# STUDIES & DESIGN OF AN ENERGY EFFICIENT INDIAN METRO STATION

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SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENT FOR DEGREE OF
**MASTER OF ENGINEERING**
**IN**
**ILLUMINATION ENGINEERING**

SUBMITTED BY

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**Exam. Roll No.- M4ILN22012**

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This foregoing thesis is hereby approved as a creditable study in the area of Illumination Engineering, carried out and presented by **SHASHI SHANKAR PANDEY**, 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.

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## DECLARATION OF ORIGINALITY AND COMPLIANCE OF ACADEMIC ETHICS

I hereby declare that this thesis contains literature survey and original research work by the undersigned candidate, as part of my Master of Engineering in Illumination Engineering studies.

All information in this document have been obtained and presented in accordance with academic rules and ethical conduct.
I also declare that, as required by these rules and conduct, I have fully cited and referenced all materials and results that are not original to this work.

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The title of his thesis was **"Studies & Design of an Energy Efficient Indian Metro Station"** 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**

**Sanjay Biswas**
**Associate Vice President**
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# ABSTRACT

With the growing population and modernization, the need for Mass Rapid Transit Transport System (MRTS) has increased considerably. The objective behind Metro Lighting Design is to satisfy the visual requirements and guide the passengers safely from one station to the next. It must also be ensured that bright and dark patches are not created in the critical areas of the station.

The work starts with the introduction to the MRTS system and related definitions. A brief note on International and National Recommendations has been given.

The entire lighting design process has been elaborated after which lighting design of energy efficient metro station has been carried out for a particular Indian Metro Station. LED light fixtures have been used in the design process because of its advantages over other fixtures. The lux level standards have been followed as per International and Indian Standards. DIALux 4.13 lighting design software has been used to carry out the lighting simulation.

Finally energy efficiency evaluation has been shown for the metro station to prove that the design does not only satisfy the visual requirements but is also energy efficient.

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# CHAPTER 1

# INTRODUCTION

## 1.1. Introduction of Project :

The Population of India is increasing exponentially with time which results in the expansion of city as well as expansion in related infrastructure like traffic and transport. So the need for a transport system arises which can transport maximum number of people in minimum duration of time.

**Mass Rapid Transit System** (**MRTS**) is the solution for this problem. The world's first rapid transit system was the partially underground Metropolitan Railway which opened in 1863 using steam locomotives, and now forms part of the London Underground.

**Metro** is the most common term for underground rapid transit systems used by non-native English speakers.

According to a report published in 2021, a total of 2,636 million people travel annually in metro systems across India's thirteen major cities, placing the country as one of the busiest urban rapid transit hub in the world in terms of ridership.

## 1.2 History:

The world's first modern mass rapid transit system was born in 1863 in London, England. In the 19th century it became the world's first metro system where electric metro trains started to operate. It is one of the world's longest metro systems with nearly 45% of its MRTS system running underground and the rest elevated. More than 5 million passengers use this mode of transport with above 540 trains operating during the peak hours.

**New York City Subway** was opened in the year 1904. The Interborough Rapid Transit Company (IRT) operated the 9.1-mile long subway line that consisted of 28 stations from City Hall to 145th Street and Broadway. It is the largest system in the world in terms of number of metro stations. It is also one of the busiest metro rail systems in the world. As the MRTS system operates 24X7, the metro lines operate across different service patterns **[1].**

**China** began to develop the subway system in Beijing in1969 and continued experimenting until 1981.It was handed to the civilians in the same year. The Tianjin metro was built in the same year 1984.The growing Chinese population as well its growing economy created a huge demand for urban transport. By the end of the 20th century Beijing, Tianjin, Shanghai and Guangzhou had metro systems. By the end of 2021, China mainland has 45 metro systems in operation with more systems yet to come **[2].**

**Glasgow Subway** in Scotland is the world's third oldest metro system whose operation began in the year 1896.After the first operation, an accidental carriage collision took place which caused the network to close .However it

reopened in the year 1897.Nearly 13 million passengers commute using this mode of transportation every year **[3].**

**Berlin U-Bahn,** Germany started its operation in the year 1902.It stretches over 151km of the track. The expansion of the network was stopped during the 1st World War and after the War progress was affected due to lack of funding. As of latest report, it carries over 500 million passengers every year **[4].**

**Paris Métro** in France began its operations on 19 July, 1900.The metro system stretches over 214-km long network. A total of 197km of the network runs underground. It is the second busiest metro system in Europe. Daily approximately 7 million passengers use this mode of communication **[5]**.

**India's** first Mass Rapid Transit System was Kolkata Metro whose operation started in the year 1984.The man behind this great initiative was Elattuvalapil Sreedharan. Kolkata Metro was followed by Delhi Metro whose operation began in the year 2002.Delhi metro is the largest and the busiest network in India. Following the Delhi metro, other cities in India also started to adopt metro rail as one of its mode of transport **[6].**

**Fig 1.1 Initial construction stages of London's Metropolitan Railway in 1861**


**Fig 1.2 The New York City Subway**

**Fig 1.3 Paris Métro under construction around 1900**

**Fig 1.4 Kolkata Metro in the year 1991**

The metro system may be divided into the following three categories:

a) **Underground**: Trains run in a network of tunnel under the city. This format of the metro is popular where land cost is high.
b) **Elevated/ Surface**: Trains run on dedicated corridors, at street level or elevated above street level; and
c) **Mixed**: Trains run on a network comprising underground tunnel along with elevated and surface corridors.

The application areas can be broadly divided into two categories: **Public Areas** and **Non-Public Areas [7].**

**a) Public Areas:** These are the areas which are accessible by passengers. For ex: - Entrance /Exit Area, Platform area, Paid/Unpaid Concourse area, Restrooms & Toilets.
**b) Non-Public Areas**: These are the areas which are restricted to passengers and are used by metro staff for operation of metro services. For ex: - Back-Of-House, Undercroft, Metro Tunnels.

Lighting Design should be carried out for both the areas based on the lighting level requirements. The Lighting Design should achieve a bright look and avoid any dark patches and should provide easy and safe access to all the areas. Emergency lighting systems should be installed to ensure all the escape routes can be safely and easily identified in an emergency situation.

Lighting Design should comply with the latest standards and code of practice.

## 1.3 Motivation :

A proper lighting design should be energy efficient as well as it should provide enough illumination level to view objects around and should provide visual comfort. For a Lighting Engineer it is a challenge to design an effective lighting solution by considering money saving, energy saving and environmental friendly.
The quality of lighting, nowadays, is mainly determined by the choice of Luminaires and Lamps, and by nature of surfaces being illuminated.
A lighting designer should have creativity, innovation and good knowledge in choosing type of luminaires, light sources, electronics etc. This project is about a case study of the lighting design of a typical Indian metro station. The motivation to choose this topic came from the fact that a metro station has a wide range of areas. So this provides a vast scope of understanding lighting in many areas. This typical Indian metro station mainly consists of the designs of a platform area, concourse area, and other non-public access areas like Back-Of-House areas and Undercroft area. The designs must have to be energy efficient and the results must meet the recommended values defined by the Authority or Client. The entire designs are based on Solid State Lighting (SSL) Technology.

## 1.4 Aim of the Work :

The overall aim of the work is to investigate the required lighting level in an Indian Metro Station.
The objectives of this project are as follows:

- To design energy efficient Metro Station for normal lighting condition.
- Study the lighting quality for different areas in a Metro Station for normal lighting condition.
- Study and calculate energy efficiency of a particular Indian Metro Station (Case Study).

# CHAPTER 2

# INTERNATIONAL & NATIONAL RECOMMENDATIONS ON METRO LIGHTING DESIGN

Lighting in a Metro Station plays a very crucial role for proper navigation of passengers from one place to the other. Adequate brightness is required for passengers to see the signage boards and read instructions on it. Sufficient lighting is necessary to satisfy the visual requirements of the passengers and the metro personnel for proper operation of the metro system. Different International and Indian Standards have been proposed for Metro Lighting Design. Few of the standards which must be referred for metro system lighting design are as follows:

a) IS10322 (Part 1): 1982 – Luminaires: Part 1 General requirements.
b) BS EN 12464-1:2011- Light & Lighting, Lighting of work places(Part-1:Indoor Work Places)
c) IS3646 – Code of practice for interior illumination (Part-I and II).
d) ECBC2017 – Code for conservation of energy.
e) National Lighting Code – Part 6section 7.
f) Lighting Specification by DMRC.
g) Lighting Specification by MMRC.

Below is the Lighting Specification for different areas in a metro station. The specification must be referred to by a Lighting Designer while designing a metro rail system.

## 2.1 LIGHTING SPECIFICATION BY DELHI METRO RAIL CORPORATION (DMRC)

**2.3 Summary of standard of designed level of Illumination for different activity centers:**

| Application | Average Designed luminance in Unit Lux |
|---|---|
| **Passenger Area** | |
| Circulating and Parking Area | 30 |
| Entrance/Exit/Stairs/Escalators/Customer Care/Ticketing | 250 |
| Concourse/Corridors/Passages/ Toilets | 200 |
| Platform<br>Platform Edges | 200<br>250 |
| Train way, walk-ways and walking surfaces | 10 |
| Lifts | 150 |
| **Operation Area** | |
| Staff Working Area/Control Room/OCC | 250 |
| Tunnel | 20 |
| ECS/TVF/Signalling and Telecommunication/UPS/Battery/Pump/Chiller/Auxiliary Substation/TSS/DG Room/LT panel | 200 |

**Fig 2.1 Summary of Std. of Designed level of illumination for diff. activity areas_DMRC**

| | | |
|---|---|---|
| Lifts | | 150 |
| **Operation Area** | | |
| Staff Working Area/Control Room/OCC | | 250 |
| Tunnel | | 20 |
| ECS/TVF/Signalling and Telecommunication/UPS/Battery/Pump/Chiller/Auxiliary Substation/TSS/DG Room/LT panel etc. at station, Depot and Office building | | 200 |
| Underground Track Area and cable galleries | | 10 |
| **Metro Depots** | | |
| Metro Lines Stabling | Uncovered | 20 |
| | Covered | 100 |
| Depots Inspection Bays/ Repair Sections | | 200 |
| Stores Room | | 200 |
| **Administrative Offices** | | |
| Offices | | 200 |
| **Metro Rakes** | | |
| Metro Vehicle | | 300 |

Page **10** of **19**

**Fig 2.2 Summary of Std. of Designed level of illumination for diff. activity areas_DMRC**

## 2.2 LIGHTING SPECIFICATION BY MUMBAI METRO RAIL CORPORATION

The illumination levels for various areas shall be as follows:

| Areas | Average Normal (Lux) | Minimum Emergency (Lux) |
|---|---|---|
| UG Sump Room | 150-200 | 25-50 |
| Lift Maintenance Room | 150-200 | 25-50 |
| Pump Room | 150-200 | 25-50 |
| Inert Gas Room | 200-250 | 25-50 |
| Medium Voltage Switch Gear (MVSGR) | 200-250 | 25-50 |
| Low Voltage Switch Gear (LVSGR) | 200-250 | 25-50 |
| UPS Room | 300 | 25-50 |
| DG (fenced area) or DG Room | 200-250 | 25-50 |
| Transformer Room (ASS Room) | 200-250 | 25-50 |
| Signalling Equipment Room | 300-500 | 50 |
| Signalling Control Panel Room | 300-500 | 50 |
| Communication Equipment Room | 300-500 | 50 |
| Communication Maintenance Room | 300-500 | 50 |

**Fig 2.3 Summary of Std. of Designed level of illumination for diff. activity areas_MMRC**

| Areas | Average Normal (Lux) | Minimum Emergency (Lux) |
|---|---|---|
| Telecom closet | 200 | 50 |
| Station Control Room | 300-500 | 50 |
| Excess Fare Office | 250-300 | 25-50 |
| Ticket Issuing Window/Ticket Office | 250-300 | 50 |
| Secure Suite (SS) | 200 | 25-50 |
| Ticket Office Store & safe (TOST) | 200-250 | 25-50 |
| AFC Maintenance Room | 200-250 | 25-50 |
| Station Entrances & Passage ways | 250 | 50 |
| Concourse Public area | 200-250 | 50 |
| Security Room | 200-300 | 25-50 |
| Lift Lobby | 200-300 | 50 |
| Toilets | 100-150 | 25-50 |
| Locker Rooms | 200-300 | 25-50 |
| Lunch Room | 200-300 | 25-50 |
| Cleaners Room | 150-200 | 25-50 |
| Refuse Room | 100-150 | 25-50 |
| Store Room | 150-200 | 25-50 |
| PH Toilet | 100-150 | 25-50 |
| Janitors Closet | 150-200 | 25-50 |
| Retail/Commercial | 200-300 | 25-50 |
| Parking | 100-200 | 25-50 |
| Link Bridge | 200-300 | 50 |
| Janitors Closet | 150-200 | 25-50 |
| Retail/Commercial | 200-300 | 25-50 |
| Parking | 100-200 | 25-50 |
| Link Bridge | 200-300 | 50 |
| Corridor/Passage way | 200-300 | 50 |
| Fire Escape staircase | 200-300 | 50 |
| Paid Lobby Area | 200-300 | 50 |
| Unpaid Lobby Area | 200-300 | 50 |
| Platform (General) | 200 | 50 |
| Platform (Edge) | 250 | 50 |
| Tunnel Ventilation room | 150-200 | 25-50 |
| ECS and other plant Rooms | 150-200 | 25-50 |
| Tunnel Area (including cross-passages) | 25-50 | 25-50 |

**Fig 2.4 Summary of Std. of Designed level of illumination for diff. activity areas_MMRC**

# CHAPTER 3

# INTRODUCTION TO THE COMPUTER AIDED LIGHTING DESIGN

**3.1. Introduction:** Lighting simulation softwares are being used to simulate and visualize any design virtually. Different lighting softwares have been developed to design any lighting installation such as DIALux, AGi32, Lighting Reality pro, Relux, CGLux, Calculux, Photolux, Sunlux, Lumen Micro, Lumen Designer etc.
All the lighting softwares are different, but their aim is same. Different lighting companies use different lighting softwares. In Crompton Greaves Consumer Electricals Ltd. mostly DIALux and AGi32 is being used for lighting design. Description of some commonly used softwares are given below:

a) **DIALux:** DIALux is complete free lighting software which has been developed by DIAL Company for professional light planning and is open to luminaires of all manufacturers. Virtual worlds can be created simply and intuitively with DIALux. Results can be documented in photorealistic visualizations. Daylight and artificial light scenarios can also be simulated. CAD data of other architectural software can be imported in this software to provide for accurate simulation and to provide a design background and the same can be exported easily. While designing, DIALux determines the energy of your light solution required and supports you in complying with the respective national and international regulations. DIALux supports the luminaires of the world's leading manufacturers and therefore have the greatest possible freedom in the design process. Benefits of DIALux are as follows:
    - Simple, effective and professional light planning
    - Support any photometric data file in required format(.ies)
    - Latest photometric data files of the world's leading manufacturers.
    - Results can be compared with international standard result
    - Dynamic light scenes with LED or other color changing luminaires
    - Planning 3D model and simulate photometric data to any buildings, landscape, façade or roadway model
    - CAD file can be imported or exported.

**Fig. 3.1 Lighting Design in DIALux 4.13**

**Fig. 3.2 Lighting Design in DIALux evo 9.1**

**b) AGi32**: Comprehensive lighting calculations, ease of modeling, and fast, high quality rendering for almost any interior or exterior environment, can be done by AGi32. It is not free software, customer needs to purchase. Benefits of AGi32 are as follows:

- Smooth, effective and professional light planning,
- Simulation time is far less than many other software,
- Support any photometric file in required format(.ies),
- Result can be compared with international standard results.

- Dynamic light scenes with LED or other color changing luminaires.
- Planning 3D model and simulate photometric data to any buildings, landscape, facade or roadway model,
- Better realistic view can be achieved,
- CAD file can be imported or exported.


**Fig. 3.3 Lighting Design in AGi32 - Lighting Analysts**

# CHAPTER 4

# THE METHODOLOGY OF LIGHTING DESIGN

## 4.1 INTRODUCTION:

Most of the information we receive about our surroundings is through the eyes, and light is an essential part of that vision. Light creates different conditions to influence our perception by the way it is distributed throughout a space. The planning of our visual environment is done by lighting design. A good lighting design creates conditions that allow us to work efficiently and move about safely in an environment by giving us a sense of safety and well-being, and also at the same time enhancing that environment aesthetically.

## 4.2 THE PROCESS OF LIGHTING DESIGN:

1. **Visiting the site and understanding the requirements:**
   The first step in any lighting design process is to visit the site and understand the requirements. This will give the Designer a fair idea of how to proceed in the design process.

2. **AutoCAD layout:**
   The Designer now has to acquire the AutoCAD floor plan and sectional level details of the design project that he/she is going to execute. All input should be clear in the CAD drawing like the Reflected Ceiling Plan (RCP) layout, location of the obstructions, objects, electrical equipment location etc.

3. **Study of different National & International Standards:**
   The Designer has to study and refer to the relevant Standards and Code of Practice for the particular design. This not only ensures the correct level of design parameters, but also ensures safety and visual comfort of the people in those areas. For example, IS3646: 1992 (Part 1 & Part 2) **[8][9]** and Energy Conservation Building Code 2011 (ECBC) **[10]** is followed for office lighting. IS 1944 Part 1 and 2- 1970 **[11]** recommends illuminance level and uniformity of illumination to be provided on road surface.

4. **Selection of Luminaires:**
   It is upon the Lighting Designer to select the type of luminaires/fixtures required to illuminate a particular area or room.

5. **Importing the AutoCAD files in the lighting design software:**
   When importing an AutoCAD file into DIALux, one should be careful about the dimension unit in the AutoCAD drawing. Many a times the AutoCAD drawing is not scaled properly, and hence has different dimensions that what is mentioned in it. So, an AutoCAD drawing

must be checked to see if it is scaled properly, and if it is not, then it must be scaled to the correct dimensions.

6. **Steps involved while using simulation program with Lighting Design Software DIALux :**

After successfully importing the AutoCAD file to the Lighting Design software, we have to proceed with the design as follows:

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

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

- Finding out the dimension of the room. Once the dimensions are found out, then the type of lighting arrangement can be decided.
- Finding out the work plane height- An approximate work plane height of 0.76 is taken for some areas (usually ones involving table work), otherwise it is taken zero.
- Finding out the ceiling type- Depending on whether the ceiling is true ceiling or false ceiling, luminaires which can be used there is decided. Surface mounted or suspended luminaires are chosen for true ceiling. In case of false ceiling, recess mounted luminaires should be chosen.
- Selecting Maintenance Factor- Maintenance factor is chosen according to what is discussed with the client, otherwise it is chosen as per standards example 0.8 for indoor areas.
- Maintenance factor – Also known as Light Loss Factor (LLF), it is "the ratio of present illuminance for a given area to the value that would have occurred if the lamps had operated at their (initial) rated lumens and if no system variation or depreciation had occurred". It is basically cumulative multiplication of some other factors like Lamp Lumen Maintenance Factor (LLMF), Lamp survival Factor (LSF), Room Surface Maintenance Factor (RSMF) and Luminaire Maintenance Factor (LMF).
  "MF= LLMF * LSF * RSMF * LMF [**12**].

Where, RSMF (Room Surface Maintenance Factor) takes account of the effect of dirt and dust accumulation and other degradation of the reflectivity of room surfaces. The main

determining factor is the environment which can be classified on a scale of Very Clean to Dirty.
LMF (Luminaire Maintenance Factor) takes account of the effect of dust and dirt accumulation on the luminaire. Luminaires are classified according to their degree of protection from dust and moisture, so dust accumulation on an open up light is more than on a sealed light.
LSF (Lamp Survival Factor) takes account of the effect of the failure of light sources during the maintenance period.
LLMF (Lamp Lumen Maintenance Factor): takes account of the effect of the lumen depreciation of the light sources during the maintenance period."
E maintained= E initial x Maintenance Factor
Where,
E maintained: maintained illuminance at working level
E initial: Initial lumen from luminaire.

- Selecting the luminaire- According to the task to be performed, illumination level required, type of ceiling, and protection required from dust, moisture, heat, chemical, etc, the luminaire is chosen.
- Finding out the number of luminaires required- The number of luminaires required to achieve the desired average illumination level for an interior is calculated by the Lumen method using the formula:
  $N = (L*B*E) / (n* \varphi *MF*UF)$
  Where,
  N= Number of luminaires
  L= Length of area in m.
  B= Width of area in m.
  E= Average maintained horizontal illumination level in lux
  n= Number of lamps per luminaire
  φ= Lumen output of Lamp in Lumens
  MF= Maintenance Factor
  UF= Utilization Factor

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

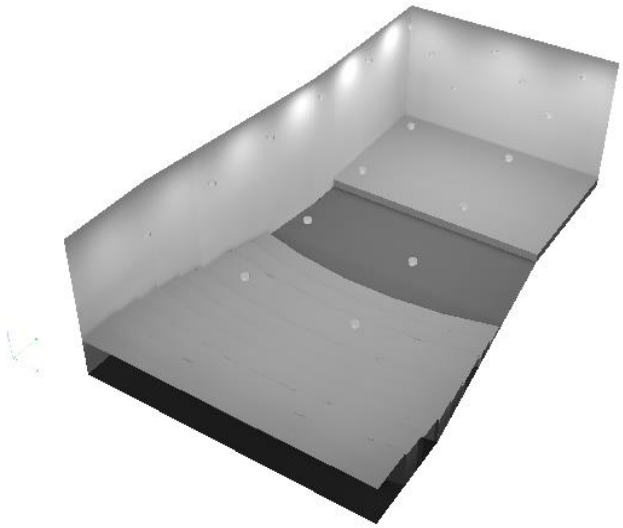

**Fig. 4.1 Lighting Design of an Auditorium area in DIALux 4.13**

The above fig. 3.1 shows the Lighting Design of an auditorium area in DIALux 4.13.

## 7. Analysis of result:

The final simulated design is reviewed and the design parameters are compared with the relevant National & International Standards. After successful completion of the design and meeting the requirements of the design, a final site visit is required after successful installation of the lighting fixtures. With the help of testing equipment like luxmeter, luminance meter etc., the practical on site results are obtained. The obtained values are compared with the software simulated results to check whether the design is feasible or not.

# CHAPTER 5

# COMPUTER-AIDED LIGHTING DESIGN AREAWISE OF AN INDIAN METRO STATION: A CASE STUDY

## 5.1 Introduction:

There are various application areas in a metro station where lighting needs to be provided. The application areas can be subdivided into **Public Areas** and **Non-Public Areas**.

1) **Public Areas:** These can be described as areas used by passengers. The public areas in a metro system are :
   a) Concourse(Paid & Unpaid)
   b) Entrance/Exit Areas
   c) Circulation Areas
   d) Platform
   e) Platform Edges
   f) Restroom & Toilets

2) **Non-Public Areas:** These are described as areas restricted to passengers and are used by metro staff for operation of metro services. The Non-Public areas in a metro system are :
   a) Back-Of-House Areas like Station Control Rooms, Signal Room, Store Room, AHU Room, Battery Room, Pantry etc.
   b) Undercroft Area
   c) Tunnel

The lighting should take into account efficiency, symmetry, application, glare, maintainability and long life. The lighting design should achieve a bright look, avoid any dark patches and afford easy safe access to all the areas. The lighting should be sufficient to avoid any unsafe situation under any normal or abnormal conditions. The lighting system requirements associated with the electrical systems and equipment should comply with the relevant latest standards and codes of practice.

## 5.2 Criteria for Design and Selection of Lighting Equipment:

Selection of lighting equipment will depend on the following factors:
a) Ceiling type;
b) Mounting height/Mounting possibility;
c) Application areas (for selection of IP classification);
d) Criticality of restricting glare;
e) Importance of color rendering index (mainly for selection of lamps);
& f) Use of lamps with proper color temperature.

## 5.3 Lamps:

LED Luminaires should be preferred over other sources because of its benefits and long life. Based on the above factors lighting fixtures should be selected for different application areas in a Metro Station.

