STUDIES ON IMPACT OF LIGHT ON ACADEMIC ENVIRONMENT

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MASTER OF TECHNOLOGY IN ILLUMINATION TECHNOLOGY AND DESIGN

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Certificate of Recommendation

*This is to certify that this dissertation entitled "**Studies on Impact of Light on Academic Environment**" has been carried out by **Nandita Rajsharma** under our supervision and be accepted in partial fulfilment of the requirement for the degree of Master of Technology in Illumination Technology and Design in School of Illumination Science, Engineering and Design, during the academic session 2016-2019.*

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

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

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

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CHAPTER 1
INTRODUCTION

1.1 INTRODUCTION

Lighting performs an important performance in our daily life. The level of illumination and quality required for general lighting of schools and other educational institutions is an important factor. The primary requirement for a student is to read and write like reading clear and bold printed matter to pen writing, atlas or precision paper work etc.. There may also be precision work such as art work, stitching work, etc which requires proper lighting conditions. The occupants may have to follow the board from a certain distance while the teacher will require having a general observation of the whole class during teaching, in such a case the contrast is important factor. Such far away observation requires for a high quality of illumination. It is also important that the increase of light level is necessary the age increases (older people will need better light levels for proper viewing). The light level required is also influenced by the area of the object to be observed, contrast and length of period of observing [1].

Higher light condition should be provided visual tasks by supplementary localized lighting. This is known as task lighting. When jobs with different necessary are to be executed at the same length of period in an area, the level of lighting condition should meet the most demanding job. If this requires for too much levels, then levels below than those may be applied, with localized supplementary lighting for certain jobs call for higher levels i.e. for drawing desk, black board, etc.these are all examples of task lights used to provide light level for the operation of a specific task. Vertical illumination is required for good viewing conditions, especially on chalk boards, display charts, etc. Generally, this is essentially fulfilled by the ambient lighting that is general lighting provided for work desk. Supplementary local lighting will require in certain cases. Fluorescent lamps are mainly used for indoor lighting. High intensity discharge lamps can be employed in physical exercise halls where color property is not important However for this study only LED lights have been used.

A student follows many materials with close observation for a long time period and so being present of glare will create strain on the eyes of the student affecting his mood. Where the eyes are desired to change/adapt various luminances for short period of time at frequent time gap causes discomfort and fatigue. To avoid discomfort, the visual environment should be good so the ambient lighting is also important. Walls, floors and ceilings should have a proper reflectance, then it is required a comfortable or good luminance design. It is required to adapt good visual condition; the lighting design should give proper luminance of work desk such that it should not exceed the task luminance required for performing the task. Lighting arrangement with direct glare should be avoided because students will frequently looks across the room, changing their field of vision from their work plane at many times as would be required to follow the teacher present in the classroom Luminance of the luminaires used in the design should be limited from normal field of vision. Articles' in notice or class boards, writing paper, and exercise copies etc require special awareness for visual comfort. Light color chalk over black or dark color boards and dark color pens over white or light color boards provide a appropriate contrast which is main criteria for good lighting. If the article has to observe from a certain distance, document used in copies, exercise books etc, should be matt and opaque (it stops glare); glossy sheet surfaces (create glare) should be avoided. Documents should have proper spacing between two lines, and print letter size should be proper.

There are many advantages of lighting design with Daylight if is properly controlled and distributed as a result of decreases consumption of energy, increases health condition, increases visual comfortness and enhances productivity [1]. But practically daylight is dynamic in nature and should not be allowed inside the class rooms due to Glare. These are avoided by uses proper shades, louvers or baffles and also by proper orientation of the building which block off excess light by reflecting it or absorbing daylight. So it is required supplementary artificial lighting system with necessary switching or controlling arrangements. Sensors can be used to detect the available daylight and turn-OFF or switch-ON the artificial lighting as and when needed. In this study an analysis has been done to study the effect of proper illuminance on the mood and attention of students present in a class. It was also done to find the appropriate light level which has the best impact on students in terms of providing good visual comfort and less strain and fatigue on the eye [2].

1.2 SCOPE OF THE THESIS

IS 3646-1 (1992) provides a range of average illuminance depending on the age of the applicants. However it does not say which level of illuminance is best for the mood of a student attending a class. The main objective of present study is to determine what level of illuminance is suitable so that students experience less fatigue and strain on their eyes; this will in turn help them to concentrate and focus in class and have a pleasant mood after the end of the period.

For this purpose a class room of dimension 10 meter x 8 meter was considered. In that room all the existing luminaires was replaced with 20W LED's and a class was conducted for a period of 4hrs. At the end of the class feedback was taken from the students on six aspects i.e. alertness, mood [3], sleepness, eyestrain, and headache. During the period of the test illuminance was varied between the ranges 225lux-350lux. From the feedback the most suitable ligh level for each student was recorded and the average illuminance was taken to be the ideal value of light level for an educational facility.

IS 3646-PART I (1992) is the Practice code of interior Illumination. As per this IS 3646 PART I, table1 page 19 , the Illumination level required for reading room is 200-300-500 Lux[4] .but there is no specification based on age group to determining the Optimum Illuminance level .

In this study the optimum Illuminance required has been specified from direct experimental and end user feedback, based on specific age group. The specified age group may help to reduced the maximum Illumination required to optimum level such that most energy saving can be done in conjunction with energy efficient modern luminaires.

1.3 CONTRIBUTION OF THE THESIS

To specify Illumination level based on age group of end users so that more energy efficient lighting can be designed for better energy savings.

This Study hopes to improve the learning environment for students so as to improve their attention and mood. This will make students more responsive to their studies and help them learn faster, thereby increasing effectiveness. It will also reduce stress and fatigue arising due to excessive lux in the room.

Also hopefully this will help reduce the amount of luminaires in the room and reduce cost associated of lighting design.

1.4 OUTLINE OF THE THESIS

Chapter 1: A brief introduction has been provided on the topic of this study. The scope of the thesis has been described to illustrate the aims and objective of study and also provided contribution of the thesis.

Chapter 2: Describes the background information about the experiment has also been discussed of the work. In this chapter describes preliminary concept related to lighting design such as Energy Management and maintenance, Lighting for Human Needs, Lighting design criteria, Some definition related to lighting design, Some characteristics of human behaviour that are affected by light, Maintenance Factor (M.F.), Utilization Factor ,types of lighting fixture, Lighting Systems, Light measuring instruments and brief description of different types of lamp etc.

Chapter 3: In this chapter describes how apparatus was set up in the classroom along with all information about the experiment .Once all the equipment was properly set up then described the procedure involved and the methodology of this experiment, with details as to how it was conducted.

Chapter 4: Describes the result of the experiment and anatysis that were done on the basis of experimental result.

Chapter 5: Contains the conclusion of the thesis .and future scope of work is also provided.

Chapter 6: Contains references that are used in the Thesis.

CHAPTER 2
BACKGROUND OF THE WORK

2.1 INTRODUCTION

Lighting mainly affects many levels of human activities for example studying, visual function, state of mind, and perception. Various studies have shown that the character and color of lighting can either reduce or increase students' visual ability and task performance. Comfortness of vision can affects student's behavioral activity, and attention and inspiration of students in the classroom also certain property of lighting can produce discomfort and reduce performance of vision and consciousness. These properties include glare produced by daylight and stroboscopic effect produced by fluorescent lighting. Other general lighting reason in many of the educational institution are an unusually poor efficient form of fluorescent tube lighting that the source of headaches, eyestrain, decreases visual abilities, few are excess illuminated with excessive fluorescent lighting and excess day lighting as a result glare is produced. Fluorescent lighting with cool white in educational room can enhance students mood and behavioral pattern also the students in the continuous (full) spectrum light classrooms are better, which causes improvement of performance. Radiation stress condition is the main reason of Hyperactivity. When the exposure of lighting radiation was minimized, behavior, activeness, motivation and performance will improve. The architectural design of schools or educational facilities can affect student's goal. Lighting of installation also affects physiological activity of human for example health, innovation, creativity, development, and performance. Various types of lighting have various properties for increasing educational room performance of student say improving visual function and that affecting attention, and encouragement, behavior, and educational performance achievement. For example, earlier cool white lighting by fluorescent lamp is recommended to illuminate in reading room for proper speed and accuracy. Artificial light in educational room affects student motivation, concentration, and cognition [5].

The lighting in a room should provide sufficient task lighting, provide suitable ambient lighting provide a sense of safety and security, should have the required CRI as per the requirement, should not provide glare, and should be energy efficient and cost effective. Based on this LED's have found wide range application in today's world. LED's have also been used for the purpose of this study as LED provides a wide range of advantages compared to the traditional lamps. LED's have good efficacy, good CRI, very good lamp life.

2.2 ENERGY CONTROL AND MAINTENANCE PROCESS

Light sources with good efficiency and luminaires must be cautiously chosen to provide the proper quantity of light, comfortable lighting. Lighting control methods such as multi-level switching, motion sensors should be provide for better lighting design.

The lighting engineer should produce written report for the maintenance process of the lighting installation. Instructions are

(1) Cleaning schedule and maintaining schedule for lamps and luminaires,

(2) The relamping or replacement schedule, and

(3) The ceiling surface, wall surface maintenance including repainting such information is not available then decreased illumination of the room for the same amount of energy [6].

2.2.1 DESIGN CONSIDERATION FOR GOOD LIGHTING QUALITY

Light sources with good efficiency can provide good visual perception, interpersonal skill of communication and our reaction. Poor lighting quality are not only uncomfortable but also confusing and decreases visual performance.

The main purpose of good or efficient lighting is to provide the fulfillment or requirement of peoples need. Lighting designer's main motto is to fulfill the needs of the people using the installation with the environmental and economical analysis in short good lighting quality depends on mainly three aspects namely human needs, Economics and environment and architecture [6].

2.2.2 LIGHTING FOR HUMAN NEEDS

There are often present some positive and negative effect of lighting. The positive effect of lighting is that it directly affects the human life: health, wealth, and safety. It is also necessary to reduce the global warming by reducing carbon dioxide emission and major emission of carbon dioxide comes from generation of electricity. So now a day's energy efficient lighting design plays important role in human life [7].

The people's requirement is very complicated. Main requirement is visibility .Once the objects are visible in the board; students can write a note, follow the facial expressions of a teacher etc. Figure 2.1 shows that visibility of students depends on task to be perform; state of mind or mood and ambiance; optical comfortness, fitness, security and public relationship.[8]

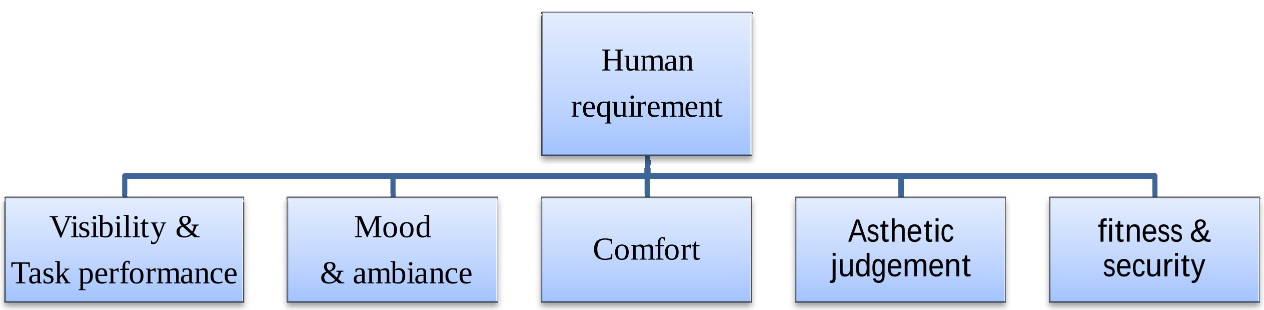


Figure 2.1 Human needs

I. VISIBILITY AND TASK PERFORMANCE

Visibility is the capability to get facts from the field of vision. It is most important condition for good-quality lighting. Contrast, luminance, time, and size are the other variable that affects the visibility of objects. Visibility depends on occupier's age for aged occupier; task should be larger and brighter than younger.

II. TASK PERFORMANCE

Task to be performed is main criteria for occupier. Task performance and visual performance is mainly based on visual performance.

III. MOOD AND AMBIANCE

Mood and atmosphere of student of educational facilities depends on the lighting environment. Priority, contentment, free from tension and anxiety, and encouragement are affected by lighting. The state of mind that can indirectly affects the task performance.

IV. COMFORTNESS

Visual or optical comfort is main human requirement that can effects task execution, fitness and security, state of mind and ambiance. Due to glaring lighting installation, occupier gets fatigued.

V. AESTHETIC JUDGEMENT

Lighting present should be aesthetically appealing to provide a pleasant ambiance. Aesthetic judgment needs differ from emotional responses. The design should be such that it prove god quality of lighting as well as visually appealing

VI. HEALTH AND SAFETY

Designer should consider the following glare, uniformity, vertical illuminace, sleepness, eyestrain, headache, sufficient level of average illiminance etc.

VII. ECONOMICS AND ENVIRONMENT

Design should be such that it has minimum installation cost, maintenance cost and running cost. Sometimes it is better to use good quality fixtures during installation which may have high price however, the running cost will be significantly lower and hence the high installation cost will be recovered.

2.2.3 DESIGN CRITERIA OF LIGHTING

To get the good efficiency of a lighting space, it is most vital factor to select proper luminaire according to the requirement of the system. There are seven basic rules for basic energy efficient Indoor Lighting Design process [9] [10].

I. Identification of requirement of lighting
   a. Requirement of Illuminance level
   b. Glare
   c. Mood of the space to be lit
   d. Light direction
   e. Day light availability

II. Method of lighting
   a. Mounting type of luminaire e.g. recessed, surface, direct, indirect, up-lighting etc .It is important to use daylight to minimize the need for artificial light if available.

III. Selection of lighting equipment
   a. Light output of the luminaire
   b. Total input wattage of luminaire
   c. Efficacy of Luminaire
   d. Life time
   e. Physical size of lamp
   f. Glare
   g. Color of emitted light of lamp
   h. Electrical characteristics of lamp
   i. Control gear
   j. Suitability for operating environment of the installation
   k. Thermal management
   l. Polar curve

IV. Calculation of lighting parameter

   a. Manual Calculation

      1) Lumen method

   b. Three dimensional method

      1) Dialux Software

   c. Visualization

V. Selection of control element

      1) The energy efficient lighting system is depends on use of control gear, light source and fixture.

VI. Selection of luminaire

   1) Good mechanical and electrical construction
   2) Availability of proper screening to minimize discomfort glare
   3) Proper heat dissipation facility to avoid overheating of lamp
   4) Easy installation, cleaning and maintenance facility

VII. Inspection of installation

2.3 SOME DEFINITION RELATED TO LIGHTING DESIGN

Lighting design should be easy and the choice of the lighting item for a system should be easily available in market. To achieve cost-effective and energy-efficient design selection of electrical product is important. Lighting design plays an important role to create pleasant, comfortable environment and nullifying unusual effects on occupant's wellness and performance [11].

This means that there are no definite rules for lighting design as well as no ideal solution present to solve the problem related lighting design. To provide or improve good lighting design, experience, proper planning, analysis and self judge are important.

2.3.1 ILLUMINANCE

It is the ratio of the luminous flux (Φ) that emitted from the lamp and incident on the plane to the area (A) of that plane containing the incident rays [12]

I. It is a scalar quantity.

II. It will give the fundamental laws of illumination.

2.3.2 LUMINANCE

It is the luminous intensity emitted by a plane in a particular direction per unit of apparent area in that direction. Luminance can vary in different directions [13]. Figure 2.2 shows the representation of Lux and Luminace.

Luminance depends upon

I. Reflection of plane (matte/ glossy)

II. Direction of light rays ;

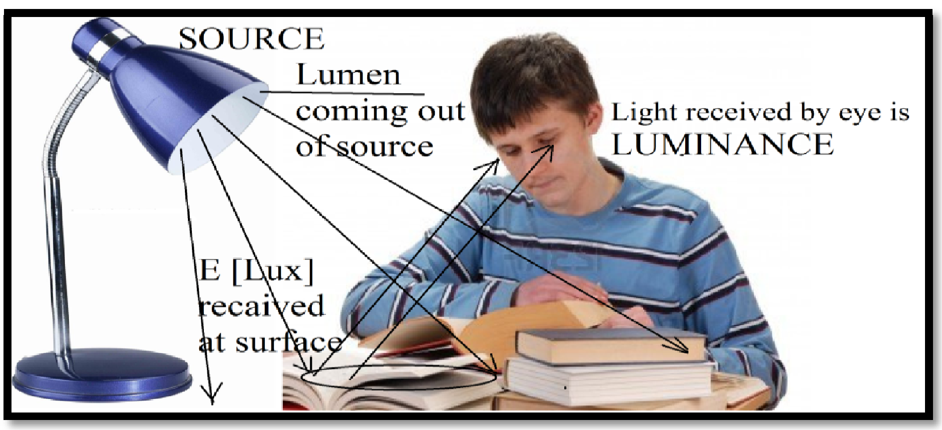


Figure 2.2 Representations of Lux and Luminance [14]

2.3.3 UNIFORMITY

It can be considered into two planes one is on the task plane illuminance and another on the surrounding plane illuminance [15]. If the illuminance changes suddenly between two areas then distraction & dissatisfaction of vision occurs. So,

$$U = \frac{E_{\min}}{E_{avg}} \geq 0.8$$

2.3.4 COEFFICIENT OF UTILISATION (COU)

COU refers that the % of luminous flux emitted from the lamp which reaches the work plane and are used to determine number of Luminaires required for lighting a room. COU is very powerful tool and are frequently used by lighting designer [16].

It will vary as a function of three factors:

I. Physical characteristics of luminaire.
II. Room proportion.
III. Percentage of light that reflected by room surfaces.

2.3.5 MAINTENANCE FACTOR (M.F.)

M.F is defined as the ratio of the average illuminance available in the working desk after use of certain time period of a lighting system to the initial average illuminance at same condition of lighting system, considering all losses including lamp lumen maintenance [17]. M.F is obtained by multiplying all the following parameters.

