Expanding the Daylight Pattern Guide Using Annual Metrics

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UNIVERSITY OF OREGON | Energy Studies in Buildings Laboratory

advanced buildings
Energy performance solutions from NBI

Daylighting Pattern Guide

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Introduction

New Buildings Institute in partnership with the University of Idaho and University of Washington has developed a freely available interactive tool for the design of proven daylighting strategies in a variety of building types. Users will be introduced to the Daylighting Pattern Guide while exploring the inter-relationship of sky, site, aperture, and space planning. The guide uses a combination of built examples and advanced simulation to set the stage for substantial reductions in lighting power consumption and overall energy use through successful daylighting design.

Contributors

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boise + puget sound

University of Idaho
College of Art and Architecture

BE COLLEGE OF BUILT ENVIRONMENTS

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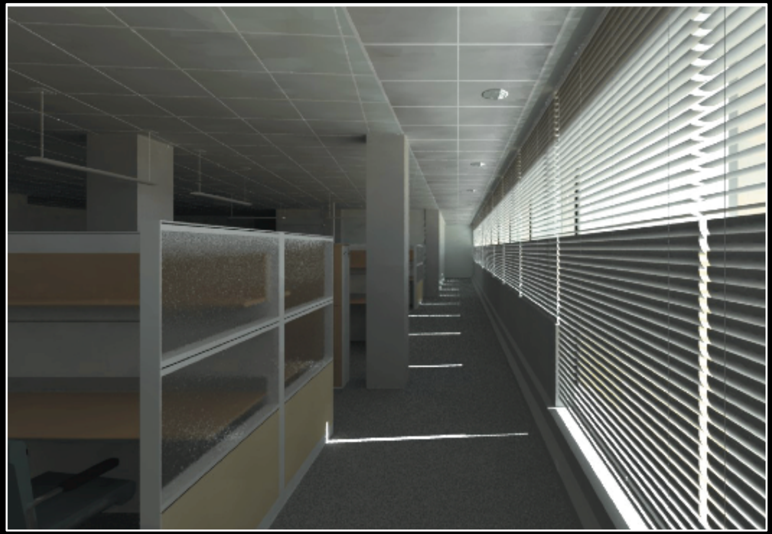
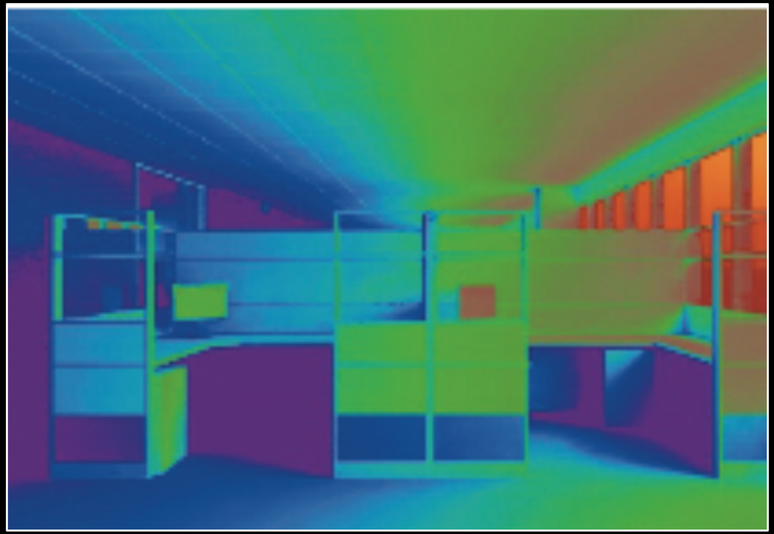
Site by Fuse IQ

Design a Classroom or Office Building

Justify a Sun Protection Decision



Collaborate with an Interior Designer



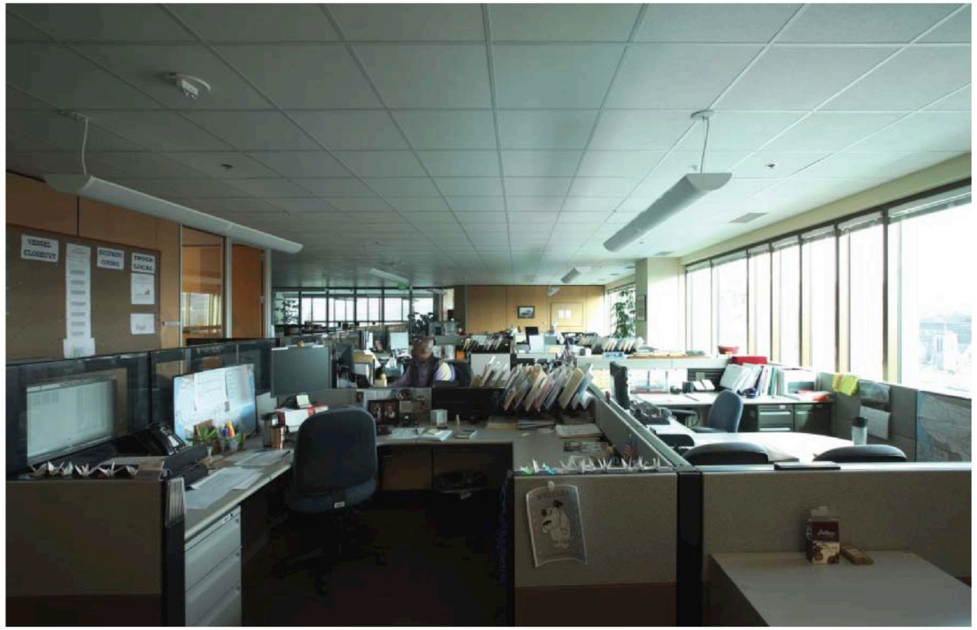
LEED Credit 8.1 Daylight & Views (v4, BD+C New Construction)

Metrics:

- **Daylight Autonomy (DA/300Lux)** is a *time-based* metric which quantifies the percent of occupied hours of the year (8am to 6pm) during which a single analysis point is above 300 Lux.
- **Spatial Daylight Autonomy (DA/300Lux/50%)** is an *area-based* metric which quantifies the percentage of floor area (analysis points) that is at or above 300 Lux for at least 50% of the occupied hours of the year. (8am to 6pm)
- **Annual Sunlight Exposure (ASE/1000Lux/250hours)** is another *area-based* metric which quantifies the percentage of floor area (analysis points) that is at or above 1000 Lux for at least 250 hours out of the occupied hours of the year. (8am to 6pm)

Pattern 3: Window Area

Daylight from One Side



OVERVIEW:

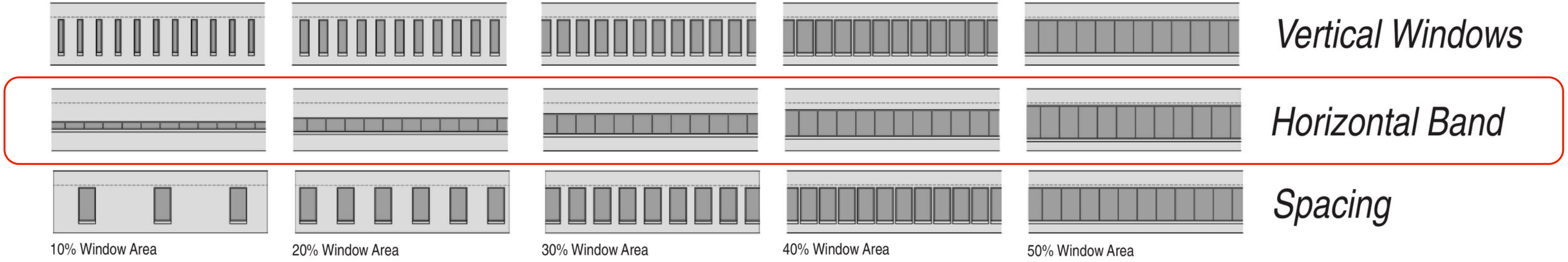
When discussing daylighting in buildings, "section The area of glass relative to opaque wall area is one of the key inter-relationships when designing daylit buildings. Generally the effective distribution of daylight from perimeter windows is a function of the head height of the windows. However, some themes emerge when we consider the position, configuration and overall window area.

Glazing in the upper portion of a wall tends to increase daylight illumination levels in the zone roughly twice the head height of the window, though its contribution is negligible at distances beyond this point. Additionally, when glazing is concentrated in a limited portion of the wall area, contrast between views to the exterior and the surrounding opaque wall can begin to detract from visual comfort. Glazing in continuous bands tends to provide a more unobstructed view corridors to the exterior.

Typically, vertical windows tend to provide a more even distribution of daylight illumination across the floor area at lower glass areas (below 40%). At glass areas above 40% daylight distribution remains similar since the distribution of glazing on the wall is similar when the sill is set at 2'-6" or greater. Glass areas below 30% deliver a daylight distribution that is limited to the immediate area (15'-0") adjacent to the window.

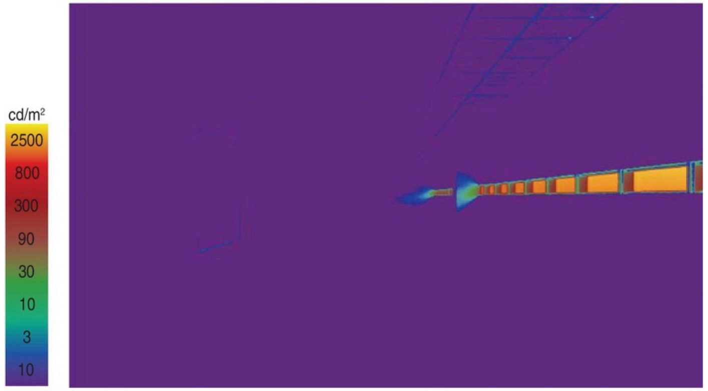
Bear in mind that even with 100% glass area walls, the distribution of effective daylight to the interior is unlikely to exceed 25'-0" in multi-story buildings, even considering very optimistic assumptions with respect to ceiling height, interior surface reflectances, and furniture build out. Many designers working with deep floor plates will over-glaze the perimeter in an effort to drive light deeper into the building. However this commonly increases glare and contrast to a degree that blinds are deployed continuously to maintain visual comfort. This will defeat the purpose of the glazing and substantially compromise both daylight illuminance and views. A far better option is to glaze the building to provide even distribution of daylight across a realistic daylight depth at lower glass areas and to ensure that occupied areas are situated within reach of a daylight aperture. Rather than trying to "get more light into the building" it is typically more effective to "get more of the building into the light."

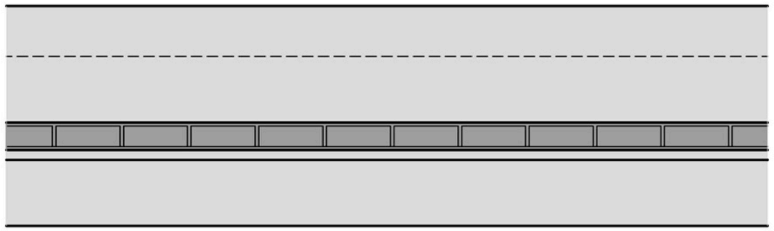
Our case study patterns are based on the Banner Bank Building in Boise, ID. It includes a 40% window to opaque exterior wall ratio with a window head height at 9'-6", a sill height at 3'-0" and a ceiling height at 10'-0". Interior reflectances are roughly 80-50-20 for ceiling, walls, and floors, respectively.