## 5.4 Design Parameters:

1. **Illuminance (E) :** It is the amount of luminous flux incident on a unit of a surface. The SI unit is lux.
2. **Overall Uniformity (Uo) :** It is the ratio of the minimum Horizontal Illuminance(Emin) to the average Horizontal Illuminance(Eavg) on the area under consideration. A good overall uniformity ensures that all surfaces on the area is sufficiently visible.

## 5.5 Design Inputs and Ceiling Details:

One of the criteria for selection of Lighting Equipment is the ceiling type and the mounting height details. Below are the Room Ht. and ceiling type details for a typical Underground Metro Station:

| | CONCOURSE LEVEL & BOH | | | | | |
|---|---|---|---|---|---|---|
| Sl. No. | Room Name | Room Ht.(m) | Ceiling Type | | | |
| 1 | Tunnel Ventilation Fan Room(M-10.1) | 5.5 | | | | |
| 2 | Station AHU Room(M-15.1) | 5.5 | | | | |
| 3 | TVS ROOM SWITCHGEAR(P-02.1) | 5.5 | | | | |
| 4 | STAIRCASE(ST-16) | 5.5 | | | | |
| 6 | SCADA ROOM(A-07) | 5.5 | | | | |
| 7 | AUDIT & CASH STORE ROOM(A-05.1) | 3.5 | False Ceiling | | | |
| 8 | UPS FAN ROOM(M-14.1) | 5.5 | | | | |
| 9 | PASSAGE(O-15) | 3.5 | False Ceiling | | | |
| 10 | UNPAID CONCOURSE AREA(O-03) | 3.5 | False Ceiling | | | |
| 11 | TICKET ISSUING WINDOW(A-03.1) | 3.5 | False Ceiling | | | |
| 12 | TOILET FEMALE(O-08F.1) | 3.5 | False Ceiling | | | |
| 13 | STAFF CHANGE ROOM FEMALE(O-24F.1) | 3.5 | False Ceiling | | | |
| 14 | TOILET MALE(O-08M.1) | 3.5 | False Ceiling | | | |
| 15 | STAFF CHANGE ROOM MALE(O-24M.1) | 3.5 | False Ceiling | | | |
| 16 | ACCESSIBLE TOILET(O-09.1) | 3.5 | False Ceiling | | | |
| 17 | PAID CONCOURSE/MEZZANINE AREA(O-02) | 3.5 | False Ceiling | | | |
| 18 | TICKET ISSUING WINDOW(A-03.2) | 3.5 | False Ceiling | | | |
| 19 | AUDIT & CASH STORE ROOM(A-05.2) | 3.5 | False Ceiling | | | |
| 20 | DB ROOM(P-09.1) | 5.5 | | | | |
| 21 | DB ROOM(P-09.2) | 5.5 | | | | |
| 22 | SECURITY CHANGE ROOM MALE(O-26M) | 3.5 | False Ceiling | | | |

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**Fig 5.1 Room wise Ceiling Details and Room ht.**

| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | CONCOURSE LEVEL & BOH | | | | | |
| 4 | Sl. No. | Room Name | Room Ht.(m) | Ceiling Type | | |
| 24 | 21 | DB ROOM(P-09.2) | 5.5 | | | |
| 25 | 22 | SECURITY CHANGE ROOM MALE(O-26M) | 3.5 | False Ceiling | | |
| 26 | 23 | LUNCH ROOM(O-13) | 3.5 | False Ceiling | | |
| 27 | 24 | SECURITY CHANGE ROOM FEMALE(O-26F) | 3.5 | False Ceiling | | |
| 28 | 25 | TOILET MALE(O-08.2M) | 3.5 | False Ceiling | | |
| 29 | 26 | ACCESSIBLE TOILET(O-09.2) | 3.5 | False Ceiling | | |
| 30 | 27 | TOILET FEMALE(O-08.2F) | 3.5 | False Ceiling | | |
| 31 | 28 | STATION CONTROL ROOM(A-01) | 3.5 | False Ceiling | | |
| 32 | 29 | UPS FAN ROOM(M-14.2) | 5.5 | | | |
| 33 | 30 | TVS ROOM SWITCHGEAR(P-02.2) | 5.5 | | | |
| 34 | 31 | Tunnel Ventilation Fan Room(M-10.2) | 5.5 | | | |
| 35 | 32 | Station AHU Room(M-15.2) | 5.5 | | | |
| 36 | 33 | CORRIDOR/PASSAGEWAY(O-15) | 5.5 | | | |
| 37 | 34 | AUDIT & CASH STORE ROOM(A-05.3) | 3.5 | False Ceiling | | |
| 38 | 35 | STATION MANAGER ROOM(A-06) | 3.5 | False Ceiling | | |
| 39 | 36 | TICKET ISSUING WINDOW(A-03.3) | 3.5 | False Ceiling | | |
| 40 | | | | | | |
| 41 | PLATFORM LEVEL | | | | | |
| 42 | 37 | AUXILLARY SUBSTATION(ASS) ROOM(M-12.1) | 5.5 | | | |
| 43 | 38 | UPS ROOM(P-11.1) | 5.5 | | | |

**Fig 5.2 Room wise Ceiling Details and Room ht.**

| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | CONCOURSE LEVEL & BOH | | | | | |
| 4 | Sl. No. | Room Name | Room Ht.(m) | Ceiling Type | | |
| 39 | 36 | TICKET ISSUING WINDOW(A-03.3) | 3.5 | False Ceiling | | |
| 40 | | | | | | |
| 41 | PLATFORM LEVEL | | | | | |
| 42 | 37 | AUXILLARY SUBSTATION(ASS) ROOM(M-12.1) | 5.5 | | | |
| 43 | 38 | UPS ROOM(P-11.1) | 5.5 | | | |
| 44 | 39 | FIRE ESCAPE PUBLIC STAIRCASE(F-03) | 5.5 | | | |
| 45 | 40 | DB ROOM(P-09.1) | 5.5 | | | |
| 46 | 41 | PLATFORM(O-18) | 3.5 | False Ceiling | | |
| 47 | 42 | SEWAGE WATER PUMP/SUMP ROOM(M-04.1) | 5.5 | | | |
| 48 | 43 | SEEPAGE WATER PUMP/SUMP ROOM(M-03.1) | 5.5 | | | |
| 49 | 44 | PSD PANEL ROOM(C-11) | 5.5 | | | |
| 50 | 45 | TELECOM CARRIER ROOM(A-08.1) | 3.5 | False Ceiling | | |
| 51 | 46 | UPS ROOM(P-11.2) | 5.5 | | | |
| 52 | 47 | AUXILLARY SUBSTATION(ASS) ROOM(M-12.2) | 5.5 | | | |
| 53 | | | | | | |
| 54 | UNDERCROFT LEVEL | | | | | |
| 55 | 48 | UNDERCROFT LEVEL | 2.5 | | | |
| 56 | | | | | | |
| 57 | | | | | | |
| 58 | | | | | | |
| 59 | | | | | | |

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**Fig 5.3 Room wise Ceiling Details and Room ht.**

## 5.6 Lighting Design of Public Areas:

### a) Concourse (Paid/Unpaid):

**Introduction:**

It is a large open area in a Metro Station. Concourse areas generally have a height of 2.4 to 5 m. The concourse area can be divided into two parts; Paid Concourse and Unpaid Concourse. The light level required for both these areas is generally the same which is 200-250 lux. Luminaires selected should be suitable for recessed mounting, should have good efficiency and good aesthetics so that it is visually pleasing to the passengers.

**Layout & Description:**

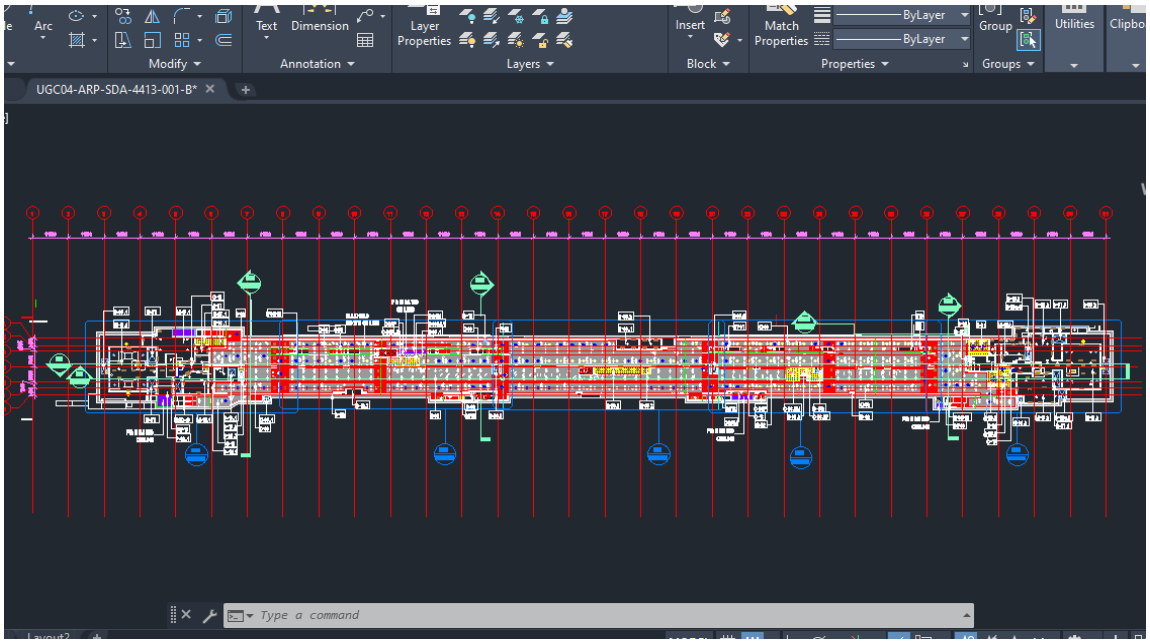



**Fig 5.4 AutoCAD layout (Floor Plan) of a typical Underground Metro Station Concourse**

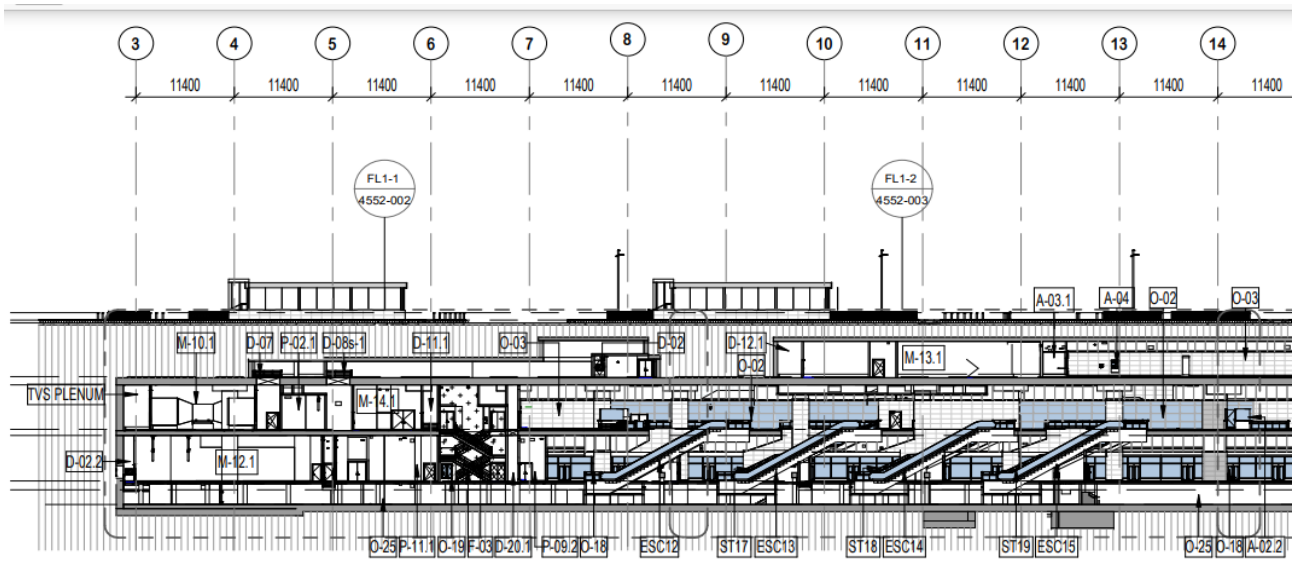



**Fig 5.5 Layout(Sectional) of a typical Underground Metro Station Concourse**

Above is the floor plan and sectional layout of a typical Underground Metro Station Concourse. It is upon the Lighting Designer to decide the type of fixtures required to illuminate this section for standard lux value. False ceiling details and mounting ht. details can also be found out from the floor and sectional plan. For this typical Metro Station Concourse, **Baffle Type False Ceiling** has been proposed in the AutoCAD floor plan at a ht. of 3.5m from Finishing Floor Level (FFL).

## What is Baffle Type False Ceiling?

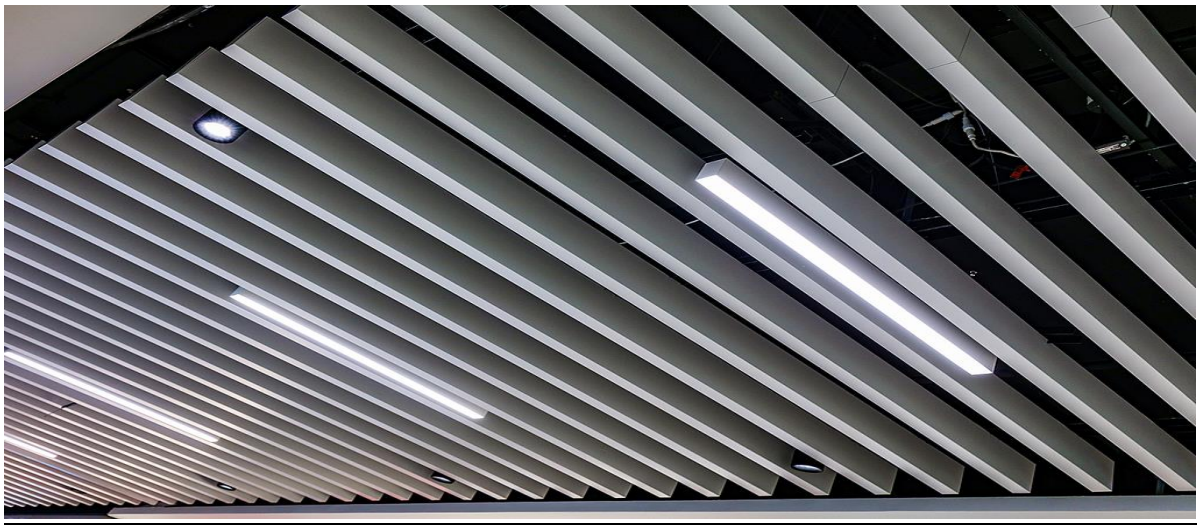


**Fig 5.6 Typical Aluminium Baffle Type Ceiling**

**Baffle Ceiling**, also known as **Acoustic Sound Baffle** or **Hanging Baffle Metal Ceiling** is an open type ceiling construction. It is a set of vertically hung linear profiles in various patterns and combinations, made up of aluminium, wood or any sound absorbing material that reduces the strength (level) of airborne sound. Acoustic Sound Baffles are a kind of suspended ceiling system, or drop out ceiling, an excellent choice for use in spaces that are large like **Concourse Areas**, have limited wall space and may require restricted visual and physical access to services at ceiling level.

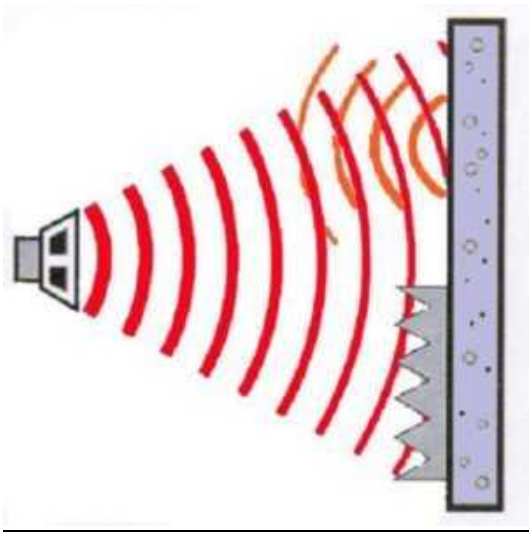


**Fig 5.7 Baffles Reducing the Intensity of Airborne Sound.**

**Baffle Ceilings** produce distinctive ambience, which is contemporary and very functional, and provides good aesthetic view. Baffle to Baffle gap width is usually 50mm, so accordingly light fixtures should be selected.

## IP Ratings for Lighting Products:

IP stands for Ingress Protection. IP ratings are defined as IPXX where the first X indicates the degree of protection against solid objects and the second X indicates the degree of protection against water. The table below indicates the IP Ratings and the corresponding degree of protection:

| Degrees of protection against solid objects | |
|---|---|
| **IP0X** | Non-protected |
| **IP1X** | 50mm diameter and greater |
| **IP2X** | 12.55mm diameter and greater |
| **IP3X** | 2.5mm diameter and greater |
| **IP4X** | 1.0mm diameter and greater |
| **IP5X** | Dust-protected |

| | |
|---|---|
| **IP6X** | Dust-tight |
| **Degrees of protection against water** | |
| **IPX0** | Non-protected |
| **IPX1** | Vertically falling water drops |
| **IPX2** | Vertically falling water drops with enclosure tilted |
| **IPX3** | Spraying water |
| **IPX4** | Splashing water |
| **IPX5** | Water jets |
| **IPX6** | Powerful water jets |
| **IPX7** | Temporary immersion |
| **IPX8** | Continuous immersion |

IP rating is also one of the design criteria for selection of lighting equipment. For Concourse area generally IP20 type of fitting is considered as Underground Concourse is not exposed to dusty environment and also it is not a semi indoor area.

**Glare:**

Condition of vision in which there is discomfort or a reduction in the ability to see details or objects, caused by an unsuitable distribution or range of luminance, or to extreme contrasts. It can be subdivided into two forms:

a) **Discomfort Glare:** Condition of vision in which there is discomfort without impairing the vision of objects.
b) **Disability Glare:** Condition of vision that impairs the vision of objects without necessarily causing discomfort.

For indoor areas, Discomfort Glare is more of a concern than Disability Glare. Discomfort Glare is assessed using **UGR (Unified Glare Rating)**, a parameter which was proposed by **CIE** (**Commission Internationale de l'éclairage).**

For Underground Metro Concourse Lighting Design, preferably light fixtures which will create glare free environment are recommended, as Concourse Building is a large public access area. Therefore it is required to provide a visually pleasing environment to passengers.

**Color Rendering Index (CRI):**

Measure of the degree of the color shift objects undergo when illuminated by the light source as compared with the colors of those same objects illuminated by a reference source.


**Fig 5.8 CRI values and Color Rendition**

CRI>80 is considered good for good color rendition of objects which is provided by Metal Halide Luminaires and standard LED's.

**Design Considerations:**

For Metro Concourse Lighting Design, following are the design considerations:

- Maintenance Factor is considered as 0.8.
- Room Surface Reflectance is considered as 50% (Ceiling), 30% (Walls) and 20% (Floor).

Considering all the above design criteria requirements, lighting design of Concourse Building can be carried out using Lighting Simulation Softwares like DIALux 4.13,DIALux evo or AGi32 Lighting Analysts Software. 3D Rendering of a typical Underground Metro Concourse has been shown below:

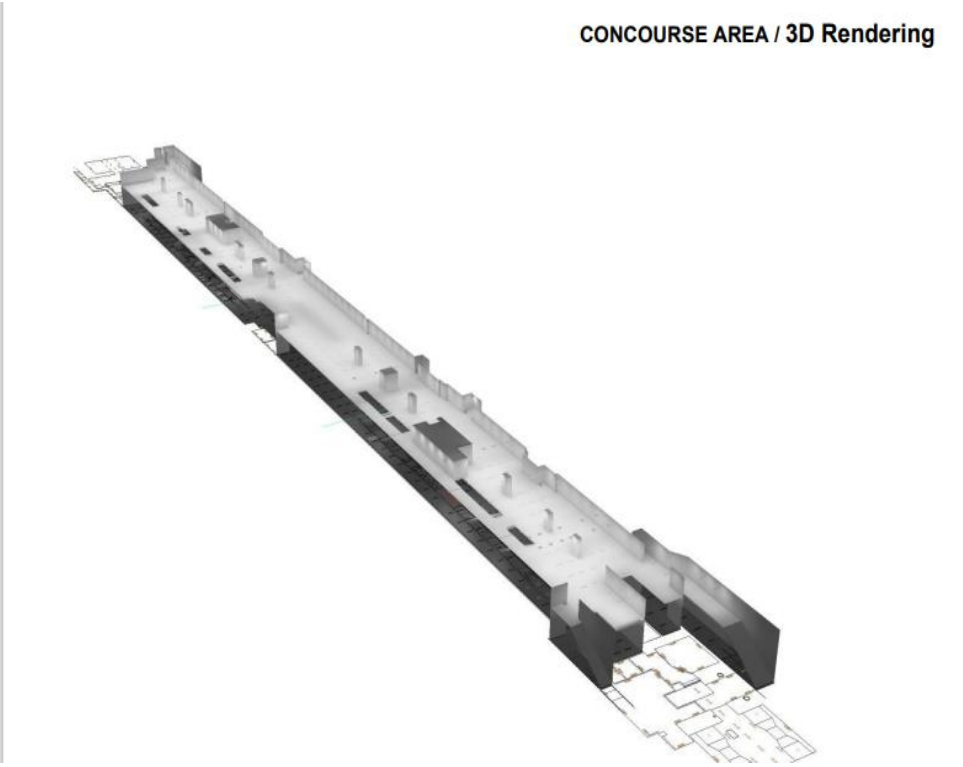



**Fig 5.9 Typical Underground Metro Concourse 3D Rendering**

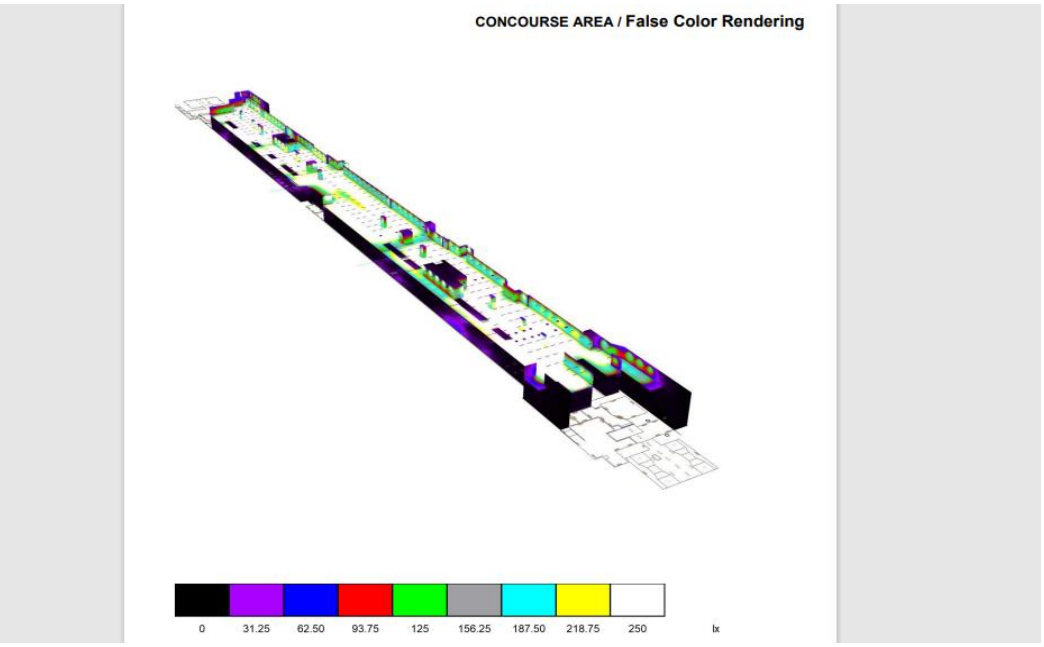



**Fig 5.10 Typical Underground Metro Concourse False Color Rendering**

The above simulation has been carried out in DIALux 4.13.As per the required standard, lighting design has been carried out for average

200-250 lux for Concourse Area and 200-300 lux for Staircase as per MMRC tender.

