUMEN) = 21993 lm

-WATTAGE = 200W

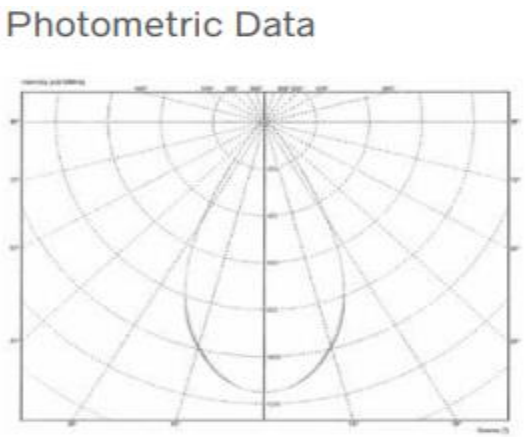
-SYSTEM EFFICACY (in lm/W) = 110 lm/W

-CCT (in K) = 5700 K

-CRI = ≥70



A. DIMENSIONS



B. POLAR CURVE

C. HIGHBAY IMAGE

4.DESIGN CONSIDERATION

-the followings are the design considerations of an interior illumination

- mounting height of luminaire = 20m
- maintenance factor = 0.8
- work plane height = 0 i.e. floor level

5.3D RENDERING VIEW

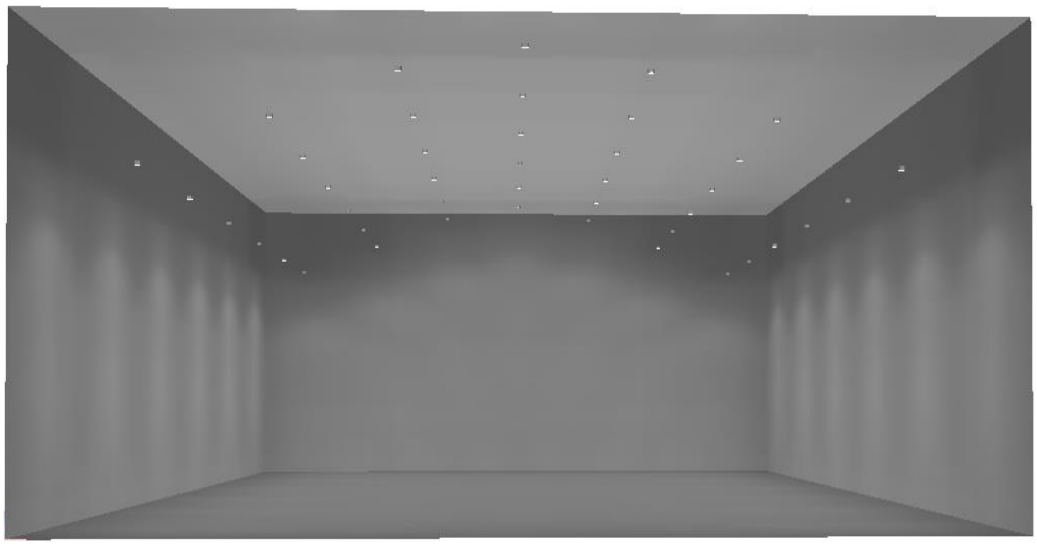


Fig 5.2 simulated 3d rendering front view of warehouse

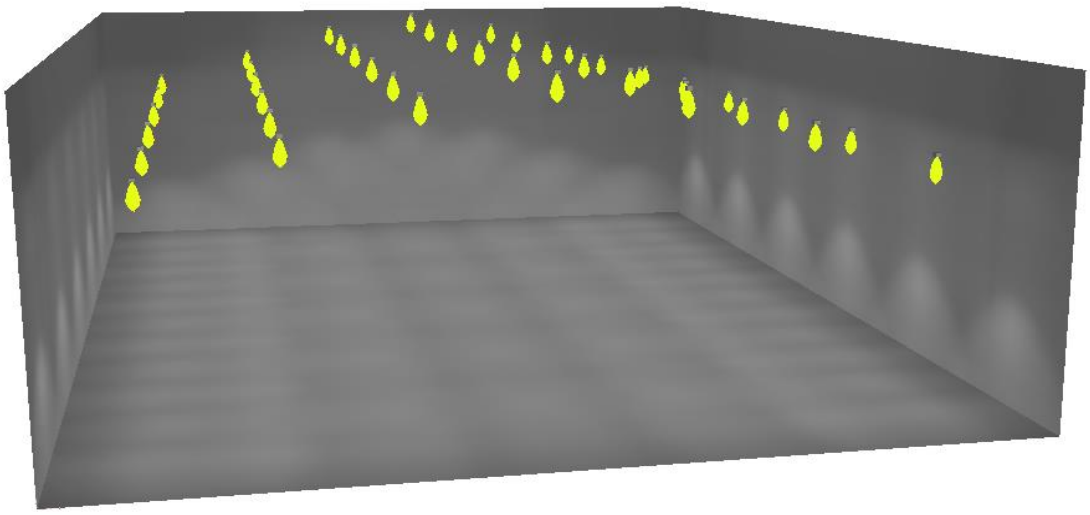
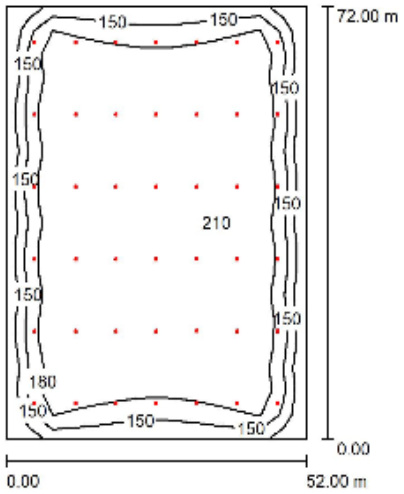


Fig 5.3 simulated 3d rendering warehouse

6.RESULT

SHED / Summary



Height of Room: 20.000 m, Light loss factor: 0.80 — Values in Lux, Scale 1:925

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	183	92	229	0.504
Floor	20	184	62	235	0.338
Ceiling	50	25	16	32	0.639
Walls (4)	30	40	16	90	/

Workplane:
Height: 0.000 m
Grid: 18 x 13 Points
Boundary Zone: 0.000 m
Illuminance Quotient (according to LG7): Walls / Working Plane: 0.216, Ceiling / Working Plane: 0.138.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	42	Crompton Greaves Consumer Electricals Ltd 01 LHB11-200-CDL/60-M (1.000)	21993	22000	198.5
			Total: 923691	Total: 924000	8337.0

Specific connected load: 2.23 W/m² = 1.22 W/m²/100 lx (Ground area: 3744.00 m²)

7.SUMMARY

As per the standards and codes we achieved our requirement for the given design

AREA	REQUIRED		ACHIEVED	
WAREHOUSE	E_{AVG} (lx)	U_0	E_{AVG} (lx)	U_0
	150 lx	0.4	183 lx	0.504

Table no.1 summary table

5.2 LIGHTING DESIGN OF WAREHOUSE WITH MEZZANINE

1. DESIGN AIM

-Maintained Average Illuminance (in lux)

- For shed = 300 lx
- For mezzanine = 150 lx

-Overall Uniformity (U0) = 0.4

2. LAYOUT AND DESCRIPTION OF THE AREA

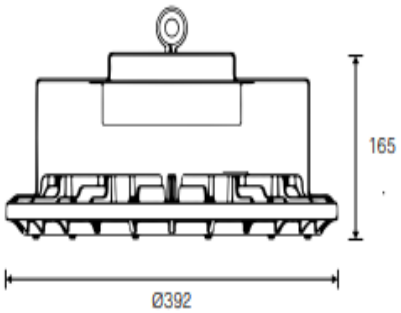
This is warehouse with mezzanine, a mezzanine is elevated floor/platform that is installed between the main floor and ceiling of the warehouse. The maintained illuminance are different for mezzanine floor but for some cases it can be same as overall areas according to the task performed. For this particular design the required illumination level for shed is 300 lx and for mezzanine it is 150 lx. As the mezzanine is an industrial battern is used and for warehouse highbay is used.

Fig 5.4 Plan layout of warehouse with mezzanine

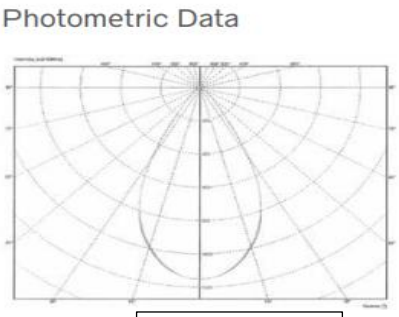
Fig 5.5 elevation or cross section of the area

3. LUMINAIRE USED

- **LED HIGHBAYS PARABOLA NEO**
- **LUMINAIRE LUMIOUS FLUX (IN LUMEN) =** 24095 lm
- **-WATTAGE =** 200W
- **-SYSTEM EFFICACY (in lm/W) =** 120 lm/W
- **-CCT (in K) =** 5700 K
- **-CRI =** ≥70



A. DIMENSIONS



B. POLAR CURVE

C.HIGHBAY

LUMINAIRE USED

- **LED T8 Lamp ECO-I**

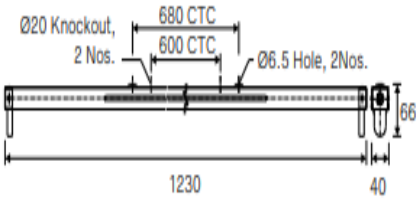
- **LUMINAIRE LUMIOUS FLUX (IN LUMEN) =** 4281 lm

-WATTAGE = 40W

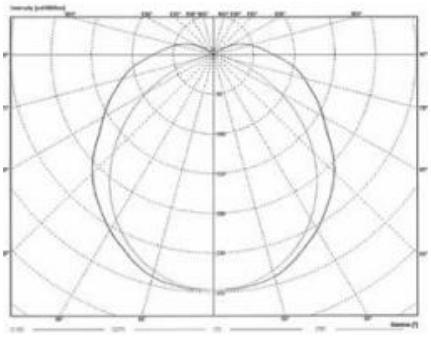
-SYSTEM EFFICACY (in lm/W) = 100 lm/W

-CCT (in K) = 5700 K

-CRI = ≥70



A. DIMENSIONS



B.POLAR CURVE

C.BATTERN

4.DESIGN CONSIDERATION

- **mounting height of luminaire:**

1. WAREHOUSE = 15 M
2. MEZZANINE 1 = 7M
3. MEZZANINE 2 = 3.6M

- **maintenance factor** = 0.8
- work plane height = 0 i.e. floor level

5. 3D RENDERING VIEW

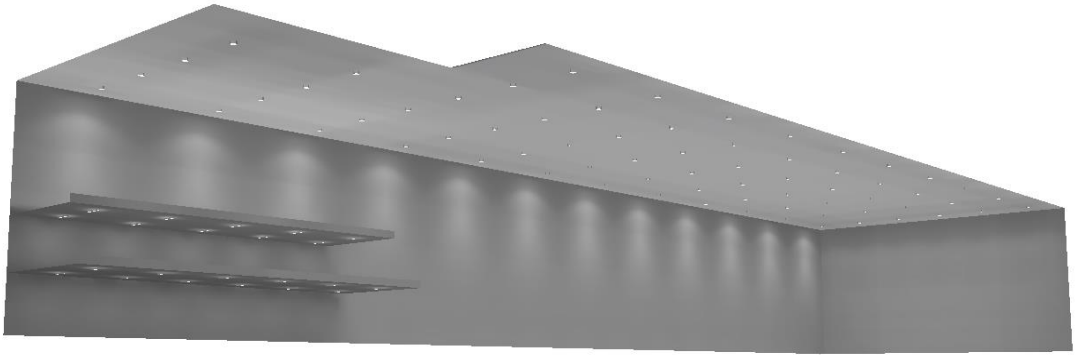


Fig 5.6 3d rendering of warehouse with rack

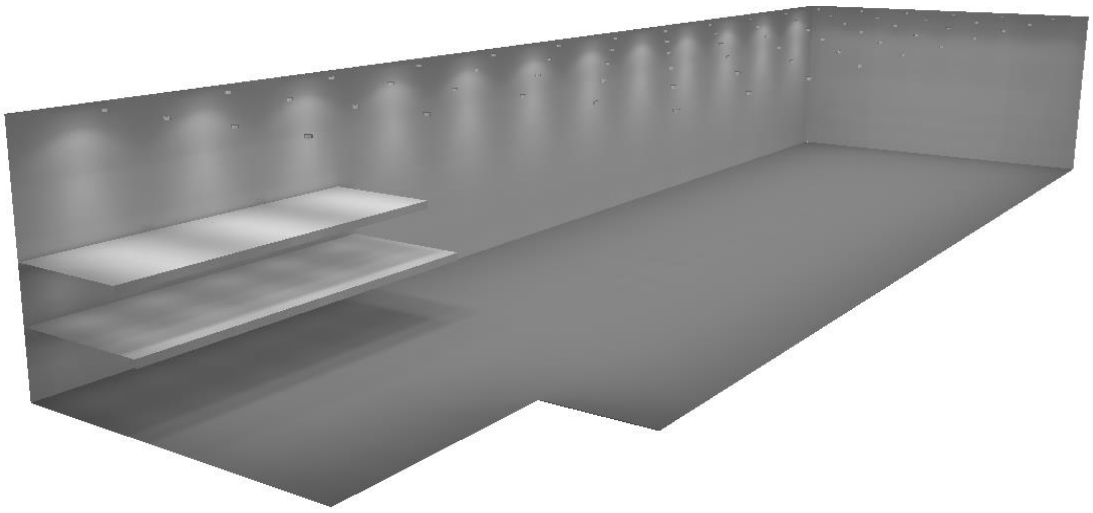
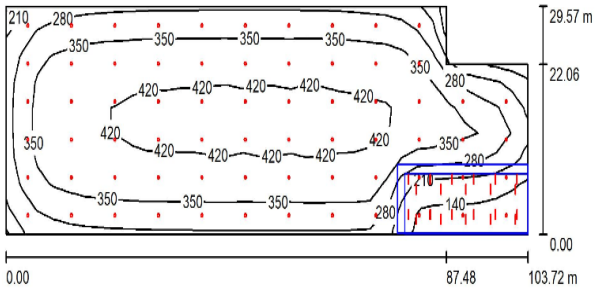


