Daylight Design for Multistory Offices: Advanced Window Wall Design in Practice

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ABSTRACT

Daylighting continues to be a primary design strategy to reduce energy use, electrical loads and peak electrical demand in new commercial buildings. Daylighting can also account for important LEED™ points toward certification. Daylighting office buildings greater than four or five stories, however, continues to be a difficult design problem. This paper presents state of the art daylighting design of six recent large, multistory office buildings. The fundamental challenges remain constant across the projects: how to admit useful levels of daylight as deeply as possible and deliver a high quality visual environment with no excessive contrast or uncontrolled sun penetration, within budget and acceptable to the aesthetic criteria of architect and client. The daylighting design solution for each building is discussed in terms of building massing, the window wall design and integration with structural and mechanical designs.

Introduction

Office buildings are typically occupied during daylighted hours. In the United States, we occupy more than 10 billion square feet of office space that consumes nearly 200 billion kWh of electricity (EIA 1999). The portion of that electrical use expended on lighting has been estimated at 40% to 60% with recorded data for northern California at 41% (PG&E 1997). The opportunity for savings by designing for daylight is huge. In addition, peak electrical demand for most office buildings coincides with utility summer afternoon electrical demand peaks, stressing both the electrical supply and generating capacity. Work is still in progress on issues of productivity gains due to daylighting. To the extent that these can be confirmed and quantified, they are likely to be attractive to building owners and occupants.

Daylighting can also contribute toward LEED™ (Leadership in Energy & Environmental Design) certification. The section "Daylight and Views" requires significant floor area to be daylighted and even more floor area to have access to views outside. This section accounts for 2 points in the LEED™ 2.0 Rating System and can contribute toward the 2-10 points available for Optimized Energy Performance. LEED™ certification is of growing interest in both private and public sectors. The US Green Building Council, which develops and administers LEED™ Certification, has over 1,000 members, including building and design professionals, building owners and financial industry leaders. (http://www.usgbc.com)

We find that the LEED™ Rating System creates value for sustainable design approaches, including daylight, within standard practice. Sustainable design features can be quantified, much as costs are quantified in Value Engineering sessions. LEED™ certification may prove more important to building owners than the economics of energy conservation.
Challenges to Daylighting the Multistory Office Building

For many building types, such as single story retail or low-rise offices, daylighting is easy because the building skin is located close to most occupants. Daylighting office buildings greater than two or three stories, however, is a difficult design challenge. The economics and resulting standard practice of office development in the United States tend to run counter to the architectural and technical requirements of daylighting. First cost and leasing practices favor large, deep floorplates rather than thin building sections. Land costs and envelope costs mean that few projects can increase the building skin enough to position every office worker within the easily daylighted perimeter zone of 15-20 feet.

Sidighting, which is the only option in a tall office building, is inherently problematic. (Hopkinson 1966) Bringing daylight in through the window wall creates an over-lighted zone near the window and a sharp gradient from light to dark as one moves deeper into the space. In trying to distribute the daylight more evenly through the office, high glazing is essential, as is control of the brightness in the perimeter areas. Keeping the head height of the window high, even with a generous floor to floor dimension, requires extensive coordination with structural engineers and mechanical engineers on the project. Often the top of the window is lowered more than the clear ceiling height due to a spandrel beam or a hung ceiling plenum. In order to assist the daylighting performance the structural and mechanical designs will likely need to be more adventurous than standard practice, for example incorporating an upturned beam design or underfloor air delivery.

Additionally, the control of sun penetration and glare is a serious issue for daylighting performance. Without means to control direct beam radiation, occupants face glare on their computer monitors and in their workspace. Standard practice is to specify a low shading coefficient and low visible transmission glass (tinted or reflective) and mini-blinds in each office area. Under diffuse skies, the blinds are open and the glass controls heat gain and glare, even if there is insufficient daylight admitted. When the sun enters, the blinds are closed. The electrical lighting is turned on, even during bright daylight hours. With advanced glazings, such as spectrally selective glass with high visible transmission and low shading coefficients, the glass will control heat gain and continue to admit daylight. Those close to the window can lower blinds as they desire, adjusting them to admit enough daylight to work while excluding direct sun. However, when the curtain wall includes a high clerestory window, sun penetration can reach much deeper into the open office space. Daylighting requires a design of the curtain wall that can both intercept direct beam radiation and continue to deliver diffuse daylight deep into the office floor.