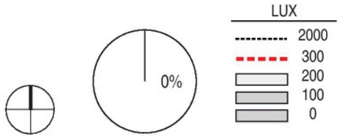
Pattern 3.1-H: *Window Area 10% (Horizontal Band)*

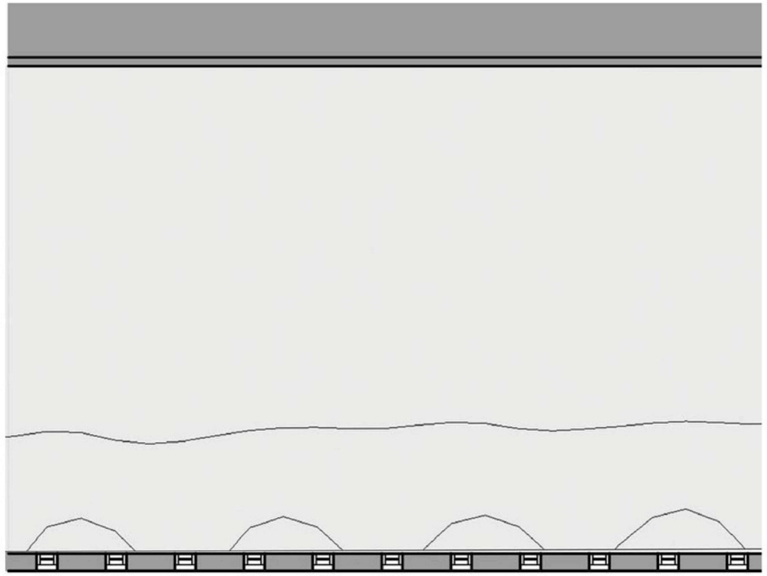
A horizontal band of windows at 10 percent of the opaque wall area provides no area that meets or exceeds commonly accepted minimum daylight illumination criteria. The intense contrast between interior surface and line of sight to the exterior creates an extreme likelihood of glare and visual discomfort. All interior surfaces are dark in relation to the glazing.





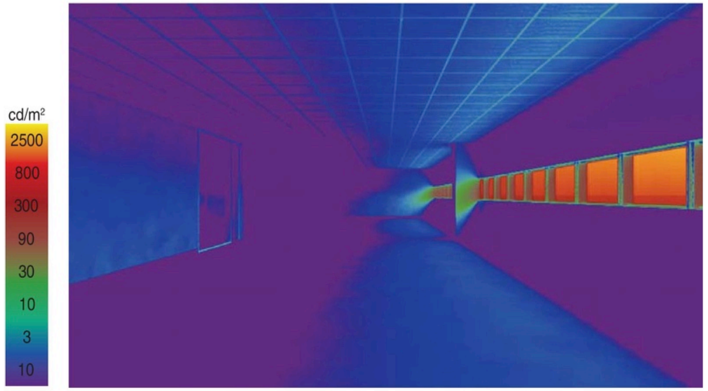
Exterior Wall Elevation

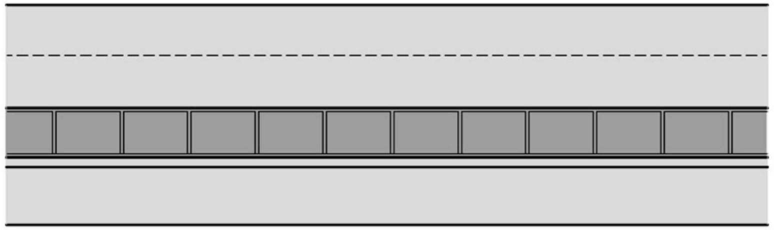




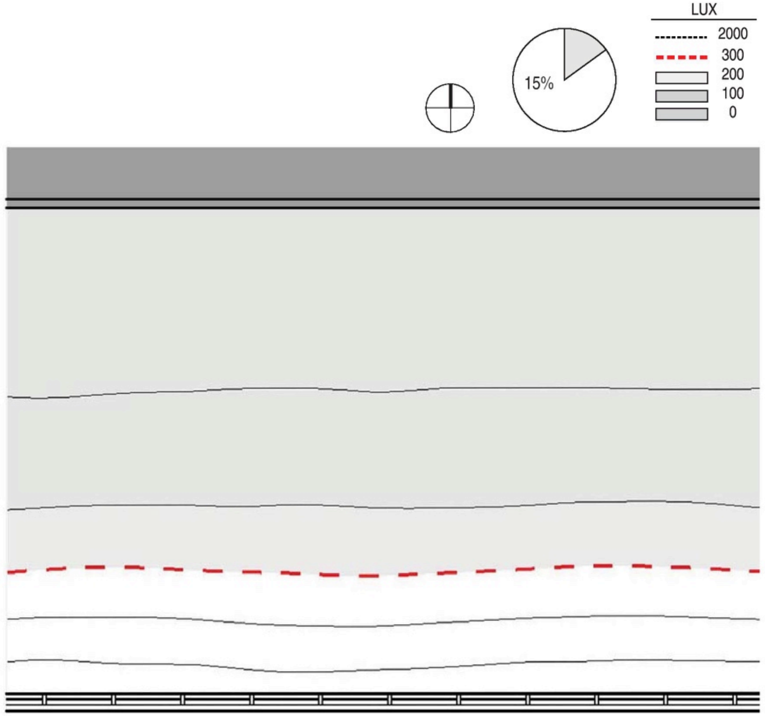
Pattern 3.2-H: *Window Area 20% (Horizontal Band)*

A horizontal band of windows at 20 percent of the opaque wall area provides daylight illumination that meets or exceeds commonly accepted minimum daylight illumination criteria at approximately 15 percent of the adjacent 26’-0” section. A high level of contrast exists between the interior surfaces and the glazing. None of the interior surfaces receive sufficient illumination to balance the contrast of the glazing, this is especially problematic at the interior surfaces surrounding the glazing, creating a likelihood of visual discomfort.



