

LIGHTING DESIGN FOR ART, MUSEUMS AND ARCHITECTURE

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Fig. 1. A daylighting simulation of the two-story gallery of The Art Museum of Estonia. Exterior conditions: horizontal illuminance 10 klx, vertical illuminance 5 klx.

INTRODUCTION

In the history of lighting, art galleries have been the forerunners of advanced solutions. Their basis lay in museum architecture, which developed strongly during the 19th century. Since then architecture and art itself have changed a lot. But the basic lighting problem has remained, perhaps even more severe than before because of the wide use of glass surfaces. Here we present some aspects of lighting design, starting from the needs of art and architecture and the latest design methods and available knowledge. Our case study is a modern museum, but the same approach applies to both new galleries and renovation projects.

THE OBJECTIVE: DISPLAYING WORKS OF ART WHILE PRESERVING THEIR VALUE

There are many kinds of radiation, also in the visible region, that are potentially harmful to materials used in art. Therefore the limits of light exposure must be considered in lighting design. These values have recently been revised by the CIE and they depend on materials which are divided into three sensitivity classes. The most important are the maximum illuminances and the allowed annual exposures to light (see table 1). In many cases, 200 lx is a convenient illuminance for low-sensitivity materials. UV radiation should be totally suppressed.

Material classification	Examples of materials	Limiting illuminance	Limiting annual exposure
a) Insensitive	metal, stone, glass, ceramic	no limit	no limit
b) Low sensitivity	canvases, frescoes, wood, leather	200 lx	600 000 lxh/a
c) Medium sensitivity	watercolor, pastel, various papers	50 lx	150 000 lxh/a
d) High sensitivity	silk, newspaper, sensitive pigments	50 lx	15 000 lxh/a

Table 1. Limiting illuminances and annual exposures for material sensitivity classifications (CIE Div. 3 TC3-22, 'Museum lighting and protection against radiation damage').

Because of the dynamic nature of daylight, lighting design according to these limits may pose a complex task. Time compensation should be used in potential overexposure situations.

THE METHOD: COMBINING ELECTRIC LIGHT, DAYLIGHT AND ARCHITECTURE

Light is brought into the space from electric sources and the window system. Windows are easily understood to be both a lighting device and an architectural motive. Basically the same applies to electric light. For example, the light cove is an architectural element. The placement of windows and light coves depends on the architectural design. On the other hand, these elements and the resulting light become a part of architectonic expression. Hence, there is a mutual relation between lighting and architecture. Together, they provide the basis for a good lighting result.

Electric light and daylight are complementary. The former is easily controllable and extremely versatile, the latter is 'natural' in appearance and color but also very dynamic and potentially hazardous. The window system (glazing, shades etc.) is essential in daylighting. The combination of electric light and daylight (the light mix) is another issue. Some kind of a control system is usually needed. However, well-designed architecture may greatly reduce the complexity of such systems.

In the architectural profession, the design process depends greatly on visualizations. They provide feedback about how the design should be improved. Scale models and mock-ups are traditionally used for this purpose. Computer simulations provide an alternative method. Whatever tool is used, it should enable to study the effects of daylight and light mix.

THE PROCESS: THE KEY OF THE SUCCESSFUL LIGHTING DESIGN

In this context, the design process becomes important. The following principles help improve the design (see also figure 7).

1. The conceptualization of the lighting result. It is preferable to define the desired lighting result for the design team. Various 'design process' definitions may be used here, e.g. the three categories of Richard Kelly: ambient light, focal glow, and play of brilliance. A good master plan is also important.

2. Cooperation with the architect from an early stage. The architectural design of a building fixes the window openings and the spatial system, both essential for a daylighting design. Therefore, an early consideration of the lighting system is useful for the architect, the lighting result, and the economy of the project. For the architect, it may give useful elements for her/his design. When the functional features of the lighting system are known, economic and technology risks can be controlled. The lighting designer and the architect should cooperate as early as possible.