Fig 5.7 3D rendering view

6. RESULT

SHED / Summary



Height of Room: 15.000 m, Light loss factor: 0.80

Values in Lux, Scale 1:742

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	341	96	431	0.282
Floor	20	343	62	433	0.180
Ceiling	50	60	38	85	0.638
Walls (6)	30	135	29	269	/

Workplane:

Height:	0.000 m
Grid:	33 x 9 Points
Boundary Zone:	0.000 m

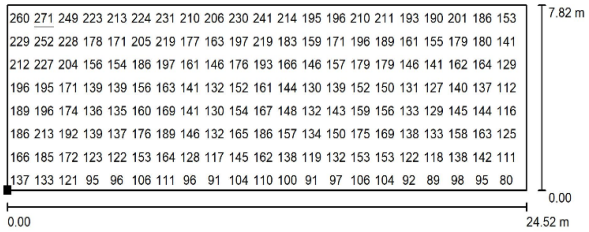
Illuminance Quotient (according to LG7): Walls / Working Plane: 0.395, Ceiling / Working Plane: 0.176.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	68	Crompton Greaves Consumer Electricals Ltd 01 CIP-326-200-57-60D-HL2-LM-NSG (1.000)	24095	24100	197.0
2	22	Crompton Greaves Ltd. 01 IGP162LT8-20 (1.000)	4281	4284	40.0
			Total: 1732670	Total: 1733041	14276.9

Specific connected load: 4.85 W/m² = 1.42 W/m²/100 lx (Ground area: 2945.02 m²)

SHED / MEZZANINE 2 / Value Chart (E, Perpendicular)



Values in Lux, Scale 1 : 176

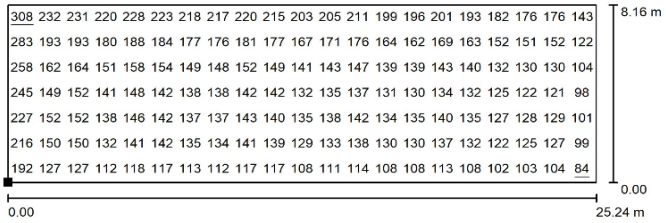
Not all calculated values could be displayed.

Position of surface in room:
Marked point: (79.200 m, 0.110 m, 4.300 m)

Grid: 64 x 32 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
161	65	271	0.406	0.241

SHED / MEZZANINE 1 / Value Chart (E, Perpendicular)



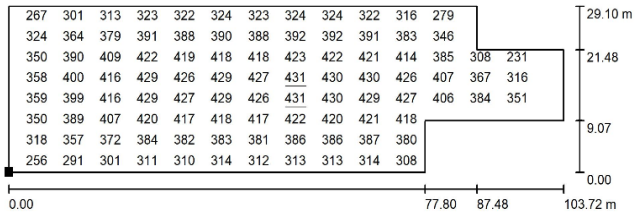
Values in Lux, Scale 1 : 181

Position of surface in room:
Marked point: (78.090 m, 0.689 m, 0.000 m)

Grid: 21 x 7 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
152	84	308	0.549	0.272

SHED / SHED / Value Chart (E, Perpendicular)



Values in Lux, Scale 1 : 742

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (0.000 m, 0.110 m, 0.000 m)

Grid: 30 x 8 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
364	177	431	0.487	0.411

7.SUMMARY

AREA	REQUIRED		ACHIEVED	
	E_{AVG} (lx)	U_0	E_{AVG} (lx)	U_0
WAREHOUSE	200 lx	0.4	364 lx	0.411
MEZZANINE 1	150 lx	0.4	152 lx	0.549
MEZZANINE 2	150 lx	0.4	161 lx	0.40

Table no.2 summary table

5.3 LIGHTING DESIGN OF WAREHOUSE WITH RACK SYSTEM

1. DESIGN AIM

-Maintained Average Illuminance (in lux)

- For shed = min 150 lx
-Overall Uniformity (U_0) = 0.4

2. LAYOUT AND DESCRIPTION OF THE AREA

Warehouse racking, also known as storage or pallet racking, is a material handling system suitable for mass storage of goods. In this layout the racks are about 7m height , it is very important to place the luminaire avoiding the racks and the luminaire should not be placed directly above the racks as it will create glare for the workers. In this design the required lux level is min 150 lx , highbay is being used here.

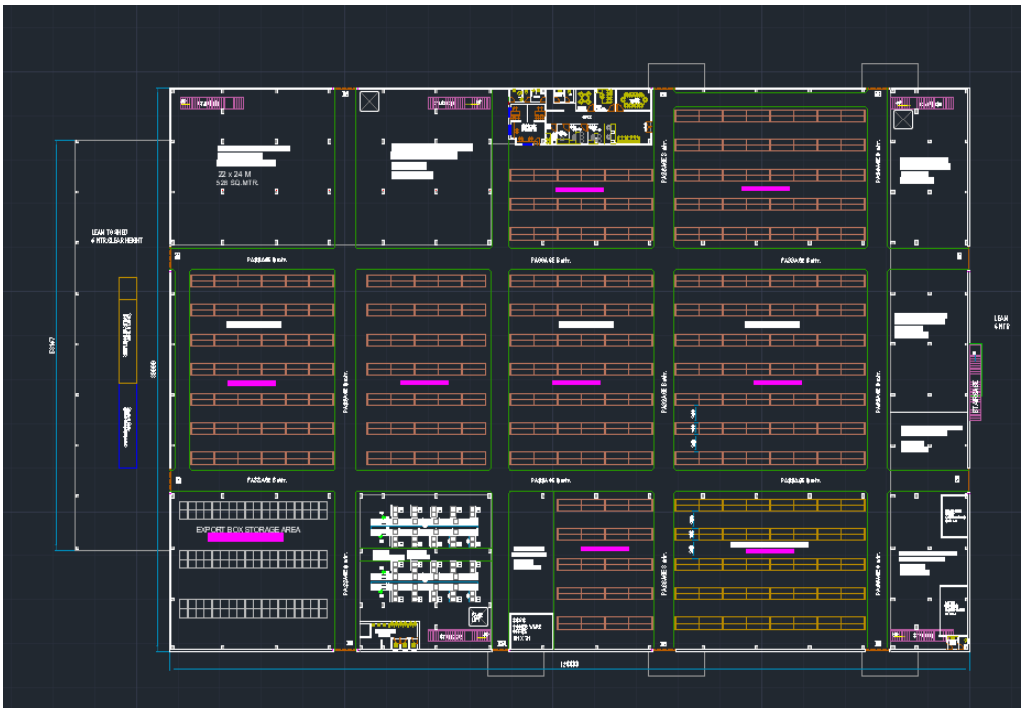


Fig 5.8 Plan layout of the warehouse with rack

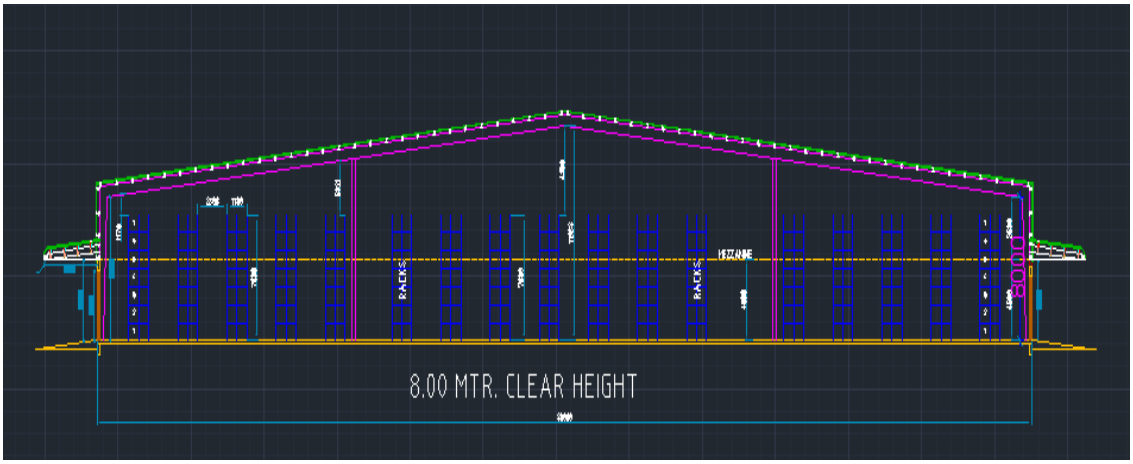


Fig 5.9 elevation or cross section of the area

3. LUMINAIRE USED

- LED RECTANGULAR HIGHBAY JUPITAR NEO

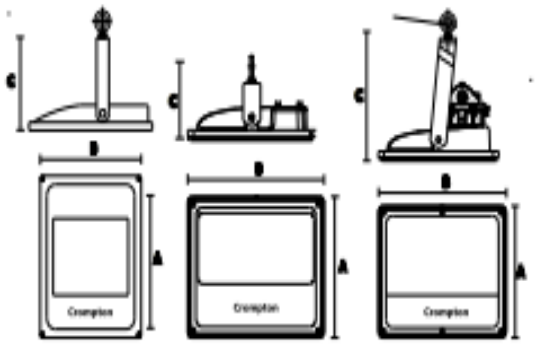
- LUMINAIRE LUMIOUS FLUX (IN LUMEN) =16497 lm

-WATTAGE = 150W

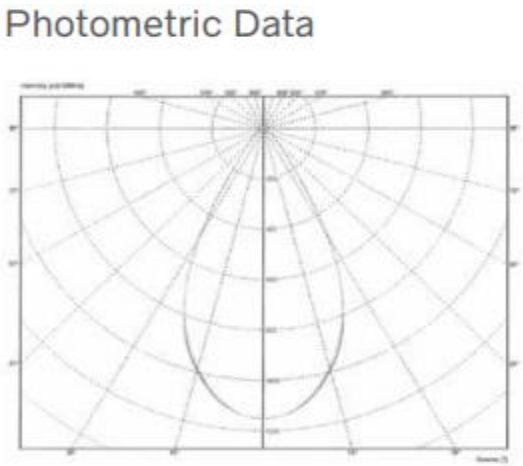
-SYSTEM EFFICACY (in lm/W) = 110 lm/W

-CCT (in K) = 5700 K

-CRI = ≥70



A. DIMENSIONS



B. POLAR CURVE

C. HIGHBAY IMAGE

4.DESIGN CONSIDERATION

- **mounting height of luminaire =** 12 M

- maintenance factor = 0.8

- work plane height = 0.76

Here, the work plane height is taken as 0.76 because of the type of task is to be performed as the rack are very high the illuminance level should reach different level.

5. 3D RENDERING VIEW

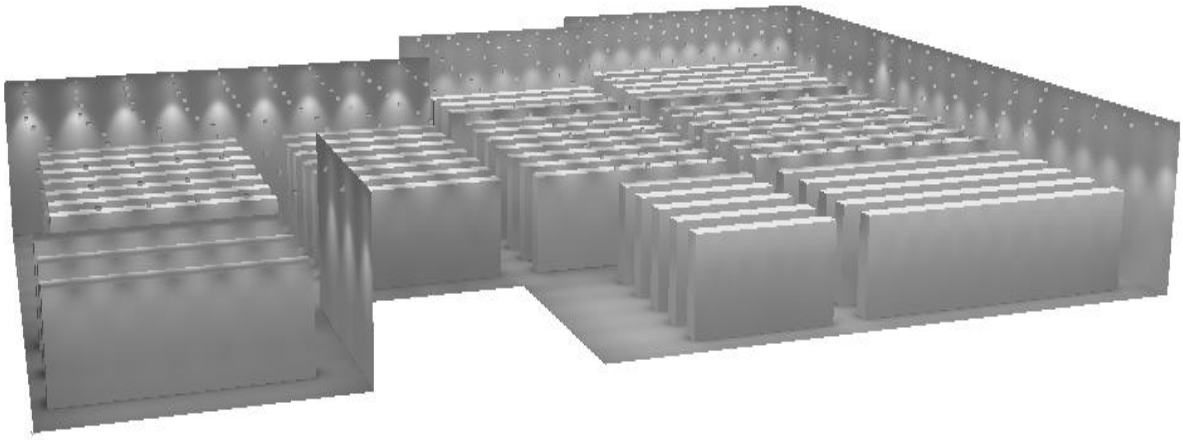


Fig 5.10 simulated 3d view

- here, given below in the fig 5.11 we can see the luminaires are placed in such a way that it should not be directly on the top of the racks because it can create glare or discomfort directly to the worker's eyes. Its is very important to provide good quality and quantity of illumination over the area but also lighting system should provide visual comfort.