Fax
e-Mail

**CONCOURSE AREA / Calculation surfaces (results overview)**


Scale 1 : 1957

**Calculation Surface List**

| No. | Designation | Type | Grid | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 | $E_{min}$ / $E_{max}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | CONCOURSE LVL_01 | horizontal | 8 x 8 | 336 | 312 | 365 | 0.931 | 0.856 |
| 2 | STAIR_01 | perpendicular | 11 x 3 | 250 | 151 | 358 | 0.604 | 0.421 |
| 3 | CONCOURSE LVL_02 | horizontal | 8 x 8 | 385 | 343 | 425 | 0.891 | 0.808 |
| 4 | CONCOURSE LVL_03 | horizontal | 17 x 8 | 347 | 276 | 407 | 0.797 | 0.679 |
| 5 | CONCOURSE LVL_04 | horizontal | 8 x 8 | 294 | 265 | 332 | 0.901 | 0.798 |
| 6 | CONCOURSE LVL_05 | horizontal | 8 x 8 | 260 | 211 | 306 | 0.811 | 0.690 |
| 7 | CONCOURSE LVL_06 | horizontal | 8 x 8 | 283 | 240 | 323 | 0.847 | 0.741 |

**Fig 5.11 Calculation Surface Overview**

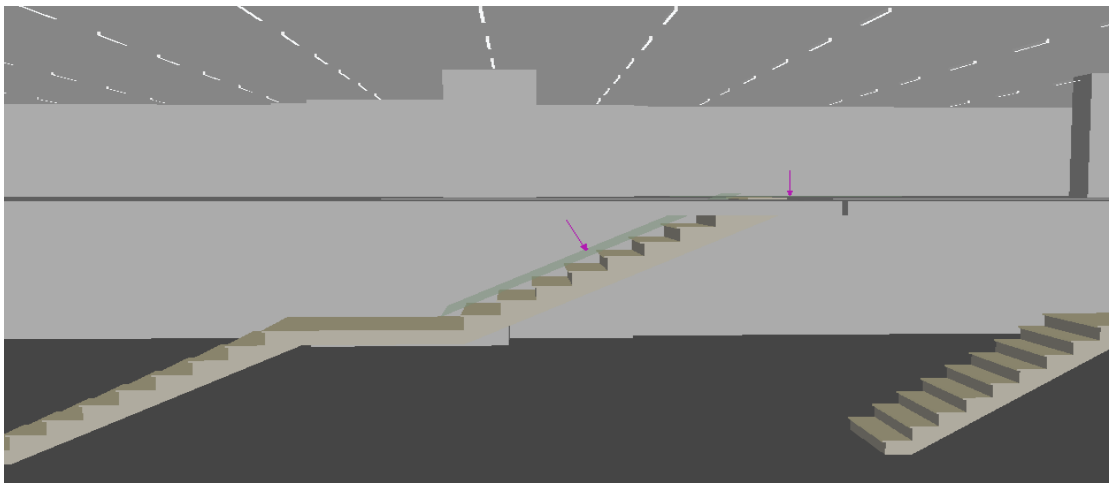


**Fig 5.12 Calculation Surface for a typical Concourse Staircase**

Fig. 5.11 shows the Calculation Surface overview result for the Concourse Area and for Staircase.

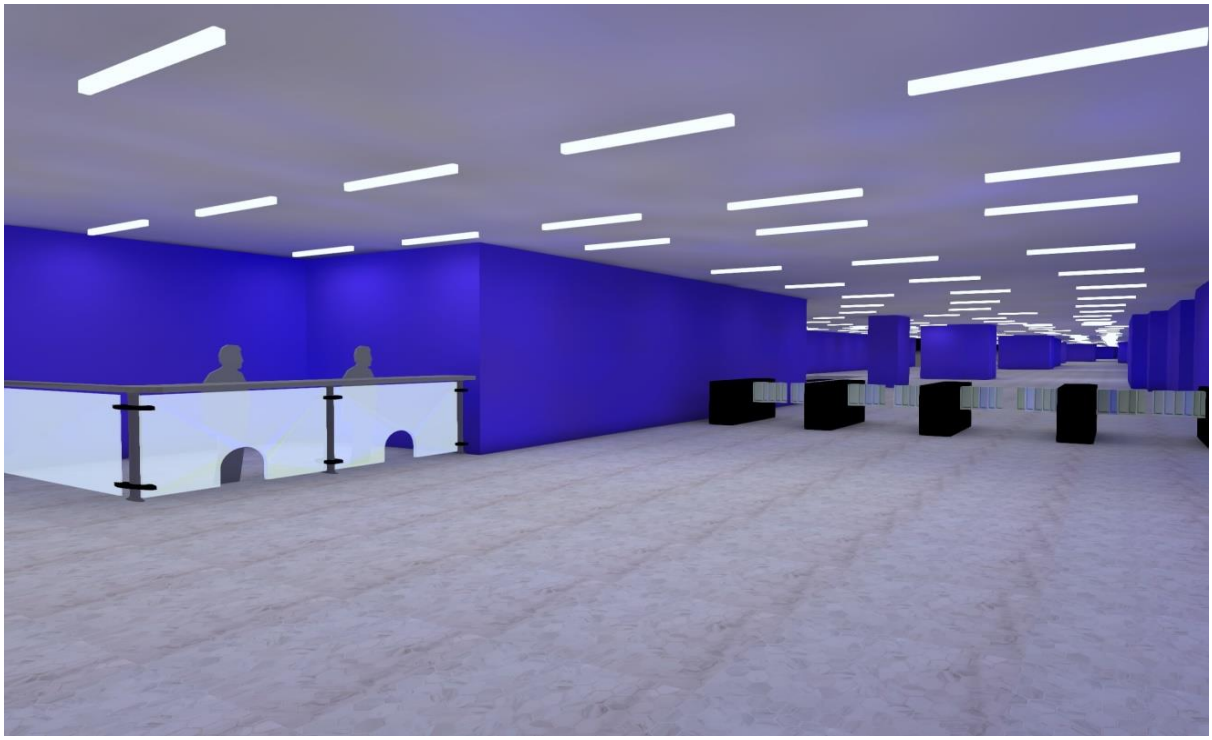


**Fig 5.13 Typical Underground Metro Concourse(Unpaid) 3D Rendering**

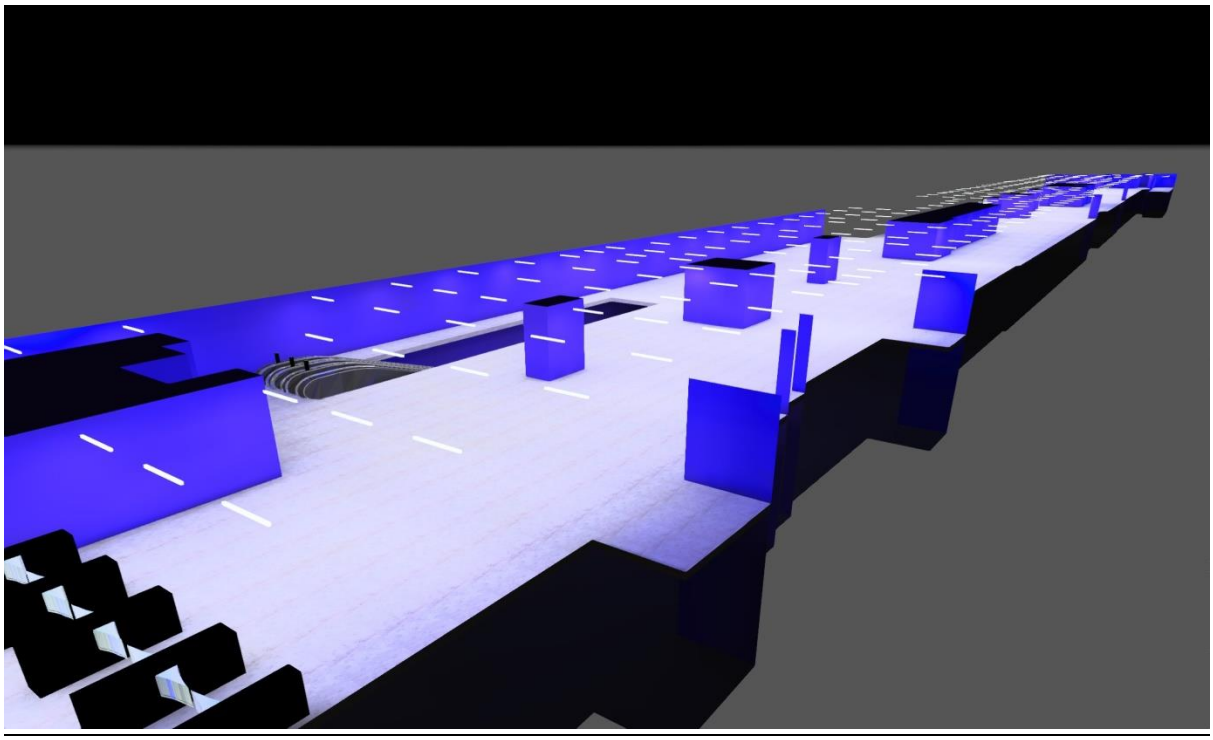


**Fig 5.14 Typical Underground Metro Concourse(Paid) 3D Rendering**

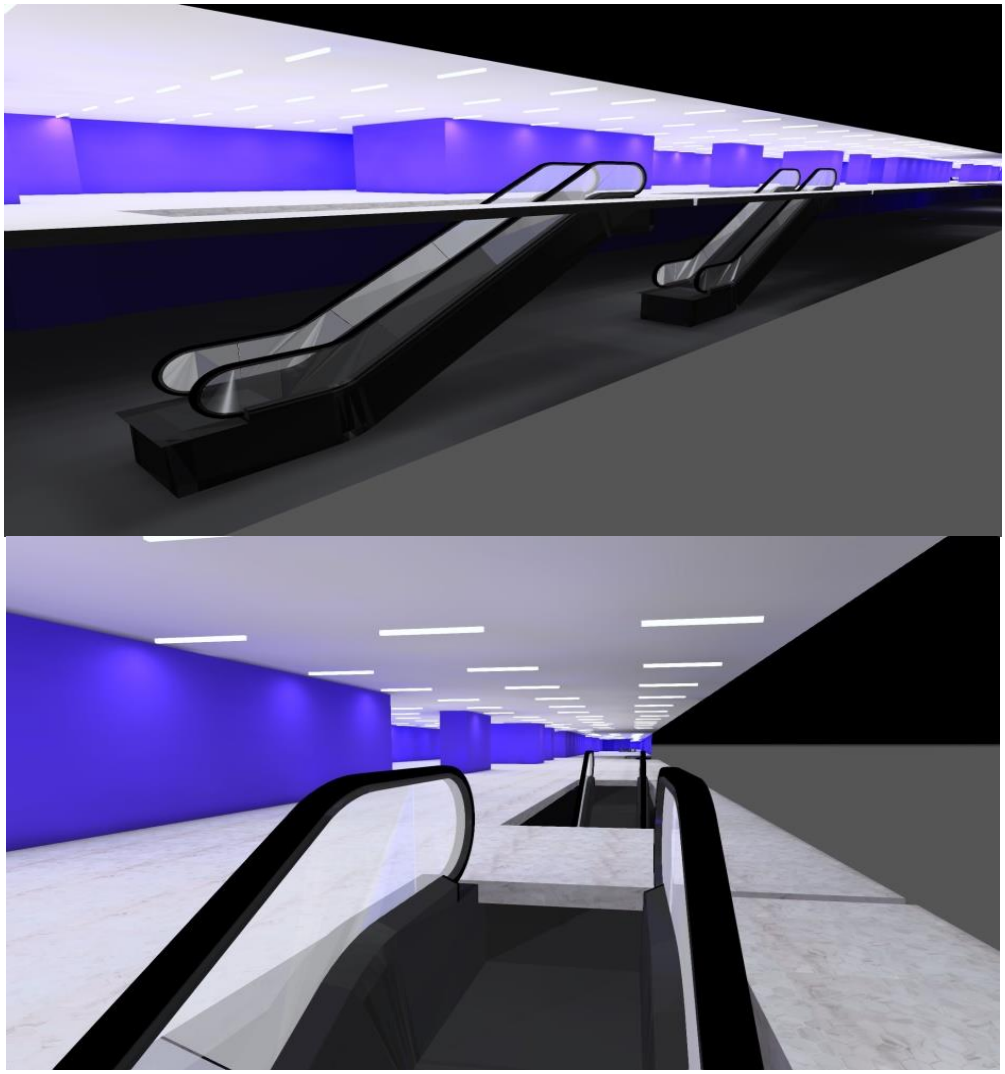


**Fig 5.15 Typical Underground Metro Concourse Stair 3D Rendering**

Fig 5.13 to 5.15 shows the 3D rendering images of a typical Metro Concourse Building. The simulation has been carried out in DIALux evo lighting design software.

## Technical Details Of Luminaires Used:

1. **Suspended Linear LED downlight :**

   Lamp: 40W LED
   Ingress Protection: IP20
   CCT: 5700K
   Lumen output: 4491 lm
   Efficacy: >110Lm/W
   Length (mm): 1200
   Approx. wt. (kg): 2.8

In Fig. 5.16 image of the dimensions of the 40W Linear LED Downlight has been shown.

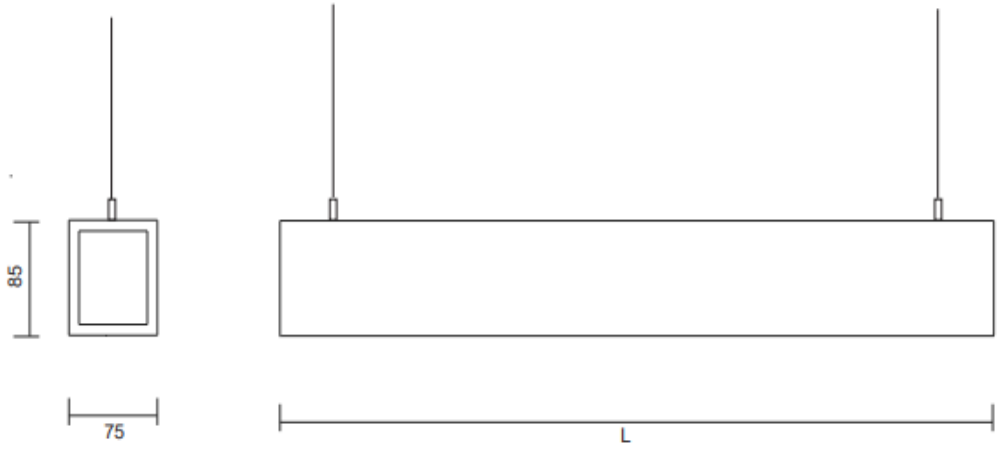



**Fig 5.16 Dimensions of the 40 W Linear LED downlight**

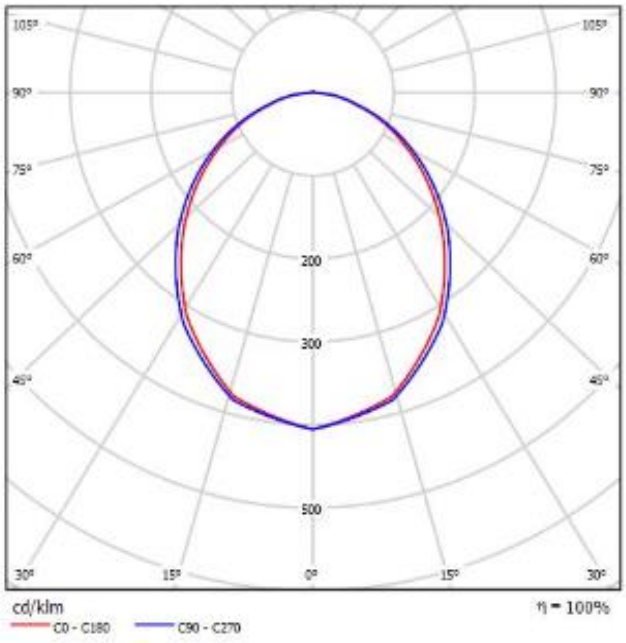



**Fig 5.17 Luminous Intensity Distribution Curve of the Luminaire**

Fig 5.17 shows the luminous intensity distribution curve of the luminaire used in the Concourse Area.

**MATERIAL SPECIFICATION:**

1. Housing — Extruded Aluminium White powder coated.
2. Endcap — Plastic Injection molded.
3. Diffuser — High translucent Frosted PMMA.
4. Internal Wiring — PVC insulated copper wire.
5. Mains Terminal cable — 3 Way 10 amp suitable for max 2.5 sqmm incoming
6. Hardware — SS

**ELECTRICAL PARAMETERS:**

| | | |
|---|---|---|
| Rated Voltage (V) | : | 240V~ |
| Frequency (Hz) | : | 50 |
| Operating Voltage Range | : | 150V~ -270V~ |
| Input Current (A) | : | 0.175 |
| Rated Wattage (W) @240 | : | 40 |
| PF | : | >=0.95 |

The above luminaire has been used in **Metro Concourse** Area, mounted on Baffle False Ceiling.

**b) Platform Area :**

Platforms can be considered as semi-outdoor areas with a typical height of 2.7 to 4 m. It is the area where passengers board and alight from the train, so lighting design of this area becomes very much critical and is a challenge for a Lighting Designer to select the right optics with proper photometric distribution.

## Layout & Description:

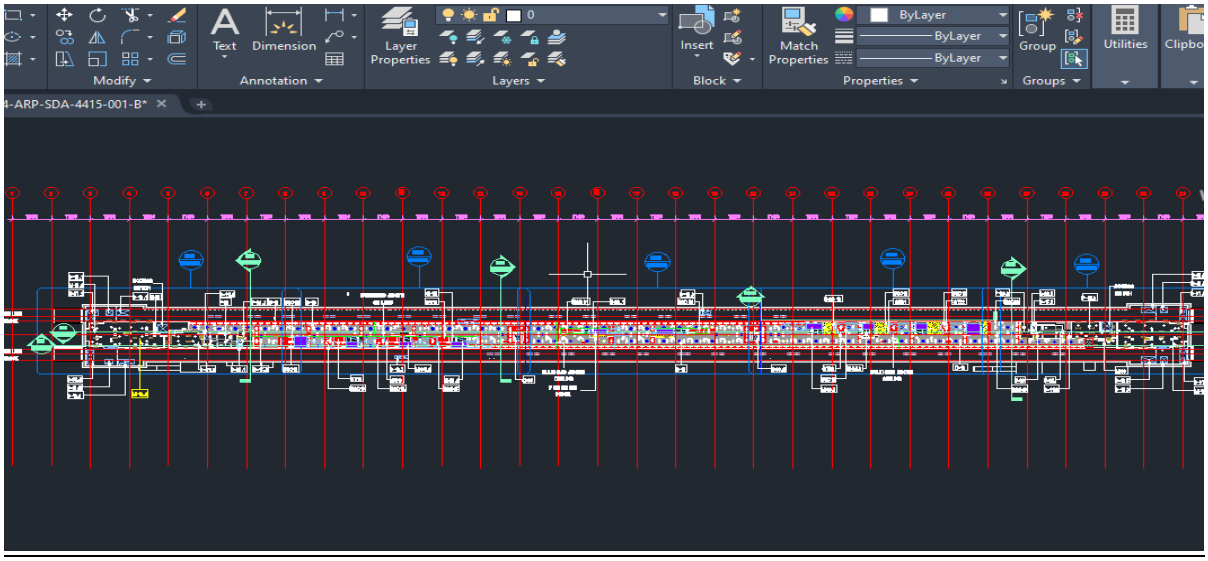



**Fig 5.18 AutoCAD layout (Floor Plan) of a typical Underground Metro Station Platform Area**

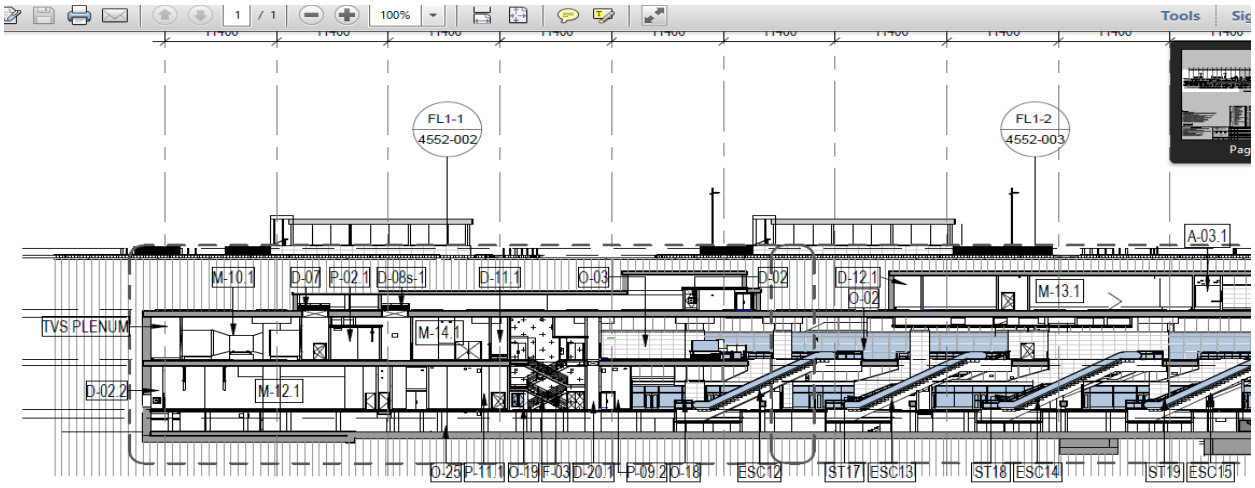



**Fig 5.19 Layout(Sectional) of a typical Underground Metro Station Platform Area**

Above is the floor plan and sectional layout of a typical Underground Metro Station Platform Area. It is upon the Lighting Designer to decide the type of fixtures required to illuminate this section for standard lux value. False ceiling details and mounting ht. details can also be found out from the floor and sectional plan. For this typical Metro Station Platform Area, **Baffle Type**

**False Ceiling** has been proposed in the AutoCAD floor plan at a ht. of 3.5m from Finishing Floor Level (FFL).Lighting design of Platform Level is very critical for proper visibility and care must be taken for achieving good uniformity along the platform edges.

IP20 type fitting is preferable in Platform Area whereas IP65 type fitting is preferable in extended Platform Area as the extended Platform Area is semi-indoor space which is connected to metro underground tunnel.

For Underground Metro Platform Area lighting design, preferably light fixtures which will create glare free environment are recommended, as Platform Area is a large public access area. Therefore it is required to provide a visually pleasing environment to passengers.

CRI>80 is considered good for good color rendition of objects which is provided by Metal Halide Luminaires and standard LED's.

**Design Considerations:**

For Metro Platform Lighting Design, following are the design considerations:

- Maintenance Factor is considered as 0.8.
- Room Surface Reflectance is considered as 50% (Ceiling), 30% (Walls) and 20% (Floor).

