
A study on the Energy Efficient Interior Lighting System of a Heritage Building

Anubrata Mondal*¹, Dr.Kamalika Ghosh*²

*¹Research Scholar, School of Illumination Science,
Engineering and Design, Jadavpur University, Kolkata-
and Head of the Department of Electrical Engineering, South Calcutta Polytechnic, Kolkata.

*²Former Director, School of Illumination Science,
Engineering and Design, Jadavpur University, Kolkata

ABSTRACT: *The majority of India's architectural heritage sites and buildings are unprotected. Those constitutes a unique civilization legacy. Heritage buildings are a vital component of urban civilization and it helps us to experience the glory of our previous days. Heritage buildings are also increasingly accepted as important venues linking a new generation with an older one, and thus as places to be used for the purpose of education and citizenship. So maintenance of the internal and external architectural lighting characters is important for preventive preservation. Therefore Interior lighting designing approach is significant for achieving this goal. Chandannagar Museum, formerly Chandannagar Governor House is one of the oldest and finest museums of the entire region. It boasts a beautiful collection of French antiques (like cannons used in Anglo-French war, proper documents, wooden furniture of 18th century, etc.) which have some antique value. This paper attempts to give a brief idea about the interior Lighting design approach followed for some typical galleries of Chandannagar Museum with the help of modern and energy efficient artificial lamp using DIALux-Lighting Software.*

Keywords: *Heritage, Preservation, French, Gallery, Lighting Software*

1. BACKGROUND : Chandannagar^[1] was established as a French colony in 1673, when the French obtained permission from Ibrahim Khan, the Nawab of Bengal, to establish a trading post on the right bank of the Hooghly River. Bengal was then a province of the Mughal Empire. It became a permanent French settlement in the year 1688. In the year 1730 Joseph François Dupleix was appointed as governor of the city. During his administration more than two thousand brick houses were erected in the town and a considerable maritime trade was carried on. These buildings symbolize the heritage and cultural influence of the town.

2. ARCHITECTURAL INFRASTRUCTURE OF CHANDANNAGAR MUSEUM: The house and the museum is located near strand at Chandannagar. It is a symbol of the glorious heritage of the town and also it houses old books, newspapers, artefacts, paintings which can be helpful for research on contemporary history of Chandannagar, as well as whole of Bengal province.

The building consists of 9 rooms, each of them are currently in use as museum rooms. Two rooms among them are conserved as the bedroom of Governor Dupleix and dining room of him. Other rooms are being used as a gallery of paintings, books, newspapers, artefacts etc.

Table 1: Description of various room in Chandannagar Museum

Room No.	Room type and Purpose	Materials
Room 1	The gallery of French East India Company and European settlement in Bengal.	Photographs,Artefacts,Books,Newspapers
Room 2	French period-gallery-comprises of 19th century-furniture and crockery, Bronze bust of Dupleix and others, Lithographs.	Paintings,Artefacts,Books,Newspapers
Room 3	Gallery of Chandernagore, 18th century Map of Chandernagore, Archival documents, sample of 19th century Industrial products and Textiles.	Paintings,Artefacts,Books,Newspapers
Room 4	Dupleix gallery with early 19th century furniture, including a bed believed to be that of Dupleix.	A High Bed with mirror
Room 5	Gallery - Freedom of Chandernagore, Indo-France collaboration. Chandernagore 1947-1954.	Paintings,Artefacts,Books,Newspapers
Room 6	Indian freedom movement and Chandernagore. The memory of Martyr Kanailal Dutta and other patriots.	Paintings,Artefacts,Books
Room7	(North wing) Paintings, Coins, Sculptures, Durga (11th century), Buddha, Vishnu (7th century).	Paintings,Artefacts,Books,Newspapers, Idols
Room 8	Handicrafts, Mediaeval Temple Terracotta, Cireperdue casting (metal casting), Ivory and painting on Ivory.	Tables,Chairs,IvoryCaskets,Candle stands
Room 9	Miscellaneous Gallery.	Paintings,Artefacts,Books,Newspapers
Room 10	Painting Gallery. Paintings of local Artists, 19th century.	Paintings,Artefacts,Books,

3. INTERIOR LIGHTING DESIGN STEPS:

- Physical survey of the Museum.
- Photometric study of the existing lighting of the Museum.
- Identification of shortcomings of existing designs.
- Exploring different lamps and luminaires that could be used in rooms and various galleries.
- Redesigning the rooms and galleries based on aesthetics, energy-efficient, technical requirements in compliance with relevant codes and validates the above design with DIALux-software.

