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Integration of Artificial Lighting in Textile Museum Exhibition Space

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ABSTRACT:Textiles have been manufactured in India since the artwork conveys the heritage, tradition, and culture of the past. Museums are the only ways to provide complete information related to traditions, history, art and craft. Lighting in textile museums plays an important role. In museums, lighting is needed not only for ancient artifacts but also terms for a high degree of integration of technology. This paper discusses the role of light in the textile museum. It addresses the various types of artificial lighting suitable for textile museums, various display techniques of exhibits, lighting angle, height, and various lighting system for different purposes. It also discusses the preservation of textile exhibits from light radiation. Some of the artificial light produces a large amount of radiation which can easily deteriorate the textile exhibits. So, this paper discusses the amount of lux needed for sensitive and insensitive textile exhibits to avoid deterioration. Simulation has been done by using DIALux software and their datasets have been compared which shows the types of lights that can be used in an exhibition gallery. This study helps in identifying the suitable types of artificial lights for sensitive and insensitive textile exhibits, angles, and systems with proper illumination.

KEYWORDS: Artificial Lighting, museum lighting, DIALux software, Amount of lux, Textile display techniques.

I. INTRODUCTION

The museum's purpose is to display, preserve, and educate. Exhibition and protection play with each other, as high display quality required high visual sensitivity which can damage the textile exhibits through ultraviolet and infrared radiation of light. The lighting design in the textile museum presents a significant challenge for architects and interior designers, as it attracts the public. The primary responsibility of a museum is to care for its collections. It is necessary to pay attention to creating a proper environment in the museum by installing suitable types of lights according to the need for space and exhibition collection. As some of the textile exhibits are light-sensitive which requires suitable types of lights that produce less ultraviolet radiation.

Highlighting the textile exhibits are also very common in the museum. It is necessary to explore the different angles of light suitable for exhibits and the proper distance of the light from the exhibits with the suitable lighting system.

Preventive conservation is an important aspect of museum policy. It is necessary to protect the environment of textile exhibits. A museum should carefully check the condition of exhibits to determine when textile exhibits need conservation work. Its aim is to delay deterioration by providing a properly maintained environment for every textile exhibit. And provide the required amount of illumination for the textile exhibits to avoid deterioration.

AIM:

An attempt to integrate and understand artificial lighting into textile museum exhibition space through appropriate architectural intervention.

OBJECTIVE:

- To study the different types of artificial lighting and their applications in museum exhibition space.
- To identify the amount of lux required for sensitive and insensitive textile exhibits to avoid deterioration.

SCOPE:

- The study would cover the various types, display techniques, height, angles, and system of artificial lighting for textile museum exhibition space.
- Identification of types of lighting in an exhibition gallery with the required amount of lux for light-sensitive and insensitive exhibits.

LIMITATION:

- The study will only be limited to the museum exhibition galleries.

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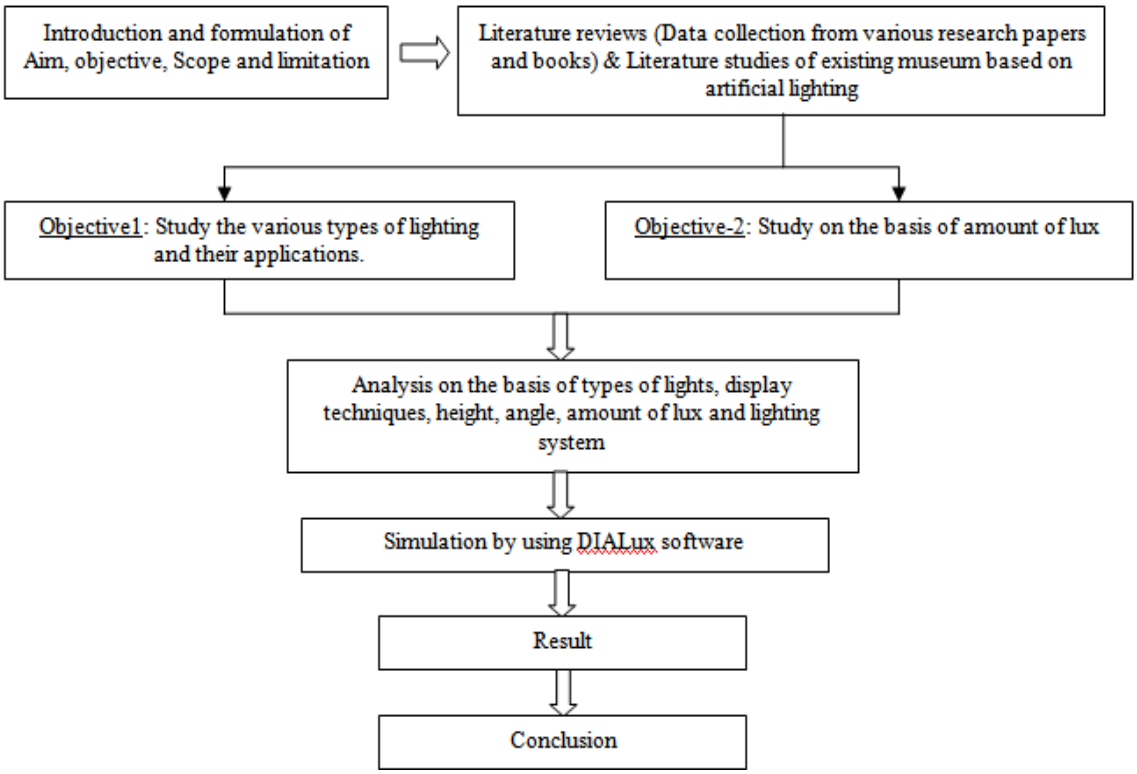
- The study focuses on types of artificial lighting and amount of lux for textile exhibits, not on the material been used.

II. METHODOLOGY

It is first important to identify what are the different types of artificial light used in museum exhibition space for sensitive and insensitive exhibits, which types of artificial lights are used to highlight the sensitive exhibits inside the showcases. And also what are the different display techniques, angles of lights, and lighting system. Hence, firstly it is important to identify different types of lights and their applications using the data collection from various literature reviews and literature studies. The parameters are types of artificial lights, display techniques, height, angle, and lighting system. And the second phase includes the amount of lux required for sensitive and insensitive exhibits. The data collection has been analysed through a comparative study. And then parameters have been considered on the basis of analysis for simulation. Then finally all these studies give a result and conclusion which should be considered while designing the textile museum.



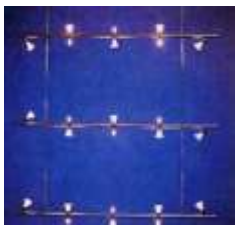
III. LITERATURE REVIEW

Model Kristin McWilliam Bennett (2008), Lighting in architecture: Natural and Artificial lighting techniques that brighten our sacred spaces:

This research paper discusses the various lighting system that is downlighting, uplighting, spotlighting, track lighting, linear lighting, decorative lighting, and task lighting.