Amory Lovins has recently identified an integrated building design with emphasis on daylighting performance as the "perfect building" for the future viability of commercial buildings. (Monroe 2002) Our experience as daylighting and energy consultants emphasizes the complexity of achieving this goal in practice. In the following sections, we present the daylighting design of six recent large, multistory office buildings. The fundamental challenges remain constant across the projects: how to admit useful levels of daylight as deeply as possible while delivering a high quality visual environment with no excessive contrast or uncontrolled sun penetration, within budget and acceptable to the architect and the client. The strategies and solutions for these buildings begin to converge on a version of "the perfect building" but each differs in the degree of its success and limitations.
**Table 1. Comparative Daylighting Characteristics**

<table>
<thead>
<tr>
<th></th>
<th>NIKE European Headquarters</th>
<th>The Johnson Building</th>
<th>Corporate Campus</th>
<th>Speculative Office/Retail Complex</th>
<th>Cal Trans District 7 Headquarters</th>
<th>State Compensation Insurance Fund</th>
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</thead>
<tbody>
<tr>
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<td>9'-6&quot;</td>
<td>10'-10&quot;</td>
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**Design and Simulation Methodologies**

We work with the architect and the design team at the earliest stages of schematic design and continue in design development with increasingly detailed models. Component specifications and protocols are addressed in construction documents. We use both Radiance and DOE 2.1e to test design possibilities through multiple parametric simulations, with the objectives of maximizing occupant comfort and green performance. The modeling is often speculative, in that we attempt to find an approach to the integration of daylight, structure, mechanical systems, space planning and exterior building image that resolves many problems simultaneously and identifies positive economic tradeoffs.

Radiance simulations begin with runs that look at the basic geometry of the office bay, along with a number of alternatives for glazing, light redirection and shading. We use real site information for exterior conditions, talk with the design team to establish interior reflectances and workspace layouts. Initially we model the solstices and equinoxes for morning, noon and afternoon hours under both CIE clear and CIE overcast skies. We build a physical model and test it in a calibrated mirror box sky for overcast conditions to calibrate the Radiance model. We typically generate illumination levels represented by isolux contours in plan, perspectival renderings of the office and false color images with luminance mapping. As the design direction and dimensions develop, further simulations address specific questions such as sizing and material specification. The diffusing roller shades are modeled with a material specification of similar transmission and diffusing characteristics, however we use these simulations primarily to address the issue of daylight penetration through the open upper glazing, not perimeter zone illumination levels.
Nike European Headquarters, Hilversum, the Netherlands
Architect: William McDonough + Partners

Completed in 1999, this 375,000 square foot complex houses nearly 1,000 employees in four office buildings. (Figure 1a) A fifth building includes reception, gymnasium facilities and restaurants with parking underneath the central lawn area. Utilizing a variety of sustainable features, such as ground source heat pumps, storm water collected for flushing toilets and irrigation, and natural ventilation, the building is projected to be the most energy efficient office of its size in the Netherlands.

The four-story office buildings that define the central lawn area are L-shaped with office legs oriented both north-south and east-west. (Figures 1c and 1d) The building section is kept thin: 60 feet in the sections oriented east and west and 41 feet for the offices facing north and south, informed by the Dutch practice of having office workers no farther than 18 feet from an operable window and the ARBO (Safety Guidelines) that control the ratio of daylight apertures to floor area. (Figure 1b) The program required that daylight apertures equal or exceed 5% of the work floor area with the width of openings to provide outdoor views equal to 10% of the dimensions of the work floor. The thin section also responded to the long-term sustainable program for the building that prepares the office space for conversion to residential use.

The floor to floor dimension is 12'-0” with ceiling height and window head height fairly low due to a ceiling plenum for lighting and air handling (see Table 1). On the fourth floor, the curtainwall has a greater percentage glazing than on lower floors, with a deep overhang on all sides that caps the building. Additionally, the north roof is lifted to receive a PV array in the future. This lift creates a double height studio facing north with a tall window head height. (Figure 1e) Taking further advantage of daylight on the top floor, clerestory monitors with east and west glazing are popped up through the roof over the central office areas. On the ground floor, the offices view green lawn, athletic courts and buildings opposite, with less view of the sky than the floors above. Access to daylight is further reduced by a covered path facing the central lawn. Radiance simulations determined that the covering should be as transparent as possible and the ground surface light in color to maximize daylight delivered to the ground floor offices. (Figures 1f and 1g)

Daylighting is well coordinated with electric lighting through the use of individually sensored and controlled fluorescent fixtures. With each fixture dimmed individually, the system makes the most of any daylight reaching the workstations. Coordination with the mechanical and interior design points up an area in which full design integration is typically more difficult to achieve. Except in the double height studio, the mechanical services are supplied through a hung ceiling plenum, effectively lowering the window head height and decreasing the penetration of daylight. The interior design of some areas has resulted in high partitions and dark furnishings that do not make the best use of the daylight.

