THE MEDITERRANEAN BLIND: LESS LIGHT, BETTER VISION

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ABSTRACT

The Mediterranean blind is one of the most efficient and sophisticated technical system to allow natural illumination in building. A simple solution permits good visual conditions with low heat gains and high ventilation. This solution shows how in architecture, simple designs following thoroughly understood principles can achieve far more suitable environment results than high-tech solution applied without criteria. © 1998 Published by Elsevier Science Ltd. All rights reserved.

Throughout the Mediterranean countries, with their mild temperatures, torrential rains, gentle winds in winter and stifling humidity in summer, where streets and squares almost become part of family life, we are constantly aware of the sun. In this sun and its vibrant light, buildings are transformed into an ever changing interplay of light and shade in which colour is a secondary issue and volume gains greater importance. In the winter people walk on the sunny side of the street, while in houses windows are kept shut but curtains, awnings and blinds are kept open to let the sun in. In the summer people seek shade in the streets and squares, and blinds stop the sun's intense rays from entering the windows.

In the warmer places, with short winters and long summers -- islands warmed by sea breezes, for example -- the architecture is white, shimmering in the sun with the reflected glare of the whole spectrum of visible light. Surprisingly, however, windows are protected by dark green (sometimes brown) blinds which stand out in contrast to the light-coloured walls of the building.
Could this be nostalgia for colours lost under the blinding sun? An aesthetic whim in architectural styles so often lacking in economic resources? Or perhaps an extension of the fisherfolk’s use of colour into the realm of architecture? Whatever the reason, the phenomenon is puzzling, since the dark colour of the blind will absorb radiation and transmit more heat into the air, and the lack of light would appear to render the interior useless.

One lazy summer afternoon in an old house on a Mediterranean island, we were sat reading the sort of interminable books that never fail to fill out the holidays. A friend came in from the street and asked "where are you?", still dazzled by the light outside, thus sparking off a series of questions about light and the miracle of the dark room where no one had the slightest trouble reading.

We are theoretically aware of how adaptable the human eye is to changing conditions in its environment, and how glare can impair vision in places where there is more than enough light, but in order to fathom these phenomena which are so commonplace that we accept them without understanding them, we must consciously observe our experiences with lit space.

Experience with light in architecture is consistent, and the same principles can be applied to any architectural space. In offices, schools, museums, libraries and rooms in private houses, light always works in the same way. The level of light is important, but the distribution of light areas (technically called luminances) in the field of vision is even more so, and in the final analysis it is this that determines the quality of the light conditions.
In order to understand the case of the Mediterranean blind, and with it many other lighting phenomena in architecture, it is important to bear in mind how light functions, in terms of some of its basic physical, physiological and even psychological principles.

Physically, natural light is a type of electromagnetic radiation, with energy at all wavelengths of the visible spectrum. It sheds a cold white colour, or a warm one in the case of very large quantities of light (high illuminances). Illuminance is defined as the quotient of the luminous flux over the elementary area illuminated by the source. Its unit is the lux (lumen/m²).

\[ E = \frac{I_a}{d^2} \cos \alpha \]

Fig. 4. Illuminance concept

With a clear sky, in a summer situation, a horizontal plane exposed to the sun receives around 100,000 lux (lumens per m²), whereas with an overcast sky (in winter time) the figure drops to some 10,000 lux.

The solar radiation that reaches buildings falls into three different categories. Direct radiation comes directly from the sun in a clear sky. Diffuse radiation comes from the entirety of the sky dome. Finally, the indirect radiation is reflected off the ground and neighbouring buildings. In the first case the light reaches the building in parallel beams and casts sharp shadows, whereas with diffuse radiation light comes downwards from all directions, and in the third case the light from the sun and the sky dome is reflected off surfaces in a diffuse fashion, upwards for the most part and with lower intensity (always depending on the reflectance of the surfaces concerned).

Fig. 5. Incidences of sunlight
In the case of the Mediterranean blind, the first two types of light are unable to penetrate the interior protected by the blind. However, the third type does -- and furthermore, at the angle dictated by the slats of the blind, which direct it towards the inevitably white ceiling of the room. As a result, the interior appears as a dark space with a patch of light on the ceiling, near the window. To analyse this matter further we must now turn to how sight works in humans.

**Physiologically**, the eye gathers light from surfaces within its field of vision, which passes through the pupil, crosses the eyeball and forms images on the retina, a lining of sensitive cells at the back of the eye. Owing to the design of the system, approximately half of our surroundings can be perceived in this way, with, moreover, varying precision, depending on where on the retina the image is focused. Generally speaking, there is a small central zone where images are very sharp, and from there to the edge of the retina they become progressively ill-defined.

![Fig. 6. Field of vision](image1)

The eye always tends to adapt to the amount of light present in its field of vision, using several mechanisms. The pupil opens and closes continually in an attempt to stabilise the amount of light entering the eye, and the cells of the retina react, by means of a much slower process, to the average level of light of the field of vision. These mechanisms adapt to the average values of the luminances we perceive, we are powerless to solve cases of highly contrasting luminances (light and dark) next to each other. Such cases result in glare, vision being lost in both the lighter and the darker areas. This phenomenon does not occur regularly throughout the field of vision, central areas being far more critical than the edges, and the upper section of the field of vision is particularly protected from glare.