4. PHYSICAL SURVEY OF THE MUSEUM:

Room no. 1,4 & 7 are three important area in this Heritage Building which have furnished some indoor lighting arrangements with photographs, artefacts, idols, painting, newspaper also. Existing Lighting Arrangement of these areas are furnished in Fig 1, Fig 2, and Fig 3 respectively.

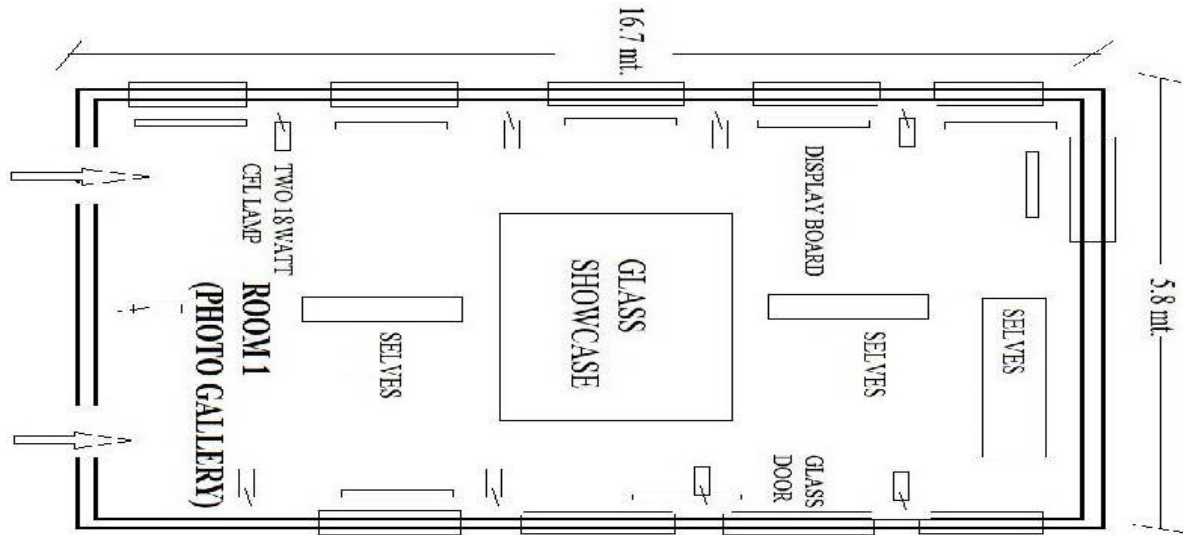


Fig 1: Existing Lighting arrangement of Room1

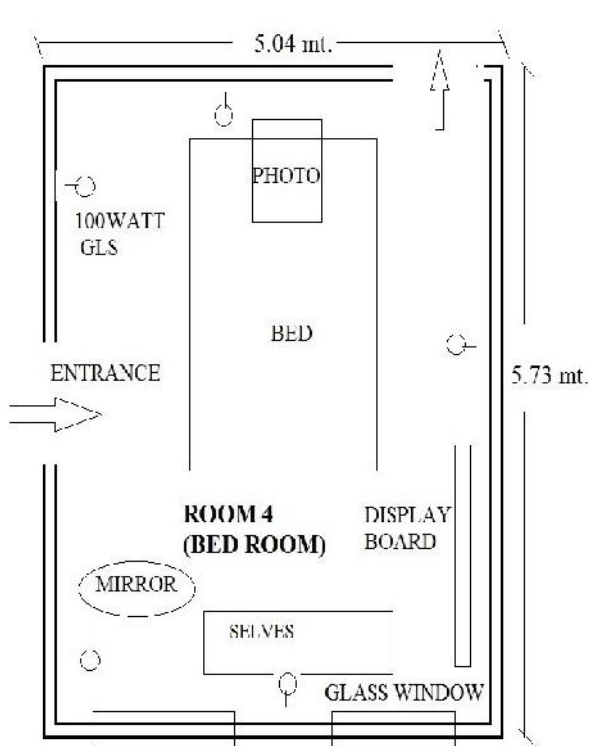


Fig 2: Existing Lighting arrangement Room 4

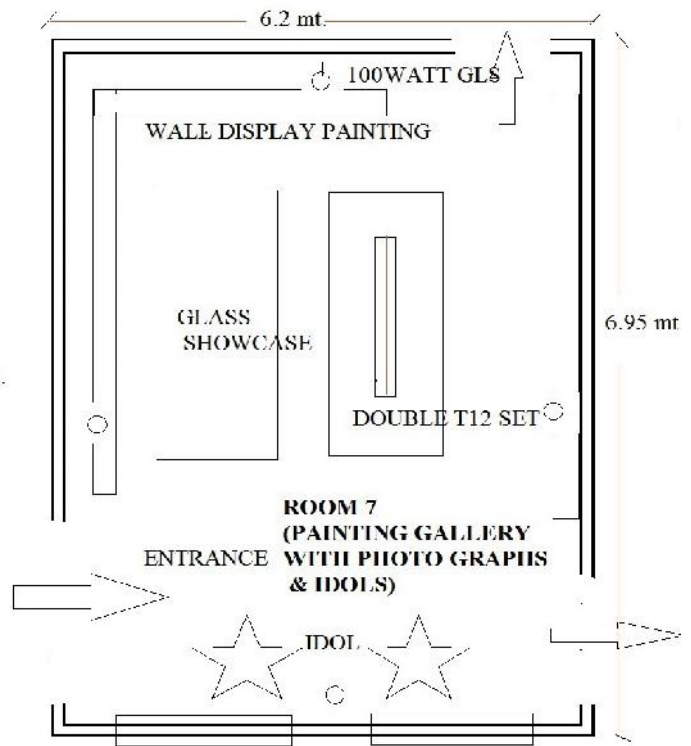





Fig 3: Existing Lighting arrangement Room 7

LEGENDS	
	18 WATT CFL
	100 WATT GLS
	DOUBLE SET T8

[Here legends are included to identified the using lamp, which are used in Museum]

4.1 EXISTING LAMP AND LUMINAIRES OF TYPICAL AREA (ROOM NO. 1 , 5 & 7):

Table 2: Brief detail about various types of photographs, artefacts and existing lamps with regard to luminaires are made

Area	Material	Lamp type	No. of quantity	Luminaries type
ROOM 1	Normal Photograph, Display Board, Newspaper	Double 18 watt CFL set	18	Wall mounted
ROOM 4	Bed, Mirror, Display Board	100 watt GLS Lamp	05	Wall mounted
ROOM 7	Painting, Photographs, Idol, Old artefacts	100 watt GLS Lamp	04	Wall mounted
		Double T12 Set	02	Suspended

5. MEASUREMENT OF PHOTOMETRIC DATA OF TYPICAL AREAS

Initial measurement for miscellaneous photometric data of typical areas, e.g., Room1, Room 4 and Room 7 has been carried out and results are furnished here in after.

- To estimate LPD value, at first calculate total power consumption per room according artificial lamps. Finally total power consumption per room divided by total area per room to get LPD value per room.
- To estimate Lux level, at first some grid points are to be taken as per room area. Then using Lux meter illuminance values at the mid-point of each grid zone have been measured. Finally for each area, the average value of these data has been taken into account.

