SCIENTIFIC DESIGN OF SKYLIGHTS

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ABSTRACT. This paper intends to present a critical reality in contemporary design, the astonishing coexistence of buildings in which daylighting has been carefully considered and simulated, and others in which this issue is treated with haphazard design gestures. Although initial simulation models in the daylighting field were very much distanced from the actual practicing architect, this is no longer the case in our opinion, and also, it is a fact, that the role of apertures in all the relevant thermal exchanges that occur in buildings has been thoroughly recognized. However, many types of designs or even bioclimatic designs do not consider lighting simulations from the beginning of the design-process, and they are presented as correct if only the thermal balance meets, even at the risk of later energy waste in lighting devices and visual or physical discomfort.

1 Introduction

In the architecture of today, there seems to be an increasing number of light admitting systems. However, the problems of direct sun over the structures can not be treated adequately from the illumination point of view, with conventional programs for overcast skies. A careful understanding of solar geometry for the particular situation is demanded, and then, tools to analyze the paramount contribution of solar gains to the day-lighted interiors. Often, in many climates, the proportion of solar illumination in the overall lighting balance is higher than 80% and still it is surprising how few scientific designers are concerned and familiar with sunlight concepts. The reasons for this strange attitude have been studied by our group in other documents that appear in the references or in the former Plea conferences.

In this occasion we would focus on the results that the designers could obtain, as we did with the help of last-generation simulators. Moreover, the simulation packages proposed by our group are capable of dealing with the questions of architectural form, often neglected in the less subtle thermal analysis that exclude radiant modeling by taking radiation as a whole in the loads input, and thus disregard formal issues, as the typical engineering approach does. Henceforth, even historical complex skylights can be tested in the computer and prove their said -but seldom tested- reputation, in order to be applied to new designs with awareness of their performance.

This is, from our point of view, a very important fact in tropical lands and climates in which not much previous ancient experience is acknowledged when dealing with daylighting in non-residential buildings, i.e. there are not many daylighting historical typologies for public buildings and many mistakes are derived from imitation of other, say European, buildings types, as is the case of Brazil, Equator, Japan and Australia. The particular features of sunny climates have been studied by our group and are presented in this paper through several examples of old and new buildings; we would include some contemporary projects in Spain and Denmark, simulations of antique buildings in Seville, Köln and Rome, and simulations for retrofitting in

Spain. With this entire outcome we would try to attain a new Science for the Architecture of the 21st century, a science that we would name History of Daylighting.

2 Simulated examples

2.1 Skylights of conoidal shape. Seville (Spain)

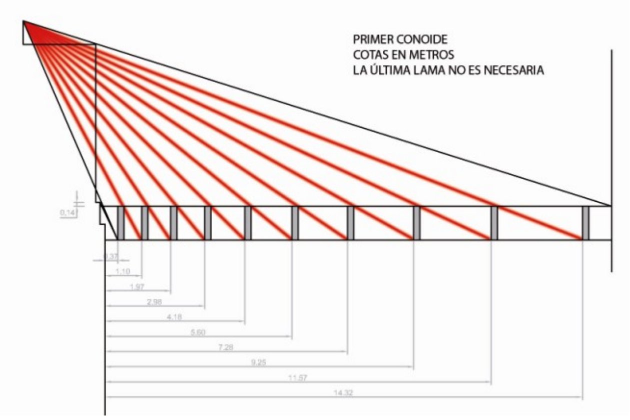


Fig 1. Distribution of blinds under the conoid, showing the uneven spacing between them. Museum of Archaeology. Seville.