Table1. Description of various lighting system:

Lighting system	Pictorial presentation	Description
Down-lighting		It can be used to provide direct light and indirect light also if it is placed along the top of walls. It is used to reduce glare. It can be used to highlight the

	 **Figure1:** Down-lighting	wall.
Up-lighting	 **Figure2:** Up-lighting	It is used to highlight the exhibits in the museum and also it can create a dramatic effect. It can be easily installed in showcases. It can be used to brighten the ceiling.
Spotlighting	 **Figure3:** Spotlighting	It is mainly used for its dramatic effect to highlight exhibits. These lights are mostly used in museums, exhibition galleries to attract visitors to specific elements. It helps to create visual interest within a space.
Track lighting	 **Figure4:** Track lighting	Track lights can be directly mounted onto a wall and ceiling or suspended to provide a decorative effect. It can be rise above and below the track to provide different heights.
Linear lighting	 **Figure5:** Linear lighting	It is similar to the track lighting system. But the basic difference is instead of light sources located at different points along a track the entire track is a light source. It can be mounted, suspended, or recessed on surfaces.
Decorative lighting	 **Figure6:** Decorative lighting	It can be used to produce decorative effects in a space. It produces glamour and dramatic effects. It should be used in accordance with the form of ambient lighting.
		It is used to provide extra light in task-specific areas.

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Task lighting	 **Figure7:** Task lighting	It provides the necessary brightness needed for adequate vision. These lights are small in scale. It can be incorporated into cabinets and showcases. It is excellent for providing different amounts of brightness where required.

(**Source:** Lighting in architecture: Natural and Artificial lighting techniques that brighten our sacred spaces by Kristin McWilliam Bennett)

James R. Druzik (2010), Good lighting for museum, galleries and exhibitions:

Showcases are small scale exhibition room which contains exhibits. The exhibits need to be illuminating with diffuse or directional light. The types of lighting required in showcases are depending on the characteristics of exhibits.

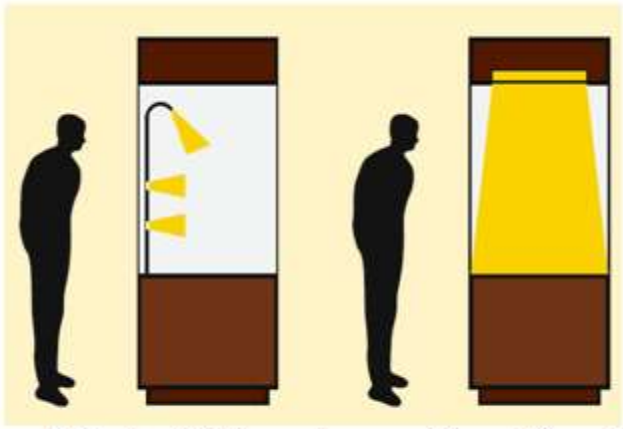

Figure8: Directional lighting makes more prominent the exhibits

Figure9: Planar lighting makes uniform illumination

(**Source:**Good lighting for museum, galleries and exhibitions by James R. Druzik)

Integrated lighting is used in shallow display cabinets, high or box-shaped showcases, and small cabinets. One of the best advantages of integrated lighting is that no reflection creates on the cabinet or showcase of glass. It is easy to avoid direct glare due to bright unprotected light sources.

Exhibits are illuminated from the side in small display cabinets. But in high display cabinets or showcases, exhibits can be illuminated from the top and the base of the cabinet. Separate ambient lighting is generally necessary for the showcase. The exhibition room lighting should be low level than the showcase lighting depending on illumination permitted for conservation and atmosphere requirement. Dedicated orientation lighting should not be very low.

The most important consideration for showcase lighting is light protection because lamps in showcases are closer to exhibits. The enclosed space of a showcase has its own microclimate. LED doesn't contain IV or IR radiation, so LED is the most appropriate light for showcases. Fiber-optics also have very low UV /IR content. So these lights are suitable for the illumination of exhibits in very small display cabinets. The safeguards are required in a showcase for halogen lamps and fluorescent lamps.

Pooja singh, Ekta Sharma and Hargis Fatima (2017), A case study on conservation of textile in Allahabad Museum, Uttar Pradesh:

This paper discusses the various types of textile antiquities and protection and safeguarding techniques utilized in the Allahabad exhibition hall. Textile has a wonderful past in India which reflects change patterns in a period of civilization and history. Dirt, dust, air pollution and contact with harmful materials, light (especially radiation), careless fingers, and damp and sticky are the

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various problems for the textile museum. There are two types of conservation techniques to protect the museum textile from this problem are Preventive conservation and curative conservation.

Light sensitive and light durable are two types of collection especially in relation to light. Light-sensitive exhibits should be illuminated to 50 lux. The total amount of lux illuminated on exhibits in a year is 200,000 lux hours (~ 50lx for 10 hours/day 365 days/year). And light durable collections need the illumination of 250 lux.

Textile exhibits also harm by insects. Cockroaches may lead to severe damage. Some dust particles in the environment may cut the fibers of artifacts. There are some dust particles that are sufficiently large and perform like knives that cut the fibers as the textile enlarge and contract due to fluctuations in relative humidity.

Clamps and hooks have been preferred props for the display of textiles. Hooks with adhesive are used for no damage to the textile. They also used to slide a wooden dowel with a small diameter in and the hooks are hung on the dowel resulting in a fine straight top edging. Nails were not used, as it gets rust easily.

The most appropriate covering material for displayed textile articles are glass cases followed by protective transparent sheets and lamination with scratch-resistant, gas-impermeable, and laminated or coated with UV-filters.

Stitching, darning, patchwork, lining, backing, pasting, and netting are different methods used for strengthening textiles.

Table2. Pretreatments for textile antiquities are:

Pretreatments	Cotton	Silk	Wool
Strengthening	✓	✓	✓
Insecticide			
Fumigation	✓	✓	

NCERT (2007), Human Ecology and Family Sciences- Part-2 (Textile conservation in museum):

This book states the various factors leading to the deterioration of textiles. The textile museum largely consists of natural fibers. Natural and man-made are factors of deterioration. It is necessary to understand the causes of damage to textile, how to prevent the damage.