Considering all the above design criteria requirements, lighting design Platform Level can be carried out using Lighting Simulation Softwares like DIALux 4.13, DIALux evo or AGi32 Lighting Analysts Software. 3D Rendering of a typical Underground Metro Concourse has been shown below:

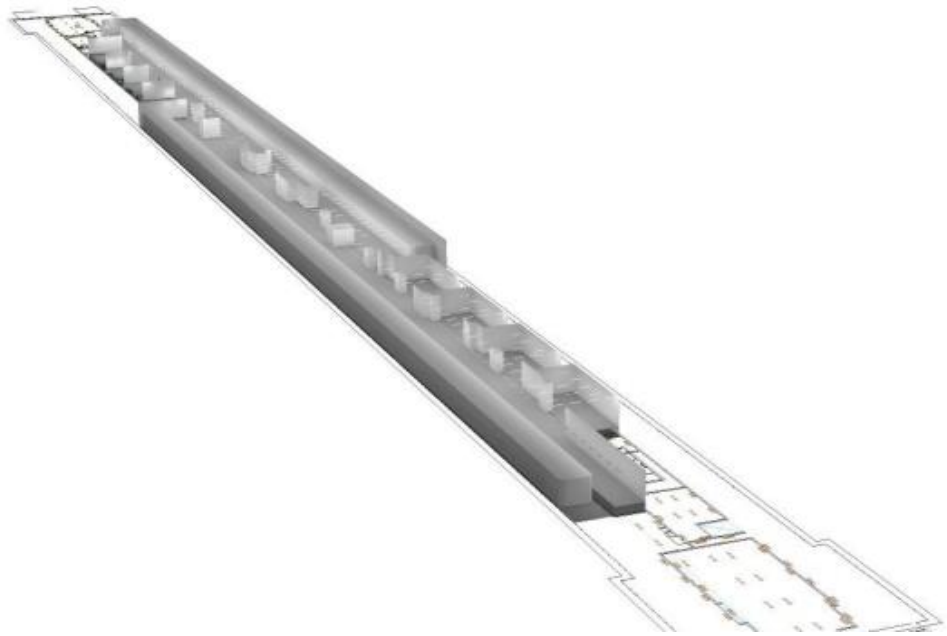


**Fig 5.20 Typical Underground Metro Platform 3D Rendering**

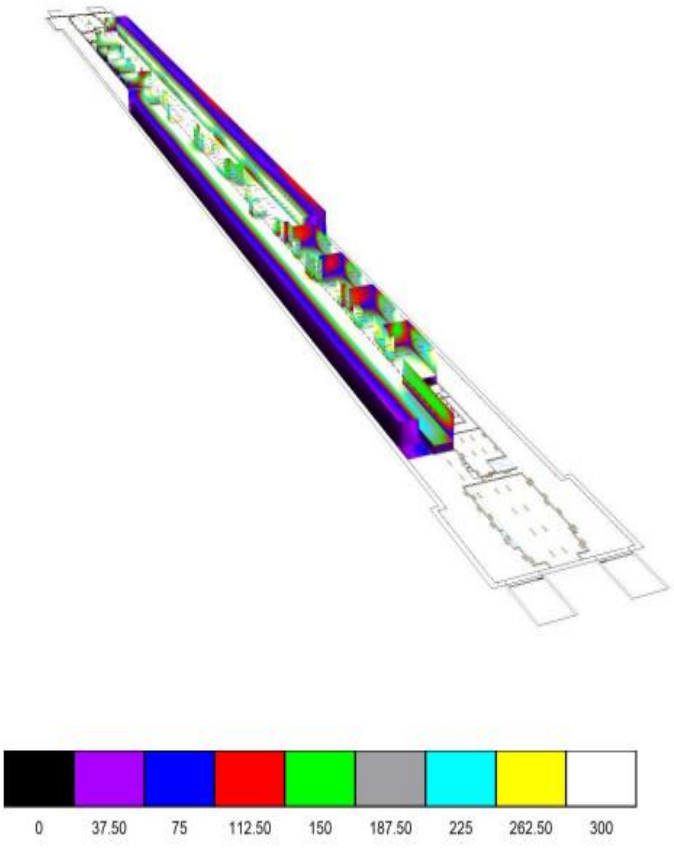
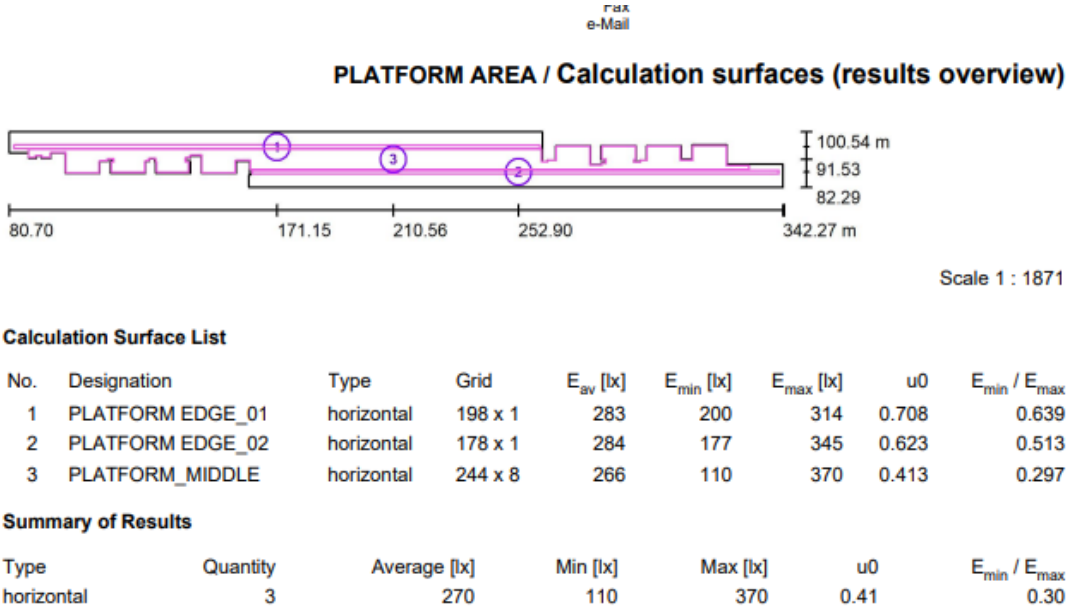



**Fig 5.21 Typical Underground Metro Platform False Color Rendering**

The above simulation has been carried out in DIALux 4.13.As per the required standard, lighting design has been carried out for average 200 lux for Platform Area and 250 lux for Platform Edge as per MMRC tender. Overall Uniformity of 0.6 for platform edge and 0.4 for platform middle area should be maintained to avoid dark patches on the platform level and provide easy commutation of the passengers.




**Calculation Surface List**

| No. | Designation | Type | Grid | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 | $E_{min}$ / $E_{max}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | PLATFORM EDGE_01 | horizontal | 198 x 1 | 283 | 200 | 314 | 0.708 | 0.639 |
| 2 | PLATFORM EDGE_02 | horizontal | 178 x 1 | 284 | 177 | 345 | 0.623 | 0.513 |
| 3 | PLATFORM_MIDDLE | horizontal | 244 x 8 | 266 | 110 | 370 | 0.413 | 0.297 |

**Summary of Results**

| Type | Quantity | Average [lx] | Min [lx] | Max [lx] | u0 | $E_{min}$ / $E_{max}$ |
|---|---|---|---|---|---|---|
| horizontal | 3 | 270 | 110 | 370 | 0.41 | 0.30 |

**Fig 5.22 Calculation Surface Overview**

Fig. 5.22 shows the Calculation Surface overview result for the Metro Platform Level.

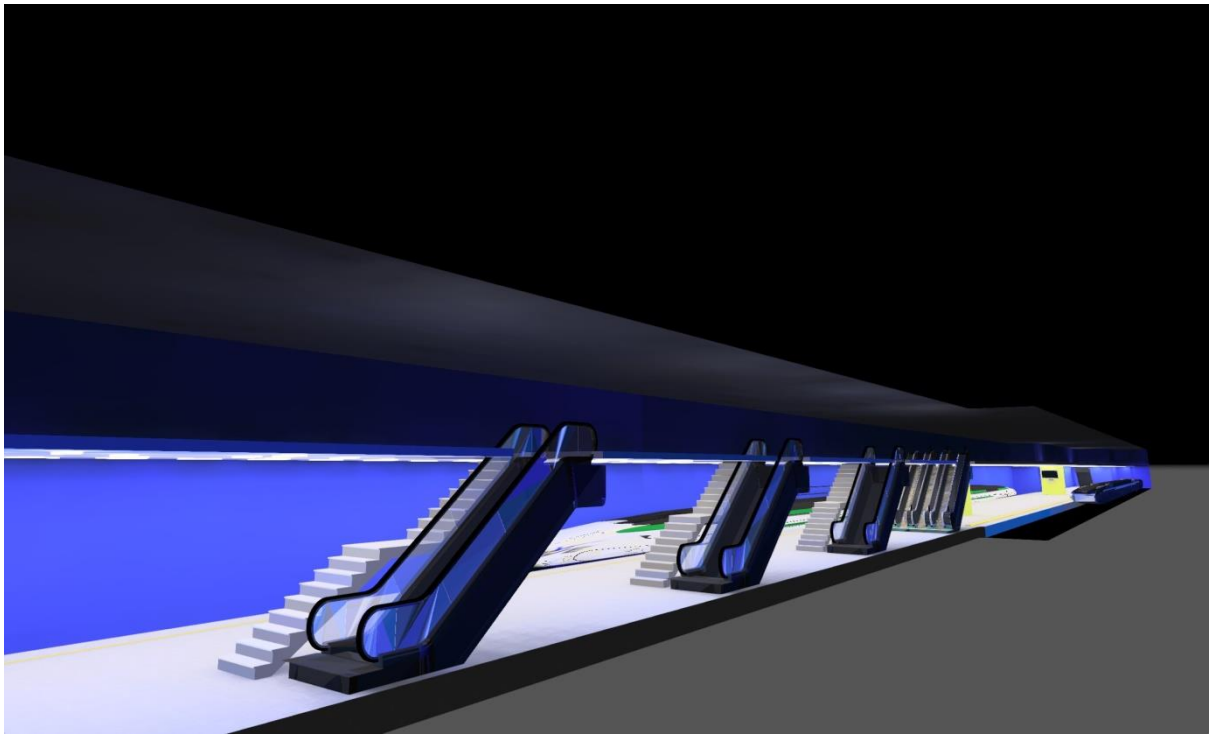


**Fig 5.23 Typical Underground Metro Platform 3D Rendering**

**Fig 5.24 Typical Underground Metro Platform 3D Rendering**

**Fig 5.25 Typical Underground Metro Platform 3D Rendering**

**Fig 5.26 Typical Underground Metro Platform 3D Rendering**

Fig 5.23 to 5.26 shows the 3D rendering images of a typical Metro Platform Area. The simulation has been carried out in DIALux evo lighting design software.

## Technical Details Of Luminaires used:

1. **LED Integrated Batten :**

   Lamp: 40W LED
   Ingress Protection: IP20
   CCT: 5700K
   Lumen output: 4409 lm
   Efficacy: >110Lm/W
   Length (mm): 1207
   Approx. wt. (kg): 0.8

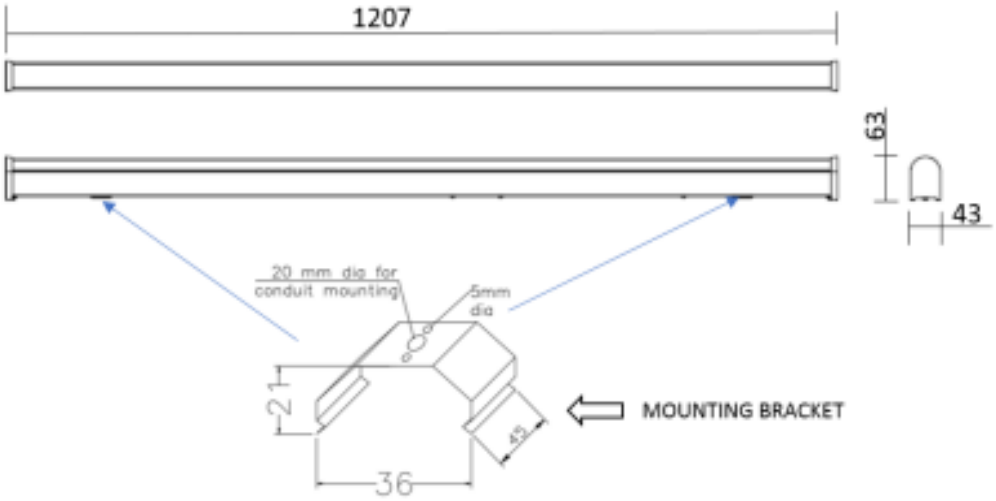



**Fig 5.27 Dimensions of the 40 W LED Integrated Batten**

In Fig. 5.27 image of the dimensions of the 40W LED Integrated Batten has been shown.

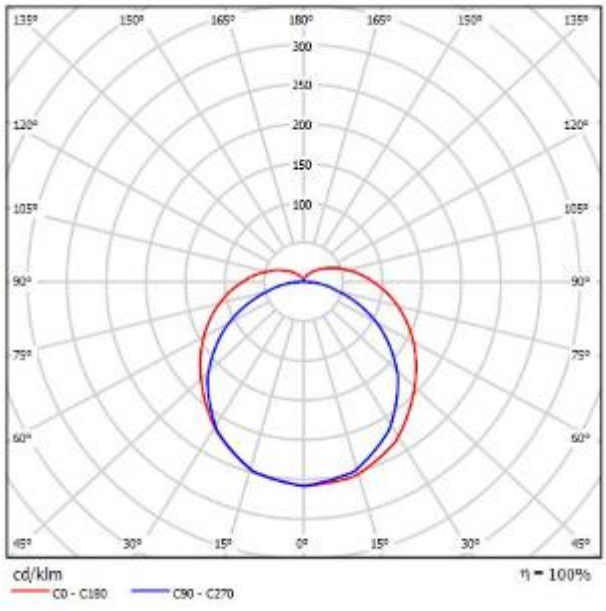



**Fig 5.28 Luminous Intensity Distribution Curve of the Luminaire**

Fig 5.28 shows the luminous intensity distribution curve of the luminaire used.

**MATERIAL SPECIFICATION:**

1. Housing : Aluminum Extruded, powder coated white finish.
2. Cove : High translucent PC.
3. Internal Wiring : FRLS-Zh
4. Mains Terminal : 3 way10 amps suitable for terminating max. 2.5 sq.mm incoming cable.
5. Earthing : 1 No. suitable for 14 SWG earthing wire.

**ELECTRICAL PARAMETERS:**

| | | |
|---|---|---|
| Rated Voltage (V) | : | 240V~ |
| Frequency (Hz) | : | 50 |
| Operating Voltage Range (V) | : | 140V~ - 270V~ |
| Current (A) @ 240V | : | 0.175 |
| Wattage (W) @240V | : | 40 |
| PF | : | >=0.95 |
| THD | : | <5% |
| On Board Surge Protection | : | 4kV |

The above luminaire has been used in **Metro Platform (Middle)** area.

**2. LED Linear Trunking Luminaire:**

Lamp: 40W LED
Ingress Protection: IP20
CCT: 5700K
Lumen output: 4400 lm
Efficacy: >110Lm/W
Length (mm): 1213
Approx. wt. (kg): 0.8

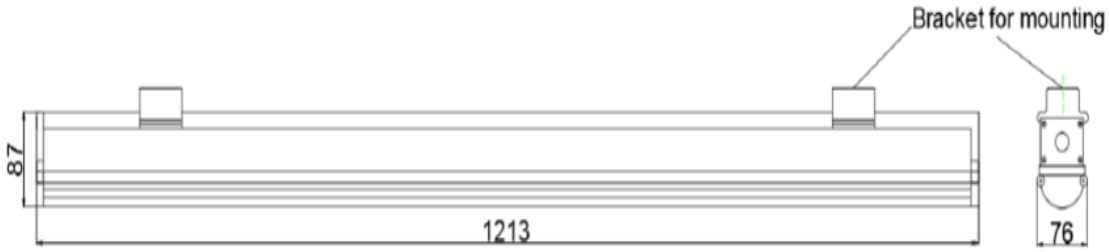



**Fig 5.29 Dimensions of the 40W LED Linear Trunking Luminaire**

In Fig. 5.29 image of the dimensions of the 40W LED Linear Trunking Luminaire has been shown.

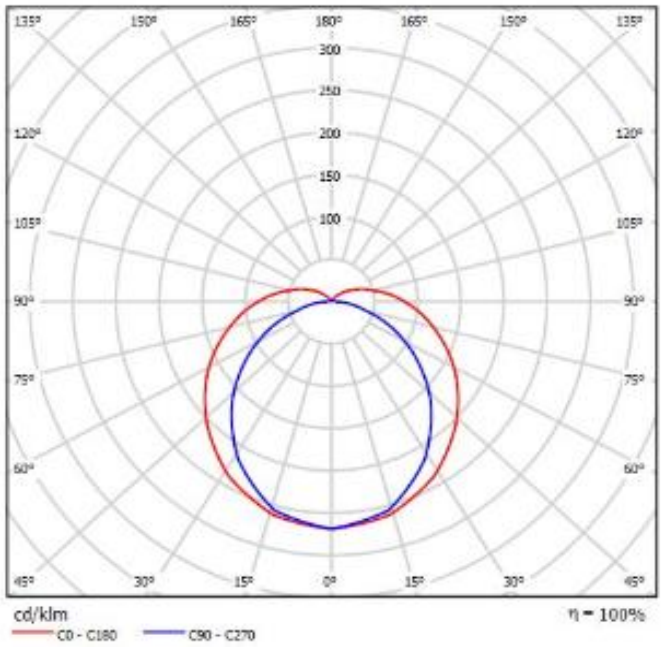



**Fig 5.30 Luminous Intensity Distribution Curve of the Luminaire**

Fig 5.30 shows the luminous intensity distribution curve of the trunking luminaire used.

| MATERIAL SPECIFICATIONS: | |
|---|---|
| Housing | Alluminum Extrusion, Housing white powder coated & Black trunk |
| Diffuser | Polycarbonate |
| Internal Wiring | 0.5sq mm FRLS-ZH wire |
| Mains Terminal | 3 way10 amps suitable for max. 2.5 sq. mm incoming cable and outgoing(LILO) |
| Earthing | No. suitable for 14 SWG earthing wire. |
| | |
| | |
| | |
| | |
| | |

**Fig 5.31 Material Specifications of the LED Trunking Luminaire used**

| ELECTRICAL PARAMETERS: | |
|---|---|
| Rated Voltage (V) | 240V |
| Frequency (Hz) | 50 |
| | |
| Operating Voltage Range (V) | 140V~ - 270V |
| Current (A) @ 240V | 0.175 |
| Wattage (W) @240V | 40 |
| P.F. | > 0.95 |
| I THD | <5% |
| On Board Surge Protection | 4KV |
| | |
| Lumen | EFFICACY : >110 Lumens/Watt |

**Fig 5.32 Electrical Parameter Details of the LED Trunking Luminaire**

The above luminaire has been used in **Metro Platform (Edge)** area.


**Fig 5.33 Real Time Image of Underground Metro Platform**

Along the platform edge in Fig. 5.33, LED linear trunking luminaire has been mounted to achieve good uniformity and standard lux level so that the commuters can safely board and alight from the train.

### c) Restroom & Toilets :

Restrooms are generally areas with false ceilings. Lighting should be done using downlighters to minimize energy consumption. LED lamps are generally chosen for their compact size, ease of installation, high efficacy along with long life and good color rendering.

**Layout & Description:**

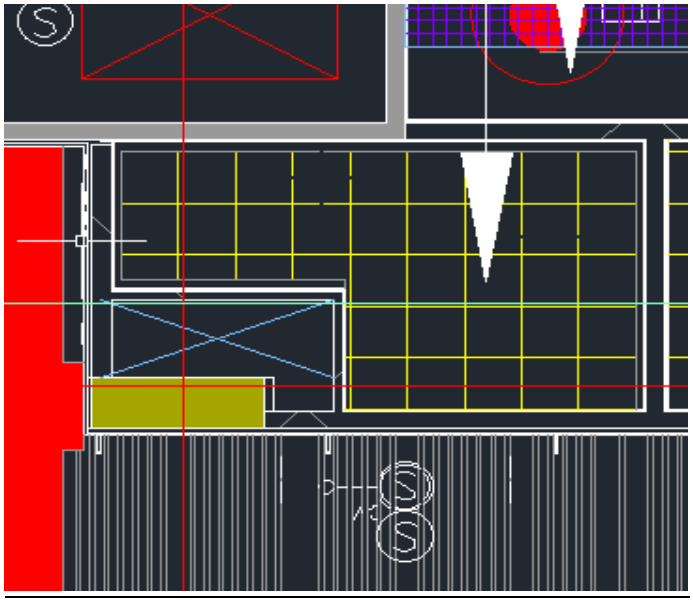


**Fig 5.34 AutoCAD layout (Floor Plan) of a typical Toilet room**

Above is the floor plan of a typical Underground Metro Toilet Room. Gypsum 2'X2' Grid Ceiling has been proposed at a ht. of 3.5m from FFL. Design as per standard has to be carried out in any simulation software for 100-150 lux. Proper lighting fixture has to be selected to illuminate this section. Generally lower wattage downlighters are used in Washroom & Toilet areas, as lux level required is not very high. So energy saving can be done as these areas are lit up for many hours of the day.

## Design Considerations:

For Restroom & Toilets Lighting Design, following are the design considerations:

- Maintenance Factor is considered as 0.8.
- Room Surface Reflectance is considered as 50% (Ceiling), 30% (Walls) and 20% (Floor).

3D Rendering of a typical Underground Metro Restroom & Toilets has been shown below:

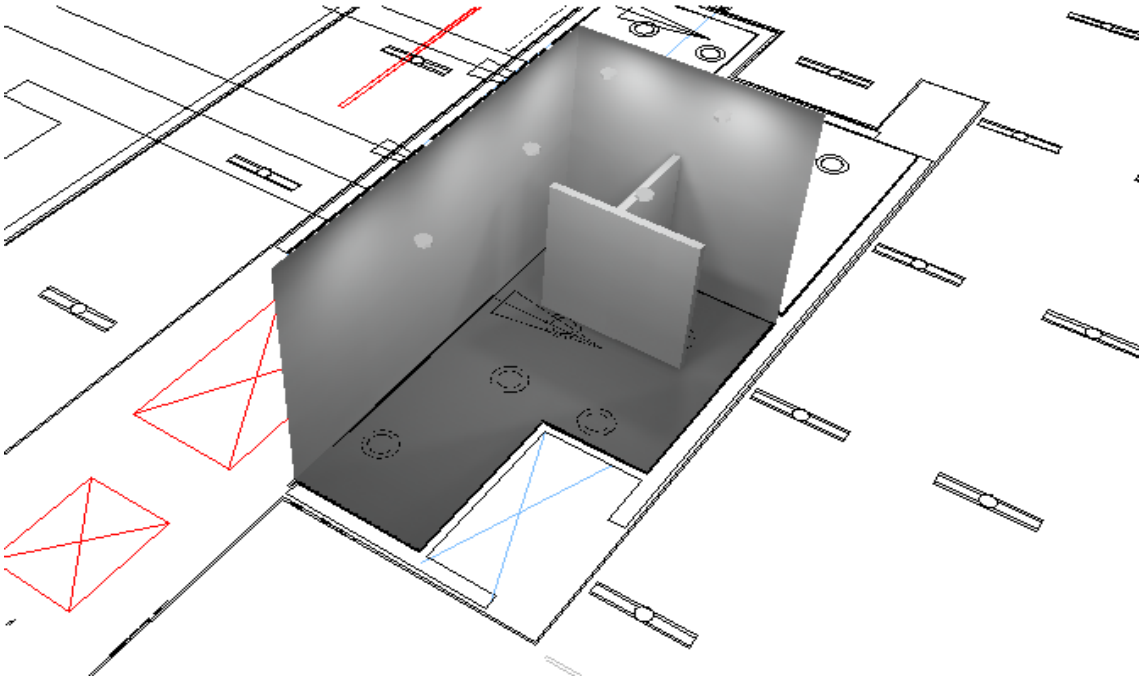


**Fig 5.35 Typical Metro Toilet 3D Rendering**

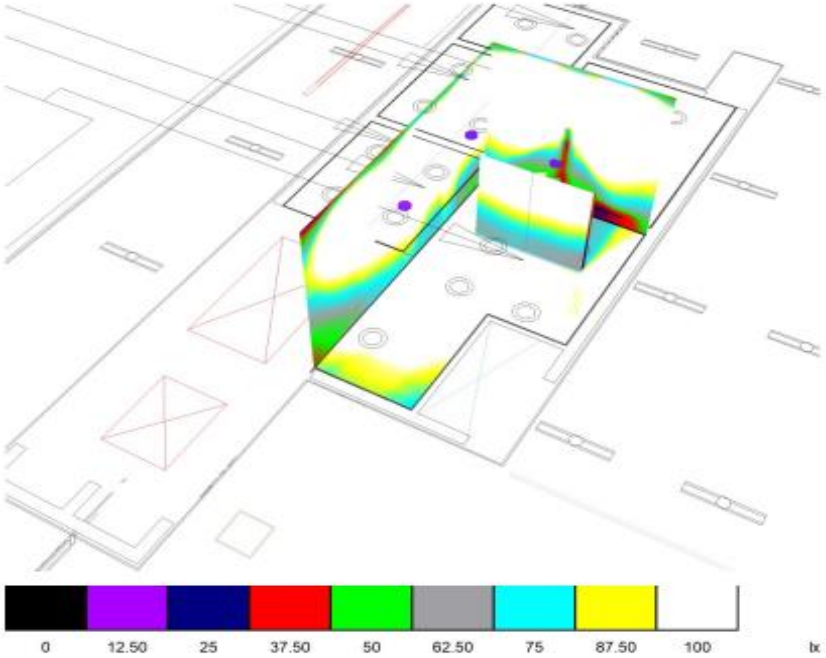
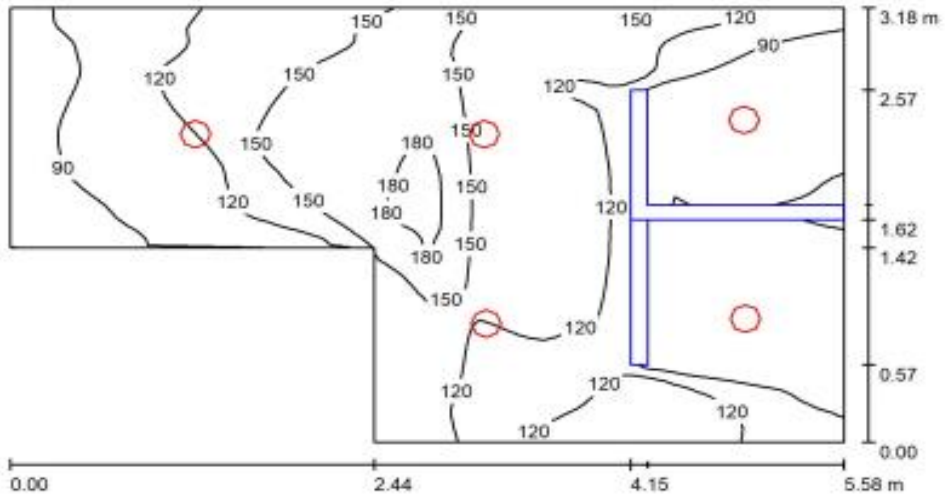



**Fig 5.36 Typical Metro Toilet False Color Rendering**

The above simulation has been carried out in DIALux 4.13.As per the required standard, lighting design has been carried out for average 100-150 lux. Low wattage and glare free downlighters has been used in this area.