Fig 5.11 simulated 3d view from the top

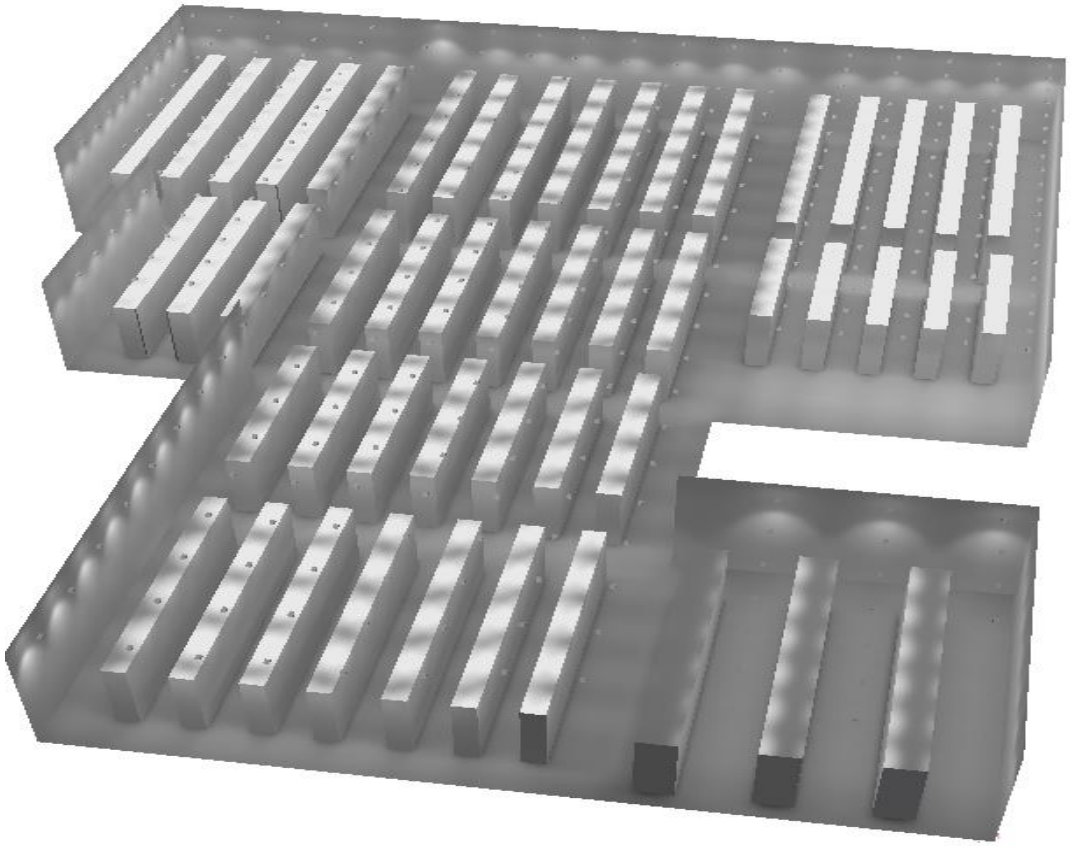
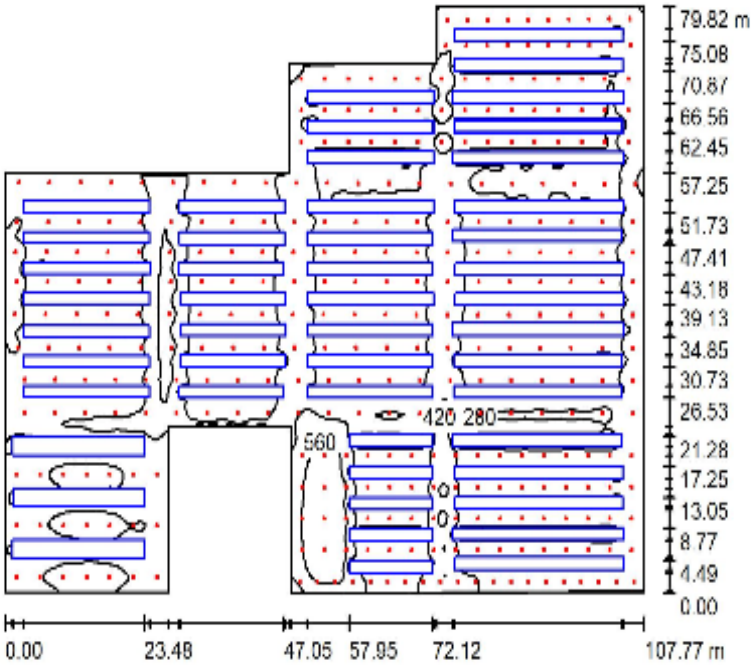


Fig- 5.12 simulated 3d rendering view

In this design calculation surface has been taken as the uniformity will not be uniform in this case because of the obstruction that is racks that is why a calculation surface was taken to that specifics area to check if the parameters are achieved. In this case we are working with minimum 150 lux that means every point should be received 150 lux.

6.RESULT



Height of Room: 12.000 m, Mounting Height: 12.000 m, Light loss factor: 0.80

Values in Lux, Scale 1:1025

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	309	51	709	0.165
Floor	20	211	12	682	0.056
Ceiling	50	92	42	196	0.457
Walls (12)	30	180	43	577	/

Workplane:

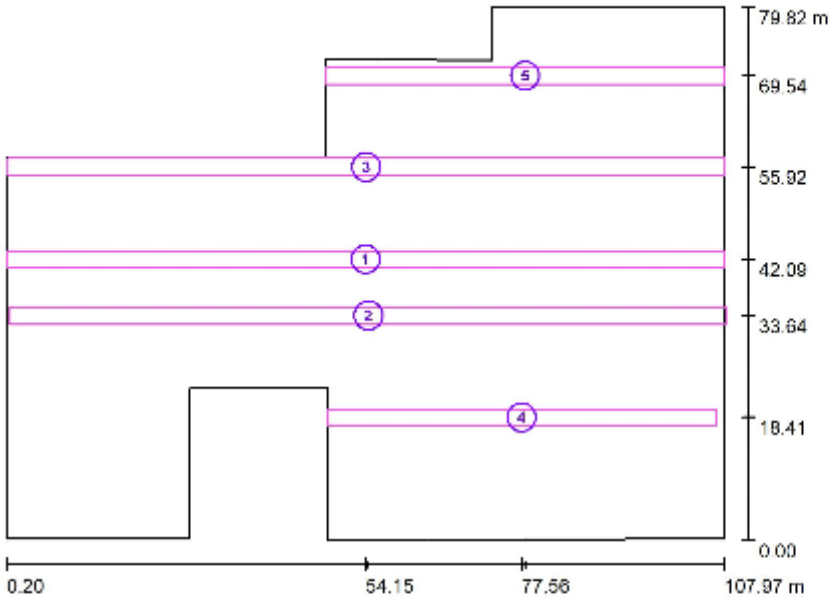
Height: 0.760 m
Grid: 128 x 128 Points
Boundary Zone: 0.000 m

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.603, Ceiling / Working Plane: 0.298.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	338	Crompton Greaves Consumer Electricals Ltd 01 LHB11-150-CDL/60-M (1.000)	16497	16500	144.7
			Total: 5576085	Total: 5577000	48908.6

RACK / **Calculation surfaces (results overview)**



Scale 1 : 909

Calculation Surface List

No.	Designation	Type	Grid	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1	Calculation Surface 1	perpendicular	128 x 8	273	211	473	0.773	0.446
2	Calculation Surface 1	perpendicular	128 x 8	265	182	469	0.685	0.387
3	Calculation Surface 1	perpendicular	128 x 8	263	195	380	0.741	0.513
4	Calculation Surface 2	perpendicular	64 x 4	389	295	640	0.760	0.462
5	Calculation Surface 3	perpendicular	128 x 32	325	259	523	0.796	0.494

Summary of Results

Type	Quantity	Average [lx]	Min [lx]	Max [lx]	u0	E_{min} / E_{max}
perpendicular	5	290	182	640	0.63	0.28

7. SUMMARY

AREA	**REQUIRED**			**ACHIEVED**		
WAREHOUSE WITH RACK	E_{AVG} (lx)	E_{MIN} (lx)	U_0	E_{AVG} (lx)	E_{MIN} (lx)	U_0
	200 lx	150 lx	0.4	290 lx	182 lx	0.63

Table no.3 summary table

5.4 LIGHTING DESIGN OF PETROL PUMP CANOPY (M/S WOODLAND SERVICE STATION)

1. DESIGN AIM

-Maintained Average Illuminance (in lux) for under canopy = 450-550 lux

-Overall Uniformity (U0) = 0.4

For under canopy a separate recommendation standard were given, this project is design according to this recommended standard as shown in fig 5.13

3. Based on recommendation and observation made during pilot implementation; following illumination standard is finalized form implementation

Sl No	Location at RO	Lux level
1	Under Canopy	450-550
2	In approach area/ entry / exit	100-110
3	In approach area/ entry / exit (Large format RO)	200-250
4	Electrical room	100-120
5	Customer care Room	120-150
6	Boundary / yard	120-150
7	Boundary / yard (Large Format RO)	200-250

Fig 5.13 standard for under canopy

2. LAYOUT AND DESCRIPTION OF THE AREA

This is a layout of a service station, the part which is to be designed is the petrol pump canopy. As it is an outdoor design the only thing which is going to be different from indoor illumination is that here, an exterior scene has been taken then rest of all are

same. The standard says the lux level for the under canopy is 450 – 550 lux , which will be our requirement .

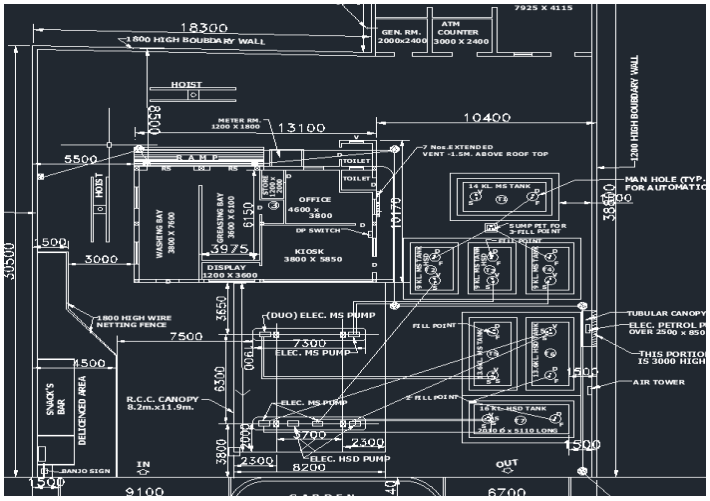
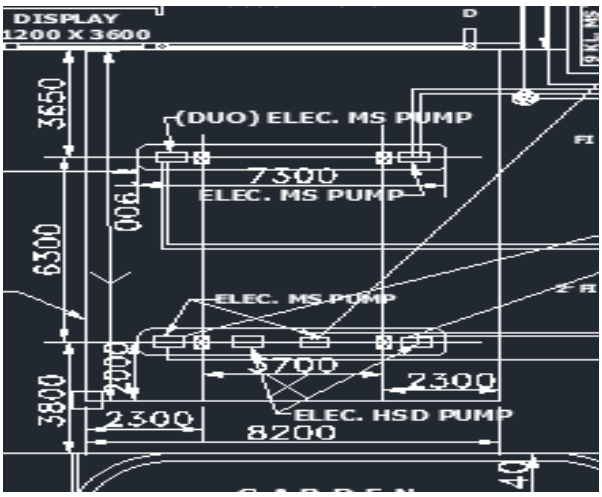


fig 5.14 plan layout of the area



5.15 plan layout of the m/s woodland service station

3. LUMINAIRE USED

-**LED Under Canopy NEPTUNE NEO-II80**

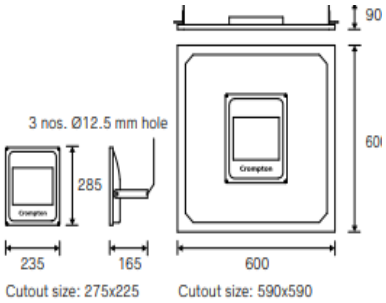
- **LUMINAIRE LUMIOUS FLUX (IN LUMEN) =**8796 lm

-**WATTAGE =** 80 W

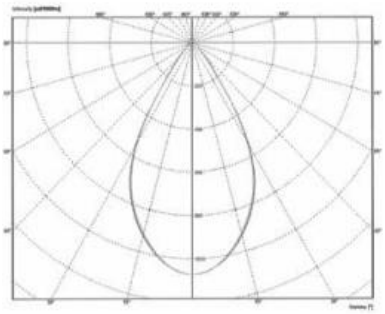
-**SYSTEM EFFICACY (in lm/W) =** 110 lm/W

-**CCT (in K) =** 5700 K

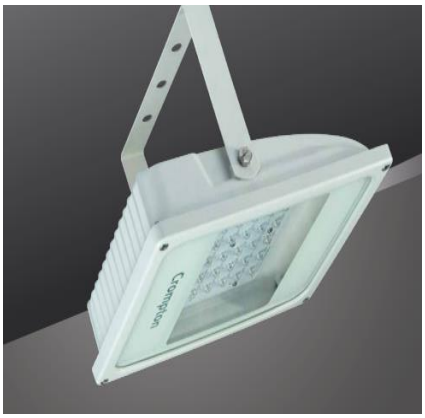
-**CRI =** ≥70



A) cut dimensions



b) polar curve



c) under canopy

4.DESIGN CONSIDERATION

The followings are the design considerations for under canopy design

- Maintenance Factor: 0.8
- Canopy Dimensions: 8.2 M * 11.9 M
- Luminaire Mounting Height: 5.5 M from floor level

5. 3D RENDERING VIEW

Fig 5.16 is the plan layout after importing the AutoCAD file in the DIAlux software, here it is more clear about the area where the lighting design is to be done.

