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Value Assessment Of Lighting Interventions In Adaptive Reuse Of Heritage Structures

a layer-based study of mehboob mansion, hyderabad

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Abstract: Adaptive reuse enables continued use of historic buildings, but it often introduces new service interventions that can affect heritage significance. Among these, lighting is frequently treated as a technical necessity rather than a conservation issue. This paper examines how lighting interventions influence architectural legibility, material perception, spatial hierarchy, authenticity, and long-term integrity in heritage structures undergoing adaptive reuse. Using Mehboob Mansion, Hyderabad, as the principal case study, the research adopts a layer-based framework that reads heritage buildings through site context, spatial organisation, structural logic, masonry systems, and surface articulation. The study combines literature review, precedent comparison, and conservation principles such as minimal intervention, reversibility, compatibility, and significance retention. Findings suggest that even small lighting insertions may produce cumulative and lasting impacts on heritage character. The paper proposes a value-assessment framework to guide conservation-sensitive lighting design.

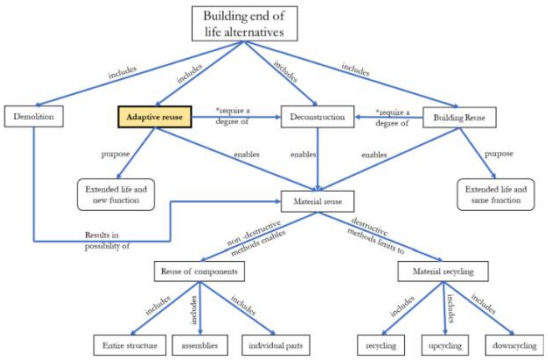
Index Terms - Adaptive reuse; architectural conservation; heritage value; lighting interventions; value assessment

I. INTRODUCTION

Historic buildings are more than just old buildings; they hold memories of culture, craftsmanship, spatial intelligence, and how people respond to their surroundings. Their worth comes not just from their age or size, but also from how their architecture reflects the social, material, and technological conditions of the time they were built. The heritage significance of a building comes from things like its spatial hierarchy, structural systems, masonry traditions, ability to adapt to different climates, and decorative articulation. So, preserving historic buildings isn't just about keeping the walls and surfaces intact; it's also about understanding and keeping the connections between the many layers that make up architectural meaning. Many heritage buildings today are also under pressure to become obsolete, be abandoned, be underused, or become functionally irrelevant. In these situations, adaptive reuse has become one of the most effective and long-lasting ways to protect historic buildings, as it lets them stay useful in modern urban and social life. [see fig. 1] Adaptive reuse can help with long-term maintenance by allowing people to continue living in older buildings and giving them new or improved functions. This can save energy and cut down on demolition. But the process of reuse also puts new demands on buildings that weren't built to meet today's standards for comfort, safety, accessibility, or service infrastructure. This makes it hard to keep the historic character while also meeting modern needs. The continued occupancy and use of existing structures frequently necessitate architectural interventions. These may involve diverse modifications, ranging from structural reinforcement and material restoration to the integration of new services, spatial reconfigurations, and enhancements in environmental control systems or circulation pathways. In conservation practice, such interventions are typically guided by established principles, including minimal intervention, reversibility, material compatibility, and the

preservation of authenticity. However, the practical assessment of these interventions often exhibits a notable inconsistency. Big changes to buildings, like major repairs or adding new parts that you can see, usually get a lot of attention. On the other hand, smaller jobs or adding things for services are often just seen as regular technical tasks. This difference leads to a big problem in deciding how to preserve old buildings, letting common and cumulatively important changes happen to historic buildings without fully checking how they affect their heritage value. Out of all the ways services are added, lighting upgrades are a particularly important but not well-studied area. Lighting is usually thought of as just a basic technical need for seeing, creating a mood, or showing things off. But in historic buildings, lighting does much more than just light up a space. It changes how people see the architecture, how they interpret the decorations, how they understand the textures of the materials, and how the importance of different spaces is visually shown. It can highlight some parts while downplaying others, make surfaces look deeper or flatter, make rooms seem bigger or more dramatic, and change the overall feeling and interpretation of a historic place. When buildings are repurposed, especially when they go from being used privately or in a limited way to public, institutional, hotel, or exhibition spaces, lighting becomes even more important.

