The effect of interior design on daylighting

By Scott Schuetter, Energy Center of Wisconsin

Daylighting experts often talk about the importance of an integrated, multidisciplinary approach to design: the architect, lighting designer, electrical engineer, interior designer and commissioning agent must all work together to see the design through to successful implementation. Additionally, the building’s facilities and maintenance staff should be on board, as their training will ensure energy savings throughout the system’s lifetime.

One discipline that is often underemphasized, however, is interior design. When building designs do not take interior design considerations into account early on, the effects of daylighting may be thwarted. The reason is that the interior designer makes decisions about the placement, height, and color of furniture as well as the color of the walls, ceilings, and floors. These decisions can have a large influence on the availability of natural light in a space and how much energy savings a daylighting system actually achieves.

Consider Figure 1, which gives examples of cubicles with low and high partition heights.

![Figure 1. Examples of cubicles with (a) low and (b) high partition heights.](image)

These pictures show just how much of a shading effect partitions can have on natural light from windows. Note how much darker the cubicle with high partitions is with respect to its surroundings than the cubicle with lower, transparent partitions. Also note that low partitions not only allow deeper penetration of natural light, but greater access to views of the outdoors for occupants.
To demonstrate the magnitude of this effect, an AGi32 daylight analysis model was built of a south facing open office in Madison, Wis. Figure 2 illustrates the rendered model, both without and with cubicles.

![AGi32 model both (a) without and (b) with cubicles.](image)

The open office has a large, south-facing window with a 10’ window head height and 3’ deep exterior overhang. The visible transmittance of the glass is 60%. The cubicles are clustered in 2 sets of 4 cubes each, and offset from the window by an aisle. The set of cubicles on the left has 3.5’ partition heights and a taller partition dividing the cubes east to west, such as in Figure 1(a). The set of cubicles on the east has 5.5’ partition heights, such as in Figure 1(b).

Figure 3 gives more specifics about the model’s dimensions.

![AGi32 model dimensions.](image)

Default reflectance values of 20% for the floor reflectance ($\rho_{fl}$), 50% for the wall ($\rho_{wa}$) and partition reflectance ($\rho_{pa}$), and 80% for the ceiling reflectance ($\rho_{ce}$) were used for the baseline model. From an architectural perspective, the design is ideal for letting plenty of diffuse natural light into the space. This is evidenced by the contour plot in Figure 4, which shows illuminance values throughout an office without cubicles at noon on June 21st under sunny sky conditions.
Figure 4: Illuminance distribution (a) across entire space and (b) plotted on a single line in an open office without cubicles.

Figure 4(a) shows a contour plot of illuminance values in footcandles (fc) across the entire space. Figure 4(b) plots the illuminance levels along the blue line in Figure 4(a) which is at a height of 2.5’. Note the even distribution of light levels, with a target illuminance level of 50 fc being achieved throughout the entire space. If we all worked in offices without furniture, utilizing natural light would be much easier. However, when furniture is added, it has a dramatic effect on the light level distribution. Figure 5 shows illuminance values throughout an office with cubicles at noon on June 21st under sunny sky conditions.

Figure 5: Illuminance distribution (a) across entire space and (b) plotted on a single line in an open office with cubicles.

Figure 5(a) shows a contour plot of illuminance values in footcandles (fc) across the entire space. Figure 5(b) plots the illuminance levels along the green and red lines in Figure 5(a) which are at a height of 2.5’. When cubicles are added to the space, the lighting levels are reduced significantly. The set of cubicles farthest from the windows with the high partitions are now having difficulty meeting the target light level of 50 fc, even under this very favorable sky condition. If the day were cloudy instead of sunny, the situation would be even worse. This means that for large portions of the year, several occupants in this space would need electric light to supplement the low natural light levels.
The choice of surface finishes has a similar effect on the amount of light available in a space. To show this, the surface finishes were all adjusted to lower reflectance levels. Table 1 summarizes the original and low reflectance values.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Baseline</th>
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<tbody>
<tr>
<td>Floor Reflectance</td>
<td>ρ_f</td>
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<td>10%</td>
</tr>
<tr>
<td>Wall Reflectance</td>
<td>ρ_wa</td>
<td>50%</td>
<td>40%</td>
</tr>
<tr>
<td>Ceiling Reflectance</td>
<td>ρ_ce</td>
<td>80%</td>
<td>70%</td>
</tr>
<tr>
<td>Partition Reflectance</td>
<td>ρ_pa</td>
<td>50%</td>
<td>40%</td>
</tr>
</tbody>
</table>

Figure 6 shows the effect that the darker interior colors have on the light levels in the cubicles with the tall partitions.

In this case, the illuminance levels are reduced even further, effectively negating the daylight design even under the best sky conditions. Because the interior design can have such a strong impact on light levels, it is important to bring the interior designer into the design conversation early.

Ideally, low partitions and light interior colors would be implemented. However, high partition heights are often utilized for privacy, cost, or acoustic concerns. Further, a client may favor a dark color or a material may be chosen for its durability. If the interior designer knows the impact that these decisions have on a daylighting system, then the tradeoffs can be considered and balanced accordingly.

For more in-depth analysis of these topics, please check out Advanced Buildings’ Daylighting Pattern Guide (Pattern 4).

http://patternguide.advancedbuildings.net/patterns?characteristic=All

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