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Evaluating Daylight Performance of Sharjah Archaeology Museum in UAE with a Reference of Kuwait National Museum

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ABSTRACT: This paper presents the evaluation results of daylight performance at Sharjah Archaeology Museum (SAM) in UAE. The museum was analyzed through inspections and assessments of the actual space and computer simulation programs. Light performance and illuminance levels in different indoor spaces were assessed by using Light Meter (LM-8000A) and computer programs such as ECOTECT and REVIT. The results indicated several lighting problems in the museum due to the absence of daylight penetration. The simulation has reviewed and calculated illuminance levels at different locations in the museum. As the existing case has no windows or openings inserted to its physical body, the readings during day-hour time were taken when artificial lights were on in order to evaluate the existing condition. A proposal with integrated windows has been introduced and simulated taking into consideration of internal electricity network "off" to show the impact of natural daylight on indoor illuminance environment. The results showed the proposed case could achieve the desired interior illuminance levels and save energy by 45%; so the retrofitting is an essential approach to improve lighting performance and reduce energy consumption in museums.

Keywords: Light Meter, Ecotect, Daylight, Sharjah, Kuwait

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INTRODUCTION

Sharjah Archaeology Museum was built in 1997 to offer the opportunity of exploring rich heritage and deep-rooted history of Sharjah City figure 1. The reports of many excavation expeditions showed that humans have settled in Sharjah for a period of not less than 125.000 years. The museum sheds light on the lifestyle of the region's inhabitants from the stone, modern, and the following ages until the rise of Islam (Sharjah Museum Department, 2015). Kuwait National Museum (KNM) was designed by the French architect Michel Ecochard in the 1950s, but actually built in the 1970s figure 1. The museum houses collections of Dar al-Athar al-Islamiyyah Museum (DAI) in Mathaf Al-Kuwait Al-Watani in Kuwait City. The museum comprises more than 35,000 objects and other objects from all over the Islamic world that includes manuscripts, wood, ivory, metal, glass, jewellery, wools, silks, leather, cotton, carpets, textiles and tapestries, and any kind of object which relates to the scientific and practical life of Muslims (Beltrán, 2003). Both museums contain hundreds of ancient, ivory, metal, glass, jewellery, and wools; and share similar climatic and lighting condition. Sharjah Archaeology Museum consists of six main exhibition halls from eleven sections which are: Stone Age, Bronze Age, Rocky Art Gallery, Iron Age, Greater Arabia and Al-Buhais Gallery figure 2, while Kuwait National Museum contains six main exhibition halls from twelve sections which are: DAI Exhibition, DAI Exhibition, Planetarium, KNM Land of Kuwait, Sadu House, Bader House figure 2. The case of Kuwait has certain problems in having extra sunlight penetrating actual spaces which need to be controlled. However the case of Sharjah Museum has the opposite scenario as it lacks daylight penetrating indoor which needs improvement to allow natural light penetrates indoor spaces but with preserving museum components. The case of Kuwaiti Museum was investigated and evaluated by Beltrán (2003), while the case of Sharjah Museum yet has not been studied or investigated. This is why both museums are put in comparison as they have identical problems in dealing with daylight. Sharjah Archaeology Museum is one of existing sixteen museums at Sharjah City Figure 3.

Lighting in Museums

Museum lighting must balance the exhibition and conservation needs and enrich the museum experience (Beltrán, 2003). As lighting plays an important role in reducing energy consumption in buildings, the study has selected museums to retrofit because the retrofitting field has not yet received adequate attention in practice or even in regulation. Most of the energy in buildings worldwide is used by existing buildings, while the replacement rate of existing buildings with new buildings is between 1% and 3% per annum (Zhenjun et al., 2012). Retrofitting existing buildings to green buildings provides direct energy saving in addition to reduced energy consumption, thus increasing the buildings' energy efficiency (Al-Ragom, 2003). The energy consumption of the Emirates increased significantly from 2003 to 2012 to meet the demand of the buildings. The following Figure 4 shows the increasing electricity consumption in UAE by agency

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and years. The amount of electricity consumed has increased by 140% between 2003 and 2012. Therefore, this study presents an introductory approach to retrofit an existing museum to spread awareness among designers and specialists to the retrofitting importance to be given a highest priority.