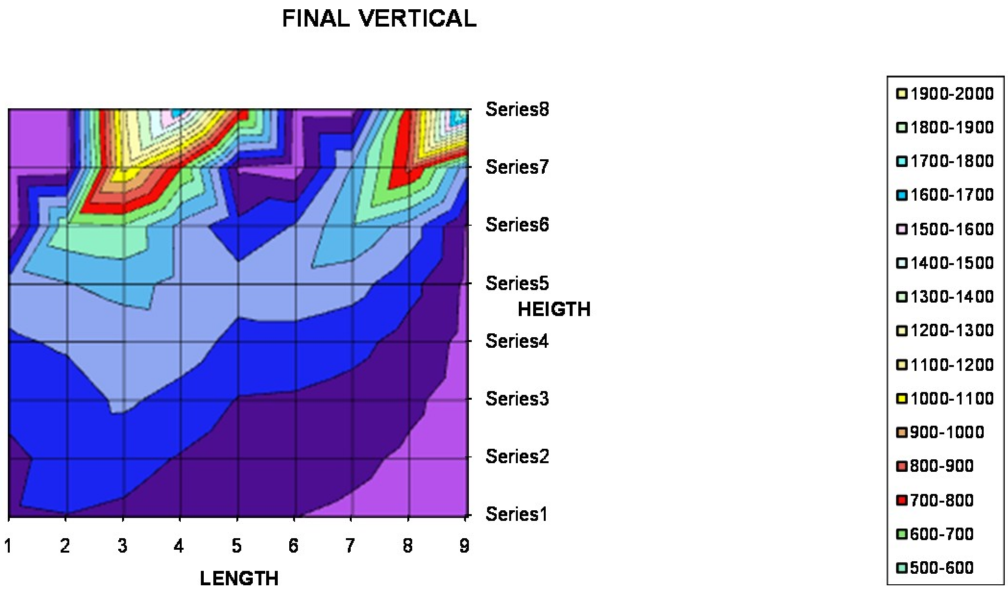


Fig 2. Sectional daylighting field with sunlight on the aforementioned blinds. Winter. Values in lux.

The conoid shape is a consequence of the transformation of an existing cylindrical or tilted vault to avoid overheating and to control excessive solar gains. The impinging sunlight is then distributed with the help of blinds, located at specific positions which depend on the solar altitude of the given site.

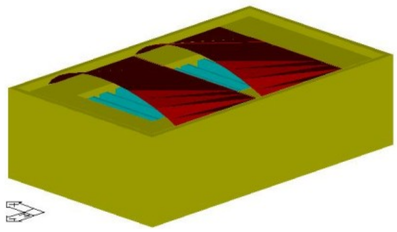
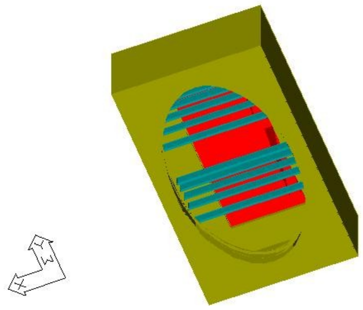


Fig.3. View of the conoidal monitors with the interior blinds



In this situation, knowledge of the defining equations is critical to asses the values used in the calculations, like the normal to the surface at any point often used in illumination magnitudes.

$$a^2 * \frac{z^2}{y^2} + x^2 = b^2$$

The normal is depicted by the following differentials:

$$N = (F_x, F_y, F_z)$$

Hence

$$N = k * (x, -a^2 * \frac{z}{y^3}^2, +a^2 \frac{z}{y^2})$$

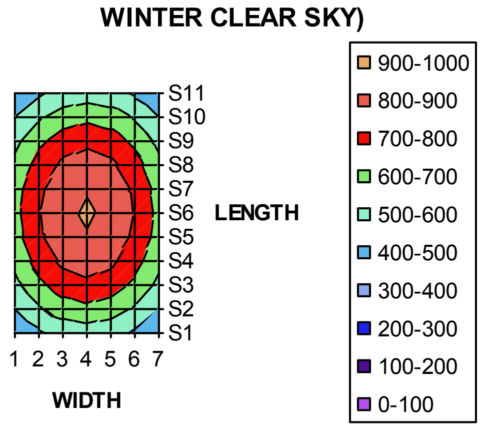


Fig. 4. Daylighting field in plan with the former glazed vault. Winter. Values in lux.