Table3. Various factors of deterioration of artifacts:

Natural factors	Man-made factors
Light	Accidents
Temperature	Bad storage
Pests	Neglect
Humidity	Mishandling
Pollutants in the atmosphere	Fire

(**Source:**Human Ecology and Family Sciences-Part-2 **(**Textile conservation in museum))

Textiles are organic in nature which allows damage by light, heat, moisture, pollutants, and pests. One of the greatest problems of textile is light. Light is a form of energy that can fade the color of textile and can cause physical and chemical degradation of textile fibers. Natural has more ultraviolet light which can easily damage the textile exhibits. Fading of colors, changes of hues are the easiest way to detect signs of light damage. Firstly, textile loses their flexibility and then become weak and finally break into fragments, tears and ultimately. This process can go along with general yellowing and browning of textile which indicates a poor state. Natural light is capable to cause a great amount of damage within a short time because natural light has a huge amount of ultraviolet rays. There is various preventions damage from light:

1. Show the displays to light for a minimum timeframe.
2. The maximum amount of illumination for sensitive textile exhibits should not exceed 50 lux.
3. Minimize the intensity of light falling on exhibits.
4. Remove the photo-chemically active radiations from the light.

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Figure10: Textile fading from light
(**Source:**Human Ecology and Family Sciences- Part-2 **(**Textile conservation in museum))

Bureau of Indian Standard (1992), IS 3646 (Part-1) (Code of practice for interior illumination):

Table4. Amount of lux for different types of exhibits-

Types of Exhibits	**Amount of Lux**	**Remarks**
Light insensitive exhibits	200lx	This is the maximum amount of lux to be provided on the plane of exhibit.
Light sensitive exhibits	50lx	This is the maximum amount of lux to be provided on the plane of exhibit.

Riccardo Bianchini (November-2019), Inexhibit, Light sources for exhibition design- part-1, 2, and 3:
This paper talks about the different types of artificial lighting. Incandescent lamp, fluorescent lamp, LED, incandescent lamp, metal halide lamp and fiber optics are different types of artificial lighting that have been examined.

1. Incandescent Lamp:

An incandescent lamp is a glass bulb that contains a thin filament. At the point when a current passes through the filament, it warms up and produces light. It has a glass chamber that protects the filament from contact with air. Incandescent are lamps which illuminate our world for centuries. Thomas Edison had invented the incandescent lamp in 1880. He invented the long-lasting tungsten filament of an incandescent lamp. The lamp exists in a wide range of shapes, forms, colors, applications, and voltages. It has very poor energy efficiency and has a short life span. They are cheaper to make and buy and they have a good spectrum, color rendering, and consistency. It produces lots of heat and it has a very short life span. Incandescent lamps are the most common electric light source. It is still widely used.

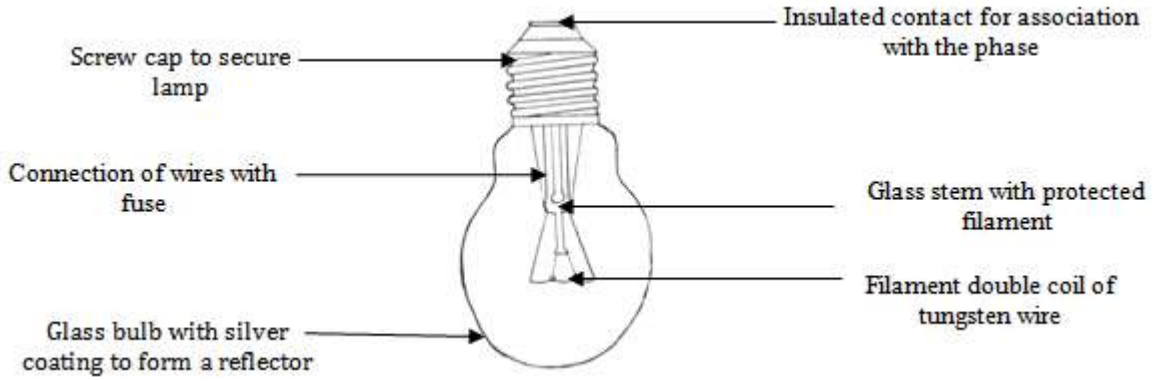

Figure11: Incandescent lamp

(**Source**-Self)

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2. Fluorescent Lamp:

Fluorescent lamps are constructed utilizing a rounded glass envelope covered inside with a blend of phosphors. Fluorescent lamps are available in various shapes, linear, globular, and circular. This light works by changing over the bright light transmitted from an electrically energized gas into apparent light by a surface kept phosphor. Fluorescent lamps are suitable for exhibition lighting as it has long working life. It is inappropriate for direct illumination. It is a good resource for exhibitions such as object lighting. It has been broadly utilized in huge lighting establishments due to its long life, decreased explicit electrical utilization, and low surface temperature. These lamps are eight times more efficient than incandescent lamps. Fluorescent lamps are used for showcase illumination.

3. Metal-Halide Lamp:

Metal halide lamps are utilized to make diffuse lighting in display exhibition space. They are the pieces of the gas-release lights in which light is delivered by simulating the electrons of gas by an electric discharge. They are the most powerful lamps for the interior. They are long-lasting and most efficient. Their huge emission at short ultraviolet wavelengths is the drawback of unshielded metal halide which requires the expansion of ultraviolet channels to stop the harm of display exhibits. Metal halide lights are utilized for making diffuse foundation lighting to be finished with directional lights.

4. Halogen lamps:

The incandescent light is a halogen light where the gas chamber is with halogen gas. It allows the light to operate at higher temperatures, last longer, and more compact. Halogens are higher in performance than normal incandescent. It has higher efficiency and a longer life span but more costly. It can be used as a high-quality spot light. Halogen lamps are most normally utilized in inside lighting.

5. LED:

LED stands for Light Emitting Diode. It utilizes a semi-conductor to change over electrical energy straightforwardly into the light. It has the quality of long-lasting and highly efficient. It gives a longer battery life than different sorts of light sources. LEDs are mostly used in exhibition lighting. It can be installed very close to exhibits because it has a very low surface temperature. It is used to only available in red, white, green, and yellow. These lights are not suitable for general lighting because of their low energy efficiency. LED has been developed for decent general lighting. LED has an extremely poor spectrum.

6. Fiber Optic:

Optical fibers are mediums through which light from a source to the emitter. These are cables that are made by a bundle of plastic filaments. It can transport light from one point to another point with very low adsorption and diffusion rates. There are two types of fiber optics used for exhibition lighting:

1) Side-emitting: It is mainly used for eye-catching. Their effect is similar to those obtained with LED strips and fluorescent lamps. This is usually large and more flexible than end emitting. It is much more visible in ambient light. It looks better in darkness as it creates a diffused glow.
2) End-emitting: It is also called an end glow or end light. They are generally stiffer than side-emitting fibers. It is mainly used like halogen lamps for spotlighting small objects. End-emitting light becomes visible in the dark when little light along the stand gathers into bunches.

Figure12: Optical fibers have been used to achieve different lighting effects.