Climatic Conditions

The climate in UAE is considered one of the harshest in the globe; temperatures can reach up to 50°C during summer season (Al-Sallal et al, 2013). Summer in the UAE can be described as extending from May to October. Temperatures range from 28°C to 36°C, reaching a maximum of 48°C in the stifling months of July and August (Taleb, 2014). Since this research focuses on retrofitting museums in the city of Sharjah, no specific climatic data file was obtained from Ecotect. Therefore, the climatic data file of Dubai was available in Ecotect and used instead because the close proximity of Dubai to Sharjah city is within a 50 km radius circle from Dubai. The study uses the same approach of Taleb (2014) where Abu Dhabi data replaced Dubai in the simulation. Prevailing wind in Sharjah city comes from different direction during the year but favorable wind comes from northwest direction with wind speed between (34 km/h to 46 km/h) as shown in Figure 4.

Research Objectives

The study attempts to adjust gradually the level of daylighting in exhibitions and galleries so that it adds more opportunities for people to stay longer inside the space. The research attempts to improve the existing luminous environment and investigate the impact of daylight on energy consumption in Sharjah Archaeology Museum. The outcome of the study aims to provide a good lesson on how to integrate daylight in the museums to be applied in other museums of Sharjah.

Figure 1. (Left) Sharjah Archaeology Museum, (Source: sharjahmuseums.ae, 2015); (Right) Kuwait National Museum, (Source: archnet.org, 2015).

