SynthLight Handbook

Chapter 5: Case Studies

Part 1: Museu National de Arqueologia
Lisbon, Portugal

Author: Axel Jacobs
Low Energy Architecture Research Unit, LEARN
London Metropolitan University

This is part 1 of chapter 5 of the handbook for the SynthLight on-line course on lighting:

1. Fundamentals
2. Daylighting
3. Artificial Lighting
4. Integrating Artificial Light and Daylight
5. **Case Studies**

For more material and the other chapters, please visit the SynthLight web site at: http://www.learn.londonmet.ac.uk/packages/synthlight/index.html.

This site also has an on-line test consisting of 15 questions each for each of the four main chapters. If you answer more than 80% of questions correctly, you will be sent a Certificate of Virtual Attendance.

Acknowledgements

SynthLight was part-funded by the European Commission under the SAVE programme. The project number is 4.1031/Z/01-123/2001.

Disclaimer

Although much care has been taken in ensuring that all facts and concepts laid out in this document are correct, the author can not be held liable for any mistakes that might have crept in. If you discover any inconsistencies, please notify <a.jacobs@londonmet.ac.uk>, so future revisions of this document can be corrected.

Introduction

The Archeological Museum in Belém which is part of Lisbon, Portugal's capital, is situated in a wing of the old Manuelin Jeronimos monastery. Its construction began in 1501 and was finished about one century later.

The building has a special baroque style with marine elements to celebrate the Portuguese maritime exploits of the 16th century, usually known as “Manuelin” style after King D. Manuel I who ordered it built. It is a national monument and the exterior cannot be substantially altered.

Illustration 1: *Main entrance to the Archeological Museum*

The wing hosting the museum is east-west aligned. While the ground floor is the exhibition space, the top floor is now used for offices but is being converted to create more floor area for the vast collection of exhibits from Portugal's past.

The museum is quite popular with locals and tourists. On average, there are 1320 visitors per week in winter, 2208 in summer.

Illustration 2: *Ground floor gallery. The space is being prepared for a new exhibition. A concret platform has been created to raise the floor by about 1.0m.*

The museum currently occupies the two floors of the south wing of the Jerónimos Monastery. It is located by the river in Belém, in a pleasant historical setting,

surrounded by gardens and other monuments. The lower floor is used for exhibitions, and the top floor is used for offices, library, laboratories, and other supporting spaces. The west end of the lower floor houses the reserve collection.

Internally the galleries are long and narrow, constructed entirely of stone, with gothic vaults. This space in inherently reverberant, so improving the acoustics was another objective. The reverberation time of the empty gallery was measured at 4.2 sec at 500Hz. The difficulty is that a conventionall acoustic treatment with insulation panels cannot be applied.

Illustration 3: *View from the balcony above the main entrance across the Praça do Império*

To convert the building into a museum in the mid 20th century, the ground floor arches were closed with windows fitted with expanded metal grills that block away daylight almost completely.

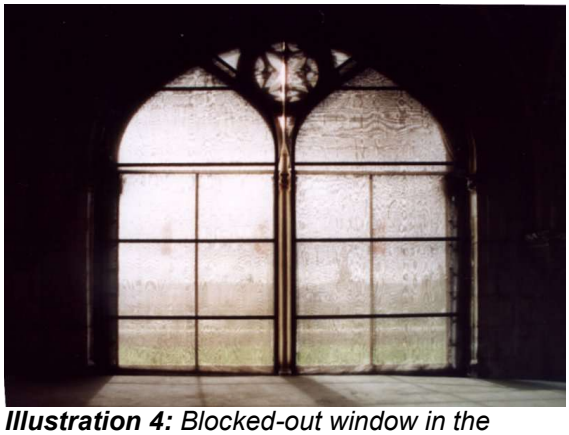

Illustration 4: *Blocked-out window in the ground floor gallery*

Exhibitions thus depend almost exclusively upon electric lighting, with significant energy consumption. There is no indoor environmental control system but, nevertheless, the indoor environment is quite stable. It is comfortable in summer, with temperatures around 25ºC even when outdoor temperatures surpass 30ºC, but slightly cold in winter, typically around 16ºC, even in the coldest days outdoors when the temperature drops to 5-6ºC at night. This results from a very high internal building inertia, with walls, pavement and ceiling made of thick (~1 m) marble or limestone.

