STUDIES ON THE ILLUMINATION DESIGN OF A FIRE STATION

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

Master of Technology

IN

Illumination Technology and Design

Submitted by

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Exam Roll Number: M6ILT22019

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

FINAL EXAMINATION FOR EVALUTION OF THESIS

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DECLARATION OF ORIGINALIT AND COMPLIANCE OF ACADEMIC ETHICS

I hereby declare that this thesis contains literature survey and original research work by the undersigned candidate, as part of his **Master of Technology (Illumination Technology and Design)** studies during academic session 2019-2022.
All information in this document has been obtained and presented in accordance with academic rules and ethical conduct.

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

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ABSTRACT

This thesis attempts to prepare a lighting design solution for the Behala Fire station in Kolkata. First, the architectural plan of the building was studied and three types of spaces i.e. office space, garage space and barrack spaces were identified. These spaces are distributed across three floors of the fire station building.

The illumination level for the different areas is selected as per the Indian Standards where lighting levels are mentioned for cases. Lighting simulation has been carried out using various lighting simulation software like DIALux 4.13. Energy efficiency comparison with ECBC standards and energy bill calculation has also been done.

Table of Content

CHAPTER 1: INTRODUCTION

1.1: BACKGROUND OF THE STUDY :-

Nature has given us light as well as eyesight to appreciate its bounty, mainly during the day. As night fell, human activities stopped as there was no natural light to support. But this was till man invented electric light and started working even after the sun has set. This invention revolutionized the way we live and work. In the quest of further development in this field, Illumination engineering profession has emerged to address the issues of 'good lighting'. The many facets of lighting include not only appropriate task performance, but also optimization of energy and safety.

This is particularly true in the context of emergency services and built environment of the emergency service providers. Fire stations in cities are such areas where workers at all levels have to be alert and vigilant so that they can rush to save people in distress. Illuminating such spaces can be very challenging as lighting also affects both mental and physical well-being of people. Illumination designers are faced with the task of achieving such quality in the interior environment of such offices.

This thesis attempts to design illumination for one such fire station office building in Behala, Kolkata, covering the aspects of both energy and cost efficiency, so that the design solution is close to its optimized best.

The chapters have been organized covering the significance of fire stations, background of Kolkata fire stations and their distribution in the city, introducing the fire station in question followed by its illumination design through DIALux along-with its energy and cost assessment.

1.2: ABOUT FIRE STATION :-

A fire station (also called a fire house, fire hall, firemen's hall, or engine house) is a structure or other area for storing firefighting apparatus such as fire engines and related vehicles, personal protective equipment, fire hoses and other specialized equipment. Fire stations frequently contain working and living space for the firefighters and support staff.

A fire station will at a minimum have a garage for housing at least one fire engine. There will also be storage space for equipment, though the most important equipment is stored in the vehicle itself. The approaches to a fire station are often posted with warning signs, and there may be a traffic signal to stop or warn traffic when apparatus are leaving or returning to the station.

Before the commencement of design, it is very important to know the types of spaces that a fire station usually has. These are as follows:

Apparatus bay(s): The place where the fire fighting and emergency response vehicles are stored.

Apparatus bay support and vehicle maintenance: Here the vehicles and other firefighting equipment are cleaned, maintained, and stored.

Administrative and training areas: These include office spaces, work areas, dispatch facilities, and training and conference rooms.

Residential areas: These include the dormitory rooms, day room/kitchen, and residential support areas such as bathrooms and other amenities.

[Source: https://www.wbdg.org/building-types/community-services/fire-station]

Other than these, the compound area of the fire station building is also very important from illumination point of view.

The interrelationship between the different spaces of the fire station is given below:

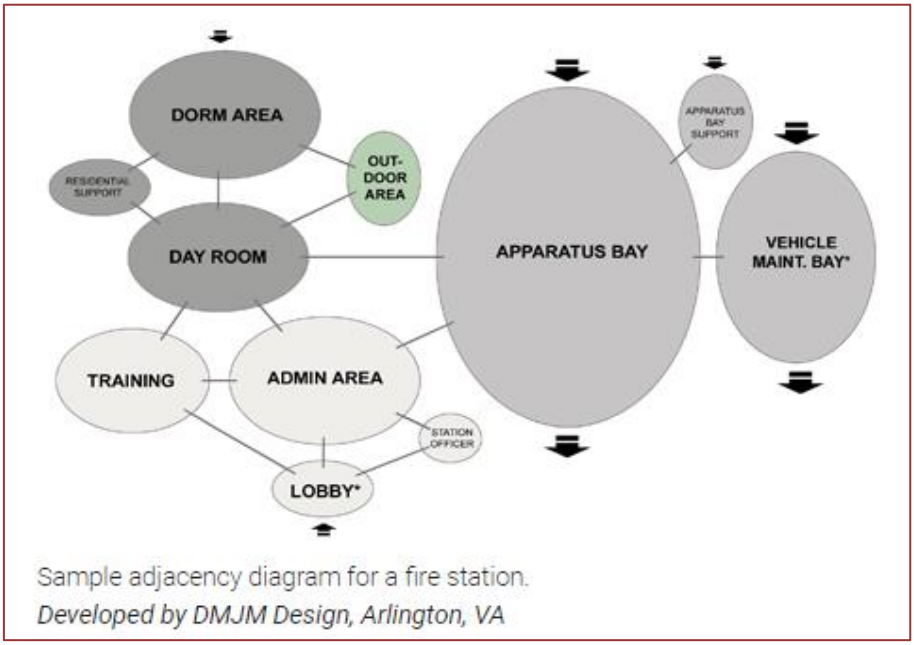


Figure 1 Bubble diagram showing spaces in a typical Fire station

A building floor plan of a typical fire station is as follows:

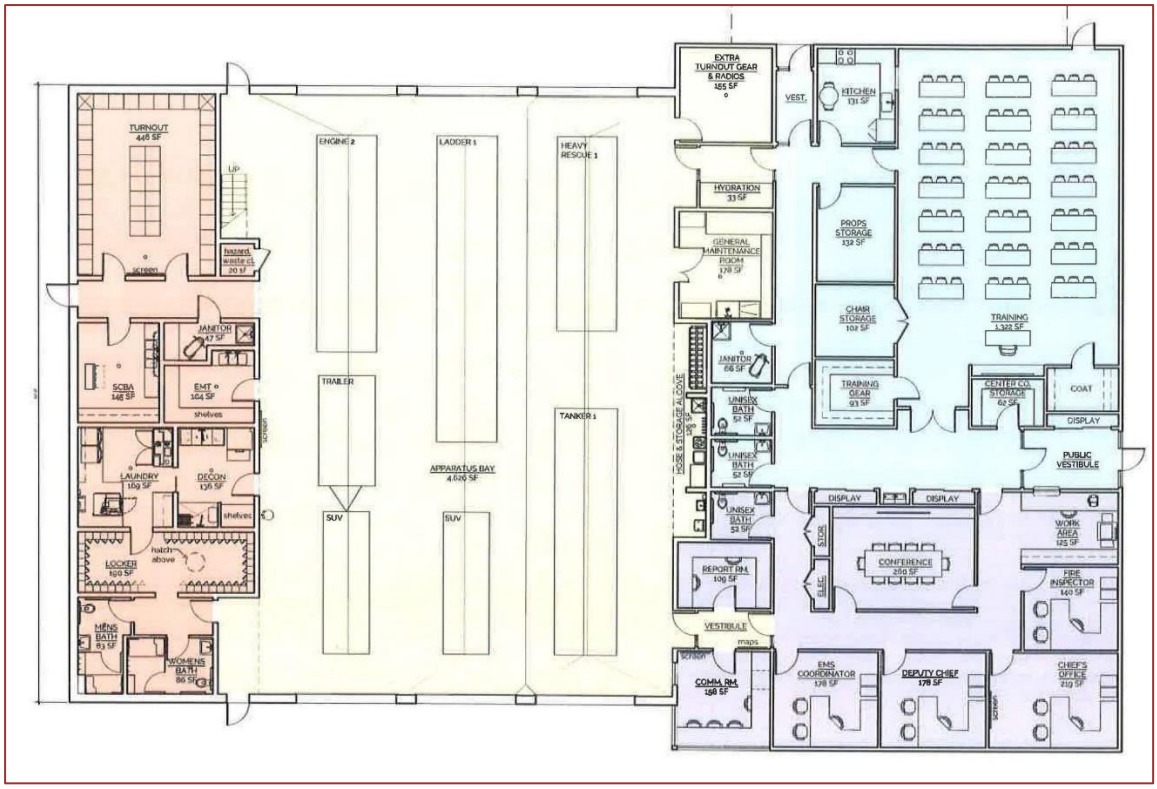


Figure 2 – Floor plan of Fire Station, Swanzey, USA

Fire stations have often been built with a tower, for purposes that have changed with time. A drill tower is used for practicing high-rise rescue, while a hose tower is used for hanging hoses to dry to prevent rot. Historically, towers were lookouts for spotting fires.

Activities at a fire station include regular inspection and cleaning of the apparatus and equipment, and training drills in which the firefighters practice their skills. Some fire companies also host public activities at the fire station during events such as a "fire prevention week", and the facility may also be used for fund-raising by the "firemen's association", "**fire buffs**", or "fire auxiliary".

As emergency services, fire stations operate 24 x 7 by firefighters in continuous 24-hour shifts. Hence, having a comfortable indoor space for the personnel is very important, such as:

- Sufficient natural light and good illumination at night. It may be a good idea to have illumination that is similar to daylight at night.

- Since the firefighters themselves are to remain safe in the building with the presence of hazardous materials, the lamp and luminaire are to be carefully selected so that heat emission is minimum.

- There should not be any unnatural finishes, textures, and colors.
- Fire station has different functional spaces such as residences, office, workshop and garage, just to name a few. Therefore they also need different lighting considerations- light levels, light color and in some cases the ability to be dimmed or go on/off when the room is in use or empty for better energy management.

From this, the criteria of lighting design for fire stations appear as follows:

I. To identify and understand the different type of spaces and their lighting needs.
II. To select lamps that have the right colour temperature and colour rendering index.
III. To select lamps that do not produce much heat, i.e. with high luminous efficacy.
IV. To have sensor-based lighting design.

[Source: https://www.firehouse.com/home/article/12235187/selecting-lighting-for-your-next-fire-station-project]

1.3: AIMS AND OBJECTIVES :-

Accounts for 33% of total electricity consumption in India among them commercial building accounts for 9% of total electricity consumption in India. Lighting and HVAC are the most energy users in commercial buildings. Approximately lighting load constitutes 59% of total power consumption in commercial buildings and 19% of total power generation in India.

The objectives of this study are:

I. To study the illumination design criteria of areas of the Fire sector and to design those areas following relevant codes and guidelines of

illumination as well as energy parameters with the help of illumination software's like DIALux 4.13.

II. Designing of the Fire spaces by following the "Human Centric Lighting" approach.
III. To study new energy-efficient technology in the field of illumination.
IV. To simulate the designs by using conventional luminaires and energy-efficient LED luminaires and compare the results based on illumination and power consumption parameter and calculated cost savings.