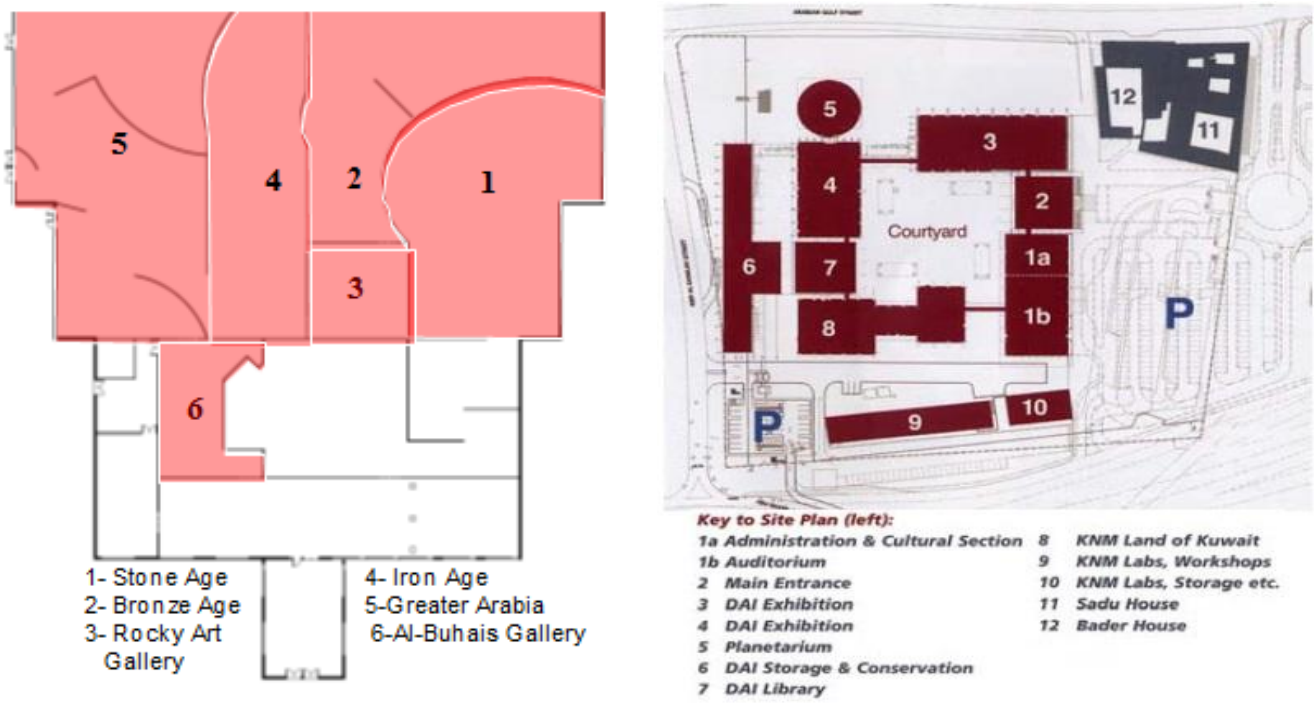

Figure 2. (Left) Sharjah Archaeology Museum's exhibitions, (Source: Author, 2015); (Right) Kuwait National Museum's site plan, (Source: Bareed ad-Dar 2003)

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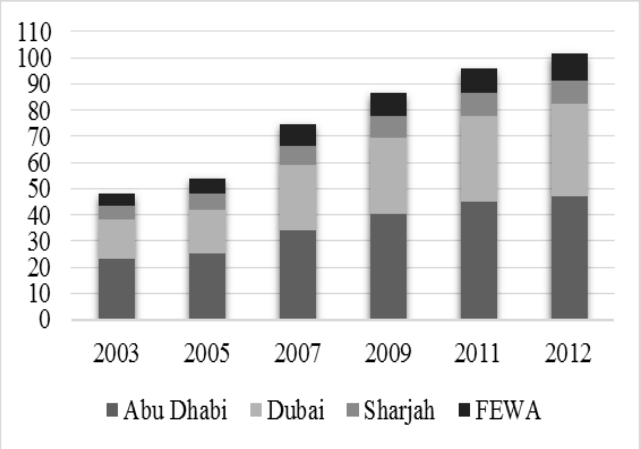
1. Majlis Al Midfaa.
2. Sharjah Aquarium.
3. Sharjah Discovery Centre.
4. Sharjah Classic Cars Museum.
5. Sharjah Heritage Museum.
6. Bait Obaid Al-Shamesi.
7. Sharjah Archaeology Museum.
8. Sharjah Science Museum.
9. Sharjah Museum of Islamic Civilization.
10. Sharjah Fort (Al Hisn).
11. Bait Al-Naboodah.
12. Bait Sheikh Saeed Al Qasimi.
13. Sharjah Art Museum.
14. Al Eslah School Museum.
15. Annual Photography

Figure 3. The Sixteen museums of Sharjah City. (Source: Author, 2015)



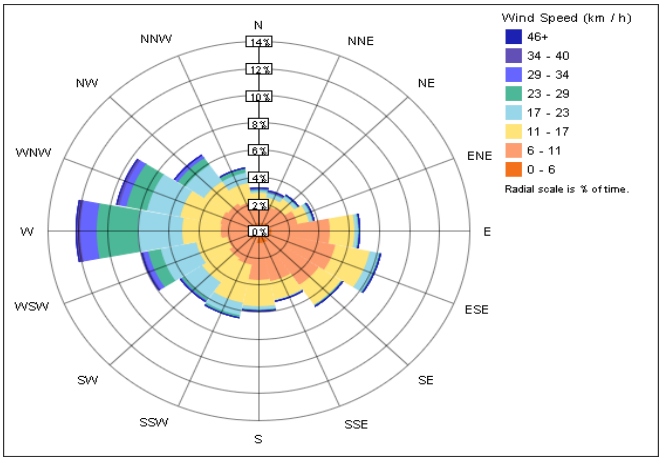


Figure 4. Left: Annual electricity consumption by agency and years (Source: DSC, 2010); Right: Annual Wind Rose at Sharjah by Revit (Source: Author, 2015).