(**Source:** Inexhibit, Light sources for exhibition design- part-3 by Riccardo Bianchini)

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Optical fibers provide good chromatic performances especially when coupled with a halogen lamp, at the same time illuminated objects without overheating, which is required for very fragile artifacts. The disadvantage of fiber optics is the high cost of the complete systems. It reduces the luminous flux provide by single emitters. It needs the place to illuminate rather close to the target, secured and vent space.

IV. LITERATURE STUDY

Literature Study 1: The Allahabad Museum

- Location – Allahabad, Uttar Pradesh
- Building Type- National Museum
- Year of construction- 1931

Figure13: Baluchar saree, Murshidabad 20th Century

(**Source:**A case study on conservation of textiles in Allahabad museum, Uttar Pradesh)

- The museum is famous for its different galleries. It has a total of 18 galleries that display a large collection of antiquities.
- Textile gallery contains several sensitive and magnificent textiles including Phulkari and Chikankari.
- Textile, weapons, and the document and personal effects of Nehru have been showcased.
- Various types of textile have been conserved in the museum including Phulkari, Baluchari saree, Carpet, Kurta, Jackets, Odhani, Lehnga, Chikankari kurta, Painting on cloth of 19th century, Shawl, Cotton print, Paithani Saree, Tribal veil cloth, etc.
- The most common types of artificial light used in the museum are incandescent bulbs.
- Used incandescent bulbs with value of 70 lux.
- Showcasing, roller, hangers, and tables were the most usable display techniques used for textile antiquities.
- Dummies and mannequins are also the most preferred display techniques.
- Cove lighting has been used in mannequins.

Literature Study 2 : Cedar Hill Museum of History

- Location – Cedar Hill, United States
- Building Type- Historical museum
- Year of construction- 1978
- Name of Architect- William R. Walker
- Indirect, direct, spots, track system, downlight, and floods are different illuminators that are utilized to give the layering impact of lighting.
- The mix of different types of lighting produces the ideal nature of light and enlightens the planned shows.
- The various types of lighting that have been used are-

1. Metal halide lamp
2. Compact fluorescents lamp
3. Fiber optics,
4. Gobo projectors, and
5. Linear fluorescents lamps

- There is a lowered ceiling with compact fluorescent downlights at the entrance of the museum.
- Dummies are featured with metal halide PAR 20 floods and clipped with metal halide PAR 20 narrow spotlights.
- Niches that display artifacts are lighted with fiber optics to highlight the texture.
- There is a glass curtain on the north and west side to emit natural light into space.
- Linear fluorescents with an extraordinary precise focal point in Display cases to spread the light for the situation for review.
- The height of the ceiling is 12 feet and cove lighting has been installed.
- Distance between the wall and tracking system is 3 feet with different light sources.
- Metal halide and downlights are various types of lights use for the track systems.

Literature Study 3 : Liaoning Provincial Museum

- Location – Shenyang, China
- Building Type- History and art museum
- Year of construction- 1949

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- Name of Architect- Sutherland and Hussey Architects.
- Fluorescent lamp is the most common artificial light which has used in the museum.
- The maximum illumination in the museum is 200 lx which has used in a pleasant area.
- There is a dark adaptation process under the darker lightness on the entrance of the museum.
- Textiles, printed matter, dyed leather comes under the categories of sensitivity to light sources.

Table5:Lighting parameters for conservation of artifacts

Sensitive of light	**E.max (lx)**
Low (e.g. marble and metal objects)	300
Medium (e.g. oil paintings and frescoes)	150
High (e.g. textiles and manuscripts)	50

- Printed matter, manuscript documents and description labels have displayed on vertical walls.
- Exhibition case is made of transparent glass or acrylic.
- The most proper projection angle is 30 degrees for light distribution illumination in order to avoid glare.
- Lamp and lanterns are the outside lighting which has placed directly in front of the cabinet and project downward.
- Lamp interlayer or light box is arranged inside the display cabinet on top. The aim is to provide illumination for the artifacts displayed in the cabinet.
- Lamps and lanterns have installed at suitable positions at the inside, back, and bottom of the cabinet.
- Auxiliary lighting has used to show the material and shape of the 3-D exhibits.
- Two-point light distribution has used for 3-D exhibitions, i.e. - one main light and one auxiliary light.
- The original lighting level is very low for special scenes such as dark nights and ancient caves.
- Stand-alone cabinets and wall-to-wall cabinets are two types of display cabinets that have used.
- Lighting outside the display cabinet to highlight is generally used in low-rise display cabinets.

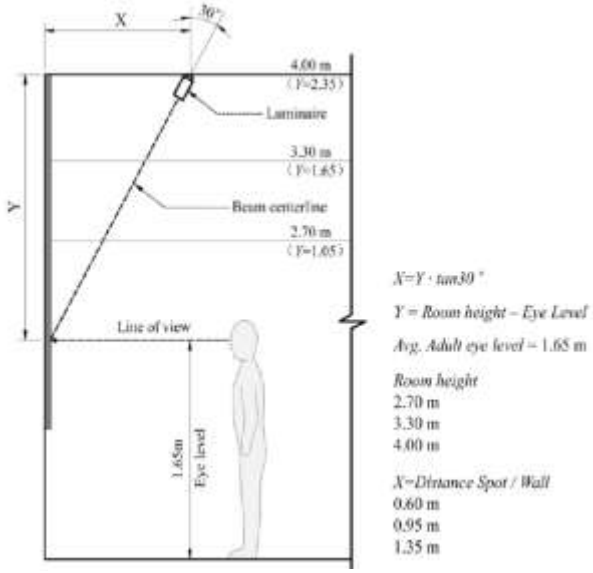

Figure14: 30 degree projection angle to avoid glare

(**Source:**Artificial Lighting in Museums: an Interdisciplinary Approach towards Improving Museum Visitors' Emotive Experience by Zhisheng Wang, Yukari Nagai, Zhi Sun and Nianyu Zou)

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- Height of the room is 4.00m.
- Average eye level is 1.65m.
- Distance between the light and artifact is 1.35m.
- Display cabinets are also a common means to display exhibits, as it protects the exhibits from damage.

Table6: Average illuminance values of different spaces of Liaoning Provincial Museum

Space	**Average illuminance**
 **Figure15**: Hall of the Museum	126.6 lx
 **Figure16**: Exhibition hall 8	3.107 lx
 **Figure17:** Exhibition hall 2	6.030 lx
 **Figure18:** Corridor of the museum	121.2 lx

Literature Study 4: Living & Learning Design Centre.