3. Advanced tools. Correctly used, computer simulation and other modern tools provide valuable information. Since there are criteria for gallery lighting, these tools allow an accurate design. In this way they reduce risks caused by the vast diurnal and annual fluctuation of daylight and the complex nature of light behavior. Modern design tools do not necessarily imply high-tech solutions. Compared to mock-ups (which also are useful) their benefits are lower cost, the possibility of studying electric light, and a broad variety of material properties and sky models.

The relations between architecture, lighting design, and conservation aspects during the process have been outlined schematically in fig. 7.

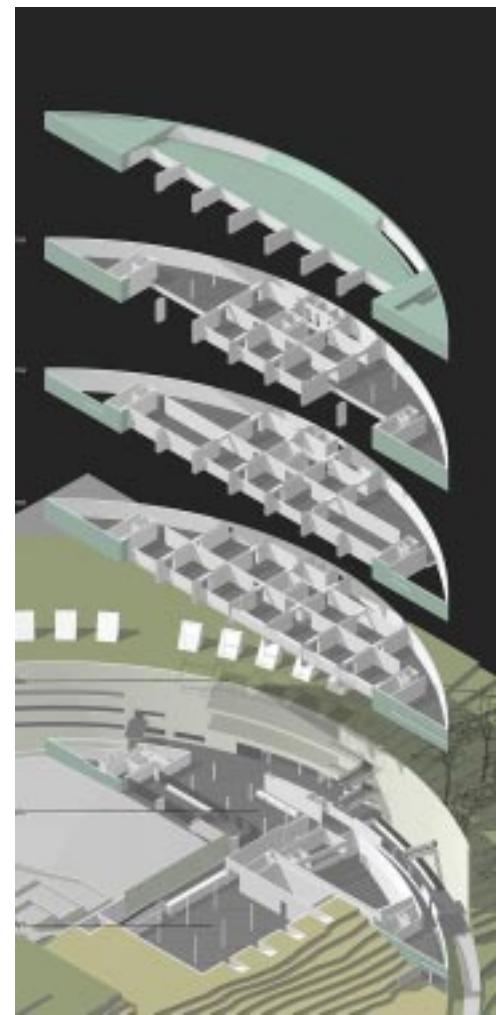
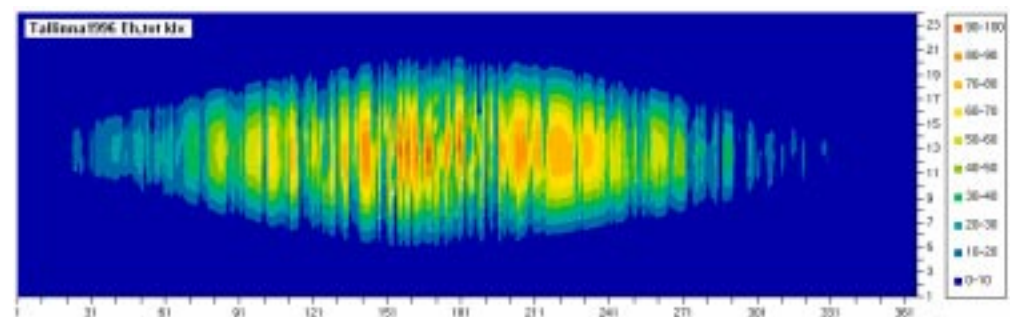


Fig. 3 and 4. The Art Museum of Estonia, the winning proposal 'Circulos' (images by courtesy of Arosuo & Vapaavuori Architects, Turku, Finland)



Fig. 2. Knowledge about annual lighting conditions on the site gives an opportunity to exactly dimension the daylighting systems.