5.1 MEASUREMENT OF LIGHT POWER DENSITY (LPD) AND LUX LEVEL OF ROOM 1 :

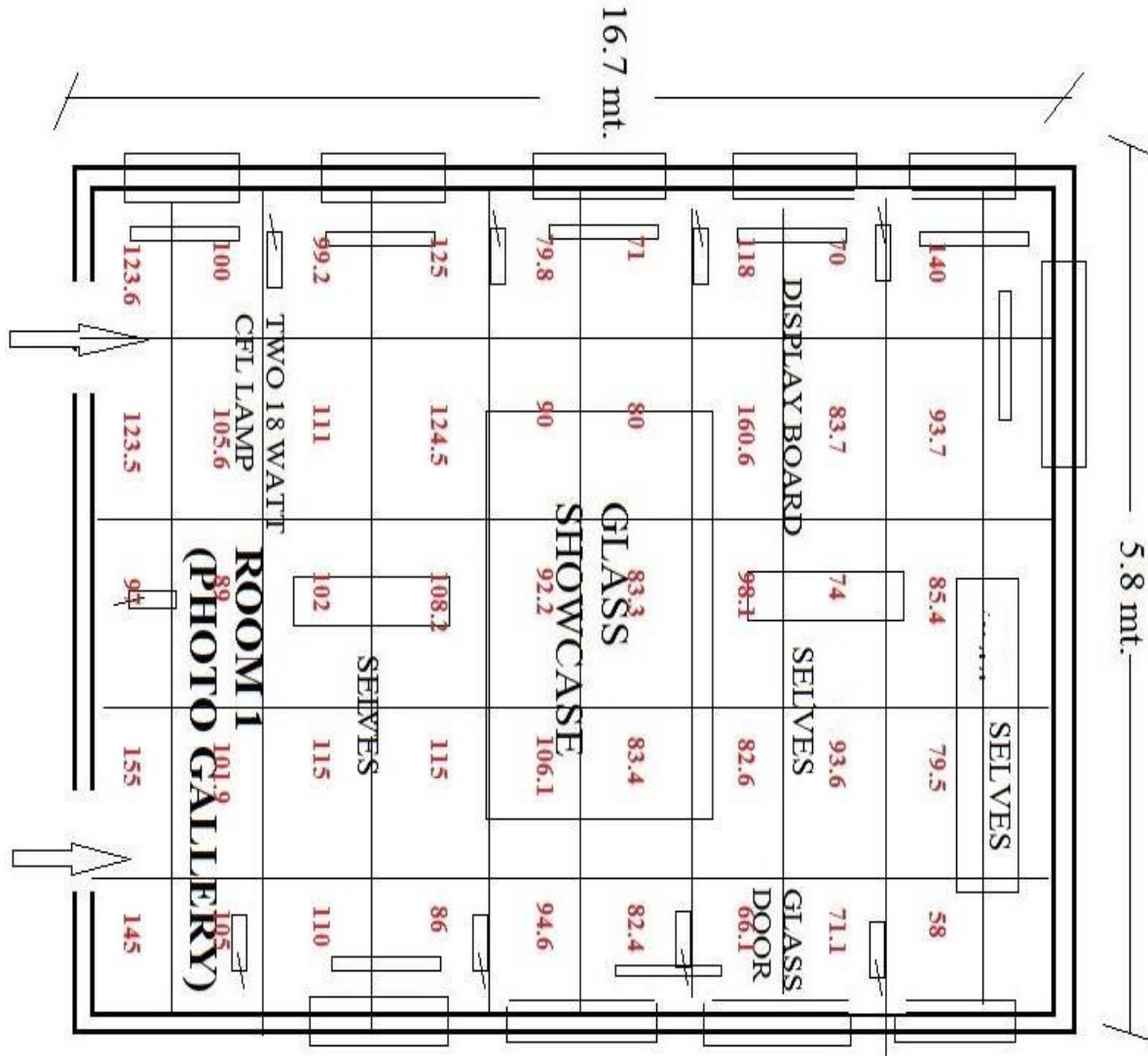


Fig 4 : Photometric view of Room 1

- **Area Calculation:** Total Area of Room no 1=96.86m².
- **Wattage Calculation:** In the Room no 1 there are 9 pair nos. (Double set) of 18 watts CFLlamp available. Due to integrated ballast 04 watts loss will take in every CFL. Total power consumptions = [(18x 18) + [(18x04) = 396watt.
- **LPD (Light Power Density):** Total wattage/Total area = (396/96.86) = 4.08 watt/m².
- **Lux Calculation:** Avg. Level of illuminance = (4478.3/45) = 99.53 lux.

5.2 MEASUREMENT OF LIGHT POWER DENSITY (LPD) AND LUX LEVEL OF ROOM 4:

Photometric view of Room 4

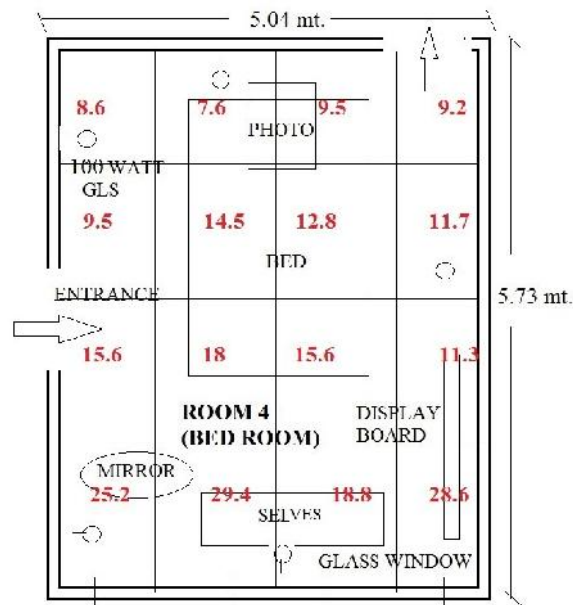


Fig 5: Photometric view of Room 4

- **Area Calculation:** Total Area of Room no 4=26.712m².
- **Wattage Calculation:** In the Room no 4, there are 5 nos.of 100 watts GLS lamp available. Total power consumptions = [(100x5) = 500 watt.
- **LPD (Light Power Density):** Total wattage/Total area = (500/26.712) = 18.71 watt/m².
- **Lux Calculation:** Avg. Level of illuminance = (245.9/16) = 41 lux.