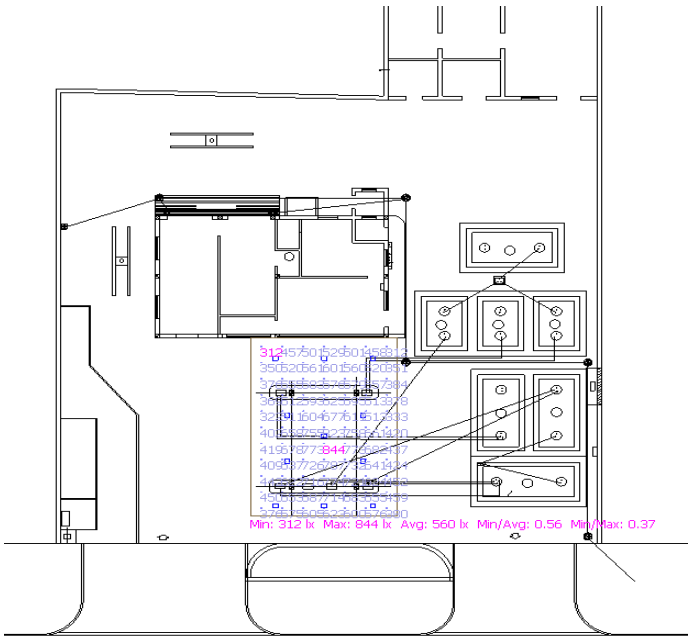


fig 5.16 imported plan layout of under canopy

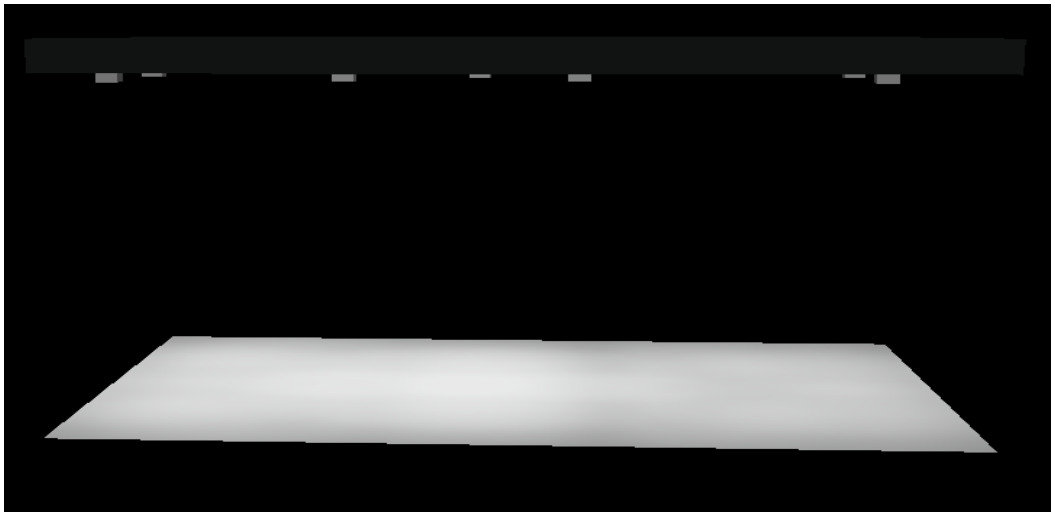


Fig 5.17 simulated 3D rendering of petrol pump canopy

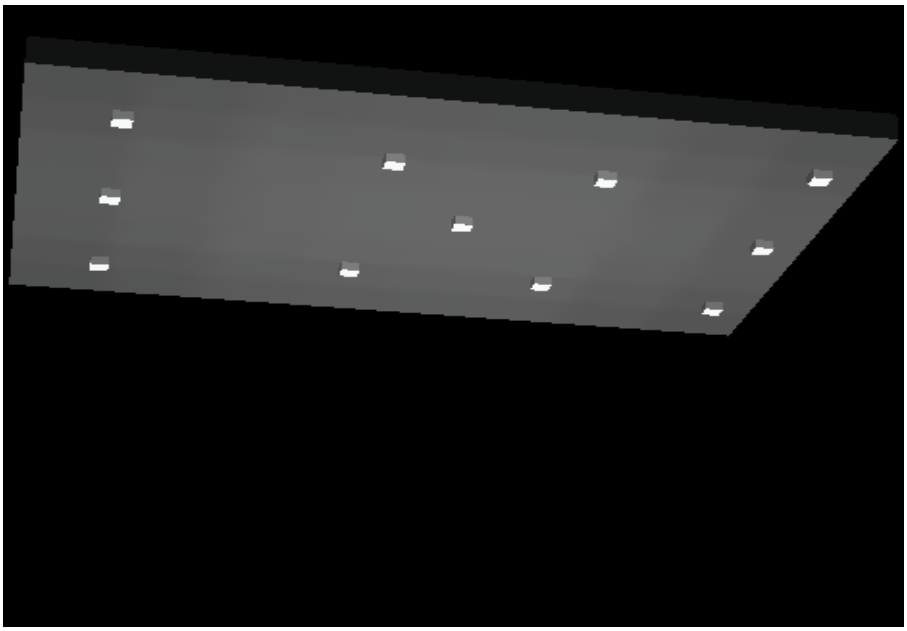


Fig 5.18 simulated 3d rendering of petrol pump canopy

Here, the luminaires LED 80 Watt Recessed Under Canopy luminaire (LCNP-80-CDL/60-M) is being used and the Luminaire layout considered as per site Condition.

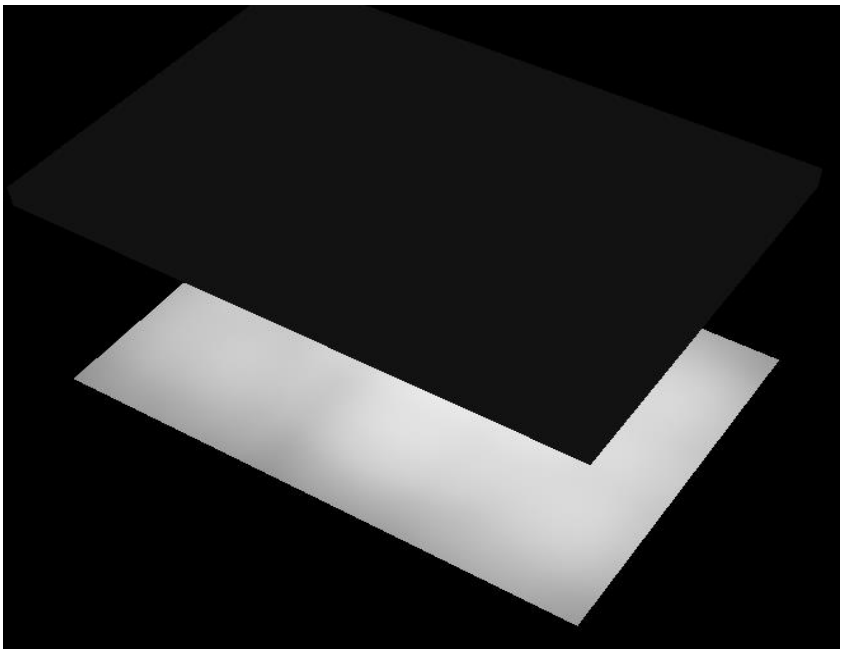
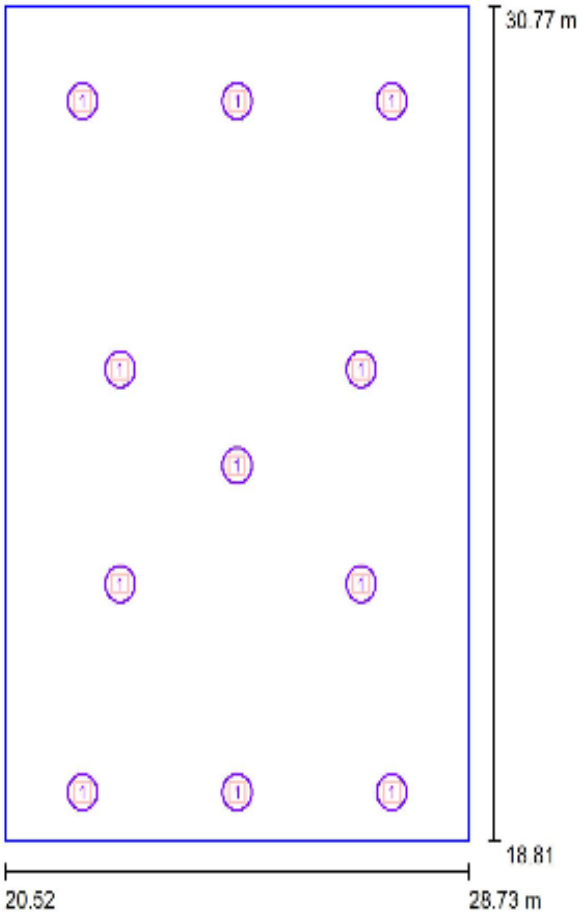


Fig 5.19 simulated 3d top view of petrol pump canopy

6. RESULT

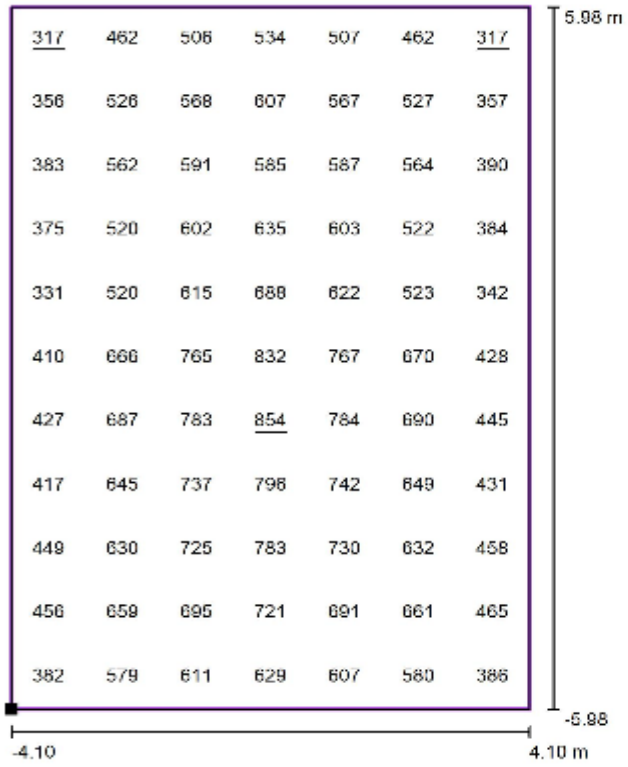


Light loss factor: 0.80, ULR (Upward Light Ratio): 0.0%

Scale 1:111

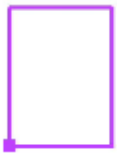
Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	11	Crompton Greaves Consumer Electricals Ltd 01 LCNP-80-CDL/60-M (1.000)	8796	8800	77.6
			Total: 96760	Total: 96800	853.9



Values in Lux, Scale 1 : 96

Position of surface in external scene:
Marked point: (20.527 m, 18.808 m, 0.000 m)



Grid: 7 x 11 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
568	317	854	0.56	0.37

7. SUMMARY

AREA	REQUIRED		ACHIEVED	
UNDER CANOPY	E_{AVG} (lx)	U_0	E_{AVG} (lx)	U_0
	550 (lx)	0.4	568 (lx)	0.56

Table no.4 summary table

5.5 LIGHTING DESIGN OF 418 MLD DHARAVI OUTDOOR LIGHTING

This project involves the construction, operation and maintenance of 418 MLD waste water treatment facility, including 209 MLD tertiary treatment plant, to fulfil the growing need of cycling and reusing water waste.[16]

1. DESIGN AIM

-Average Illuminance of the area surrounding tanks and building = 20 lux

Uniformity plays a very important part in a lighting design whether it is for commercial or industrial lighting. It is very important to maintain uniformity of light for lighting brightness to ensure that everything is fully illuminated. When referring to the uniformity of light in an area, objects or any obstruction should also be considered in the surrounding task area. But sometimes the calculation and measurement of light uniformity within a space is very difficult to achieve because the obstruction that is present there or because of the complex design of the area.