R.S.M.F (Room Surface Maintenance Factor):

This factor considers the effect of dirt and dust deposition and other reason that causes decrement of reflection property of room surface.

L.M.F (Luminaire Maintenance Factor)

Luminaire Maintenance Factor considers the effect of dust and dirt deposition on the luminaire surface.

L.S.F (Lamp Survival Factor)

Lamp Survival Factor considers the effect of the non performance of light sources during the period of maintenance.

L.L.M.F (Lamp Lumen Maintenance Factor)

Lamp Lumen Maintenance Factor considers the effect of the lumen depreciation of the lamp during the period of maintenance.

$$E_{maintained} = E_{initial} \times \text{Maintenance Factor}$$

Where,

$E_{maintained}$ is maintained illuminanace at working level : $E_{initial}$ is initial lumen from luminaire

2.3.6 UTILISATION FACTOR

Utilization Factor is defined as the ratio of total lumens received on the working plane to the total lumens emitted by the lamp [18].

Utilization factor = Lamp Lumen received on the working desk / Lumens emitted by the source

2.3.7 REFLECTANCE

Reflectance refers as the ration of the reflected luminous flux to the incident luminous flux [19] .To know the Effect of different wall colors changes the reflectance of light that influences the indoor lighting quality on classroom and office and light scenes on indoor lighting quality on office workspace [20] . In working interior, to reduce the contrast between luminaires and surrounding ceiling, the ceiling reflectance should be as high as possible. In order to avoid that the ceiling may be otherwise appear too dark, the ceiling light level should not be lower than l/l0th of the task Illuminance. In order to obtain a proper balanced luminance distribution, the ratio of the min. to the average Illuminance should not be less than 0.8. The average Illuminance of the general installation of a working are should normally not be less than l/3 of the average Illuminance of the task area(s) [21].

2.3.8 CONTRAST

It refers to the difference of luminance or color of an object compared to that of surroundings. Luminance contrast (C) is the difference between object luminance (L_o) and background (L_b) expressed as a portion of background luminance (L_b) [22]

$$C = \frac{L_0 - L_b}{L_b}$$

Surface contrast is associated to contrast b/w an object (print) and its background (paper); Variation of Luminance is as shown in figure 2.3

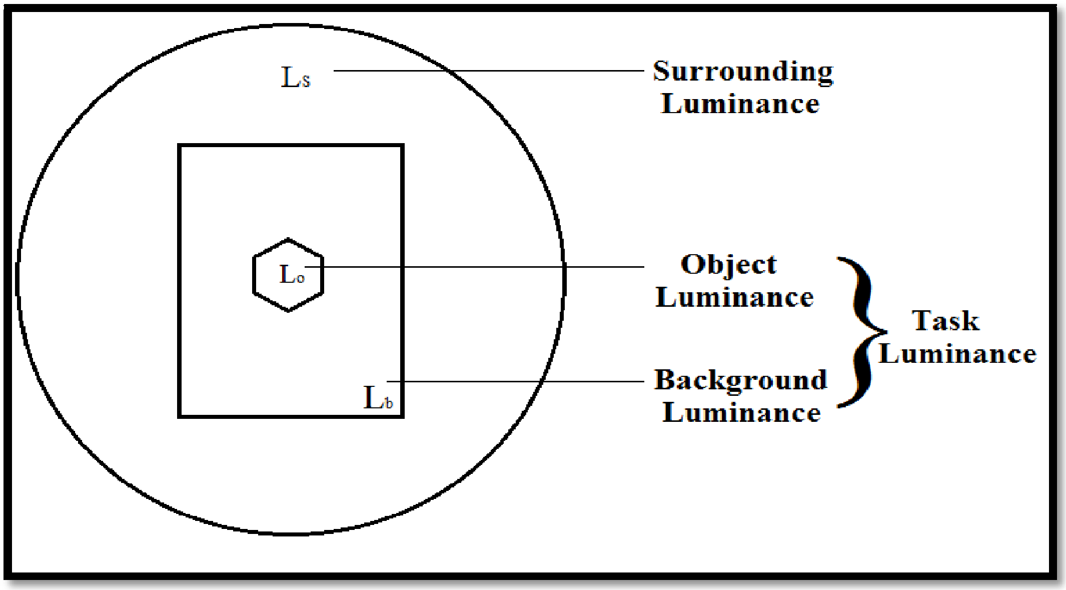


Figure: 2.3 Variation of Luminance [23]

I. If $L_s >> L_t$; Then Task visibility is lost

II. If $L_s << L_t$; Then Task visibility is high then creates discomfort and

III. If $L_s / L_t \approx (0.1 - 1)$ Then this is for exact visibility & comfortable vision

2.3.9 GLARE

It is the violent bright source of light that appears in the field of view provides discomfort and loss of visibility called glare i.e. Glare creates when one part of the visual part is great brighter than the other part of the field of vision [24]. For a perfect luminous environment, Occupants must not see any glare because it restricts the visual comfort and decreases the ability of the eye to identify the exact main task. Proper position of light is shows in figure 2.4. Pattern glare from window blinds produces visual stress, headaches and migraines [25]. Physical discomfort / discomfort glare is uncomfortable but tolerable & would not stop occupant's main task But visibility / disabilities glare is intolerably strong & can be so effective that the worker is compelled to stop occupants' main work.

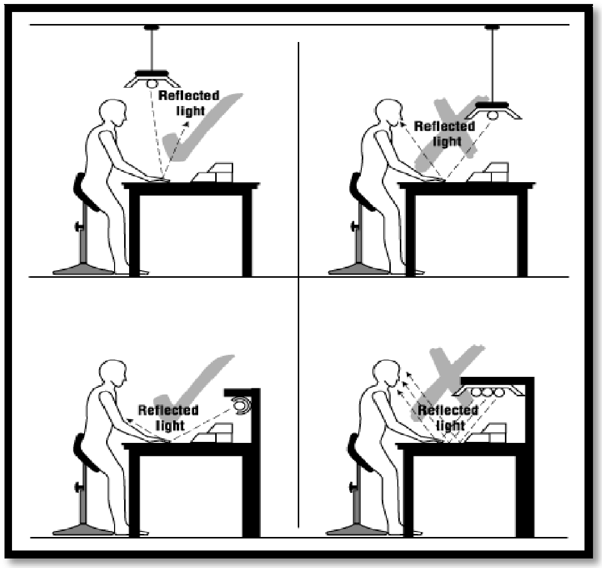


Figure: 2.4 Position of Light [26]

But visibility / disabilities glare is intolerably strong & can be so effective that the worker is compelled to stop occupants' main work.

A. TYPES OF GLARE

a) Direct glare is due to the presence of lamp with high brightness on the surface of vision – direct Sunlight)

b) Indirect glare is due to reflected bright light in the path of view light reflected from shinny surface.

c) Discomfort glare is more common in outdoor lighting may be experience by floodlight/ spotlight. Interior workplaces may have discomfort glare usually creates directly from bright luminaires / windows If discomfort glares can be eliminated then disability glare is not so important aspect.

B. EVALUATION DUE TO DISCOMFORT GLARE

I. Investigation to find the mechanism of glare & effects on human organs:

II. Investigation to find a logical relation between glare sensation photometric & geometric characteristics of light

III. Design from the general point of view, data in control of glare.

First try is not successful then second try is able to derive some formula for single source but complex for multiple sources to evaluate glare. But the third try develops glare prevention methods.

i. British glare index s/m.

ii. Visual comfort probability (VCP) method.

iii. CIE unified glare rating (UGR) s/m [27]

2.3.10 QUALITY AND QUANTITY OF LIGHT

Characteristics of Light emitted from the lamp source are defined by two parameters one is quality and another is quantity. These two parameters of illumination are inter-related. A lighting design should prepare the appropriate illuminance for the task to avoid reflection cause glare, veiling reflections and huge luminance in the field of vision may causes reduction of visibility and as a result of low light quantity. So control of direct glare; horizontal and vertical illuminance; light distribution on surfaces; and light distribution on the task plane (uniformity) are the most important factor. The term “Quality” related to the luminaire used in this experiment. It is the property of lamp. The quality of the lamp depends on two parameters:

a) CORRELATED COLOR TEMPARATURE (CCT)

It is the Color characteristics of light all lamp source. We should be aware of the Black-body radiator (BB).When a perfect black body is heated to a uniform temperature. The radiation of all possible “λ”, coming out through its fine hole, called a BB radiator. When the temperature of BB is raised ,it radiates EM spectrums is visible spectrum in the following fashion - Red, Orange, Yellow, Bluish White finally white-as seen in next BB curve. Therefore color temp. of a source can be determined in connection with a BB radiator. For e.g. BB is heated to 3000 K, it gives the light of incandescent so color temperature of incandescent lamp is 3000 K. To know the color temperature to a lamp, following two items must be same with black body radiator

I. Color appearance (chromaticity)
II. Special power distribution ((SPD) [28]

b) COLOR RENDERING INDEX

Color rendering relates to the way objects appear under a given light source. The measure is called the "color rendering index", or CRI. A low CRI means the viewing things looks not natural under the light emitted by the lamp. While a light with a good C R I color of object looks more natural. For "warm" color temperature light the reference point is GLS lamp. For cool color temperature the reference is light emitted from sun. The following Table 2.1 shows the typical values of C R I of different Lamp [29].

Table:-2.1 Variation of lamp CRI [30]

CRI	Lamps	Applications
20-22	HPSV Lamp or SON lamp	Road lighting
60-63	4 ft Fluorescent tamp	Office or commercial lighting
82-86	CFL (warm white)	Residential building
84-85	Premium 4 foot fluorescent tube	Retail shop
85-95	LED lamp	Residential, office, shop
98	Incandescent lamp	Residential building

Lights with CRIs 80 or greater are mostly considered as high CRI. The CRI rating should be compared when the lamps have same color temperature.

c) QUANTITY

The amount of light available on the working desk is the Quantity of light .Quantity of light can vary for different experiments. The illuminance of the room was varied from 225lx to 350lx with interval 25 Lux.

2.4 CALCULATIONS OF LIGHTING

For lighting calculation manufactures data sheets are required.

To calculate Average illuminance on the work desk ,

$$E_{av} = \frac{\Phi total \text{ x } U.F \text{ x } M.F.}{A}$$

Here,

E_{av} = Avg. Horizontal Illuminance

Φ = Total lumen coming from source in Lumens.

A = Area of space in meter^2

UF = Utilization factor

MF= Maintenance factor

This is valid when occupants placing 0.76-0.91 above floor and while standing 0.86-1.1 m above floor. [31]

2.5 TYPE OF FIXTURE

Health, well-being and cognitive performances may vary by changing the proportion of direct and indirect quantity of light. The photometric measurements confirm that the respective proportion of direct and indirect lighting have a separate impact on the illuminated ambiance. [32]

There are many types of lamp source fixtures are available to direct the light in many paths. The ambiance of rooms, areas and objects greatly depends on the types of lighting and lighting fixtures. Many types of light fixture is suitable in every design condition. The quality and amount of light is required for a definite work place or desk will decide which fixture is most appropriate.

I. DIRECT LIGHT FIXTURE

Direct light fixture creates an uniform illumination on the horizontal task plane or desk. Direct light have an axially symmetric light distribution emitted downwards for illuminating the usable surfaces. It projects 95 to 100 % of total light downward on task area or work desk. Direct lighting produce shadows. The value of uniformity on the task area increases as the height of enhances or the beam angle increases. Directed light produces good quality of form as well as good texture of surface. Efficient use of energy can be possible by direct lighting. Secondary glare must be considered at the working area. It is seen from above discussion that use of that type of fixture have many advantages and disadvantages. In other words proper utilization of energy can be possible. It is suitable for zonal illumination and it creates attractive illumination, 3-D object lighting etc.There are many disadvantage say it creates harsh dark shadow etc.

Typical diagram for direct lighting is as shown in figure 2.5.

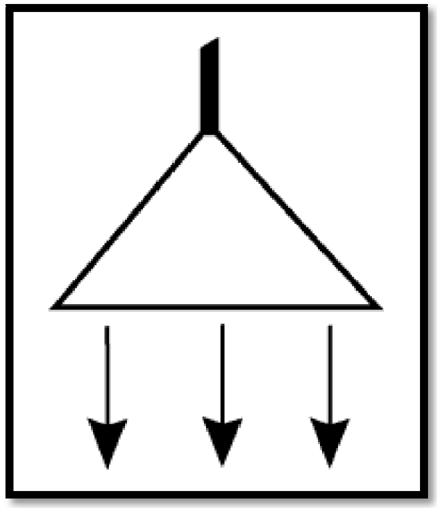


Fig. 2.5: Direct Lighting [33]

II. DIRECT – INDIRECT FIXTURE

Direct-indirect light fixtures refer to a use of both lighting with respect to the horizontal position or working area. The surface of ceiling, wall and other acts as surface of reflection . Light distribution in up and down directions is equal. Fixture of this type reflects light off the ceiling surface of ceiling and different surfaces of room. Few amount of light is produced in the horizontal plane so direct glare is frequently diminished. These are mainly used in "clean" production areas. Schematic diagram for direct-indirect lighting is as shown in figure 2.6.

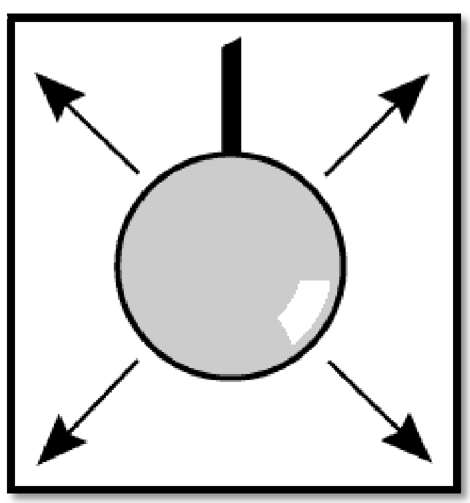


Fig. 2.6: Direct - Indirect Lighting [34]

III. INDITECT FIXTURE

These types of fixture are used as a secondary reflector. Here wall, ceiling or different surface of room acts as secondary Refector. It directed 85 to 98 percent of the light upward. The ceiling surface and walls surface should be dust free and high degree of reflective so that the light can reaches the work desk. This fixture provides the most even illumination and produces small amount of direct glare. These types of fixtures are generally used in office and commercial building. Compared to first type of fixture illumination, a comparably high lumen is necessary for obtaining the same light on the working areas. Typical diagram is shown in figure 2.7.

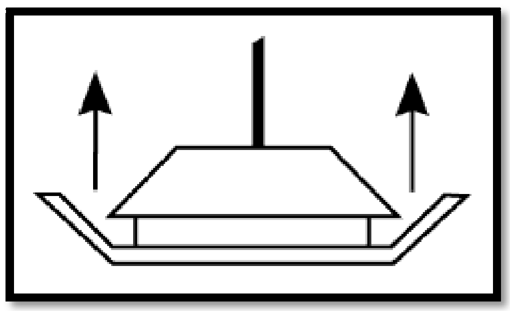


Fig 2.7: Indirect Lighting [35]

Indirect lighting usually reduces screen glare in many places where visual display is used. Because screen glare is rarely properly controlled by indirect lighting [36]

IV. SHIELDED FIXTURE

Shielded light fixture uses Len, louvers and diffusers to shade the lamps from direct field of vision by the occupant. So it helps to prevent glare .Figure 2.8 shows different types of louvers.

Translucent or partially-transparent shades or covers made mainly plastic or glass. To control the glare and shininess, this covers are used on the both sides and bottom sides of the fixture.

Lenses are clear or transparent glass, or plastic covers. The prisms are used in lens to give definite direction of light. Len are mainly glass (transparent or clear) plastic cover. To shield the lamp from direct field of view, louvers are used. Louvers are acts as baffles that redirect the light. To control the amount of light and brightness, baffles are used. Parabolic louvers with parabolic shape are generally used grids that focus and spread light properly [36] .

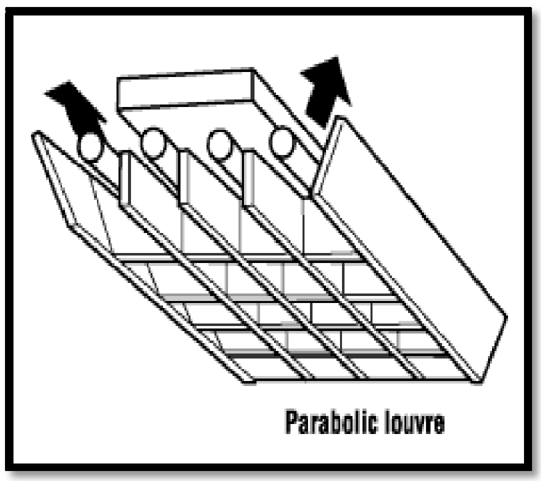


Fig. 2.8: Shielded Lighting [36]

2.6 LIGHTING SYSTEM

Lighting can be done by three ways

I. General Lighting

II. Localized General Lighting

III. Local Lighting

I. GENERAL LIGHTING

In General lighting system, lighting is provided by a regular array of luminaries. In majority of installations general direct lighting is used. It provides the required horizontal illumination level and uniformity in the total areas. Such a system can be used in any place say office and education or institution lighting. Figure 2.9 shows a general lighting scheme.

