COMPUTER-BASED DAYLIGHTING DESIGN - BALANCING QUALITATIVE AND QUANTITATIVE CONSIDERATIONS

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INTRODUCTION

Research has revealed that the total life cycle costs of professional service-related businesses are dominated by employee-related costs with payroll accounting for more than 90% of the total business costs (Hattis and Ware 1971). Consequently, the satisfaction and productivity of the highly paid professionals who comprise much of the commercial buildings sector is receiving increased attention by those who commission new buildings. Daylighting is a design strategy that can both enhance the quality of the work place and reduce energy-related operating costs and peak electrical demand. Effective daylighting design therefore requires balancing qualitative and quantitative considerations. Recent advances in computer simulation capabilities have made sophisticated daylighting analysis of both qualitative and quantitative design considerations affordable.

This work summarizes a computer-based daylighting design analysis conducted during schematic design for a proposed combined-use building to be located on the campus of California State Polytechnic University, Pomona.

QUALITATIVE DESIGN CRITERIA

The quality of a daylit work place is significantly influenced by the:

- distribution of daylight and
- glare potential.

In work places, uniformity of light, including daylight is generally desirable. If not properly managed, daylight levels can vary widely. Likewise, discomfort glare due to daylight can become a significant problem, especially in highly automated work settings. Both of these design criteria are largely controlled by the building envelope design (fenestration and shading).

QUANTITATIVE DESIGN CRITERIA

The objective of this design analysis was to balance the qualitative design criteria above with more quantitative criteria including:

- daylighting-related cost savings
- energy (kWh) savings
- peak demand (kW) reduction

each of which are largely governed by both building envelope design and automatic lighting control type.

COMPUTER ANALYSIS TOOLS

The daylighting analysis was conducted using two state-of-the-art computer analysis programs: DOE2.1D and Superlite 1.0 (Birdsall, et al. 1990; Windows and Daylighting Group 1985). Both of these computer programs were developed under the direction of the U.S. Department of Energy and have been widely reviewed and validated in the public domain.

DOE2 was specifically developed for evaluating building energy performance including an hour-by-hour evaluation of the energy interactions between daylighting and HVAC design. DOE2 also includes an algorithm to evaluate discomfort glare based on the Cornell/Hopkinson Glare Index (Hopkinson 1966).

Superlite was developed to provide more detailed daylighting analysis of complex spaces and fenestration designs and can provide a more reliable means to evaluate the spatial distribution of interior daylight illuminance.

ANALYSIS RESULTS

Daylight Distribution

Figure 1 illustrates the Superlite predicted distribution of interior daylight illuminance in two typical spaces under average sky conditions. The average illuminance in both spaces is approximately 50 foot candles; however, note the improved uniformity of daylight achieved in case 2 (Figure 1b).

Glare Potential

Figure 2a summarizes the glare potential of two alternate designs. Case 1 uses a high performance glazing (visible transmittance > shading coefficient) while Case 2 uses a high performance glazing in conjunction with mini blinds to reduce glare potential (visible transmittance = 50%). Both design cases in Figure 2a assume typical office illuminance levels (50 foot candles). In Figure 2b, the same design cases are summarized assuming a low illumination level (10 foot candles) more representative of computer operations areas. Under low interior illumination requirement, glare potential is shown to be much more significant.

Daylighting-Related Savings

Figures 3a through 3d summarize savings or reduction in utility costs, electric energy use, peak electric demand and peak cooling load by automatic lighting control type. The on/off-type controllers out perform the dimming controllers due to dimmer "stand-by" losses during daylight saturated hours.

CONCLUSIONS

Based on the analysis summarized here, it was possible to recommend envelope and lighting control strategies which:

- provided near-uniform interior daylight illuminance
- minimized glare potential, and
- provided substantial energy, cost and peak demand benefits.

Using currently available computer-based analysis methods, both qualitative and quantitative daylighting design considerations can be readily evaluated.