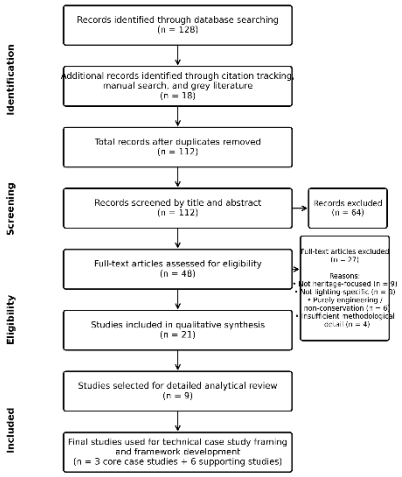
Fig 1: Building end of life



I RESEARCH METHODOLOGY

Basically, this study looks at how different lighting setups affect the historical importance of old buildings being repurposed. It uses a qualitative and analytical approach, as shown in figure 2. The core idea is that lighting isn't just about the technical side of things; in historical places, it really impacts both the building's structure and how we see the architecture. So, the method mixes ideas from conservation, breaking down buildings layer by layer, comparing different examples, and creating a system to figure out the value. This methodological sequence was already identified as moving from literature review to layer-based analysis, lighting parameter evaluation, intervention impact scoring, case study comparison, and finally framework development. The first stage of the methodology consists of a systematic literature review. This stage is intended to establish the theoretical foundation of the study by examining research in architectural conservation, adaptive reuse, heritage value, lighting design, and service interventions in historic buildings. As indicated in the synopsis, the literature review is conceived through a PRISMA-based approach involving identification, screening, eligibility, and inclusion. The purpose of this stage is not merely to gather references, but to identify how existing scholarship treats interventions in heritage structures and where lighting remains insufficiently addressed as a value-based conservation issue.

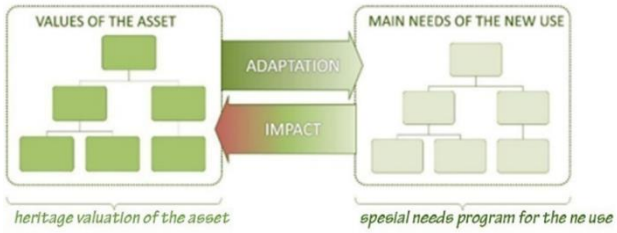
Fig 2: PRISMA Flow Diagram for Literature Selection



Layer-Based Reading of Heritage Buildings

The review also helps to clarify important ideas like authenticity, reversibility, minimal intervention, compatibility, and how we perceive architecture, all of which play a role in the evaluation framework that comes later (see figure 3). The next step is to see heritage buildings as complex systems with different parts. Instead of looking at the old building as just one thing, this study breaks it down into various architectural layers that, when combined, create its importance. For this research, these layers include the surrounding area, how the building is organized, its structural setup, how the masonry is built, and the details on its surfaces. This way of organizing things was already decided upon in the research draft because it acknowledges that any work done on historic buildings rarely affects just one part.

Fig 3: The compatibility of alternatives can be measured by identifying the characteristics that contribute to the heritage significance and to analyze their compatibility with proposed new uses (Source: Claver and Domı´nguez, 2015).



Lighting as an Architectural Intervention

A change introduced through lighting may affect the visibility of ornament, the reading of material texture, the perception of spatial hierarchy, and in some cases even the fabric of masonry or surface finishes. The layer-based approach therefore serves as the primary analytical lens for understanding impact. The third stage of the methodology focuses specifically on lighting as the intervention under study.

Sl. No.	Paper Title	Year	Primary Focus	Decision	Reason for Inclusion / Exclusion
1	*Adaptive Reuse of Heritage Buildings; A Systematic Literature Review of Success Factors*	2023	Adaptive reuse success factors; systematic review methodology	**Included**	Included for methodological guidance on systematic review structure and screening logic; useful for PRISMA framing and identifying evaluative criteria in adaptive reuse studies.
2	*Adaptive Reuse of Heritage Buildings: From a Literature Review to a Model of Practice*	2022	Adaptive reuse process and heritage value retention	**Included**	Included for understanding adaptive reuse as a structured conservation process and for supporting the conceptual framing of intervention compatibility.
3	*Adaptive Reuse in Sustainable Development*	2019	Sustainability benefits of adaptive reuse	**Included**	Included for establishing the broader sustainability relevance of adaptive reuse, though not directly lighting-specific.
4	*Adaptive Reuse as a Strategy Towards Conservation of Cultural Heritage*	2012	Theoretical basis of adaptive reuse and conservation	**Included**	Included for historical and theoretical grounding of adaptive reuse within conservation discourse.
5	*Multi-Criteria Decision Making for Adaptive Reuse of Heritage Buildings: Aziza Fahmy Palace*	2019	Decision-making criteria for reuse selection	**Included**	Included for its evaluative logic and relevance to structured assessment methods, though adapted in this research toward intervention evaluation rather than use selection.
6	*Adaptive Reuse of the Interior Design of Heritage Buildings as Museums*	2025	Interior adaptation of heritage buildings	**Partially Included**	Included selectively for discussion on interior adaptation and compatibility; excluded as a primary source where the focus becomes too interior-design specific rather than intervention evaluation.
7	*Examination of Contemporary Additions Made with Adaptive Reuse of Historic Building Heritage*	2023	Contemporary additions and adaptive reuse	**Included**	Included for understanding how new insertions interact with historic fabric and how contemporary interventions may affect heritage character.