- The uniformity that is given by the client for this area is 0.2

2. LAYOUT AND DESCRIPTION OF THE AREA

In fig 4.19 the luminaires layout was given with the AutoCAD file and then considering all the objects / obstructions in the area, the luminaires were selected according to that.

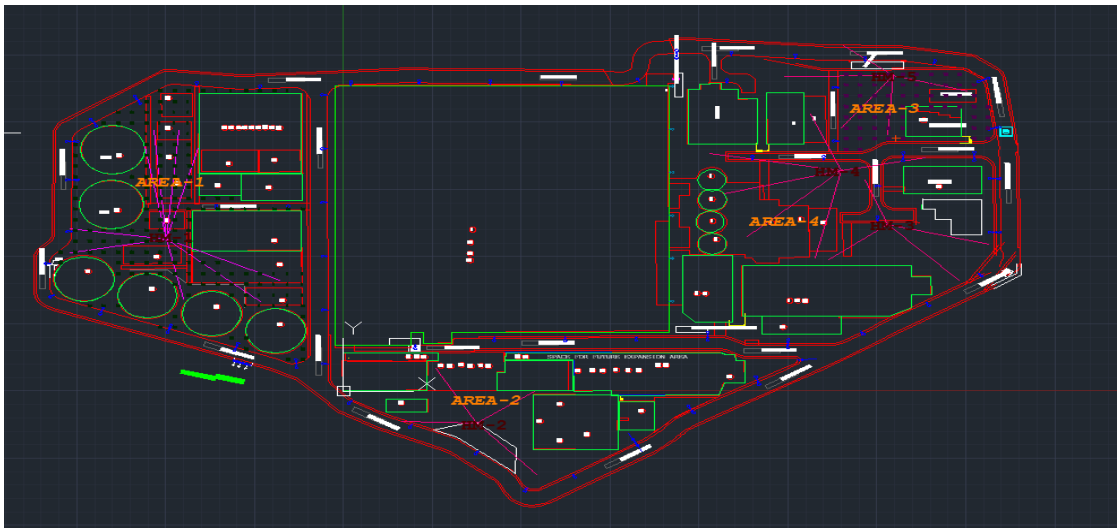
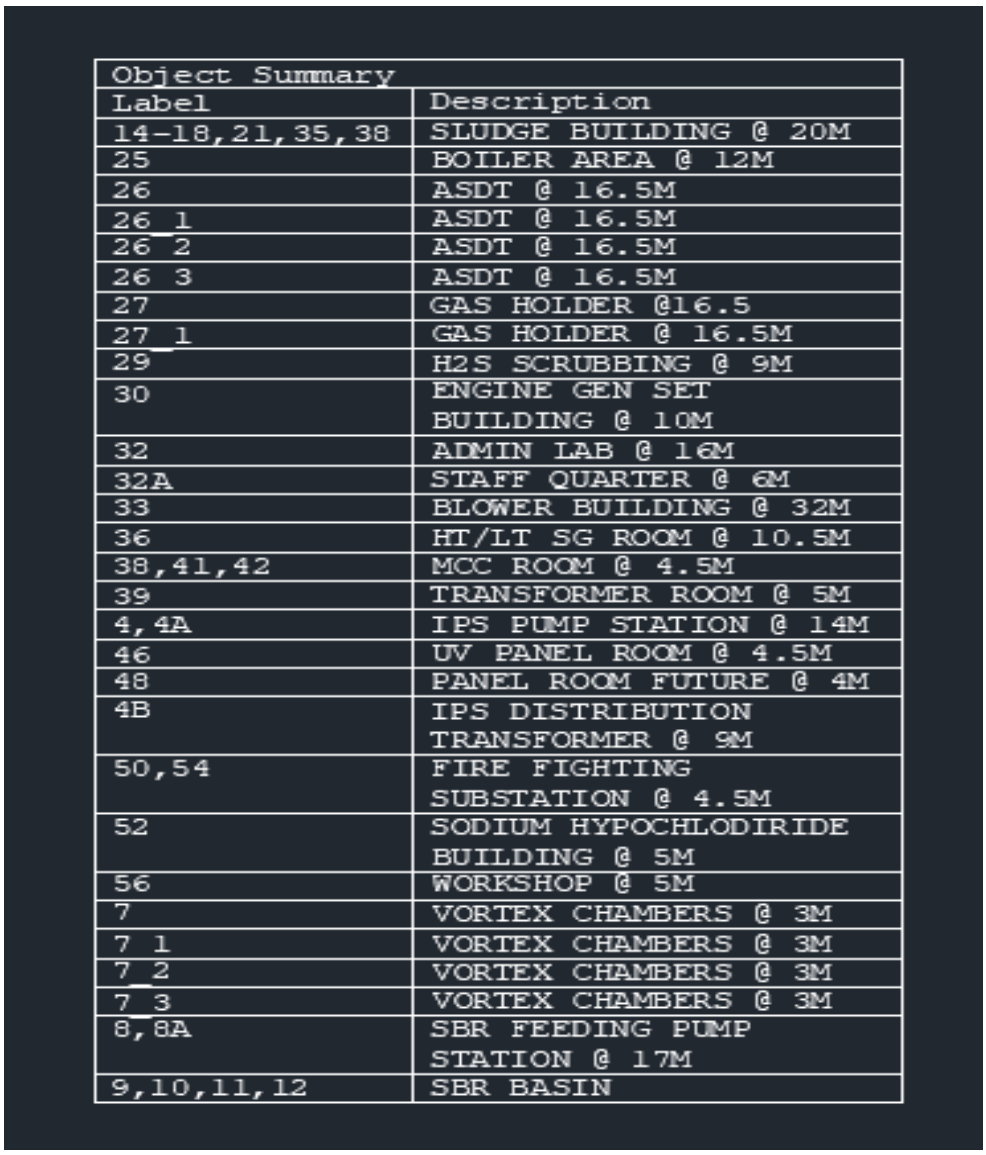


Fig 5.20 plan layout of the area

When selecting luminaires for outdoor industrial lighting, it's important to make sure they fit the space's environmental requirements. There are often extremes of temperature, humidity, vibration, and/or corrosive environment in industrial facilities. Since rubber and plastics react differently to certain substances, information on any airborne compounds is crucial. Furthermore, lighting equipment must be carefully chosen in hazardous locations to eliminate any potential for fire or explosion.

The luminaires that are used here are LED street lights, flame proof flood light. The details description is given below.



Object Summary	
Label	Description
14-18,21,35,38	SLUDGE BUILDING @ 20M
25	BOILER AREA @ 12M
26	ASDT @ 16.5M
26_1	ASDT @ 16.5M
26_2	ASDT @ 16.5M
26_3	ASDT @ 16.5M
27	GAS HOLDER @16.5
27_1	GAS HOLDER @ 16.5M
29	H2S SCRUBBING @ 9M
30	ENGINE GEN SET BUILDING @ 10M
32	ADMIN LAB @ 16M
32A	STAFF QUARTER @ 6M
33	BLOWER BUILDING @ 32M
36	HT/LT SG ROOM @ 10.5M
38,41,42	MCC ROOM @ 4.5M
39	TRANSFORMER ROOM @ 5M
4,4A	IPS PUMP STATION @ 14M
46	UV PANEL ROOM @ 4.5M
48	PANEL ROOM FUTURE @ 4M
4B	IPS DISTRIBUTION TRANSFORMER @ 9M
50,54	FIRE FIGHTING SUBSTATION @ 4.5M
52	SODIUM HYPOCHLODIRIDE BUILDING @ 5M
56	WORKSHOP @ 5M
7	VORTEX CHAMBERS @ 3M
7_1	VORTEX CHAMBERS @ 3M
7_2	VORTEX CHAMBERS @ 3M
7_3	VORTEX CHAMBERS @ 3M
8,8A	SBR FEEDING PUMP STATION @ 17M
9,10,11,12	SBR BASIN

Fig5.21 object summary

The obstruction summary was given along with dimension, so that we can chose the luminaires according to the requirements. for examples the area with storage tank there should be use flame proof luminaires so that it can eliminate any potential for fire or explosion.

-In this design three different types of luminaires have been used for different purposes

3. LUMINAIRE USED

- LED Street light RAPTOR PRO-I & II 60W

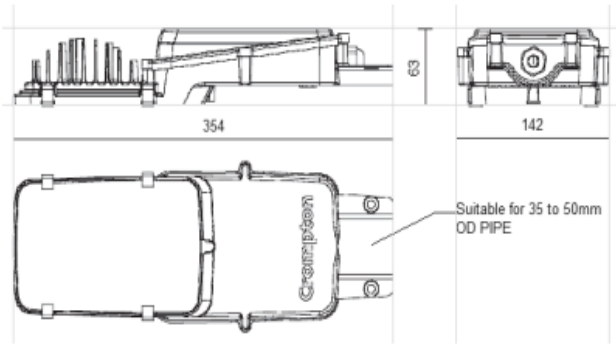
- LUMINAIRE LUMIOUS FLUX (IN LUMEN) = 6587 lm

-WATTAGE = 60 W

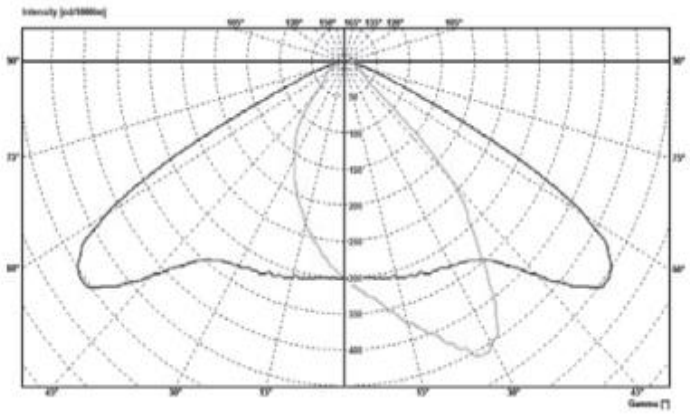
-SYSTEM EFFICACY (in lm/W) = 110 lm/W

-CCT (in K) = 5700 K

-CRI = ≥70



A) cut out dimension



B) polar curve

C) image

- FLOGA FLAMEPROOF FLOODLIGHT

- LUMINAIRE LUMIOUS FLUX (IN LUMEN) =29996 lm

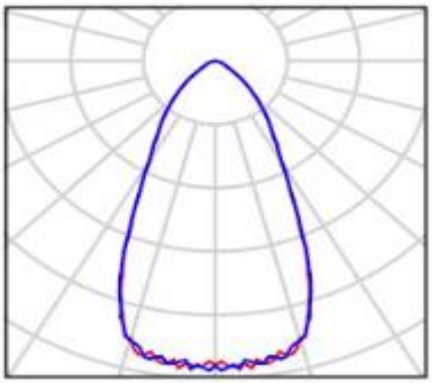
-WATTAGE = 300 W

-SYSTEM EFFICACY (in lm/W) = 110 lm/W

-CCT (in K) = 5700 K

-CRI = ≥70

A) image



B) polar curve

-LED FLOOD LIGHT PLUTO PRO PLUS

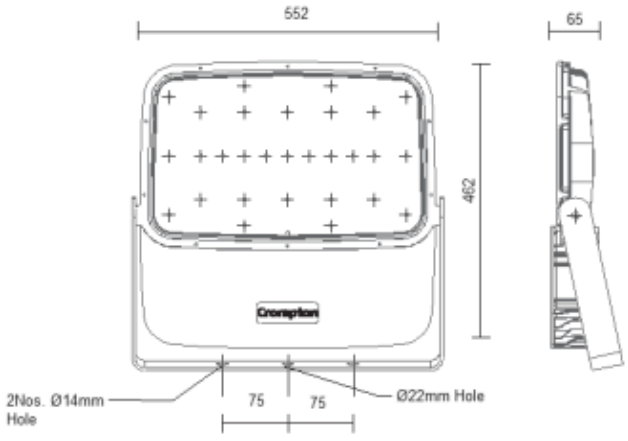
- LUMINAIRE LUMIOUS FLUX (IN LUMEN) =32994 lm

-WATTAGE = 300W

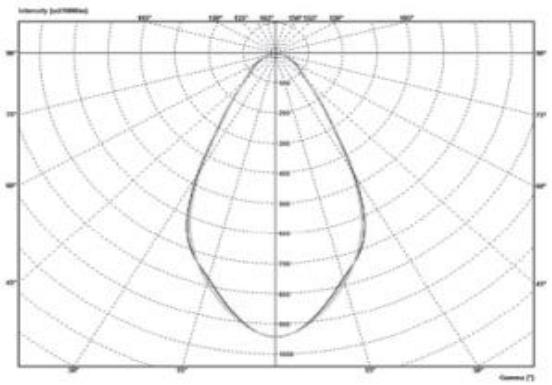
-SYSTEM EFFICACY (in lm/W) = 110 lm/W

-CCT (in K) = 5700 K

-CRI = ≥70



A) cut out dimension



B) polar curve

C) image

4.DESIGN CONSIDERATION

The followings are the design considerations are:

- DESIGN CONSIDERATION FOR HIGH MAST :

Luminaire used 300 w led flood light

300 w flameproof flood light

- **Maintenance Factor**: 0.7
- **Height of high mast** = 15 m
- **Number of High masts** = 5
- **Luminaires per mast**

HM 1 = 9

HM 2 = 4

HM 3 =4

HM 4 = 6

HM 5 = 5

Here, the luminaires LED 300Watt Flood light and 300watt flame proof flood light is being used and the Luminaire layout considered as per site Condition.