The Retrofit

The museum is planning a retrofit to expand exhibition areas. The retrofit plan calls for the use of the two floors as exhibition space, with auxiliary and administrative spaces moved to the two adjacent towers, which then are divided into four rather than the existing three floors, as shown in the floor plans and section. Visitors shall walk along each hall and back, and then move upstairs and repeat an identical path.

It is desired to keep the good indoor performance of the space in terms of temperature in summer, while improving it in winter by taking better advantage of daylight. Acoustic improvements are also desired, to counteract the highly reflective indoor surfaces that cause a very reverberant space.

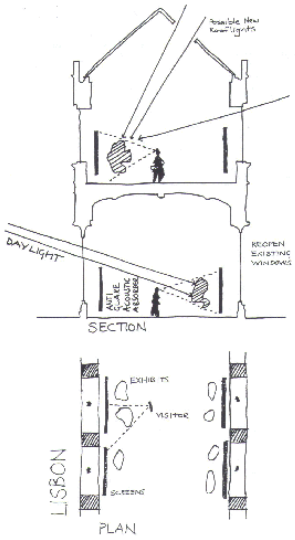

Illustration 5: *Cross-section and detail of the plan after the refitting.*

The Solution

This report presents the results of a daylighting study undertaken to assess various options for the refurbishment of the National Archeological Museum of Lisbon.

The daylight studies were undertaken using the RADIANCE lighting simulation software. RADIANCE is a raytracing software renowned for its accuracy which is widely used in the research community, and increasingly also by architects and building engineers.

A number of different approached were investigated. They are outlined below.

Description of the Options

The simulations have been undertaken for the museum's principal ground floor gallery. All options are based on the use of free-standing display panels acting as backdrops to display elements. The application of acoutically absorbing material to the panels ensures a improved acoustic performance of the space, while the fact that the panels are not attached to the walls ensures the utilisation of thermal mass as a passive cooling device.

Option 1: The perimeter display zone option

Vertical panels 5.5 m long and 3.2 m high are placed centrally in front of the ground floor windows. The back face of the panels is set 0.2 m in front of the stone piers between the windows.

A horizontal light shelf is fixed to the top of each panel and this projects 1.2 m beyond the face of each panel into the gallery space. It is designed to prevent visitors seeing the top of windows behind the display panel.

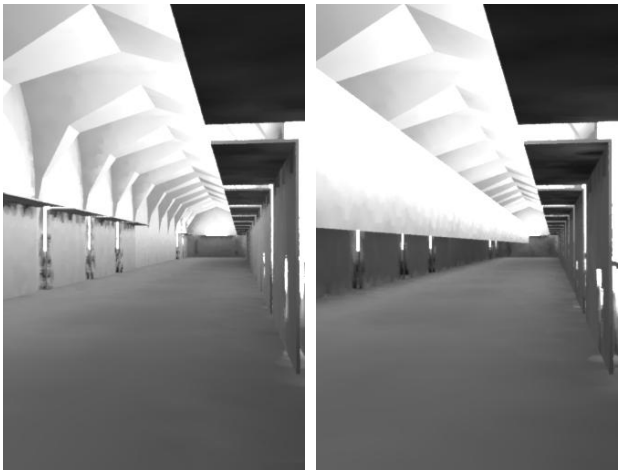

Illustration 6: *Options 1 (left) and 2 (right)*

Option 2: The perimeter display zone option with a suspended central diffuser

This option is the same as option 1. However, a vertical diffusing screen is suspended centrally within the gallery. This diffuser intercepts direct sun light and prevents sun patches falling on the display panels. So as to be effective it needs to be quite large, but allow people to pass underneath. It starts 2.0 m above the finished floor level and has a vertical dimension of 2.3 m. While this was quite effective it dominated the space and was not considered an appropriate solution.