8	*Recurring Issues in Historic Building Conservation*	2016	Common conservation challenges	**Included**	Included for identifying recurring implementation and maintenance issues relevant to service interventions in historic structures.
9	*Identifying Sustainable Retrofit Challenges of Historical Buildings: A Systematic Review*	2024	Retrofit challenges in historic buildings	**Included**	Included because retrofit challenges overlap with service intervention concerns, particularly where technical upgrades must be balanced with heritage sensitivity.
10	*Adaptive Reuse of Buildings: Eco-Efficiency Assessment of Retrofit Strategies for Alternative Uses of an Historic Building*	2017	Retrofit performance and environmental efficiency	**Partially Included**	Included selectively for technical understanding of retrofit implications; not central to lighting, but useful in discussing intervention impacts in adaptive reuse.
11	*Potential Economic and Energy Impacts of Substituting Adaptive Reuse for New Building Construction*	2020	Economic and energy benefits of adaptive reuse	**Excluded**	Excluded from core analytical review because the paper focuses primarily on economic and energy modelling at a macro scale rather than architectural or lighting-specific intervention assessment.
12	*Assessing the Environmental Benefits of Adaptive Reuse in Historical Buildings: A Life Cycle Assessment Approach*	2024	Environmental impact and LCA in adaptive reuse	**Partially Included**	Included selectively for sustainability and environmental framing; excluded from the core analytical framework because it does not directly address lighting or perceptual architectural impact.
13	*The Green Aspects of Adaptive Reuse of Hotel Penaga*	2016	Green adaptive reuse and hotel conversion	**Excluded**	Excluded from detailed analytical use because its focus is largely hospitality-oriented and not sufficiently aligned with intervention-specific heritage lighting concerns.
14	*Adaptive Reuse of Heritage Architecture as a Sustainable Development Tool: Opportunities and Challenges*	2023	General adaptive reuse opportunities and challenges	**Included**	Included as a general support source for adaptive reuse discourse and conservation relevance.

15	*Adaptive Re-Use of Heritage Structure in India: Jatan Nagar Palace, Odisha*	2024	Heritage reuse in Indian context	**Partially Included**	Included selectively for contextual relevance to Indian heritage reuse discourse, but not used as a primary analytical source due to limited technical focus on intervention assessment.
16	*Colonial Modernity in the Princely State of Hyderabad*	2025	Nizam-era architectural and cultural context	**Included**	Included for contextual understanding of Hyderabad's architectural milieu and stylistic background relevant to Mehboob Mansion, though not part of the technical lighting literature.
17	*Sustainable Exterior Lighting for Cultural Heritage Buildings and Monuments*	2021	Heritage lighting, light pollution, beam control	**Included**	Included as a core technical source because it directly addresses lighting control, spill light, façade illumination, and conservation-compatible exterior lighting methods.
18	*Lighting for Cultural and Heritage Site: An Innovative Approach for Lighting in the Distinct Pagoda-Style Architecture of Nepal*	2021	Heritage lighting, luminaire placement, colour temperature, glare	**Included**	Included as a core technical source because it directly examines heritage lighting failures and performance criteria relevant to the present research.
19	*A Framework for Heritage Lighting*	2017	Heritage lighting strategy and architectural legibility	**Included**	Included as a core conceptual and technical source for understanding lighting hierarchy, architectural emphasis, reversibility, and heritage-sensitive lighting logic.
20	*Evaluating and Enhancing Thermal Comfort and Indoor Air Quality in a Library Building*	2025	Thermal comfort and indoor air quality	**Excluded**	Excluded because it is unrelated to heritage lighting or intervention assessment, despite being building-environment related.

Comparative Case Study Analysis

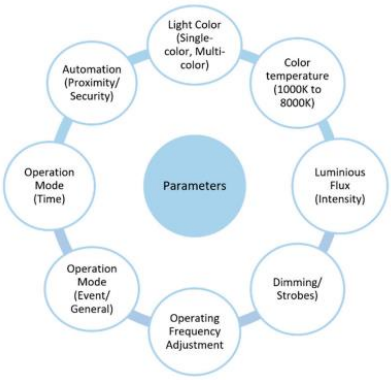
In order to avoid treating lighting only as an abstract design topic, the research considers it through both technical and architectural parameters. The research draft already includes the Royal Liver Building in Liverpool, the Tripureshwor Mahadev Temple complex in Nepal, and the Church of St. Thomas in Slovenia as key comparative examples. These case studies are used because they demonstrate varying concerns such as architectural hierarchy, controlled illumination, environmental sensitivity, minimisation of light pollution, and compatibility with historic material and ornament. Through this comparison, the study identifies recurring principles and failures that can inform the final framework for assessment. The fifth stage is case study application through Mehboob Mansion, Hyderabad. The research therefore moves from theoretical understanding toward a practical assessment model that may be used in similar heritage contexts. The final methodological stage is interpretive synthesis. After examining theory, case studies, and the primary site, the study brings these strands together in order to argue that lighting interventions should be understood as small but cumulative architectural actions rather than neutral technical insertions. This synthesis stage is important because it allows the research to connect physical intervention, visual perception, and conservation value within one analytical structure. It is through this stage that the paper positions lighting as a critical subject within heritage conservation discourse and proposes a more rigorous value-sensitive approach for adaptive reuse practice.

II. TECHNICAL PARAMETERS FOR LIGHTING IN HERITAGE STRUCTURES

2.1 Illuminance and Visibility Balance

Illuminance is one of the most fundamental parameters in lighting design, as it defines the amount of light incident on a surface and directly affects visibility, usability, and safety. In heritage structures, however, illuminance must be treated cautiously *[refer fig 4.]*. Excessive illuminance may flatten architectural depth, suppress shadow conditions that are integral to the original character of the space, and produce visual overexposure on ornamented or textured surfaces. Conversely, insufficient illuminance can reduce usability, create discomfort, and compromise safe movement.

