Advanced Daylighting Examples

About These Examples

This document contains examples of daylighting design for common space types and visual comfort criteria. Each example contains photographic documentation of the space, a narrative description of the daylighting design intent, key concepts, and architectural components.

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Contents

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Open Office: Toplighting

Photo: C. Meek/UW IDL

Project: Kenmore City Hall
Architect: Weinstein A|U

Overview

Open offices provide an ideal opportunity for bringing in daylight from above (toplighting). This allows for the uniform distribution of daylight illumination regardless of position relative to perimeter windows. It has the distinct advantage of allowing for quality light distribution even where office workstation "cubicle" panels are tall.

The best toplighting opportunities are present where open office areas occur in single story structures or are on the top floor with direct access to rooftop skylights.

Key concepts in successfully toplighting for open office areas include:

• Design and specify apertures that provide for effective sunlight and daylight diffusion. This can be accomplished with diffusing laminated glass, prismatics, white acrylics, fiberglass panels, diffusing polycarbonates, or tubular daylighting devices.

•Ensure proper sizing and placement of apertures to ensure effective light distribution under the most common sky conditions (clear or overcast).

•Provide illumination at key vertical surfaces, including perimeter walls.

•Provide high reflectance values to avoid excessive contrast, especially at the ceiling plane.

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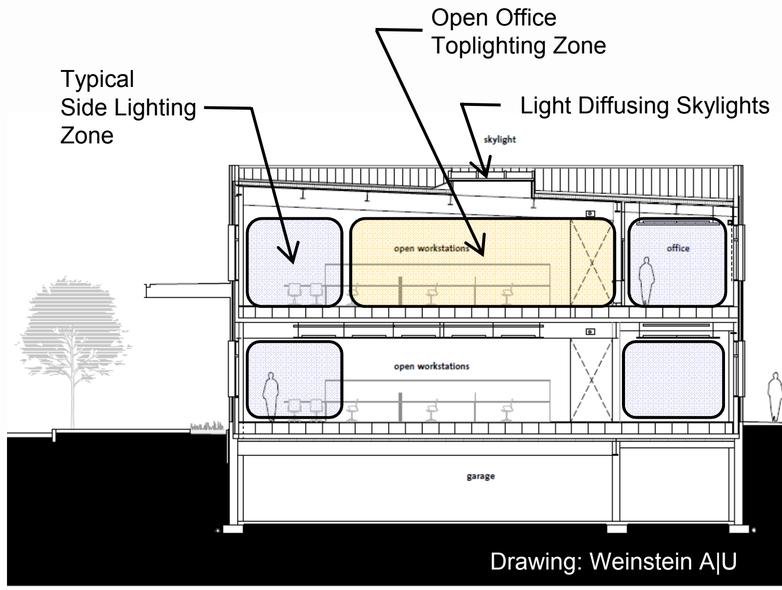
Open Office: Toplighting

Photo: C. Meek/UW IDL



Drawing: Weinstein A|U

Sky-lit open office area with all general lighting controlled off via photo-cell. High efficiency accent and aisle way lighting provides sparkle and focal points. Re-lites through provide offices enables views to the exterior.

The inclusion of toplighting at the upper floor open office nearly doubles the functionally daylit area of the building.

Project Information

Project: Kenmore City Hall

Architect: Weinstein A|U

Lighting Designer: WSP Flack + Kurtz

Completed: 2010

Location: Kenmore, WA

Design Goals

- Diffuse ambient daylight distributed across entire open office area sufficient to meet general lighting requirements during more than 50% of occupied hours.
- Complete control of direct beam sunlight to avoid glare and overheating.
- Views to the exterior for all occupants.

Daylighting Strategy

- Diffuse skylights at upper floor open office area illuminate the center of the office floor plate.
- Laminated glass skylights with light diffusing inner-layer. Skylights sized to 4% of floor area (excluding perimeter daylight zone). Daylighting studies helped identify these ratios.
- High reflectance interior surfaces in the upper volume of the office.
- Automated photo-responsive dimming to off, with manual over-ride on general lighting.
- Operable windows for daylight, views, and natural ventilation.
- High efficiency accent lighting at corridor for visual sparkle and focus.

Existing Building: Sidelighting Retrofit

Photo: C. Meek/UW IDL

Project: Perkins+Will Seattle Office
Architect: Perkins+Will

Overview

Nearly all existing buildings offer the potential to use daylight as a source of illumination. This is especially the case with buildings constructed prior to 1950. Retro-fits and renovations can provide an opportunity to realize substantial lighting power savings and reduce heating and cooling loads by increasing window performance, incorporating daylighting strategies, and integrating lighting controls.

This existing office building tenant improvement designed by Perkins+Will provides new high performance glazing, optimized interior space planning, light reflective surface finishes, and zoned perimeter electric lighting with photo sensor control to create an extremely energy efficient and high quality lighting system.

Key concepts in successfully sidelighting retrofits include:

• Understanding the existing patterns of diffuse daylight and sunlight at each of the areas included in the retro-fit or renovation.

•Using space planning principles and low partition heights that put occupants within the daylight zones and afford views.

•Provide automated or manual glare window coverings to ensure effective glare control.

•Provide high reflectance finishes to enhance daylight inter-reflectance within the interior volume.