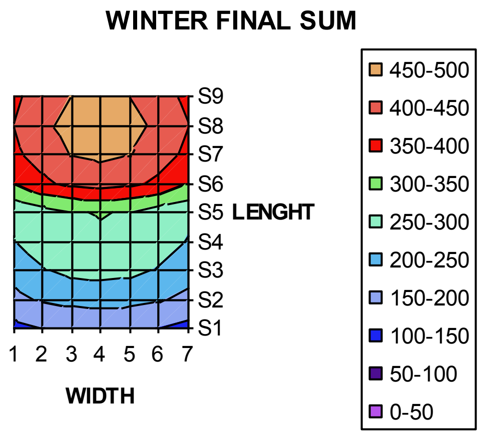


Fig.5. Daylighting field in plan with sunlight on the blinds. Winter. Values in lux.

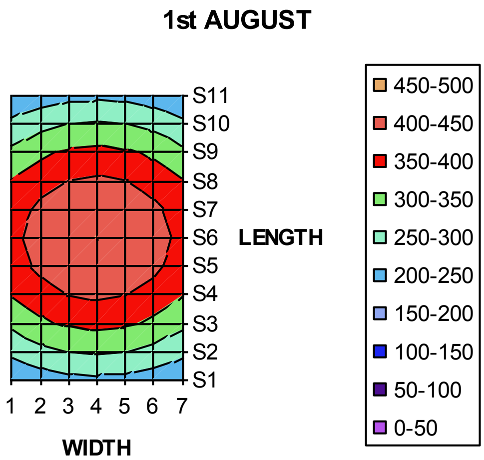


Fig.6. Daylighting field with sunlight on the blinds. Summer. Values in lux.

2.2 Centralized skylights. Copenhaguen (Denmark), Majorca (Spain).

In the school of Egebjerg, near Copenhaguen, we would retrofit the old plastic pyramids with a new clear glazing device provided with a grid of blinds, as shown in the figures.

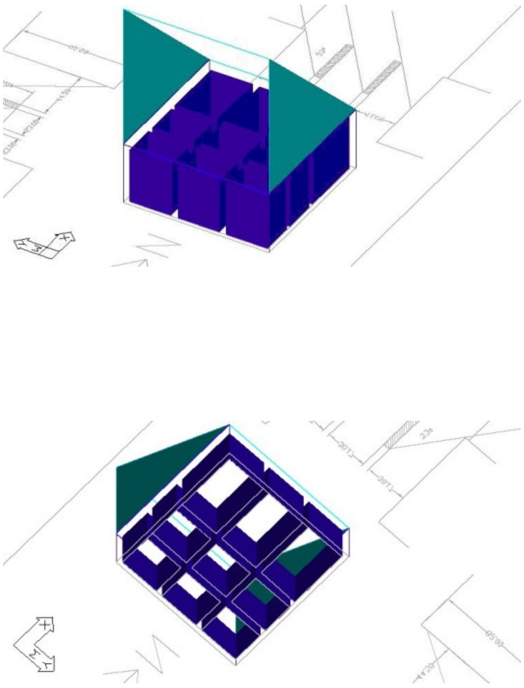
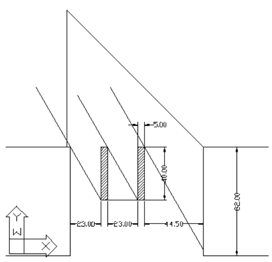


Fig.7. Several views and sections of the proposed skylight.