The climatic location of this building is key to the shading solution, which uses interior manual blinds and a high performance glass (visible light transmission approximately 60% and shading coefficient approximately 40%). Sky conditions in Hilversum are predominantly overcast, with only 17% clear skies in the winter months and a maximum of 44% clear skies in the summer. The design opens to available daylight as much as possible and allows the occupants to use the blinds whenever the sun is perceived to be a problem.
Figure 1a. NIKE European Headquarters. The Netherlands

Figure 1c. Exterior of Office Building, Northwest Corner

Figure 1e. Interior Photograph of the Upper Floor

Figure 1b. Typical Section

Figure 1d. Typical Plan

Figure 1f. Walkway as Built with Glass Roof

Figure 1g. Simulation of Walkway Designs
The Johnson Building, Racine, Wisconsin, USA
Architects: William McDonough + Partners and Eppstein Uhen Architects

Scheduled for occupancy in 2002, this corporate headquarters is designed to house a total of 500 employees in 180,000 square feet. In addition to office floors, the building includes ground floor retail and restaurant facilities. (Figure 2b) Sustainable strategies were identified by the client in selecting the architect and early in the team planning stages. The building is registered for LEED™ 2.0 certification.

Occupying a full downtown block and surrounded by low-rise buildings, the project could easily have taken a large floor plate strategy. However, the first move was to create narrow floor plates of 53 feet and 77 feet organized around a courtyard that opens toward Lake Michigan to the east. (Figure 2d) Office floors have substantial glazing oriented toward all cardinal orientations and high floor to ceiling dimension. The window head is located at the 10'-0" ceiling plane, which rises to 10'-10" in the center of the floor. (Figures 2a and 2c) Office floors experience a view of the sky in all directions and a sense of exposure and connection to the outside world that is unusual in contemporary office buildings.

Balancing the control of sun and glare with space planning and economics was central to the design of this building. Direct beam control begins with exterior shading and high performance glass. The upper light glazing is set deep in the wall for exterior shade. Exterior shading for the view glass is provided by 18" overhangs mounted at the bottom of the clerestory on the east, south and west orientations. It is neither feasible nor economic to size exterior overhangs to deliver 100% shade year round in all orientations. Instead, diffusing roller shades are installed as the secondary system and shade both clerestory and view glass. Mounted inside the glazing, they do not significantly reduce the solar radiation load. However, they diffuse the direct beam sun, providing daylight without glare during those periods when the exterior overhangs cannot shade 100% of the glass. The shades for the open office areas are automatically controlled with an astronomical timer and sensor mounted on the roof. Similar shades in the perimeter private offices are manually controlled by the occupants.

DOE2.1e parametrics revealed that dimming lighting controls would contribute more to energy savings than deeper overhangs, since the electric lighting was a larger factor in energy use than solar radiation gains. Radiance simulations, however, indicated that exterior overhangs contribute to visual comfort. (Figure 2e) They reduce views of the high, bright sky without blocking views of the horizon, city, landscape and lake. More importantly, they reflect daylight up onto the canted ceiling surface close to the window, reducing contrast between the ceiling and the sky. (Figure 2f) The advanced glazing is designed to work with the daylighting and shading strategies. The selective coatings maximize visible transmission of daylight into the offices (60%), control solar gain (SC=0.41), and keep view to the outside perceptibly clear.

Interior light shelves were proposed to block and redirect sun penetration through the clerestory glazing. (Figure 2e) As the building neared design completion, the allocations of open office areas and private offices became more complex than simple perimeter vs. interior zoning. The private offices on the perimeter do not require interior light shelves, while the open office areas will be shaded with full length Mecho shades mounted at the head of the clerestory. The interior light shelves were eliminated for flexibility in determining private office locations.
Corporate Campus, San Jose, California
Architect: William McDonough + Partners and HOK, San Francisco

This corporate campus design includes 10 buildings totaling 1.6 million square feet, with five buildings and the campus commons in the first phase. As the architect states: "The challenge was to design an environment that is technically advanced but architecturally calm and harmonious. These goals informed every scale of the project, from the master plan to the architectural details." (www.mcdounoughpartners.com/projects) As the master site plan (Figure 3b) illustrates, the buildings face all eight cardinal and inter-cardinal orientations.