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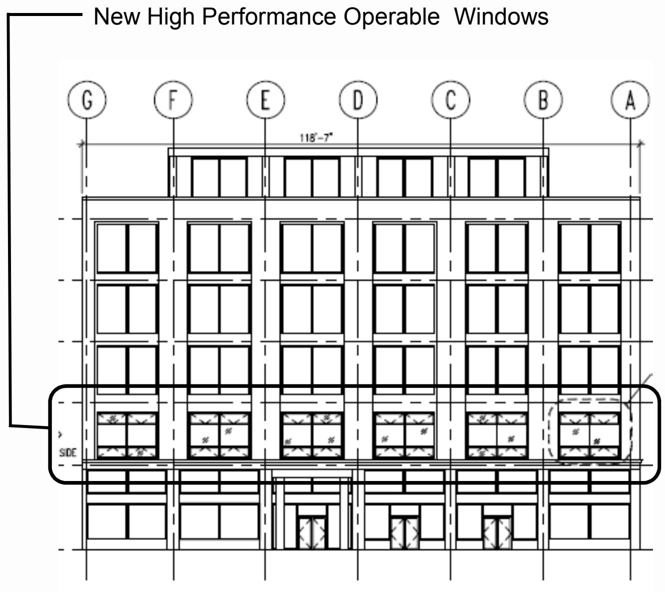
Existing Building: Sidelighting Retrofit


Photo: C. Meek/UW IDL



Drawing: Perkins + Will

The Seattle office of Perkins+Will occupies the second floor of the Galland Building, originally constructed in 1906. The existing floor plate offers 12'-0" ceilings and a relatively shallow perimeter to core dimension offering the potential to use daylight as the primary source of illumination during day time hours.

As part of their tenant improvement, Perkins+Will provided new operable high-performance windows. This enabled high visible light transmission with better solar control and a lower U-Value. This combination of increased thermal performance and light admittance saves energy on heating, cooling, and lighting. The operable sashes enable cross ventilation and passive cooling.

Project Information

Project: Perkins+Will Seattle Office Tenant Improvement and Glazing Retrofit

Location: Galland Building, Seattle, WA

Architect: Perkins+Will

Completed: 2008

Design Goals

- Diffuse ambient daylight distributed across entire open office area sufficient to meet general lighting requirements during more than 50% of occupied hours.
- Complete control of direct sunlight and glare with manual roll-down fabric shades.
- Views to the exterior for all occupants.

Daylighting Strategy

- Open offices at the perimeter rather than small private offices.
- Low partition heights to preserve views and to avoid blocking daylight distribution to the interior workstations.
- High reflectance interior surfaces, especially at the "back wall" to balance the brightness of views to the exterior.
- Automated photo-responsive electric lighting system with occupant controls.
- Exterior venetian blinds on west facing windows to block glare from low angle sunlight and reduce cooling loads.
- High reflectance manually adjustable roll-down fabric shades to shield low angle sunlight and to block glare from sunlight on adjacent buildings.
- New high performance low-e replacement windows to increase thermal comfort.

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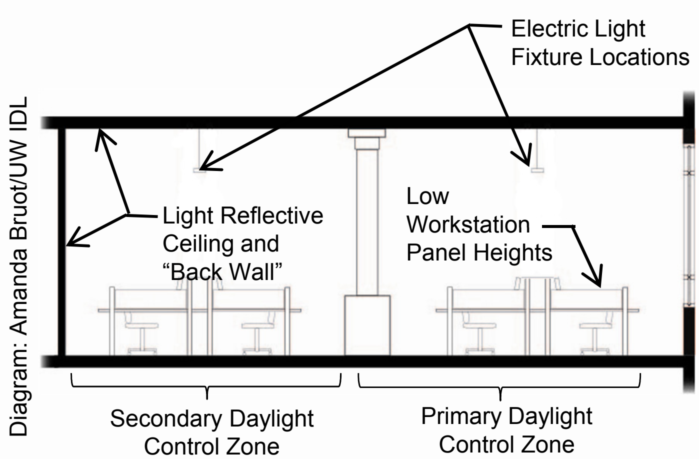
Existing Building: Sidelighting Retrofit

New high-performance windows and daylight from two sides provide sufficient daylight to maintain ambient illumination with no electric lights on at the open office area.