- Location – Ajrakhpur, Kutch, Gujarat.
- Building Type- Textile museum
- Year of construction- 2015
- Name of Architect- Uday Andhare& Mausami Andhare

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Figure19: Exhibition gallery of Living & learning Design Centre

(**Source:**Marisha Karwa (2016), DNA, This one of its kind textile museum is a tribute to Kutch artists)

- Lightwell creates a multifocal point for the exhibits.
- Panels showcasing portraits of community artisans above display cabinets, the collection, and information delivered through graphic are the three-tier information system which has been used.
- Concrete finish with a palette of muted colors to enhance the exhibits and allow one to observe the shade of style, texture, color, and so on.
- Highest grade of LED lighting has used to ensure high-quality display.

Literature Study 5 : Pushkin Museum.

- Location – Moscow, Russia
- Building Type- Art museum
- Year of construction- 1912
- Name of Architect- Roman Klein

Figure20: Pushkin Museum

(**Source:**Feilo Sylvania, "Lighting for Museum and Galleries")

- Beacon Muse LED spotlights have been installed in several halls of the museum.
- The large areas of the museum are continuously illuminated by a combination of natural daylight entering through the ceiling, recessed light boxes with a Metal halide lamp, and a variety of LED lights.
- Halogen reflector lamps are the main source of spotlight which have been installed in exhibition galleries.
- The 10-degrees tight spot is good for accent lighting to highlight the texture and color of exhibits. Its 65" wide flood distribution can be optimized for uniform illuminance.
- Beacon Muse LED can create narrow beam angles for highlighting sculptures, mannequins, and showcase when used with an elongation lens accessory.

Literature Study 6 : Yamazaki Mazak Museum.

- Location- Nagoya, Japan.
- Building Type- Art museum
- Year of construction- 2010
- Architect- Severiano Ballesteros.
- The museum gallery is outfitted with LED recessed downlights.
- The height of the exhibition room is height 4.5m.
- The size of the exhibition room is 16 X 7 m.

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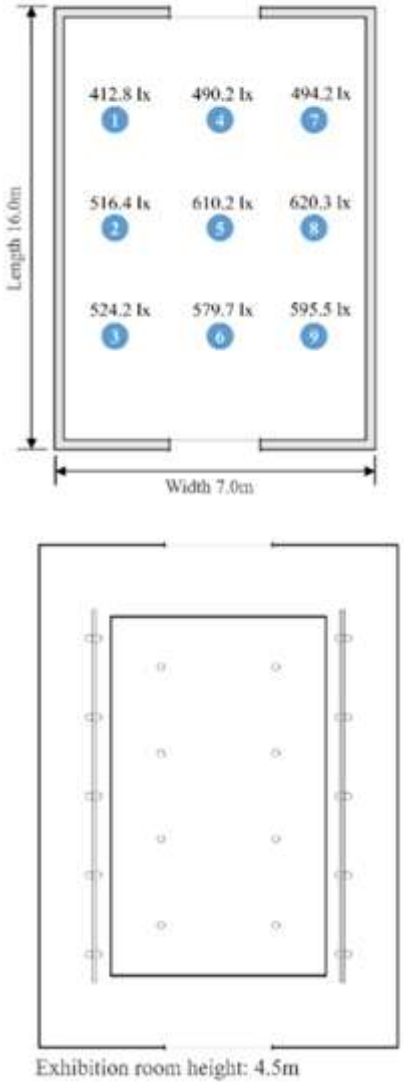

Figure21: Illuminance plane spot test

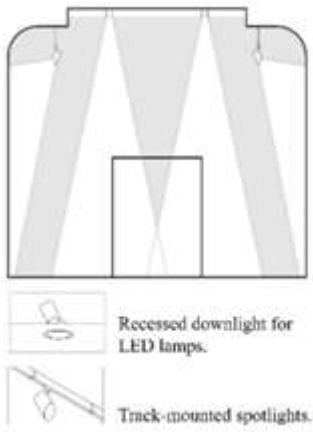

Figure22: The arrangement and elevation of the mixed lighting display source

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(**Source:**Artificial Lighting Environment Evaluation of the Japan Museum of Art Based on the Emotional Response of Observers by Jing Liang, Zhisheng-Wang, Yukari-Nagai, Jiahui Liu, and Nianyu Zou)

- The average illuminance is 538 lx.
- Use of blended lighting in the lighting climate. Both the light source straightforwardly enlightening the antiques and the ground are combined.
- A arrangement of singlets has permitted extra complement lighting utilizing spotlights.

Literature Study 7 : Goulbourn Regional Art Gallery.

- Location- Goulburn NSW, Australia.
- Building Type- Art museum
- Year of construction- 1990.
- Name of Architect- Edmund Cooper Manfred

Figure23: LED lighting in exhibition hall of Goulbourn Regional Art Gallery

(**Source:**Lighting in Museum by Palak Sadhna Kalra)

- Incandescent lamp track fittings and wall-mounted spotlights have been installed in exhibition galleries with large energy consumption.
- LED lighting has used in the showcase to enhance the appearance of the artifacts.
- Most of the LEDs are 18W LED Par38 bulbs and 10W LED MR16 fittings.
- The LED lights offer great shading delivery and otherworldly circulation to upgrade the client experience.

V. COMPARATIVE ANALYSIS

Table7: Analysis on the basis of types of lights:

Building	Halogen lamp	Fluorescent lamp	Metal Halide lamp	LED	Fiber-optic system	Incandescent lamp	Gobo projectors
The Allahabad Museum, UP						✓	
Cedar Hill Museum of History, US		✓	✓		✓		✓
Liaoning Provincial Museum, China		✓					
Living & Learning Design Centre, Gujarat				✓			
Pushkin Museum, Russia	✓		✓	✓			

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Yamazaki Mazak Museum, Japan				✓			
Goulbourn Regional Art Gallery, Australia				✓		✓	

Table8: Analysis on the basis of lighting system:

Building	**Indirect lighting**	**Direct lighting**	**Spotlight**	**Floods**	**Track system**	**Downlight**	**Pedants**	**Cove lighting**
The Allahabad Museum, UP								✓
Cedar Hill Museum of History, US	✓	✓	✓	✓	✓	✓	✓	
Liaoning Provincial Museum, China			✓					
Pushkin Museum, Russia			✓					
Yamazaki Mazak Museum, Japan			✓			✓		
Goulbourn Regional Art Gallery, Australia			✓		✓			

Table9: Analysis on the basis of Height of the exhibition space:

Building	**3.6m**	**4.0m**	**4.5m**
Cedar Hill Museum of History, US	✓		
Liaoning Provincial Museum, China		✓	
Yamazaki Mazak Museum, Japan			✓

Table10: Analysis on the basis of angle of light:

Building	**10 degree**	**30 degree**
Liaoning Provincial Museum, China		✓

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Pushkin Museum, Russia	✓	

Table11: Analysis on the basis of distance between the light and exhibits:

Building	0.9m	1.35m
Cedar Hill Museum of History, US	✓	
Liaoning Provincial Museum, China		✓

Table12: Analysis on the basis of amount of lx in exhibition hall:

