Conference Proceedings

EuroSun 2014
Aix-les-Bains (France), 16 – 19 September 2014

Daylight in Museums: Exhibition vs. Preservation

Raúl Ajmat[1-2], María Pérez Zamora[2] and José Sandoval[2]

[1]Facultad de Arquitectura y Urbanismo Universidad Nacional de Tucumán (U.N.T.).

Av. Roca 1900, Tucumán 4000, Argentina

[2]Department of Lighting, Light and Vision (DLL y V).-ILAV National University of Tucumán-CONICET

Av. Kirchner 1800, San Miguel de Tucumán 4000, Argentina.

Abstract

This paper explores the possibilities of multiple building simulation tools being used together for the analysis and prediction of the behavior of museums' buildings. The relationship between the exhibition of artistic or historical artifacts in museums and the role of lighting in generating an atmosphere is explored here. In conducting simulations special care was taken in the simulation of the amount of radiation reaching exposed artifacts. Results show a reasonable agreement between the simulated data and actual measurements "in situ". It is expected that the results will be useful in decision making, either during the design process or during refurbishment intended to improve exhibition spaces capabilities in preserving artwork or historical artifacts.

Keywords: Museums - Conservation - Preservation - Simulation - Lighting – Exhibition

1. Introduction

Museums have in common the intention to "tell a story". This intention goes beyond value and size of the exhibits, geographical location or the number of people who visit them. From this point of view, light has a dual role of great importance: to reveal the object itself (physiological function) and to contribute to the quality of the environment (significance role), where the exhibition takes place and, therefore, is part of it implicitly.

However, lighting, along with other environmental factors (such as temperature and humidity) can modify the properties of objects significantly depending on the length of time of the exhibition, leading to deterioration. Thus, a dilemma to be solved is: exhibiting versus preservation. High standards of preservation can lead to low illuminating and thus exhibiting artifacts less effectively. On the other hand, a stimulating environment for the exhibition of valuables, can lead to lower conservation standards.

The hypothesis of this paper raises the possibility of accurately predicting the behavior of museum buildings through simulation systems focusing on the conservation and preservation of objects on display. This is due to software providing the possibility of reproducing the characteristics of a room where an object is located, i.e., the physical condition, display details, proximity to windows and size, sky conditions under local climate data and in turn it is possible to simulate the conditions of artificial lighting too. Thus render the object measuring a plane which will be extracted luminance values which allow by sensitivity classification: none, low, medium or high, whether the conditions at this time are adequate or not.

2. Exhibition vs preservation

Museums are spaces for learning and discovery of the past and present history (Hunt, 2009).This is particularly important when referring to the case of Historical Houses which nowadays are transformed into museums and therefore are part of architectural heritage. These "museum-houses" are considered as valuable

doi:10.18086/eurosun.2014.05.01 Available at http://proceedings.ises.org

themselves, and so their preservation should be taken into account in the same way that the contents of museums are treated (Risnicoff de Gorgas, 2008).

A question emerges then: how it is possible to display buildings and the objects at the same time without in many cases causing irreversible damage? The main agents of deterioration are humidity, temperature, light and air pollution.

Light is arguably one of the greatest causes of deterioration in museum collections. On the one hand it can be destructive and thus conflicts with the museums role in preserving heritage; on the other hand it is essential to vision, the principal means of communicating to visitors the information held within and around the objects and buildings in museums. Light is a key interpretive tool to extend the potential of communication. It provides a context in time and space for the museum visitor, in an architectural sense as well as the relationship with a collection (Pinna, 2000).

Several factors contribute to damaging effects of light: the materials from which objects are made, the type and intensity of light they are exposed to, and the duration of the exposure.

Especially sensitive to light are objects made of organic material including documents and letters, photographs, artwork on paper, textiles, clothing and accessories. The result of exposure can be severe damage to museum artifacts. Damage is also cumulative over the life of the objects, and frequently irreversible.