5.3 MEASUREMENT OF LIGHT POWER DENSITY (LPD) AND LUX LEVEL OF ROOM 7:

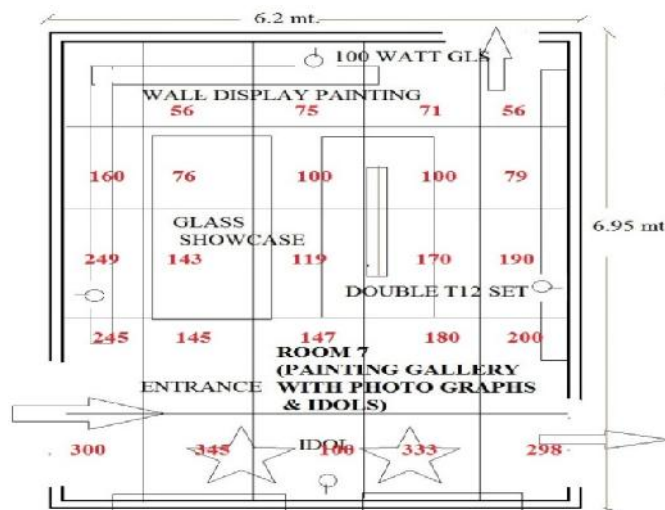


Fig 6 : Photometric view of Room 7

- **Area Calculation:** Total Area of Room no 7 = **43.09m²**.
- **Wattage Calculation:** In the Room no 7, there are 4 nos.of 100 watts GLSlamp and one double set T12 lamp available.Due to electromagnetic choke 12 watts consumes by every tube. Total power consumptions = $[(100 \times 4) + \{(40 \times 2) + (12 \times 2)\}] = 504 \text{ watt}$.
- **LPD (Light Power Density):** Total wattage/Total area = $(504/43.09) = 11.7 \text{ watt/m}^2$.
- **Lux Calculation:** Avg. Level of illuminance = $(3937/24) = 164.04 \text{ lux}$.

5.4 COMPARATIVE STUDIES WITH STANDARD GUIDELINES OF ECBC: 2009 and IS-3646^[2, 3]

Table 3 : Comparison of LPD and Lux values with standard codes and guidelines

Area	Material	Calculated LPD Value (watt/m ²) ^[2]	Recommended LPD Value as per ECBC (watt/m ²) ^[3]	Remarks	Calculated Illuminance Value (Lux) ^[2]	Recommended Illuminance Value as per IS-3646 (Lux) ^[3]	Remarks
ROOM NO.1 (Treat as general exhibition)	Normal Photograph, Display Board, Newspaper	4.08	10.8	Within limit	99.53	150	Low
ROOM NO.4	Bed, Mirror, Display Board	18.71	8.6	Exceed the limit	41	200	Very Low
ROOM NO. 7 (Treat as general exhibition)	Painting, Photographs, Idol, Old artefacts	11.7	10.8	Exceed the limit	164.04	150	compatible

6. IDENTIFICATION OF SHORTCOMINGS OF EXISTING DESIGNS^[4, 5, 6]:

- **Problem no. 1 :** Existing lighting arrangements are Fluorescent lamps of T12 with electromagnetic ballast.

SOLUTION: -Here all T12 lamps are 40 watt and use electromagnetic ballast. This includes 12 watt more power loss. So total power consumption of each T12 lamp is $(40+12) = 52 \text{ watt}$. So it can be replaced by T8 fluorescent lamp with electronic ballast. That includes $(36+4) = 40 \text{ watt}$. So per Fluorescent lamp $(52-40) = 12 \text{ watt}$ power can be save. Upcoming LED lamps that is more power consuming and give proper visualization.

- **Problem no. 2:** Objects are not visualized properly due to poor lighting arrangement.

SOLUTION: -Ambient and accent lighting concept is very much essential for this purpose. Actually ambient lighting illuminate the whole area but it can't illuminate specific object. Lighting design is very much essential to describe a room and its tradition and also feel its environment. In living room, only ambient light is used. So a visitor can't visualize each and every specific object. Used of accent lighting for specific area,

then this problem can easily be solved. But it need be kept mind that Lux level can't cross the limitation of IS-3646.