Building	3.107 lx	6.030 lx	70 lx	200 lx	538 lx
The Allahabad Museum, UP			✓		
Liaoning Provincial Museum, China	✓	✓		✓	
Yamazaki Mazak Museum, Japan					✓

Table13: Analysis on the basis on display techniques:

Building	Dummies	Mannequins	Showcase	Roller	Hanger	Cabinets	Table
The Allahabad Museum, UP	✓	✓	✓	✓	✓		✓
Cedar Hill Museum of History, US	✓	✓	✓				
Liaoning Provincial Museum, China			✓			✓	
Living & Learning Design Centre, Gujarat						✓	
Pushkin Museum, Russia		✓	✓				
Goulbourn Regional Art Gallery,			✓				

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Australia							

Table14: Analysis on the basis of types of lights used inside the display cases to highlight the sensitive exhibits:

Building	Fluorescent lamp	Metal Halide lamp	LED	Fiber-optic system
Cedar Hill Museum of History, US	✓	✓		✓
Goulbourn Regional Art Gallery, Australia			✓	

VI. SIMULATION

The simulation has been done by using DIALux software. And an exhibition space of Cedar Hill Museum of History, US has been taken for simulation. There are three galleries in the exhibition space. Light insensitive exhibits have placed in gallery1 which consists of a showcase, cabinets, dummies, and mannequins. Light sensitive exhibits have placed in Gallery 2 and showcase, hanger & cabinets are display techniques of this gallery. Gallery 3 also has light-sensitive exhibits with display techniques of hangers and dummies without any protection. The plan of the exhibition space of Cedar Hill Museum of History has shown below. The results of the simulation will show the types of lights which can be used for sensitive and insensitive exhibits.

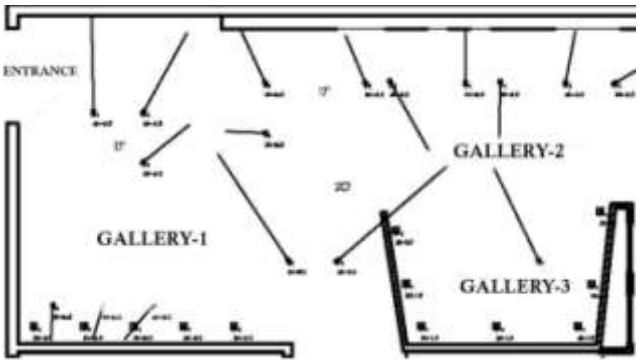

Figure24: Plan of Cedar Hill Museum of History, US

PARAMETERS:

- Area-

1) Gallery1: 70.2sq.m.
2) Gallery2: 27.5sq.m.
3) Gallery3: 16.4sq.m.

- Height of the Exhibition galleries- 3.6m
- Types of lights-

1) LED
2) Incandescent lamp
3) Metal Halide lamp
4) Fluorescent lamp
5) Halogen lamp
6) Optical fiber

- Angle of the light- 30 degree.
- Distance of light from the exhibit- 0.9m.

ABOUT SIMULATION CHART:

The simulation of case 6 has been taken to explain the simulation data. The below image shows the placement of different display techniques which has been used in the gallery. All the cases have the same display techniques. And there are total of 5 lighting fixtures in one gallery. The lighting fixture varies in each case. Incandescent lamps, Metal Halide lamps, LED, Fluorescent lamps & Halogen lamps are the types of lights which have been used in this case and the result has been shown below.

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Figure25: Simulation chart of Case-6

The simulation chart shows the amount of lux falling on different points of the surface which has been shown below. And the chart also gives the average amount of lux of a gallery. My entire simulation is based on amount of lux chart that I have obtained by using different lighting fixtures.

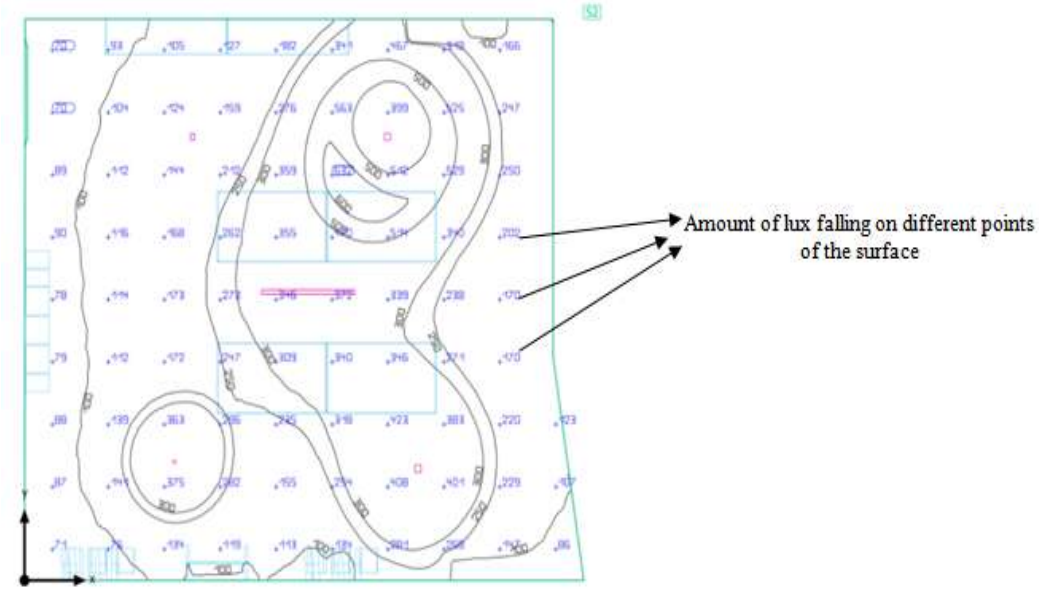

Figure26: Simulation chart of gallery 1 of Case-6

SIMULATION PROCESS:

1. Make a plan of the Cedar Hill Museum of History, US in AutoCAD. The area of the gallery 1, 2 & 3 are 70.2sq.m. , 27.5sq.m. & 16.4sq.m. respectively.

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2. Import the AutoCAD plan into DIALux software to create a 3D model of the museum. Set the 3.6m height of the exhibition galleries.
3. Arrange the exhibits of the museum. Showcase, cabinets, hangers, dummies, and mannequins are the display techniques which have been used to display exhibits.
4. Select the "Museum" on template selection and set the type of space i.e., insensitive to light exhibits and sensitive to light exhibits.
5. Choose materials for the exhibition gallery. The floor is made of Bologna log floor and the walls and ceiling are of gray white cement material.
6. Arrange the lights according to the different cases. LED, Incandescent lamp, Metal Halide lamp, Fluorescent lamp, Halogen lamp & Optical fiber are the different types of lights which have been used.
7. Calculate the amount of lux and save the results

CASE-1:

Fluorescent lamps, LED & Incandescent lamps have been used in this case for galleries 1, 2 & 3 respectively.