The office buildings (Figure 3a) are based on a narrow section of 63 feet, increased to 93 feet for areas containing core functions such as elevators, rest rooms and stairwells, with a floor-to-floor dimension of 13'-0. Extensive collaboration among the architects, structural engineers, mechanical engineers and daylighting consultants developed the initial scheme to support the daylighting requirements in an overall energy saving context.

The integrated design process resulted in upturning the structural beams in the curtain wall, so that the solid beam area could be enclosed in the spandrel section below the lighting work plane (30" or top of desk) rather than at the top of the window head. (Figure 3d) The design also includes under floor air delivery, containing the mechanical space in the section to 1'-6" rather than the typical 3'-0" air plenum. The resulting 10'-9" floor to ceiling enables significant daylight penetration into the office floor. The ceiling is finished as a white diffusing surface that meets the top of the glazing. This helps minimize glare by providing a smooth lighting gradient between ceiling and sky. Daylighting simulations with Radiance (Figures 3c and 3e) show that daylighting provides a minimum of 22 footcandles even in the center of the floorplate and visual comfort due to a controlled light gradient is provided with the design of the window wall. The ground floor offices see much less of the sky and more of the grass and landscape, which typically are low in light reflectance. To work with this, the floor to ceiling was increased to 13'-9", providing good daylight illumination levels and a deeper penetration into the office floor. (Figure 3d)

The curtain wall includes a terra cotta rainscreen cladding that addresses the client's desire for "traditional and timeless design aesthetic" and a concern for non-toxic environment as the wall sheds molecules during rain storms. A similar approach combining an advanced technical understanding and traditional design informed the curtain wall development. The plane of glazing is pushed back from the surface toward the interior to gain some shade and to reveal the wall thickness. Exterior overhangs and interior lightshelves are included to address sun penetration and glare issues in the offices, but do not provide 100% shade at all times shade is required. (Figure 3f)

San Jose can be a hot and dry climate in the summer, especially during California heat storm periods when the wind comes off the Central Valley. Winters are mild but with rain and overcast conditions common. Shading for the predominantly clear skies is critical, especially with so many orientations for the offices. Shading conditions and requirements for every floor and every orientation were identified and defined for Phase I. Manually controlled diffusing shades are specified for the vision glass. (Figure 3f) Shade for the clerestories is handled by the combination of the glazing setback in the wall depth and the interior light shelves. Diffusing shades can still be lowered on the view glass without diminishing daylight in the more interior zones.

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Speculative Office/Retail Complex, San Francisco, CA  
Architects: Adèle Naudé Santos & Associates and Dreyfuss & Blackford Architects

This large office and retail complex of 1.2 million square feet total is located adjacent to a busy freeway and a major sports complex. Phase I includes 800,000 square feet in three atrium office blocks with low rise retail to the south. The design intent is to create a nearly transparent building, highly visible from the freeway and unique in the Bay Area. (Figure 4a) The client has also specified that the building must receive LEED™ certification to fulfill terms of the financing.

The large and deep floor plates in Phase I vary from 250 feet by 180 feet at the base of the scheme to smaller plates of 155 feet by 120 feet in the towers. Such large plates are a real challenge to daylight. The scheme is based on the insertion of substantial atria into each of the three office blocks. (Figure 4c) These atria are designed to be as transparent as possible, delivering daylight and acting as an exhaust plenum for the mechanical system while providing an enhanced social space for each cluster of offices. The exterior glass facing south is clear, single pane with deep horizontal catwalk grates designed with the structural system to intercept and diffuse direct sun during the summer months. Radiance simulations were used to study the potential character of various atria conditions. (Figure 4e) The section of the offices is developed with a 13' 4" floor to floor height. (Figure 4d) Collaboration with the mechanical and structural engineers enabled the underfloor system and structure together to take only 2'-0" of this dimension, leaving an 11'-4" floor to ceiling height for admitting daylight deep into the office floors.

In the office curtain wall design, coordination with the structural engineer was crucial. Post-earthquake occupancy is not typically a consideration in the seismic codes in California, with the result that relatively few people are killed in a major quake but building damage is so extensive that many buildings cannot be quickly re-occupied. The design team proposed that a significant measure of sustainability might be building re-occupancy and continued use. This, however, meant that a deep spandrel beam was designed to run just behind the curtain wall glazing, initially blocking over 5 feet of the upper glass and reducing the effective window head height to 7'-3''. With review and discussion by the entire design team, this beam was redesigned as an open truss. (Figures 4b and 4d) A deep interior light shelf, working with the extended horizontal mullion cap at 7'-3'' up from the floor intercepts and reflects direct sun entering the upper glazing panels.

