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A Study On-Analysis and Estimation of Illumination Levels in Construction Sites

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Abstract: **Lighting or illumination is the deliberate use of light to achieve a practical or aesthetic effect. Lighting includes the use of both artificial light sources like lamps and light fixtures, as well as natural illumination by capturing daylight. Day lighting (using windows, skylights, or light shelves) is sometimes used as the main source of light during daytime in buildings. This can save energy in place of using artificial lighting, which represents a major component of energy consumption in buildings. Proper lighting can enhance task performance, improve the appearance of an area, or have positive psychological effects on occupants.**
Indoor lighting is usually accomplished using light fixtures and is a key part of interior design. Lighting can also be an intrinsic component of landscape projects.
The construction industry has the largest number of injuries compared to other industries. Many projects are often hampered by underperformance. This seems to indicate the lack of illumination level management in the way we manage projects. Thus, reducing accidents and determining construction lights are extremely important. On the other hand, it is impossible to have any projects without lighting system. Thus, it is essential to have effective illumination performed in the construction projects.
Illumination plays a vital role in indoor and outdoor activities, and it is very necessary and essential factor to do work more accurately and work to do as per design within planned time and cost. Poor illumination could bring problem to worker as well as organization. By doing analysis and estimation, whether illumination is sufficient without any strain to worker thus creates risk free working environment and no strain to the worker who is involved in night with suitable amount of illumination at same time with proper height and distance.
The analysis was conducted in a under construction site whether illumination levels are as per the requirements and standards and whether there is any lapse there by suggesting them alterations and redesigning the space so that the illumination levels are as per the standards.

Key Words: Casting of slab , Grinding, Threading of bars, Concrete of structures, Drowning, Safety, Electrical, Mechanical, Traffic controls, Training, illumination level.

CHAPTER - 1
INTRODUCTION

Good lighting plays an important role in safeguarding health at work by enabling employees to perform their work comfortably and efficiently. It also allows employees to read clearly labels and safety instructions (such as those affixed to chemical containers) to ensure compliance with safety measures for the prevention of hazards. Accordingly, there should be an appropriate level of the light falling on the surface on which employees are working. Excessive contrast, strong glare and light flickering in their fields of vision are also inappropriate.

To ensure good lighting, the person responsible for a workplace should arrange for a suitable assessment on the lighting levels in the workplace. This booklet is intended to help the responsible person understand the basic concepts of lighting assessment and the measurement of lighting levels with a luxmeter.

Readers who are not familiar with lighting requirements at work are also advised to read the publication, produced by the Labour Department, “Guidelines for Good Occupational Hygiene in a Workplace” which provides information on lighting at work in general, and on the specific illumination requirements for various tasks / activities.

CHAPTER -2
Literature Review

Lumen: Lumen or luminous flux is a unit of light output. The different types of lamps available in the market are labelled with an output rating in lumens.

Lux: The quantity of light that falls on a work surface called luminance is measured in lux or foot-candles. The lux (lX) equals 1 lumen per sq-m and the foot candle (FC) equals one lumen per sq.ft. A light meter can be used to measure the luminance.

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Average rated life: The rated life of a lamp is the value in hours, at which half of a large group of that lamp fails under standard test condition. Any particular lamp or group of lamps may vary from published rated life. For fluorescent and HID lamps, the average rated life is affected by the burn cycle (the average time that a lamp is on before it is turned off).
Lamp lumen depreciation (LLD): Light sources lose their ability to produce light over time due to age. Lamp lumen depreciation (LLD) represents the percent of initial lumens remaining at 40 percent of rate life. LLD can be calculated by dividing the design (means) lumens by the initial lumen rating. For example, for a 32-watt T8 lamp that has an initial rate of 2,900 lumens and a design lumen rating of 2,610 LLD equals 0.90 (2610/2900=0.90). This means that the T8 lamp will retain 90 percent of its initial light output after 40 percent of its average rated life. Lumen depreciation is affected by the ballast used, line-voltage tolerances, and burn cycle.

Circuit watts: circuit watt is the total power drawn by lamps and ballasts in a lighting circuit under assessment. Installed load efficacy is the average-maintained luminance provided on a horizontal working plane per circuit watt with general lighting of an interior. Unit: lux per watt per square meter (lux/W/m^2).
Installed load efficacy ratio (ILER): the installed load efficacy ratio of the average-maintained luminance provided on a horizontal working plane per circuit watt to the target luminance on a horizontal working plan. Average maintained luminance is the average of lux levels measured at various points in a defined area. The ILER is an important indicator of lighting efficacy.

$$\text{ILER} = \frac{actual\ lux}{target\ lux}\ \text{W/m}^2$$

Luminous efficacy (LPW): is the amount of light (lumens) emitted by a lamp for each watt of power consumed by the lamp circuit, i.e. including control gear losses. Unit: lumens per circuit watt (lm/W). The higher the LPW, the more efficient is the light source.
Installed power density: The installed power density per 100 lux is the power needed per square meter of floor area to achieve 100 lux of average maintained illuminance on a horizontal working plane with general lighting of an interior. Unit: watts per square meter per 100 lux (W/m^2/100 lux).