Research Methodology

In order to explore in detail the luminous environment in Sharjah Archaeology Museum, two models of existing and proposed cases were performed using computer programs. The research started by investigating interior architectural arrangement and luminance environment within the actual space. When getting into the museum you will directly face the reception, then the lobby will be on your right hand. As you get deeper inside the museum, the spaces will be darker because the museum has no windows to the actual space and totally depends on artificial lighting in all exhibitions as shown in Figure 6 (Images 2, 3, 4, 5, 6, 7). The only windows in the museum are located at the lobby which is the waiting area as shown in Figure 6 (Images1, 2), while all doors shown in the plan are kept closed.

As a part of research, Light Meter (LM-8000A) was used to quantitatively investigate and detect lighting levels in the museum. Seventeen points were tested and recorded to cover most of the actual space in the museum as shown in Table 1 and Figure 5. From the readings, it shows low illuminance environment has been recorded which negatively affects visits duration and visitors' psychology. As the museum is built to show archaeological pieces that

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don't get affected by daylight; and as per Le Corbusier and Tado Ando who are highly admired for using daylight into designing museums to provide appropriate illumination to enhance spatial orchestration (Yiannakou et al., 2012), it is recommended to improve illuminance environment by integrating daylight into museum design

Artificial Lights in Existing Project

Sharjah Archaeology Museum uses various types of artificial lights from almost all lights series, it even uses the types (UV) and (IR) in the lighting system. The concentration of (UV) lighting was under the small exhibits Figure 6 (Image5) while the concentration of (IR) lighting was used at almost everywhere Figure6 (Image6) and used some small artificial lights to define the beginning of each section, corridors, and arches inside the actual space.

Table 1. Illuminance records at Sharjah Archaeology Museum, (Source: Author, 2015).

Space Function	Illuminance(lux)
Lobby	157
Inside exhibition	8
Excavation section	170-615
Stone age exb.	8-67
Projector zone	5
Corridors between exbs.	43
Exb. Type 2	38-300
Light above models	434
Full LED light above models	73-127
Full LED light above models	22
Arcades	8

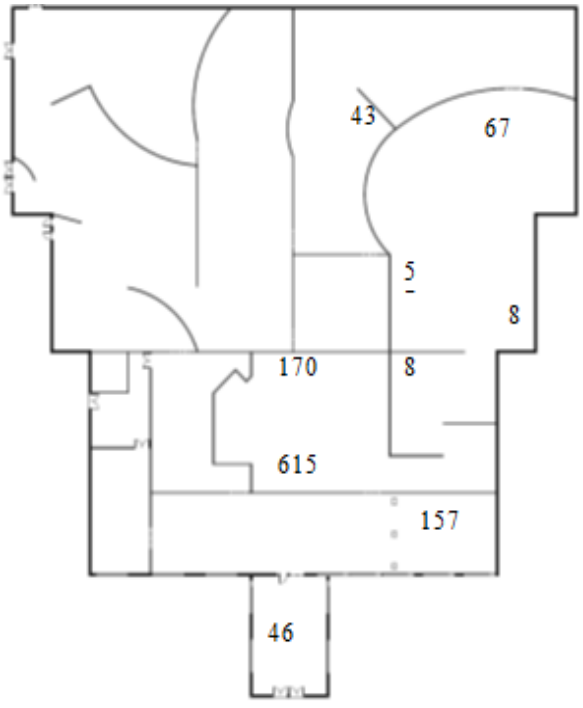

Figure 5. Location of the readings on the architectural Plan, (Source: Author, 2015).

Figure 6. Sharjah Archaeology Museum's sequence of space. (Source: Author, 2015).