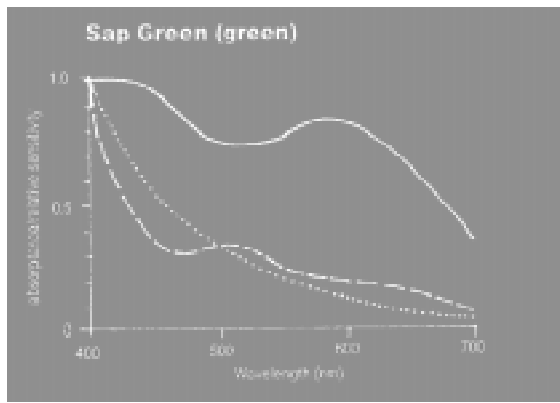
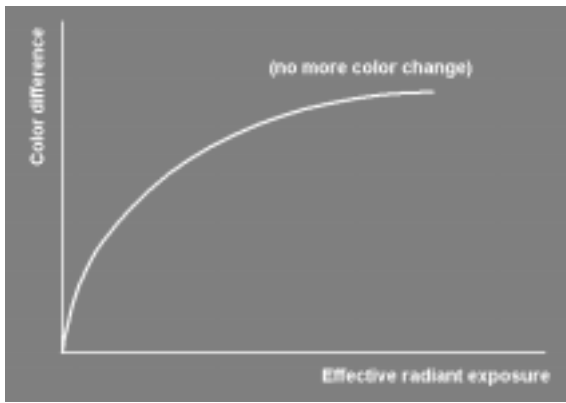


Fig. 5. The general course of color change in pigment due to radiant exposure.

Fig. 6. Illustrative radiation sensitivity and absorptance curves of a green dye.

The principles of gallery lighting design. The actual process depends on the building project.