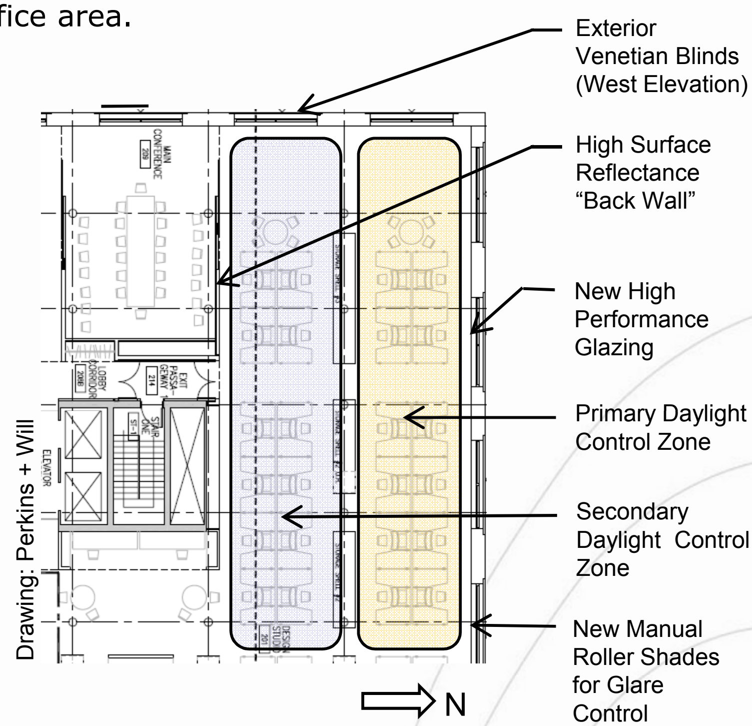


Photo control zones are grouped relative to daylight availability. Electric light sources are automatically dimmed when daylight is present. Manual over-rides give users the ability to manually turn electric lights off when not needed. Photocells are located in-plane with electric light fixtures in each zone.

The combination of low office workstation partition heights and a light-colored "back wall" allow for daylight control zones throughout open office area. The electric lighting is controlled in individual zones to allow for adjustments based on available daylight.

Large Meeting Room: Top and Sidelighting

Photo: C. Meek/UW IDL

Project: Kenmore City Hall
Architect: Weinstein A|U

Overview

Meeting rooms and public assembly facilities must be flexible to accommodate a wide range of visual tasks. However this does not preclude the use of daylight as the primary source of daytime illumination.

This large meeting room is illuminated from both toplighting and sidelighting. South facing perimeter glazing provides daylight illumination to about two-thirds of the meeting room. A diffuse, slot skylight washes the "back wall" with light, balancing the brightness of the perimeter glazing and illuminating the back third of the meeting room. Fixed exterior shading blocks direct sunlight during times when the building is likely to be in cooling mode.

Interior roll-down shades allow for space darkening as needed.

Key concepts in successfully combining sidelighting and toplighting for visual task areas include:

• Perimeter glazing generally provides effective daylight distribution roughly twice the head height of glazing.

•Balance perimeter illumination with a second source of daylight when possible via clerestories, skylights, or other vertical glazing.

•Provide exterior solar shading to reduce cooling loads and control glare from direct sunlight.

•Provide manual or automated blinds and shades to ensure visual comfort and to allow for flexibility and A/V requirements.

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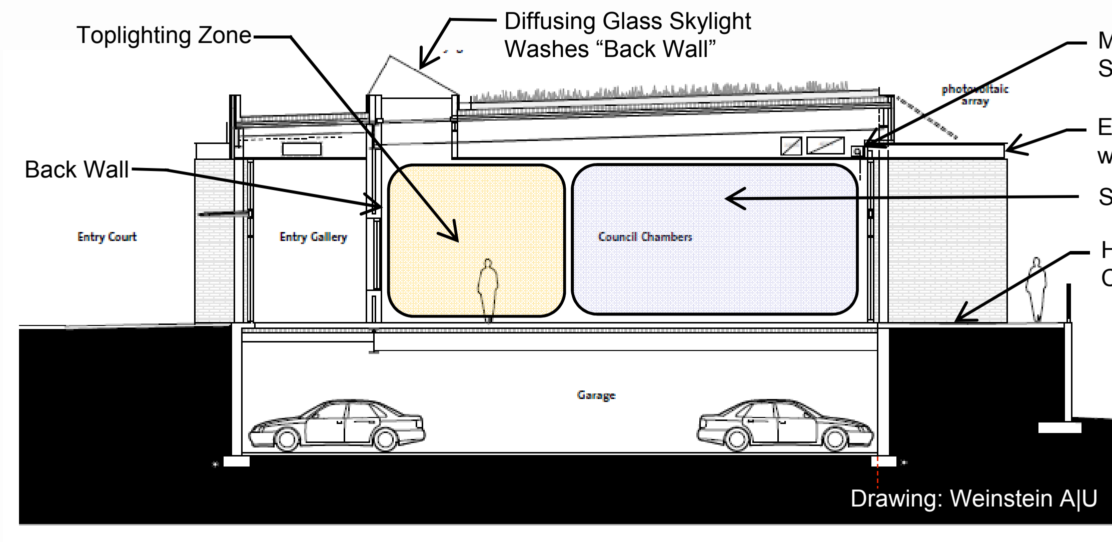
Large Meeting Room: Top and Sidelighting



Drawing: Weinstein A|U


Photo: C. Meek/UW IDL

A linear skylight in the Large Meeting Room/Council Chambers extends into an adjacent Lobby and Gallery space, providing daylight illumination at areas that have no access to perimeter glazing. All ambient electric light sources are off in this image.

Project Information

Project: Kenmore City Hall

Architect: Weinstein A|U

Lighting Designer: WSP Flack + Kurtz

Location: Kenmore, WA

Completed: 2010

Design Goals

- Diffuse ambient daylight distributed across the meeting room/council chambers sufficient to meet general lighting requirements during more than 50% of occupied hours.
- Space darkening for A/V purposes.
- Views to the exterior for all occupants.
- Sense of transparency.