Fig 4: Technical Parameter for Lighting in Heritage Structures



The challenge therefore lies in establishing context-sensitive lighting levels that are functionally adequate while remaining visually and materially compatible with the historic environment. The study on Nepal's heritage sites is particularly helpful because it highlighted how dim lighting in common areas, like stairwells and hallways dipping below 10 lux, caused significant issues with how people could use the spaces. At the same time, other parts of these buildings were too bright and unevenly lit. This shows that when lighting heritage buildings, you need to steer clear of both too little and too much light. The right lux levels shouldn't just be based on what we think is bright today, but rather on finding a good mix that works for the building's purpose, its architectural style, and what feels comfortable to look at. The warmth or coolness of the light also greatly impacts how we see old materials and spaces. Historic buildings often feature things like lime plaster, wood, brick, stone, paint, and weathered surfaces, all of

which look best under soft, warm light. Brighter, cooler light can make a space feel stark and sterile, which usually doesn't match the historical feel of a building. It can also make flaws stand out more, throw off the colors, and make the space feel less authentic to its original materials. Because of this, heritage lighting projects usually lean towards warmer lights, typically under 3000 Kelvin, as this color range complements older materials and the building's cultural vibe better. The Nepal case study explicitly recommends the use of light with colour temperature below 3000 K, not only for aesthetic compatibility but also because shorter wavelength emissions are more disruptive to nocturnal ecosystems and surrounding environmental conditions. In heritage buildings, colour temperature must therefore be understood as both a perceptual and conservation parameter rather than merely a design preference.

Table 1: Technical Lighting Parameters and Their Conservation Relevance in Heritage Structures

PARAMETER	COLOUR TEMPERATURE
TECHNICAL ROLE	Determines the warmth or coolness of emitted light and influences how surfaces and spaces are visually perceived.
NEGATIVE IMPACT IF INAPPROPRIATELY USED	Cooler colour temperatures may create a harsh, clinical visual environment, exaggerate surface imperfections, distort tonal balance, and detach the space from its historic ambience. Higher blue-spectrum content may also contribute to ecological disturbance and environmental incompatibility.
PREFERRED HERITAGE RESPONSE	Warm colour temperatures, generally **below 3000 K**, are preferred in heritage settings due to their compatibility with traditional materials and atmospheric character.
CONSERVATION / ARCHITECTURAL RELEVANCE	Helps retain the perceptual authenticity of heritage spaces, supports compatibility with aged materials such as lime plaster, timber, brick, and stone, and reduces environmental disruption.

2.2 Colour Rendering Index and Authentic Material Reading

The colour rendering index is another important technical parameter because it determines how accurately materials, finishes, and surfaces are perceived under artificial light. When it comes to old buildings, the subtle differences in colour, texture, and signs of age are often what make them special. If the colors aren't shown accurately, it can make it harder to understand the building's history and can even make the original materials look wrong. A lighting system that doesn't show colours well can make materials look flat or change how adjacent surfaces seem to relate to each other. That's why good color rendering lights are better for heritage sites; they help us see building materials and decorations as they were meant to be seen. This is especially true in buildings where the lighting is supposed to do more than just make things visible; it's also there to help us appreciate the skill, decoration, and the history of the materials used. Even though the case studies we looked at didn't pinpoint an exact number for how good the colour rendering needs to be, they consistently emphasised keeping the materials looking authentic, which really backs up the idea that heritage lighting needs high-quality color rendering. How light spreads across surfaces, which is controlled by the beam angle and how it's distributed, is also super important for how we perceive shape, texture, and what stands out. Narrow beam angles are great for highlighting specific parts of a building, like an arch, a capital, a cornice, or a sculpture. Wider beam angles spread the light out more, but if you use them everywhere, they can make things look flat and blur the lines between the main and secondary architectural elements. Heritage lighting must therefore use beam control strategically. It is often more appropriate to light selectively and precisely than to distribute light uniformly across a whole façade or interior surface.

Table 2: Technical Lighting Parameters and Their Conservation Relevance in Heritage Structures

PARAMETER	COLOUR RENDERING INDEX (CRI)
TECHNICAL ROLE	Determines how accurately colours, finishes, and material surfaces are perceived under artificial light.
NEGATIVE IMPACT IF INAPPROPRIATELY USED	Low CRI lighting may distort the appearance of original materials, flatten subtle tonal differences, reduce legibility of surface texture, and undermine appreciation of craftsmanship and ornament.
PREFERRED HERITAGE RESPONSE	**High CRI lighting** is preferred to ensure that materials, finishes, and decorative surfaces remain visually truthful and interpretable.
CONSERVATION / ARCHITECTURAL RELEVANCE	Supports material authenticity, interpretive clarity, and appreciation of layered surface history, which are essential to the heritage value of historic buildings.