The radiation that museum collections are exposed to consists of three portions: ultraviolet (UV) at one end of the spectrum, visible light in the middle, and at the other end infrared radiation. It is energy that drives the chemical reactions that are causing damage to objects through fading. (Ajmat et al, 2010) Many studies in the attempt to control the envelope as an environmental filter to prevent damage light try to protect them from exposure to artificial and natural light (Christensen E. and Janssen H. 2011). Others have recommended protecting exhibited artifacts in museums from hygrothermal damage through the use of simulation as a predictive tool (CIE, 2004).

The importance of this study lies in the ability of simulation systems to predict such conditions. Thus it is vital to estimate the amount of cumulative radiation incident on the exhibited objects. In the cases where this is excessive, it is necessary to analyze alternatives that provide a possible solution to the problem of light damage.

3. Energy simulation in buildings

Energy modelling in buildings has experienced a significant growth throughout the last five decades. Building design and operation processes can be supported by many kinds of models, including the traditional architectural scale models as well as the latest computer generated virtual buildings. From consulting engineers to architectural offices, building simulation techniques assist designers in the design process verifying their technical assumptions.

The growth in building modelling was strengthened by the need for building designers to comply with the increasing concern of regulatory bodies in promoting best practices in environmental sustainability of buildings design, either through regulations or in the form of incentives to the building industry. In the particular case of museums there are guidelines in terms of maximum level of illumination on objects depending on the sensitivity of them, together with a total amount of irradiation throughout the period of exhibition.

The requirements of compliance with energy efficiency regulations led to an increase of the availability and power of computer-based methods for the simulation of buildings' behaviour. However, building simulation techniques are not only to be applied for new designed buildings. In the context of museum architectural heritage, building performance simulation has been increasingly useful to predict refurbishments, addition of new elements or changes in an existing building. This paper explores the benefits of using such techniques to improve preservation and exhibition conditions within these particular types of museums ("museum-houses"). Irradiation modelling is one of the key issues for thermal and natural lighting calculations. Since the work presented here focuses on the simulation of devices externally, in windows or internally, irradiation modelling through transparent surfaces is particularly relevant. Irradiation modelling in its visible portion, daylight, and the consequences within the built environment, together with irradiation produced by artificial lighting is the main focus of these simulations. Some of the software packages which use irradiation modelling for the thermal calculations make comparable assumptions, for example that windows are not thermally coupled with external shading devices. They only take into account the solar radiation which is partially unobstructed by the shading device. The problem to solve is then transformed into a purely geometrical one. Solar radiation consists of two main components: direct and diffuse. In order to obtain the solar radiation impinging on the transparent surface, the direct solar radiation is assumed to be uniform. It is estimated as the product of the fraction of the window area which is sunlit and the direct solar radiation. The diffuse solar radiation is reduced by a fraction calculated as the view factor between the transparent system and the sky. No correction is made to take into account the reflection of the radiation on the shading device itself, nor the splitting of diffuse radiation into typical fractions reflected from the ground and coming from the sky.

Moreover, it is common practice in daylight calculations that only variations in altitude are considered instead of three dimensional calculations. All these considerations for the calculation of the radiation coming through the window-shading device system make the solution for the complex process taking place in transparent materials a simpler, although less accurate. Irradiance and daylight quantities, which are particularly important for windows performance evaluation, are predicted using less precise approximations (Ajmat, 2008).

Nowadays, software simulation permits reproducing the characteristics of rooms where the objects are exhibited, their physical presentation, proximity to windows and their size; they allow the calculation of sky conditions from climatic data base and, simultaneously, the simulation of artificial lighting conditions. This agrees to a classification of exhibition surfaces according to sensitivity: none, low, medium or high. Furthermore radiation data (W / m²) above the calculation plane can be extracted for estimating the accumulation thereof during the year.

4. Case Study

For this research work we took as its starting point the lighting and metric survey conducted in the Padilla's House Museum located in San Miguel de Tucumán, northwest Argentina. This museum is considered amongst the so called "Casa-Museo" (Museum-House) type. Built in 1750, this stately home reflects the typical internal distribution of its age and the façade is a great exponent of the Italian style (Figure 1). In 1973 the Provincial Government bought the property and began its restoration, opening its doors as a museum in 1976. Later in 2001was declared a being of National Historic Heritage.