1.4: SCOPE AND LIMITATION:-

The scope includes the illumination design of three types of spaces in the Behala Fire Station of Kolkata - office spaces, garage area and barracks, distributed over three floors of the fire station. The scope of thesis will also include the energy calculations and cost calculations. It will also try to investigate the solar energy potential for meeting the lighting energy requirements.

The residential quarters and amenity spaces could not be designed due to many limitations related to the pandemic.

1.5: DELIVERABLES:-

I. Illumination Design through DIALux and lux level calculations
II. Lamp and luminaire selection
III. iii. Lighting Energy assessment
IV. iv. Cost calculation for capital cost and possible

1.6: Brief Historical Background of fire stations in Kolkata:-

The West Bengal Fire Service is the state owned service that provides firefighting, rescue and emergency fire services to the state of West Bengal, India including the city of Kolkata.

The Fire Service in West Bengal is the oldest fire service in the country. Calcutta Fire Brigade and Bengal Fire Service were amalgamated in 1950 to form the organization. Fire Service Act was enacted in 1950 and amended in 1996 with inclusion of fire prevention and Fire Safety Rules. 103 fire stations are in operation. About 8000 Fire Force with over 350 fire appliances are in service.

Two of the important fire stations of Kolkata are given below:

Lalbazar Fire Station: - Lal Bazar Fire Station in Radha Bazar, Kolkata is one of the most well-known fire stations in Kolkata.

Figure 3- Lal Bazar Fire Station

Central Avenue Fire Station:- Central Avenue Fire Station in Central Avenue, Kolkata is another important fire-fighting service provider in Kolkata.

Figure 4-Central Avenue Fire Station

1.7 ABOUT THE BEHALA FIRE STATION:-

Fire Station Behala is one of the many places in the 'Public services' category that earned its significance in daily lives. Customers rated this place with 4.3. This organization provides services at the official address: Diamond Harbour Road, Barisha, Kolkata — 700008 (Near L M Dey Garden, Sealpara). The geographic system coordinates are: longitude — 88°18′41.76″E (88.311604), latitude — 22°28′29.96″N (22.474988).

Figure 5 - Behala Fire Station front view

Chapter-2

CODES AND STANDARDS UNDER DESIGN METHODOLOGY

2.1: Codes and Standards under Design Methodology :-

The codes and guidelines which are consulted for illumination design of any building are as follows:

Table 2.1.1 - Codes and Guidelines consulted for illumination design of different sectors

Sl No.	Standard	Title
1	IS:3646 (Part-I) 1992	Codes of practice for Interior Illumination
2	SP 72:2010	National Lighting Code
3	NBC 2016	National Building Code

2.2: Codes and Standards followed for Fire Station Illumination Design:-

The levels of illumination as per IS:3646 (Part-I) 1992 and NBC 2016 for illumination design of different building spaces are as follows:

Table2.2.1- Illumination levels for Hospital Illumination Design as per IS:3646 (Part 1) and NBC

Sl No.	Type of Interior of Activity	Range of Service Illumination(Lux)
1	Waiting Rooms	150-200-300
2	Corridors, Stair	50-100-150
3	Rest Room	100-150-200
4	Control Room	200-300-500
5	Mess Room	150-200-300
6	Staff Quarter	50-100-150

2.3: Energy Conservation Codes and Guidelines:-

The Energy Conservation Building Code (ECBC), was launched by Ministry of Power, Government of India in May 2007, as an initial step towards promoting energy efficiency in the building sector. The ECBC was developed by an Expert Committee, set up by India's Bureau of Energy Efficiency, with support and guidance from United States Agency for International Development (USAID) and significant inputs from various other stakeholders such as practicing architects, consultants, educational institutions and other government organizations.

Unlike ECBC 2016, ECBC 2017 has divided building rating into three divisions

i.e. ECBC Building, ECBC+ Building and Super ECBC Building depending upon least energy usage by satisfying all the criteria. The guidelines have been furnished in the following tables:

2.4: Building Area Method :-

This method provides the procedure of calculating Watt/Sq. metre for the entire building based on this method. The sum of all interior lighting powers for various areas of the building should not exceed the total watts given here.

In this section, the values of areas related and relevant with fire station and allied facilities are discussed and extracted from ECBC 2017.

Table 2.4.1: Interior Lighting Power for ECBC Buildings- Building Area Method (source: ECBC 2017)

Sl No.	Building Type	LPD (W/m^2)
1	Fire Station	9.7

Table 2.4.2: Interior Lighting Power for ECBC+ Buildings- Building Area Method (Source: ECBC 2017)

Sl No.	Building Type	LPD (W/m^2)
1	Fire Station	7.8

Table 2.4.3: Interior Lighting Power for Super ECBC Buildings- Building Area Method (source: ECBC 2017)

Sl No.	Building Type	LPD (W/m^2)
1	Fire Station	4.9

2.5: Space Function Method:-

Similar to building area method, the first step of the space function method is to identify the appropriate building type and their allowed lighting power densities, which varies according to the function of the space. In this section, the values of areas related with healthcare and allied facilities are discussed.