2.3 Beam Angle and Architectural Emphasis

The Royal Liver Building case, as already discussed in the research draft, illustrates how targeted lighting and narrow-beam emphasis can reveal architectural rhythm and façade articulation far more effectively than broad floodlighting. Similarly, the Church of St. Thomas example demonstrates that uncontrolled wide-beam lighting can lead to spill light, light pollution, and loss of architectural legibility. These examples reinforce the idea that beam angle is not merely a technical fixture specification but a key factor in conservation-sensitive lighting design.

Table 3: Technical Lighting Parameters and Their Conservation Relevance in Heritage Structures

PARAMETER	BEAM ANGLE
TECHNICAL ROLE	Controls the spread of light from the source and determines whether illumination is concentrated or diffuse.
NEGATIVE IMPACT IF INAPPROPRIATELY USED	Wide beam angles, if used indiscriminately, may flatten architectural depth, reduce contrast, and diminish the distinction between significant and secondary elements.
PREFERRED HERITAGE RESPONSE	Narrow or controlled beam angles should be used where architectural emphasis is required, particularly for significant features such as arches, capitals, mouldings, or sculptural elements.
CONSERVATION / ARCHITECTURAL RELEVANCE	Reinforces architectural hierarchy, preserves visual depth, and allows selective emphasis without over-lighting the entire surface.

2.4 Glare Control and Visitor Experience

Glare is a major technical and experiential problem in heritage lighting because it interferes with visual comfort, reduces the ability to read architectural details, and makes the light source itself more dominant than the building. In areas of cultural, ritual, or reflective importance, glare can be particularly intrusive as it disturbs the desired emotional and perceptual connection between the visitor and the environment. The Nepal case study highlights excessive glare in active ritual spaces as a frequent issue in modern heritage lighting.
This discovery is important as it shows that glare is not merely a technical nuisance but a conservation concern: it changes how a heritage site is perceived and experienced. Heritage lighting systems must utilise shielded
fixtures, direct beams accurately, and strategically place lights to stay outside of primary sightlines wh

en feasible. Minimising glare is crucial not just for comfort but also for maintaining the interpretive integrity of the architectural space*Luminous intensity* influences how strongly a source projects light in a given direction, and in heritage structures, it contributes to the creation of contrast, emphasis, and hierarchy.

Table 4: Technical Lighting Parameters and Their Conservation Relevance in Heritage Structures

PARAMETER	LIGHT DISTRIBUTION
TECHNICAL ROLE	Determines how light is spread across a space or architectural surface.
NEGATIVE IMPACT IF INAPPROPRIATELY USED	Uniform or broad distribution may erase shadow conditions, reduce relief, suppress textural variation, and visually homogenise architecturally differentiated spaces.
PREFERRED HERITAGE RESPONSE	Selective and strategic distribution is preferred, allowing light to respond to the hierarchy and geometry of the building rather than producing generic overall brightness.
CONSERVATION / ARCHITECTURAL RELEVANCE	Helps preserve the original spatial sequencing, visual rhythm, and legibility of architectural form within heritage structures.

2.5 Uniformity versus Historic Depth

If intensity is too low, significant architectural features may disappear into a general field of dimness; if too high, the lighting may create harsh visual contrast, over-accentuation, or theatrical effects inconsistent with the historic nature of the building. The goal in heritage settings is not maximum visual drama but calibrated contrast that supports architectural reading. Important spaces and elements may require emphasis, but that emphasis should emerge through controlled relationships between lit and unlit areas rather than through sheer brightness. In heritage lighting, contrast should be used to clarify form and sequence, not to create spectacle. *Uniformity* is often treated as a desirable lighting quality in contemporary buildings, especially in commercial or office environments, but in heritage structures, excessive uniformity can be highly damaging to spatial character. Historic architecture frequently depends on gradual tonal transitions, layered depth, and differentiated light conditions between primary and secondary spaces. Overly uniform lighting can erase these distinctions, making ceremonial spaces appear equivalent to passageways and flattening the experiential rhythm of the building. For this reason, heritage lighting should not aim for total uniformity across all spaces. Instead, it should permit controlled variation in brightness that reinforces spatial hierarchy and architectural sequencing. The research draft already recognises that artificial lighting can either reinforce or disturb the hierarchical reading of space, and this principle should be explicitly connected to the technical question of uniformity. Lighting design in heritage settings must therefore balance visual continuity with differentiated emphasis, allowing the original logic of space to remain perceptible. *Energy efficiency* is an important parameter in heritage lighting, particularly in adaptive reuse projects where long-term operational sustainability is necessary. However, energy efficiency cannot be treated as an isolated performance target detached from conservation concerns. The use of efficient sources such as LEDs is generally advantageous because it reduces power consumption, lowers heat output, and allows greater control over colour temperature, beam spread, and light levels. The Nepal study strongly supports this position, noting that LED systems allow variable beam angle, lumen output, and colour temperature, while also reducing energy demand and environmental impact compared to conventional incandescent or halogen sources. Yet efficiency alone does not guarantee appropriateness. A highly efficient system may still be visually or materially harmful if it is too bright, poorly directed, or installed intrusively. Thus, luminous efficacy must be considered alongside all other heritage-sensitive parameters rather than being allowed to dominate the design process.