Daylighting Strategy

- Glazing oriented due south to allow for control of direct sunlight during cooling months with fixed exterior overhangs.
- A linear, diffuse skylight supplements and balances perimeter vertical glazing allowing for effective daylight illumination across the entire meeting room.
- High reflectance interior surfaces on the ceiling, skylight well, and ground surface outside the meeting room.
- Automated photo-responsive electric lighting with manual over-ride for A/V mode.
- Intuitive switching enable occupants to turn off electric lighting when unnecessary.
- Vacancy sensors (manual on/auto off) ensure electric lights are off when the meeting room is un-occupied.

Gymnasium: Toplighting

Photo: C. Meek/UW IDL

Project: Kenmore City Hall
Architect: Weinstein A|U

Overview

High-bay single story, open volume spaces such as gyms, warehouses, and big-box retail provide an easy and effective opportunity to save lighting power by using daylight from above.

Simple analysis can identify optimum skylight to floor area ratios based on site location, climate, and prevailing sky conditions. Since daylight is delivered diffusely from above, integration with electric lighting systems is often relatively simple. When done at critical visual task areas, toplighting can allow diffuse daylight with no direct sunlight, providing a very low potential for glare.

Key concepts in successfully toplighting for high-bay open volume areas include:

• Design and specify apertures that provide for effective sunlight and daylight diffusion. This can be accomplished with diffusing laminated glass, prismatics, white acrylics, fiberglass panels, diffusing polycarbonates, or tubular daylighting devices.

•Ensure proper sizing and placement of apertures to ensure effective light distribution in clear vs. overcast climates.

•Provide illumination at key vertical surfaces including perimeter walls.

•Provide high reflectance values to avoid excessive contrast, especially at the ceiling plane.

ALG Advanced Lighting Guidelines

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Gymnasium: Toplighting

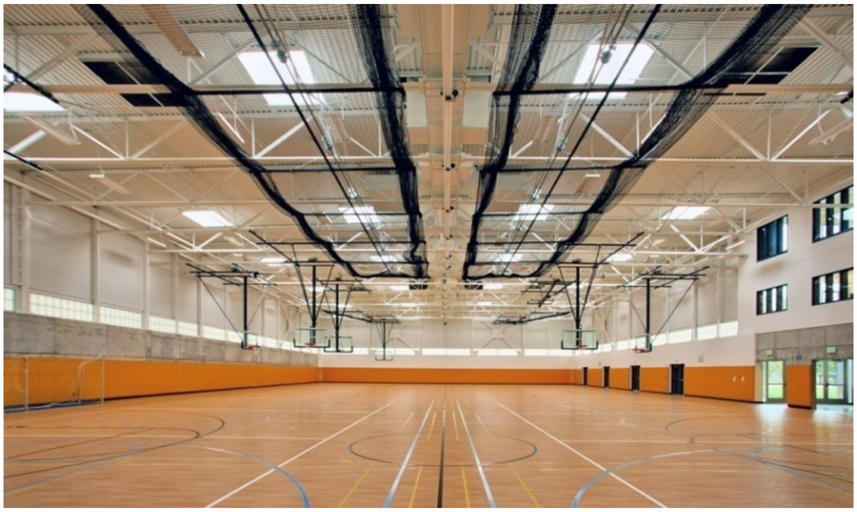


Photo: C. Meek/UW IDL

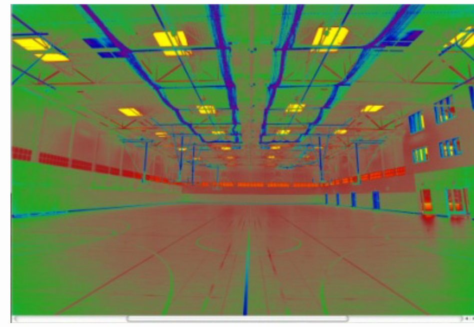
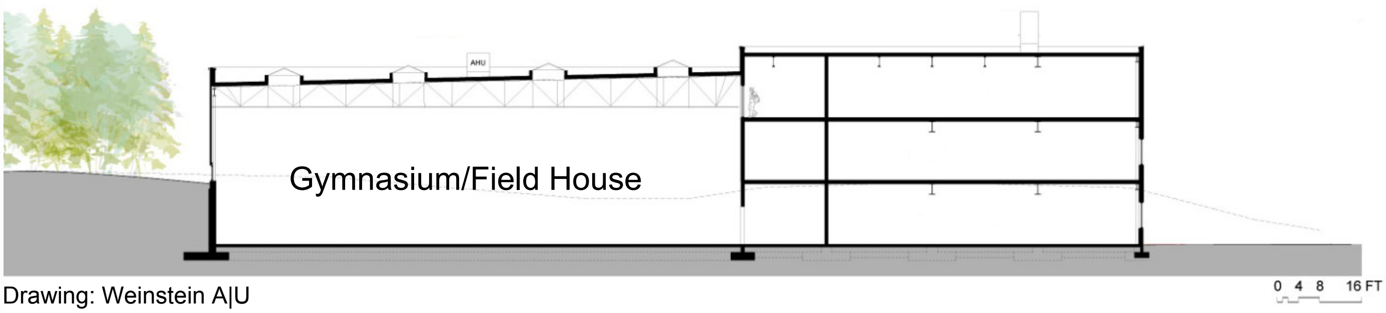


Image: C. Meek/UW IDL

False color imaging shows a an even distribution of luminance throughout the gym, even with no electric light sources on under overcast skies. Light surface finishes in the upper volume of the space provide for increased daylight inter-reflectance.