5. 3D RENDERING VIEW

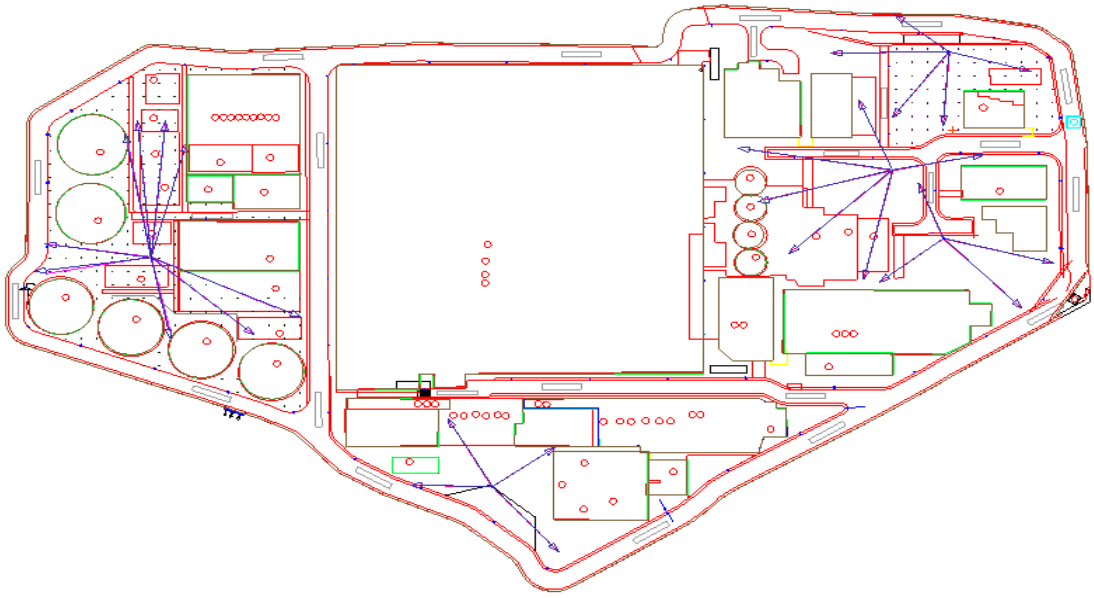


Fig 5.22 simulated plan layout

Fig 5.22 is the plan layout of the area after imported the AutoCAD file in DIAlux software.

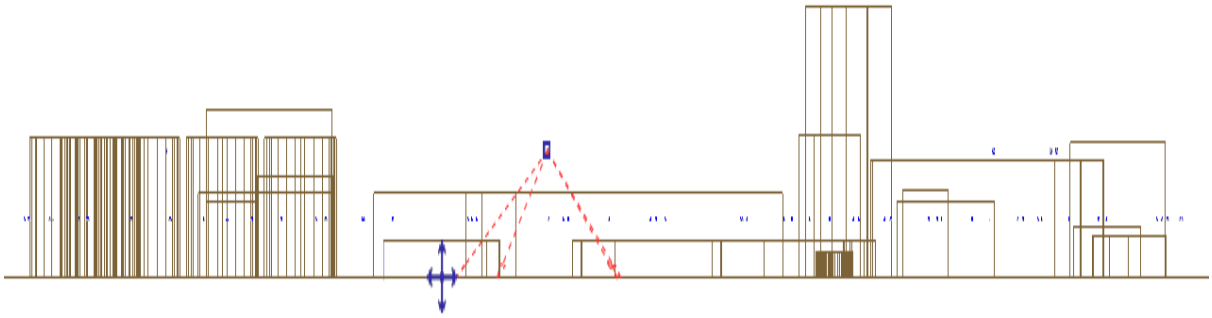


fig 5.23 front view elevation

In fig 5.23 the elevation view gives the information of the whole elevated scenario, the objects height, all the luminaires height.

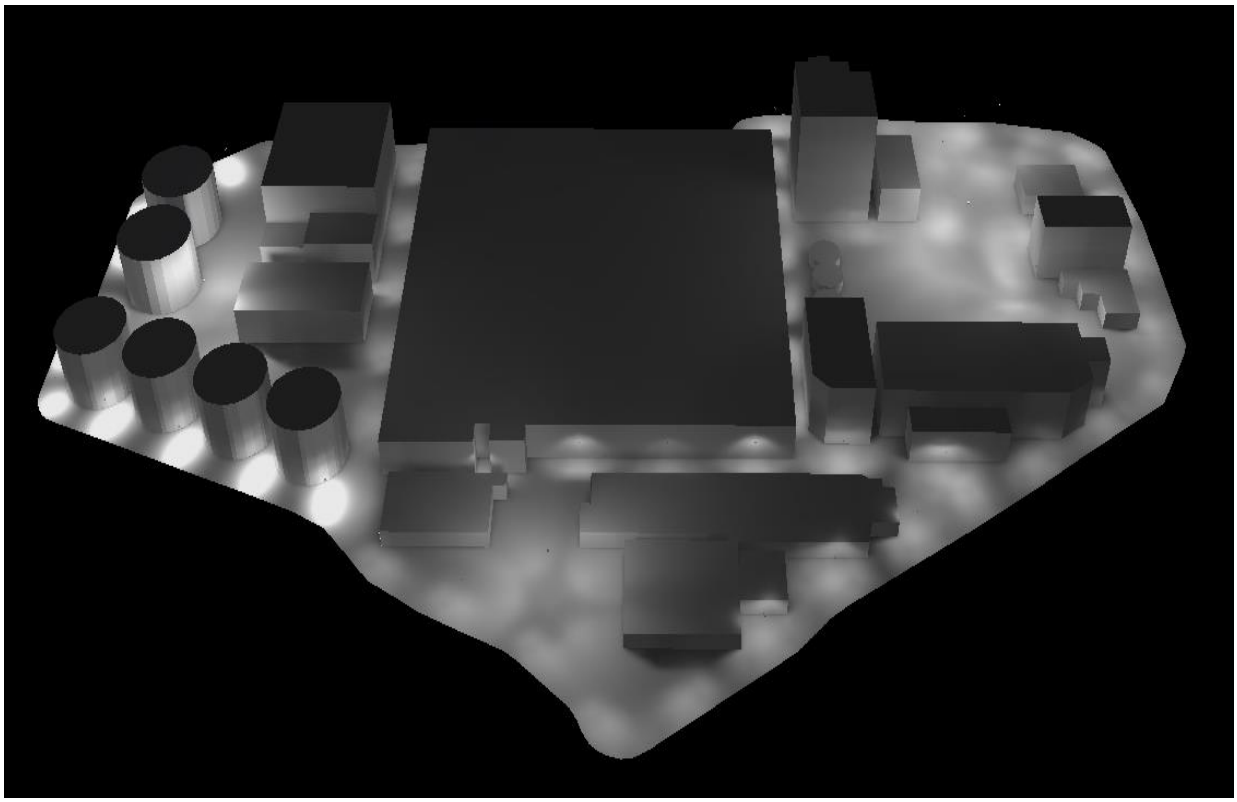


Fig 5.24 simulated 3d rendering view

In industrial lighting the selection of luminaires plays an important Role as a lighting designer for example in fig 5.26 the area is surrounded by the admin building, pump station, transformer house which is less hazardous for fire or explosion. That is why a standard LED flood light is being used here.

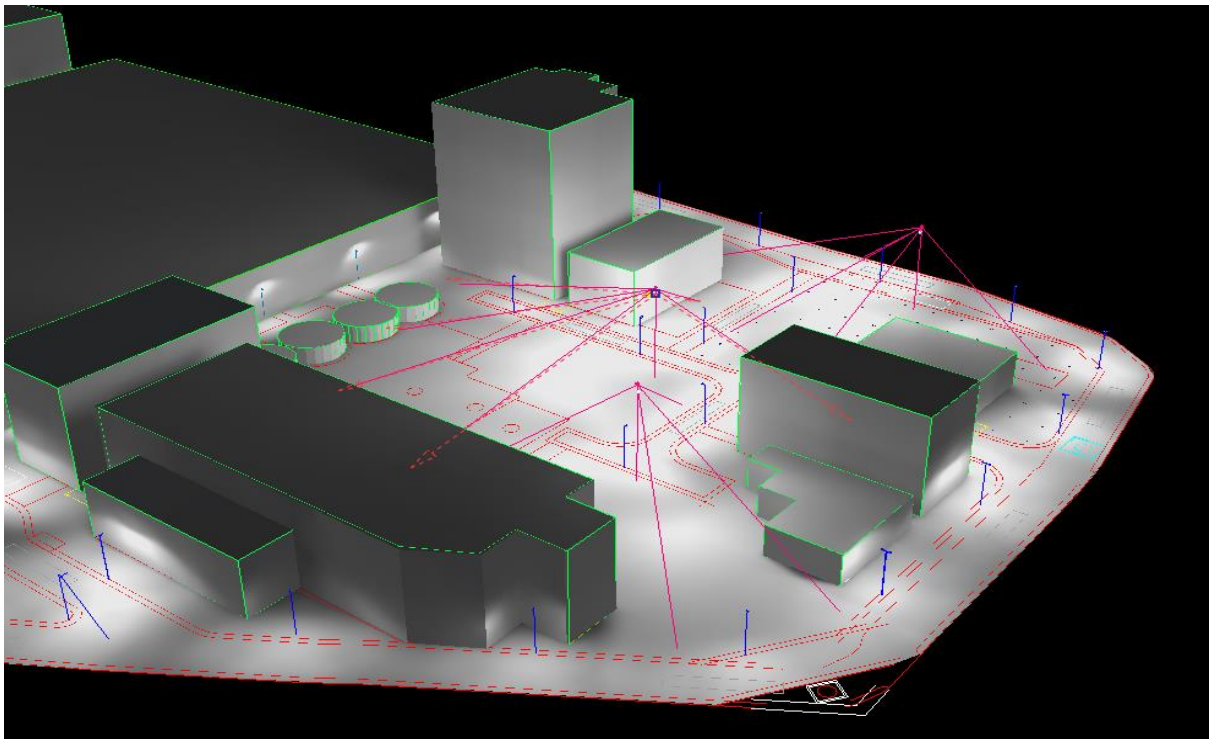
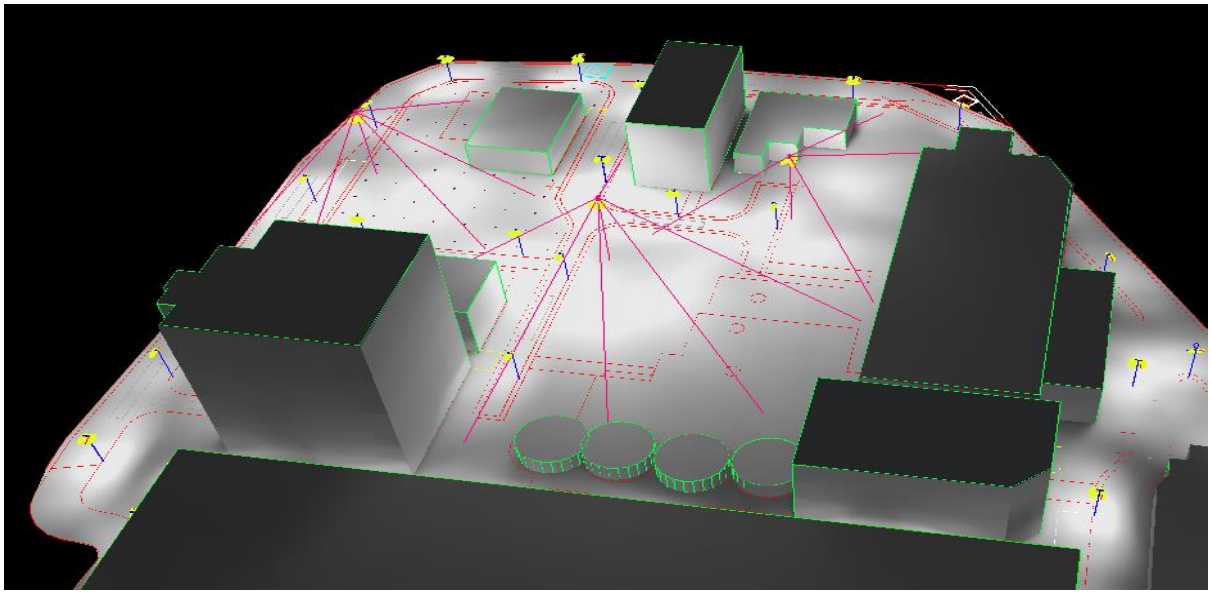