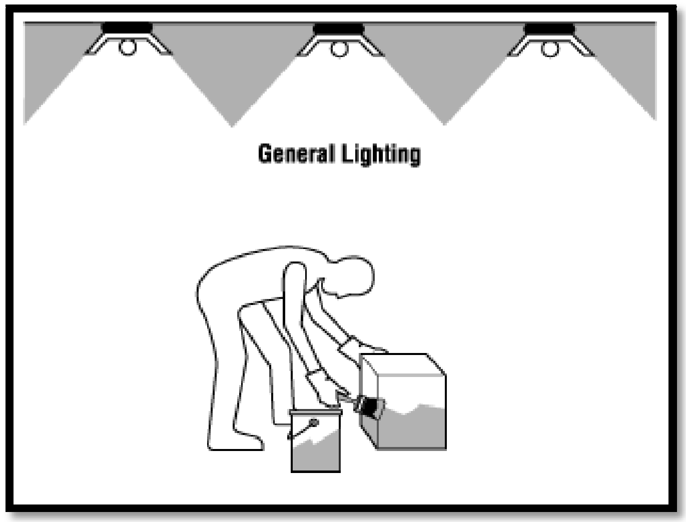


Fig 2.9: General Lighting [37]

II. LOCALIZED GENERAL LIGHTING

In Localized General Lighting system, lighting is provided by an irregular pattern related to the working zones in offices; energy savings can be done by using localized general lighting. This lighting type of lighting uses localized general lighting fixtures with general fixtures to enhance level of Illuminance definite work.

Here this type of lighting consists of ceiling lamp that depends on the lighting behavior of the apparatus and the lighting requires of each working area. This type of lighting is used for those installation or work places that will need a high light level .The luminaries should be designed in such a way that it should give the recommended illumination level at workstation and correspondingly proper luminance in unused working areas or circulation area. In circulation areas the lighting level can be reduced to fifty percent of level of light level for visual task .This system saves energy than general lighting but it has certain disadvantages. The main disadvantages are that as the layout in office changes the lighting arrangement must changes. Figure 2.10 shows a localized general lighting scheme [38] .

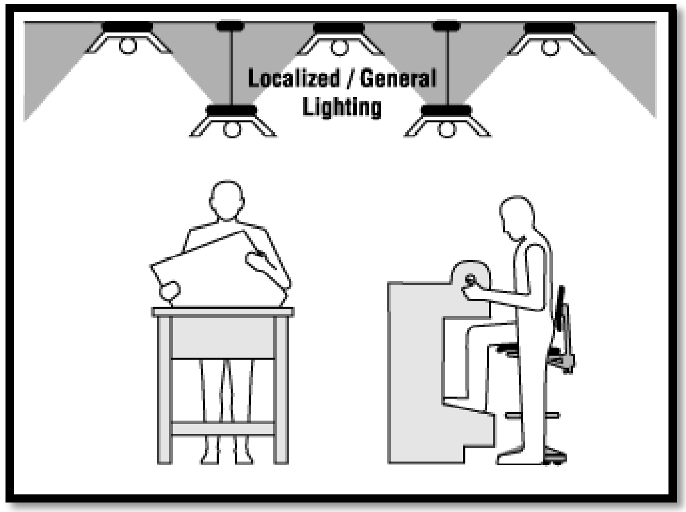


Fig 2.10 Localized General lighting [38]

III. LOCAL LIGHTING

In local lighting system, lighting is provided by additional luminaries provided at a small distance from a visual task, which illuminate only a limited area or limited zone. Local lighting /task illumination enhances illumination levels over the working desk and just surroundings area as shown in figure 2.11. Light level of Local lighting can be controlled or adjusted by users and it is flexible for other user. [39] This lighting scheme is as shown in figure 2.11.

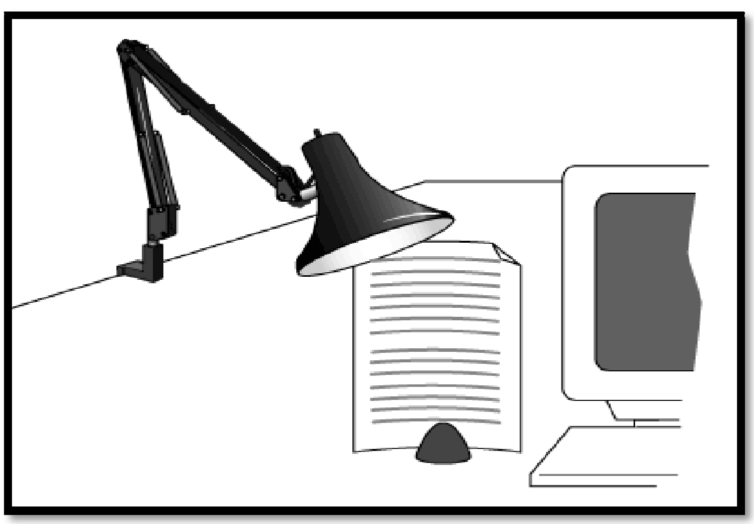


Fig 2.11 Local Lighting [39]

2.7 HUMAN BEHAVIOUR DEPENDS ON LIGHT

In this study, the effect of illuminance that affects the mood, attention, visual comfort, eyestrain as well as fatigue on the eye of the occupants.

Different light spectrum also affects pressure, body pulse, rate of respiration, brain functioning, and biological clocks. So lighting in every moment effects every situation of human physical system. It is already explained that light therapy is efficient for treatment of many selected disorders, sleepiness problem etc. [40] [41]

I. Alertness

Alertness refers to the light level which is sufficient to do any work. To measure Alertness the scale used is good, moderate and poor.

II. Mood

Mood refers to lighting required to set a favorable temporary state of mind. To measure mood the scale used is good, moderate and poor.

III. Sleepness

Sleep is the most important biological requirements for humans' for doing daily work. The lighting quality and amount of light that affects the quality/level of sleep at night in human i.e. sleepiness is to determine whether a person stays interested and active or being sleepy at that light level [42] To measure sleepness the scale used is good, moderate and poor.

IV. Headache

Headache is to determine how lighting affects health directly at that light level. To measure eyestrain the scale used is moderate, absent and poor.

V. Eyestrain

Eyestrain is another factor related to health directly at that light level .It considers pressure level on eyes. To measure eyestrain the scale used is moderate, absent and poor. Comfort of visual perception effects indirect on mood as result that effect on realizations of fitness and well-being [43].

2.8 MEASURMENT OF LIGHT

Light levels can be measured by using following methods as shown below:

I. DETECTOR

The solid state detectors are commonly used now a day. There are many types incorporating Different type of semi-conductor materials are used to work from UV to IR spectrum including visible spectrum. All these are operating in photovoltaic mode and short-circuited current is measured. It is linear and response of detector is very fast without using any capacitor. Capacitor is used to get smooth response of detector and have long time constant. This type of detector is independent of temperature variation. It gives most accurate result when operating near calibration temperature. Visible spectrum is measured by using special matched filter. This filter is used because the measured light is same as perceived by eye. Photopic response can be obtained by using filter [44] .

II. ILLUMINANCE METER

The most common light measuring instrument is Illuminance meter. Light is incident over a half hemisphere. Meter receives light from many sources at the time of measurement so it has very good cosine response so reading may vary due to stray light. In ordinary photometers, photopic filter and cosine diffuser are not present. Efficiency of this type of meter is very poor when operating above 70° Photometers need to be calibration of photometer is required from reputed laboratory to obtain proper reading

Figure 2.12 Lux meter [45]

III. LUMINANCE METER

Luminance meters uses similar component as meters and an optical system is used to see the object image on it. Most expensive luminance meters uses color filters. Color filter is used to measure the color temperature of the object and also luminance.

2.9 DIFFERENT TYPES OF CONVENTIONAL LAMP

Some light that has been used from ancient time like kerosene, vegetable fats etc. these type of lighting used during pre electrical lighting operation .The limited Illumination is provided by this type of lamp service hampered the reading capabilities of majority of people during night time hence reading work was very difficult.

After electrical lighting is introduced the study hours of the student who was interested to read became extended without much strain on the eyes**.**

2.9.1 INCANDESCENT LAMP

An incandescent lamp produces light when electric current passes through the filament and emitted light. Inert gas is used inside the glass or quartz bulb to reduce the blackening of glass bulb and increases the life of lamp.

Advantages of GLS lamp are less expensive, easy operation and have good color rendetion property but disadvantages are low efficacy and short life. The GLS lamp was primarily used for reading room, libraries, house Illumination etc. But the light of Incandescent lamp is warm white that causes headache and eyestrain and was very inefficient. Figure 2.13 show the photograph of Incandescent lamp and Figure 2.11 shows the photograph Spectral Power Distribution of Incandescent lamp [46].

Figure 2.13 Incandescent lamp [47]

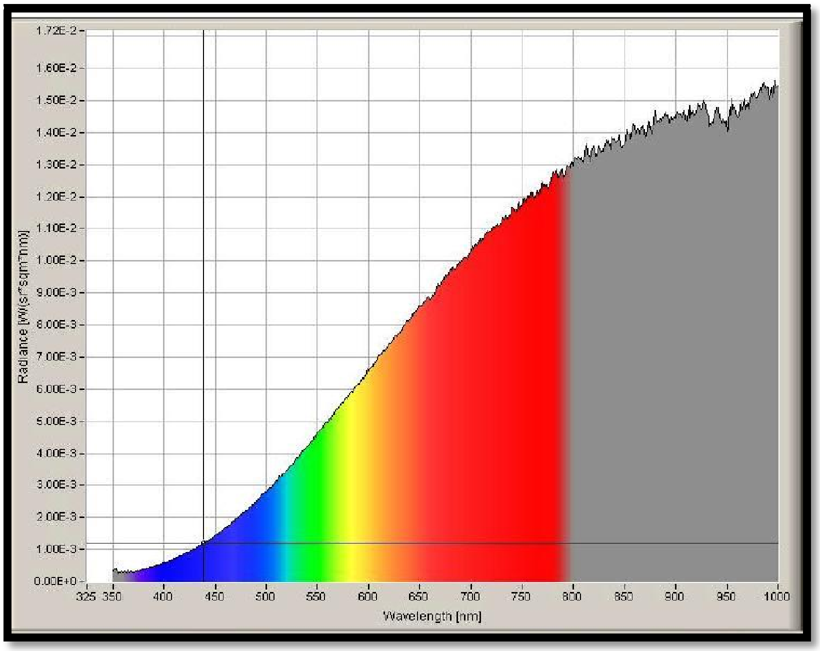


Figure2.14 Spectral Power Distribution of Incandescent lamp [48]

2.9.2 HALOGEN LAMP

Halogen gases (iodine or bromine) are used to increase both light output and life of Incandescent lamp. Halogen gas can able to reduce the problem of lamp blackening because the halogen gas reacts chemically with the evaporated tungsten to prevent blackening of glass wall and increases the life of lamp.

The Halogen lamp were also used for reading room, libraries, house Illumination etc. But the light of Halogen lamp is warm white that causes headache and eyestrain and was very inefficient, costly and sensitive lamp (cannot be touched with bare hands). 2.15 shows the picture of halogen lamp [49]

Figure 2.15 Halogen lamp [50]

2.9.3 HIGH INTENSITY DISCHARGE LAMP

It is the gas-discharge arc lamps which produces light when an electrical voltage applied across it. Occurs fused quartz or fused alumina arc tube is used.

a. HIGH PRESSURE SODIUM VAPOUR LAMP

In HPSV, xenon, sodium and mercury are filled inside the arc tube. When electric potential is applied, Ionisation gets start at the time of application of electric power across the electrode. Xenon is used to start discharge. Mercury and sodium vaporizes due heat generated by xenon discharge. The mercury vapour enhances pressure inside the tube and sodium vapour produces light. As the warm up time of the lamp is more and color rendetion property is not satisfactory so that HPSV lamp is used in outdoor lighting. Figure 2.16 shows the photograph of high pressure sodium vapour lamp [51].

Figure 2.16 high pressure sodium vapour lamp [52]

b. METAL HALIDE LAMP

A gaseous mixture of vaporized mercury and metal halides compound are used in the discharge tube of metal halide lamp .Halide compound mainly bromine or iodine are used. Mercury vaporizes after the application of electric voltage and emitted white light. Figure2.17 shows the photograph of Metal Halide lamp [53].

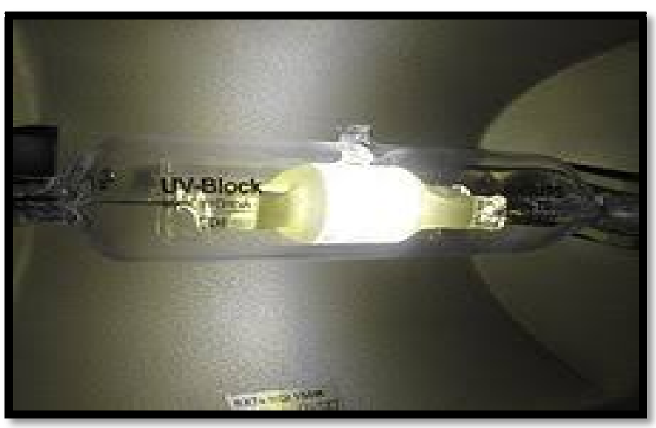


Figure 2.17 Metal Halide lamp [54]

c) LOW PRESSURE SODIUM VAPOUR LAMP

A LPHV lamp contains borosilicate glass tube. The tube contains solid sodium, neon gas (small amount) and argon gas. Penning mixture is used to start the gas discharge within the tube at low temperature. At first when discharge starts it emits red or pink light due to neon gas and warms the sodium and sodium vaporizes. This lamp produces monochromatic yellow light then after few times, to warm the sodium metal; within a few minutes as the sodium metal vaporizes. Efficacy of this lamp is good but due to poor color rendering index, this lamps are used in lighting in parking area, street lighting etc.

2.9.4 FLUERESCENT LAMP

Fluorescent lamps are low pressure mercury vapour lamps which emit Ultra-Violet radiation after discharge which converts to visible spectrum in presence of phosphor coating. It requires a ballast and starter for operation. Starter provides stating high voltage pulse to start the discharge and ballast maintains the current through lamp during operation.

Advantages of fluorescent lamps are more efficient than GLS, longer life span and disadvantages are not environmental friendly, not easily dimmable. Fluorescent lamp are used for general reading purpose because much efficient and smoothing to eyes and long reading home work can possible. Figure 2.18 shows the photograph of fluorescent lamp and Figure2.19 & 2.20 shows the photograph of Spectral Power Distribution of different fluorescent lamp [55].

Figure 2.18: Fluorescent lamp [56]

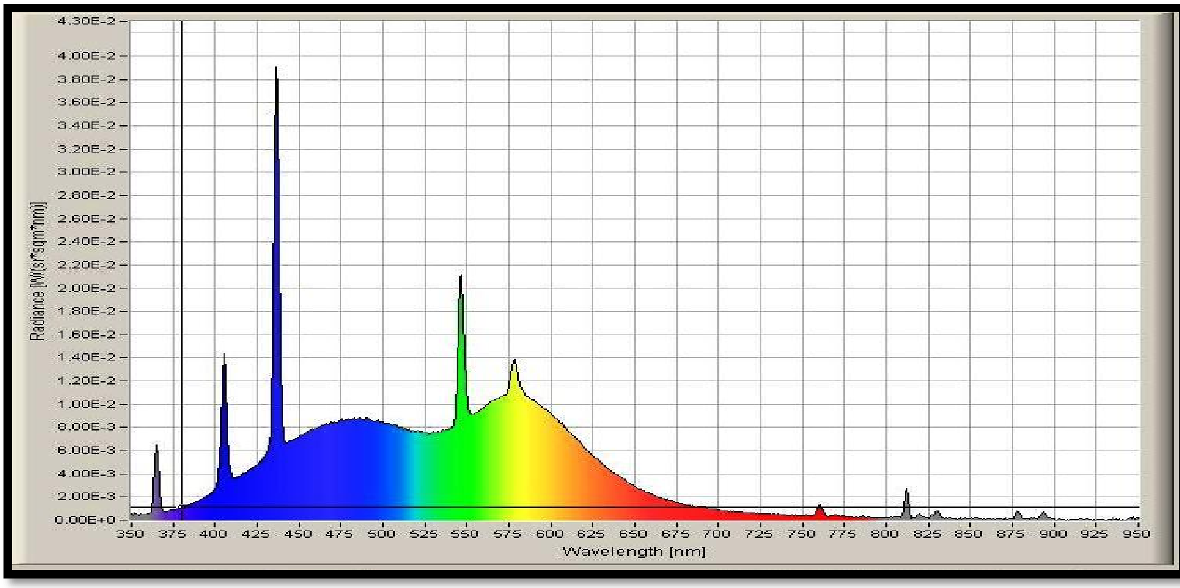


Figure 2.19: Spectral Power Distribution of Cool White Fluorescent Tube [57]

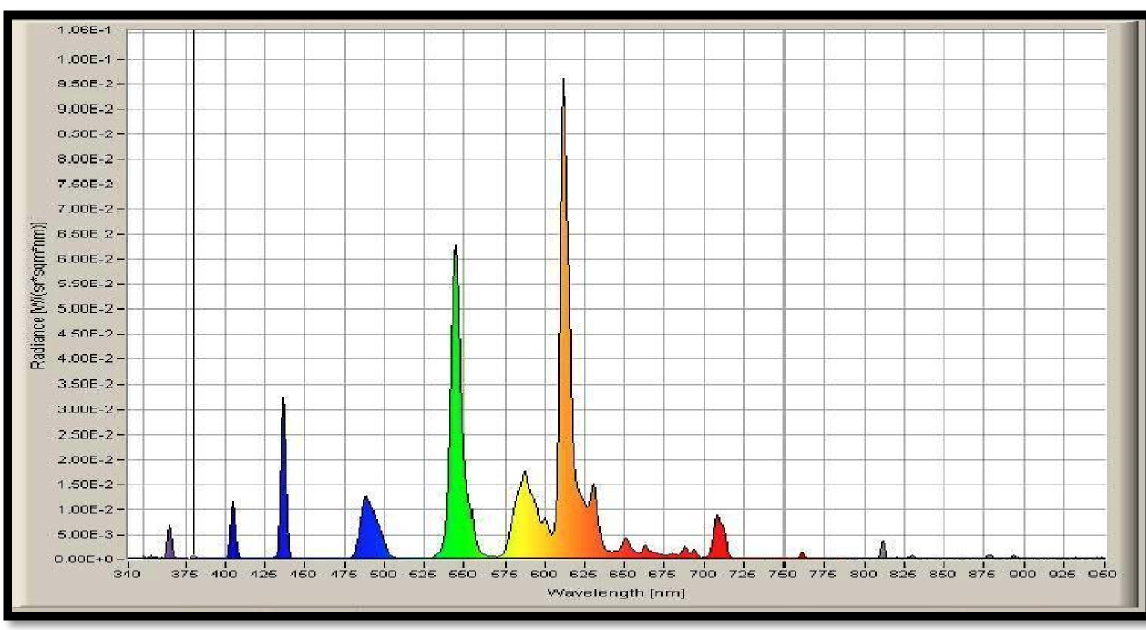


Figure 2.20: Spectral Power Distribution of Warm White Fluorescent Tube [58]

2.9.5 COMPACT FLUORESCENT LAMP (CFL)

Fluorescent lamps in compact form which is replace in place of incandescent lamp. A little amount of mercury and gas are filled in a glass tube. Lamp produces light when the Hg molecules are excited when electric voltage is applied across the lamp. It can have integral ballast and can be retrofitted directly. Figure 2.21 shows the picture of compact fluorescent lamp and Figure 2.22 & 2.23 shows the Spectral Power Distribution of Compact Fluorescent lamp [59].