Drawing: Weinstein A|U

Project Information

Project: Mercer Island Boys and Girls Club

Architect: Weinstein A|U

Lighting Designer: WSP Flack + Kurtz

Location: Mercer Island, WA

Completed: 2010

Design Goals

- Diffuse ambient daylight distributed across entire open office area sufficient to meet general lighting requirements during 75% of daylight hours.
- Complete control of direct sunlight.
- Low contrast with good visibility for active tasks.

Daylighting Strategy

- Pyramidal diffuse acrylic skylights with a 50% visible light transmission (Tvis of 0.50) completely diffuse all direct sunlight while transmitting overhead sky dome and overcast illumination.
- Daylight simulations identified skylight placement and sizing for optimum distribution of illumination on key surfaces including the ceiling walls and floor.
- High reflectance upper wall, ceiling, and floor to enhance inter-reflection within the volume.
- Automated photo-responsive multi-level switching, with manual over-ride on general lighting.
- A band of translucent panels reveals the ground plane to the west and provides a subtle visual connection to the outdoors. Shadows from trees are visible, but no direct sunlight is admitted.

ALG Advanced Lighting Guidelines

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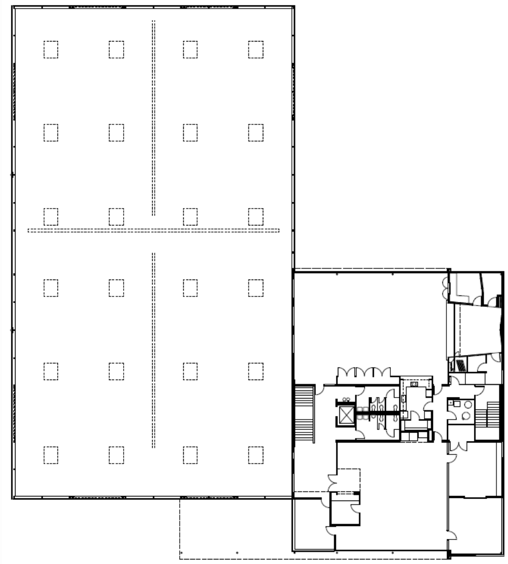
Gymnasium: Toplighting

Performance Simulation

- The target illumination is 50fc with an LPD of 1 w/sf.
- Illuminance data were calculated based on average gymnasium horizontal illumination expected at 30” above the gym floor.
- An annualized calculation was completed to determine both expected interior illuminance values and resulting lighting power savings based on a three-step switching lighting system.
- Due to satisfaction with the daylighting, users frequently leave electric lights off even when less than 50 fc of illumination is present, increasing lighting power savings.



Drawing: Weinstein A|U

CALCULATED OVERCAST ILLUMINANCES AT REFERENCE POINT (SEATTLE)

(hours of day - - - - - - - ->)

	5AM	6	7	8	9	10	11	12	1PM	2	3	4	5	6	7	8
JANUARY				7.5	15.0	18.8	21.5	22.5	21.5	18.8	15.0	7.5				
FEBRUARY			4.2	14.7	20.0	25.2	29.5	31.1	29.5	25.2	20.0	14.7	4.2			
MARCH			13.9	20.3	27.7	35.6	41.3	43.3	41.3	35.6	27.7	20.3	13.9			
APRIL		12.7	19.6	27.9	38.3	47.6	53.5	55.7	53.5	47.6	38.3	27.9	19.6	12.7		
MAY	9.1	17.0	24.1	34.5	45.7	54.8	61.6	64.7	61.6	54.8	45.7	34.5	24.1	17.0	9.1	
JUNE	11.8	18.5	26.2	37.0	48.3	57.4	65.3	69.4	65.3	57.4	48.3	37.0	26.2	18.5	11.8	
JULY	9.4	17.2	24.3	34.8	46.0	55.2	62.0	65.2	62.0	55.2	46.0	34.8	24.3	17.2	9.4	
AUGUST		12.9	19.7	28.2	38.6	47.9	53.9	56.0	53.9	47.9	38.6	28.2	19.7	12.9		
SEPTEMBER		0.7	14.1	20.5	28.0	36.0	41.8	43.8	41.8	36.0	28.0	20.5	14.1	0.7		
OCTOBER			3.7	14.5	19.8	24.9	29.1	30.7	29.1	24.9	19.8	14.5	3.7			
NOVEMBER				7.2	14.8	18.7	21.3	22.4	21.3	18.7	14.8	7.2				
DECEMBER				2.2	12.5	16.6	19.0	19.8	19.0	16.6	12.5	2.2				

AVERAGE ANNUAL ILLUMINATION (for workday of 6 a.m. to 9 p.m.) = 31.3 footcandles

ENERGY SAVINGS - PERCENT: THREE-STEP SWITCHING (33/66/100%)

(hours of day - - - - - - - ->)