RESULTS AND DISCUSSION

This section shows analyses for both cases of Kuwait and Sharjah. The first Kuwaiti case has been brought to the study as a reference study for Sharjah's case to learn its techniques and mechanisms used in research. The analysis is as follows:

Kuwait National Museum

According to Beltrán, (2003), The Kuwaiti National Museum that has huge windows allowed more natural light to penetrate the museum which disturbed visitors of the museum. Figure 7 depicts the interior illumination of three different façade systems for the SE side of The Kuwait National Museum simulated for December 21 at 9:00 AM when the sun is at a low angle in front of the window. The three façade systems presented over there were: (a) existing facade condition with no glass but with original shading devices, (b) switchable glazing at a darkened stage in combination with the outside tinted glass layer (Tvis 0.3%), and (c) all the components of (b) case with a combination of dynamic louvers. Noticed from the results showed in Figure 7-b how the space is darkened when using the switchable glazing while the darkest conditions were achieved when switchable glazing is combined with the dynamic louvers and screens. Figure 8 shows the illuminance level of the above three façade systems for the same simulation condition on 21st December, at 9:00 AM. The existing condition (Top) introduced more than 5000 lux on the floor plane; while with the switchable glazing at its darkest stage (Center) light levels are reduced to 100-1200 lux. When combined the switchable glazing with the louvers and screens (Bottom), light levels reached as low as 25-40 lux throughout the space. The study introduced methods and systems to control daylighting and not to block walls from natural light.

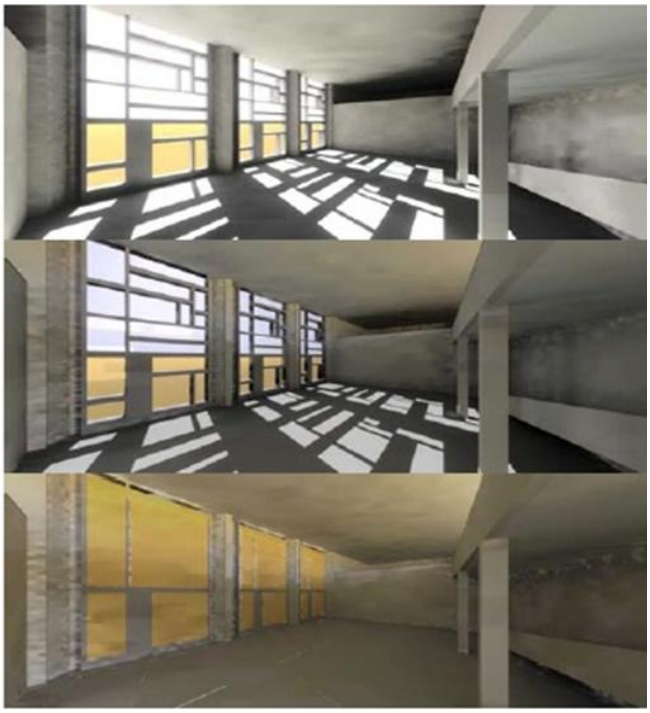

Figure 7. Interior spaces of the SE of The Kuwaiti National [Museum with different glazing systems: (top) existing conditions, (center) switchable glazing, and (bottom) switchable glazing with dynamic louvers and motorized shading. (Source: Beltrán, 2003)]