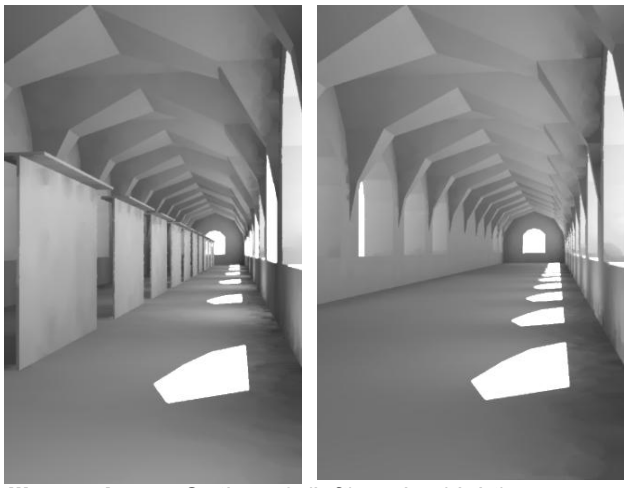

Illustration 7: *Options 3 (left) and 4 (right)*

Option 3: The central display zone option

Vertical panels, 4.8 m long and 3.2 m high are placed along the centre line of the Ground floor gallery. Panels are placed directly opposite the galleries windows. The panels are approximately 2 m apart. The panels either support items on display or act as backdrops to larger displays placed in front of them.

A horizontal shelf is fixed to the top of each panel projecting 0.4 m beyond the face of each panel (i.e. it has an overall width of 0.8 m). It is designed to prevent visitors seeing the top of windows in opposite walls when viewing the display panels.

Option 4: The original configuration without shading

Option 4 was included to have a direct comparision between the situation as it is now and the improvements that may be achieved through options 1-3. No daylighting or shading devices were put in.

For all simulations the following assumptions have been made:

- No external shading to windows;
- Double glazing has been assumed in the windows;
- The upper surface of the light shelves fixed above the display panels is reflective, we have assumed a reflectivity of 85% and specularity of 0.1 (e.g. gloss paint or plastic);
- Stone in the museum has been given a reflectivity of 35%.

The following section presents results showing horizontal illuminance measured within the museums ground floor gallery. Cases are presented for sunny and overcast skies. Illuminance is measured 0.8 m above finished floor level.

Descriptions of the sky conditions

All design scenarios were looked at under overcast sky conditions, as well as for a typical sunny day in September and November at 10.30am. Due to the depth of the walls and arches and the self-shadowing this creates, no direct sunlight will enter the space at mid-day during the high summer.

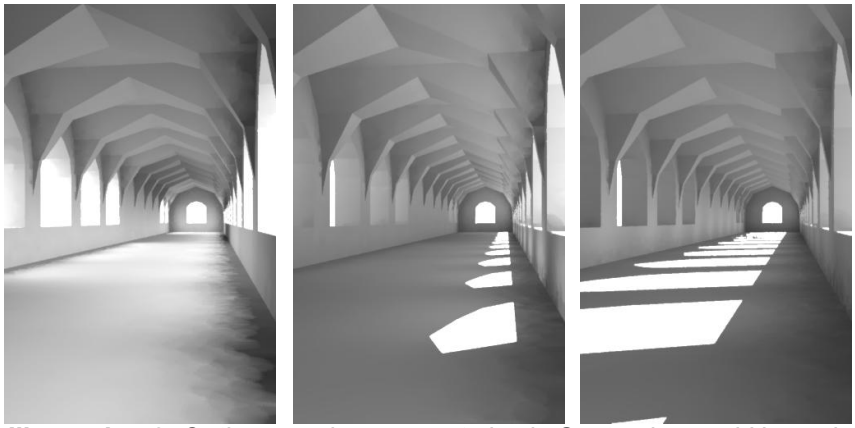

Illustration 8: *Option 4 under overcast sky, in September and November*

The Results

The charts in illu. 9 indicate levels of illumination which can be expected on the vertical display panels under overcast skies, generally the worst conditions for daylighting.