	5AM	6	7	8	9	10	11	12	1PM	2	3	4	5	6	7	8
JANUARY						0.33	0.33	0.33	0.33	0.33						
FEBRUARY					0.33	0.33	0.33	0.33	0.33	0.33	0.33					
MARCH				0.33	0.33	0.66	0.66	0.66	0.66	0.66	0.33	0.33				
APRIL			0.33	0.33	0.66	0.66	1.00	1.00	1.00	0.66	0.66	0.33	0.33			
MAY		0.33	0.33	0.66	0.66	1.00	1.00	1.00	1.00	1.00	0.66	0.66	0.33	0.33		
JUNE		0.33	0.33	0.66	0.66	1.00	1.00	1.00	1.00	1.00	0.66	0.66	0.33	0.33		
JULY		0.33	0.33	0.66	0.66	1.00	1.00	1.00	1.00	1.00	0.66	0.66	0.33	0.33		
AUGUST			0.33	0.33	0.66	0.66	1.00	1.00	1.00	0.66	0.66	0.33	0.33			
SEPTEMBER				0.33	0.33	0.66	0.66	0.66	0.66	0.66	0.33	0.33				
OCTOBER					0.33	0.33	0.33	0.33	0.33	0.33	0.33					
NOVEMBER						0.33	0.33	0.33	0.33	0.33						
DECEMBER						0.33	0.33	0.33	0.33	0.33						

Lighting Energy Savings: **49.7%**

(Considering a Work Schedule of 6:00 AM to 9:00 PM)

Open Office: Sidelighting and Controls

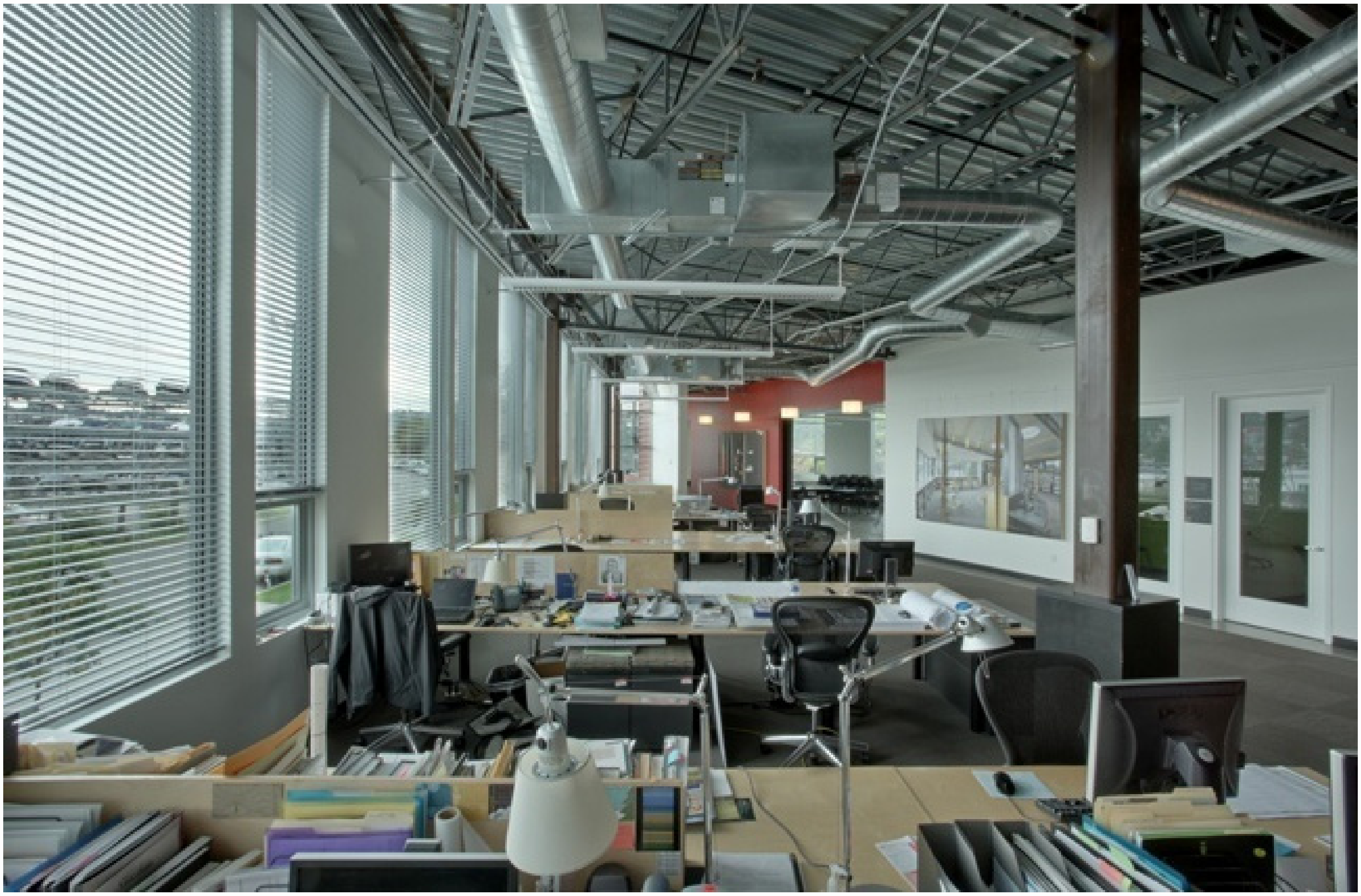


Photo: C. Meek/UW IDL

Project: University of Washington Integrated Design Lab

Overview

Daylighting through vertical windows from one side is the most common strategy for office areas. To realize maximum lighting power savings, space planning and interior workstation organization must be optimized. This means placing workstations within daylight zones and keeping partitions low where they are parallel to daylight sources.