Visual comfort probability (VCP): is a rating of lighting systems that is expressed as a percentage of people who, when viewing from a specified location and in a specified direction, will find the lighting system acceptable in terms of discomfort glare. The IESNA minimum recommendation of electronic office is 80.
Colour rendering index (CRI): colour rendering describes the effect a light source has on the appearance of coloured objects. The higher the CRI, the less distortion of the object's colour by the lamp's light. Colour rendering is measured on a scale of 0 to 100. The maximum CRI is 100 (natural sunlight). A CRI of 100 indicates no colour shift in the object when compared to a reference source. The lower the CRI, the more pronounced the colour shift will be. CRI values are only taken into consideration once a colour temperature range has been determined; however, the temperature effect cannot be discounted when assessing CRI. A low CRI indicates that some colors may appear unnatural when illuminated by the lamp. CRI values should only be compared between lamps of similar colour temperature.

Correlated colour temperature (CCT): the colour temperature is described in terms of its appearance to the eye- whether it appears "warm" or "cool". CCT is measured on a Kelvin scale, ranging from 1500 K (which appears red orange) to 9000 K, which appears blue. The greater the number, the cooler the lamp colour, the smaller the number, the warmer the lamp colour. Most light sources fall in the middle range, leaning either toward cool or warm. Generally, a lamp source should be selected to suit the colour scheme of the space; warm range lights for warm colour schemes and cool range lights for cool colour scheme.
Predominantly neutral or gray colour schemes can be lit with either to Accenture or draw the scheme one way or another, or may employ a more neutral, midrange light.
A standard incandescent lamp has a colour temperature of 2700 k and appears yellow white. When the incandescent lamp is dimmed, the colour of the light shifts to the red end of the spectrum, making reds appear more saturated while green and blues become greyed. A tungsten-halogen lamp may have a colour temperature in the range of 3000 to 3200k and appear brilliant white. These lamps render all colour very close to their actual hue.

CHAPTER – 4
METHODOLOGY

3.1 PREPARATION (before measurement)

Before starting the measurements, the following care should be taken:

- All lamps should be operating, and no luminaries should be dirty or stained.

There should be no significant obstructions to the flow of light throughout the interior, especially at the measuring points.

3.2 APPROACHES TO LIGHTING ASSESSMENT

There are basically two approaches to conducting a lighting assessment in the workplace: by means of a checklist and by lighting measurement.

3.2.1 LIGHTING ASSESSMENT BY CHECKLIST

This is a simple approach and usually does not involve measurements. For example, if the workplace is an office, the responsible person can follow the checklist provided in the publication "A Simple Guide to Health Risk Assessment – Office Environment Series – Lighting in Offices" produced by the Labour Department to assess the lighting condition there.

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3.3 ILLUMINANCE MEASURING INSTRUMENT

Illuminance is measured by a luxmeter, which is a handy instrument with a sensor for light detection. The measured illuminance is directly displayed in lux (lx). In general, luxmeters conforming to internationally recognised specification and there should be regular calibration, typically once a year, to ensure accurate measurement.

Fig: LUX METER

3.4 MEASUREMENT METHOD

- Identify the activity for lighting assessment.
- Place the light source in middle.
- Make 3 peripheries of 1m, 2m, 3m around the light source.
- Keep the lux meter 1m above the ground level.
- Take the lux meter first at 1m circle around the light.
- Do the reading at 6 different point of the periphery.
- Continue this process for rest of the 2 periphery.

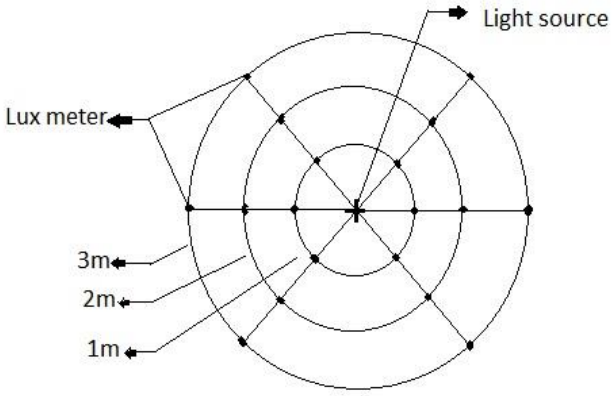
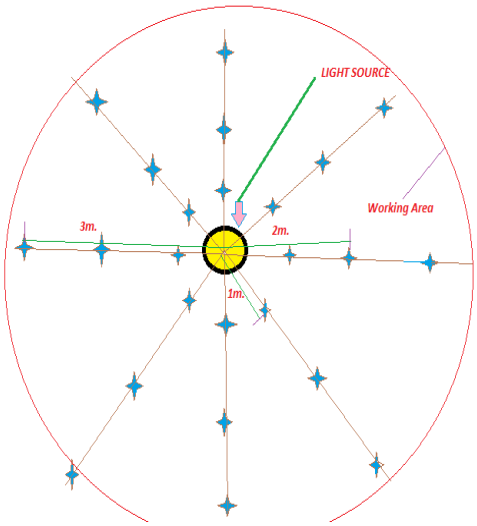