Height of Room: 3.500 m, Mounting Height: 3.500 m, Light loss factor: 0.80 — Values in Lux, Scale 1:41

| Surface | ρ [%] | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 |
|---|---|---|---|---|---|
| Workplane | / | 115 | 47 | 188 | 0.413 |
| Floor | 20 | 111 | 11 | 186 | 0.102 |
| Ceiling | 50 | 46 | 26 | 234 | 0.568 |
| Walls (6) | 30 | 127 | 19 | 432 | / |

**Workplane:**
Height: 0.000 m
Grid: 64 x 64 Points
Boundary Zone: 0.000 m
Illuminance Quotient (according to LG7): Walls / Working Plane: 1.110, Ceiling / Working Plane: 0.400.

**Fig 5.37 Typical Metro Toilet DIALux Summary**

Fig 5.37 shows the DIALux 4.13 summary of a typical metro toilet. Design has been carried out for avg. 100-150 lux.18W Downlight has been used to achieve the std. value.

## Technical Details Of Luminaires used:

1. **LED Recessed Circular Downlight:**

   Lamp: 18W LED
   Ingress Protection: IP20
   CCT: 5700K
   Lumen output: 2005 lm
   Efficacy: >100Lm/W
   Approx. Weight (kg): 0.260

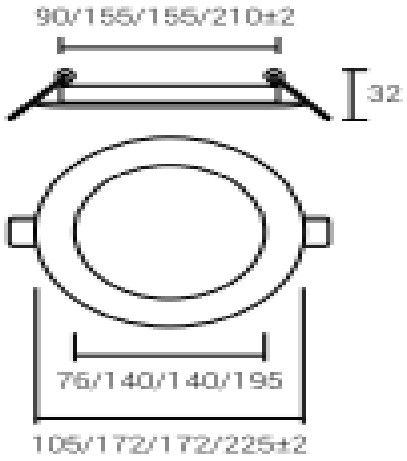



**Fig 5.38 Dimensions of the 18W LED Circular Downlight**

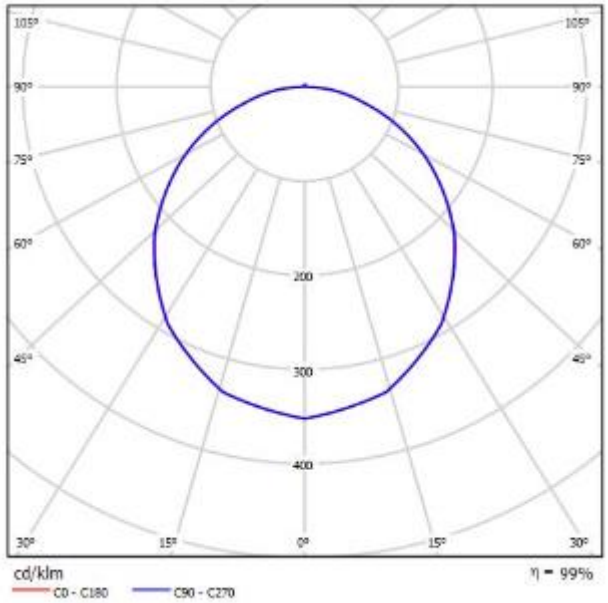



**Fig 5.39 Luminous Intensity Distribution Curve of the Luminaire**

In Fig. 5.38 image of the dimensions of the 18W LED Recessed Circular Downlight has been shown. And in Fig. 5.39 image of the Luminous Intensity Distribution Curve of the Luminaire has been shown.

**MATERIAL SPECIFICATION:**

1. Housing : Die cast in thermally conductive material, finished in white powder coating.
2. Diffuser : Polycarbonate.
3. Internal Wiring : FRLS-Zh Wire

4. Mounting clamps : Spring steel with White clip.
5. External Cable : FRLS-Zh Cable.

**ELECTRICAL PARAMETERS:**

| | | |
|---|---|---|
| Rated Voltage (V) | : | 240V~ |
| Frequency (Hz) | : | 50 |
| Operating Voltage Range (V) | : | 140V~ - 270V~ |
| Current (A) @ 240V | : | 0.078 |
| Wattage (W) @240V | : | 18 |
| PF | : | >=0.95 |
| THD | : | <5% |
| On Board Surge Protection | : | 4kV |

The above luminaire has been used in **Metro Washroom & Toilet** areas.

## 5.7 Lighting Design of Non-Public Areas:

1. **Back-Of-House (BOH) Areas:**
   Back-Of-House Area also known as **BOH** is a term used for all the behind-the-scene actions that passengers typically do not see. BOH areas in Metro Station include areas like Station Control Rooms, Signal Room, Store Room, AHU Room, Battery Room, Pantry, and Tunnel Ventilation Fan Room etc.

### 1.1 Tunnel Ventilation Fan Room

This room is essential part for metro tunnel ventilation. It consists of huge ventilation equipment essential for keeping metro tunnels ventilated round the clock.

**Layout & Description:**

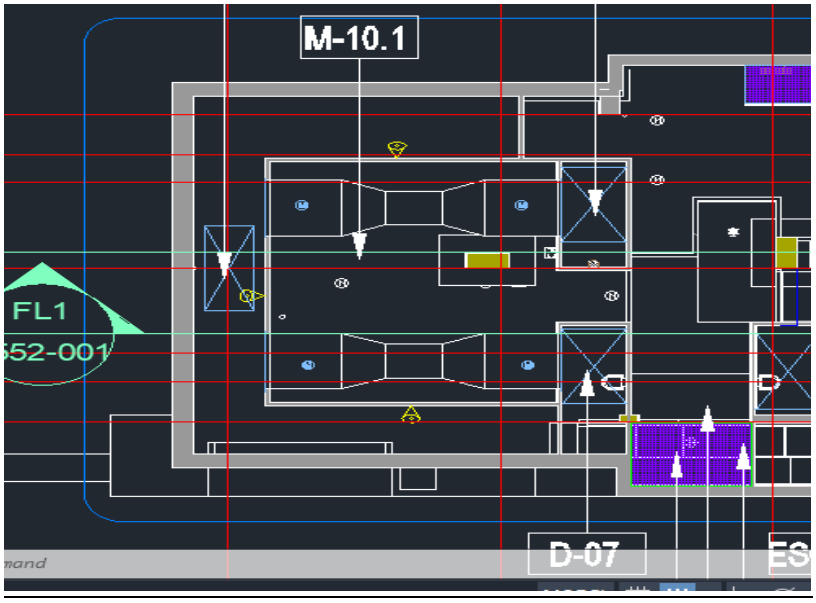



**Fig 5.40 AutoCAD layout (Floor Plan) of Tunnel Ventilation Fan Room (M-10.1)**

Above is the floor plan of a typical Underground Metro Tunnel Ventilation Fan Room (M-10.1). Ht. of the room is 5.5m as given. Lighting Design should be carried out for avg. 150-200lx.Usually integrated type battens are preferred in such areas.

**Design Considerations:**

For Tunnel Ventilation Fan Room Design, following are the design considerations:

- Maintenance Factor is considered as 0.8.
- Room Surface Reflectance is considered as 50% (Ceiling), 30% (Walls) and 20% (Floor).

3D Rendering of a typical Metro Tunnel Ventilation Room has been shown below:

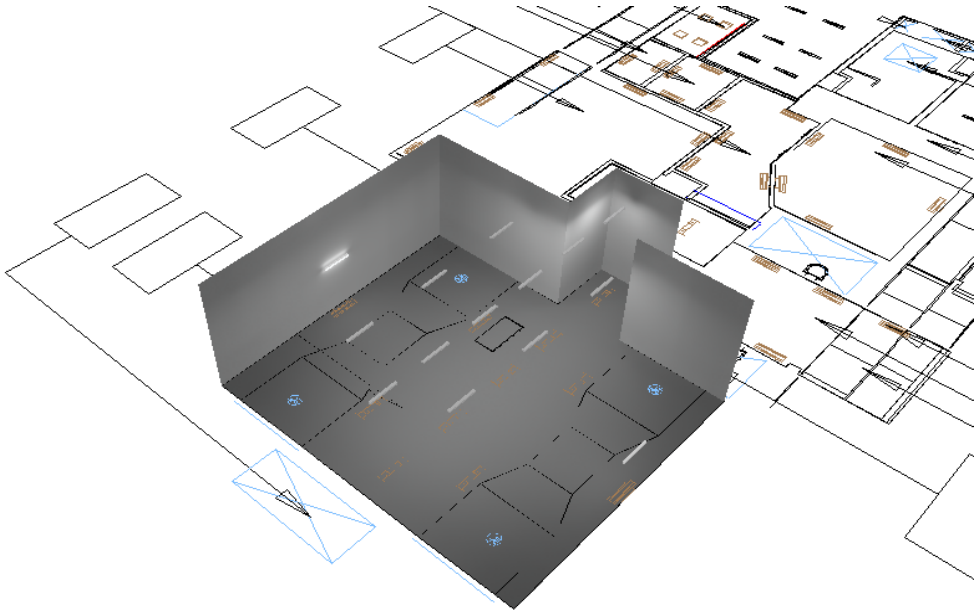


**Fig 5.41 Typical Tunnel Ventilation Fan Room 3D Rendering**

The above simulation has been carried out in DIALux 4.13.As per the required standard, lighting design has been carried out for average 150-200 lux. LED Integrated type Batten has been used to illuminate this area. Battens are wall mounted at a ht. of 2.5m from FFL and they are also suspended from the ceiling by 1m.Lighting Designer has to take care of the presence of the equipment while designing. Illumination should be done in such a manner that no lighting fixture should be mounted directly above the obstruction. This should be avoided because light won't be uniformly distributed in the room and dark patches will be created which is not desirable.

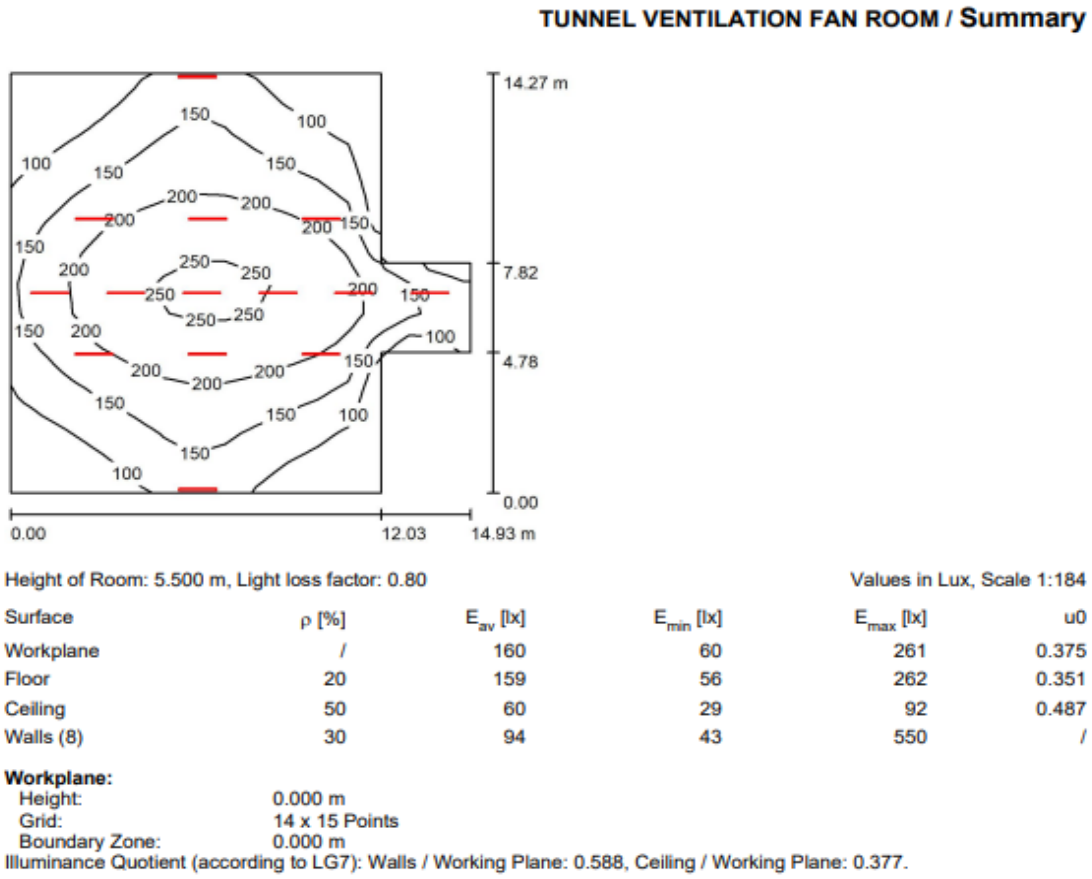



**Fig 5.42 Typical Metro Tunnel Ventilation Room DIALux Summary**

Fig 5.42 shows the DIALux 4.13 summary of a typical Metro Tunnel Ventilation Room. Design has been carried out for avg. 150-200 lux.40W Integrated type batten has been used to illuminate the area.

## Technical Details Of Luminaires used:

1. **LED Integrated Batten**

   Lamp: 40W LED
   Ingress Protection: IP20
   CCT: 5700K
   Lumen output: 4409 lm
   Efficacy: >110Lm/W
   Length (mm): 1207
   Approx. wt. (kg): 0.8

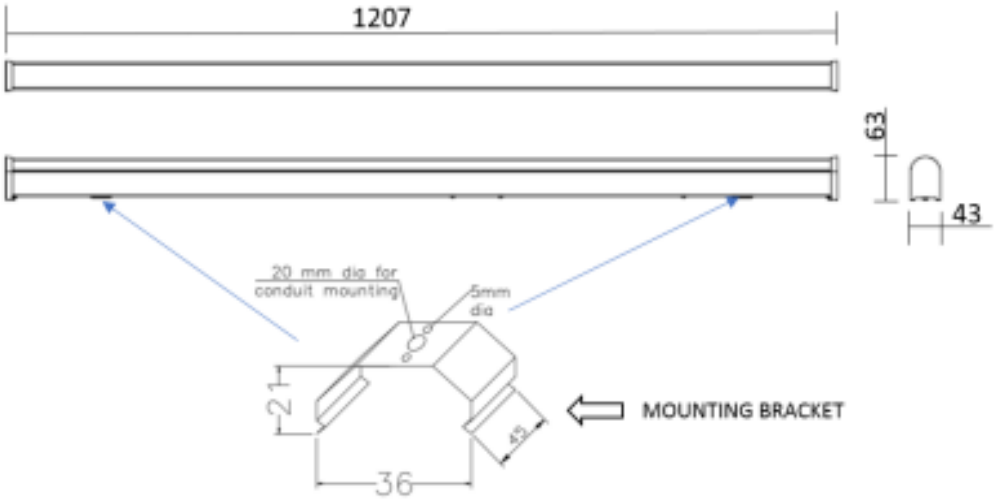



**Fig 5.43 Dimensions of the 40 W LED Integrated Batten**

In Fig. 5.43 image of the dimensions of the 40W LED Integrated Batten has been shown.

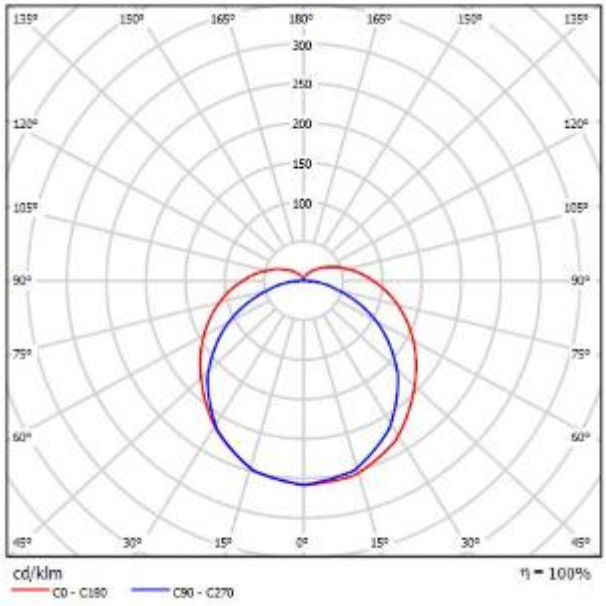



**Fig 5.44 Luminous Intensity Distribution Curve of the Luminaire**

Fig 5.44 shows the luminous intensity distribution curve of the luminaire used.

**MATERIAL SPECIFICATION:**

1. Housing : Aluminum Extruded, powder coated white finish.
2. Cove : High translucent PC.
3. Internal Wiring : FRLS-Zh
4. Mains Terminal : 3 way10 amps suitable for terminating max. 2.5 sq.mm incoming cable.
5. Earthing : 1 No. suitable for 14 SWG earthing wire.

**ELECTRICAL PARAMETERS:**

| | | |
|---|---|---|
| Rated Voltage (V) | : | 240V~ |
| Frequency (Hz) | : | 50 |
| Operating Voltage Range (V) | : | 140V~ - 270V~ |
| Current (A) @ 240V | : | 0.175 |
| Wattage (W) @240V | : | 40 |
| PF | : | >=0.95 |
| THD | : | <5% |
| On Board Surge Protection | : | 4kV |

**1.2 Station AHU Room :**

In many buildings, there is central Air conditioning system. That means instead of individual A.C's or heating equipment in different rooms, there is one single large machine that does conditioning for whole building. Mostly in case of large commercial buildings like Malls, Hotels, Metro Stations etc., these are called A.C Plants, and are housed in Basements. These Air handling units are machines that control air conditioning of various floors or various areas. The room made for these machines is an AHU room.

**Layout & Description:**

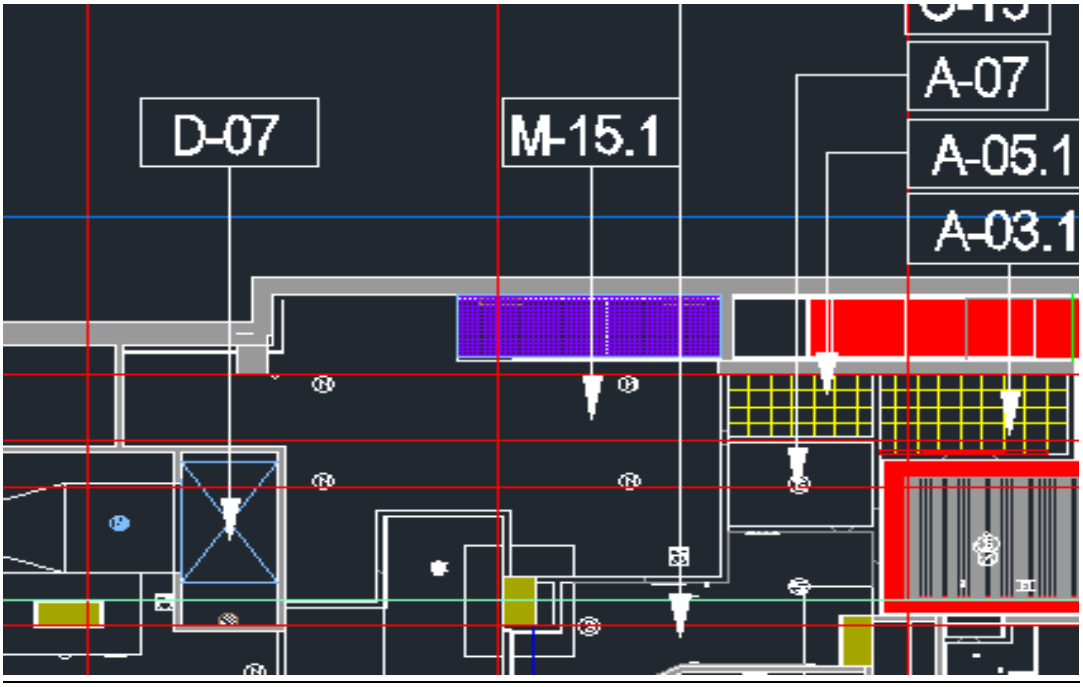



**Fig 5.45 AutoCAD layout (Floor Plan) of Station AHU Room (M-15.1)**

Above is the floor plan of a typical Metro Station AHU Room (M-15.1). Ht. of the room is 5.5m as given. Lighting Design should be carried out for avg. 150-200lx.Usually integrated type battens are preferred in such areas.

## Design Considerations:

For Station AHU Room Design, following are the design considerations:

- Maintenance Factor is considered as 0.8.
- Room Surface Reflectance is considered as 50% (Ceiling), 30% (Walls) and 20% (Floor).