Table 2.5.1 Interior Lighting Power for ECBC Buildings–Space Function Method as per ECBC2017

Sl No.	Area Category	LPD (W/m^2)
1	Rest Room	7.7
2	Storage	6.8
3	Parking	2.2
4	Stair	5.5
5	Corridor	7.1

Table 2.5.2: Interior Lighting Power for ECBC + Buildings- Space Function Method as per ECBC 2017

Sl No.	Area Category	LPD (W/m^2)
1	Rest Room	6.1
2	Storage	5.4
3	Parking	1.75
4	Stair	4.4
5	Corridor	3.6

Table 2.5.3: Interior Lighting Power for Super ECBC Buildings- Space Function Method as per ECBC 2017

Sl No.	Area Category	LPD (W/m^2)
1	Rest Room	3.8
2	Storage	3.4
3	Parking	1.1
4	Stair	2.7
5	Corridor	2.3

CHAPTER 3:

ILLUMINATION DESIGN OF BEHALA FIRE STATION

- **Overture**

The two most important criteria of illumination design are energy efficiency and lighting quality. Lighting designers sometime face the dilemma of selection between attractive, brightly lighted spaces against spaces that used a minimum of energy.

Lighting design targets depend on the space to be designed. Ideally, these targets are chosen by the collaboration between the end-users and the designers, based on the need of the project.

As mentioned earlier, fire station spaces have their own challenges that are needed to be addressed. As defined in the scope, lighting for office space and garage space have been designed and presented in this chapter.

3.1: Architectural lighting design :-

Architectural lighting design is a field of work or study that is concerned with the design of lighting systems within the built environment, both interior and exterior. It can include manipulation and design of both daylight and electric light or both, to serve human needs.

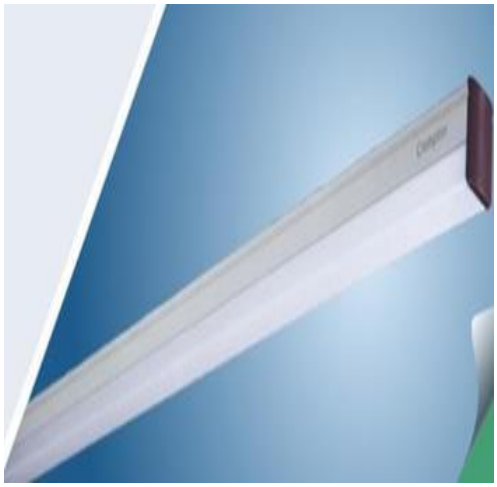
Lighting design is based in both science and the visual arts. The basic aim of lighting within the built environment is to enable occupants to see clearly and without discomfort. The objective of architectural lighting design is to balance the art and the science of lighting to create mood, visual interest and enhance the experience of a space or place whilst still meeting the technical and safety requirements.

Lighting design of the office spaces have considered the following:

- The dimensions of the space to be designed
- Function of that space and the requirements of the people using it
- Codes and standards mentioned in chapter 2

The next section shows the ground floor plan of the Behala fire station comprising of office rooms, garage and service-cum-circulation areas like staircase, toilets and corridors.

3.2: Lamp, luminaire and lighting control:-



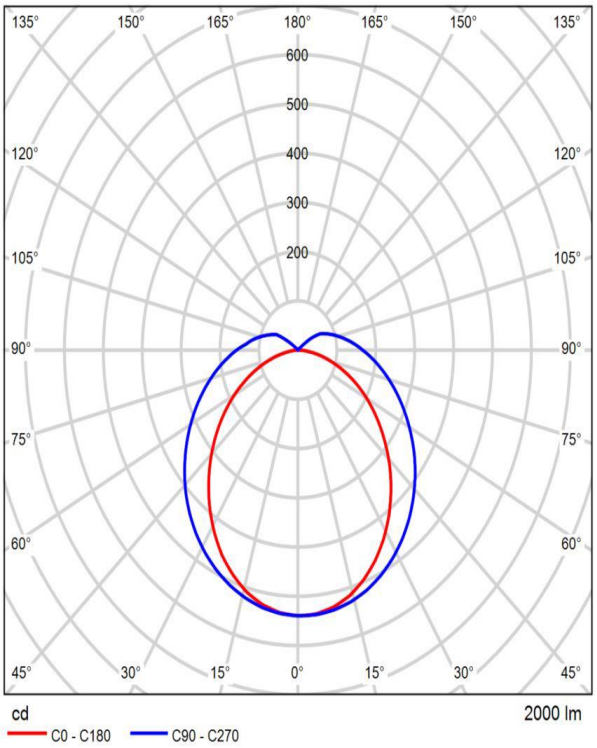


Figure 6-LED 20W Tube Light physical appearance and polar curve

Electrical and Photometry Parameters	Dimension
Nominal Voltage:- 240V	Length-1.2m
Luminaire rated power:- 20W	Width-0.036m
Light output :- 2000lm	Thickness-0.06m
CCT: - 3000K	
CRI :- >80	
Efficiency :- 100lm/W	

3.3: Office & garage Space Illumination Design output in DIALux :-

Activities at a fire station include regular inspection and cleaning of the apparatus and equipment, and training drills in which the firefighters practice their skills. Some fire companies also host public activities at the fire station during events such as a "fire prevention week", and the facility may also be used for fund-raising by the "firemen's association", "fire buffs", or "fire auxiliary".