Figure 2.21: Compact Fluorescent lamp [60]

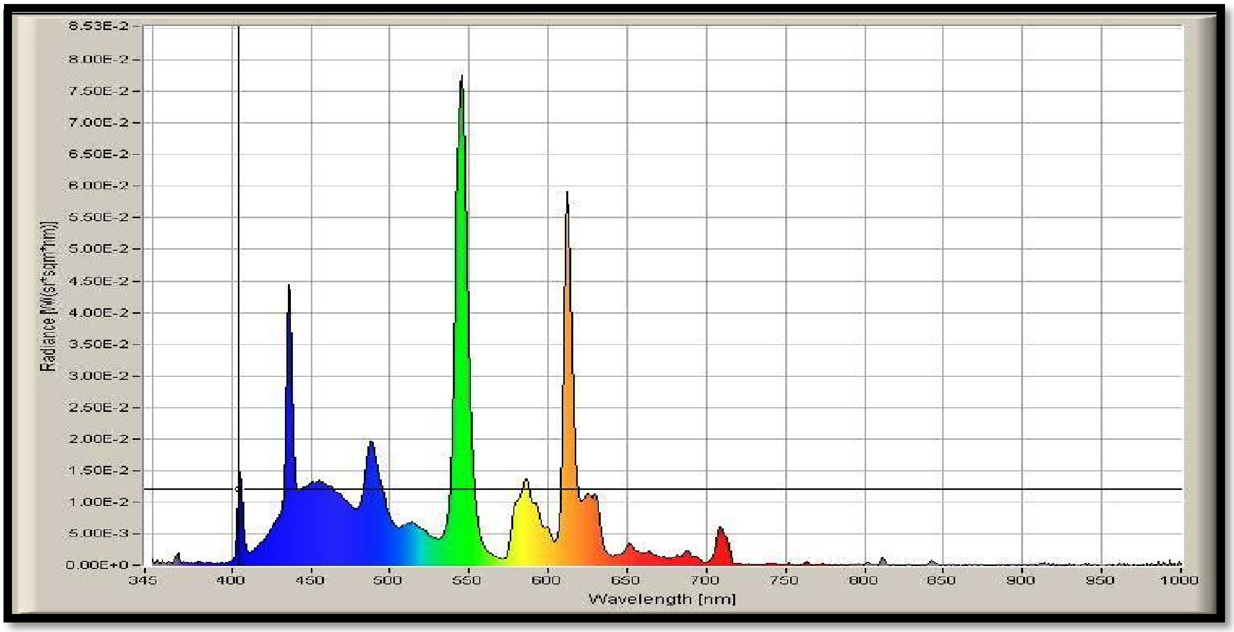


Figure 2.22: SPD of Cool White Compact Fluorescent Lamp [61]

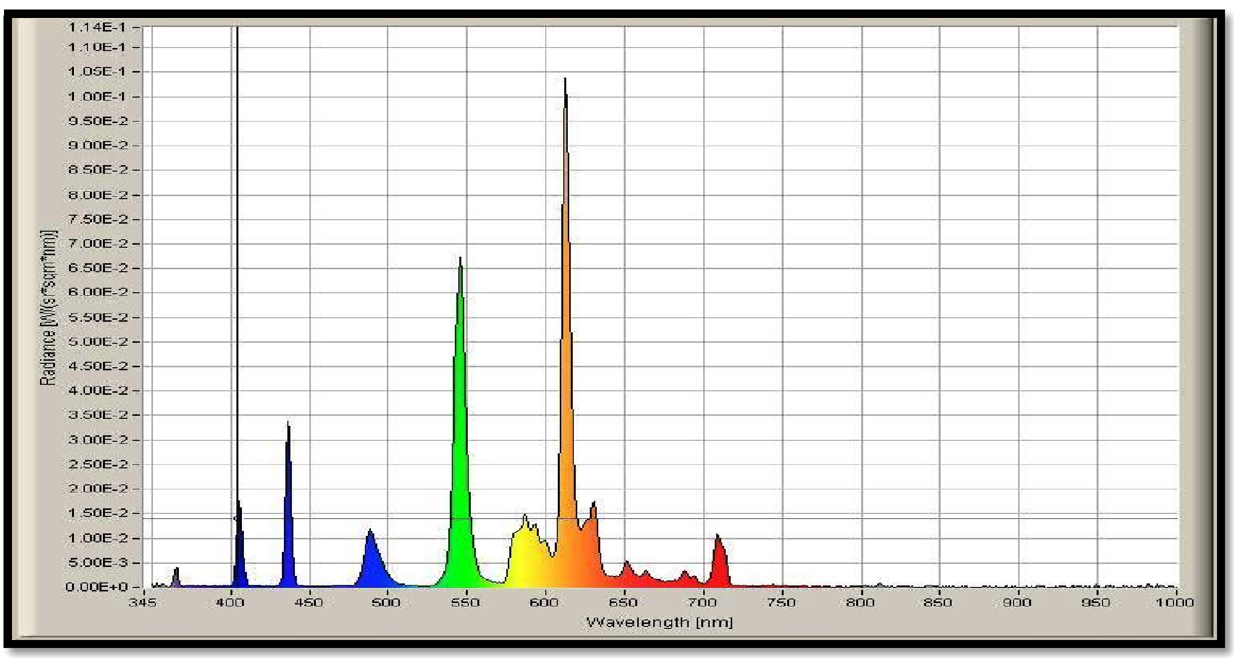


Figure 2.23: SPD of Warm White Compact Fluorescent Lamp [62]

2.9.6 LIGHT EMITTING DIODE

Light Emitting diode (LED) is a semiconductor light source. It is a two lead P N junction diode. It light is emitted from the lamp when proper potential is applied across the lamp leads then electrons are recombined with electron holes inside the lamp and as result energy is released in term of photons. This feature is known as electroluminescence [63] and the colour of the emitted light depends on the band gap or availability of energy on the photon of the semiconductor. The constructional feature of LED is same as normal p-n junction. In ordinary diode silicon and Germanium are used whereas in Led gallium, selenide, phosphorous and arsenic semiconductors are [64] .In p-n junction diodes, normally germanium are not used as it sensitive to temperature variation.

After the application of electric potential, the electrons cross from the N-region and recombine with the holes existing in the P-region for forward bias condition. Free electrons are present in the conduction band and holes are in the valence energy band so the energy level of the holes will lesser than the energy levels of the electrons. Some amount of the energy must be dissipated to recombine the electrons and the holes. This emitted energy is in the form of heat and light [65]. Figure 2.24 shows the recombination process.

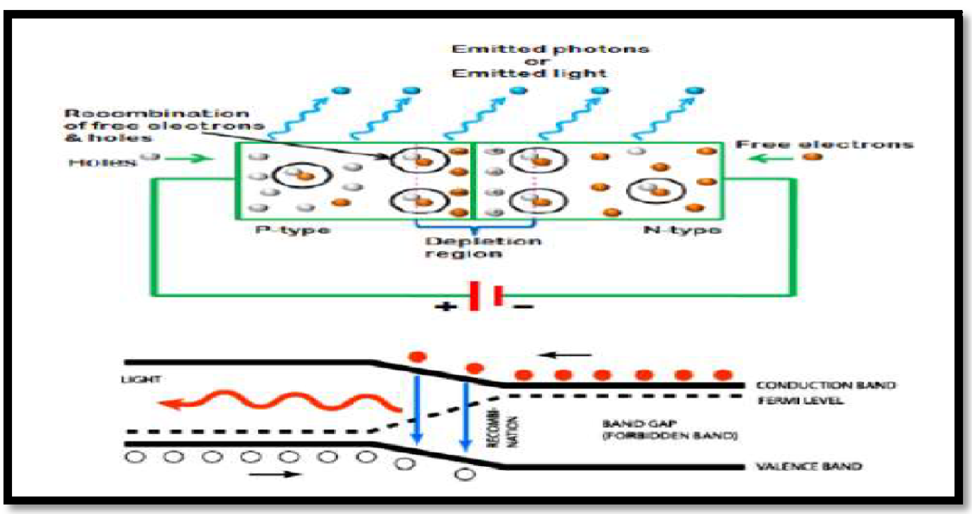


Figure 2.24 Recombination processes of LED [65]

There are some Semiconductor materials used for producing different colors [66]

I. Red color is produced by using AlGaAs semiconductor
II. Blue color is produced by using Zinc selenide (ZnSe)
III. Ultraviolet color is produced by using Aluminium gallium nitride (AlGaN)
IV. Infrared color is produced by using Gallium arsenide (GaAs)

2.10 RGB LED (WHITE LIGHT)

Single red, green, and blue LED are used to produce RGB LED. White light-emitting diodes (WLEDs) are produced by attenuating separately of 3 RGB LEDs, [67] .The use of phosphor is used to convert mono chromatic light from a blue or UV LED. There are three main methods of mixing colours to

1. Red LED + Green LED + Blue LED;
2. Near-UV or UV LED and RGB phosphor;
3. Blue LED and yellow phosphor ;

2.11 LED TECHNOLOGY

2.11.1 DUAL IN LINE CHIP

DIP is Dual In-Line Package LEDs that are the traditional LED lights [67].DIP LEDs looks like a traditional light with the chip encased in hard plastic that generally used with two straight parallel connecting pins. Figure 2.25 shows the photograph of a DIP chip.

Figure 2.25: Dual line in chip [68]

2.11.2 SURFACE MOUNTED DIODE

SMD stands for Surface mounted diode and are much smaller and efficient LEDs than DIP chips. SMD LEDs become popular due to their versatility and are typically mounted and soldered onto a circuit board. SMD chips become very important for the development of the LED industry because three diodes are able to be put on the same chip. As well as the brightness is significantly better, they have able to change colour. Some of the chips are made small that are used in high end electronics such as laptop computer indicator lights. [67]. Figure 2.26 shows a photograph of SMD LED down lighter.

Figure 2.26 Surface mounted diode [69]

2.11.3 CHIP ON BOARD

Chip on Board (COB) is the most recent development in LED technology. It uses multiple diode chips typically 9 or more. There is no casing which enables a much denser LED array of light compared to SMD. COB chips are used in an array of different devices. The COB modules produces homogeneous light. For this it can provide optimal cooling which increases efficiency and enhances service life [67]. Typically use of COB LED in small devices such as cameras and Smartphone because a high amount of lumens created for a very small amount of energy. Figure 2.27 shows the photograph of a COB chip.

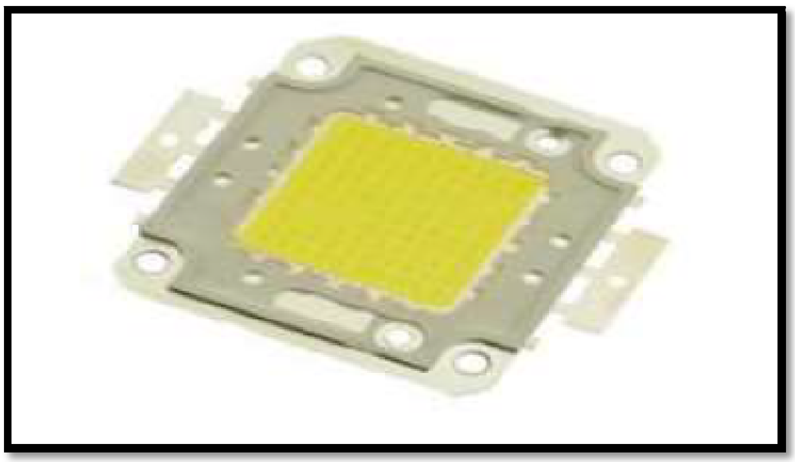


Figure 2.27: Chip on board [70]

A. COMPARISM BETWEEN COB AND SMD

a. Compared to SMD, COB LEDs are small in size. But the temperature gets as high as 74 degree which requires a bigger heat sink process. In case of SMD large LED spacing on the board for better heat dissipation faster.
b. SMD LEDs chips have higher luminous efficiency than COBs.
c. For the performance test of heat dissipation, SMD chips could pass the LM80/TM21test.While few of COB chips could pass that test.

d. Light emission: COB LEDs emits homogeneous light and produces single shadow as shown in figure 2.28. [67].

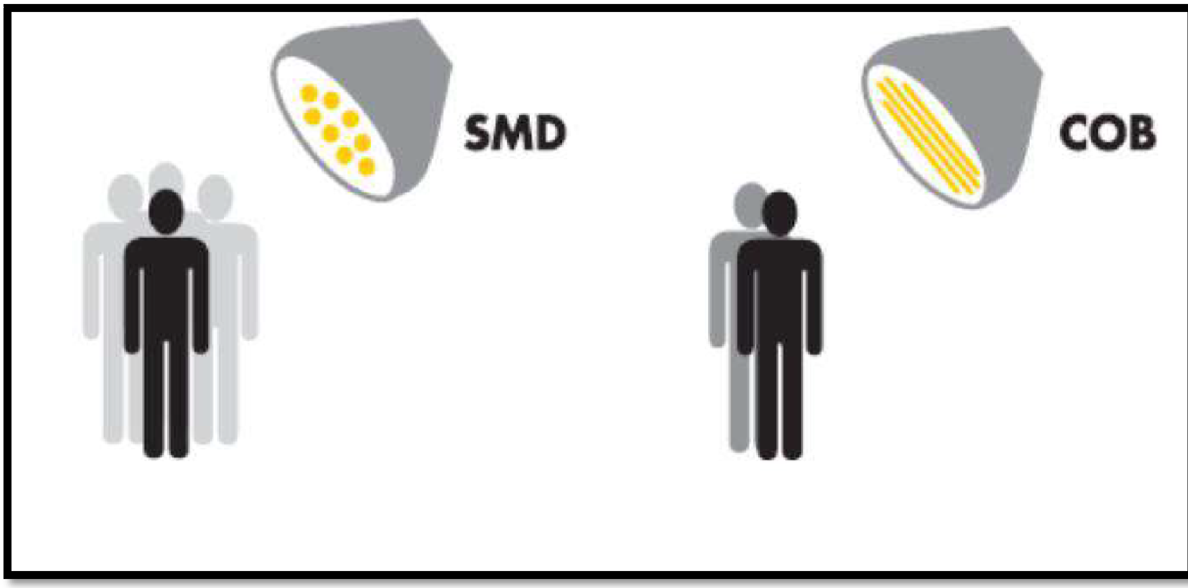


Figure 2.28: Comparisons between SMD and COB LED chip [71]

2.12 LED BINNING

During production time, charecteristics LED component may vary. As a result of these differences,chromaticity shift , change of diode forward potential, and change of lumen output ay occurs though these are produced in the same batch. Stable and homogenous light is important factor for SSL field. Due to this reason LED binning system was applied.

2.12.1 IMPORTANCE OF LED BENNING

LED-to-LED differences each other after production. As the individual LEDs differs from each others are more, the current requires for one LED may overload the other LED. Selection of applied forward voltage for LED is important [72].

The color of light emitted from the lamp may vary per LED, sometimes LED components are used to prepare a single image of light so that the color of light emitted by the lamp may not vary too much from one another [72].

2.13 MEASUREMENT STANDARD FOR LED

2.13.1 LM 79-08

It is the approved method given by IESNA for the Electrical and Photometric parameter measurements of LEDs. It LED lamp/integral lamp as a whole system is measured by using specific equipment. It is a standard method of measurements [73] The testing report is published in standard format and provided the photometric and electrical parameter .These are

I. Total lumen output.
II. Polar curve.
III. Power Characteristics.
IV. Luminous Efficacy (calculated).
V. Color properties

The BUREAU OF INDIAN STANDARDS to move together with IS-16106 in 2012 which contains “METHOD OF ELECTRICAL AND PHOTOMETRIC MEASUREMENTS OF SOLID STATE LIGHTING (LED) PRODUCTS”. It gives same experiment procedures which are required to generate the photometric parameters of LED luminaire.

2.13.2 ISTMT

Case temperature of led within the LED system (luminaries). The measurement was done when operating in it at designed position. The measurement is done at the temperature as specified by manufacturer in the packet.

LED In-Situ Testing Information:

I. LED chip/ package manufacturer and model number.
II. LED chip specification sheet and LM-80 report information.
III. Diagram mentioning where to attach thermocouple usually in the LED chip/ package specification sheet or LM-80 reports.
IV. Test voltage, current and wattage of LEDs.
V. LED Driver model number and specification.

