



UAE heritage buildings converted into museums: Evaluation of daylighting effectiveness and potential risks on artifacts and visual comfort

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ABSTRACT

This paper provides a comprehensive process that investigates daylighting performance with regards to museum lighting (adequate lux levels versus safe light exposure) and visual comfort requirements (no glare or sunlight) in the UAE traditional courtyard buildings that were converted into heritage museums. The study used several methods such as site visits, on-site measurements, surveying of architectural drawings, and statistical analysis of design data to examine existing case studies and extract information that helped identify building morphology configurations and define parameters to represent this building typology. The defined configurations helped develop the 3D geometry of the representative model in which the most dominant courtyard and exhibit room ranges were considered. Then, a comprehensive multi-scenario simulation process based on several climate-based daylight metrics under the UAE sky conditions was carried out to investigate lighting adequacy against potential risks on artifacts and visual comfort using several configurations of the developed model. The scenarios included different orientations with different window-to-wall ratios (WWR) of windows looking upon the courtyard using different configurations of the traditional verandah that helped shade the windows and reduce light exposure risks. The performance variables were analyzed against the recommended values/ranges by several international lighting standards. The study recommended several options to enhance the overall lighting environment and minimize risks on artifacts and visual comfort. This included better spatial arrangements, better designing and sizing of openings, and implementation of effective shading systems.

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1. Introduction

The discovery of oil by the end of the 1950s in the United Arab Emirates (UAE) and the beginning of oil exports in 1962 has resulted in a diversified economical power that made the UAE a regional and tourism hub. The needs of the newly formed modern society have led to many transformations in architecture and urban environments. For instance, the introduction of new construction methods/technologies enabled the construction of modern buildings with higher efficiency and flexibility than the traditional ones that had limited functions and use. The need for more lands to accommodate the expansion of the major cities resulted in demolishing a large number of heritage buildings. At a later time, the authorities realized the historical importance of these buildings in reflecting the culture's identity, and consequently they enforced new laws to conserve the remaining significant ones. The introverted courtyard configuration arranged in two floors was the common

design arrangement for the heritage building typology. Fig. 1 shows an example of these buildings (Al Ahmadiya School that was built in 1912 in Dubai [1].) The rooms in these heritage buildings usually take the shape of a rectangle. They are accessed from a verandah that looks upon the courtyard. They have windows that are predominantly oriented towards the courtyard via the verandah. Many of these buildings were converted into heritage museums with the ultimate goal of encouraging tourism economy and preserving the historical and cultural holdings of the country. Previous studies supported the preservation of heritage architecture in the Arab Gulf region by exploring how they managed to balance between environmental and sociocultural values and thus derive sustainable design approaches that can be applicable in new buildings [1–5].

The UAE heritage museums hold very valuable and rare historic documents, such as letters between rulers, contracts, as well as deeds and itineraries describing the pearl industry. All of these items need to be preserved and protected from all damage conditions; especially from the excessive sunlight that characterizes most daytime hours in the Arab Gulf region. To ensure the conser-

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Fig. 1. Al Ahmadiya School in Dubai, UAE; a top view (left) and a view inside the courtyard (right) [1].

vation and the protection of these valuable holdings, taking strict actions was required. However, these heritage buildings were not designed as museums and thus raising the question of how they function as effective museums that preserve valuable holdings (i.e.; with minimum levels of light exposure dangers) while still bringing the expected enjoyment to visitors is a viable question. From the daylighting point of view, these holdings should be protected from the excessive lighting levels that could damage them and accelerate their deterioration. In a previous paper, the authors investigated one of the UAE heritage buildings in Al-Bastakia District in Dubai (Sheikh Mohammed Centre for Cultural Understanding) [4]. They found several issues in the display spaces such as the existence of direct sunlight and high illuminance levels that could lead to the damage of exhibited artifacts and produce uncomfortable visual environment for visitors. This paper uses an extensive number of computer simulation scenarios that investigate the effect of several architectural configurations of this building typology on daylighting in the exhibit spaces and the potential dangers of light exposure on artifacts and glare issues. It attempts to answer the question; what are the architectural configurations that ensure the safest and most effective daylighting environment for these museums' valuable holdings while their visitors do not experience glare or visual discomfort issues? The study focuses only on evaluating the visible component of light. Common practice normally applied in museums to control the high levels of ultraviolet radiation should also be considered to integrate with the solutions discussed in this paper.

2. Background

Throughout history, daylight has been used to improve humans' perception of architecture and their gratitude of spatial experience. Generally, a properly designed daylight space is one that should contribute greatly in improving human performance as well as the performance of the space in which building occupants live or work. The daylighting design issues that need to be considered in building design in general, and in museums in particular, include the space's connection to the surrounding environment, the positive psychological effect when daylighting is properly-introduced, and/or adding the unique effect on the materials that receive daylight. Thus, daylighting is one of the most important aspects requiring careful investigation during the design process of any museum in order to achieve its design goals.

The mission of a museum is to: 1- Collect and exhibit art and historic artifacts for public education and enjoyment, 2- Protect the collection from damage, 3- Do this all as efficiently as possible [6].

Museums should ensure good presentation and effective preservation of the displayed artifacts. Daylighting in museums can facilitate the following: effective color rendering of artifact in order to appear vibrant and true, positive psychological impact, a greater satisfaction through artwork gratitude, enhancing the architectural experience, reduction of energy consumption and electric lighting load (thus lowering the emission of CO₂ and mitigating the greenhouse effect) [7–15].

When daylight is to be allowed to penetrate into a museum, careful attention must be given to allow just the required amount of light into the space that will not deteriorate the artifacts [16–17]. Light as a radiant energy can cause photochemical damage (fading, yellowing, darkening of colors, loss of strength, fraying of fabrics, and even dramatic color changes of some pigments) and photomechanical damage (structural damage; surface cracking, lifting of surface layers, and loss of color) [8–18]. Light can also cause non-reversible damage to artifacts caused by its high Ultraviolet (UV) radiations [19–21]. The extent of the damage that daylight can cause to displayed artifact depends primarily on the light-sensitivity of the exhibited material, the intensity of light that affect it, and the time of display of this artifact. High illuminance levels and long exposure time can accelerate the damage of the exhibited item [22–25]. There are several approaches to evaluate lighting performance in museums and the potential damage that is caused by daylight on an artifact. One of which is to measure the illuminance levels and distribution in a gallery space to make sure they are not exceeding the limits required by the lighting standards and guidelines [4,26–27].

Sixty years ago, when guidelines for museum lighting were first explored, conservation adopted 50 lx as the benchmark level for museums. This level came originally from color science that had established that this level was enough to ensure that the human eye was operating well within the range of full color vision. However, it was also discovered later that this benchmark will allow only young people (age 25) to see all the details almost as well as 50 lx as they will in full sunshine within certain conditions (e.g. a moderately light-colored object, with a moderate degree of detail, in a moderately complex pattern, in a reasonable period of time). Unfortunately they will not see the details well if the object is dark, the details are very fine, the pattern is complex, and/or the viewing time is limited. More importantly, someone older (age 65) will need several times as much light to see as well as the youth. Table 1 presents some simple (and conservative) rules for adjusting visibility for different objects [28–29].

Previous studies have indicated the importance of measuring the light levels in museum buildings in order to avoid their harm-

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