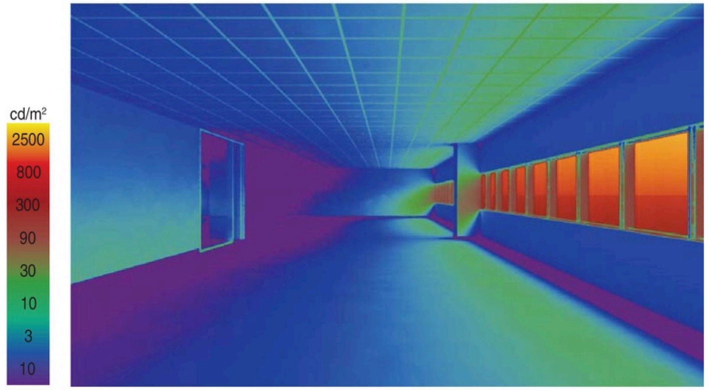


Exterior Wall Elevation

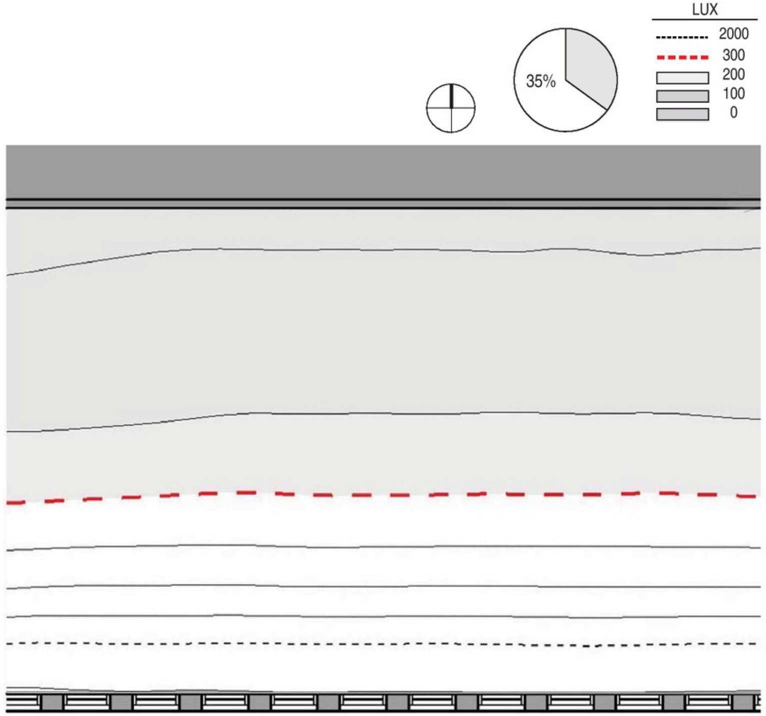


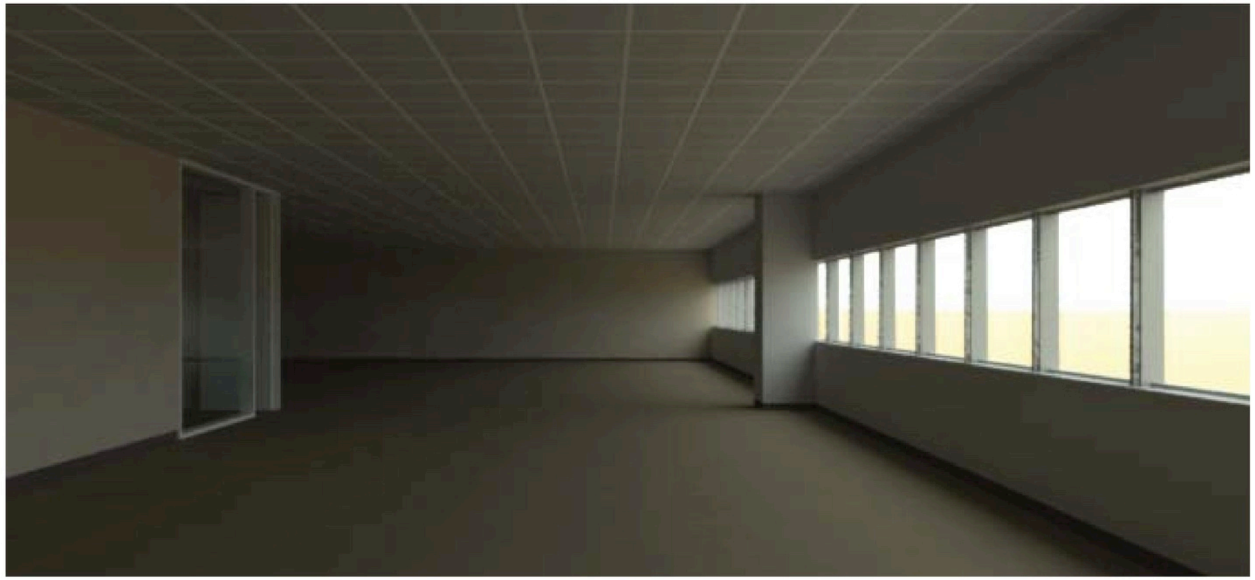
Pattern 3.3-H: *Window Area 30% (Horizontal)*

A horizontal band of windows at 30 percent of the opaque wall area provides daylight illumination that meets or exceeds commonly accepted minimum daylight illumination criteria at approximately 35 percent of the adjacent 26’-0” section. Excessive contrast remains between the interior surfaces and the glazing. The interior surfaces are beginning to receive sufficient some illumination to balance the contrast with the windows. This is most noticeable on the “back” wall (at left).