Fig: Light map



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CHAPTER – 5
ILLUMINANCE STANDARDS

IS 3646-1 (1992): code of practice for interior illumination.
Part 1: general requirements and recommendation for welding interior

This Indian standard was adopted by bureau of Indian standards, after the draft finalized by illuminating engineering and luminaries sectional committee had been approved by the Electro technical Divisions council.

The primary object of this code is to indicate the factor which should be considered to achieve good lighting.
It confines itself primarily to the lighting of working interior, such as factories, workshop, offices, commercial premises, public building, hospital, and schools, keeping two objects in mind, namely, to make the task easy to see and to create a good visual environment.
Lighting is good only when it is suitable in both quality and quantity for two purposes; for creating good environment brightness which is at the same time agreeable and beneficial to the user, and for permitting a high degree of efficiency in seeing whatever is of special interest.
Many of the recommendations holds good whether lighting is artificial, natural or combination of the two and, as far as possible, the lighting of a building is regarded as a service which should be maintained at a high standard whenever the building is occupied.
The conventional methods of planning described herein are still the subject of continual research and in special cases it is felt that planning should be extended to include consideration of illuminance patterns relating to the whole of the visual field.
Provision of good lighting system calls for co-ordination from the initial stages among the various parties concerned, namely, the architect, the consultant, and the illumination engineer.

Type of interior or activity	**Range of service illuminance in LUX**	**Quality class of direct glare limitation**	**Remarks**
Work bench or machine	200-300-500	2	Local or portable lighting
Concrete work	150-200-300	3	
Wall finishing	200-300-500	2	
Structural steel fabrication	200-300-500	3	Local lighting may appropriate
Welding shop	300-500-750	3	Local lighting is desirable
Assembly	200-300-500	3	Lighting of vertical surface is important
Mechanical Engg work	300-500-750	3	
Electrical installation	200-300-500	3	
Storage area	50-100-150	3	Avoid glare to vehicle driver

CHAPTER – 6
5. Reading and observation

The reading are taken from work site of an under construction mall, where various activity were performed at night. The work activities are interior type and provided with artificial portable lighting.

Site: TOD mall, Metro project Company: KEC International Limited

Table: 5.1

Interpretation –
The above table represents the lux-levels in a diameter of 1m, 2m & 3m for peripheral works, which concludes that the lux-level range are good enough for 1m & 2m dia but not for 3m dia. The means of 1m, 2m & 3m are coming out to be 297, 227 & 91 respectively**.**

S no.	Activity	Lux level (height of 1 m)		
		1m	3m	9m
1	concrete	100	83	32
2		212	104	45
3		206	96	33
4		73	77	25
5		175	79	28
6		160	75	23
	Maximum	212	104	45
	Minimum	73	77	23
	Average	154	85	31

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Photographs of the working activities.

[Note: As compared to IS 3646 Lux-levels, Table4.1]

Table: 5.2

S no.	Activity	Lux level (height of 1 m)		
		1m	2m	3m
1	Peripheral work	102	84	44
2		302	214	90
3		380	350	117
4		290	190	126
5		320	260	76
6		387	260	92
	Maximum	387	350	126
	Minimum	102	84	44
	Average	297	227	91

Interpretation –

Above table represents the lux-levels in a diameter of 1m, 2m & 3m for concrete works, which concludes that the lux-level range are inadequate for 1m, 2m, 3m. The means of 1m, 2m & 3m are coming out to be 154, 85 & 31 respectively.

[Note: As compared to IS 3646 Lux-levels, Table4.1]

Photographs of the working activities.

CHAPTER – 7
CONCLUSION

Provision of suitable work environment for the workers is essential for achieving higher
Production and productivity .After the process of analyzing and estimation of illumination levels for work site of a mall, we would like to conclude that by measuring illuminance level the insufficient and inadequate lighting of several activities came into exposure that may cause risk and strain to the worker. Even not all the activity shows the same outcome, some have excess lux level compared to the standard value that can also harm a worker.

This system can be made more efficient by installing modern age lighting fixture like balloon light tower & tripod lighting systems and designing the layout for placement of fixture. That will make the illuminance level of work site close in compared to the Indian standards for better work activity**.**

CHAPTER – 8
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