3D Rendering of a typical Metro Station AHU Room has been shown below:

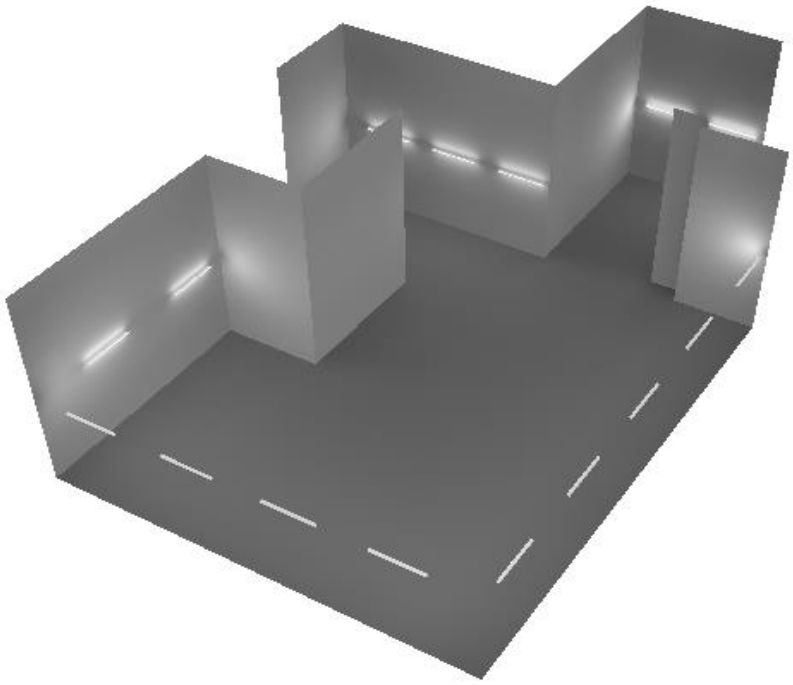


**Fig 5.46 Typical Station AHU Room 3D Rendering**

The above simulation has been carried out in DIALux 4.13.As per the required standard, lighting design has been carried out for average 150-200 lux. LED Integrated type Batten has been used to illuminate this area. Battens are wall mounted at a ht. of 2.5m from FFL. Lighting Designer has to take care of the presence of the equipment while designing. Illumination should be done in such a manner that no lighting fixture should be mounted directly above the obstruction. So in AHU rooms it is always preferable to wall mount the fixtures in all the directions.

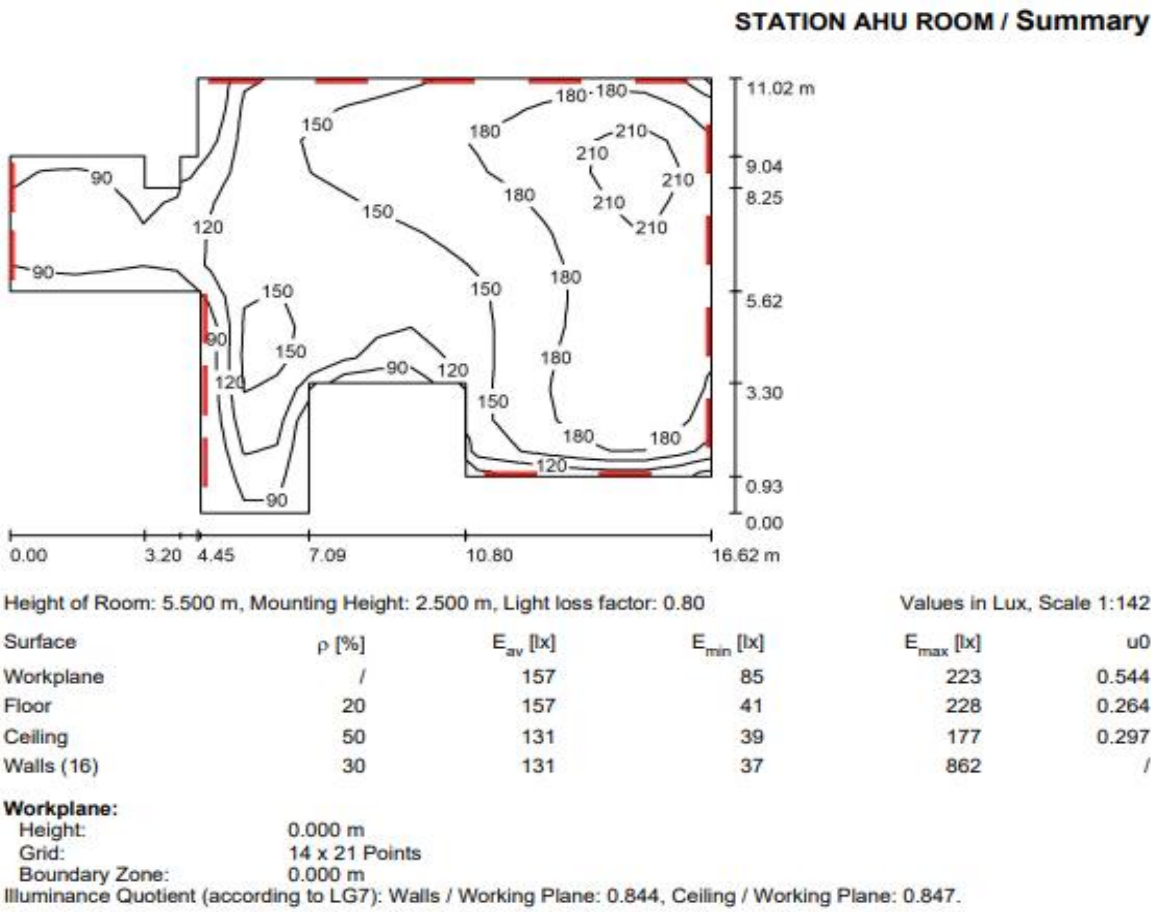



**Fig 5.47 Typical Metro Station AHU Room DIALux Summary**

Fig 5.47 shows the DIALux 4.13 summary of a typical Metro Station AHU Room. Design has been carried out for avg. 150-200 lux.40W Integrated type batten has been used to illuminate the area.

## Technical Details of Luminaires used:

1. **LED Integrated Batten**

   Lamp: 40W LED
   Ingress Protection: IP20
   CCT: 5700K
   Lumen output: 4409 lm
   Efficacy: >110Lm/W
   Length (mm): 1207
   Approx. wt. (kg): 0.8

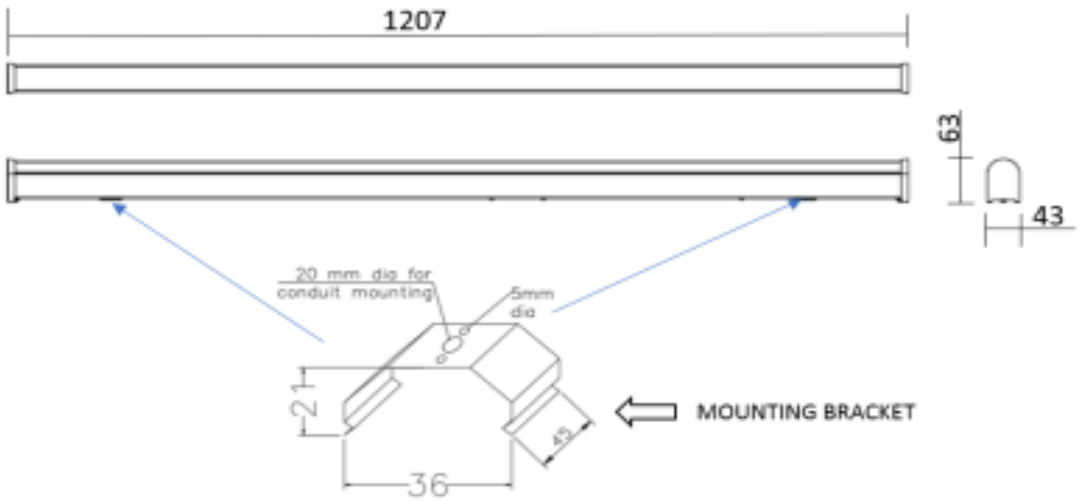



**Fig 5.48 Dimensions of the 40 W LED Integrated Batten**

In Fig. 5.48 image of the dimensions of the 40W LED Integrated Batten has been shown.

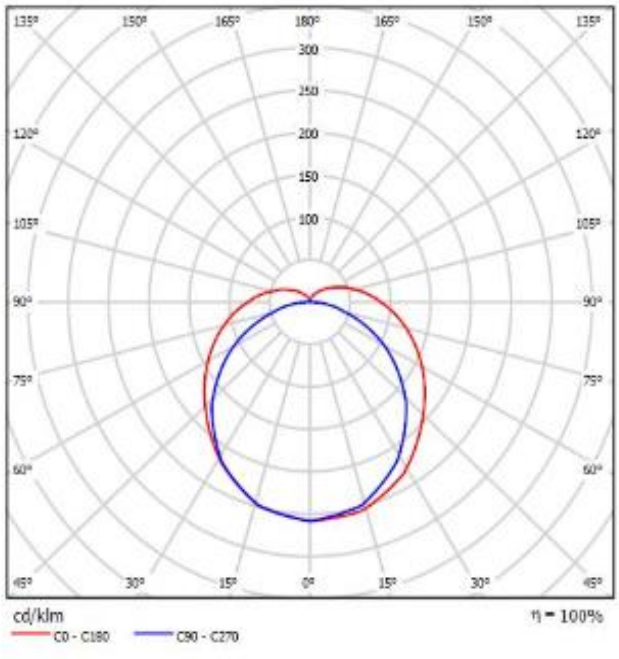



**Fig 5.49 Luminous Intensity Distribution Curve of the Luminaire**

Fig 5.49 shows the luminous intensity distribution curve of the luminaire used.

**MATERIAL SPECIFICATION:**

1. Housing : Aluminum Extruded, powder coated white finish.
2. Cove : High translucent PC.
3. Internal Wiring : FRLS-Zh
4. Mains Terminal : 3 way10 amps suitable for terminating max. 2.5 sq.mm incoming cable.
5. Earthing : 1 No. suitable for 14 SWG earthing wire.

**ELECTRICAL PARAMETERS:**

| | | |
|---|---|---|
| Rated Voltage (V) | : | 240V~ |
| Frequency (Hz) | : | 50 |
| Operating Voltage Range (V) | : | 140V~ - 270V~ |
| Current (A) @ 240V | : | 0.175 |
| Wattage (W) @240V | : | 40 |
| PF | : | >=0.95 |
| THD | : | <5% |
| On Board Surge Protection | : | 4kV |

**1.3 TVS Room Switchgear :**

It is one of the non-public access areas in a Metro Station. The room comprises of switchgear and control panels. Lighting Designer has to keep in mind the presence of panels where vertical illumination is required.

**Layout & Description:**

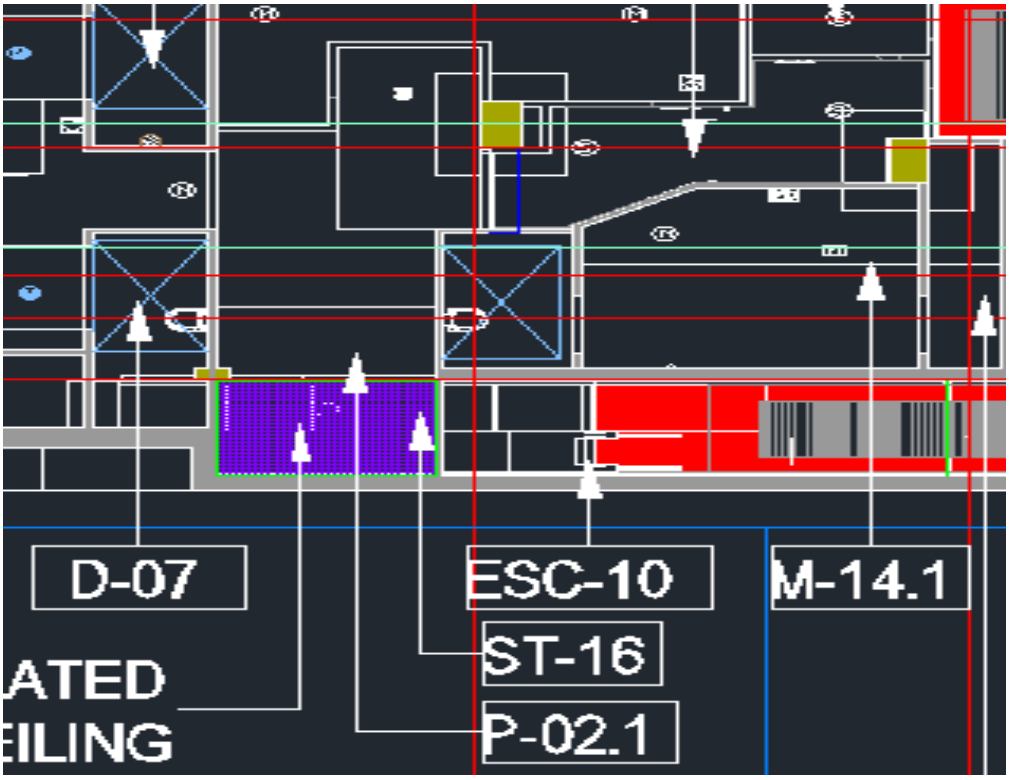



**Fig 5.50 AutoCAD layout (Floor Plan) of TVS Switchgear Room (P-02.1)**

Above is the floor plan of a typical Metro Station TVS Switchgear Room (P-02.1). Ht. of the room is 5.5m as given. Lighting Design should be carried out for avg. 200-250lx.Usually integrated type battens are preferred in such areas.

## Design Considerations:

For TVS Switchgear Room Design, following are the design considerations:

- Maintenance Factor is considered as 0.8.
- Room Surface Reflectance is considered as 50% (Ceiling), 30% (Walls) and 20% (Floor).

3D Rendering of a typical Metro Station TVS Switchgear Room has been shown below:

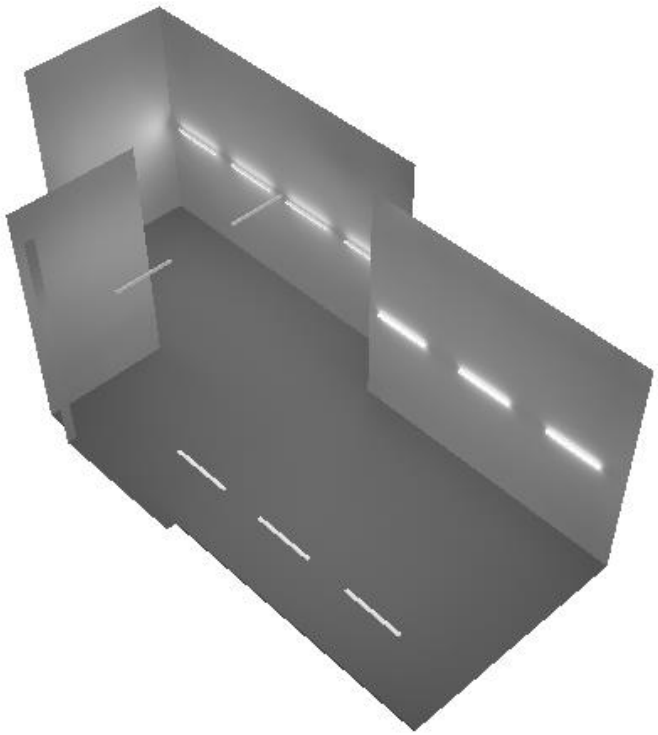
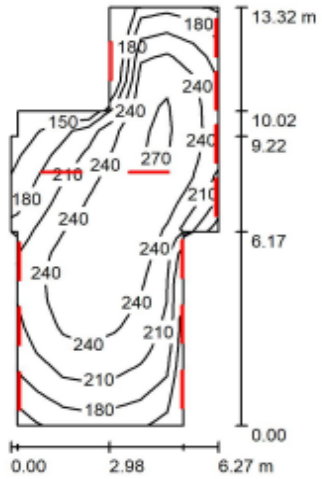


**Fig 5.51 Typical TVS Switchgear Room 3D Rendering**

The above simulation has been carried out in DIALux 4.13.As per the required standard, lighting design has been carried out for average 200-250 lux. LED Integrated type Batten has been used to illuminate this area. Battens are wall mounted at a ht. of 2.5m from FFL and also suspended from ceiling by 1m. Illumination should be done in such a manner that no lighting fixture should be mounted directly above the obstruction. So in TVS Switchgear rooms it is always preferable to wall mount the fixtures in all the directions.

**TVS ROOM SWITCHGEAR / Summary**




Height of Room: 5.500 m, Light loss factor: 0.80 — Values in Lux, Scale 1:172

| Surface | ρ [%] | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 |
|---|---|---|---|---|---|
| Workplane | / | 223 | 132 | 278 | 0.591 |
| Floor | 20 | 223 | 130 | 281 | 0.585 |
| Ceiling | 50 | 169 | 88 | 214 | 0.522 |
| Walls (12) | 30 | 188 | 77 | 1581 | / |

**Workplane:**
Height: 0.000 m
Grid: 17 x 8 Points
Boundary Zone: 0.000 m
Illuminance Quotient (according to LG7): Walls / Working Plane: 0.849, Ceiling / Working Plane: 0.759.

**Fig 5.52 Typical Metro Station TVS Switchgear Room DIALux Summary**

Fig 5.52 shows the DIALux 4.13 summary of a typical Metro Station TVS Switchgear Room. Design has been carried out for avg. 200-250 lux.40W Integrated type batten has been used to illuminate the area.

## Technical Details of Luminaires used:

1. **LED Integrated Batten**

   Lamp: 40W LED
   Ingress Protection: IP20
   CCT: 5700K
   Lumen output: 4409 lm
   Efficacy: >110Lm/W
   Length (mm): 1207
   Approx. wt. (kg): 0.8

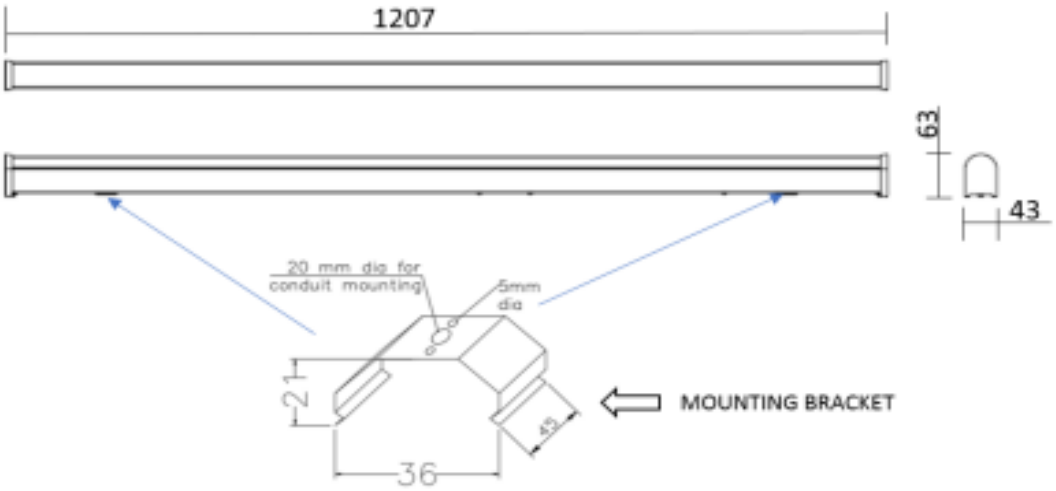



**Fig 5.53 Dimensions of the 40 W LED Integrated Batten**

In Fig. 5.53 image of the dimensions of the 40W LED Integrated Batten has been shown.

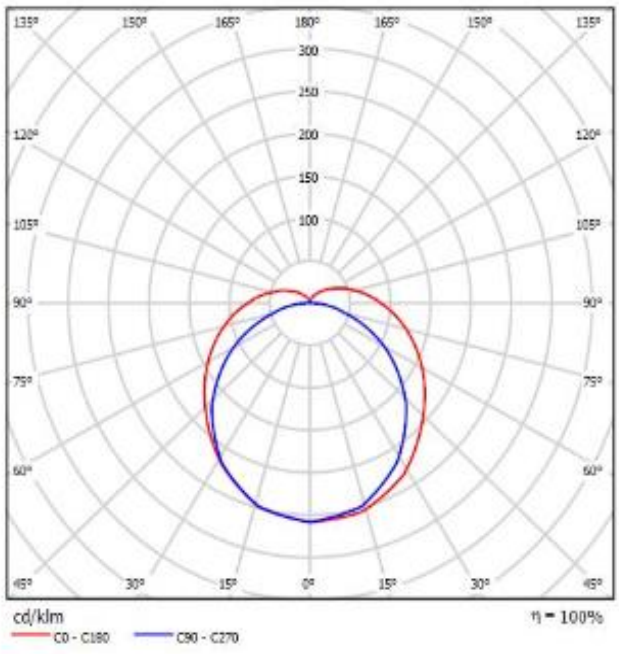



**Fig 5.54 Luminous Intensity Distribution Curve of the Luminaire**

Fig 5.54 shows the luminous intensity distribution curve of the luminaire used.

**MATERIAL SPECIFICATION:**

1. Housing : Aluminum Extruded, powder coated white finish.
2. Cove : High translucent PC.
3. Internal Wiring : FRLS-Zh
4. Mains Terminal : 3 way10 amps suitable for terminating max. 2.5 sq.mm incoming cable.
5. Earthing : 1 No. suitable for 14 SWG earthing wire.

**ELECTRICAL PARAMETERS:**

| | | |
|---|---|---|
| Rated Voltage (V) | : | 240V~ |
| Frequency (Hz) | : | 50 |
| Operating Voltage Range (V) | : | 140V~ - 270V~ |
| Current (A) @ 240V | : | 0.175 |
| Wattage (W) @240V | : | 40 |
| PF | : | >=0.95 |
| THD | : | <5% |
| On Board Surge Protection | : | 4kV |

### 1.4 Audit & Cash Store Room :

It is one of the non-public access areas in a Metro Station. It is the financial storage area of the metro station. Auditing and accounting activities takes place here. So, a visual comfortable environment is desirable in this area.

**Layout & Description:**

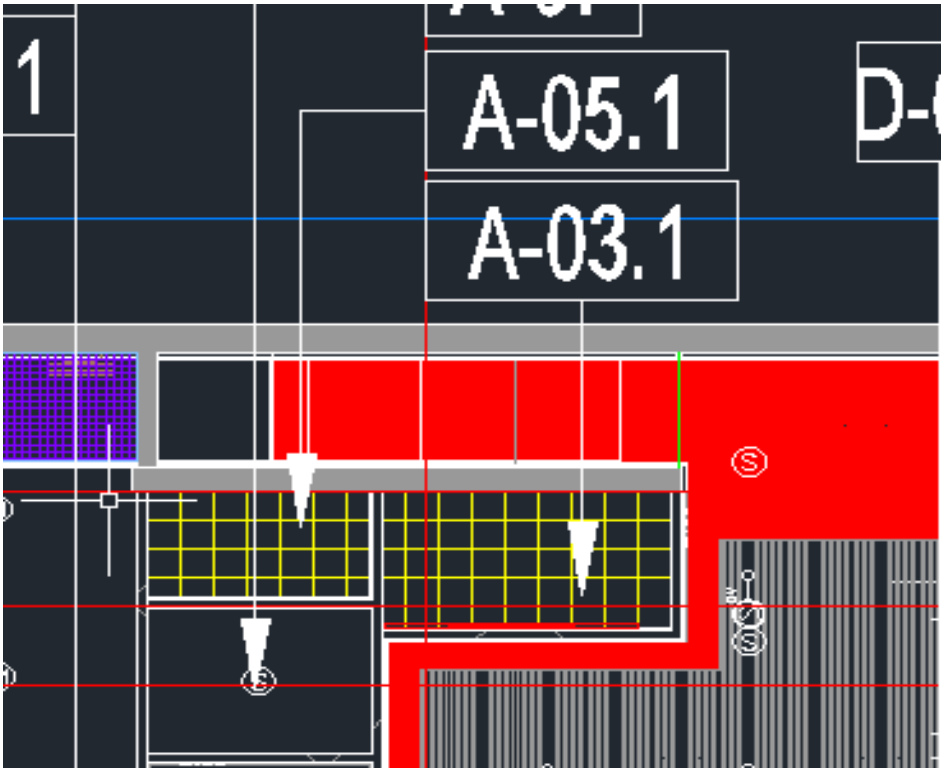



**Fig 5.55 AutoCAD layout (Floor Plan) of Audit & Cash Store Room (A-05.1)**

Above is the floor plan of a typical Metro Station Audit & Cash Store Room (A-05.1). Ht. of the room is 3.5m as given.2'X2' Grid False ceiling has been proposed. Lighting Design should be carried out for avg. 200-250lx. For achieving this lux level, it is preferable to use 2'X2' Recessed type fitting.

## Design Considerations:

For Audit & Cash Store Room Design, following are the design considerations:

- Maintenance Factor is considered as 0.8.
- Room Surface Reflectance is considered as 50% (Ceiling), 30% (Walls) and 20% (Floor).