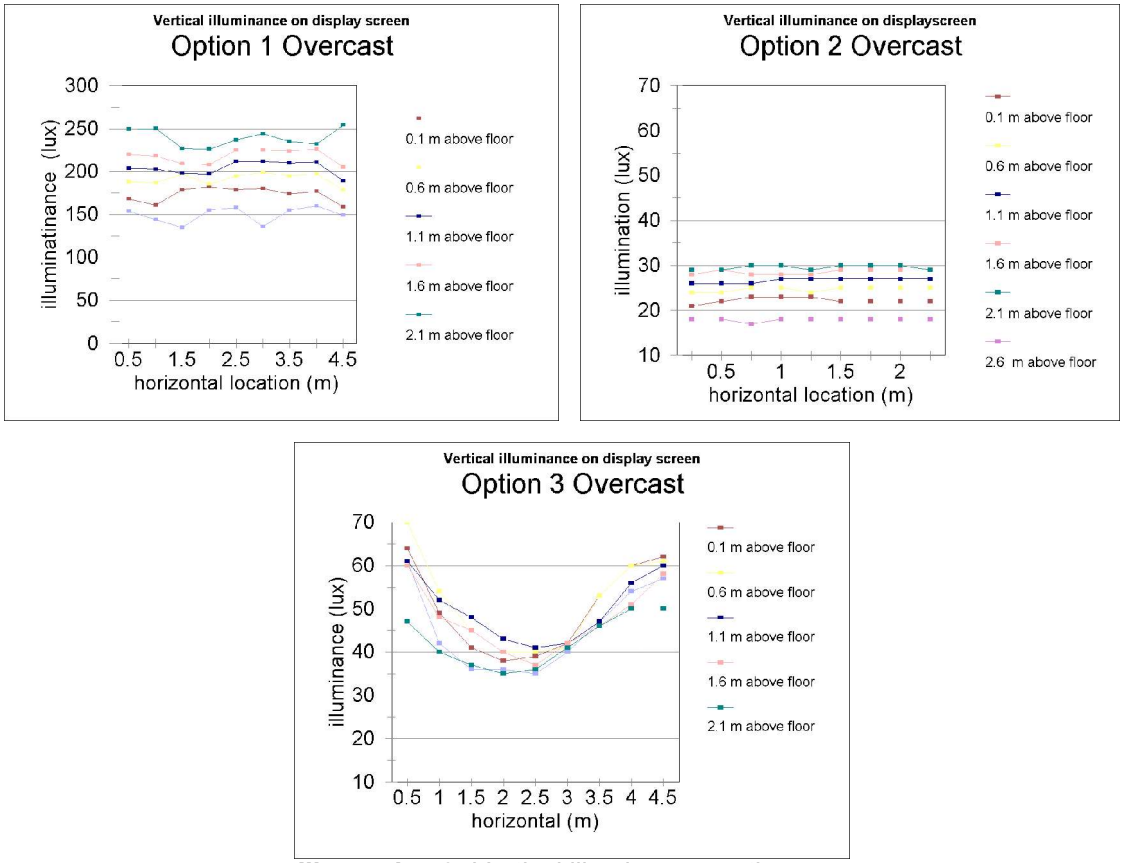

Illustration 9: *Vertical illuminance on the display panels under overcast sky conditions*

In general, the distribution of daylight is very even over the face of the panels. Levels vary considerably depending upon sky conditions and this will require particular consideration by the designers of any display.

It is also clearly the case that conservation issues will require close consideration. Although stones and rock are not susceptible to large amounts of light and UV, more delicate objects such as paintings are. For those, care needs to be taken that the total number of lux hours per year does not exceed the recommendations for museum lighting.