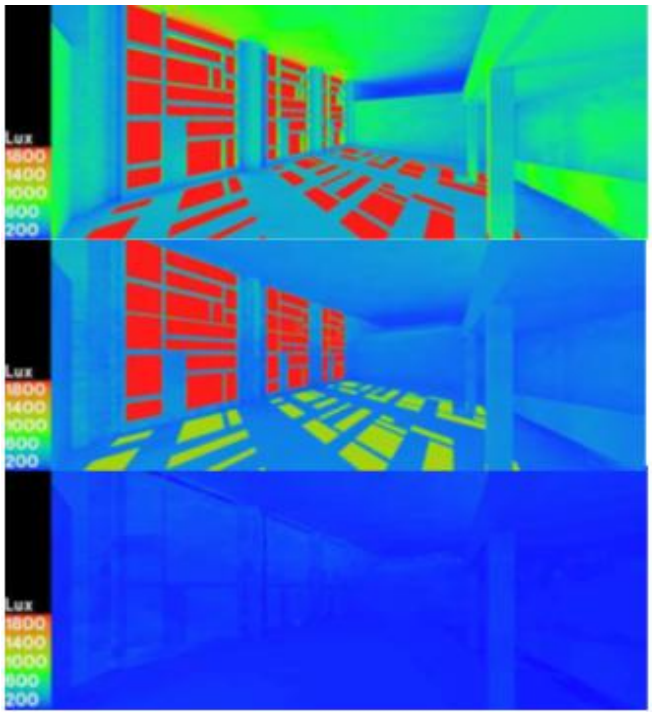

Figure 8. Illuminance levels in lux at The Kuwait National [Museum with different glazing systems: (top) existing conditions, (center) switchable glazing, and (bottom) switchable glazing with motorized shading at 9:00 AM, December 21. (Source: Beltrán, 2003)]

Therefore, as the case study of Kuwait has a similar function and weather condition of our site, the Authors recommend having a similar study by integrating daylight into actual spaces of museum. Learning from a similar case study in Kuwait, several recommendations herein are suggested to improve lighting condition in Sharjah museums. This study opens the door for further studies to improve existing buildings through the use of recent methods applied in this research.

Analysis Results of Sharjah Archeology Museum

As Sharjah Archaeology Museum has no windows on all external elevations except a small portion in the lobby area beside the main entrance, simulating the original case using programs ECOTECT and REVIT shows that the daylight levels penetrating the museum are less than required standards as shown in Figure 9. The illuminance levels in most areas are below the vision limit with an average of 10 lux inside the museum, though the analysis was done at 12:00 PM on 18th April where the sun is low in the sky and direct to the walls. The figure shows the distribution of illuminance levels range from 0.09 to 19 lux inside exhibitions except an area beside the entrance, i.e. the lobby area, with a range between 271 and 1021 lux. As per simulation's readings, the museum has less amount of daylight penetrates the actual space which in turns increases energy consumption due to the total reliance on artificial lighting in illuminating the museum. Therefore, this study introduces a further proposal to improve the existing case by inserting windows to the

external walls of the museum with a size of 5m length by 0.5m width at a sill height of 3m Figure 10. The external windows are supported by switchable glazing, while internal partitions by internal opening to provide better daylighting in the museum on the one hand and natural ventilation on the other hand. Running the programs for this proposed case, the illuminance environment of the actual space has been improved where minimum illuminance increased from 0.09 lux to 101 lux at entrance, and from 19.10 lux to 193 lux at actual space as in Figure 11. The integration of natural light through exterior windows and internal partitions into the actual spaces and exhibitions improved illuminance environment around walkways and statues which affect space occupancy positively. The entrance besides the reception, lobby, and the Café received the highest illuminance with ranges between 704 lux and 1343 lux, while the illuminance environment inside the actual space and exhibitions varied from 101 lux to 369 lux which meets with comfortable vision. On the other hand, to achieve the second aim of the study which shows the impact of daylighting on energy consumption within Sharjah Archaeology Museum, further simulation on energy consumption using Energy Analysis Plugin was performed for the original case1 and the proposed case2. From the analysis and comparison of both cases, Figure 12 shows that the first case consumes 84072 kWh annually while the proposed case2 where daylight penetrated actual spaces and exhibitions consumed 46347 kWh. The proposed case improved the lighting systems by a reduction of 45% and with a difference of 37725 kWh. This improvement has been achieved for the use of one passive parameter only, so it is recommended to utilize more passive design elements to get more reduction in energy consumption.