Due to poor lighting arrangement, the image of the luminaire seen on the photo, which is very much irritating for visitor. He/She can't visualize proper. In gallery, here used only ambient light. Actually ambient lighting illuminate the whole area but it can't illuminate specific object. Actually ambient lighting illuminate the whole area but it can't illuminate specific object, which may be discussed above.

➤ **Problem no. 3:** Lux level is not satisfied, very poor as per IS-3646 [3].

SOLUTION: -Here all luminaries are GLS, so light output is very poor. That is why light distribution is very poor and also gets poor lux level. So replaced GLS by LED, CFL or T8, the light output are increasing respectively. The lux level is increased. But replacement of LED, CFL or T8 is not only the solution to increase lux level. Other parameter and condition should be considered. Ambient and accent lighting has also been considered to maintain lux level as per IS-3646.

➤ **Problem no. 4:** Luminaire condition is very poor

SOLUTION: - Due to aging luminaire condition is very poor. So light distribution is not proper. For that reason maintenance is very much essential after certain time intervals.

➤ **Problem no. 5:** Light distribution is not uniform due to daylight.

SOLUTION: -Uniform light distribution is very much important for a good & efficient Lighting Design . In this room Daylight entered from a glass window so, Lux level is very high near the window & the lux level of other area is low. For this room during lighting design, daylight has been utilized during day time which is more efficient and for other area we use Modern Recessed/ Hanging Ceiling /Cove with LED Light have been used.

7. EXPLORING DIFFERENT TYPES OF MODERN ARTIFICIAL LAMPS [7]:

➤ **Light Emitting Diode (LED):** LED the solid state light, free from mercury, fully dimmable lamp for the future. It provides about 120 lumen/watt, which has a high efficacy, and it is claimed that approximate life is 20,000 hrs. It can emit light of an intended colour without the use of colour filters LEDs are ideal for use in applications that are subject to frequent on-off cycling.

➤ **Compact Fluorescent Lamp (CFL):** It is a unique replacement of a GLS or Fluorescent lamps complete with integrated electronic ballast Shape and size is small so the lamp is suitable for all types of luminaries. It is claimed that approximate life is 10,000 hrs. , CRI = 80-85 and Colour temp = CCT = 2700K [warm white] – 6500K [cool white]. Different colours of CFLs like Red, green, orange, blue, and pink are available.

8. USING LIGHTING SIMULAION SOFTWARE FOR INDOOR LIGHTING DESIGN^[8,9,10]:

DIALux software project launched by DIAL GmbH. It started in 1994 in Dial, Ludenscheid, Germany. This lighting design tool which is continually updated and adapted to the requirements of the planners, where the luminaires of the world's leading manufacturers and therefore have the greatest possible freedom in the design process. And the list of international partner companies is getting longer and longer.

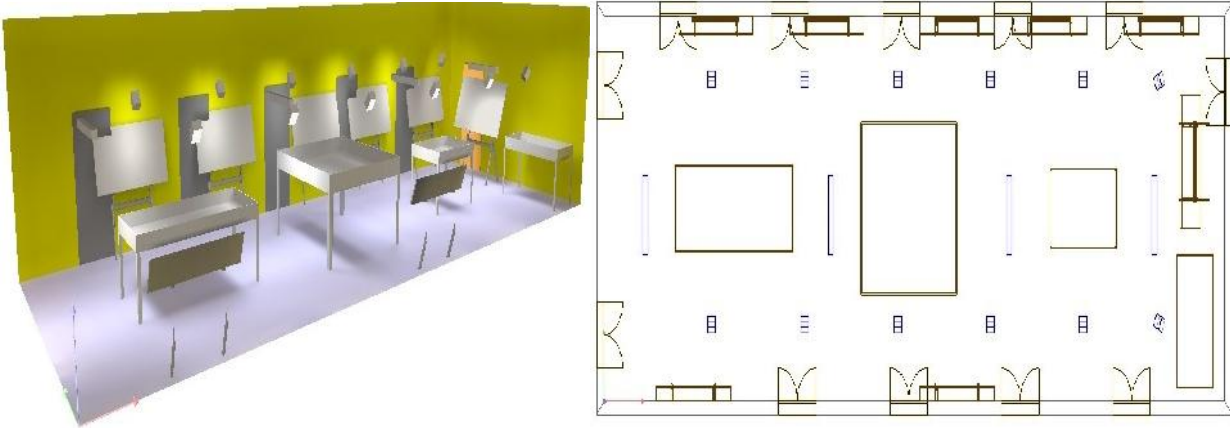
Advantages of DIALux software in interior lighting:

➤ Simple, effective and professional light planning, latest luminaries' data of the world's leading manufacturers and planning whole buildings including outdoors spaces.