In this case, daylight provides the primary source of ambient illumination with localized task lighting via fluorescent desk lamps when needed. Overhead direct/indirect pendants with dimming ballasts and photocell control automatically reduce light output and turn off fixtures when ambient illumination exceeds 20fc.

Key concepts in successful sidelighting for open office areas include:

•Shallow building section allows open office workstations within a distance less than two times the head height of the window.

•Orient glazing to allow control of direct beam sunlight during occupied times.

•Provide window coverings that enable complete sun control, while maintaining diffuse daylight performance.

•Provide light reflective vertical surfaces opposite glazing to enable a balanced composition of bright surfaces.

•Specify photo-controls to provide comfortable transitions between daylight and night time electric illumination "scenes."

Advanced Lighting Guidelines

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Open Office: Sidelighting and Controls

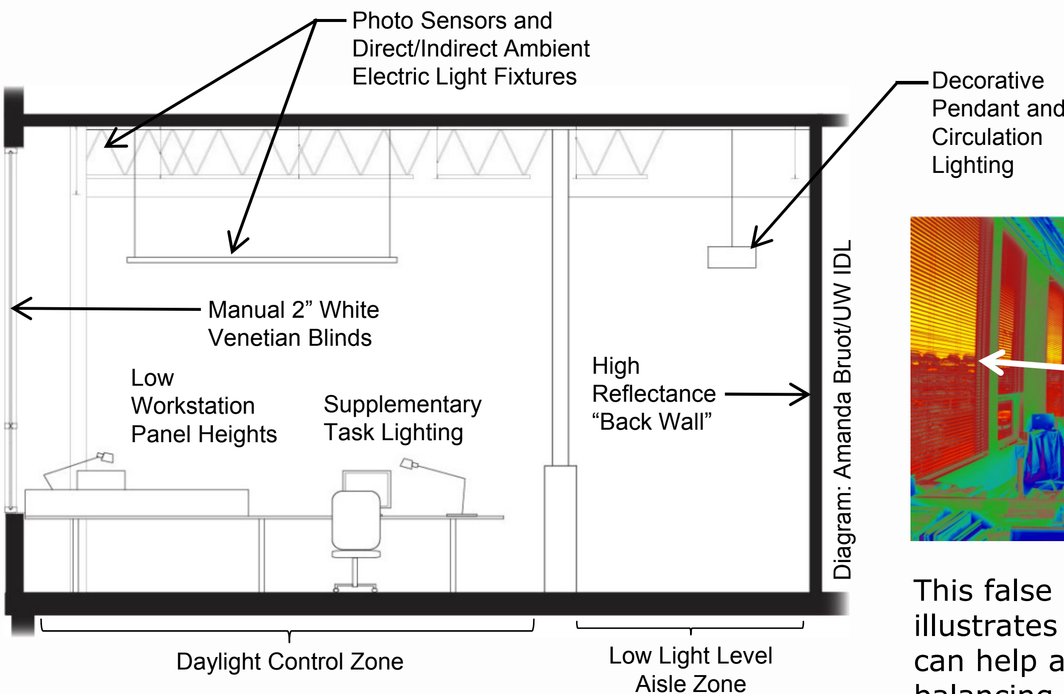

Diagram: Amanda Bruot/UW IDL

A 13'-0" window head height enable effective daylight distribution across all workstations in this open office.

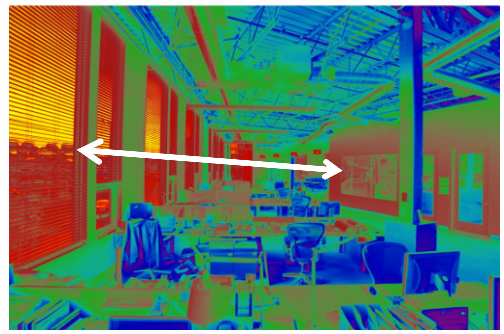

Image: C. Meek/UW IDL

This false color luminance map illustrates how high reflectance walls can help avoid the "cave effect" by balancing the brightness of the perimeter glazing and reducing contrast.

Project Information

Project: University of Washington Integrated Design Lab

Tenant Improvement: Jones Tsukamaki/UW IDL

Shell and Core: The Miller Hull Partnership

Photocontrols: WattStopper/Legrand

Location: Seattle, WA

Completed: 2009

Design Goals

- Diffuse ambient daylight distributed across entire open office area sufficient to meet general lighting requirements during more than 75% of occupied hours.
- Complete control of direct sunlight.
- Daylight and views to the exterior for all occupants.