III. MATERIAL COMPATIBILITY AND INTEGRITY CONSIDERATIONS

3.1 Physical Sensitivity of Historic Fabric

One of the most critical aspects of the proposed lighting strategy is its relationship to the material integrity of Mehboob Mansion. Historic structures are materially sensitive environments, and lighting systems must therefore be assessed not only for visual outcome but for their effect on the physical condition of the building *[refer table 5.]*. Where lime plaster, mouldings, or decorative finishes are present, direct fixing of luminaires should be avoided as far as possible. These surfaces are vulnerable to cracking, chipping, and localised failure under drilling or anchoring.

Table 5: Color temperature and recommendation for different construction material

S.N	Temperature	Color	Recommendation
1	1000 K		
2	1500 K		Carved Wood
3	2000 K		Mortar
4	2500 K		
5	3000 K		
6	3500 K		Bricks and tiles
7	4000 K		
8	4500 K		
9	5000 K		
10	5500 K		Stone
11	6000 K		
12	6500 K		
13	7000 K		
14	7500 K		** White Stone
15	8000 K		
16	Pure White		

** Without considering light pollution.

3.2 Risks of Direct Fixture Mounting

The proposal, therefore recommends that luminaires be attached only to **non-decorative, structurally stable, or previously altered surfaces**, or else supported through independent systems that bypass sensitive finishes. Concealed conduit chasing into historic masonry is considered inappropriate in significant areas of the mansion due to the irreversible loss of material and disturbance to original wall systems. Even where visually concealed, such intervention compromises physical integrity and creates long-term maintenance issues. Surface-routed systems, if carefully detailed and visually minimised, may in many cases be more conservation-compatible than embedded installations. The proposal strongly favours **LED lighting systems** because of their lower heat output and reduced risk of material stress compared to incandescent or halogen sources. However, even LED systems must be selected carefully to avoid unnecessarily high output, inappropriate colour spectrum, or proximity to sensitive surfaces. Lighting should therefore be positioned with sufficient distance from fragile materials and designed so that no localised overheating or concentrated exposure occurs.

3.3 Thermal Impact and Heat Management

A central proposition of this research is that heritage buildings must be understood as layered systems rather than singular physical objects. Lighting systems in heritage settings can generally be divided into ambient, accent, and task lighting, with each playing a distinct role in spatial awareness. Ambient lighting offers general illumination and guarantees fundamental visibility, yet when used consistently, it can diminish architectural hierarchy and reduce depth. Accent lighting, conversely, serves to emphasise particular architectural features like columns, mouldings, arches, or decorative surfaces, thus enhancing hierarchy and guiding visual focus. Task lighting is often incorporated for practical reasons in adaptive reuse contexts, including reading zones, circulation routes, or exhibition areas, and should be thoughtfully integrated to prevent visual disruption. The effectiveness of these lighting systems is assessed using quantifiable metrics such as illuminance (lux), luminance, colour temperature, colour rendering index (CRI), beam angle, and glare. Illuminance signifies the quantity of light striking a surface and is essential for assessing the visibility and functionality of an area. Nevertheless, high levels

of brightness in historic interiors can result in surface overexposure, which decreases contrast and lessens the perception of texture. Conversely, insufficient illuminance results in visual discomfort and limited usability.

Table 6: Analytical synthesis of precedent-derived lighting parameters for conservation-sensitive adaptive reuse

Parameter	Key Risk / Issue Identified	Heritage-Sensitive Response	Application to Present Research
Illuminance Adequacy	Under-lighting reduces usability and safety, while over-lighting suppresses texture, flattens relief, and disrupts spatial experience.	Lighting levels should be calibrated to ensure visibility without visually overpowering the architectural fabric.	Used to define appropriate lighting intensity ranges for different spatial zones in Mehboob Mansion.
Glare Control	Excessive glare interferes with visual comfort, reduces architectural readability, and affects interpretive experience.	Shielded luminaires and controlled viewing angles should be adopted to minimise direct visual discomfort.	Supports the selection of low-glare lighting systems for heritage-sensitive adaptive reuse.
Fixture Placement and Mounting	Direct or poorly placed fixtures create visual clutter, unwanted shadows, and physical intrusion into significant surfaces.	Fixtures should be discreetly positioned using reversible, detached, or secondary mounting strategies.	Informs the placement and installation strategy for lighting within architecturally sensitive zones of Mehboob Mansion.
Beam Control and Optical Precision	Broad and uncontrolled lighting causes spill, loss of hierarchy, and flattening of architectural form.	Narrow or calibrated beam lighting should be used to reveal detail selectively and maintain depth.	Helps determine where accent lighting and focused illumination are appropriate within the building.
Material Compatibility	Inappropriate lighting may distort material appearance and contribute to long-term stress through heat, spectrum, or invasive installation.	Lighting systems should be compatible with historic materials in terms of output, spectral quality, and installation method.	Supports the use of low-heat, materially compatible lighting strategies for Mehboob Mansion.
Environmental and Ecological Sensitivity	Artificial lighting may create spill light, ecological disturbance, and disruption to nocturnal environmental conditions.	Exterior lighting should be restrained, warm-toned, and environmentally controlled.	Expands the lighting proposal to include precinct-level and night-time contextual sensitivity.