Figure27: Simulation chart of Case1

Table15: Case-1

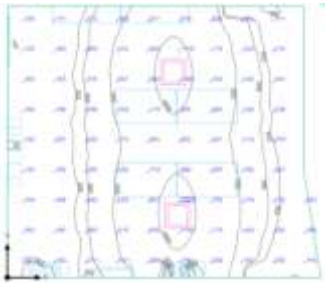
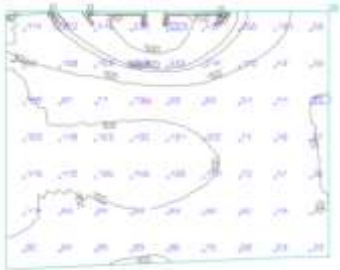
Gallery	Types of lights	Simulation Chart	Data obtained	Conclusion
1.	Fluorescent lamp	 **Figure28:** Simulation chart of gallery 1 of Case-1	Amount of lux obtained= 451lx	The fluorescent lamp cannot be installed for insensitive exhibits.
2.	LED		Amount of lux obtained= 124lx	The LED light can be installed for sensitive exhibits with protection.

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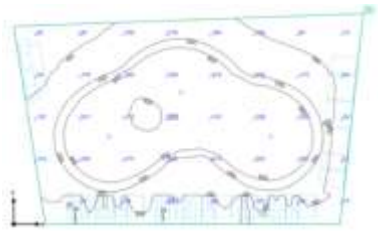
		Figure29: Simulation chart of gallery 2 of Case-1		Showcases & Cabinets can be use.
3.	Incandescent lamp	 **Figure29:** Simulation chart of gallery 3 of Case-1	Amount of lux obtained= 226lx	The incandescent lamp cannot be installed for sensitive exhibits.

CASE-2:

Metal Halide, Halogen lamp &Fiber optics have been used in this case.

Figure30: Simulation chart of Case2

Table16: Case-2

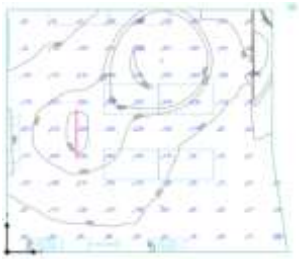
Gallery	Types of lights	Simulation Chart	Data obtained	Conclusion
1.	Metal Halide, Halogen lamp & Fiber optics	 **Figure31:** Simulation chart of gallery 1 of Case-2	Amount of lux obtained= 177lx	These lights can be installed together for insensitive exhibits.
2.	Metal Halide, Halogen lamp & Fiber optics		Amount of lux obtained= 248lx	These lights cannot be installed together for sensitive exhibits.

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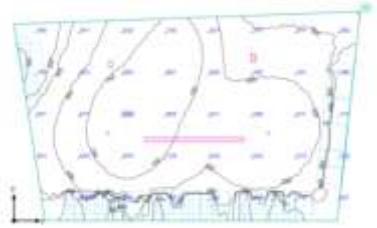
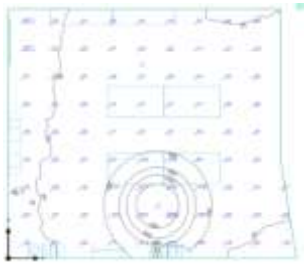
		 **Figure32:** Simulation chart of gallery 2 of Case-2		
3.	Metal Halide, Halogen lamp & Fiber optics	 **Figure33:** Simulation chart of gallery 3 of Case-2	Amount of lux obtained= 506lx	These lights cannot be installed together for sensitive exhibits.

CASE-3:

LED & Halogen lamps have been used in this case.

Figure34: Simulation chart of Case3

Table17: Case-3

Gallery	Types of lights	Simulation Chart	Data obtained	Conclusion
1.	LED & Halogen lamp	 **Figure35:** Simulation chart of gallery 1 of Case-3	Amount of lux obtained= 59.9lx	These lights can be installed together for insensitive exhibits.

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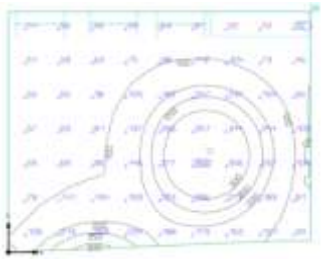
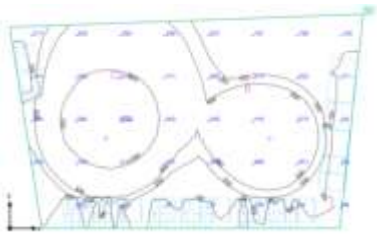
2.	LED & Halogen lamp	 **Figure36:** Simulation chart of gallery 2 of Case-3	Amount of lux obtained= 138lx	These lights can be installed together for sensitive exhibits with protection. Showcases & Cabinets can be use.
3.	LED & Halogen lamp	 **Figure37:** Simulation chart of gallery 3 of Case-3	Amount of lux obtained= 294lx	These lights can be installed together for insensitive exhibits.

CASE-4:

Halogen lamp has been used in this case.

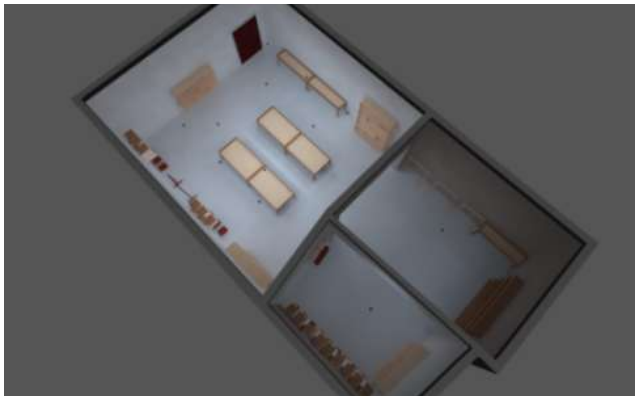
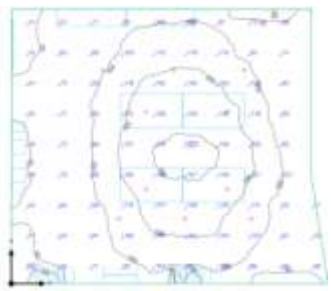
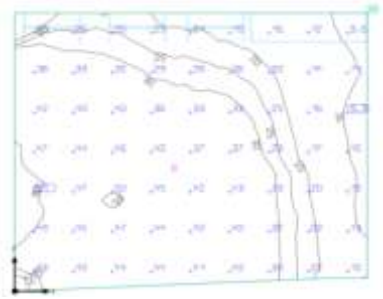


Figure38: Simulation chart of Case4

Table18: Case-4

Gallery	Types of lights	Simulation Chart	Data obtained	Conclusion
1.	Halogen lamp	 **Figure39:** Simulation chart of	Amount of lux obtained= 95.4lx	The Halogen lamp can be installed for insensitive exhibits.

		gallery 1 of Case-4		
2.	Halogen lamp	 **Figure40:** Simulation chart of gallery 2 of Case-4	Amount of lux obtained= 31.3lx	The Halogen lamp can be installed for sensitive exhibits.
3.	Halogen lamp	 **Figure41:** Simulation chart of gallery 3 of Case-4	Amount of lux obtained= 30.2lx	The Halogen lamp can be installed for sensitive exhibits.