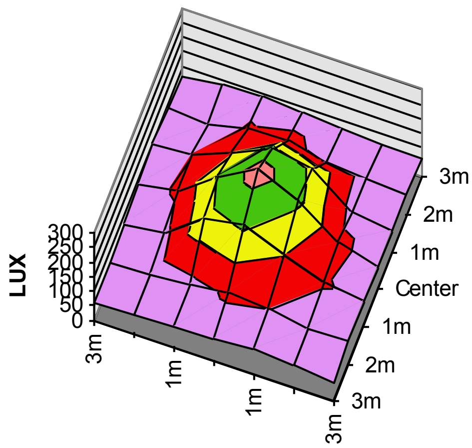
Some results of performance under overcast and sunny skies for different times of the year are presented in the graphs

June

- **Overcast**

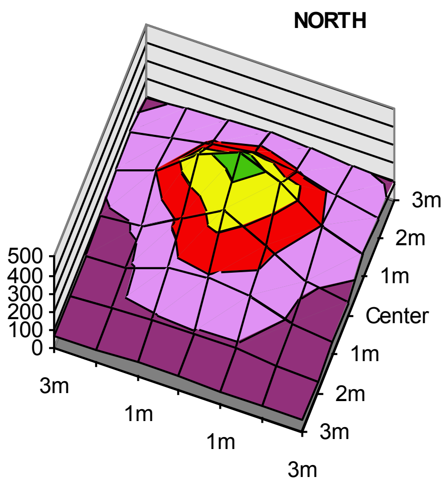
200 to 250 lux, 100 lux at 7 hours solar time, in the morning

EGEBJERG-JUNE-10:05H-13:55H-OVERCAST



- **Clear sky with sun**
- Over 300 lux

EGEBJERG - JUNE - 12H - CLEAR+SUN

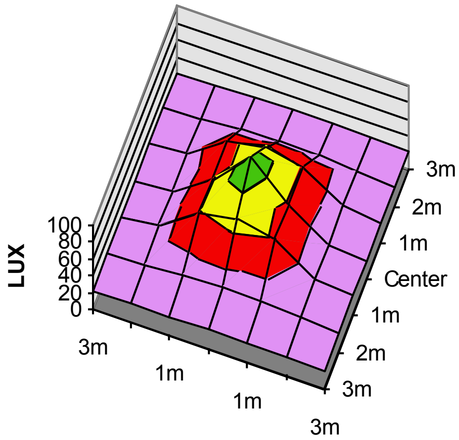


December

- **Overcast**

Less than 100 lux, seldom reaching 50 lux at 8:40 in the morning solar time

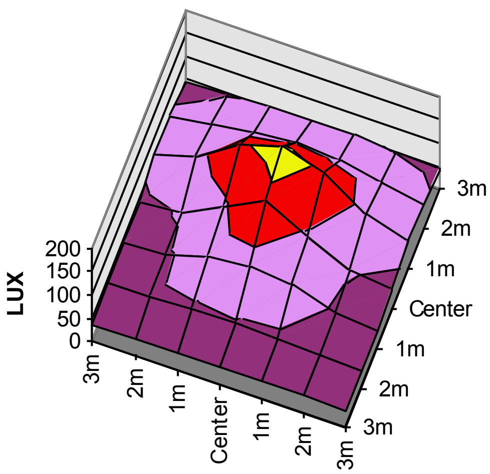
EGEBJERG - DECEMBER - 12H - OVERCAST



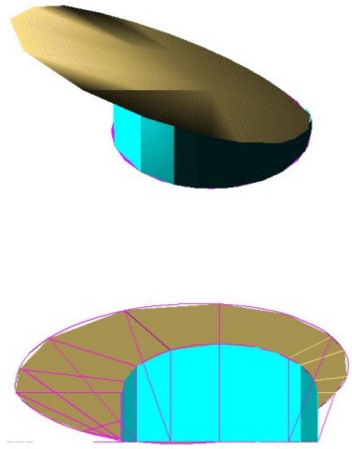
- **Clear sky with sun**

In the range of 100-150 lux, reaching this last value (150 lux) at 12:00 hours solar time.