Electric Lighting Integration

- Installed lighting power density of 0.6w/sf.
- Automated photo-responsive dimming to off, with manual over-ride on general lighting.
- Operational lighting power density below 0.25 W/sf (due to photo controls).
- Ambient lighting dims to 10% (minimum) light output, before turning off to avoid jarring and unexpected transitions in electric light levels. Light fixtures are re-energized at low light output.
- Daylight provides high ambient light levels during daylight hours and the low electric lighting design illumination (20fc set point) allows for lower light levels at night.
- Private office areas and "quiet rooms" are placed away from the daylight zone due to intermittent occupancy.
- High efficiency decorative pendants along the aisle way provide focal points and rhythm while giving a sense that the office is "open."

Conference Room: Automated Blinds

Direct Beam Sunlight Glare

General Meeting Mode: Glare Control and Maintained View With Diffuse Daylight

A/V Mode Darkening

Photos: C. Meek/UW IDL

Overview

Dynamic Shading Systems allow for flexibility and control of daylight intensity and distribution. Automation can provide optimized performance based on weather station control or user input. A key benefit of automated shading systems is that they do not require on-going user attention to maintain performance over time. Blinds can be programmed to respond to dynamic variables including sky condition and outdoor air temperature. This allows blinds to be deployed at optimum slat angles when direct sunlight is present and retracted during overcast days and retracted during overcast days. One of the challenges with manual blind and shade systems is that they are often deployed in the "worst case scenario" position since occupants tend to deploy shade when glare is present, yet do not immediately retract blinds when the glare source is no longer present.

Key concepts for automated shading:

•Optimizes daylight performance where solar orientation is not conducive to control through fixed shading devices.

•Can be programmed to provide "scenes" for A/V or other spaces with variable visual comfort criteria.

•Can substantially reduce cooling loads and system size.

•Provide predictable performance throughout the year, without relying on continual occupant adjustment.

•Provide light re-directing capability to maintain high-quality light distribution.

•Can be internal or external depending on performance goals.

ALG Advanced Lighting Guidelines

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Conference Room: Automated Blinds

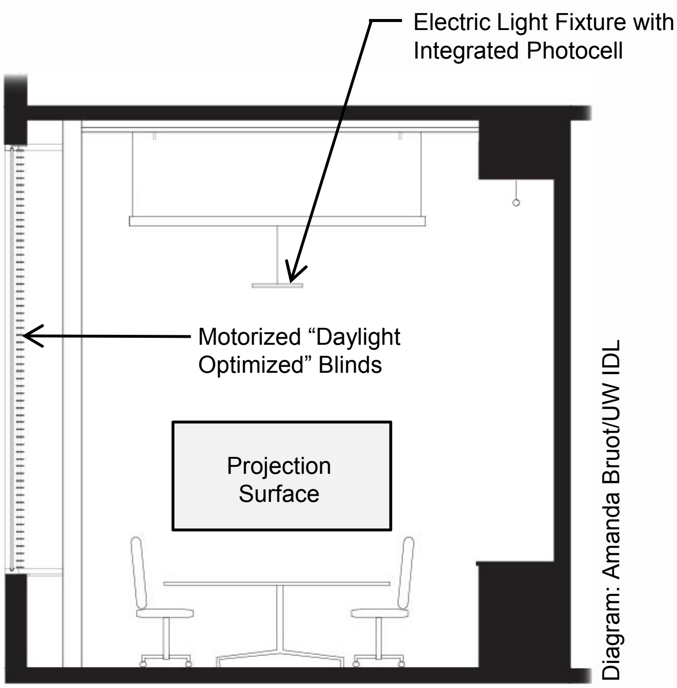
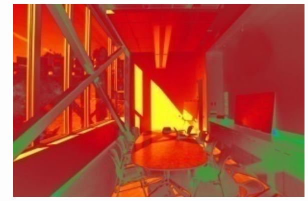


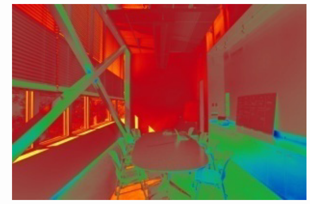
Diagram: Amanda Bruot/UW IDL

Motorized blinds provide glare control and darkening in a small conference room with extensive west-facing glazing.

Direct Sunlight



Diffuse Daylight with Glare Control



A/V Mode Darkening

A/V Darkening with Electric Lighting On

Luminance Maps: C. Meek/UW IDL

Project Information

Project: University of Washington Integrated Design Lab Offices

Blinds: Warema/Iris Window Coverings

Tenant Improvement: IDL/Jones Tsukamaki

Shell and Core: The Miller Hull Partnership

Location: Seattle, WA

Completed: 2009

Design Goals

- Diffuse ambient daylight distributed across entire open office area sufficient to meet general lighting requirements during more than 75% of occupied hours.
- Complete control of direct sunlight and A/V Darkening.
- Views to the exterior.

Daylighting Strategy

- Motorized interior venetian blinds to control glare on extensive west southwest glazing.
- Manual control to optimize blinds settings for glare control, view, A/V darkening, and diffuse daylight redirection.
- Ceiling cloud to receive diffuse daylight and indirect electric light sources.
- Motorized blinds help reduce solar gains during cooling periods.
- High reflectance walls help to reduce contrast and provide a projection surface for LCD projector.