Fig 5.26 3D RENDER



5.27 lighting design of admin building side of the area

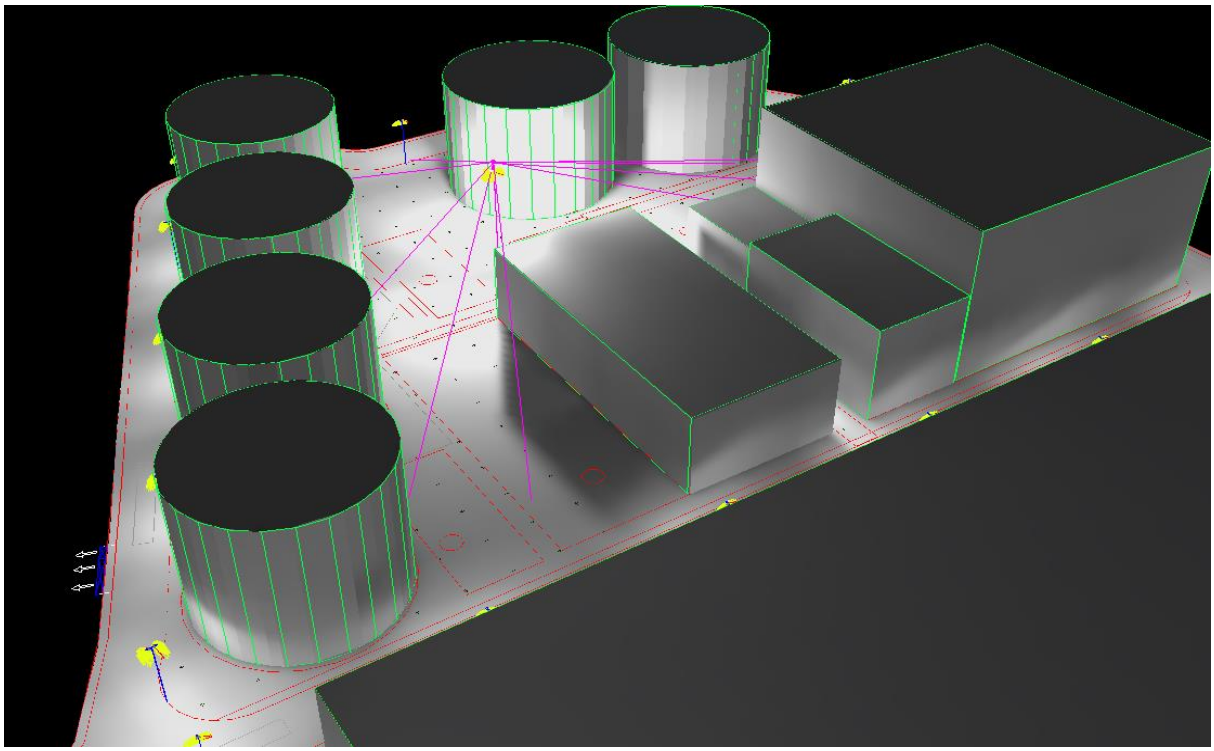


Fig 5.28 simulated 3d view

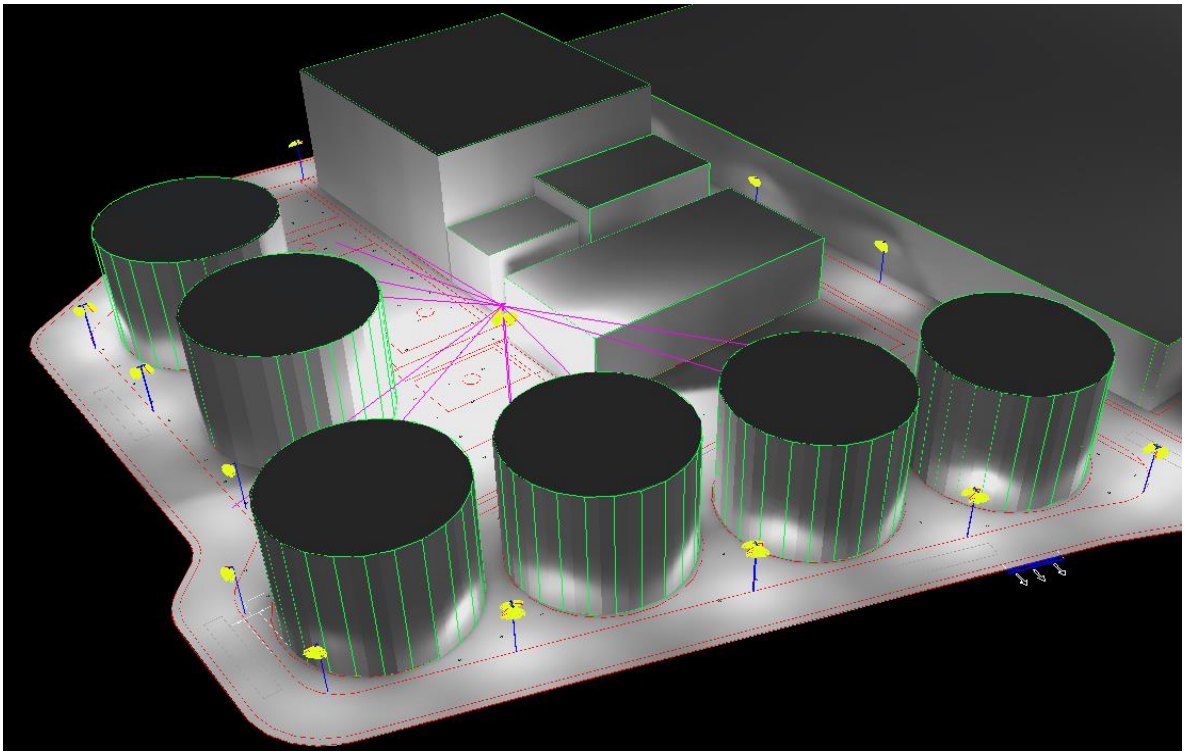


Fig 5.29 simulated 3d rendering surrounded by the tank storage

Above fig 5.28 and 5.29 in this case the luminaires are different from the previous fig. here the scenario is different as the areas are surrounded by the storage tank. Flameproof lighting is used near large storage tanks to ensure safety in hazardous environments where the risk of explosions and fire is high. Lightning-related storage tanks fires are more common than most people think. According to a review of petroleum storage tank fires between 1951 and 2003, the number of tank fires reported in the worldwide media is in the range of 15 to 20 fires per year.[14]

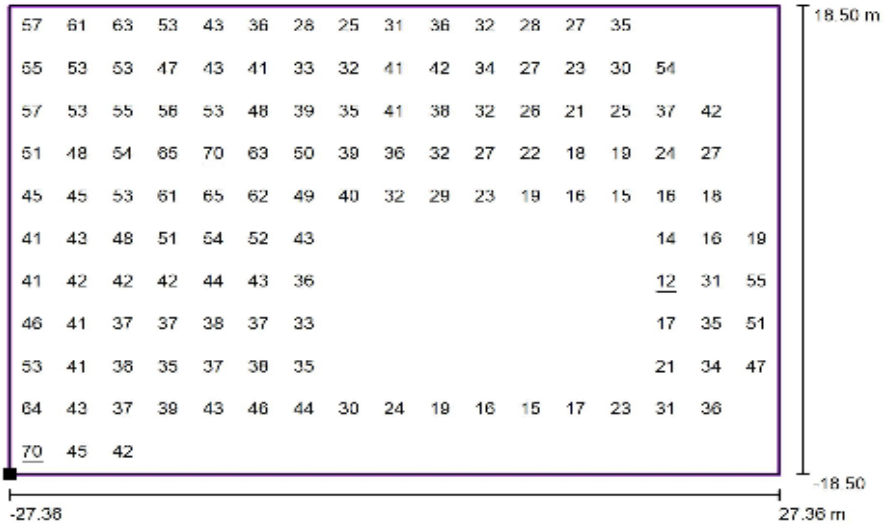
The purpose of flame-proof fixtures is to completely enclose any electrical or heat-producing elements to prevent them from coming into contact with any flammable vapours, gases, dusts, or chemicals that are often utilized in heavy industries. These fixtures also need to be designed with heat in mind, and any sparks or flames from the lighting are entirely contained and sealed inside the fixture.

Several components that aid in preventing explosions are included in the design of LED flameproof lighting. First of all, the fixtures are made with a housing that can tolerate high pressure and temperatures. Typically, non-conductive and non-sparking materials like cast aluminium or stainless steel are used to make this housing.

- **Containment of Sparks**: By resisting high-energy arcing or sparking components inside the enclosure, flameproof lights reduce the possibility of electrical equipment explosions.

- **Prevention of Fire Propagation**: Flameproof lamp enclosures assist to stop fires from spreading because they are constructed from sturdy materials like steel or aluminium that can withstand high temperature.

6.1.RESULT OF AREA 1



Values in Lux, Scale 1 : 415

Position of surface in external scene:
Marked point: (174.080 m, 112.000 m, 0.000 m)

Grid: 136 Points

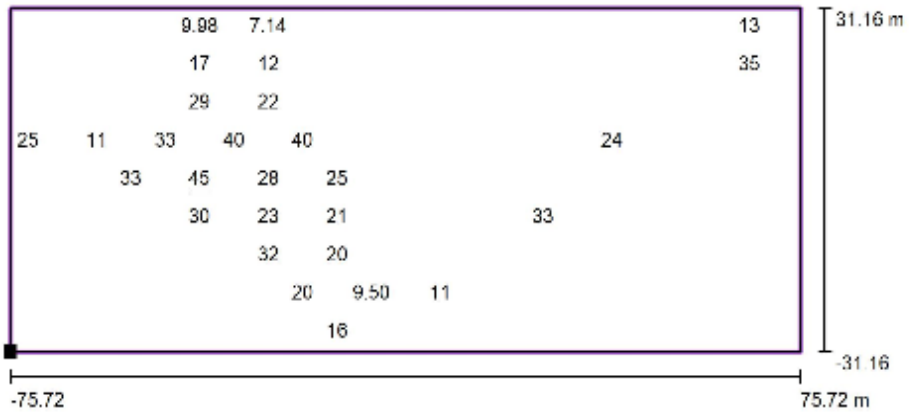
E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
39	12	70	0.32	0.18

7.1 SUMMARY

AREA	REQUIRED		ACHIEVED	
AREA 1	E_{AVG} (lx)	U_0	E_{AVG} (lx)	U_0
	22 lx	0.2	39 lx	0.32

Table no.5 summary table

6.2 RESULT OF AREA 2



Values in Lux, Scale 1 : 1149

Not all calculated values could be displayed.

Position of surface in external scene:
Marked point: (1.365 m, -44.200 m, 0.000 m)

Grid: 49 Points

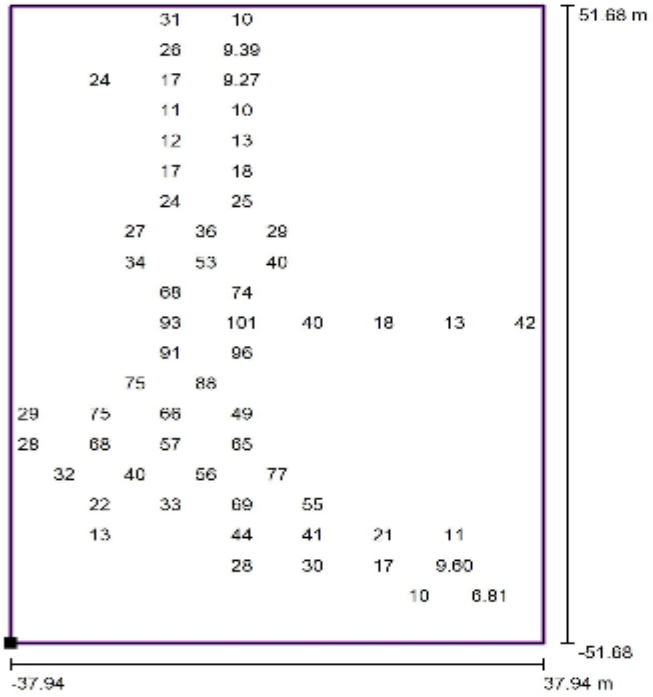
E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
24	7.13	45	0.30	0.16

7.2 SUMMARY

AREA	REQUIRED		ACHIEVED	
AREA 2	E_{AVG} (lx)	U_0	E_{AVG} (lx)	U_0
	20 lx	0.2	24 (lx)	0.3

Table no.6 summary table

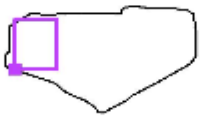
6.3 RESULT OF AREA 3



Values in Lux, Scale 1 : 863

Not all calculated values could be displayed.