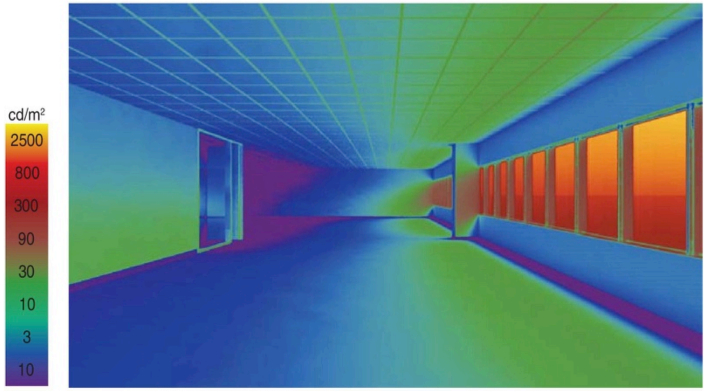
Exterior Wall Elevation

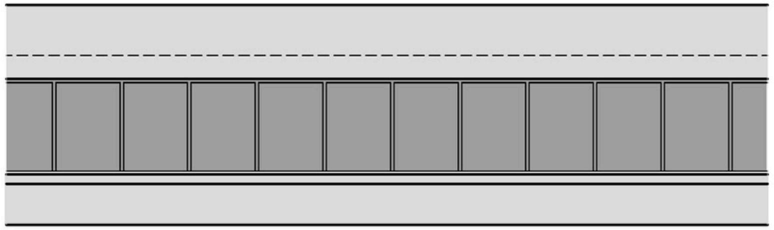




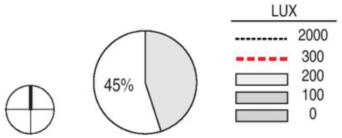
Pattern 3.4-H: *Window Area 40% (Horizontal)*

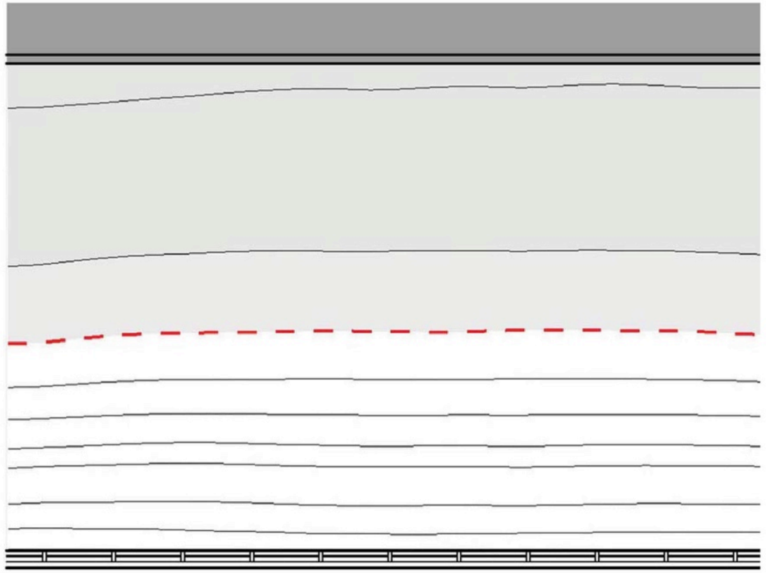
A horizontal band of windows at 40 percent of the opaque wall area provides daylight illumination that meets or exceeds commonly accepted minimum daylight illumination criteria at approximately 45 percent of the adjacent 26'-0" section. Some contrast remains between the interior surfaces and the glazing, though it should be noted that the "back" wall (at left) shows a substantial increase in surface brightness to balance the luminosity across the section.





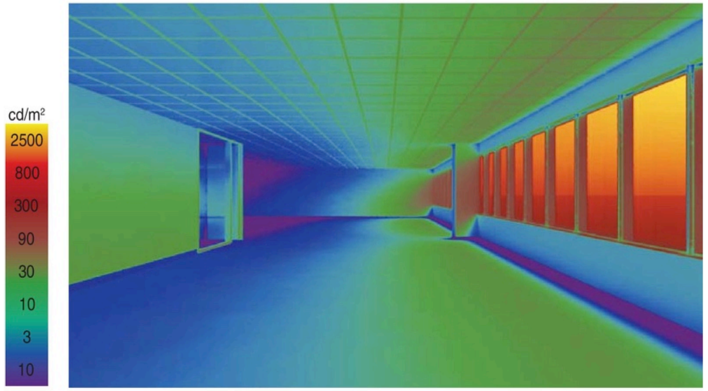
Exterior Wall Elevation

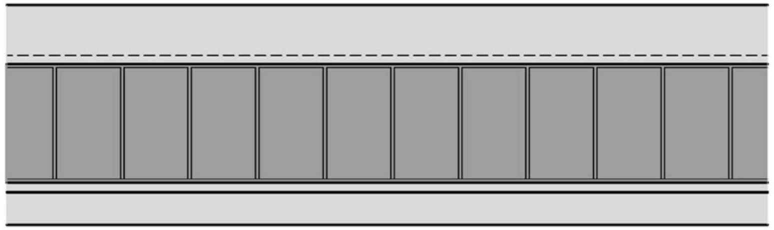




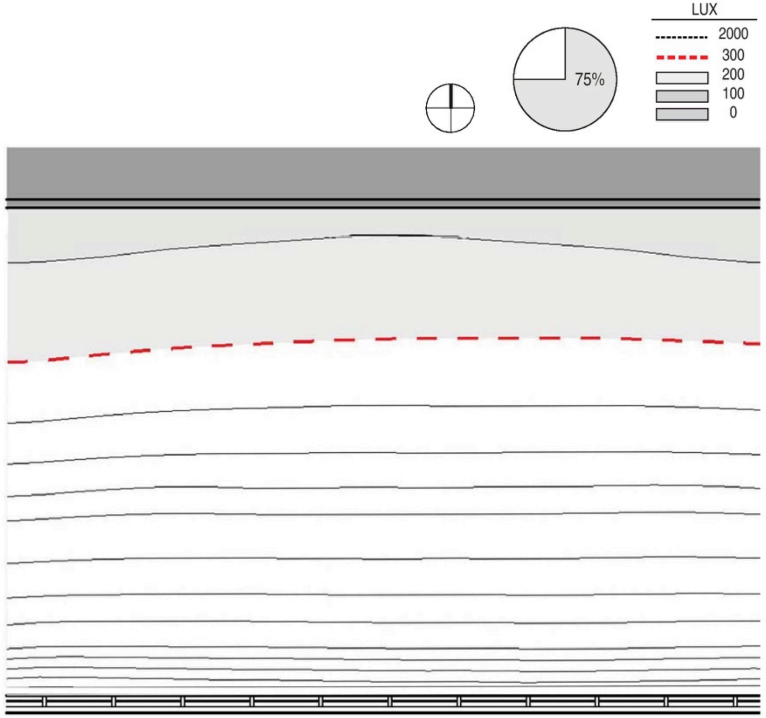
Pattern 3.5-H: *Window Area 50% (Horizontal)*