Figure 7 - Drawing and Layout of Ground Floor

3.4: Illumination Design of the ground floor of the Fire Station in DIALux:-

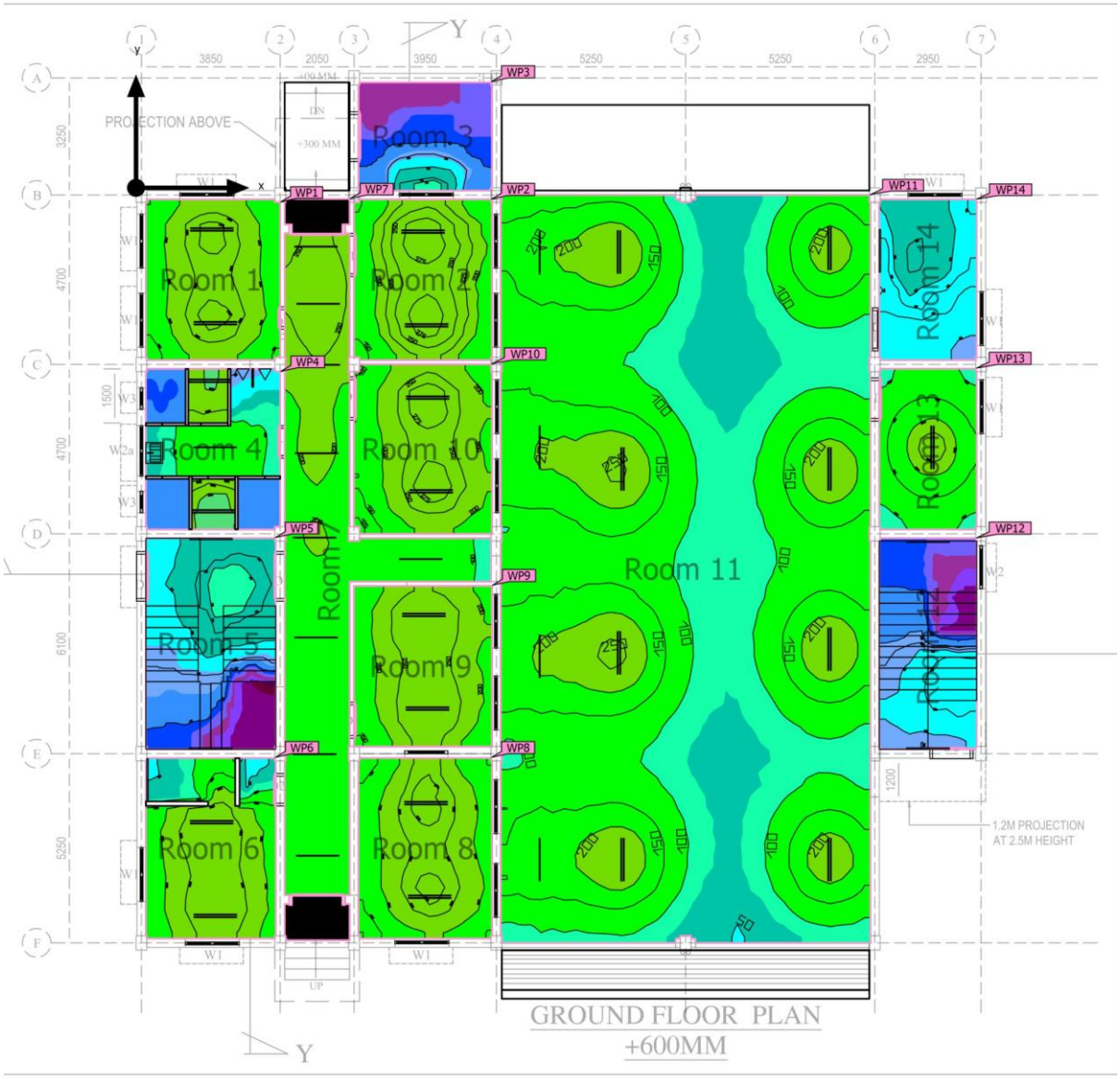


Figure 6 Illumination distribution of Fire Station ground floor

Figure 7 Layout of first floor of the fire station

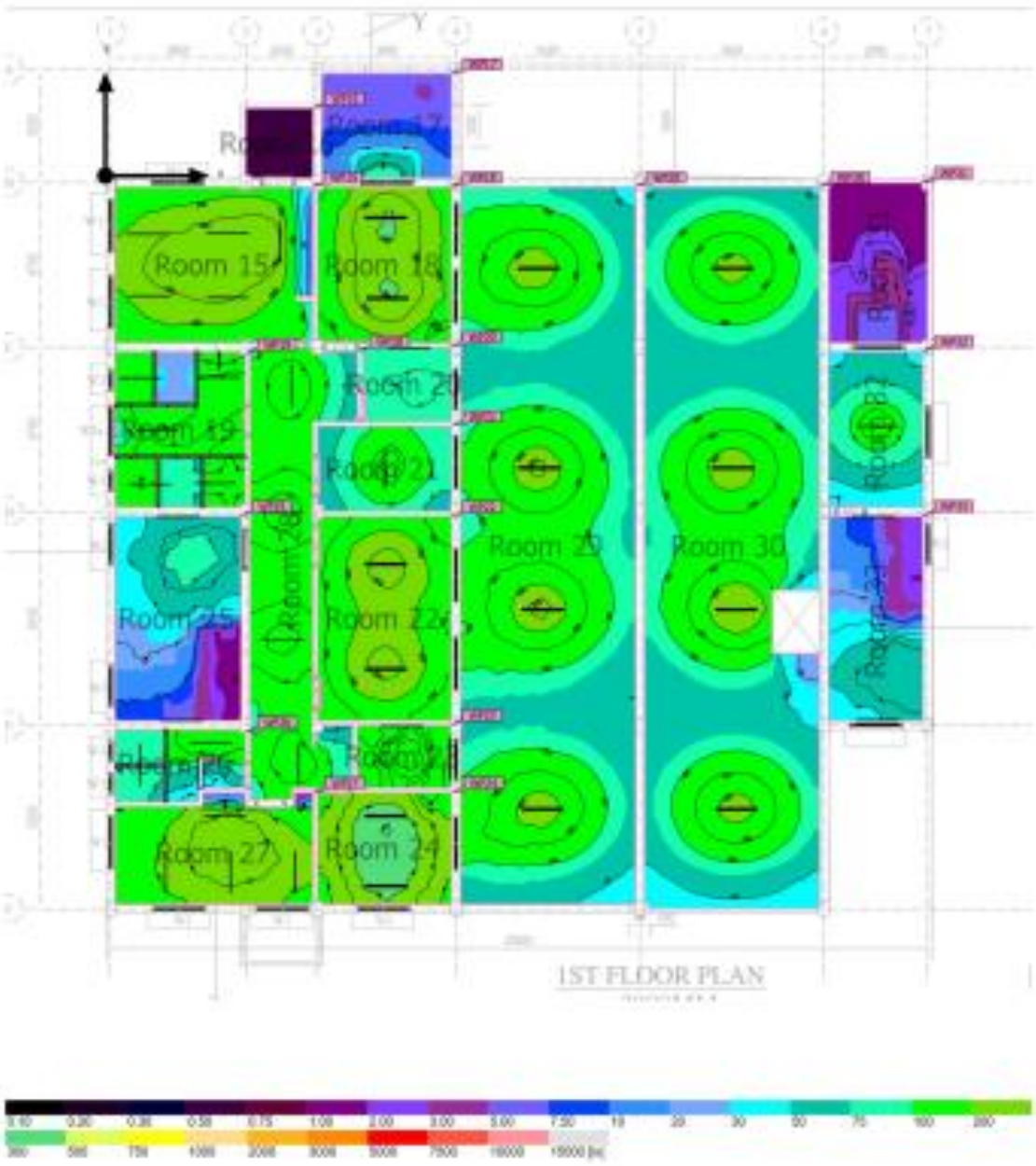


Figure 8 Illumination distribution of Fire Station first floor

Figure 9 Layout of third floor of the fire station

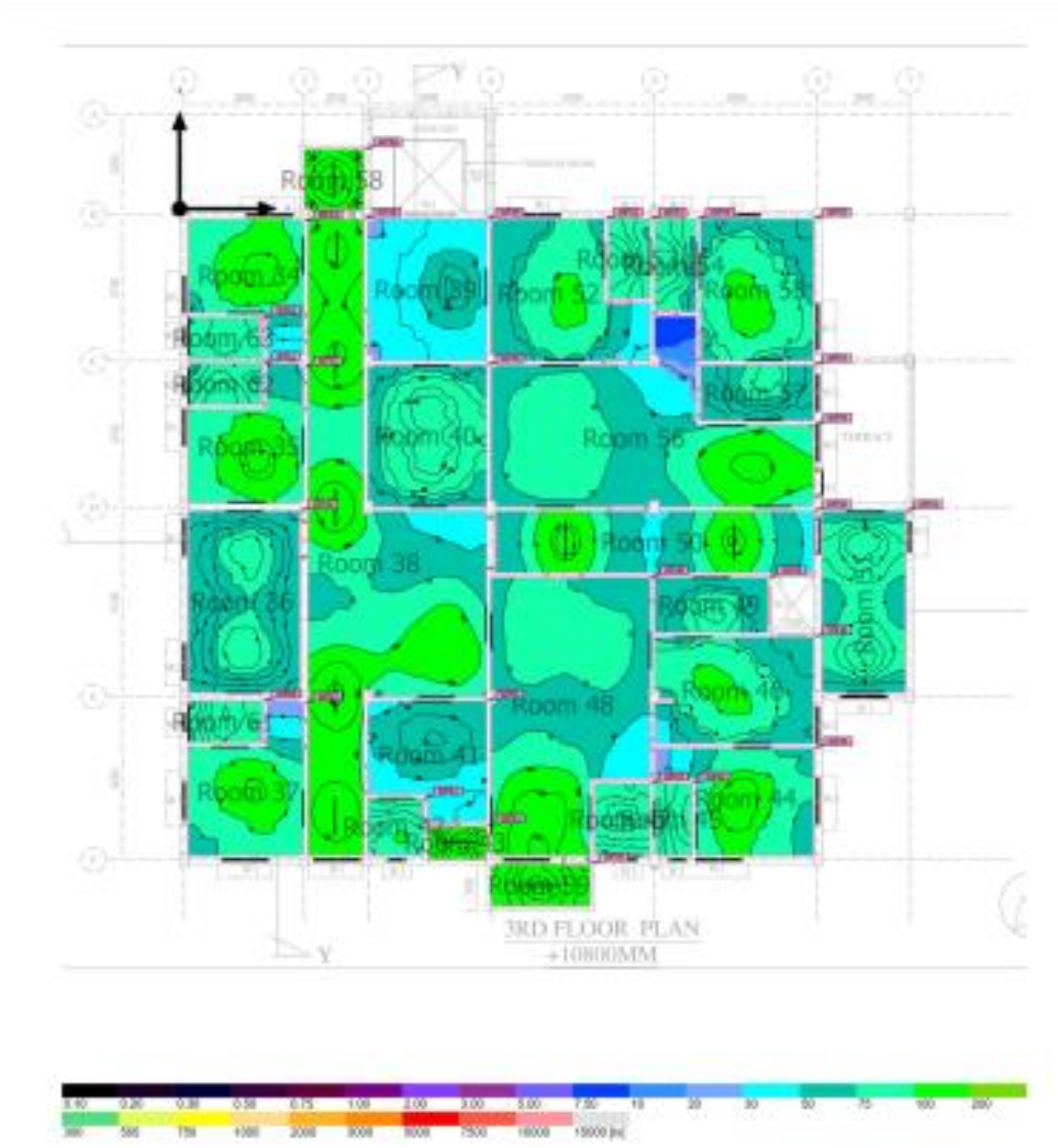


Figure 10 Illumination distribution of Fire Station third floor

- **Lux Level of Various Room at Ground Floor of Behala Fire Station**

Table3.3.1- Lux Level of Various Room at Ground Floor of Behala Fire Station

Serial No.	Room Name and No.	Illumination Level (Standard) (Lux)	Illumination Level (Achieved) (Lux)
1	Office Room1	200-300-500	219
2	Office Room2	200-300-500	201
3	Dining Room	150-200-300	227
4	Store Room1	50-100-150	217
5	Store Room2	50-100-150	165
6	Control Room	150-200-300	223
7	Fire Vendor Waiting Room	50-100-150	132

The details are given in the DIALux report in the annexure.

CHAPTER 4: ENERGY EFFICIENCY & COST CALCULATION OF ILLUMINATION DESIGN OF THE BEHALA FIRE STATION

- **Introduction :-**

Fire stations are a 24 x 7 facilities that operate round the clock and throughout the year. Energy used on account of lighting in these buildings accounts for a significant percentage of total energy consumption. This depends greatly on the lighting design, choice of lamps & luminaires and occupants' behavior.

- **Energy Efficiency of a Building :-**

Energy efficiency is the use of less energy to perform the same task or produce the same result. Energy-efficient homes and buildings use less energy to heat, cool, and run appliances and electronics, and energy-efficient manufacturing facilities use less energy to produce goods.