2.13.3 LM-80-08

LM 80-08 is the Illuminating Engineering Society of North America (IESNA) provided standard for evaluating lumen maintenance of led lamp. LM-80 is applicable to the LED package/array/module only. This does not gives guide line for extrapolation of test result [73] .The testing report published in a standard format that will be provided lumen output for a given current for 6,000 hours period with intervening time of measurements. Lumen output will measured at temperature 55ºC, 85ºC and 3rd temperature to be chosen by manufacturer. the chromaticity shifts are also measured during measurement time.

This report gives

I. Luminous Flux maintenance over 6000 Hrs. of Testing.
II. Life time LED
III. Maximum chromaticity shift

2.13.4 TM 21-11

It is the Illuminating Engineering Society of North America (IESNA) approved method for Measuring Lumen Maintenance of LED Light. This document provides recommendations for projecting long term lumen maintenance of LED light sources using data obtained when tested them as per IES LM-80-08. Then the results can be used to interpolate the lifetime of an LED source within a system (luminaries or integrated lamp) by using the in-situ LED source case temperature. It is a mathematical method based on LM-80-08 collected data [73]. Among another thing, TM-21-11 will consider:

I. If total LM-80 data life period is between 6,000 and 10,000 hrs, we consider the last 5,000 hours.
II. If total data life period is above 10,000 hours then use the last half of collected data.
III. Projections are limited to 6 times the data period available in LM-80 report so projected and reported lifetime may or not be the same.

The method will provide a projected lifetime for the LED source or system. Life notation results will then use the following standardized nomenclature: L_p ($_{Yk}$) P: Lumen maintenance percentage. For LED luminaries we consider that L70 to be the standard. After 30% lumen depreciation, we consider the system is not performing its duty anymore and should be replaced anyhow (see Lifetime section of Lighting Guide for more details) Y: Length of LM-80 data period in thousands of hours Example: L70 (6k) = 36,000 hours [73].

2.14 PHOTOBIOLOGICAL SAFETY REPORT

As per IEC62471:2006 with CIE "Photobiological Safety of Lamps and Lamp Systems" has been published. The subject matter of the report is to provide a guideline of the photobiological safety of lamps and lamp systems. The method of measurement and duration of exposure period (on the basis of ICNIRP) are given in table 2.2. Light exposure time on skin and eye is eight hours. It was not taken in the non working day. Long-term exposure of light is not taken into account [74].

Table 2.2 Hazards			
Sl. No.	Hazard	Principal Bio effect	
		Skin	Eye
1	Actinic UV skin & eye	Erythema (Sunburn) Elastosis (aging,wrinkles)	Photo keratitis Cataractogenesis
2	Effect on ultraviolet A on eye	Nil	Cataractogenesis
3	Blue Light on retina	Nil	Photo retinitis
4	Thermal effect on retina	Nil	Burn on Retinal
5	IR radiation on eye	Nil	Cornea burn cataractogenesis
6	Temparature effect on skin	Sun Tanning	Tanning

A 4-tier structure on the basis of permissible exposure period of illumination not exceeding the EL of each hazard as shown in table 2.3

TABLE 2.3 FOUR TIER CLASSIFICATION STRUCTURE [74]		
Sl. No.	Risk Group	Philisophical Basis
1	Exempt	No hazard
2	RG1	No hazard under normal condition
3	RG2	As response of aversion are present so hazard are not present to very bright illumination or absence of thermal comfort
4	RG3	Hazardous as a very short time light exposure

For retinal hazards, aversion response time of eye is considered. Note that this classification is different from the class system. The evaluation comprises of a complicated measurement series of 200 nm to 3000 nm of wavelength to evaluate the hazards on the skin and eye (front surface) 300-1400 nm of wavelength is taken into consideration of retinal hazard. Measurements are obtained in specific conditions i.e. eye movement due to retinal illumination depend on distance between source and eye i.e. general lighting service (GLS) or other lamp. In 2012, BIS also created their own Photobiological standards i.e. IS-16108 which adopts the IEC62471:2006 [74]

2.15 LED Tube

LED tube is typical LED lamp that used in fluorescent tube fittings [74] .The most important merits of this types of lamps are most energy efficient and long useful life time. This type of lamps are sometimes also called 'LED fluorescent tubes' though the light is coming out from LED components and no fluorescent substance is available in the tube so 'LED tube' is most correct term than LED fluorescent tube lamp. These are mainly manufactured by a huge number of low or medium-powered LED and lumen output and heat dissipation are proper across the tube. The tube temperature of LED tubes is lesser at the time of operation as compared to traditional lamp and at the same time heat dissipation property of LED tube is lesser than traditional lamps.

The light distribution property of led lamps is most important i.e. it is possible to direct the light in the tube in a narrow beam. Energy consumption of LED tube is lower than other conventional lamp source. LED tubes are generally made of durable plastic and aluminium that means that Led tube will not be shattered as they made of plastic (durable) and light weight Alluminium. Popularity of LED tubes has been rapid throughout their entire marketing period in the world due to its technical development. Generally, the control gear is placed inside the LED tube but sometimes it can also be kept outside from lamp.

Figure 2.29 shows the photograph of LED tube and Figure 2.30 shows the beam distribution curve of LED tube [75] .

Figure 2.29: LED tube [76]

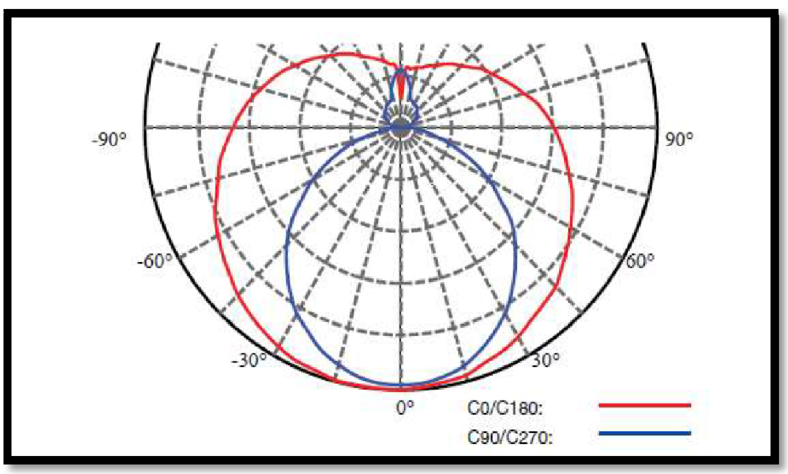


Figure 2.30: Typical Beam distribution of LED luminaires [77]

2.16 ADVANTAGES OF LED

There are some advantages over other conventional lamp as follows: [75]

I. **Efficiency**

Efficiency of LED luminaire is better than other conventional lamp. Typical value of Efficacy of LED lamps is 135lumens per watt.

II. **Life**

Useful Life of LED lamp is relatively better than other lamp. Life of LED is nearly thirty five to fifty thousand hours .

III. **Color**

In LED technology, we are able to obtain each illumination light color.Color of emitted light from the LED can be changed without using color filter as used in conventional lighting methods. It is efficient and it can be diminished initial costs.

IV. **Size**

It can be manufactured very small in size nearly two mm^2 and are easily placed on PCBs.

V. **Warm up time**

Time is required to warm up the lamp and it takes time to reach maximum brightness. LED Lamps are instant on means it will reach full brightness immediately as soon as turned on. Time require to reach full brightness within few nanosecond.

VI. **Dimming**

LEDs can be dimmed easier by analog dimming and PWM but it is very costly. Analog dimming simply controls the forward current of the LEDs. the current is linearly reduced to provide dimming from zero in the off condition. In pulse-width modulation (PWM) dimming, the LEDs are operated with full amplitude pulses of current and the width of the pulses can be varied to control the apparent brightness of LEDs.

VII. **Cycling**

When frequent on-off cycling is required, LED lamp are suitable for that application, but in case of fluorescent lamps that burn out very quickly when operated frequently, or Restarting time of HID lamp is more.

VIII. Slow failure

Light output of LEDs mostly decreases but not ruptured immediately over time whereas a sudden failure of incandescent lamps occurs.

IX. Shock resistance

LEDs are solid state lamp that is not damaged easily by external shock whereas Fluorescent and GLS lamp are fragile in nature.

X. Environment friendly

LED lights contain no toxic elements. The LED Luminaire was primarily used for the experiment due to above advantages.

CHAPTER 3
EXPERIMENTAL SET UP AND EXPERIMENTAL PROCEDURE

3.1 INTRODUCTION

To carry out the experiment, an experimental set up has been developed in the classroom of E-1-4 in electrical engineering department, Jadavpur University. The main aim of experimental set up is to determine the appropriate range of illuminance level required in the classroom. The details of the experimental set up are described in the following section.

3.2 EXPERIMENTAL SET UP

Figure 3.1 shows the dimension of classroom, height of luminaire from reading desk and height of reading desk from the floor. The dimension of classroom was 10m x 8m with ceiling height 4m.The height of luminaire from reading desk was 2m and height of reading desk from floor was 0.75m. Around 12-14 students were chosen for this experiment. Two students per bench were seated. Experimental set up is as shown in figure 3.3.

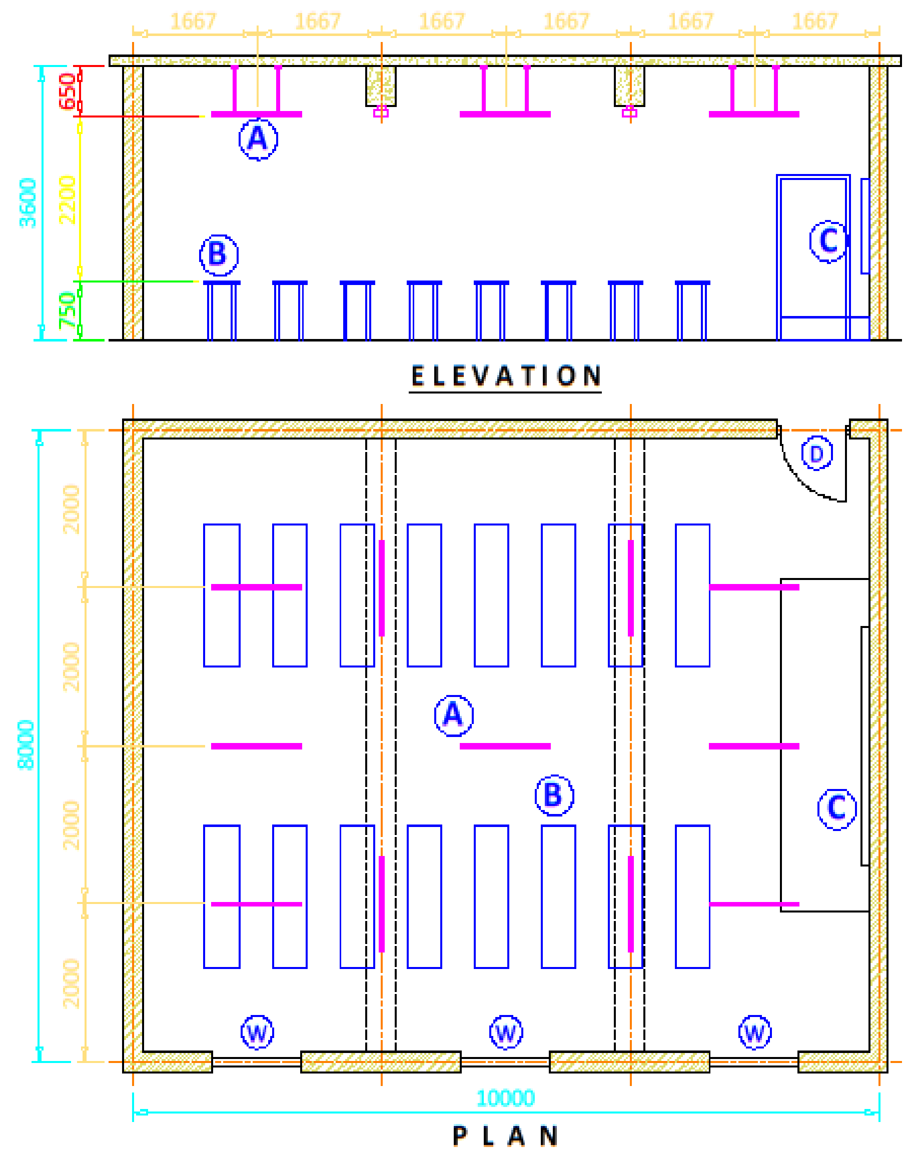


FIGURE :- 3.1 DIMENSIONS OF EXPERIMENTAL SETUP

1.	ROOM DIMENSION	10M X 8M X 3.6M
2.	FLOOR TO WORK DESK HEIGHT	750 MM
3.	WORK DESK TO LUMINARIES MOUNTING HEIGHT	2075 MM
4.	ALL DIMENSIONS ARE IN MM.	
5.	SCALE :- 1 : 75	

LEGENDS :-

1.	(A)	LUMINARIES
2.	(B)	WORK DESK
3.	(C)	BLACK BOARD
4.	(D)	DOOR
5.	(W)	WINDOW

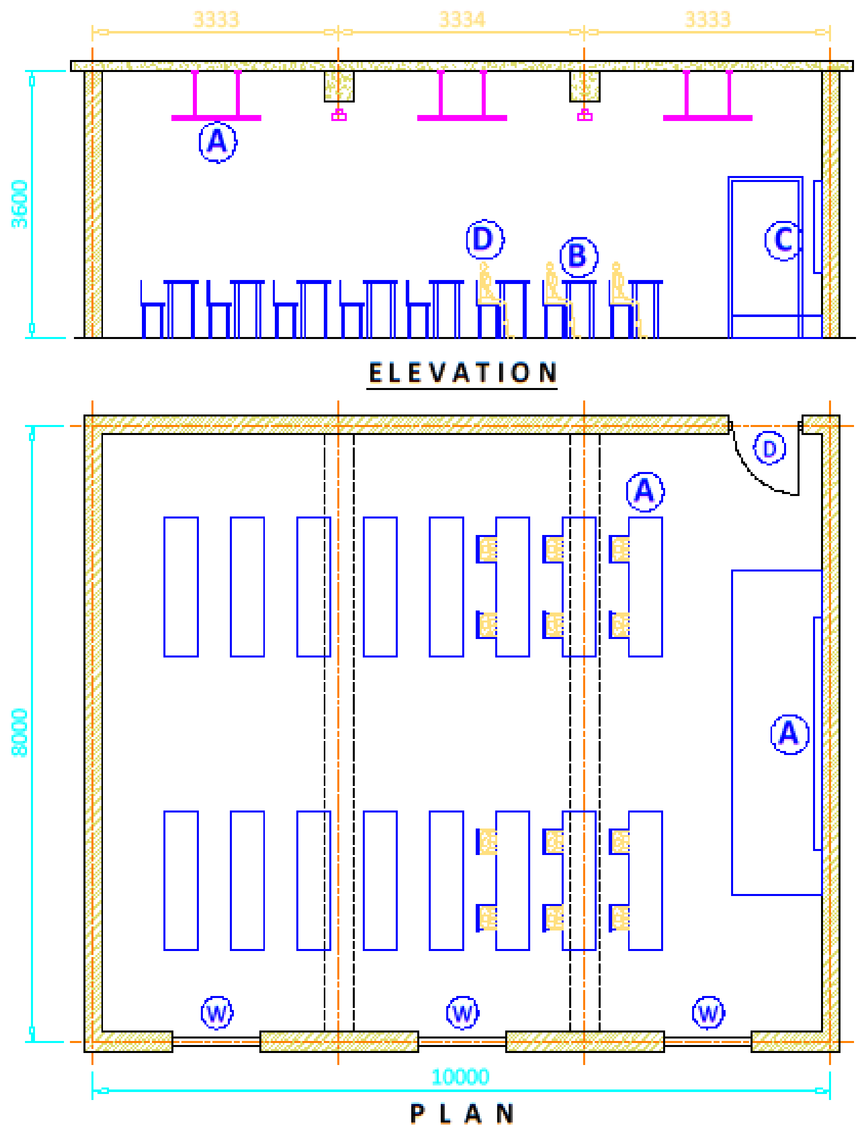


FIGURE :- 3.2 DRAWING SHOWS THE SITTING ARRANGEMENT OF STUDENTS IN CLASS

1. ALL DIMENSIONS ARE IN MM.
2. SCALE :- 1 : 75

LEGENDS :-

1.	(A)	LUMINARIES
2.	(B)	WORK DESK
3.	(C)	BLACK BOARD
4.	(E)	STUDENT
5.	(D)	DOOR
6.	(W)	WINDOW

Figure 3.3 Experimental set up

3.3 SELECTION CRITERIA OF STUDENTS

This experiment aims to determine the appropriate illuminance level required in the class. For the purpose of experiment around 12-14 students were chosen. Figure 3.2 shows the setting arrangement of the student. Two students per bench were seated in the mentioned classroom. They were selected based on the criteria that

I. All students suffers no diseases
II. have normal vision
III. Working at their individual reading task.
IV. Age between 20-25 years

For this purpose, in the class room E-1-4 all the existing conventional lamps were replaced with 20w led fixtures. Each of exiting luminaire was taken down and in their place LEDs were suspended with the help of a ladder. The LED's were placed exactly at the same locations were the previously existing luminaires were hung, keeping both the mounting height and reading desk height as it was previously as shown in figure 3.1. After the luminaires were placed the average illuminance of the room was measured and if it was found to be low additional luminaires were attached to the sides of the fixtures rigidly and tightly fastening with a rope.

3.4 EXPERIMENT PROCEDURE

This experiment aims to determine the appropriate illuminance level required in the class. For this purpose the existing lamps in the classroom were replaced by LED lights. The number of luminaires varied from 12 to 22 numbers during the period of six experiments. Then normal scheduled classes were conducted inside the classroom for a period of four hours. The illuminance of the room was varied from 225lx to 350lx Lux with interval of 25 Lux and at the finish of the period the occupants were asked for their feedback about eyestrain, headache, attention etc. Their responses were recorded in a scale of good, moderate and poor. Based on this the ideal average illuminance for a classroom environment was determined.