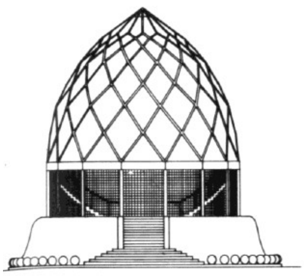
EGEBJERG-DECEMBER-12H CLEAR+SUN



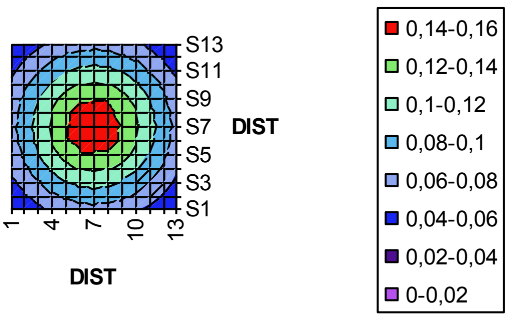
The same strategy of solar and thermal control produces a very different appearance in the much warmer climate of Majorca



2.3 Historical skylights. Bruno Taut's Glashaus (Köln), Pantheon. Saint Ivo (Rome), Saint Louis (Spain).



GLASHAUS1



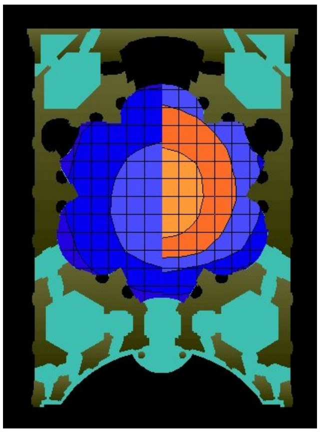
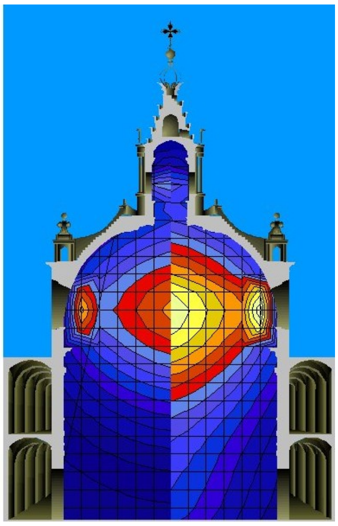


Fig. 8. Several views of the simulated interior in the church of Sant'Ivo alla Sapienza. Rome.



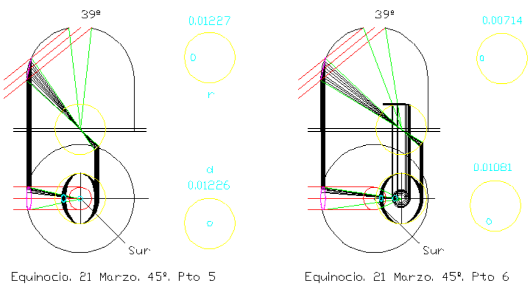


Fig.9. Calculations to obtain daylighting distribution in the Pantheon. Rome.

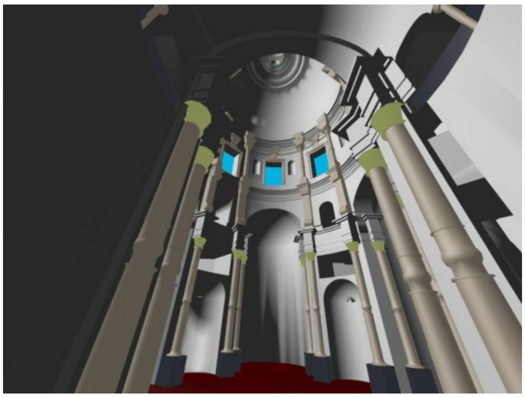


Fig.10. Virtual reality depiction of the church of Saint Louis in Seville. Spain.

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