Fig. 1: Padilla's House Museum. Left: East Façade; Right up: Floor plan; Right down: E-W Section

The first step of in situ measurements provided illuminance data that the display conditions in which objects are exhibited are considered critical compared with the values recommended by the CIE.

Hall 1 (shaded in the floor plan) is the area with greater complexity from the point of view of natural lighting examined in this study. It has windows in 60% of its perimeter; the main ones are facing east and are unprotected from sunlight.

The modelling of the room was done in the models Sketchup 8 and RADIANCE. A measuring plane corresponds with the south wall of HALL 1. A room divider, classified as a medium sensitivity artifact, is exhibited in HALL 1 (Figure 2).

Fig. 2: Left: Sketch-up model; Right: Hall 1

It is expected of this methodology that we provide the ability to predict the behavior of the building based on the envelope, thus to know the consequences of variations in it. There are five scenarios studied in this work, related with the openings facing east.

• The first is the current situation; windows have a common glass with a transmittance of 82%.

• The second is the use of a gray glass with a reduce transmittance, of 39%.

• The third is the addition to the common glass window of an awning and exterior protection.

• The fourth experimented with placing a sheet of perforated vinyl 45% on ordinary glass.

• Finally the current situation i.e. the use of artificial lighting of the room.

For the last scenario were incorporated eleven 53W halogen lamps located inside the chandelier luminaire (Figure 3).

Fig. 3: Chandelier in Hall 1 Left: Radiance Simulation; Right: Picture

The reason for choosing the two first scenarios is that they allow us to become aware of the current situation of the room. The remaining three are part of the efforts to contribute through simulation methods by experimenting with simple, rapid and less costly interventions.

From the study it is possible to extract the values of radiation on the calculation plane at each point conceived as virtual photocells. Thus, you can observe the current situation in which maximum radiation values close to 45000 Watt / m² per year accumulated on a point in the plane of measurement for a natural lighting situation, and 55000 Watt / m² for the situation presented by the combined effect of natural and artificial lighting (Table 1).

By replacing window glass with of similar thickness glass but in grey color, with 39% transmittance, a large decrease in the amount of accumulated energy is observed on the plane hovering around 50%.

For the case of the sheet, the interpretation is made from an overall average resulting from the relationship between the area covered by the window and the open area; allowing for a reduction of annual accumulated radiation values of approximately 30%.

For the scenario of micro perforated vinyl glazed sheet on the windows´ glazing, values were similar to that obtained in calculation with external protection (canopies) reducing the radiation and illuminance values by almost 30%.