Position of surface in external scene:
Marked point: (-90.700 m, 35.000 m, 0.000 m)



Grid: 110 Points

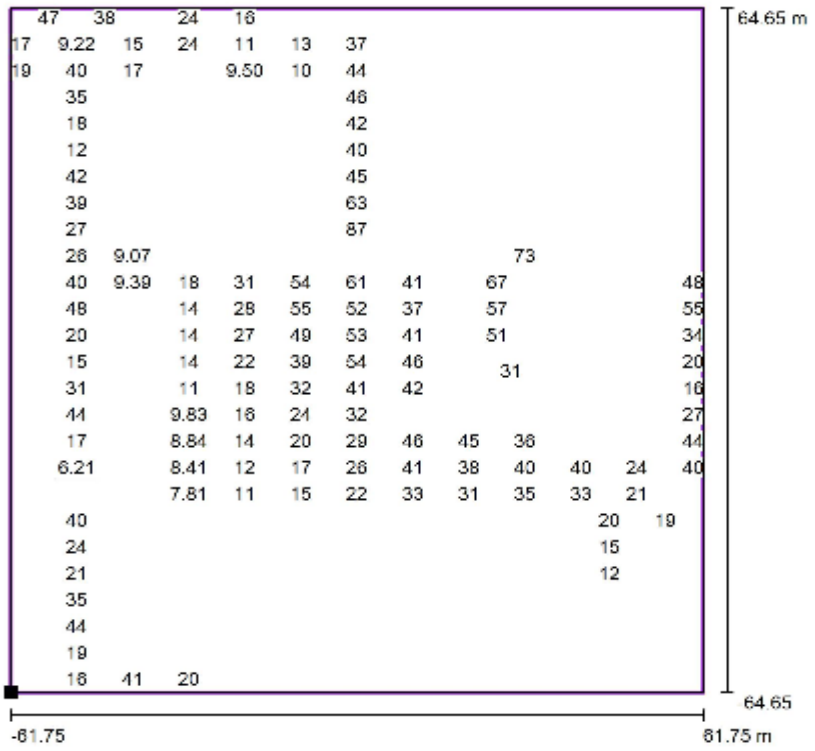
E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
38	5.66	121	0.15	0.05

7.3 SUMMARY

AREA	REQUIRED		ACHIEVED	
AREA 3	E_{AVG} (lx)	U_0	E_{AVG} (lx)	U_0
	20 (lx)	0.2	38 (lx)	015

Table no.7 summary table

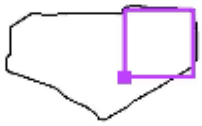
6.4 RESULT OF AREA 4



Values in Lux, Scale 1 : 1079

Not all calculated values could be displayed.

Position of surface in external scene:
Marked point: (105.800 m, 27.500 m, 0.000 m)



Grid: 204 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
32	6.21	95	0.20	0.07

7.4 SUMMARY

AREA	REQUIRED		ACHIEVED	
AREA 4	E_{AVG} (lx)	U_0	E_{AVG} (lx)	U_0
	20 (lx)	0.2	32 (lx)	0.2

Table no.8 summary table

5.6 LIGHTING DESIGN OF 418 MLD DHARAVI INTERNAL ROAD

The internal road in a huge storage tank's outside roadways are often peripheral roads that are encircled by the various storage area buildings. One tank area and another tank region are connected by these routes to carried out the transferring of oil, liquid, waste etc.

1. DESIGN AIM

- According to the standard and codes the required maintained illumination for internal factory road is 20 lux

- Uniformity required 0.2

2.DESIGN CONSIDERATION FOR STREET LIGHT:

Luminaire used 60 w led street light

Maintenance factor = 0.7

Height of the pole = 7m

Bracket arm = 0.5

Tilt = 15 degree

Sometimes it is difficult to achieve the result of an area, if so many obstructions are present in that area. It is very important to take calculation grid avoiding those obstruction otherwise, the uniformity becomes zero.

3. LAYOUT AND DESCRIPTION ABOUT THE AREA

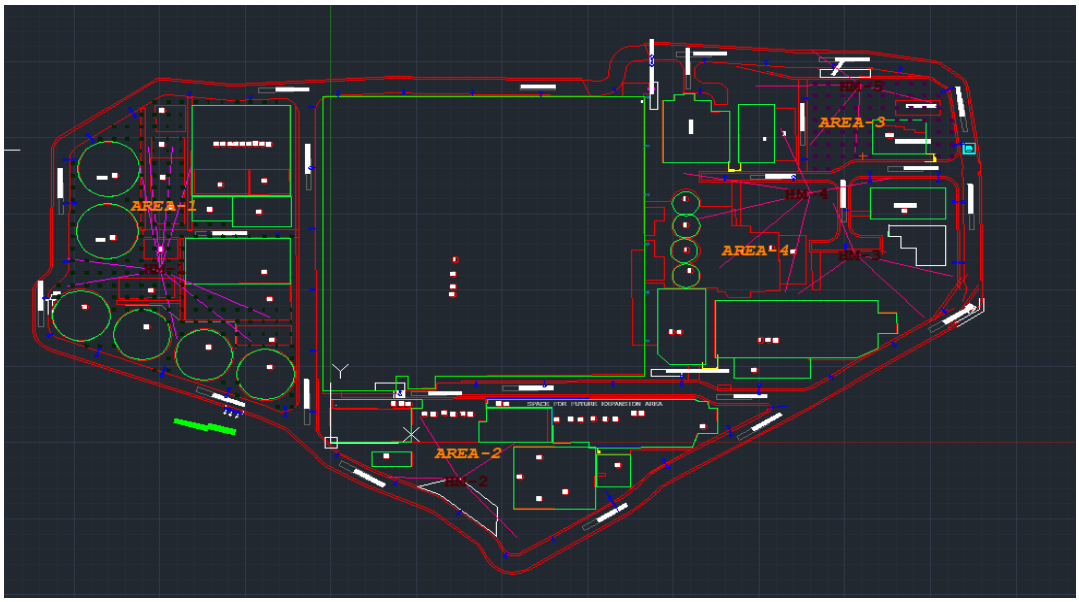


Fig 5.30 plan layout of internal load

These large tank storage areas have internal roads that are connected with one and other. According to the standard the average illuminance of the internal factory road is 20 lux.

4. 3d rendering view

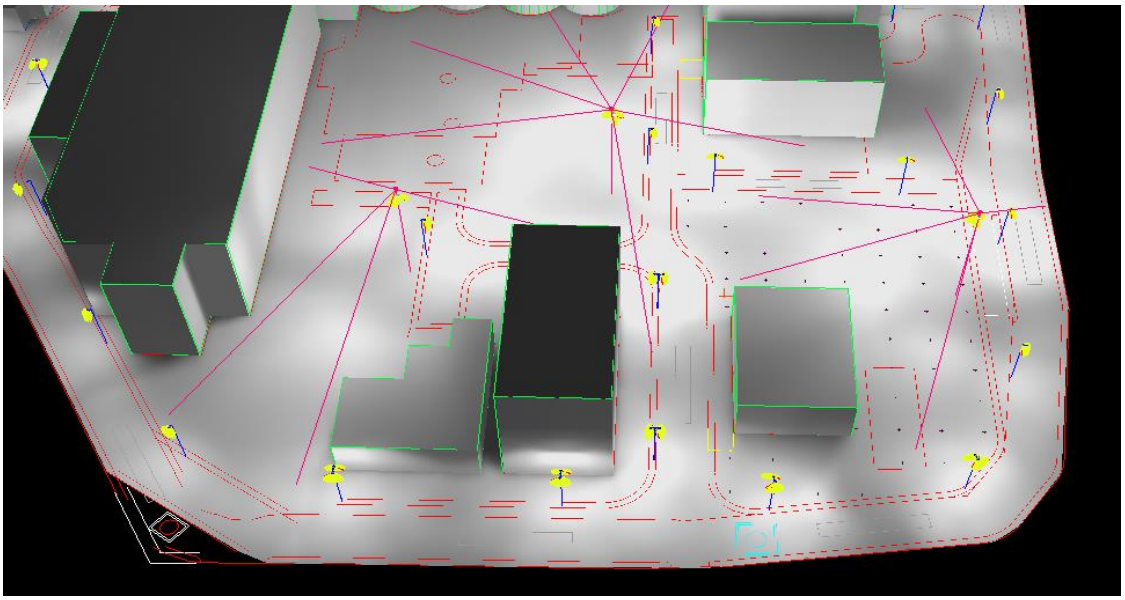
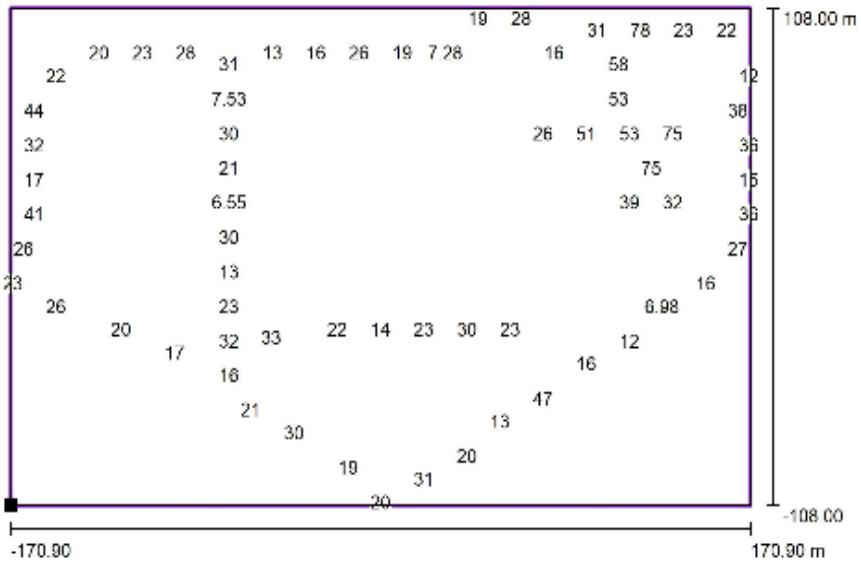


Fig 5.31 simulated 3D rendering image of internal road

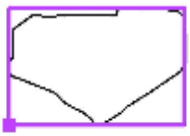
5.RESULT



Values in Lux, Scale 1 : 2592

Not all calculated values could be displayed.

Position of surface in external scene:
Marked point: (-108.891 m, -52.499 m, 0.000 m)



Grid: 364 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
28	6.19	100	0.22	0.06

6. SUMMARY

AREA	REQUIRED		ACHIEVED	
INTERNAL ROAD	E_{AVG} (lx)	U_0	E_{AVG} (lx)	U_0
	20 (lx)	0.2	28 (lx)	0.22

Table no.9 summary table

7.OVERALL SUMMARY OF ALL THE AREAS

INDOOR AREAS

Sl No	Type of Area	Average Illuminance Eavg				Overall Uniformity	
		Required E_{avg} (lx)		Achieved E_{avg} (lx)		Required Uo	Achieved Uo
1	Ware house	150 lx		183 lx		0.4	0.504
2	Warehouse	200 lx		364 lx		0.4	0.411
3	Mezzanine1	150 lx		152 lx		0.4	0.549
4	Mezzanine 2	150 lx		161 lx		0.4	0.4
5		E_{avg} (lx)	E_{min} (lx)	E_{avg} (lx)	E_{min} (lx)		
6	Warehouse With rack	200lx	150lx	290 lx	182 lx	0.4	0.63

OUTDOOR AREAS

Sl No	Type of Area	Average Illuminance Eavg		Overall Uniformity	
		Required E_{avg} lx	Achieved E_{avg} lx	Required Uo	Achieved Uo
1	Petrol pump canopy	550 lx	568 lx	0.4	0.56
2	Area 1	20 lx	39lx	0.2	0.32
3	Area 2	20 lx	24 lx	0.2	0.3
4	Area 3	20 lx	38 lx	0.2	0.15
5	Area 4	20 lx	32 lx	0.2	0.2
6	Internal road	22 lx	28 lx	0.2	0.22

CHAPTER 6
CONCLUSION AND FUTURE SCOPE

6.1 CONCLUSION

The design was to demonstrate how industrial lighting fixtures can significantly enhance visibility, lower the risk of accidents, and boost overall productivity. Since the employing of LED luminaires for every job area, this paper work able to develop the most efficient lighting system for all industrial areas throughout the case study while keeping all those objectives, specifications, and design considerations in mind. In addition to being energy-efficient, LEDs significantly lower the danger of burns and fire risks, as demonstrated by the case study. In this way, we have satisfied our need for industrial lighting. Conventional bulbs, such as incandescent, lose almost 90% of their energy consumption as heat, making them less safe and effective.

6.2 FUTURE SCOPE

In the future, industrial lighting should incorporate circadian LED lighting solutions to improve the quality of life for those living in care facilities. Advanced circadian algorithms powering the lighting systems run automatically to provide optimal circadian support day and night.

It contains full spectrum controlled smart lights that are equipped with an innovative driver technology and a carefully chosen set of LED chips. This technology adjusts to the time of day to provide the ideal combination of colours and light intensity for each space.

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