3.5 MEASUREMENT OF AVARAGE ILLUMINANCE OF THE CLASSROOM

The light level on the working plane is measured by Grid method and average Illuminance Level on each grid is measured by Lux meter. The entire room was decided into grids and illuminance was measured along grid.In this experiment each grid was 0.5m x 0.5m and a gap of 0.25 m was left from each wall .The Luxmeter was placed on these grid points and the average Illuminance of room was recorded. This procedure was carried out for the illuminance range 225 Lux to 350 Lux with interval of 25 Lux i.e. six number of experiments were performed and each time the luminaire were adjusted till the required value of average Illuminance was obtained.

3.6 APPARATUS USED

For the purpose of measurement, there are different type of apparatus used for measurement of light level and parameter of light that emitted from LED luminaires. Table 3.1 shows the list of apparatus used for the measure purpose.

TABLE 3.1 APPARATUS USED

Sl. No.	Apparatus name	Quantity	Rating	Makers name
1.	SpectroRadiometer	1	Model no. Spectros 1200 Software JETI Lival V5.01	JETI Sl. No.319454
2.	Lux meter	1	200/2000/20000 Lux	METRAVI made in Taiwan Sl.No.10030005
3.	UV Radiometer	1	Model: UM A25 Sensor Model no. a)UM 400 (A) b)UM 360(B) c) UM 250(C)	KONICA MINOLTA; Made in Japan
4.	LED Luminaire	20	20W Tube	Philips
5.	Wire	20 m	1.5 Sq mm	Polycab
6.	Extension Cord	1	-	-
7.	Measuring Tape	-	15 meter	-
9.	Marker pen	-	-	-

3.7 DESCRIPTION OF APPARATUS

To measure the light level and lamp parameter there are various type of instrument are used. The following instruments are used in the experiment

i. Spectroradiometer
ii. Lux Meter
iii. UV Radiometer

3.7.1 BRIEF DESCRIPTION OF SPECTRORADIOMETER

Spectroradiometer measures the Spectral Energy Distribution of lamp source. Spectral power distribution determines the radiometric quantities, colorimetric quantities as well as photometric quantities of light that emitted from lamp. Figure 3.4 shows the image of Spectroradio meter [78].

The same CIE V_λ curves are stored in the software and that are used to produce the data from the measured SPD of the light source under test. Hence the error related with the photometer and filter colorimeter is avoided in this instrument to avoid stray light the experiment was performed in the dark room.
This is the fastest and more accurate measuring instrument.

Figure: 3.4 Spectroradiometer [78]

3.7.2 MEASUREMENT OF SPECTRAL POWER DISTIBUTION

The Spectral Power Distribution of sample LED lamp was measured by SpectroRadiometer. The test was performed in the dark laboratory of Illumination Engineering Department at Jadavpur University. The SpectroRadiometer was placed at the height of 2.5 ft from floor and lamp was placed at distance 10ft from the spectroradiometer and was placed horizontally with the floor. The lamp test set up is as shown in fig. 3.5.

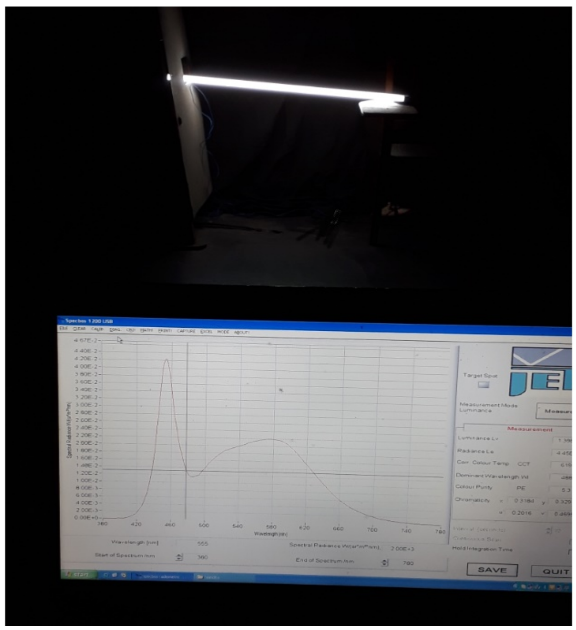


Figure 3.5: Lamp test set up

3.7.3 PATERN OF SPECTRAL POWER DISTIBUTION

LED luminaire are used in the experiment as discussed in the previous section. Only one lamp is taken as a sample. The energy diagram is as shown in figure 3.6; it is observed that the most of the light energy is radiated by LED lamp in the range of 420nm to 460nm wavelength which is in the blue region. It is also seen that spatially distributed energy in the range of 500nm-700nm wavelength which is in yellow to red region. So the LED light is blue dominated.From the diagram it is also observed that the LED lamp CCT was 6189 K [79] .

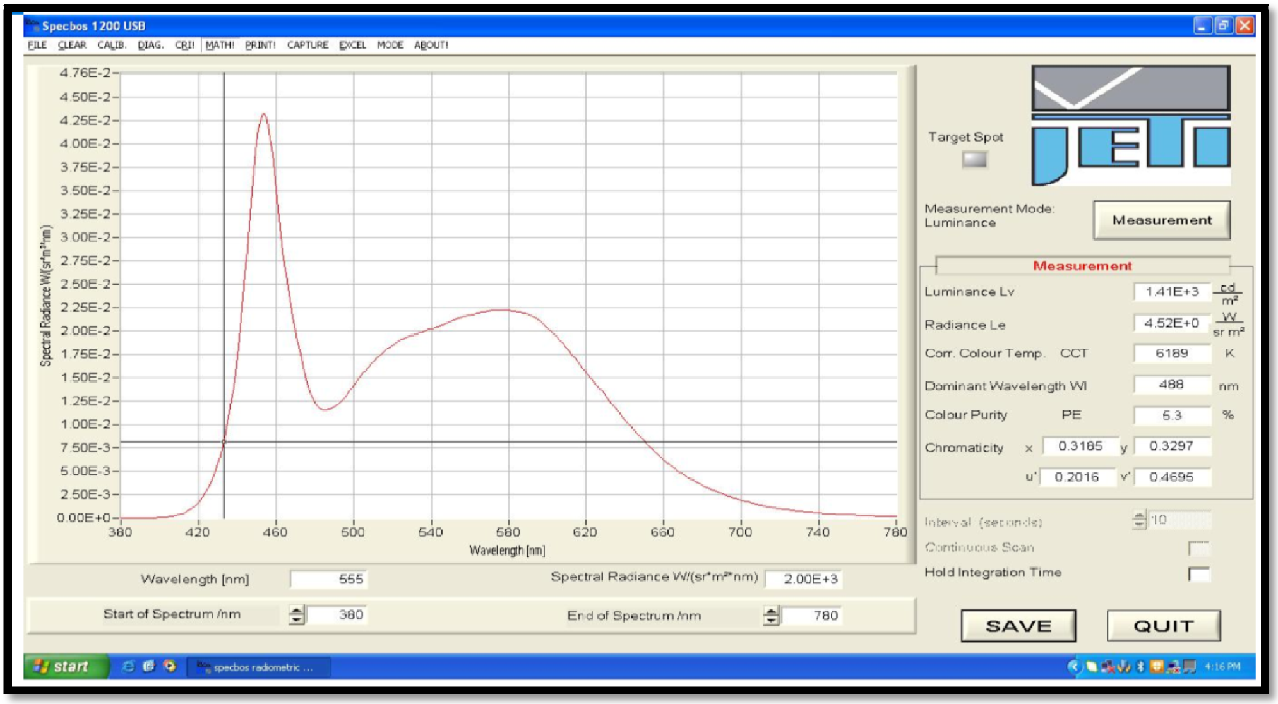


Figure 3.6: Spectral Power Distribution of LED

3.7.4 BRIEF DESCRIPTION OF LUX METER

Lux Meter is used to measure the level of light available in the working plane or working desk. A photocell is present in the lux Meter which captures the light and then converts this light to an electrical current. This current allows the meter to calculate the Lux value of the captured light. Figure 3.3 shows the photograph of lux meter [80].

3.7.5 MEASUREMENT OF LIGHT LEVEL

As discussed earlier, Grid method is used to measure the illuminance level or quantity of light available in the workplace or work desk. For this the entire room was divided into grids and illuminance was measured along each grid point In this experiment each grid was 0.5m x 0.5m and a gap of 0.25 m was left from each wall .The Lux Meter was placed on these grid points and the Illuminance of each grid point of the work plane was recorded. To get average Illuminance Level of the work plane, sum the value of light on each grid point and divided by no. of grid point.This procedure was carried out for the illuminance range 225 Lux to 350 Lux with interval of 25 Lux i.e. six number of experiments were performed and each time the luminaire were adjusted till the required value of average Illuminance was obtained. Figure 3.7 shows the photograph of lux Meter.

Figure 3.7: Lux Meter [80]

3.7.6 BRIEF DESCRIPTION OF UV RADIOMETER

Ultraviolet radiation is the main cause of skin cancer .There is three types of UV radiation

I. UVA ; Range from 315 to 400nm
II. UVB ; Range from 280 to 315 nm
III. UVC ; Range from 100 to 280 nm

UVA and UVB can damage the skin cell and skin DNA.UVC have more energy than UVA & UVB causes most skin cancer but UVC normally absorbed by atmosphere so UVC are not a cause of skin cancer. Sometimes UV radiation may occur from some light source. Prolong use of this type of lamp may be damaged and skin .It may also affects our retina.

Radiometer is a device which is use to measure the intensity of radiant energy. Mainly a single photocell sensor is used in the radiometer .To measure radiation emitted from a certain spectrum normally an optical filter is used.

UV radiometer mainly measures outside of visible spectrum i.e. ultraviolet and infrared radiation. So by using this meter one can know the amount of UV and IR radiation present in the lamp source. Figure 3.8 shows the photograph of UV Radiometer.

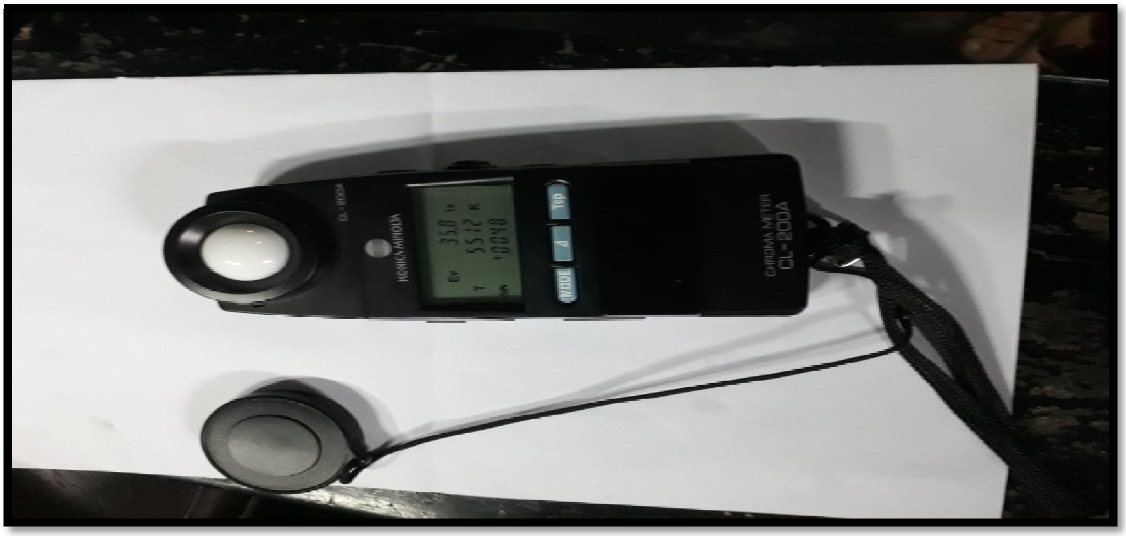


Figure 3.8 UV Radiometer

3.7.7 MEASUREMENT PROCEDURE OF ULTRAVIOLET RADIATION

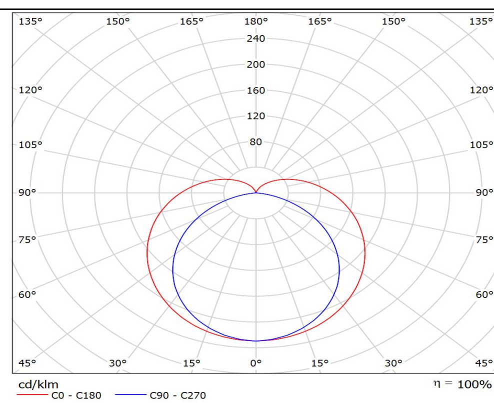
UV radiometer [81] was placed at a distance 6 meter from the LED lamp .Table 3.1 shows the amount of UV radiation is present in the LED lamp :

Table 3.1 shows the amount of UV radiation			
Sl. No.	UVA (μw/cm^2)	UVB (μw/cm^2)	UVC(μw/cm^2)
1	0.6	0	0.3

From this experiment it is observed that the amount of ultraviolet radiation from the LED lamp is not remarkable. So LED lamp can be used for short time as well as long time.

3.8 LUMINAIRE DETAILS

Detail description of luminaire used is as shown in table 3.2

TABLE NO 3.2 LUMINAIRE DETAIL		
Sl.no.	Item description	Item Specification
1	Luminare Part List & Technical Data	1. Lamp wattage 20W 2. Efficacy 100Lm/Watt 3. CCT 6500K ± 30 4. CRI > 8 5. Power factor > 0.95 6. THD < 10% 7. Lumen output > 2000Lumen
2	Image of Luminaire	
3	Light distribution curve	

Chapter 4
EXPERIMENT RESULT

4.1 INTRODUCTION

Lighting affects different human activities depends on light exposure and duration of light exposure such as alertness, vision, mood, and sleepness, it's mainly effects on studying and environment of the classroom. The spectrum of lighting can either increases or decreases students' visibility and then increases study time of students [83] .

The illuminance of the room was varied from 225lx to 350lx and at the complete of the test period the occupants were asked for their feedback about eyestrain, headache, sleepness, mood, alertness etc. Their responses were recorded in a scale of good, moderate and poor. Based on this the ideal avg. illuminance for a classroom environment was determined. While setting up the LED lights care was taken in their installation so that it should not cause visual discomfort, glare etc. for the students as well as for the teachers.

4.2 DESCRIPTION OF EXPERIMENT FOR LIGHT LEVEL 225 LUX

The description of experiment for light level 225 Lux are as shown in table no. 4.1.

TABLE 4.1 : EXPERIMENTAL DATA		
1.	Light Exposure time	4 hours
2	Luminaire type	Suspended commercial luminaire containing one T 8
3.	Lamp type	20 Watt LED T8 Tube
4.	Average working plane Illuminance	225 Lux
5.	Lamp CCT	6200
6	Ceiling and wall color	White

4.3 REACTIONS OF STUDENTS FOR LIGHT LEVEL 225 LUX

The Individual reactions of five dependent variables (Alertness, mood, sleepness, headache and eyestrain) with corresponding weighted value at light level 225 lux are as shown in following table no. 4.2 .The feedback of the students were recorded on a scale of 1 to 5 where 1,2,3,4 and 5 means absent, poor, present, moderate and good respectively.

TABLE 4.2: REACTION OF STUDENTS FOR LIGHT LEVEL 225 LUX

Sl no	Student	Alertness	Mood	Sleepness	Headache	Eyestrain
1	Student1	4	2	5	3	2
2	Student 2	4	2	5	3	2
3	Student 3	4	2	5	3	2
4	Student 4	4	2	5	3	2
5	Student 5	5	2	5	3	3
6	Student 6	4	2	5	3	2
7	Student 7	4	2	5	3	1
8	Student 8	4	2	5	3	2
9	Student 9	4	2	5	3	2
10	Student 10	4	2	5	3	2
11	Student11	4	2	5	2	2
12	Student 12	5	2	4	3	3

4.4 GRAPHICAL REPRESENTATION OF REACTION OF STUDENTS FOR 225 LUX

The graphical representation of reaction of students for the light level 225 Lux is as shown in figure 4.1.

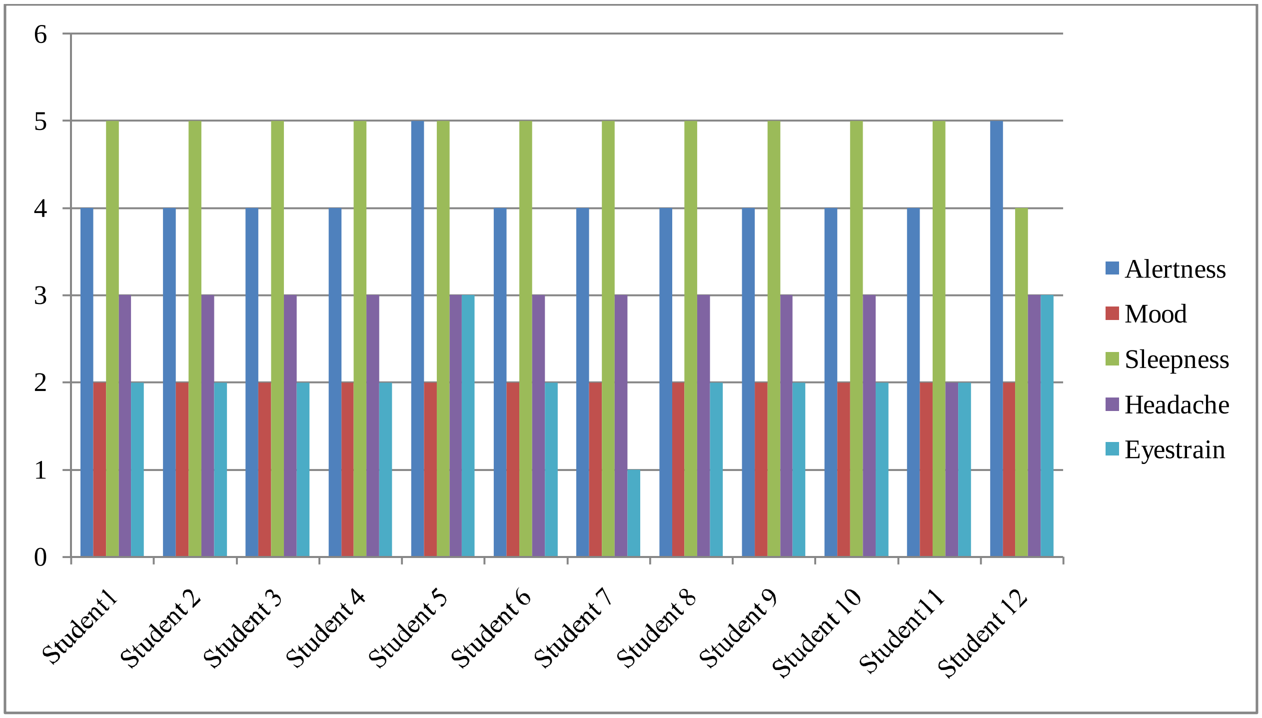


Figure 4.1: Graphical representation of reaction of students for the light level 225 Lux

It is observed for average light level 225lux, the alertness was moderate, mood was poor, sleepness was good and absent of headache and eyestrain. The reactions of most of the students for Average Illuminance Level on working plane of 225 Lux is as shown in table no. 4.3.