CASE-5:

Incandescent lamps, Metal Halide, LED & Halogen lamps have been used in this case.

Figure42: Simulation chart of Case5

Table19: Case-5

Gallery	Types of lights	Simulation Chart	Data obtained	Conclusion
1.	Incandescent lamp, Metal Halide, LED & Halogen lamp		Amount of lux obtained= 157lx	These lights can be installed together for insensitive exhibits.

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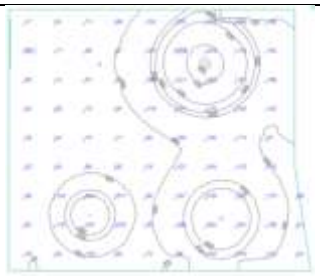
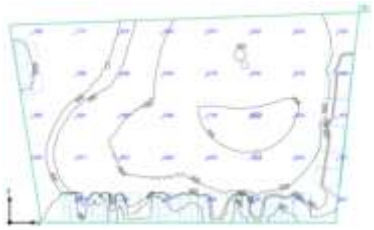
		 **Figure43:** Simulation chart of gallery 1 of Case-5		
2.	Incandescent lamp, Metal Halide, LED & Halogen lamp	 **Figure44:** Simulation chart of gallery 2 of Case-5	Amount of lux obtained= 332lx	These lights cannot be installed together for sensitive exhibits.
3.	Incandescent lamp, Metal Halide, LED & Halogen lamp	 **Figure45:** Simulation chart of gallery 3 of Case-5	Amount of lux obtained= 435lx	These lights cannot be installed together for sensitive exhibits.

CASE-6:

Incandescent lamps, Metal Halide, LED, Fluorescent lamps & Halogen lamps have been used in this case.

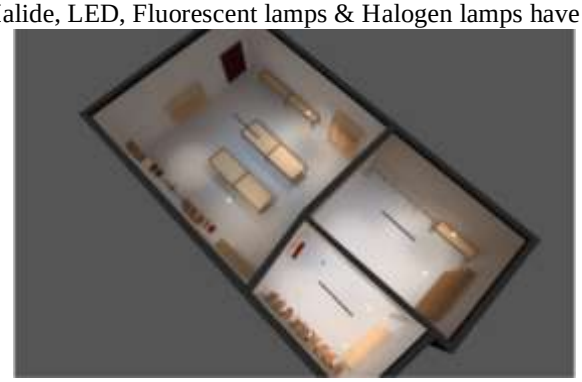


Figure25: Simulation chart of Case6

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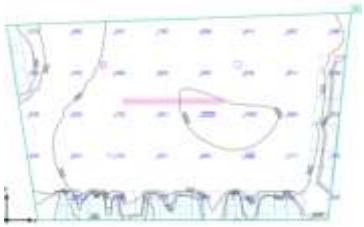
Table20: Case-6

Gallery	Types of lights	Simulation Chart	Data obtained	Conclusion
1.	Incandescent lamp, Metal Halide, LED, Fluorescent lamp & Halogen lamp	 **Figure26:** Simulation chart of gallery 1 of Case-6	Amount of lux obtained= 199lx	These lights can be installed together for insensitive exhibits.
2.	Incandescent lamp, Metal Halide, LED, Fluorescent lamp & Halogen lamp	 **Figure46:** Simulation chart of gallery 2 of Case-6	Amount of lux obtained= 493lx	These lights cannot be installed together for sensitive exhibits.
3.	Incandescent lamp, Metal Halide, LED, Fluorescent lamp & Halogen lamp	 **Figure47:** Simulation chart of gallery 3 of Case-6	Amount of lux obtained= 643lx	These lights cannot be installed together for sensitive exhibits.

VII. RESULT

- The most common types of artificial lighting which is used inside the textile museum are LED, Fluorescent lamp, Metal Halide, Incandescent lamps, fiber optics, and Halogen lamps.
- Spotlight, Track system, down light are the most common lighting system used in exhibition galleries.
- Generally the height of the museum gallery is 4m.
- The most common distance between the light and exhibits are 0.9m, and 1.35m.
- The amount of lux for sensitive textile exhibits should be up to 50lx to avoid short-term deterioration.
- The amount of lux for insensitive textile exhibits should be up to 200lx.
- Natural light should not be adopted in textile museum.
- Dummies, Mannequins, showcase, cabinets, and hanger are the various display techniques that are used for textile exhibits.
- LED, Fluorescent lamp, metal halide, and fiber optics should be used to highlights the sensitive exhibits.
- LED and fiber optics contain very less amount of radiation. So, these lights must be installed

inside the small showcase or cabinets to highlight the textile exhibits.

- Mixed light should be used inside a exhibition gallery.
- Incandescent lamps, Metal Halide, LED, Fluorescent lamps & Halogen lamps can be used together for insensitive exhibits.
- Only one type of light can also be used for sensitive and insensitive exhibits.
- Two types of light (i.e., LED and Halogen), three types of light (i.e., Metal Halide, Halogen lamp, and fiber optics) and four types of light (i.e., LED, Metal Halide, Halogen lamp, and incandescent lamp) can also be used in one gallery.

VIII. CONCLUSION

It has been observed that lighting is important in the exhibition space. Light is an essential part of establishing a pleasant environment. Lighting in museums not only needs artifacts but also terms for a high degree of incorporation of technology and artifacts in order to fulfill the urgent need for high-level exhibition lighting.

The combination of different types of light with different lighting systems creates a sense of attachment in the textile museum. Types of artificial light should be carefully designed. It provides comfortable exhibition conditions for visitors. And the types of lights should carefully install inside the display cabinet. Proper angle and proper distance should be maintained for better illumination and for highlight properly.

Textile exhibits in museums need a high level of maintenance. Highly sensitive textile sensitive should be very carefully displayed. The lighting in the museum should also focus on protecting exhibits and reducing the damage of textile exhibits caused by light radiation.

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During the preparation of this paper, I have come to know that light plays a critical role in the museum exhibition space and how to protect the textile exhibits from light radiation.

At last, a lot of people have knowingly and unknowingly helped me during the course of this project. And I would like to thank all of them.

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