A further rethinking of standard practice addressed the issue of shades. Mechanical roller shades mounted separately for the clerestories and the view glass are classified as required tenant improvements. They can be automatically controlled by the building automation system with protocols developed to maximize the use of daylight. Lighting controls would then effect the energy savings possible through the coordinated design.

The site is among the windiest in the Bay Area and large-scale wind turbines are under study as part of the overall project. The turbines, coupled with PV arrays on the lower roofs, address LEED™ Renewable Energy points. The structural post-occupancy strategy will be submitted under the Innovation in Design credits. This attitude governed many aspects in the design process and decision making, not the least of which was the attention to daylighting potential, performance and eventual commissioning.
Figure 4a. Speculative Office Building / Retail Complex, San Francisco, California

Figure 4b. Radiance Simulation Overcast Sky

Figure 4c. Environmental Strategies Diagram

Figure 4d. Section Through Office Curtainwall

Figure 4e. Simulation of Atrium Daylight
This design of a 720,000 square foot office building for downtown Los Angeles was one of three finalists in the Fall 2001 design-build competition sponsored by the California Department of Transportation (Figure 5a). The design team submitted a cost-and performance guaranteed building design including a full technical submittal addressing in detail the required measures of sustainability. Building performance was predicted to better the 2001 California Title 24 by 31.7% and to ensure a LEED™ silver rating.

The program requires large blocks of open office space of 48 feet deep. Past designs have resulted in double-loaded corridor schemes that yield floor plates of 110 foot depths. This design, in contrast, organizes the floor plates into 50 foot sections, most with an exterior wall on one side and a large light court on the other (Figure 5d). In areas where the floor plan is deeper, the 120 foot section includes a core and two 50 foot sections lighted from one side. The spandrel beam is upturned to keep the ceiling flush with the head of the clerestory glazing (Figures 5c and 5e). Daylighting components include high quality glazing, light redirecting glass, reflecting louvers, exterior overhangs, interior light shelves and manually operated diffusing shades. Throughout, ceiling surfaces adjacent to the window wall and photosensor-based light controls optimize visual comfort and energy savings from daylight (Figure 5b). The typical window wall is divided into the upper clerestory glazing assembly, which controls deep sun penetration, and the lower vision glass. It allows the occupants to adjust the shades on the vision glass while maintaining daylight delivery to the deeper office areas.

Special light redirection glass allows deep light penetration on the north and south facades (Figure 5c). Light redirection glazing is a spin-off from the automotive world that uses total internal reflection to redirect daylight toward the ceiling. (Figure 6b) It is similar in performance to prismatic glass, which was used historically, but without the weight and cost penalty. We tested Serraglaze, manufactured in Great Britain, that effectively increases the usable daylight deeper than any currently used technology within standard office building budgets. (http://www.serraglaze.redbus.co.uk) On the south, the glazing does not redirect all solar radiation, so a shading system is also necessary. A 4'-0" interior light shelf controls sun penetration on the south facade for 98% of the annual working hours. The vision glass is protected by a 12" exterior overhang to control both glare and solar radiation. In addition, there is an interior roller shade.

On the east and west facades, a custom fixed louver system, optically designed, shades direct sun from all solar angles while admitting usable indirect daylight with a double reflection system (Figure 5e). The fins are extruded aluminum coated with a reflective finish to increase effectiveness. The optics are designed to diffuse the reflected light on the ceiling, coupling daylight with the electrical lighting system controls. In the exterior light court, the west facade is identical to the north facade with two-foot interior light-shelves and light redirecting glass in the clerestory. The eastern facing facade changes floor by floor.

These innovations in curtain wall design and manufacture are predicted to deliver 30 footcandles of daylight at 30 feet from the window wall. The electric lighting is designed to recognize the daylight and provide sufficient in-fill light through a controlled dimming system.
Figure 5a. CalTrans District 7 Headquarters, Los Angeles, Site Model

Figure 5b. Simulation of Office Building, Daylighting Only

Figure 5c. Light Redirecting Curtainwall

Figure 5d. Typical Floor with Curtainwall Strategies

Figure 5e. Louver Redirection and Shading Curtainwall
State Compensation Insurance Fund Building, San Francisco, CA
Architect: HOK San Francisco

Scheduled to be occupied by 2004, this 289,000 square foot office building sits just southeast of an older 16 story building owned and occupied by the same client in downtown San Francisco. (Figure 6a) LEED™ certification has been a goal for the owner since the start of the project. PV's are scheduled for the roof and the design team is exploring the use of an underground river for heat rejection.