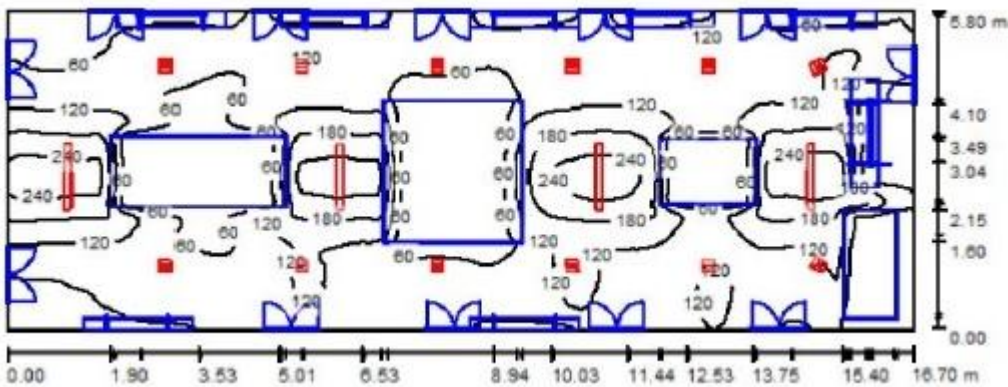
➤ Latest state of the art software always available free of charge and energy evaluation at the drop of a hat.

9. PROPOSED LIGHTING DESIGNING USING DIALUX SOFTWARE:

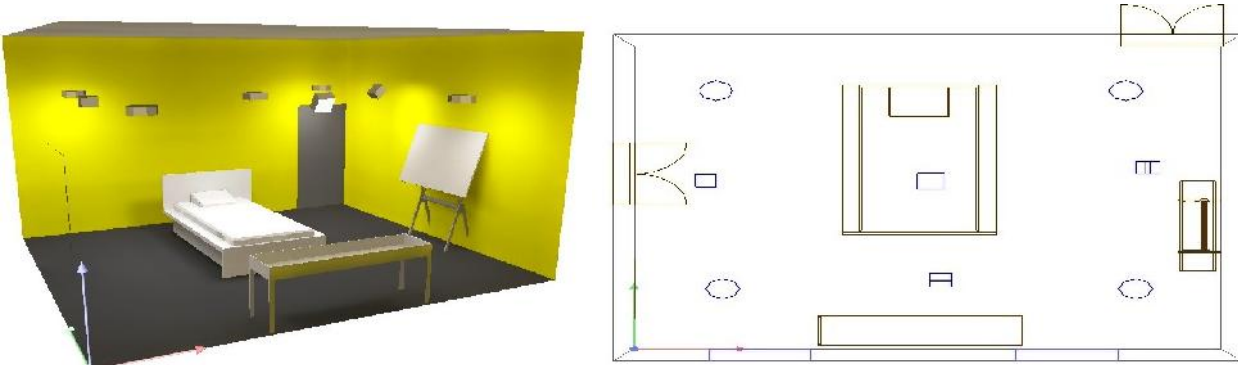
9.1 Room No. 1:



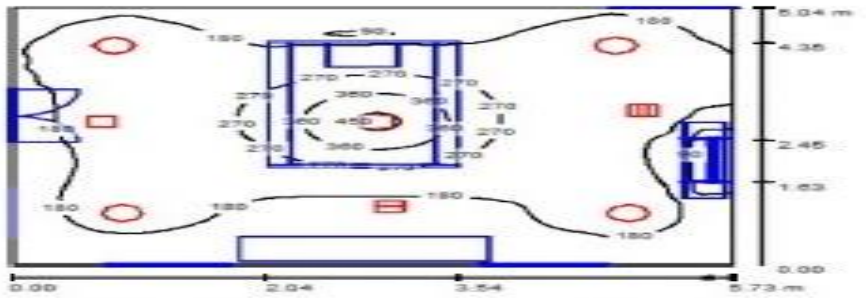
DIALux simulation result:



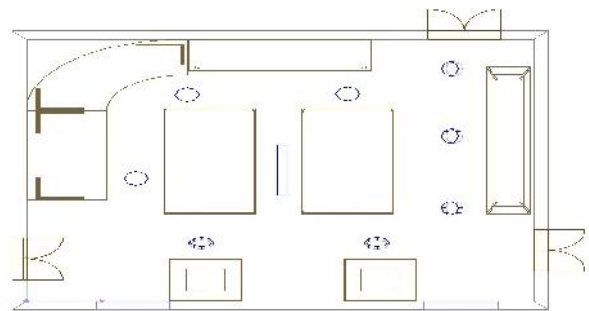
9.2 Room No. 4



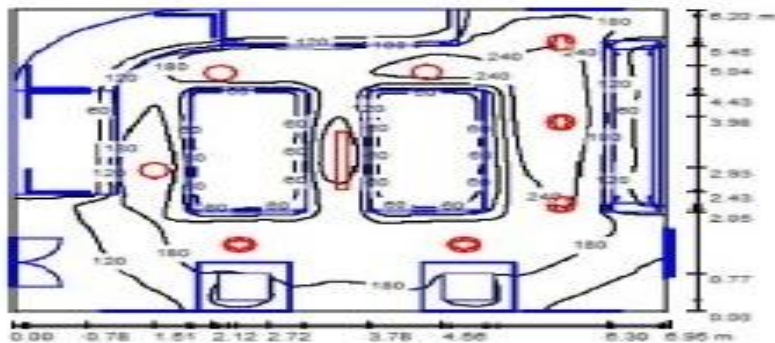
DIALux simulation result:



9.3 Room No. 7



DIALux simulation result:



10. COMPARISON OF PROPOSED PHOTOMETRIC DATA WITH EXISTING DESIGN:

Table 4: Here, calculated LPD and lux values are compared with standard codes and guidelines after redesigning with DIALux software.

Area	Calculated LPD value (watt/m ²)	Recommended LPD value as per ECBC (watt/m ²)	Remarks	Calculated LUX Value (LUX)	Recommended LUX Value as per IS-3646 (LUX)	Remarks
Room No. 1	4.03	10.8	Within limit	100	150	Satisfactory with utilization of Day light
Room No. 4	7.65	8.6	Within limit	202	200	Satisfactory Depending on photo material
Room No. 7	5.67	10.8	Within limit	131	150	Satisfactory with utilization of Day light

11. USE OF LAMPS AND LUMINAIRES FOR PROPOSED DESIGN^[8,9,10]:

Table 5: Various IES files of Lamps and Luminaires which are used for redesign with DIALux software of Room No. 1, 4, 7

Area	Lamp and Luminaries Type	No. of Quantity
Room No. 1	TCS 306 / 136 M1 (1.000)	4
	Selecon Wing RGB -GREEN (1.000)	12
Room No. 4	Eclipse lighting - LED recessed luminaire 85-S-LED80H-2EBU-93 with white interior and prismatic flat glass lens (1.000)	1
	Eclipselighting hor-15-LED25-3K-120- SA 15-1/4"DIA. X 3-3/4"H. LED luminaire. Diffused lens. (1.000)	4
	Selecon wing RGB -green (1.000)	3
Room No. 7	TCS 306 / 136 M1 (1.000) Eclipse lighting hor-15-LED25-3K-120-	1
	SA 15-1/4"DIA. X 3-3/4"H. LED luminaire diffused lens. (1.000)	8

12. LOAD CALCULATIONS– EXISTING AND PROPOSED^[11]:

Table 6 : A simple comparison of power consumption between existing and proposed design

Sl. No.	Area	Wattage Calculation Each Room (Watt)- Existing	Wattage Calculation Each Room (Watt)- Proposed
1	Room No. 1	396	390.8
2	Room No. 4	500	220.8
3	Room No. 7	504	244.5
TOTAL		1400	856.1

13. TOTAL ENERGY SAVING FOR THIS TYPICAL AREA:

(Proposed Design)

- Power consumption with existing arrangement = 1400 watt
- Power consumption after modification = 856.11 watt
- So, total power savings = (1400-856.1) = 543.9 watt

Percentage of energy savings = $[(1400-856.1)/1400] \times 100\% = 38.85\%$

14. CONCLUSION:

This paper is centred on the Interior Lighting Design of a Heritage Building, where main objectives were to propose a new energy efficient, aesthetic and modern Interior lighting design for these galleries with the help of energy efficient lamp. To illuminate the interior part of the buildings with proper light sources increases its attraction among tourists as well as helps preserving the old materials and artefacts inside the building. It saves energy, adds value to local tourism and helps to create local employment. Sadly, these buildings are generally neglected in our country and many such buildings are in a very poor condition. With a little effort, these buildings can be revitalized using lights and minimum maintenance and heritage walks or light and sound shows can also be arranged to recreate the past.

15. ACKNOWLEDGEMENT:

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