The energy efficiency of a building is the extent to which the energy consumption per square meter of floor area of the building measures up to established energy consumption benchmarks for that particular type of building under defined climatic conditions. Building energy consumption benchmarks are representative values for common building types against which a building's actual performance can be compared.

4.1: <u>Energy efficiency calculation of the Office space illumination design</u>:-

The illumination levels obtained through lighting design has been compared with the lighting power density values prescribed by ECBC under space-function method and is presented in the table below. The design is found to be within the energy efficiency limits.

Table 4.1.1-Interior Lighting power for the fire station office spaces in comparison with LPD allowance as per ECBC Buildings-Space Function Method

Sl. No.	Category Name	LPD Value ($W/m^{2)}$ (Allowance)	LPD Value ($W/m^{2)}$ (Achieved)	Remarks
1	Office Room	9.1	5.56	The design is well-within the lighting power allowance.
2	Control Room	11.5	6.04	
3	Store Room	6.8	4.71	
4	Rest Room	3.8	2.70	
5	Stair Way	5.5	2.53	
6	Corridor/ Transition	7.1	4.34	
7	Parking Bay	2.2	1.88	

4.2:Energy efficiency calculation of the Garage space illumination design :-

Similarly, the garage space has also been compared with the ECBC recommended allowance and is presented below.

Table 4.2.1-Interior Lighting power for the fire station garage spaces in comparison with LPD allowance as per ECBC Buildings-Space Function Method

Sl No.	Category Name	LPD Value (Allowance)	LPD Value (Achieved)	Remarks
		W/m^2	W/m^2	
1	Parking Bay	2.2	1.88	The design is well-within the lighting power allowance.

4.3:Energy efficiency calculation of the Barracks space illumination design:-

The firefighters' barracks located at the first floor of Behala Fire Station has capacity to accommodate about 25 fire fighters at a time. There are three shifts in a day. There is also a control room which receives all the fire accident calls of the entire South 24 Pargana area. The energy efficiency calculation of Barrack is as follows:

Table 4.3.1-Interior Lighting power for the fire station barrack spaces in comparison with LPD allowance as per ECBC Buildings-Space Function Method

Sl No.	Category Name	LPD Value (W/m^2) (Allowance)	LPD Value(W/m^2) (Achieved)	Remarks
1	Dormitory	9.1	4.84	The design is well-within the lighting power allowance.
2	Gymnasium	10.0	3.58	
3	Dining Hall	12.2	4.72	
4	Kitchen	6.3	3.7	
5	Rest Room	7.7	1.56	

4.4: Cost Calculation of Illumination Design of Behala Fire Station:-

The unit of electrical energy is the kilowatt-hour (kWh), found by multiplying the power use (in kilowatts, kW) by the number of hours during which the power is consumed. By multiplying that value with the cost per kWh, we can get the total energy cost.

Total energy cost = (Power in watts/1000) × hours operating × cost per kWh

Table 4.4.1: Cost Calculation of Illumination Design of Behala Fire Station

Spaces	LED Tube Light	Power	Consumable time per day	Energy per day	Unit per day
	Nos.	Watt	Hour/day	Wh/day	kWh/day
Ground Floor	66	1320	13.4	17688	17.688
1st Floor	57	1140	11.6	13224	13.224
2nd Floor	52	1040	8.0	8320	8.320
Compound Light	9	788	12.0	9456	9.456
Total energy used for lighting					48.688

- Total Unit used for Fire Station illumination per day is = 48.688 unit

  Considering the per unit tariff of electricity as Rs 7.00/-,

- Energy cost/per day = 48.688 x 7.00/- = Rs. 340.816
- Hence, total energy cost for illumination per month

  = 340.816 x 30 = Rs. 10225.00

CHAPTER 5: RENEWABLE ENERGY INTEGRATION OF BEHALA FIRE STATION

5.1: Renewable Energy Integration of Behala Fire Station :-

Solar power is energy from the sun that is converted into thermal or electrical energy. Solar energy is the cleanest and most abundant renewable energy source available, and there is a lot of scope of solar energy integration in buildings in India.