The building is 12 stories tall with an angled northwest window, admitting daylight into the plaza created between the two buildings. The elevations are oriented off the cardinal to the NE, SE, SW and NW. The constricted site and need to maximize usable floor area led to a large, rectangular building plate (average of 140 feet by 184 feet) with a central core. (Figure 6a) This leaves deep 54 foot office bays to be daylit from one side on the northwest and southeast. The office depths are narrower on the southwest and northeast. Recognizing site height restrictions, the floor to floor dimension is 13'-9" with a 9'-10" floor to ceiling height to accommodate deep beams for the long spans.

The design team undertook a serious attempt to maximize daylight and comfort in the office floors in spite of the relatively deep plan and low ceiling height. Extensive DOE2 modeling early in the schematic design phase enabled the mechanical design to optimize the under floor air distribution design, with a ceiling plenum used for the return air. Thermal modeling convinced the team that perimeter reheat could be dropped from the mechanical design if the glass selection was changed to improve the U-value of the glazing and the spandrel panels were more heavily insulated. If necessary, local reheat units can be dropped in to solve an individual comfort problem once the building is occupied.

On the southeast curtain wall, light-redirecting glass (Serraglaze) is specified for the clerestory glazing (Figure 6b). Tests demonstrated this would deliver daylight much farther into the office plan than is achievable with a simple high clerestory design. To improve the visual quality of the workspace, the column line is moved back from the window wall the ceiling at the perimeter is lit with reflected light from a combination exterior overhang and interior light shelf (Figure 6e). The overhang and light shelf work together to block direct sun penetration through the clerestory glass. The view glass can be shaded with manually controlled diffuse roller shades as desired by the occupants.

On the northwest slanted curtain wall, the low angle sun penetration during summer months generated the use of OkaSolar in the clerestory light (Figure 6d). OkaSolar is imported from Germany (information is available for the United States at http://www.us.schott.com). This product is an integrated louver unit designed to redirect direct beam radiation toward the ceiling rather than allowing it to penetrate deep into the office floor. A tracked roller shade can then be used on the view glass to control sun penetration.

The shorter northeast and southwest curtain walls do not have to deliver daylight as deeply as the other two elevations. However, shading is still serious issue on these elevations. The design has incorporated deep horizontal grates as exterior overhangs and assigned interior spaces tolerant to direct beam radiation to these areas.
Figure 6a. State Compensation Insurance Fund Building, San Francisco, California, Aerial View

Figure 6b. Test Cell, Light Redirection Glazing  
Figure 6c. Plan Showing Daylighted Areas

Figure 6d. Section of Northwest Curtainwall  
Figure 6e. Section of Southeast Curtainwall

Conclusions

Only one of these buildings is currently occupied. Future research would be useful to evaluate the overall energy implications of the daylighting designs. We can draw some conclusions, however, about the daylighting design in contemporary office buildings:

- The initial design moves which lay the groundwork for successful office daylighting (thin floor plates and high floor to floor dimensions) are expensive and far from standard practice.
- Integration of architectural, structural, mechanical, electrical and daylighting disciplines is absolutely essential and is still bumpy in practice.
- Under floor air delivery couples well with daylighting strategies by decreasing plenum depth and increasing the floor to ceiling dimension.
- Shading for clerestory glazing must be solved or it is at risk of being solved retroactively with aluminum foil or blackout shades.
- Light redirecting glazing demonstrates significant potential in achieving daylight penetration for open offices.
- High performance glazing, diffusing shades, interior light shelves, exterior overhangs and lighting controls are all likely to be seen as expendable as the budget becomes tighter, unless they can be understood as an integrated system.
- The LEED™ rating system and increased demands for sustainability on the part of governmental and institutional clients are likely to increase the viability of daylighting in commercial buildings.

Acknowledgements

We wish to acknowledge the important work of our associates on these projects: Christian Humann, Radiance simulations; Santosh V. Philip, DOE2 simulations; Paul LaBerge, physical models and test cells; Leslie Gold, research. The drawings were developed from those provided by project architects. All photographs are by the authors, except those of The Johnson Building provided by Mark Rylander of WM+P. Most importantly, none of this would be possible without the vision and commitment of the architects and clients with whom we have worked.

References