TABLE 4.3: AVARAGE REACTION OF STUDENTS FOR LIGHT LEVEL 225 LUX						
Sl no	**Lux level**	**Alertness**	**Mood**	**Sleepness**	**Headache**	**Eyestrain**
1	225 lux	Moderate	Poor	Good	Present	Poor

4.5 DESCRIPTION OF EXPERIMENT FOR LIGHT LEVEL 250 LUX

The description of experiment for light level 250 Lux are as shown in table no. 4.4.

TABLE 4.4 : EXPERIMENTAL DATA		
1.	Light Exposure time	4 hours
2	Luminaire type	Suspended commercial luminaire containing one T 8
3.	Lamp type	20 Watt LED T8 Tube
4.	Average working plane Illuminance	250 Lux
5.	Lamp CCT	6200
6	Ceiling and wall color	White

4.6 REACTION OF STUDENTS FOR LIGHT LEVEL 250 LUX

The Individual reactions of five dependent variables (Alertness, mood, sleepness, headache and eyestrain) with corresponding weighted value at light level 250 lux are as shown in following table no. 4.5. The feedbacks of the students were recorded on a scale of 1 to 5 where 1,2,3,4 and 5 means absent, poor, present, moderate and good respectively.

TABLE 4.5: REACTION OF STUDENTS FOR LIGHT LEVEL 250 LUX

Sl no	Student	Alertness	Mood	Sleepness	Headache	Eyestrain
1	Student1	4	2	5	2	2
2	Student 2	4	2	5	2	2

3	Student 3	4	2	5	2	2
4	Student 4	4	2	5	2	2
5	Student 5	4	2	5	2	2
6	Student 6	4	2	5	2	2
7	Student 7	4	2	5	2	2
8	Student 8	3	2	5	2	2
9	Student 9	4	2	5	2	2
10	Student 10	4	2	5	2	2
11	Student11	4	2	5	1	2
12	Student 12	4	2	4	1	2

4.7 GRAPHICAL REPRESENTATION OF REACTION OF STUDENTS FOR LIGHT LEVEL 250 LUX

Graphical representation of different level of reaction of each student for light level 250 Lux is as shown in figure 4.2.

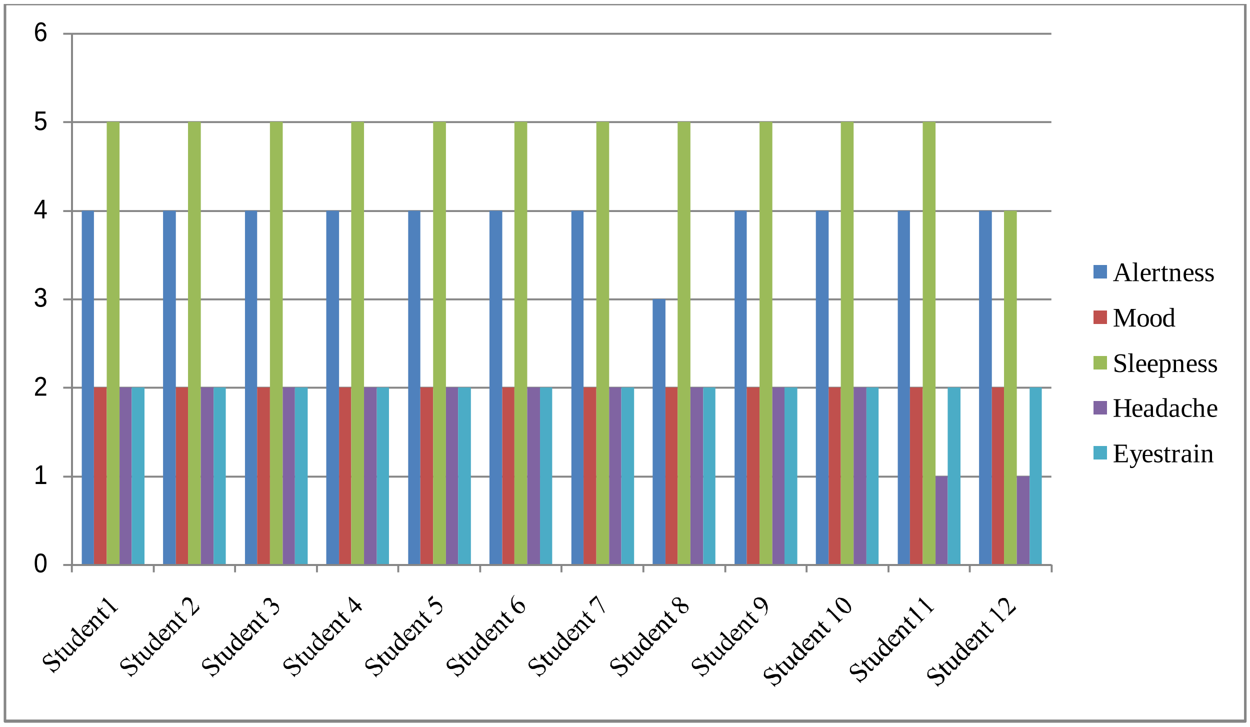


Figure 4.2 Graphical representation of reaction of students for the light level 250 Lux

It is observed that for average light level 250lux, the alertness was moderate, mood was poor, sleepness was good and absent of headache and eyestrain. The reactions of most of the students for Average Illuminance Level on working plane of 250 Lux is as shown in table no. 4.6.

TABLE 4.6: AVARAGE REACTION OF STUDENTS FOR LIGHT LEVEL 250 LUX						
Sl no	**Lux level**	**Alertness**	**Mood**	**Sleepness**	**Headache**	**Eyestrain**
1	250 lux	Moderate	Poor	Good	Poor	Poor

4.8 DESCRIPTION OF EXPERIMENT FOR LIGHT LEVEL 275 LUX

The description of experiment and corresponding reaction of students for light level 275 Lux are as shown in table no. 4.7.

TABLE 4.7 : EXPERIMENTAL DATA		
1.	Light Exposure time	4 hours
2	Luminaire type	Suspended commercial luminaire containing one T 8
3.	Lamp type	20 Watt LED T8 Tube
4.	Average working plane Illuminance	275 Lux
5.	Lamp CCT	6200
6	Ceiling and wall color	White

4.9 REACTIONS OF STUDENTS FOR LIGHT LEVEL 275 LUX

The individual reactions of the five dependent variables (Alertness, mood, sleepness, headache and eyestrain) with corresponding weighted value at light level 275 lux are as shown in following table no. 4.8. The feedbacks of the students were recorded on a scale of 1 to 5 where 1,2,3,4 and 5 means absent, poor, present, moderate and good respectively.

TABLE 4.8: REACTION OF STUDENTS FOR LIGHT LEVEL 275 LUX

Sl no	Student	Alertness	Mood	Sleepness	Headache	Eyestrain
1	Student1	4	4	4	2	2
2	Student 2	4	4	4	1	2

3	Student 3	4	3	4	1	2
4	Student 4	4	4	4	1	2
5	Student 5	4	4	4	1	2
6	Student 6	4	4	4	1	2
7	Student 7	4	4	4	1	2
8	Student 8	3	4	4	1	1
9	Student 9	4	4	4	1	1
10	Student 10	4	4	3	1	2
11	Student11	4	4	4	1	1
12	Student 12	5	3	3	2	2

4.10 GRAPHICAL REPRESENTATION OF REACTION OF STUDENTS FOR LIGHT LEVEL 275 LUX

The Graphical representation of different level of reaction of each student for average light level 275 Lux is as shown in figure 4.3.

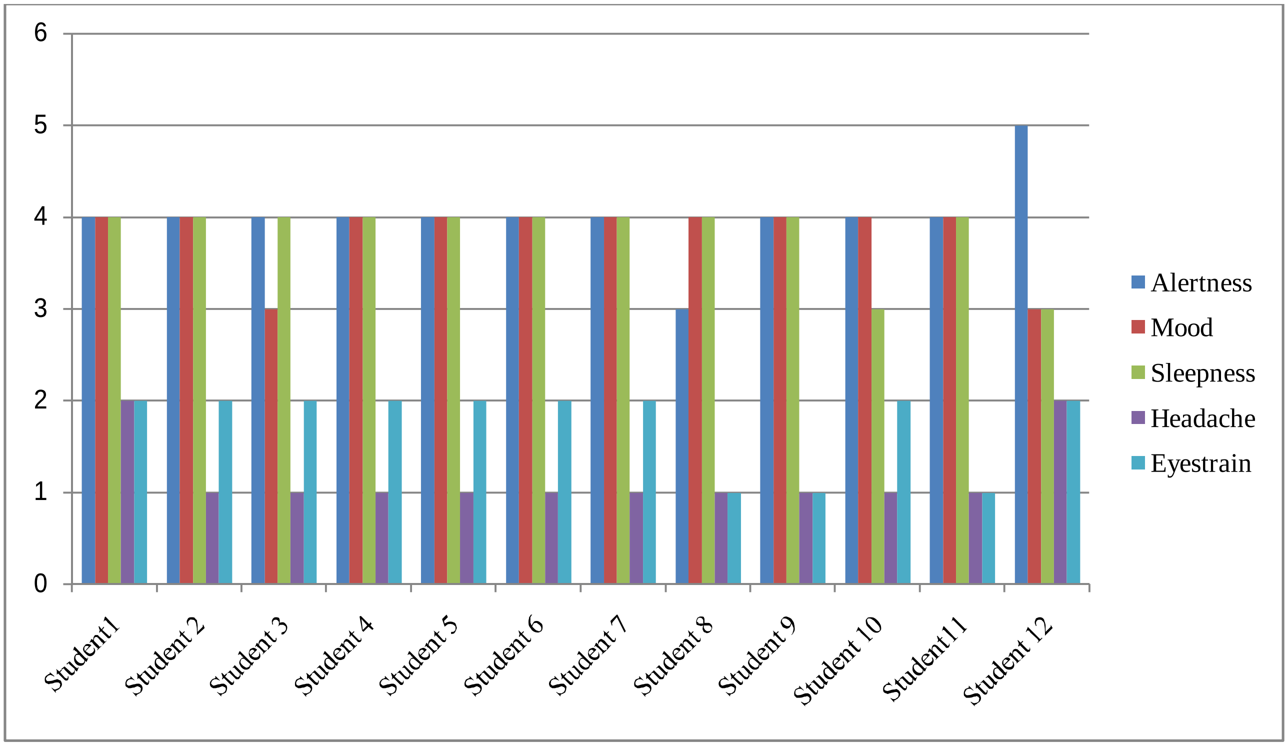


Figure 4.3 Graphical representation of reaction of students for the light level 275 Lux

It is observed that for average light level 275lux, the alertness was moderate, mood was poor, sleepness was good and absent of headache and eyestrain. The reactions of most of the students for Average Illuminance Level on working plane of 275 Lux is as shown in table no. 4.9.

TABLE 4.9: AVARAGE REACTION OF STUDENTS FOR LIGHT LEVEL 275 LUX						
Sl no	**Lux level**	**Alertness**	**Mood**	**Sleepness**	**Headache**	**Eyestrain**
1	275 lux	Moderate	Moderate	Moderate	Absent	Poor

4.11 DESCRIPTION OF EXPERIMENT FOR LIGHT LEVEL 300 LUX

The description of experiment and corresponding reaction of students for light level 300 Lux are as shown in table no. 4.10.

TABLE 4.10 : EXPERIMENTAL DATA		
1.	Light Exposure time	4 hours
2	Luminaire type	Suspended commercial luminaire containing one T 8
3.	Lamp type	20 Watt LED T8 Tube
4.	Average working plane Illuminance	300 Lux
5.	Lamp CCT	6200
6	Ceiling and wall color	White

4.12 REACTIONS OF STUDENTS FOR LIGHT LEVEL 300 LUX

The individual reactions of the five dependent variables (Alertness, mood, sleepness, headache and eyestrain) with corresponding weighted value at light level 300 lux are as shown in following table no. 4.11. The feedbacks of the students were recorded on a scale of 1 to 5 where 1,2,3,4 and 5 means absent, poor, present, moderate and good respectively.

TABLE 4.11: REACTION OF STUDENTS FOR LIGHT LEVEL 300 LUX

Sl no	Student	Alertness	Mood	Sleepness	Headache	Eyestrain
1	Student1	5	5	1	1	1
2	Student 2	5	5	2	1	1

3	Student 3	5	5	1	1	1
4	Student 4	5	5	1	1	1
5	Student 5	5	5	1	1	1
6	Student 6	4	5	1	1	1
7	Student 7	5	5	1	1	1
8	Student 8	4	5	1	1	1
9	Student 9	5	4	1	1	1
10	Student 10	5	5	1	2	2
11	Student11	5	5	1	1	1
12	Student 12	5	5	1	1	1

4.13 GRAPHICAL REPRESENTATION OF REACTION OF STUDENTS FOR LIGHT LEVEL 300 LUX.

The graphical representation of different level of reaction of each student is as shown in figure 4.4.

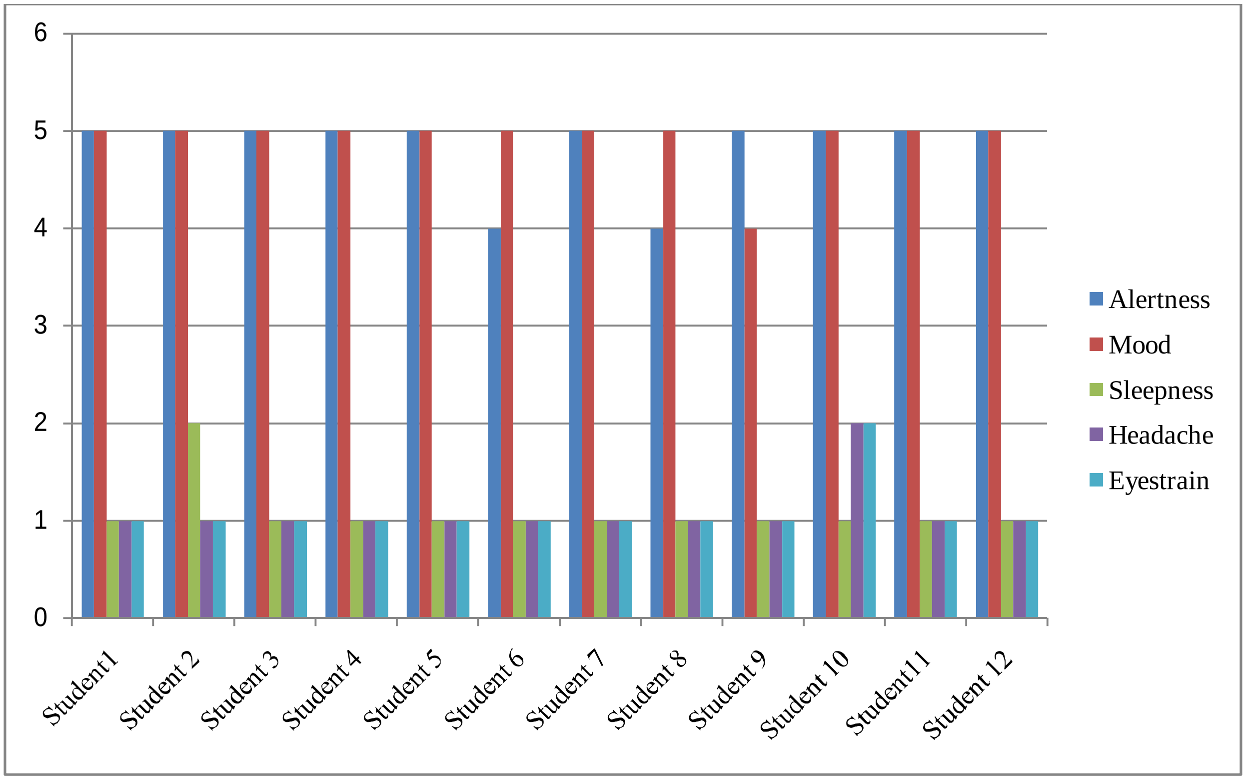


Figure 4.5 Graphical representation of reaction of students for the light level 300 Lux

It is observed for average light level 300lux, the alertness was moderate, mood was poor, sleepness was good and absent of headache and eyestrain. The reactions of most of the students for Average Illuminance Level on working plane of 300 Lux is as shown in table no. 4.12.