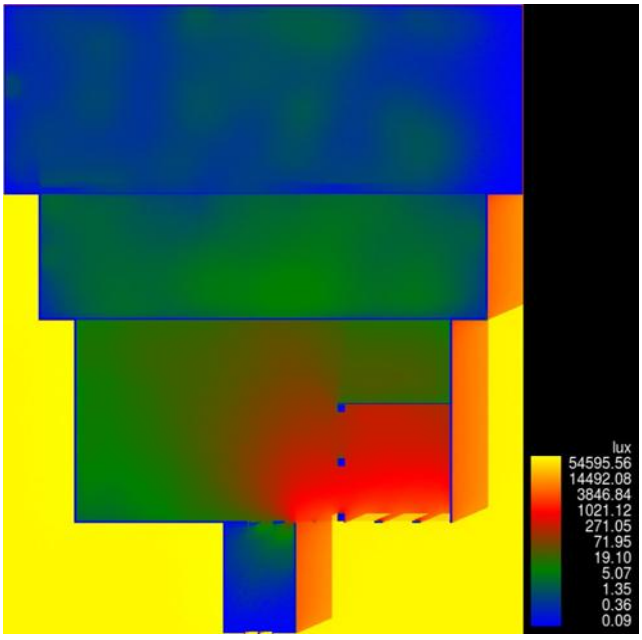

Figure 9. (left) Illuminance levels in lux using ECOTECT Lighting analysis. (Source: Author, 2015)

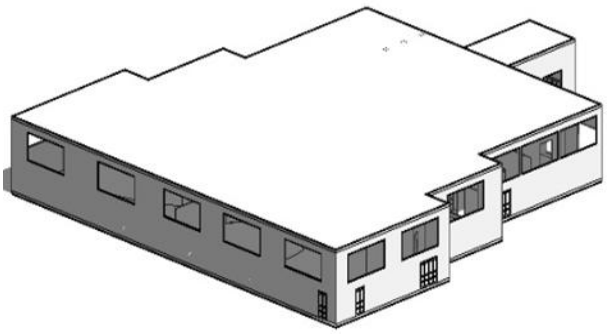

Figure 10. 3-D view Proposal with windows at Sharjah Archaeology Museum by Revit Architecture 2014, (Source: Author, 2015).

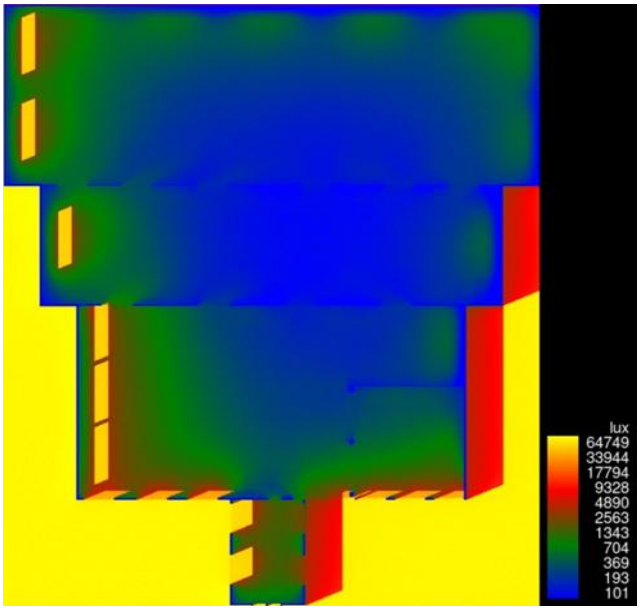

Figure 11. Illuminance levels in lux at 12:00 PM on April 18 for the plan of Sharjah Archeology Museum after adding exterior windows and interior openings using ECOTECT Lighting Plugin at Revit Architecture 2014. (Source: Author, 2015)

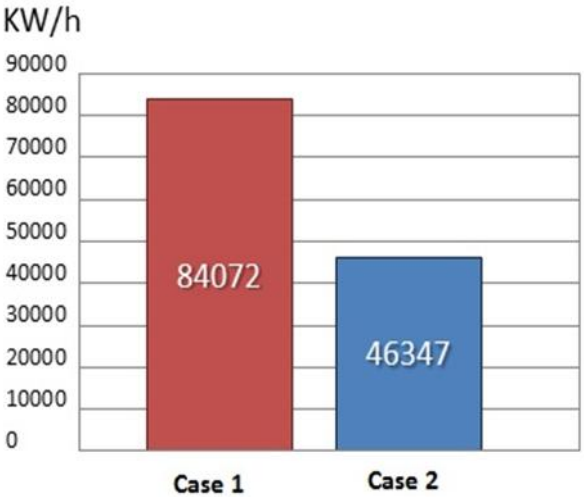

Figure 12. Annual energy consumption comparison between original case1 and proposed case2. (Source: Author, 2015)