Preserving the value of works of art

The gallery as an experience

Light – the 4th dimension of architecture

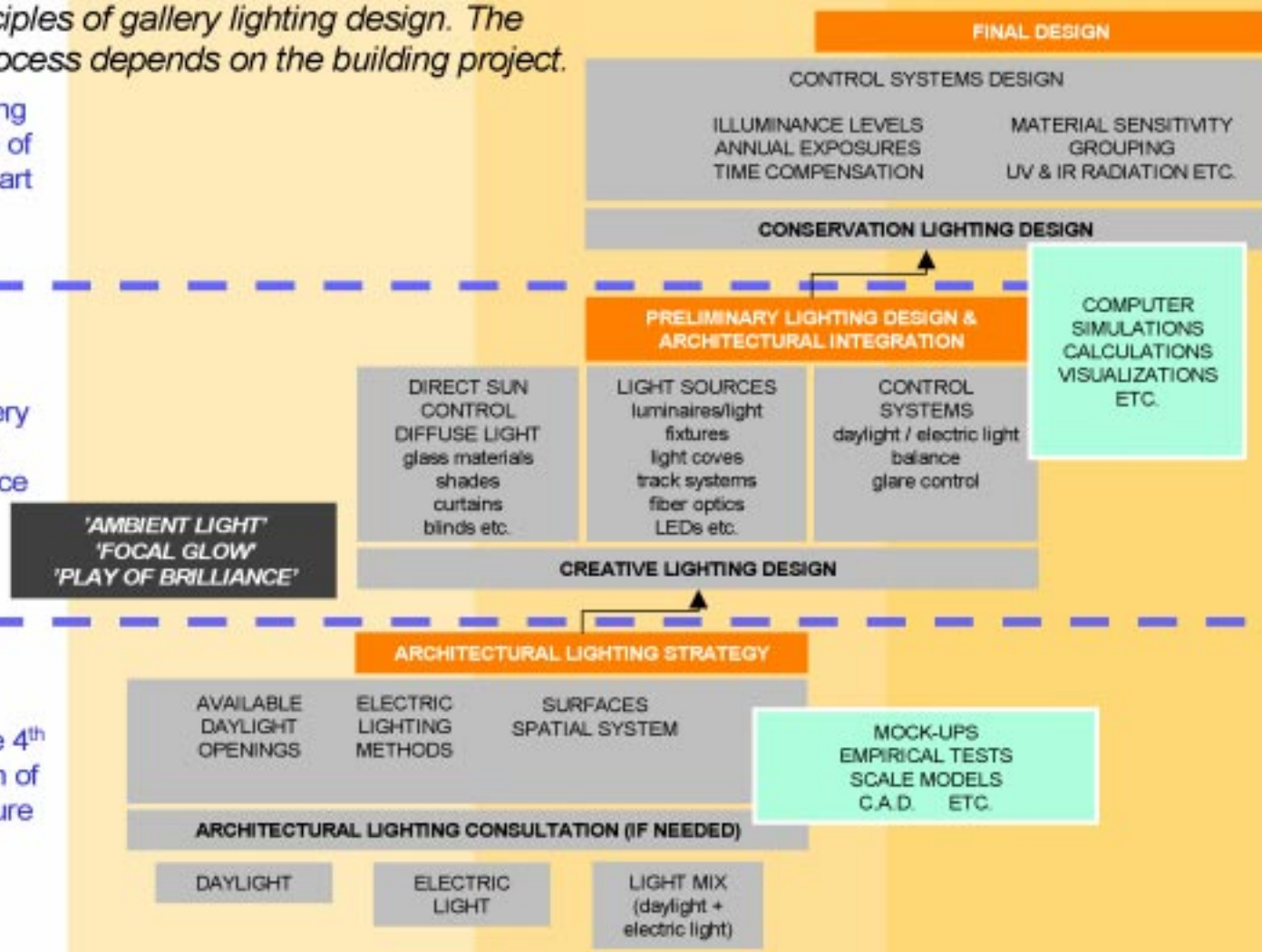


Fig. 7. A synoptic scheme of the conservation lighting design of an art gallery.

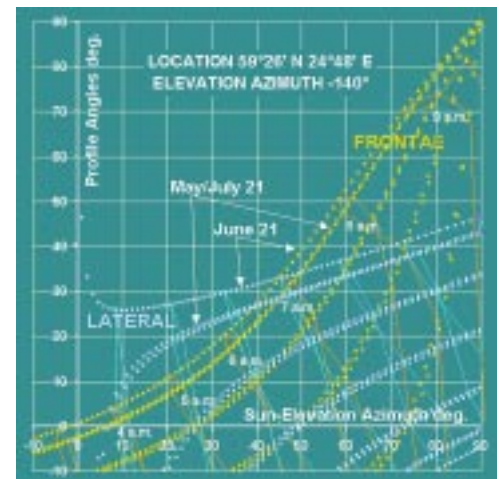
CASE: THE ART MUSEUM OF ESTONIA

The Eesti Kunstimuseum project is based on the winning proposal 'Circulos' of an international architectural competition in 1993-94. In the design by architect Pekka Vapaavuori, the building volume rests within a great circle embedded in a hillside in Kadriorg park in Tallinn. The main galleries are behind the northeastern double envelope façade. The architectural design goals are simplicity and spatial anonymity allowing room for the art.

The starting points of the lighting design of the galleries are the allowed annual exposures, visual appearance, methods of illumination, and lighting control strategy.

The double façade is a critical element for the daylighting design. Its behavior was simulated under three different sky models. These were maximum illuminance in summer (the sun at the highest position), morning light (clear sky with sun), and an overcast sky (moderate external illuminance). The results form the basis for further technical design of the wall.

Fig. 8. Monthly profile angle curves plotted for the Art Museum of Estonia, northeastern elevation. Profile angles are useful for the architect when considering the sun-shading effects of façade structures.



Light coves and spotlights provide the electric light. The light cove is often a good way of lighting the gallery walls. For the Art Museum of Estonia, the cove makes it possible to fit together electric light and daylight.

When there is enough daylight the light coves are switched off. They switch on gradually when the vertical illumination levels decrease below a set limit (usually 150 lx). Illumination levels exceeding an upper limit (200 lx) are suppressed by shades between the window glazings. The maximum allowed exposure for canvases (600 klxh/a) allows flexibility for the system.

The design of a good light cove was one of the most important tasks. In this case, ceiling and intermediate floor heights and other dimensions limited the geometry of the cove. Therefore, the 'optimal' cove type could not be applied. The properties of the cove were studied using a lighting simulation for three heights of the cove and three depths of the opening, altogether nine (3x3) cases. Three of them are presented in fig. 10. In the simulation the light source was replaced (with good accuracy) by a diffuse plate. The light cove was then applied in a daylight simulation in order to study the light mix (fig. 11). The color of the source was taken into account. The intended real light source for the cove consists of three parallel fluorescent lamps. A special luminaire was designed for this purpose (fig. 9).