Every type of green energy is renewable, but some types of renewable energy are not green. Solar energy is renewable because the sun will always produce power, and it is also green because solar power does not emit greenhouse gases like carbon dioxide.

Solar technologies convert sunlight into electrical energy either through **photovoltaic (PV)** panels or through mirrors that concentrate solar radiation. This energy can be used to generate electricity or be stored in batteries or thermal storage.

FOUR Main Types of Solar Energy:-

- Solar Photovoltaic Plants. Solar photovoltaic systems are the most common type of solar energy system that produces electricity directly from sunlight. ...
- Solar Water Heating Systems. ...
- Concentrated Solar. ...
- Technical Passive Solar Heating.

Solar irradiation data is needed at all levels of solar power development, from initial government planning through to large-scale project development or the calculations needed to size smaller systems. In the past such data was provided at a relatively course level from NASA and other global providers, but more recently specialist models have been developed to more precisely calculate global horizontal irradiation (GHI) and direct normal irradiation (DNI) using primarily cloud cover data from satellites. A number of firms now offer such data as a commercial service. Based on this, it is possible to calculate average annual power output from a theoretical photovoltaic power plant (PVOUT), taking into account temperature, tilt, and the efficiency of the equipment being used (solar panels and balance of system components).

5.2: Solar Technologies & Techniques:-

Solar energy technologies refer primarily to the use of solar radiation for practical ends. All other renewable energies other than geothermal derive their energy from energy received from the sun.

Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute sunlight. Active solar techniques include the use of photovoltaic modules (also called photovoltaic panels) and solar thermal collectors (with electrical or mechanical equipment) to convert sunlight into useful outputs. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air.

Active solar technologies increase the supply of energy and are considered supply side technologies, while passive solar technologies reduce the need for alternate resources and are generally considered demand side technologies.

The global formula to estimate the electricity generated in output of a photovoltaic system is :

$$E = A * r * H * PR$$

E = Energy (kWh)
A = Total solar panel Area (m^2)
r = solar panel yield or efficiency(%)
H = Annual average solar radiation on tilted panels (shadings not included)
PR = Performance ratio, coefficient for losses (range between 0.5 and 0.9, default value = 0.75)

Source- https://www.dynamicslr.com/a-guide-on-how-to-calculate-solar-panels-output/

5.3: Solar Output Calculations :-

The simple formula for calculating solar panel output is:

Average hours of sunlight × solar panel watts x 75% = daily watt-hours

First, 75% accounts for all the above variables. Now, let's look at an example.

5.4: Solar Panel Calculation of Behala Fire Station :-

Total Energy use for Behala Fire Station only for Lighting illumination

is 50kWatt.

Average hours of sunlight × solar panel watts x 75% = Daily Watt-hours

6 x Solar panel Watt x 75% = Daily Watt-hours

So Solar panel Watt = 50/6 x 0.75 = 11.11 kWatt

That will be 11.11 kW rating solar panel is used for fire station.

Source- https://www.dynamicslr.com/a-guide-on-how-to-calculate-solar-panels-output/

Space required for 1kW is 10 m^2. Therefore, total space required for 11.11kW is 111.1 m^2 approximately. This can be done on the rooftop of the fire station building.

Chapter 6:
CONCLUSION

6.1: Observation and Summary:-

This thesis illustrates fire station illumination designs through a live case in Behala, Kolkata by using the DIALux software.

During the practical implementation of these designs however minor changes may occur due to practical site constraints faced during installation. Considering the possibility of such slight variations, in several instances, the measured values have been maintained at a lower level compared to the required level.

6.2: Conclusion:-

Satisfactory lighting conditions are basic for execution of visual assignments by staff in emergency sector, and poor lighting conditions may wind up in mistakes. It also suggests that biological lighting needs of humans are different from visual lighting needs, and lack of adequate light for provisions for controlling biological stimulation can result in performance glare and temperature problems. This is often particularly important for workers who work during night shifts, but is additionally relevant for workers who work for long periods of time without exposure to sunlight.

There's also strong evidence that shows that exposure to light helps in maintaining circadian rhythms and alertness among staff and, thus, supports in work efficiency. Unmistakably, a crucial objective for facility designers ought to be to satisfy human requirements for light and achieve an excellent lit condition. Building interiors are lit by a mix of daylight and electric lighting.

There's clearly a powerful preference for daylight over light bulb. However, additionally to natural light, light bulb is required in parts of various section, though the requirement for artificial lighting is reduced by efficient utilization of sunlight wherever possible. While making decisions regarding lighting, economic factors (initial costs, energy consumption, and maintenance) were taken into consideration.

6.3: Challenges Faced:-

Most of the inputs of lighting simulations are generally received in terms of AutoCAD file or documents or client's datasheet from where only the dimensions of the room are available and not the details like color of the walls, clean or dusty environment. Thus, the consideration of some standard values for the sake of calculation are included. But such calculation may differ from the actual value due to tolerances in calculation methods, testing procedure field condition (voltage, power supply and temperature variations). If the actual site condition does not meet with the input data, differences may happen and inconsistent result may be produced.

In some cases, the illumination levels specified in National Lighting Code- 2010 or relevant Indian Standards are not same as the values that are client specified. During illumination design calculation, scope of daylight utilization hasn't been considered due to lack of information about window parameters and other necessary parameters needed for daylight calculation. Hence, there is a huge scope of energy conservation if daylight had been integrated with the artificial lighting calculation.

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ANNEXURE