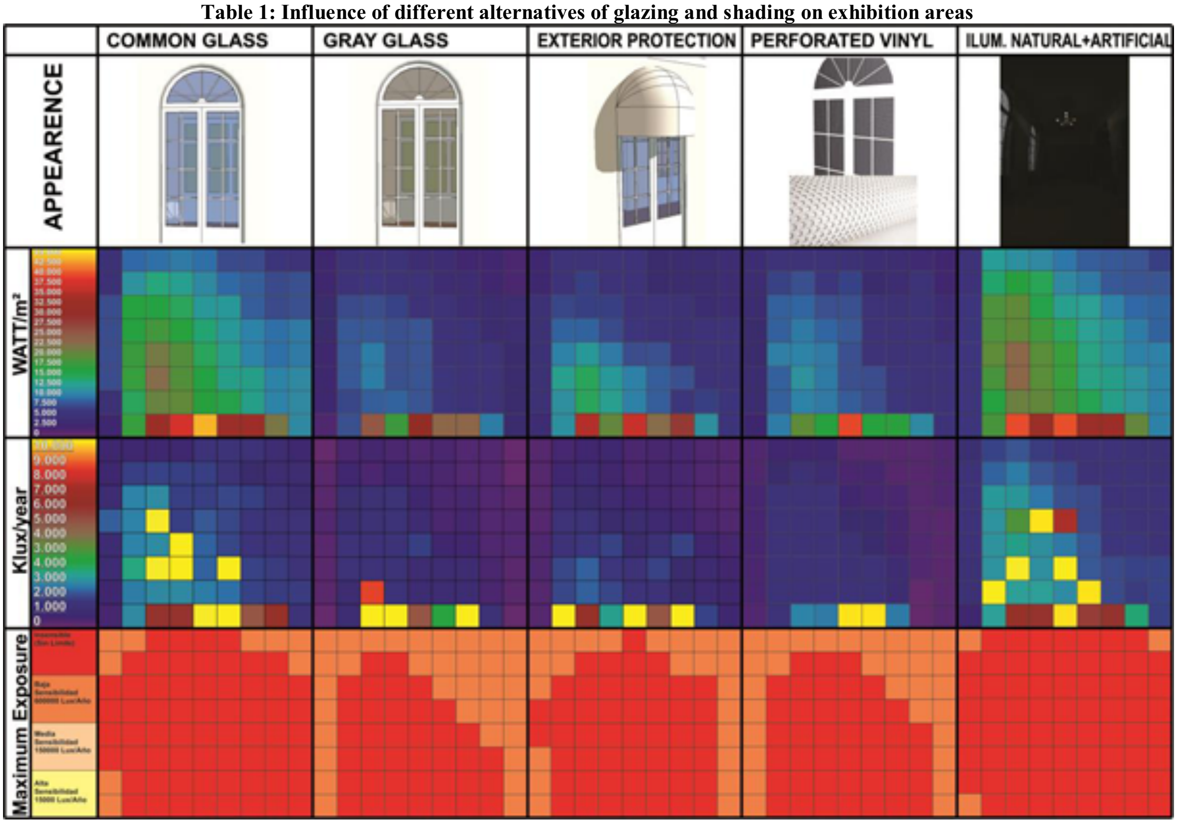
Extracting the recommendations on the measuring plane, one can determine different areas with different possibilities of exhibition, i.e. the areas that do not meet the values of lux-hours/per year eligible for certain objects and therefore becoming restricted areas for them.

The methodology allowed us to determine the possibility of extending the range of display for varying elements of the envelope, in this case the glass.

It also allowed us the possibility of performing calculations taking in account the use of artificial lighting currently installed in the room during museum opening hours.

Table 1 shows the comparative results for the five variations simultaneously; making clear both the efficiency of the use of awnings and replace existing ordinary glass by one of reduced transmittance.

Table 1: Influence of different alternatives of glazing and shading on exhibition areas



5. Conclusions

With this methodology it is possible to adequately reproduce the current situation of the building and predict the effects of possible changes. From the results obtained for the measurement plane it can be considered that the current situation of the building has no proper conditions for the display of objects of high, medium and low sensitivity. Moreover, the addition of artificial lighting in the simulation helps to raise both illuminance values and radiation, bringing the measurement plane to a critical situation in which only insensitive elements could be exposed. While the contribution of artificial lighting provides higher values on the plane, this contribution is not as significant as expected, since only tends to increase the values by 7%.

By replacing the glass with that of reduced transmittance a noticeable improvement in the values were obtained, bringing them, towards the eligibility with the CIE (International Commission on Illumination) rules on the display of objects considered of low sensitivity. The incorporation of external protection contributes to the reduction of the values but less than expected as they reduce the exposed area of the window.

The addition of micro perforated vinyl proved highly effective at reducing the time of daylight access through the window, lowering photosensitive damage inside the room. This has the advantage of being a lower cost alternative, less invasive and requires low-skilled labor to be used. This same study performed in all the rooms will permit development of a display scheme that is based on the behaviour of the envelopes and informing the curators how to organize the space considering the sensitivity of each object and the space available for it.

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7. Acknowledgements

The authors would like to express thanks to the collaboration of the authorities of the Tucuman Cultural Office (Ente Cultural de Tucuman) and the Padilla's House Museum personnel, and to the National Research Council of Argentina (CONICET) through its research scholarship program.