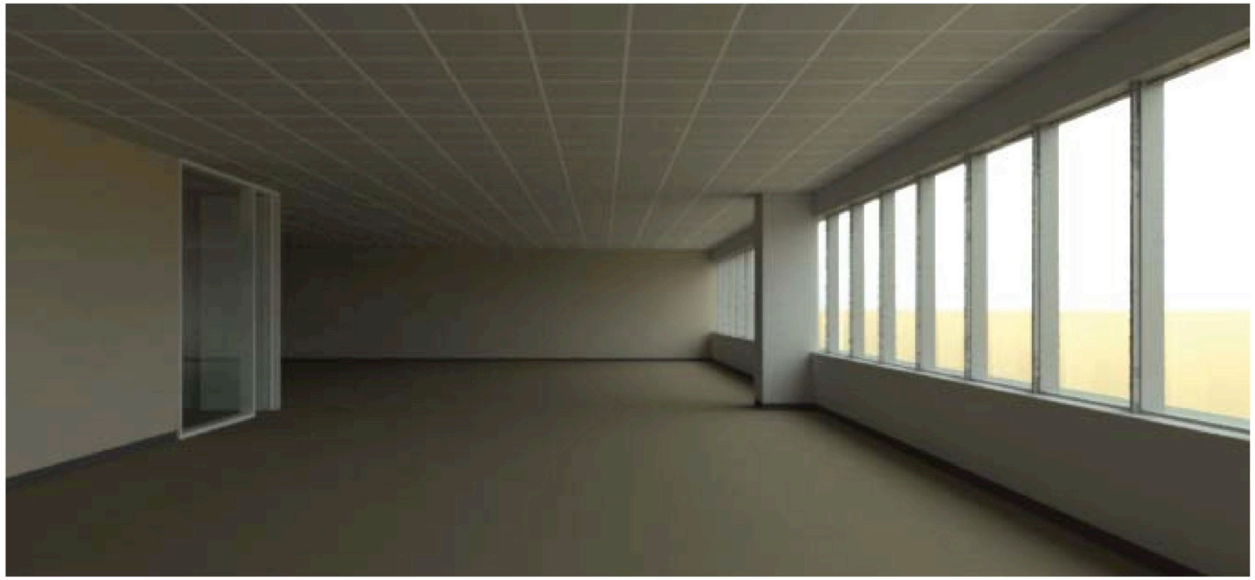
A horizontal band of windows at 50 percent of the opaque wall area provides daylight illumination that meets or exceeds commonly accepted minimum daylight illumination criteria at approximately 80 percent of the adjacent26'-0" section. Some contrast remains between the interior surfaces and the glazing, though the "back" wall (at left) shows a substantial increase in surface brightness to balance the luminosity across the section.





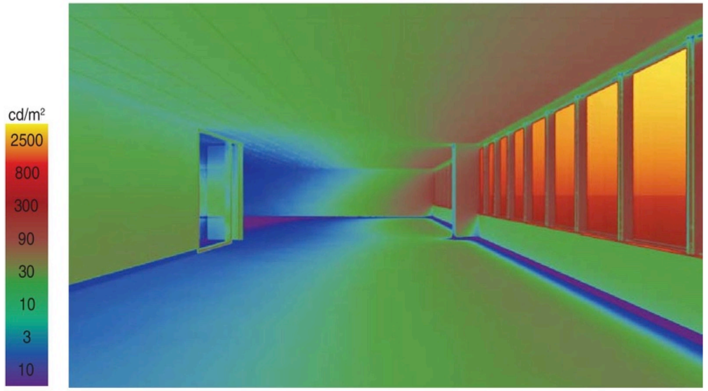
Exterior Wall Elevation

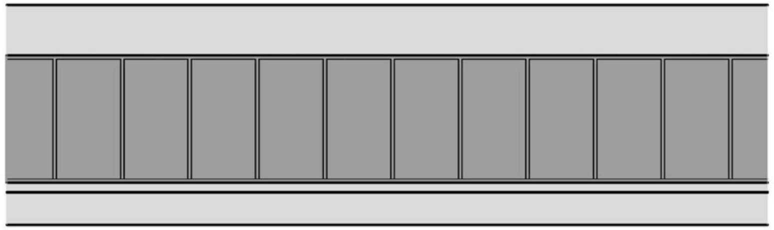




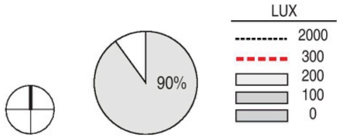
Pattern 3.6-H: *Window Area 60% (Horizontal)*