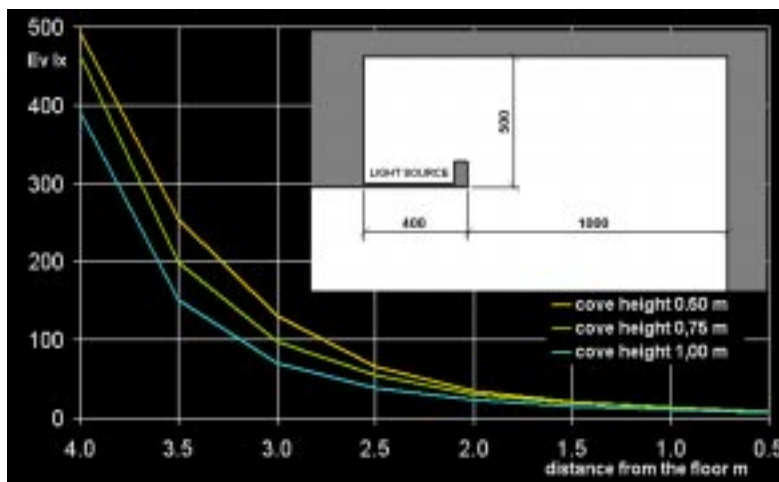
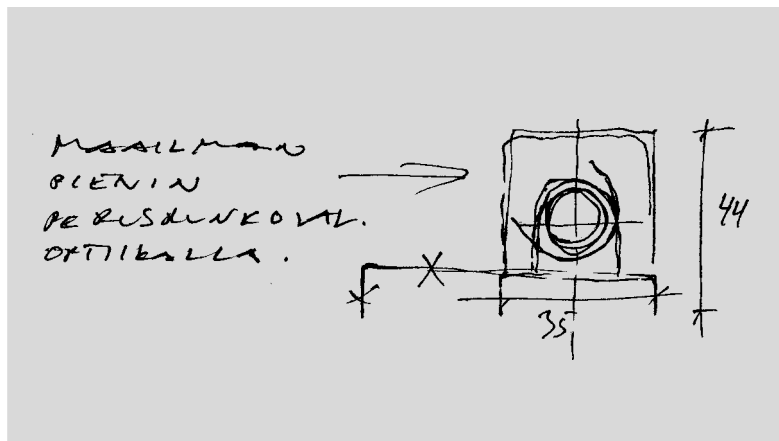
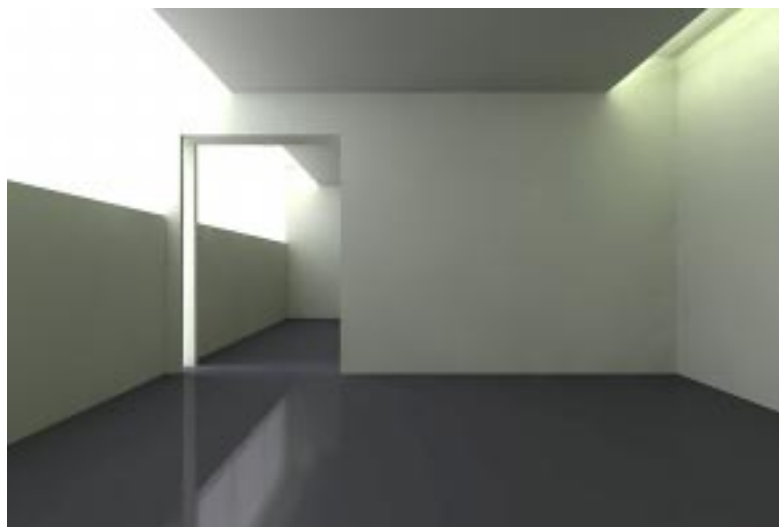


Fig. 9. A custom luminaire for the light cove. The dimensions are small and the reflector is pivoting.

Fig. 10. The simulated vertical illuminances for three light cove alternatives. In practice the eye does not perceive the attenuation of light as strongly as the curves suggest.

Fig. 11. The simulated effect of the light cove. The exterior conditions are the same as in fig. 1.



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CIE Div. 3 TC3-22

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