TABLE 4.12: AVARAGE REACTION OF STUDENTS FOR LIGHT LEVEL 300 LUX

Sl no	Lux level	Alertness	Mood	Sleepness	Headache	Eyestrain
1	300 lux	Good	Good	Absent	Absent	Absent

4.14 DESCRIPTION OF EXPERIMENT FOR LIGHT LEVEL 325 LUX

The description of experiment and corresponding reaction of students for light level 325 Lux are as shown in table no. 4.13.

TABLE 4.13 : EXPERIMENTAL DATA		
1.	Light Exposure time	4 hours
2	Luminaire type	Suspended commercial luminaire containing one T 8
3.	Lamp type	20 Watt LED T8 Tube
4.	Average working plane Illuminance	325 Lux
5.	Lamp CCT	6200
6	Ceiling and wall color	White

4.15 REACTIONS OF STUDENTS FOR LIGHT LEVEL 325 LUX

The individual reactions of the five dependent variables (Alertness, mood, sleepness, headache and eyestrain) with corresponding weighted value at light level 325 lux are as shown in following table no. 4.14. The feedback of the students was recorded on a scale of 1 to 5 where 1,2,3,4 and 5 means absent, poor, present, moderate and good respectively.

TABLE 4.14: REACTION OF STUDENTS FOR LIGHT LEVEL 325 LUX

Sl no	Student	Alertness	Mood	Sleepness	Headache	Eyestrain
1	Student1	5	5	1	1	1
2	Student 2	5	5	2	1	1

3	Student 3	5	5	1	1	1
4	Student 4	5	5	1	1	1
5	Student 5	5	5	1	1	1
6	Student 6	4	5	1	1	1
7	Student 7	5	5	1	1	1
8	Student 8	4	5	1	1	1
9	Student 9	5	4	1	2	1
10	Student 10	5	5	1	1	1
11	Student11	5	5	1	1	2
12	Student 12	5	5	1	1	1

4.16 GRAPHICAL REPRESENTATION OF REACTION OF STUDENTS FOR LIGHT LEVEL 325 LUX

The graphical representation of different level of reaction of each student for average light level 325 Lux is as shown in figure 4.5

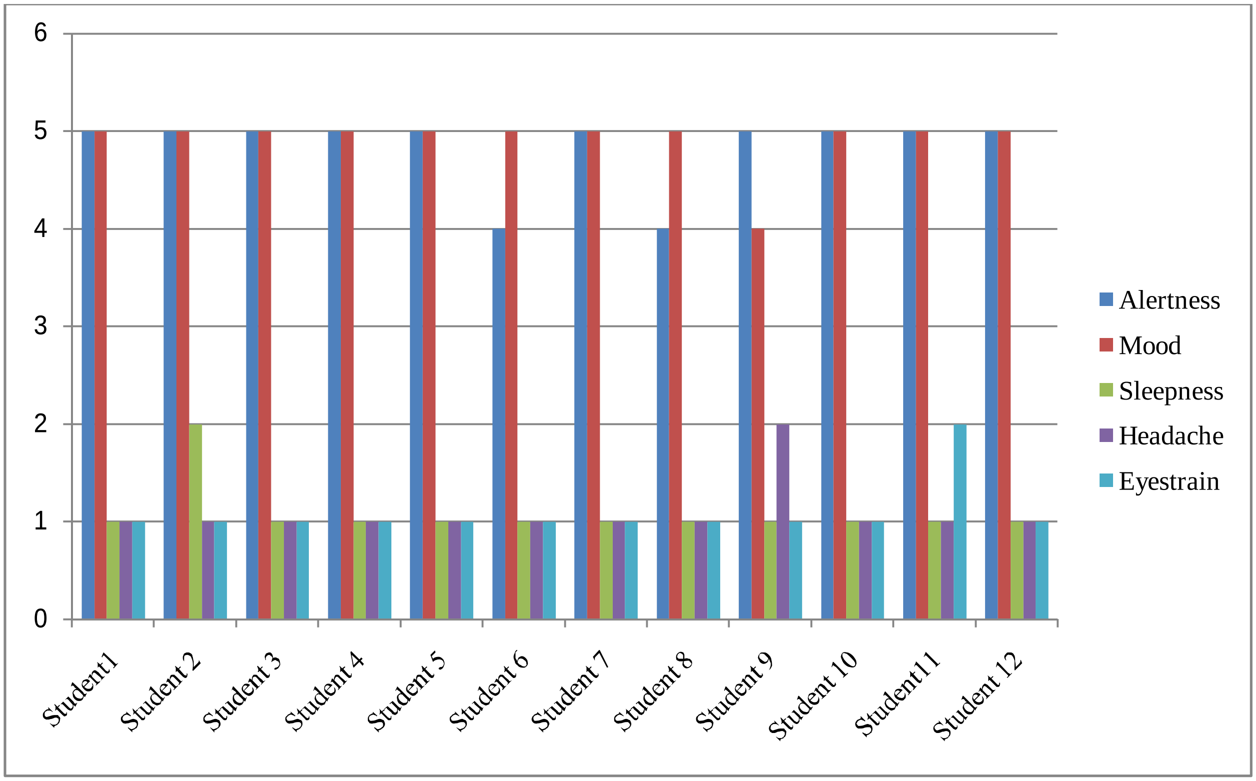


Figure 4.5 Graphical representation of reaction of students for the light level 325 Lux

It is observed that for average light level 325lux, the alertness was moderate, mood was poor, sleepness was good and absent of headache and eyestrain. The reactions of most of the students for Average Illuminance Level on working plane of 325 Lux is as shown in table no. 4.15.

TABLE 4.15: AVARAGE REACTION OF STUDENTS FOR LIGHT LEVEL 325 LUX						
Sl. No.	**Lux level**	**Alertness**	**Mood**	**Sleepness**	**Headache**	**Eyestrain**
1	325 lux	Good	Good	Absent	Absent	Absent

4.17 DESCRIPTION OF EXPERIMENT FOR LIGHT LEVEL 350 LUX

The description of experiment and corresponding reaction of students for light level 350 Lux are as shown in table no. 4.16.

TABLE 4.16 : EXPERIMENTAL DATA		
1.	Light Exposure time	4 hours
2	Luminaire type	Suspended commercial luminaire containing one T 8
3.	Lamp type	20 Watt LED T8 Tube
4.	Average working plane Illuminance	350 Lux
5.	Lamp CCT	6200
6	Ceiling and wall color	White

4.18 REACTIONS OF STUDENTS FOR LIGHT LEVEL 350 LUX

The individual reactions of the five dependent variables (Alertness, mood, sleepness, headache and eyestrain) with corresponding weighted value at light level 350 lux are as shown in following table no. 4.17. The feedback of the students was recorded on a scale of 1 to 5 where 1,2,3,4 and 5 means absent, poor, present, moderate and good respectively.

TABLE 4.17: REACTION OF STUDENTS FOR LIGHT LEVEL 350 LUX

Sl. No.	Student	Alertness	Mood	Sleepness	Headache	Eyestrain
1	Student1	5	4	1	2	1
2	Student 2	5	4	2	2	3

3	Student 3	5	4	1	3	3
4	Student 4	5	4	1	2	3
5	Student 5	5	4	1	2	3
6	Student 6	5	4	1	2	3
7	Student 7	4	4	1	2	3
8	Student 8	5	4	1	2	3
9	Student 9	5	4	1	2	3
10	Student 10	5	4	1	2	3
11	Student11	5	4	1	1	2
12	Student 12	4	4	1	2	3

4.19 GRAPHICAL REPRESENTATION OF REACTION OF STUDENTS FOR LIGHT LEVEL 350 LUX

The graphical representation of different level of reaction of each student for average light level 350 Lux is as shown in figure 4.6.

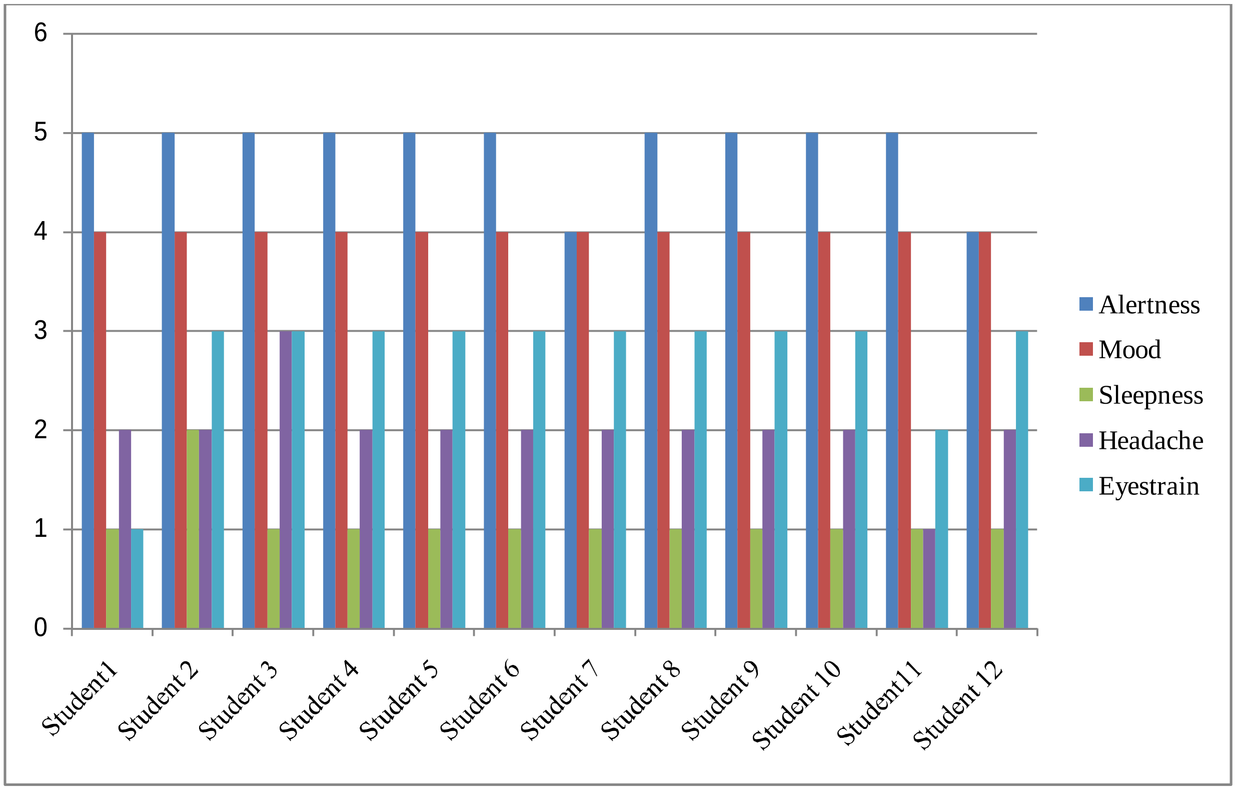


Figure 4.6 Graphical representation of reaction of students for the light level 350 Lux

It is observed that for average light level 350 lux, the alertness and mood were good, sleepness, headache and eyestrain were absent. The reactions of most of the students for Average Illuminance Level on working plane of 350 Lux is as shown in table no. 4.18.

TABLE 4.18:AVARAGE REACTION OF STUDENTS FOR LIGHT LEVEL 350 LUX

Sl. No.	Lux level	Alertness	Mood	Sleepness	Headache	Eyestrain
1	350 lux	Good	Moderate	Absent	Poor	Present

It is seen from experimental data for above six tests, the reactions of student at different Illuminance level with corresponding weighted value is as shown in table no 4.19. The feedbacks of the students were recorded on a scale of 1 to 5 where 1,2,3,4 and 5 means absent, poor, present, moderate and good respectively.

TABLE 4.19: BEHAVIORAL RESPONSE AT DIFFERENT LIGHT LEVEL

Sl.no.	Light level	Alertness	Mood	Sleepness	Headache	Eyestrain
1.	225Lux	4	2	5	3	2
2.	250Lux	4	2	5	2	2
3.	275Lux	4	4	4	1	2
4.	300Lux	5	5	1	1	1
5.	325Lux	5	5	1	1	1
6.	350Lux	5	4	1	2	3

4.20 GRAPHICAL REPRESENTATION OF REACTION OF STUDENTS AT DIFFERENT LIGHT LEVEL

Graphical representation of reaction of students at Different light level condition is as shown in figure 4.7.

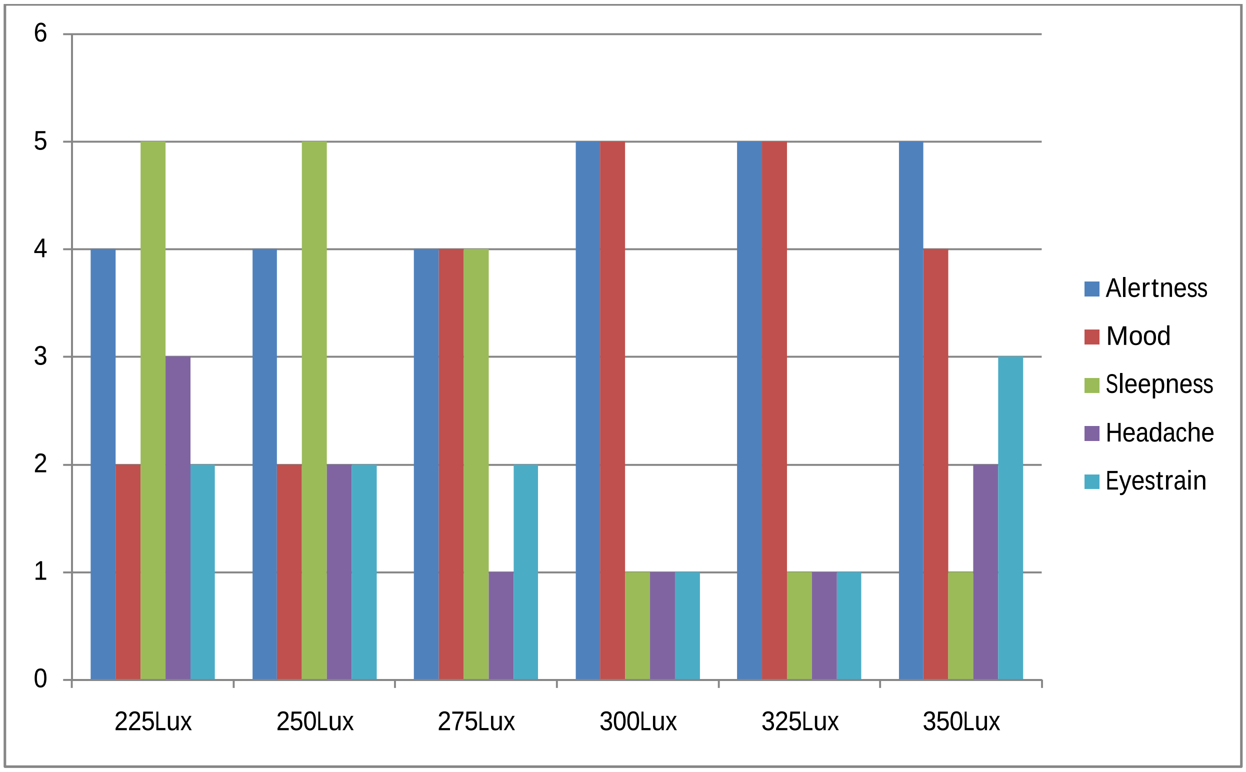


Figure 4.7: Graphical representation of reaction of student at Different light level

CHAPTER 5
OBSERVATION AND FUTURE SCOPE OF WORK

5.1 OBSERVATION

The lighting in a room should provide sufficient task lighting, provide suitable ambient lighting provide a sense of safety and security, should have the required CRI as per the requirement, should not provide glare, and should be energy efficient and cost effective. Based on this LED's have found wide range application in today's world. LED's have also been used for the purpose of this study as LED provides a wide range of advantages compared to the traditional lamps. LED's have good efficacy, good CRI, very good lamp life etc.

Light also has very deep physical and psychological effects on humans. Well designed lighting environment can alleviate eyes' strain, and increase visual stability or durability. Hence, the present research was designed to identify the influence of light on students' concentration performance and health exposure within learning environments [83]

The effect of proper illuminace on human health and awareness was studied by using these LED lights in a classroom. The effect of this studied on students who attended class for a period of 4hrs and their feedback was taken for finding the appropriate illuminance level.

This study has been framed based on the survey of the end user comfort levels for certain period of reading work with the experimental Illuminance level.The experiment has been set up in class room E-1-4 of Jadavpur University Electrical Engineering department. The Light exposure time was taken for most of the experiment of four hours duration. Luminaire type was used Suspended commercial luminaire containing one T8 lamp. Lamp type and lamp CCT was taken 20W LED T8 Tube and 6100 ± 300 K. Total 6 (six) nos. experiments has been performed with same parameter for light exposure time, luminaire type, lamp type, lamp CCT but with different average Illuminance level. The Illuminance level for different experiments has been varied by changing the no of luminaires.

From the experimental observations by survey and feedback, it has been found that the average age of the students was 20-25 years.

It is also observed that at the Illuminaton level of 300-325 Lux the Alertness and mood was at the very good state and sleepness, eyestrain and headache was absent.

For any light level above 300-325 Lux eyestrain increase and mood deteriorate. For any light level below 300-325 lux the Alertness, mood and sleepness deteriorate.

Hence the optimum light level suggests would be 300-325 Lux for age group 20-25 years for the purpose of reading.

5.2 FUTURE SCOPE OF WORK

The student for this study has been based on the restricted age group of 20-25 years students using the Illumination for reading purpose. Further elaborated comprehensive study may be made with all age group from 25-35, 35-45 and 45-60 and 60-75 years for finding the optimum Illumination level for each age group.

So different Illumination level is required for different age group ,segregation of seating arrangement can be made for public reading room or libraries where reading from the different or mixed age group uses the facility.

If group lighting with segregated areas with different Illumination levels are maintained these can be opportunity for the better efficient lighting with optimum Illumination levels for all age group of the reader.

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