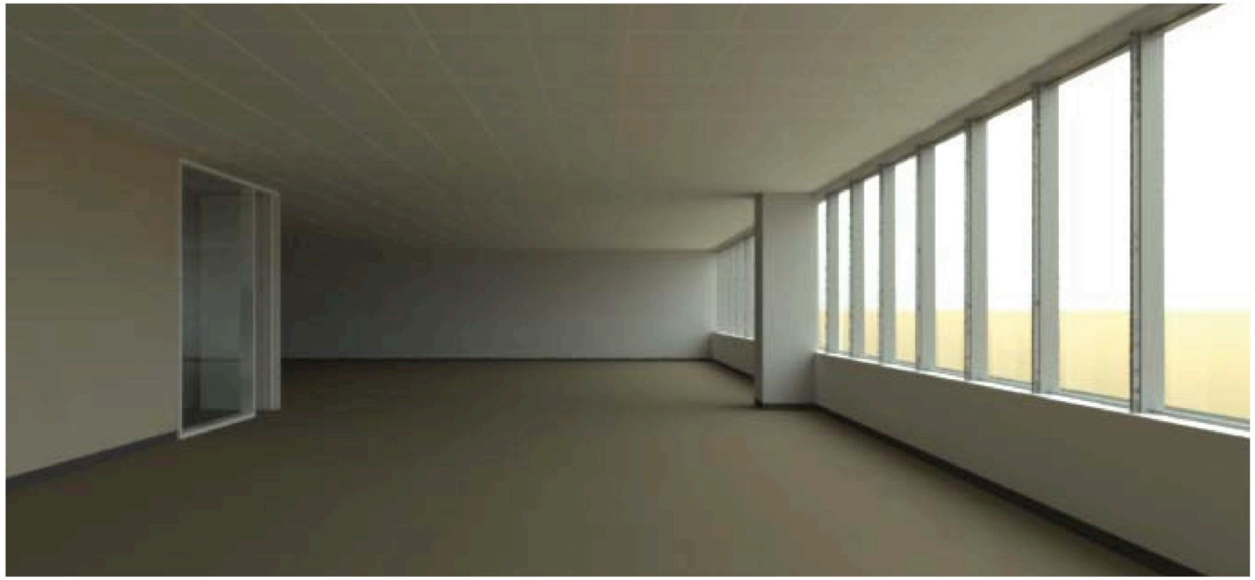
A horizontal band of windows at 60 percent of the opaque wall area provides daylight illumination that meets or exceeds commonly accepted minimum daylight illumination criteria at more than 90 percent of the adjacent 26'-0" section. Minimal contrast remains between the interior surfaces and the glazing, and the brightness of the "back" wall (at left) provides a balance of brightness across the section.

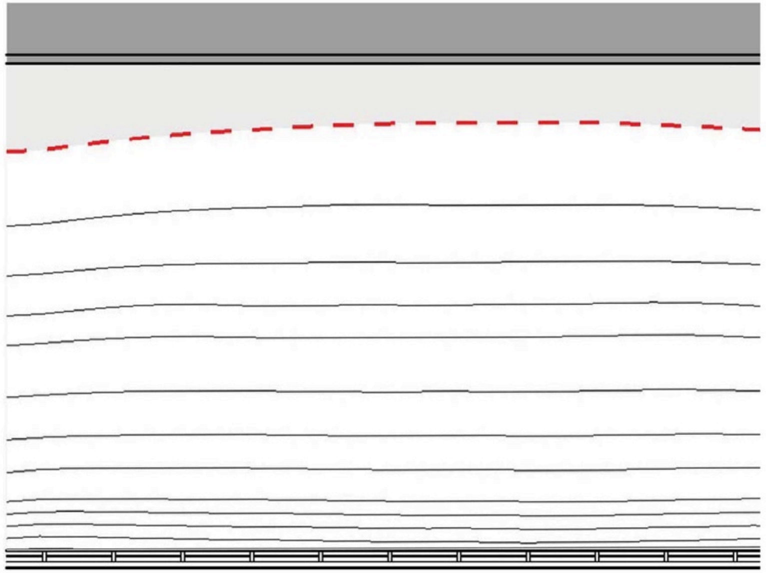




Exterior Wall Elevation

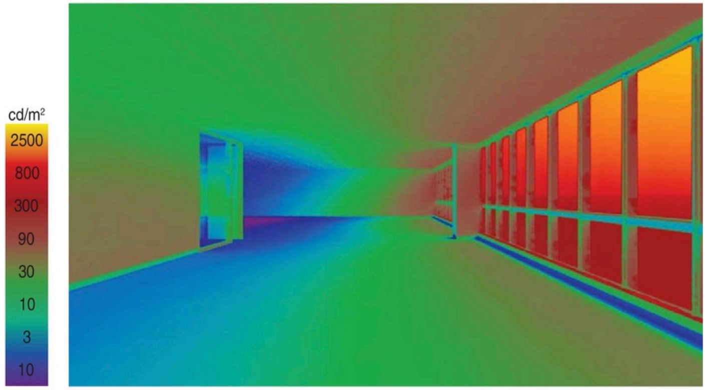


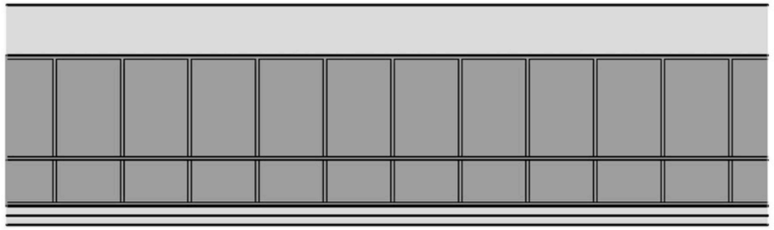




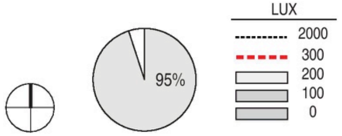
Pattern 3.7-H: *Window Area 75% (Horizontal)*