Architectural Hierarchy and Legibility	Uniform lighting reduces depth, spatial sequencing, and distinction between significant and secondary architectural elements.	Lighting should reinforce existing hierarchy through selective emphasis rather than equal illumination of all surfaces.	Provides the basis for zoning the building according to significance and lighting priority.
Day–Night Visual Integrity	Lighting systems may perform adequately at night but introduce intrusive fixtures or clutter in daytime conditions.	Lighting apparatus should remain visually subordinate in both day and night conditions.	Supports the choice of discreet lighting systems that do not compromise the daytime reading of the mansion.
Maintenance and Long-Term Adaptability	Frequent servicing or inaccessible fixtures increase long-term risk to the heritage fabric.	Lighting systems should be accessible, replaceable, and maintainable with minimal disturbance to the building.	Informs the selection of adaptable lighting systems suitable for long-term adaptive reuse.

IV. RESULTS AND DISCUSSION

The lighting strategy proposed for Mehboob Mansion adopts a **minimum-intervention and reversibility-based approach**. In heritage structures, the visual success of a lighting system cannot justify physical damage to the original fabric. Therefore, the proposed system prioritises lighting methods that reduce or eliminate direct cutting, embedding, or drilling into historically significant surfaces. Recessed lighting systems, which require insertion into ceilings, cornices, walls, or floors, are considered largely unsuitable for the significant architectural zones of the mansion because they necessitate irreversible modification of original or historic fabric. Their apparent visual neatness does not outweigh the conservation risk associated with material loss and structural disturbance.

Fig. 9: Drone view of Mehboob mansion and its precinct.

Instead, the proposal favours **surface-mounted, suspended, bracket-mounted, or freestanding lighting systems**, provided that they are carefully designed and visually restrained. These systems align better with conservation principles as they permit maintenance access, simplify future replacements, and often can be taken out with minimal evidence left behind. In a heritage setting like Mehboob Mansion, where enduring adaptability is crucial, reversibility should be viewed as a design factor rather than an afterthought.

The suggested approach also dismisses the use of standard uniform lighting. Consistent lighting often diminishes architectural depth, diminishes material texture, and lessens the perceived hierarchy of historic environments. The proposal highlights targeted and multi-layered lighting, where illumination is allocated based on spatial use, architectural importance, and material responsiveness instead of utilising a uniform brightness level throughout the structure.

4.1 Zonal Lighting Strategy Based on Heritage Sensitivity

In order to ensure compatibility with the architectural significance of Mehboob Mansion, the lighting proposal is structured through a **zonal approach**. This means that the building is not treated as a single lighting environment, but as a set of spatial zones with varying degrees of significance and therefore different requirements for illumination and intervention.

4.1.1 High-Significance Architectural Zones

The most architecturally and visually significant spaces of the mansion—such as principal halls, ceremonial rooms, entrance spaces, and areas containing ornamental surfaces, mouldings, decorative plasterwork, arches, or major volumetric expression—should receive the most restrained and conservation-sensitive lighting treatment. In these spaces, the primary objective of lighting is not brightness but **architectural legibility**. Illumination should reveal the hierarchy of the space, reinforce volumetric depth, and allow material texture to remain perceptible without exposing surfaces to excessive brightness or direct fixture attachment. For such spaces, the proposed strategy recommends **low to moderate ambient illumination combined with highly controlled accent lighting**. Ambient lighting should remain soft and indirect, ideally provided through concealed secondary supports, reversible suspended systems, or peripheral wall-mounted luminaires positioned away from ornamental zones.

Fig. 10: Multifoil Mughal arches in the first floor

Accent lighting may be used sparingly to reinforce significant architectural elements such as arches, capitals, cornices, or thresholds *[refer fig. 10.]*, but should avoid producing theatrical spotlighting or decorative spectacle. Where surface detail is important, **grazing light** may be used in a limited and controlled manner to enhance relief and texture. However, this should be done carefully, as excessive grazing can over-dramatise imperfections or create an artificial reading of historic surfaces. The intention should be to support the truthful visibility of material and craftsmanship rather than to aestheticise decay or exaggerate ornament.

4.1.2 Moderate-Significance Transitional Zones

Corridors, circulation spaces, stair approaches, and secondary halls may be treated with a slightly more flexible lighting strategy, as these spaces are more functionally driven and often require clearer navigation *[refer fig. 11]*. However, even in these zones, lighting must continue to support the spatial sequence of the building rather than reducing it to generic contemporary circulation. For these areas, the proposal recommends **controlled ambient lighting with moderate uniformity**, avoiding both dramatic contrast and complete visual flattening. Surface-mounted or wall-integrated reversible fixtures may be acceptable here if they are installed on non-significant or previously altered surfaces. In such spaces,

lighting should support movement, orientation, and safety while remaining visually quiet and materially non-invasive.