REFERENCES

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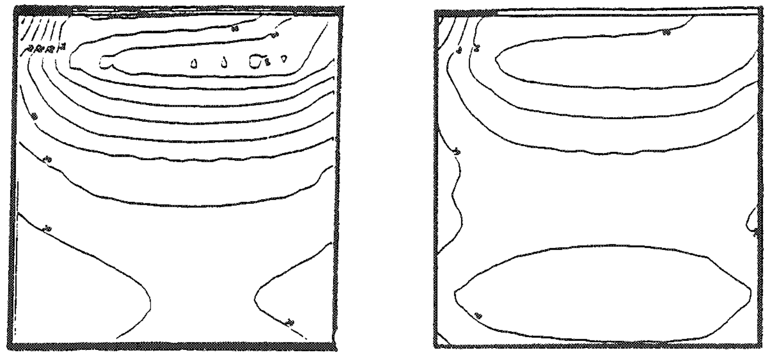

a: Case 1
Ave Illum = 50 fc
Min/Max Illum = 10/100 fc

b: Case 2
Ave Illum = 50 fc
Min/Max Illum = 30/65 fc

Figure 1. Daylight Distribution in a 35' x 35' Space - DOE2 Average Sky Condition

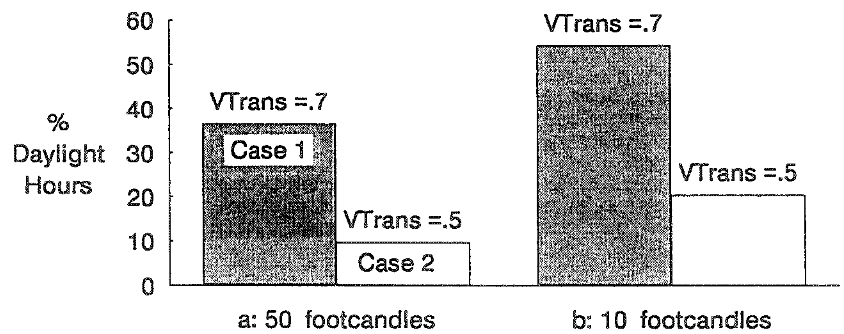

Figure 2. Percent of Daylight Hours Greater than Maximum Recommended Glare

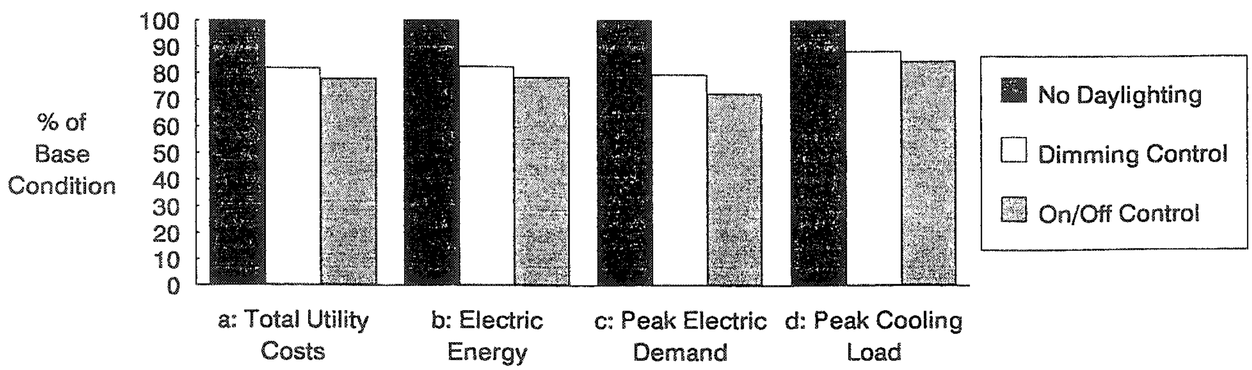

Figure 3. Daylighting-Related Savings