Returning to the case of the Mediterranean blind, the result of the physical process analysed above is a relatively dark visual environment with a patch of light (high luminance) on the ceiling, the most important parts of the field of vision having lower luminances.

![Fig. 7. Drawing of the field of vision, superimposing image of interior as seen by eye (stereographic projection)](image2)
There is, then, no surface producing glare; the dark colour of the blind reduces the luminance of the window, and the highest levels of light we see are on the table, the book we are reading or the work we are doing, which are illuminated by the patch of light on the ceiling. If we were to change the conditions and open the blinds, we would have much more light in the space, but our vision of the exterior given the extremely high luminances outside, would produce a far worse result. Furthermore, in this way a great deal more heat would enter.

If we evaluate the phenomenon described above using the concepts and units of lighting technology, we find that with exterior illuminances of the order of 10,000 lux and the blinds shut, typically we get interior illuminances on a horizontal plane of the order of a hundred lux, and more importantly, relations of a maximum of 3:1 among the work surface, the surrounding walls and the inside of the blind.

For the evaluation, we consider the geometric configuration of the blind as made by louvers: 5 cm long separated by a gap h and set at 45°. The outer surface receives light from the sun, the ground and other elements such as the walls of buildings, which are highly reflective (r = 0.7, for example).

As in the Mediterranean climate there is a summer exterior illuminance in the order of: Ee = 100,000 lux, the exterior apparent luminance will therefore be: Le = Ee*r/π = 22,300 cd/m².

Taking the geometric configuration and the luminance Le, the amount of light that reaches the inside of the blind can be calculated by evaluating the amount of light (flux) entering through a slit between the louvers where the exterior of the blind has a luminance Le (on the vertical surface). The flux reaching the interior is the illuminance on the inner surface multiplied by its surface area. Therefore, the total flux for a given blind can be known if we know the flux resulting from the gap between louvers per unit of surface area, multiplied by the effective (unobstructed) surface of the blind.
The illuminance produced by a given louver can be calculated by studying the case of a vertical strip of the inner opening in a normal (average) situation in which the gap (i.e., the width between louvers) is much narrower than the length.

The flux $\Phi$ per unit of surface area on a strip is calculated using the following expression:

$$\Phi = \sum \frac{L e \cos^2 \theta}{d^2} dS$$  \hspace{1cm} (1)

The summation or integral is performed numerically using the emitters into which the source is divided, subsequently adding in order to find the flux, by ascertaining the illuminance $E_i$ of the various elements of the receiver.

The result of the integral is shown in the following table. Specifications of the blind: angle $45^\circ$; length of the louver $d = 5$ cm; vertical gap between the louvers: $h$; luminance of the exterior: $L_e$

<table>
<thead>
<tr>
<th>h/d</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flux $\Phi/m^2$</td>
<td>0.075 $L_e$</td>
<td>0.153 $L_e$</td>
<td>0.279 $L_e$</td>
<td>0.417 $L_e$</td>
<td>0.560 $L_e$</td>
<td>0.708 $L_e$</td>
<td>0.860 $L_e$</td>
</tr>
</tbody>
</table>

As an example, consider a window measuring $3 \text{ m}^2$ with blinds with louvers $5 \text{ cm}$ long set at $45^\circ$, 50% of the surface area being open (vertical free space between louvers). If the gap between the louvers is $1 \text{ cm}$, this yields: $h/d = 0.2$, and consequently the flux that enters is $\Phi = 0.153 \text{ Le } 3 \text{ m}^2 0.5 = 5100 \text{ lumen}$.

Owing to the angle of the louvers, this flux is directed towards the ceiling, where it produces a luminance $L_s$ which can be calculated on the basis of the reflection of the ceiling $r_s$ (in the neighbourhoods of 0.8):

$$L_s = \frac{5100 \text{ lumen}}{r_s}$$  \hspace{1cm} (2)

In turn, this patch of light casts an illuminance on the work surface, which is located about $3 \text{ m}$ from and normal to the patch, of the following approximate value:

$$E = \frac{L_s S_s \cos^2 \alpha}{d^2} = 144 \text{ lux}$$  \hspace{1cm} (3)

Which is a value large enough to develop relatively delicate tasks as reading, thanks to the eye accommodation.

CONCLUSION

When we have stopped to admire the effectiveness of what is considered to be such a conventional solution, all that remains is to analyse how this concept can be applied to other cases of natural lighting in architecture.

The first point to make is that when designing the lighting of a space the distribution of luminances in the field of vision must be given higher priority than the quantitative entry of light. Other points to consider are the need to control the direction from which the light enters, the importance of the vision of the exterior, how any glare occurring in that vision can be reduced (outdoor vegetation, darker glass at the bottom of the window, etc.), and above all, the relationship between light and central or peripheral vision, using distributional solutions and planned interior finishes.

To conclude our analysis of this seemingly simple but actually very complex and subtle phenomenon, we can say that energy-conscious architecture does not require huge, sophisticated technical systems to improve its performance. Simple designs following thoroughly understood principles can achieve far more suitable environmental results than high-tech solutions applied without criteria.