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CONCLUSION

The integration of daylighting in the museums' design is a critical aspect helps visitors stay longer as well as reduce energy consumption. With the growing awareness in terms of energy conscious building designs, it is necessary that museum designers give proper considerations to the efficiency aspects in design. The designers of museums often misinterpret this fact and restrict the actual space and exhibits from being attached to environment. This study presented a summary of the current state of the lighting design for both Sharjah Archaeology Museum and The Kuwait National Museum. The study displayed a solution of the glazing type at Kuwaiti museum and introduced a solution of adding top lighting system at Sharjah's original case with no access of natural light into actual spaces and exhibits in the museum. Using windows with switchable glazing type positioned on top of external walls could reduce energy consumption by 45% compared to the original case with no windows. The illuminance environment of the proposed case improved the quality and quantity of light inside the actual space and exhibitions from 0.09 lux to 101 lux and from 19.10 lux to 193 lux and 1343 lux. Results showed that the proposed case with daylight penetrating the actual space can achieve the desired interior illuminance levels. The proposed case presents a well thought study that is carefully designed with toplighting system to introduce adequate light levels in the exhibits, and to provide a connection with external environment by illuminating actual spaces and exhibits with natural light. This is an excellent study that is successfully illuminating internal spaces with daylighting. Further research on thermal comfort and energy efficiency are recommended to understand more about museum design.

After this analysis, this paper would raise a primary question to designers as follows: "If the actual space displays traditional artefacts that used live and mix with natural light together, then why do the architects imprison these status and artefacts in a blocked mass detached from light. They lived and mixed together in nature. As a principle in architecture that form follows function, then why not actual space gets exposed to nature and follows nature.

REFERENCES

Al-Ragom F (2003). Retrofitting residential buildings in hot and arid climates. Energy Conversion and Management, 44 (14), 2309-2319.

Al-Sallal K, Al-Rais L, Bin Dalmouk M (2013) Designing a sustainable house in the desert of Abu Dhabi, Renewable Energy, vol. 49, 80-84.

Bareed ad-Dar (2002-03). Newsletter of the Friends of Dar al-Athar al Islamiyyah, Vol.3, Issue 1. Autum/Winter 2002/2003, p.7.

Beltrán LO (2003). Lighting a Museum, ISES Solar World Congress 2003, Goteborg, Sweden,14-19 June 2003.

Dubai Statistical Center (2010). Statistical Year Book-Emirates of Dubai. Vol. 22. Dubai, UAE

Plummer H (2009). The Architecture of Natural Light. London: Thames & Hudson.

Sharjah Museum Department.(2015) Website. From http://www.sharjahmuseums.ae/OurMuseums/Sharjah-Archaeology-Museum.aspx?lang=en-US.

Taleb H (2014). Using passive cooling strategies to improve thermal performance and reduce energy consumption of residential buildings in U.A.E. buildings, Frontiers of Architectural Research, 3 (2): 154–165.

Yiannakou et al. (2012). Luminous Environment in Le Corbusier's Museum: An investigation of light in Chandigarh Museum in India and the Museum of Western art in Tokyo, PLEA2012-28th Conference, Opportunities, Limits & Needs Towards an environmentally responsible architecture, Lima, Perú, 7-9 November 2012.

Zhenjun M, Cooper P, Daly D, and Ledo L (2012), Existing building retrofits: Methodology and state-of-the-art. Energy and Buildings, 55 (0): 889-902. doi: http://dx.doi.org/10.1016/j.enbuild.2012.08.018.