Fig. 11: Broken terrace floor in first floor

4.1.3 Low-Significance / Serviceable Zones

Rooms or areas with lower decorative sensitivity, previously altered surfaces, or greater functional adaptability may accommodate a more utilitarian lighting approach, particularly if these spaces are likely to support service, administration, interpretation, or adaptive reuse infrastructure. Even here, however, the strategy does not advocate visually dominant or highly exposed contemporary systems. Instead, the proposal recommends that these areas function as **service-supporting lighting zones**, where technical requirements *[refer fig. 12.]* may be met more directly without compromising the architectural core of the mansion. This zonal strategy is important because it ensures that the highest level of restraint is reserved for the most sensitive areas, while allowing controlled flexibility in spaces where adaptive reuse demands are stronger.

Fig. 12: External view of the mansion

4.2 Layered Lighting Composition

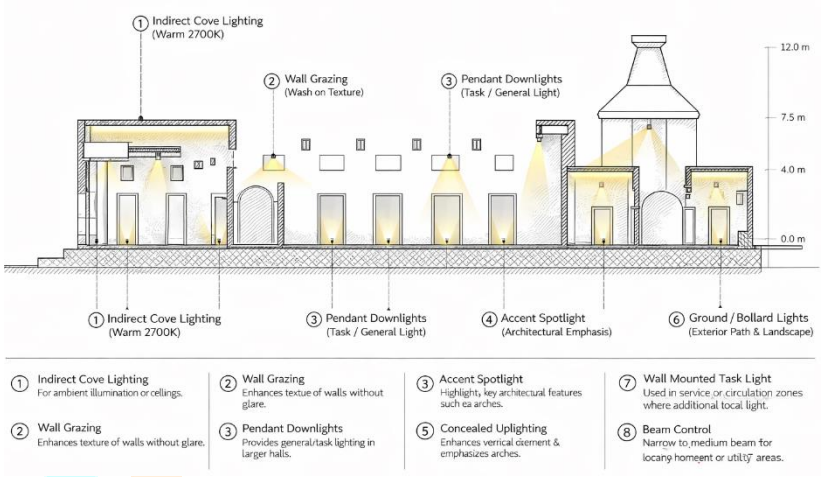
The proposed lighting strategy for Mehboob Mansion is based on a **layered lighting composition**, rather than reliance on a single lighting type *[refer Fig. 13.]*. This approach allows different forms of light to perform different roles while maintaining control over intensity, hierarchy, and visual impact.

4.2.1 Ambient Lighting Strategy

Ambient lighting should serve as the foundational layer of illumination within the mansion, but it should remain **soft, indirect, and spatially differentiated**. In heritage interiors, ambient lighting should not aim to eliminate shadow completely, since shadow itself is often part of the architectural character of the space. Instead, ambient lighting should provide sufficient visibility for use and circulation while preserving the tonal variation and depth that support heritage experience. For Mehboob Mansion, ambient lighting should ideally be delivered through **indirect wall-mounted or suspended systems with shielded sources**, avoiding direct frontal wash over significant surfaces. Concealed linear lighting

may be used only where concealment does not require damage to original fabric and where secondary insertion points are available. In most high-significance spaces, ambient lighting should remain within a restrained range and should not overpower natural daylight conditions where they continue to play a role in the reading of the interior.

Fig. 13: Sectional Lighting Strategy Showing Spatial Distribution of Proposed Lighting Types



4.2.2 Accent Lighting Strategy

Accent lighting must be applied strategically to emphasise architectural hierarchy and highlight important features without dominating the area. In Mehboob Mansion, this can involve careful lighting of arches, crafted transitions, vertical highlights, or important architectural points like entryways and significant openings. Accent lighting is warranted solely when it enhances the current architectural design; it must not establish a new hierarchy that was absent in the structure. The suggestion advocates for the utilisation of narrow-beam or adjustable LED fixtures with regulated output for highlight illumination. These must be installed reversibly and arranged in a way that the source itself appears visually secondary. Accent lighting must be adjusted to create emphasis via contrast instead of through overwhelming brightness.

4.2.3 Task Lighting Strategy

Task lighting should be implemented only in areas where the adaptive reuse function requires it, such as reading spots, interpretive exhibits, reception areas, or workspace-related repurposing situations. Given that task lighting is usually more purpose-driven and visually dominant, it ought to be confined spatially and minimised in areas of great ceremonial importance or architecturally expressive designs unless completely necessary. Where required, task lighting should preferably be delivered through **freestanding, furniture-integrated, or minimally attached systems**, so that the lighting requirement is met without compromising historic surfaces or introducing unnecessary visual clutter into the architecture. If exterior lighting is proposed for Mehboob Mansion, it should be approached with extreme restraint. The objective of façade lighting should not be to “light up” the building as an urban spectacle, but to allow limited and controlled night-time legibility where appropriate. Any façade lighting strategy should therefore reject broad floodlighting, colour-changing systems, theatrical effects, and upward-directed uncontrolled beams. Instead, the proposal recommends **selective, low-intensity, warm-toned façade illumination** only where it supports architectural reading and does not disrupt the nocturnal atmosphere of the precinct. Beam angles should remain narrow and targeted, with spill light strictly minimised. Wherever possible, luminaires should be positioned on **detached, landscape-based, or secondary supports** rather than fixed directly onto the façade.

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