3D Rendering of a typical Metro Station Audit & Cash Store Room has been Shown below:

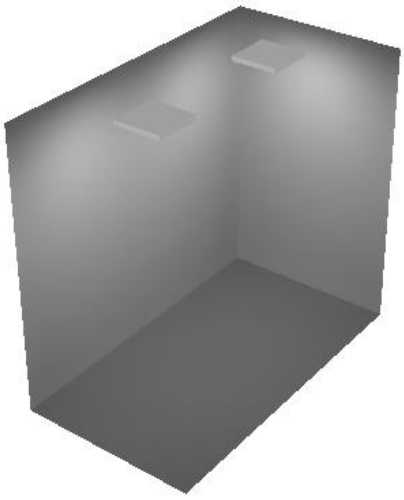
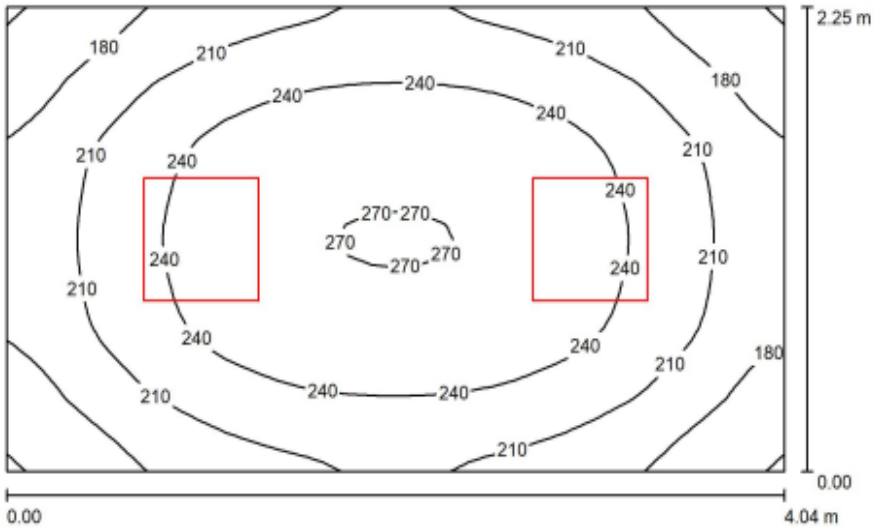


**Fig 5.56 Typical Audit & Cash Store Room 3D Rendering**

The above simulation has been carried out in DIALux 4.13.As per the required standard, lighting design has been carried out for average 200-250 lux. LED Recessed 2'X2' Tile 36W luminaire has been used to illuminate this area. Using this type of luminaire will reduce glare and will create a visually soothing environment.

**AUDIT & CASH STORE ROOM / Summary**




Height of Room: 3.500 m, Mounting Height: 3.500 m, Light loss factor: 0.80 — Values in Lux, Scale 1:29

| Surface | ρ [%] | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 |
|---|---|---|---|---|---|
| Workplane | / | 223 | 149 | 271 | 0.668 |
| Floor | 20 | 164 | 125 | 192 | 0.760 |
| Ceiling | 50 | 51 | 37 | 89 | 0.722 |
| Walls (4) | 30 | 156 | 39 | 369 | / |

**Workplane:**
Height: 0.760 m
Grid: 32 x 32 Points
Boundary Zone: 0.000 m
Illuminance Quotient (according to LG7): Walls / Working Plane: 0.801, Ceiling / Working Plane: 0.231.

**Fig 5.57 Typical Metro Station Audit & Cash Store Room DIALux Summary**

Fig 5.57 shows the DIALux 4.13 summary of a typical Metro Station Audit & Cash Store Room. Design has been carried out for avg. 200-250 lux.36W Recessed 2'X2' Tile luminaires have been used to illuminate the area.

## Technical Details of Luminaires used:

### 1. LED Recessed 2'X2' Tile Luminaire

Lamp: 36W LED
Ingress Protection: IP20
CCT: 5700K
Lumen output: 3946 lm
Efficacy: >100Lm/W
Dimension (mm): 600X600
Approx. wt. (kg): 3.1

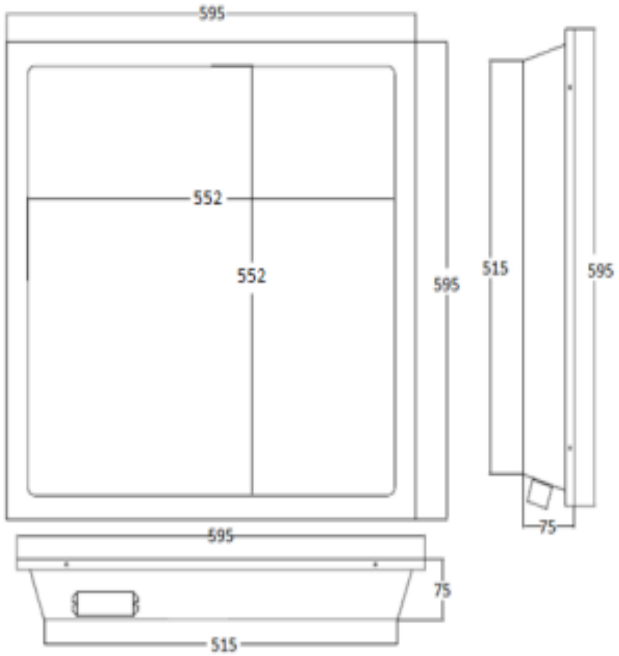



**Fig 5.58 Dimensions of the 36 W LED Recessed 2'X2' Tile Luminaire**

In Fig. 5.58 image of the dimensions of the 36W LED Recessed 2'X2' Tile Luminaire has been shown.

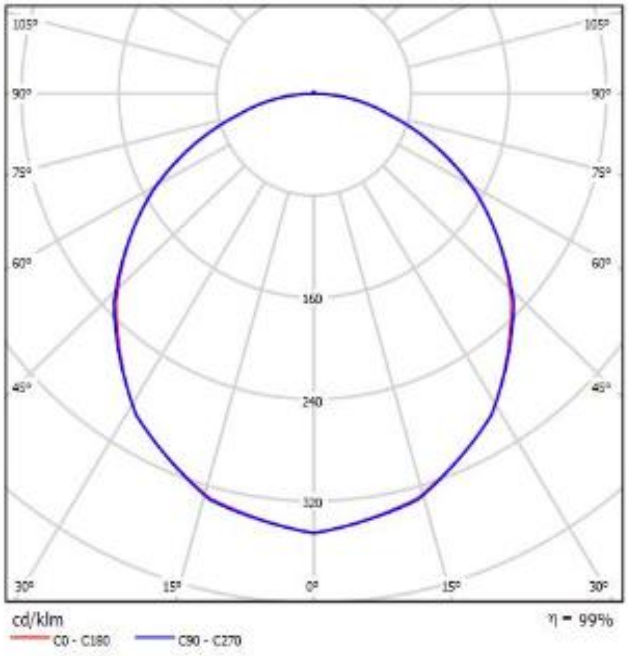



**Fig 5.59 Luminous Intensity Distribution Curve of the Luminaire**

Fig 5.59 shows the luminous intensity distribution curve of the luminaire used.

**MATERIAL SPECIFICATION:**

1. Housing : CRCA, White powder coated
2. Frame : CRCA, White powder coated
3. Diffuser : Polycarbonate
4. Internal Wiring : FRLS-Zh Wire
5. Mains Terminal : 3 Way 10 Amps
6. External Cable : FRLS-Zh Cable

**ELECTRICAL PARAMETERS:**

| | | |
|---|---|---|
| Rated Voltage (V) | : | 240V~ |
| Frequency (Hz) | : | 50 |
| Operating Voltage Range (V) | : | 140V~ - 270V~ |
| Current (A) @ 240V | : | 0.142-0.172 |
| Wattage (W) @240V | : | 36 |
| PF | : | >=0.95 |
| THD | : | <5% |
| Lumen | : | >3600 |
| Surge | : | 4kV |

### 1.5 Station Control Room :

The Station Control Room manages the traffic and is responsible for continuously informing passengers and other metro staff about the operation. The control room is manned 24 hours a day, all year round. It is one of the non-public access areas in a Metro Station. This area has to be illuminated in such a manner that it provides a visually comfortable and glare free environment so the working personnel can perform his/her duty comfortably without stress.

**Layout & Description:**

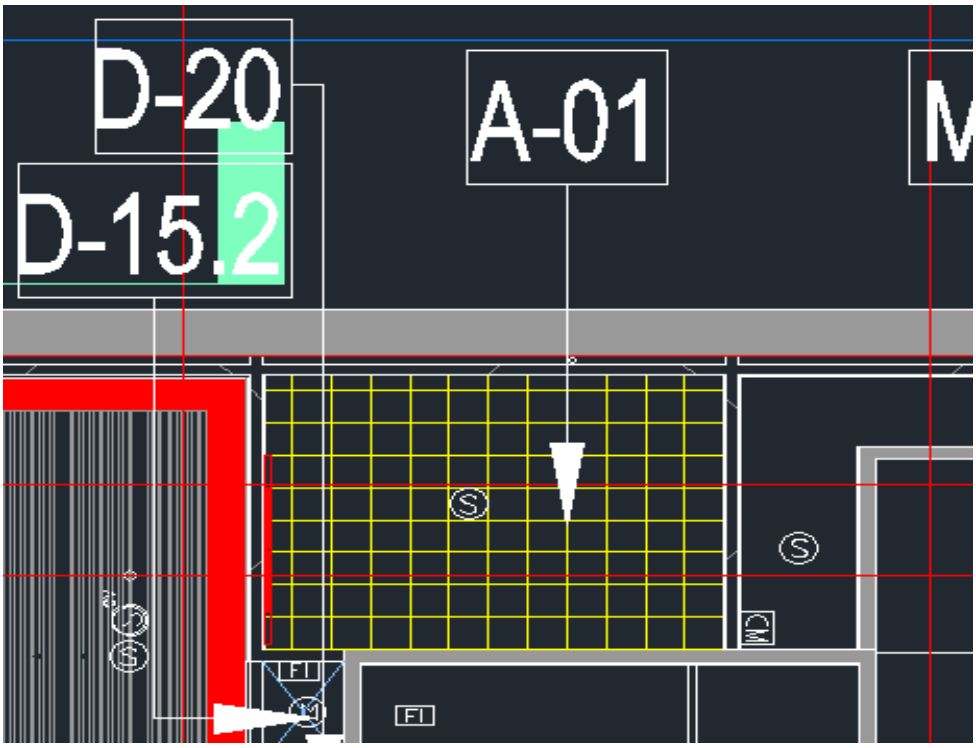



**Fig 5.60 AutoCAD layout (Floor Plan) of Station Control Room (A-01)**

Above is the floor plan of a typical Metro Station Control Room (A-01). Ht. of the room is 3.5m as given.2'X2' Grid False ceiling has been proposed. Lighting Design should be carried out for avg. 300-500lx. For achieving this lux level, it is preferable to use 2'X2' Recessed type fitting.

**Design Considerations:**

For Station Control Room Design, following are the design considerations:

- Maintenance Factor is considered as 0.8.
- Room Surface Reflectance is considered as 50% (Ceiling), 30% (Walls) and 20% (Floor).

3D Rendering of a typical Metro Station Control Room has been Shown below:

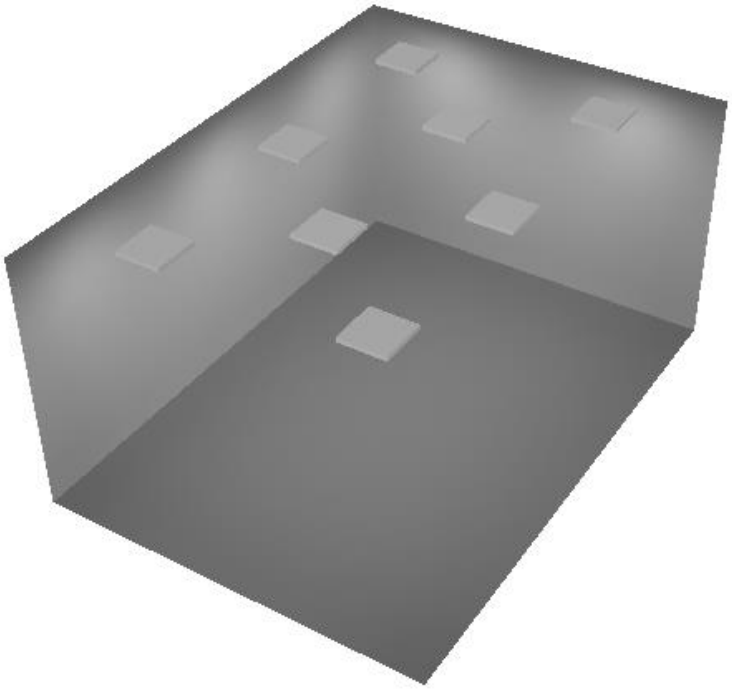
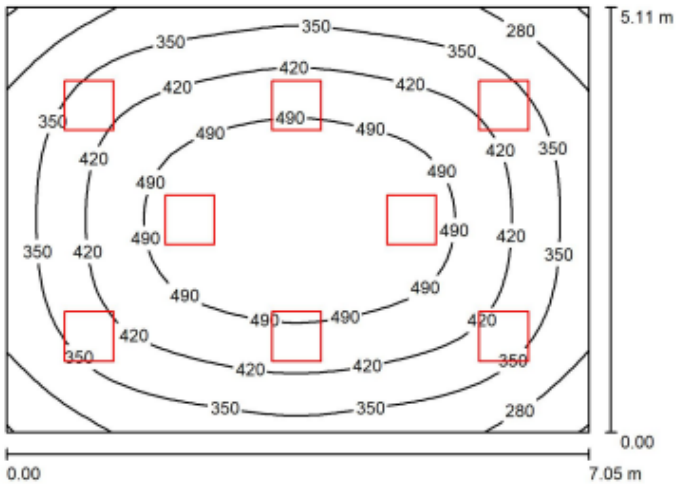


**Fig 5.61 Typical Metro Station Control Room 3D Rendering**

The above simulation has been carried out in DIALux 4.13.As per the required standard, lighting design has been carried out for average 300-500 lux. LED Recessed 2'X2' Tile 36W luminaire has been used to illuminate this area. Using this type of luminaire will reduce glare and will create a visually soothing environment for the staff to work.

**STATION CONTROL ROOM / Summary**




Height of Room: 3.500 m, Mounting Height: 3.500 m, Light loss factor: 0.80 — Values in Lux, Scale 1:66

| Surface | ρ [%] | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 |
|---|---|---|---|---|---|
| Workplane | / | 406 | 209 | 547 | 0.514 |
| Floor | 20 | 341 | 216 | 442 | 0.633 |
| Ceiling | 50 | 72 | 54 | 111 | 0.750 |
| Walls (4) | 30 | 232 | 60 | 422 | / |

**Workplane:**
Height: 0.760 m
Grid: 32 x 32 Points
Boundary Zone: 0.000 m
Illuminance Quotient (according to LG7): Walls / Working Plane: 0.605, Ceiling / Working Plane: 0.177.

**Fig 5.62 Typical Metro Station Control Room DIALux Summary**

Fig 5.62 shows the DIALux 4.13 summary of a typical Metro Station Control Room. Design has been carried out for avg. 300-500 lux.36W Recessed 2'X2' Tile luminaires have been used to illuminate the area, thus giving a visually comfortable and glare free environment.

## Technical Details of Luminaires used:

1. **LED Recessed 2'X2' Tile Luminaire**

   Lamp: 36W LED
   Ingress Protection: IP20
   CCT: 5700K
   Lumen output: 3946 lm
   Efficacy: >100Lm/W
   Dimension (mm): 600X600
   Approx. wt. (kg): 3.1

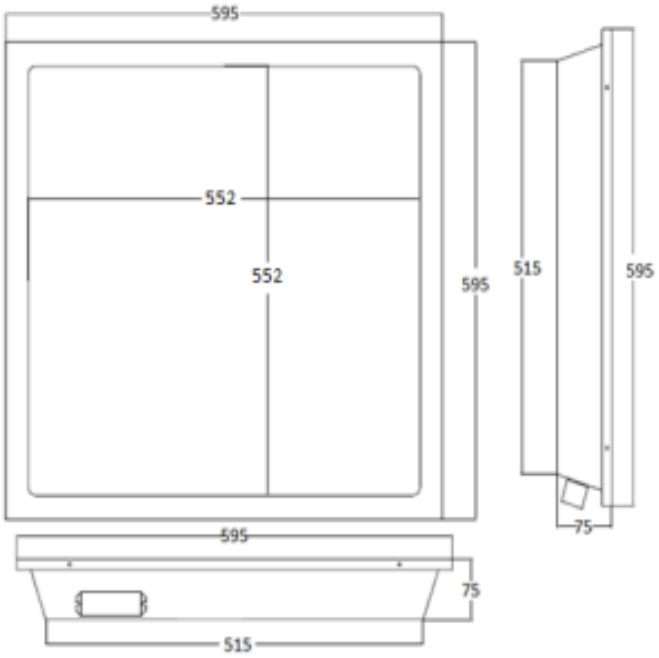



**Fig 5.63 Dimensions of the 36 W LED Recessed 2'X2' Tile Luminaire**

In Fig. 5.63 image of the dimensions of the 36W LED Recessed 2'X2' Tile Luminaire has been shown.

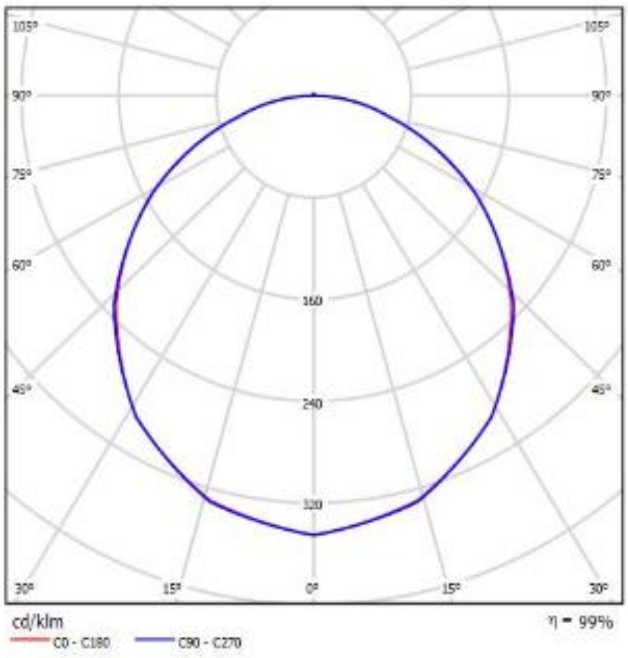



**Fig 5.64 Luminous Intensity Distribution Curve of the Luminaire**

Fig 5.64 shows the luminous intensity distribution curve of the luminaire used.

**MATERIAL SPECIFICATION:**

1. Housing : CRCA, White powder coated
2. Frame : CRCA, White powder coated
3. Diffuser : Polycarbonate
4. Internal Wiring : FRLS-Zh Wire
5. Mains Terminal : 3 Way 10 Amps
6. External Cable : FRLS-Zh Cable

**ELECTRICAL PARAMETERS:**

| | | |
|---|---|---|
| Rated Voltage (V) | : | 240V~ |
| Frequency (Hz) | : | 50 |
| Operating Voltage Range (V) | : | 140V~ - 270V~ |
| Current (A) @ 240V | : | 0.142-0.172 |
| Wattage (W) @240V | : | 36 |
| PF | : | >=0.95 |
| THD | : | <5% |
| Lumen | : | >3600 |
| Surge | : | 4kV |

## 1.6 Station Manager Room :

The Station Manager is the person who is in charge of the metro station. The Station Manager is responsible for the management of the metro station and holds responsibility for safety and the efficient running of the station. Lighting Design has to be carried out in such a way that it meets the visual requirement as well as provides a visually soothing environment.

**Layout & Description:**

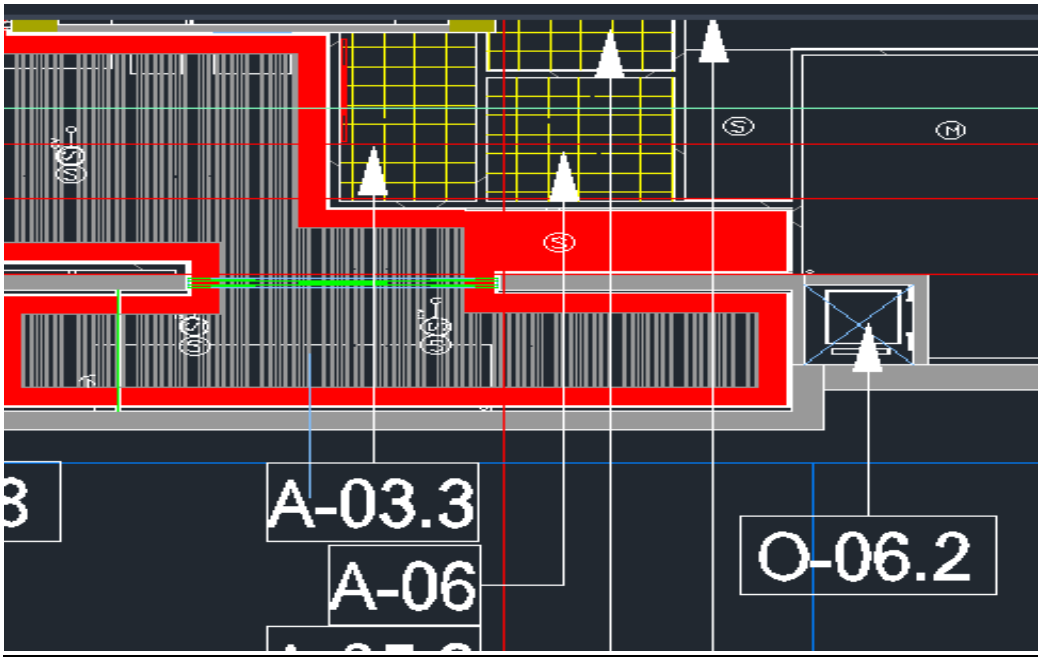



**Fig 5.65 AutoCAD layout (Floor Plan) of Station Manager Room (A-06)**

Above is the floor plan of a typical Metro Station Manager Room (A-06). Ht. of the room is 3.5m as given.2'X2' Grid False ceiling has been proposed. Lighting Design should be carried out for avg. 300-500lx. For achieving this lux level, it is preferable to use 2'X2' Recessed type fitting.

**Design Considerations:**

For Station Manager Room Design, following are the design considerations:

- Maintenance Factor is considered as 0.8.
- Room Surface Reflectance is considered as 50% (Ceiling), 30% (Walls) and 20% (Floor).

3D Rendering of a typical Metro Station Manager Room has been Shown below:

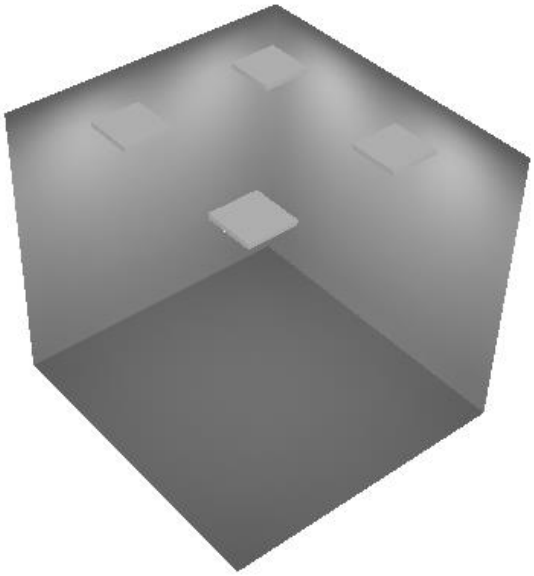
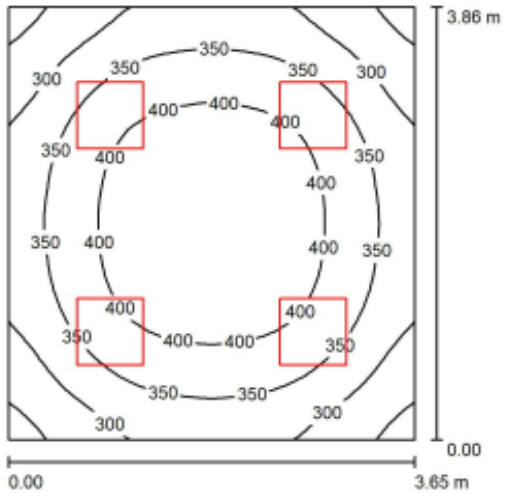


**Fig 5.66 Typical Metro Station Manager Room 3D Rendering**

The above simulation has been carried out in DIALux 4.13.As per the required standard, lighting design has been carried out for average 300-500 lux. LED Recessed 2'X2' Tile 36W luminaire has been used to illuminate this area.

**STATION MANAGER ROOM / Summary**




Height of Room: 3.500 m, Mounting Height: 3.500 m, Light loss factor: 0.80 — Values in Lux, Scale 1:50

| Surface | ρ [%] | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 |
|---|---|---|---|---|---|
| Workplane | / | 358 | 239 | 445 | 0.667 |
| Floor | 20 | 278 | 201 | 332 | 0.725 |
| Ceiling | 50 | 75 | 57 | 116 | 0.750 |
| Walls (4) | 30 | 239 | 62 | 491 | / |

**Workplane:**
Height: 0.760 m
Grid: 32 x 32 Points
Boundary Zone: 0.000 m

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.742, Ceiling / Working Plane: 0.211.

**Fig 5.67 Typical Metro Station Manger Room DIALux Summary**

Fig 5.67 shows the DIALux 4.13 summary of a typical Metro Station Manager Room. Design has been carried out for avg. 300-500 lux.36W Recessed 2'X2' Tile luminaires have been used to illuminate the area, thus giving a visually comfortable and glare free environment.

## Technical Details of Luminaires used:

1. **LED Recessed 2'X2' Tile Luminaire**

   Lamp: 36W LED
   Ingress Protection: IP20
   CCT: 5700K
   Lumen output: 3946 lm
   Efficacy: >100Lm/W
   Dimension (mm): 600X600
   Approx. wt. (kg): 3.1

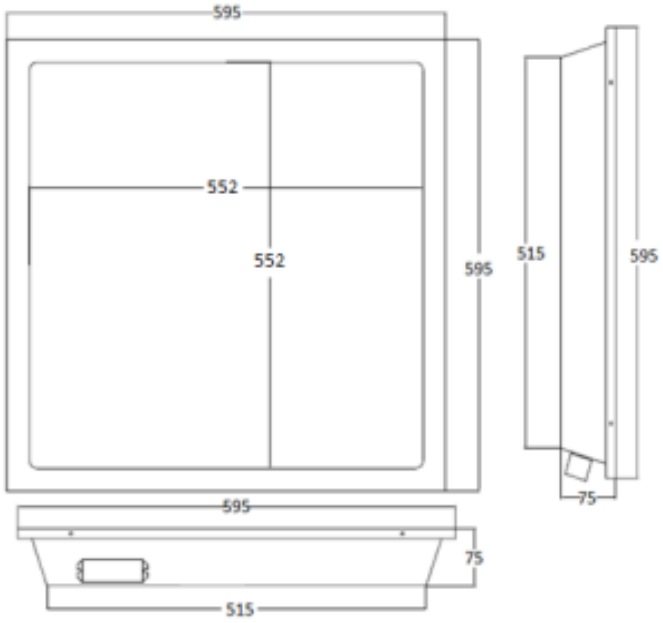



**Fig 5.68 Dimensions of the 36 W LED Recessed 2'X2' Tile Luminaire**

In Fig. 5.68 image of the dimensions of the 36W LED Recessed 2'X2' Tile Luminaire has been shown.

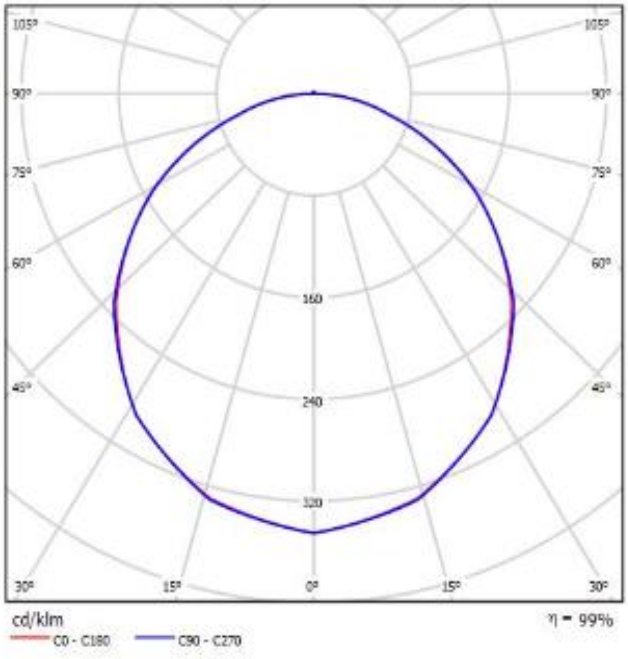



**Fig 5.69 Luminous Intensity Distribution Curve of the Luminaire**

Fig 5.69 shows the luminous intensity distribution curve of the luminaire used.

**MATERIAL SPECIFICATION:**

1. Housing : CRCA, White powder coated
2. Frame : CRCA, White powder coated
3. Diffuser : Polycarbonate
4. Internal Wiring : FRLS-Zh Wire
5. Mains Terminal : 3 Way 10 Amps
6. External Cable : FRLS-Zh Cable

**ELECTRICAL PARAMETERS:**

| | | |
|---|---|---|
| Rated Voltage (V) | : | 240V~ |
| Frequency (Hz) | : | 50 |
| Operating Voltage Range (V) | : | 140V~ - 270V~ |
| Current (A) @ 240V | : | 0.142-0.172 |
| Wattage (W) @240V | : | 36 |
| PF | : | >=0.95 |
| THD | : | <5% |
| Lumen | : | >3600 |
| Surge | : | 4kV |

2. **Undercroft Level:**
   An **undercroft** is traditionally a cellar or storage room, often brick-lined, and used for storage in buildings since medieval times. It is the lowest level of an underground metro station. Electric lines, services of drainage, ducts beside the wheels of metro can be found at this level. This is also a part of non-public access area in a metro station.

**Layout & Description:**

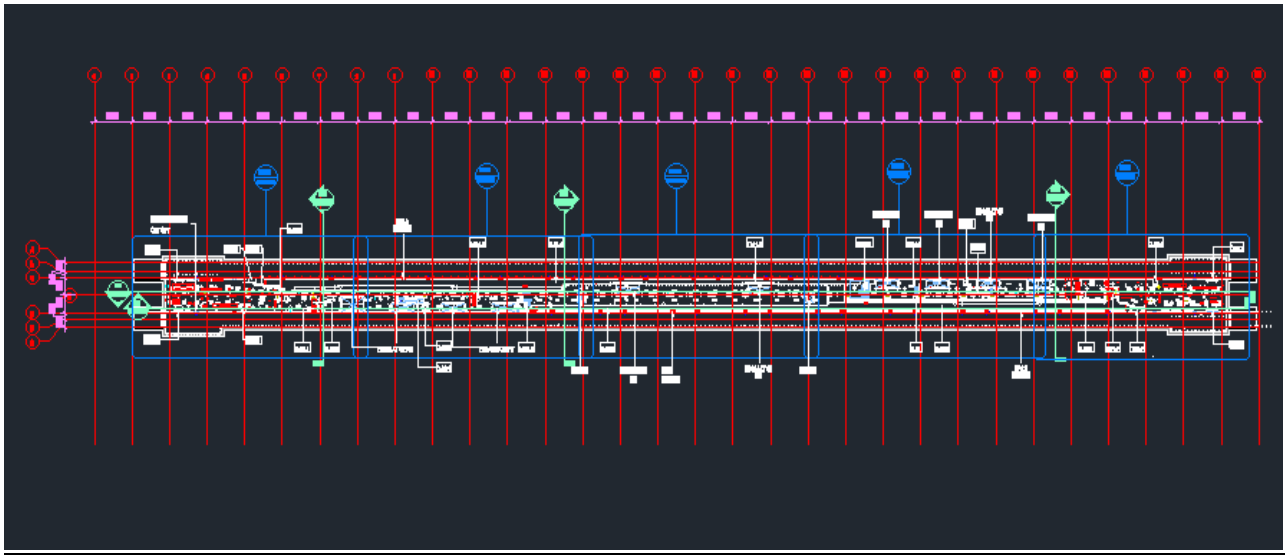


**Fig 5.70 AutoCAD layout (Floor Plan) of a typical Underground Metro Undercroft Level**

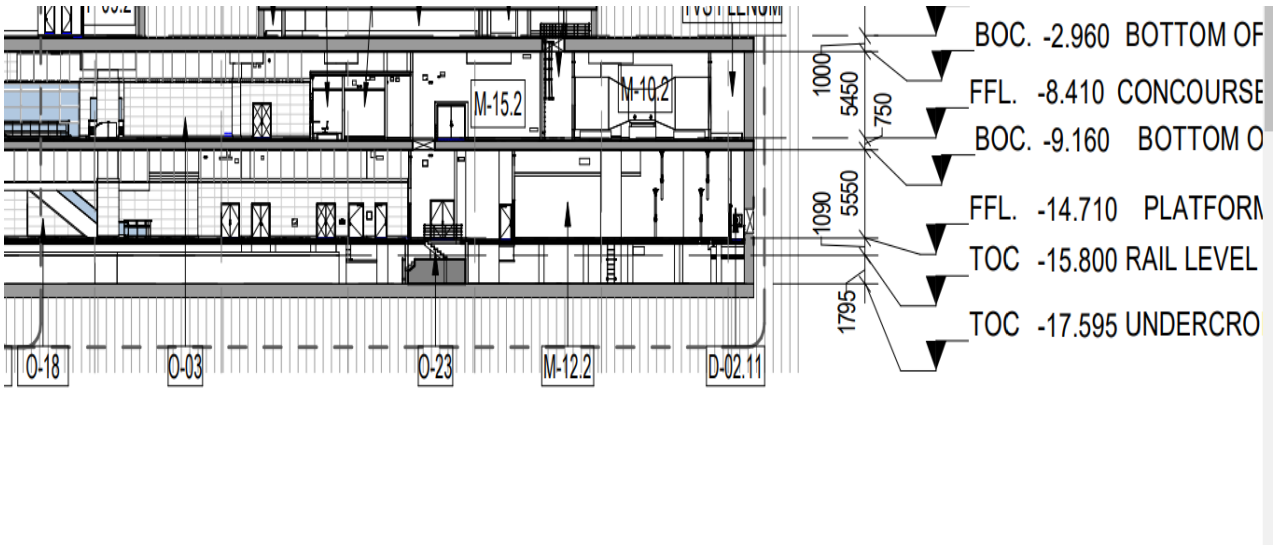



**Fig 5.71 Layout(Sectional) of a typical Underground Metro Undercroft Level**

Above is the floor plan and sectional layout of a typical Underground Metro Undercroft Area. Generally the Undercroft area is dusty, less maintained. So choice of lighting fixtures should be done based on its IP rating. Generally IP 65 type of fitting is preferred in this area.

**Design Considerations:**

For Metro Undercroft Lighting Design, following are the design considerations:

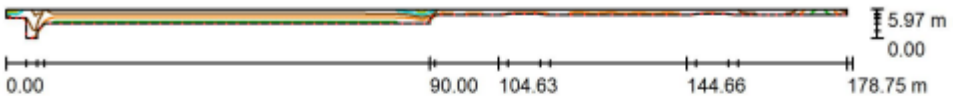
- Maintenance Factor is considered as 0.8.
- Room Surface Reflectance is considered as 10% (Ceiling), 10% (Walls) and 10% (Floor).

Considering all the above design criteria requirements, lighting design for Undercroft Level can be carried out using Lighting Simulation Softwares like DIALux 4.13, DIALux evo or AGi32 Lighting Analysts Software. 3D Rendering of a typical Underground Metro Undercroft has been shown below:

**Fig 5.72 Typical Underground Metro Undercroft 3D Rendering**

The above simulation has been carried out in DIALux 4.13.As per the required standard, lighting design has been carried out for average 20 lux for Undercroft Area. IP65 Bulkhead type of luminaire has been used to

illuminate the area. Room ht. is considered as 2.5m as per input received and the Bulkhead luminaires have been wall mounted at 2m from floor level.




Height of Room: 2.500 m, Mounting Height: 2.000 m, Light loss factor: 0.80 — Values in Lux, Scale 1:1278

| Surface | ρ [%] | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 |
|---|---|---|---|---|---|
| Workplane | / | 25 | 4.15 | 49 | 0.163 |
| Floor | 10 | 27 | 3.76 | 52 | 0.139 |
| Ceiling | 10 | 55 | 1.83 | 315 | 0.033 |
| Walls (23) | 10 | 32 | 1.25 | 348 | / |

**Workplane:**
Height: 0.000 m
Grid: 89 x 3 Points
Boundary Zone: 0.000 m
Illuminance Quotient (according to LG7): Walls / Working Plane: 1.229, Ceiling / Working Plane: 2.041.

**Fig 5.73 Typical Metro Station Undercroft Area DIALux Summary**

Fig 5.73 shows the DIALux 4.13 summary of a typical Metro Station Undercroft Area. Design has been carried out for avg. 20 lux.10W Bulkhead type of fittings have been used to illuminate this section of the metro station.

## Technical Details of Luminaires used:

1. **LED Bulkhead Luminaire :**

   Lamp: 10W LED
   Ingress Protection: IP65
   CCT: 5700K
   Lumen output: 856 lm
   Efficacy: >85Lm/W
   Approx. wt. (kg): 0.75

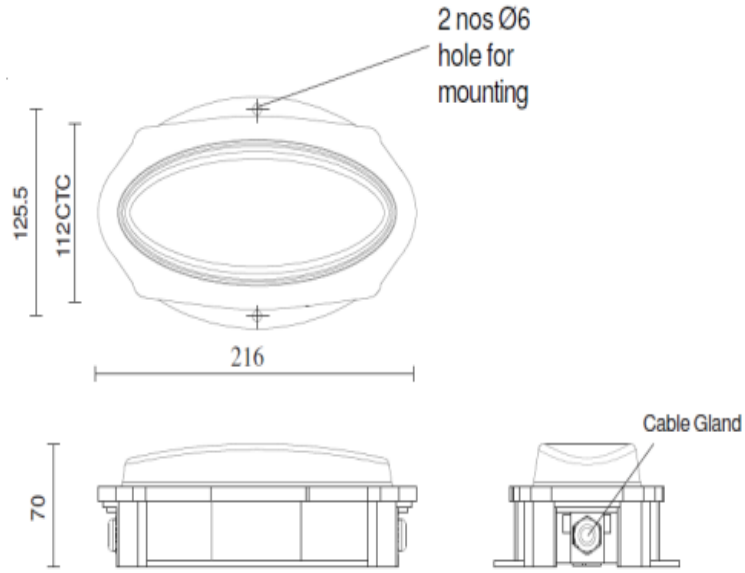



**Fig 5.74 Dimensions of the 10W LED Bulkhead Luminaire**

In Fig. 5.74 image of the dimensions of the 10W LED Bulkhead Luminaire has been shown.

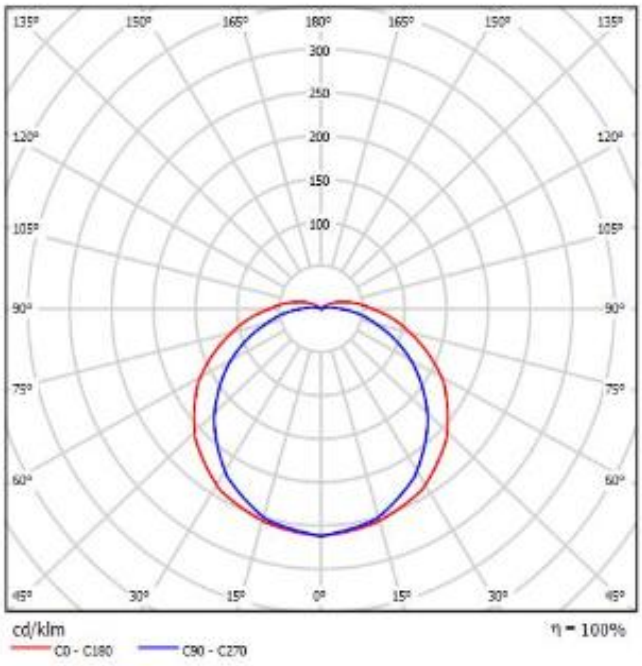



**Fig 5.75 Luminous Intensity Distribution Curve of the Luminaire**

Fig 5.75 shows the luminous intensity distribution curve of the luminaire used.

**MATERIAL SPECIFICATION:**

1. Housing : Die cast Aluminum powder coated in Black shade
2. Cover : Polycarbonate OPAL
3. Internal Wiring : FRLS-Zh Wire
4. Mains Terminal : 3 way 10 amps suitable for terminating max. 2.5 sq.mm incoming FRLS cable
5. Earthing : 1 No. earthing provide

**ELECTRICAL PARAMETERS:**

| | | |
|---|---|---|
| Rated Voltage (V) | : | 240V~ |
| Frequency (Hz) | : | 50 |
| Operating Voltage Range (V) | : | 150V~ - 270V~ |
| Current (A) @ 240V | : | 0.045 |
| Wattage (W) @240V | : | 10 |
| PF | : | >0.9 |
| THD | : | <10 |
| Lumen | : | >850 |
| On board surge protection | : | >2.5kV |

# CHAPTER 6

# RESULT & ENERGY EFFICIENCY EVALUATION

## 6.1 Introduction

In the previous chapter of the case studies, some important design of the different areas in a metro station has been shown. It should also be kept in mind that the design should fulfill the requirements of the Authority and should also be energy efficient.

So all the areas in the metro station have been designed using LED luminaires. No conventional type of fixtures has been used in design. So the case studies don't incorporate any designs using conventional luminaires. Energy efficiency can be shown by evaluation of the LPD values for different areas in the metro station.

## 6.2 EVALUATION OF LPD:

Lighting power density is a measurement that indicates whether a certain space offers scope for energy savings. "Lighting Power Density (LPD) is defined as watts of lighting per square foot of room floor area (W/f^2) or as watts of lighting per square meter (W/m^2) of room floor area. In Metro Railway Lighting, Authority accepts the unit W/m^2. Other energy-saving methods such as incorporating day-lighting or occupancy sensors in combination with reduced lighting power density can be done to achieve additional savings.

## 6.3 LPD Evaluation in some areas of metro station building:

| Sl. No. | Name of Area | Total Wattage of Lighting System(W) | Total Floor Area(m^2) | LPD(W/m^2) |
|---|---|---|---|---|
| 1. | Concourse | 15254.6 | 4333.81 | 3.52 |
| 2. | Platform | 10845.0 | 3653.04 | 2.97 |
| 3. | Restroom & Toilets | 92.0 | 14.25 | 6.45 |
| 4. | Tunnel Ventilation Fan Room | 595.0 | 180.47 | 3.30 |
| 5. | Station AHU Room | 680.0 | 130.56 | 5.21 |
| 6. | TVS Room Switchgear | 552.5 | 65.76 | 8.40 |
| 7. | Audit & Cash Store Room | 68.4 | 9.08 | 7.53 |
| 8. | Station | 273.6 | 36.03 | 7.59 |

| | | | | |
|---|---|---|---|---|
| | Control Room | | | |
| 9. | Station Manager Room | 136.8 | 14.10 | 9.70 |
| 10. | Undercroft Area | 840.6 | 366.74 | 2.29 |
| | Total | 29338.5 | 8803.84 | **3.33** |

**Table 1**

As per Metro guidelines, the LPD value of a Metro Station must be lower than or equal to 7.4 W/m2. From the LPD evaluation table, it can be stated that the obtained LPD value of the areas of the metro station is approximately 3.33 W/m2. So, it can be stated that the designs are feasible, and hence it can be stated that it is an **Energy Efficient Design**.

# CHAPTER 7

# CONCLUSION & FUTURE SCOPE

This project dealt with analyzing the processes and activities in various areas of an underground metro station, and provided an optimal illumination design for it so as to provide aesthetic look and energy efficient lighting solution in adherence to all required lighting standards, which will lead to efficient energy savings. Illumination designs in all areas were done using LED luminaires.

## 7.1 Conclusion:

Comparing LED fixtures with conventional light sources, for the same lumen package, LED luminaires offer lower power consumption compared to conventional luminaires, hence LED luminaires provide energy efficient lighting solution compared to other light sources.

The initial price of the LED luminaires may be high but the cost can be covered easily after a few years as running cost of LED luminaires will be low.

LED luminaires lasts longer compared to conventional fixtures, thus avoiding the hassle of frequent changing of luminaires.

LED's can be smartly operated, can be dimmed to various levels easily and CCT variation can be done easily which makes it a preferred choice over other type of light fixtures.

Nowadays for Metro Station Lighting Design, LED's are being preferred over other light sources because of its advantages. The design solution should ensure energy efficiency while meeting the visual requirements and visual comfort of the passengers and the metro operating staff.

## 7.2 Future Scope:

Lighting control and smart lighting in metro station can further lead to energy savings. Integration of occupancy based sensors, daylight sensors for elevated platforms can help in energy savings.

Compared to some of the best metro stations in the world in terms of aesthetics, Indian metro station still does not find a place among them.

Light output control with LED's can be done very easily. DALI is a great innovation of new era. By means of DALI complete lighting control can be done such as daylight harvesting, scheduled illumination, occupancy controlled illumination, etc. Incorporating Human centric based lighting (HCL) solution can also prove to be beneficial for health and wellbeing of the travelling passengers **[13].**

Some images of the Indian metro station completed projects as follows:


**Fig 7.1 Platform area of a Kolkata Metro Station(KMRC)**

**Fig 7.2 Platform area of a Mumbai Metro Station(MMRC)**


**Fig 7.3 Concourse area of a Delhi Metro Station(DMRC)**

Along with Lighting Control and other energy saving strategies, architectural based lighting solution should also be adopted in the metro stations to make the journey impressive and worth it.
Metro stations are often thought of as being dingy, dark, and unsafe and not a place where anyone would like to hangout. But there are some metro stations in the world that are no less than an art gallery or museum. Some of them are really amazing in terms of their interiors and their lighting solutions.
Few examples of some of the best and iconic metro stations in the world are as follows:

- **Stockholm Underground, Sweden :**

  The Stockholm Underground Metro system has been called "the world's longest art gallery". Over 90 of the 100 subway stations in Stockholm have been decorated with sculptures, mosaics, paintings, installations, engravings and reliefs by over 150 artists. Functional Lighting along with artistic lighting solution has been provided to make it look fascinating **[14].**

**Fig 7.3 Stockholm Underground Metro Station, Sweden**

- **Moscow, Komsomolskaya Station:**

The Design is more like a ballroom and is inspired by a wartime speech of Stalin. Chandelier lights along with functional lights have been used to light up the station. Huge halls with high ceilings give the ambience of a museum rather than a metro station **[15].**

**Fig 7.4 Komsomolskaya Station, Moscow**

- **Naples, Italy, Toledo Metro Station:**

  The Station was opened in the year 2012. It has been decorated by mosaics and a seascape made up of LED wall panels. The station inner view is just breathtaking. The artistic view has been created based on the theme of water and light **[16].**

**Fig 7.5 Toledo Metro Station, Naples, Italy**

- **Dubai, U.A.E., Khalid Bin Waleed Station:**

  The Station has been designed and created based on Dubai's history. The theme of this station is water based on Dubai's history of fishing and pearl diving. The blue mood architectural lighting along with fiber optic chandeliers makes the station look absolutely magnificent **[17].**

**Fig 7.6 Khalid Bin Waleed Station, Dubai, U.A.E**

Indian metro stations along with functional lighting, different control strategies, daylight harvesting should also consider artistic and architectural solutions to make the area fascinating, captivating, enthralling and exciting. Such technologies in Indian metro stations should be implemented in future to make the journey of a passenger not only a journey but a pleasant and memorable experience.

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