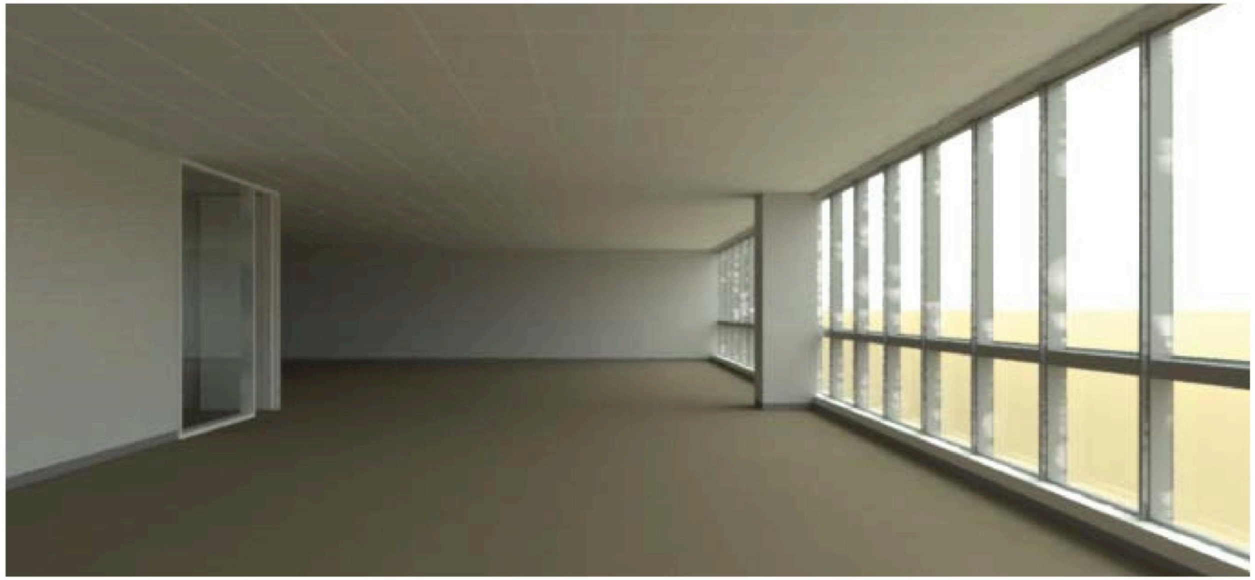
A horizontal band of windows at 75% percent of the opaque wall area (~100% of the interior wall area). provides daylight illumination that meets or exceeds commonly accepted minimum daylight illumination criteria at more than 90 percent of the adjacent 26’-0” section. Minimal contrast remains between the interior surfaces and the glazing, and the brightness of the “back” wall (at left) provides a balance of brightness across the section.

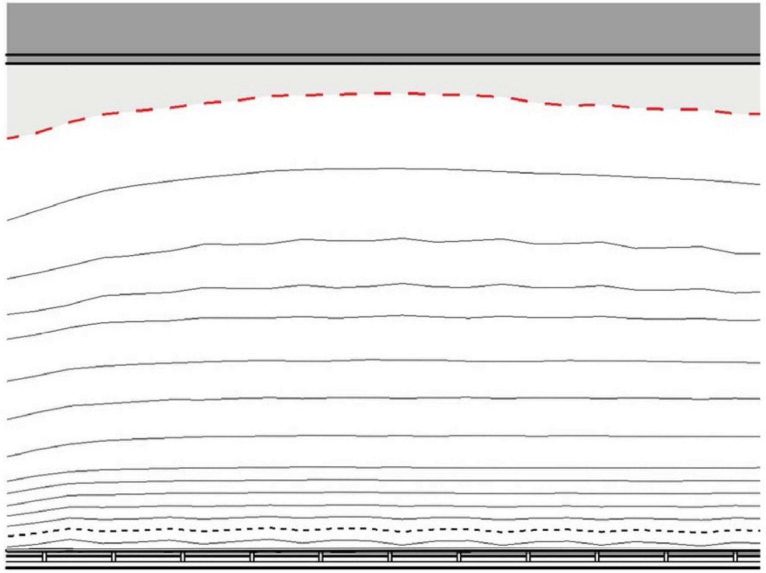




Exterior Wall Elevation







Ecotect

Ecotect 2010

export
materials.rad

export geometry
model.dwg

Rhino

create geometry
model.obj

SketchUp

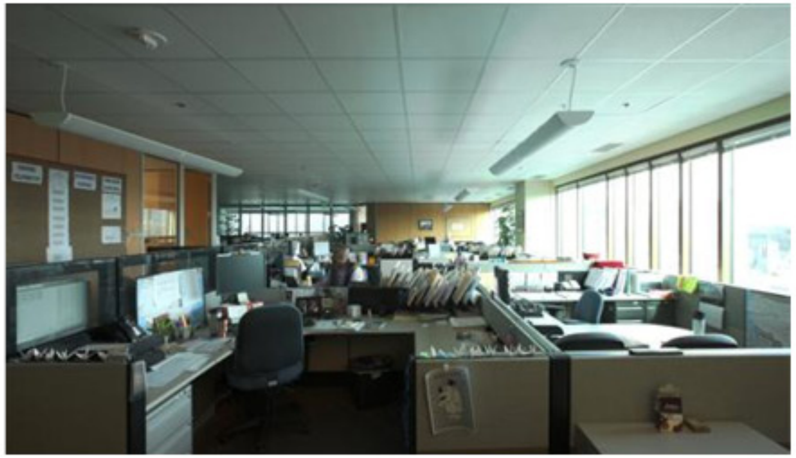
correct window
surface normals

su2Rad

Radiance

Brute force rTrace for
ASE and determination
of 2% blinds trigger

3-phase method for
generation of hourly
annual illumination
plots (sDA)



Pattern 2: Window Area (Horizontal Windows)

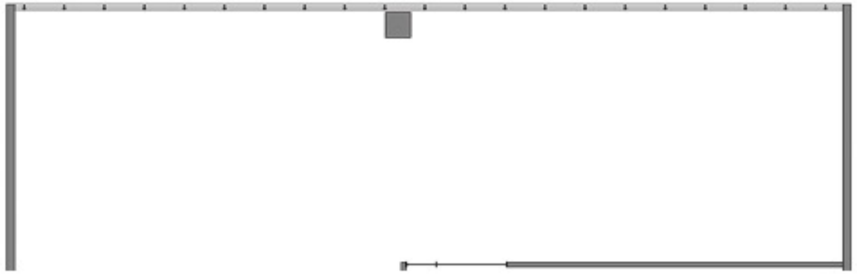
Sidelit Office

This case study pattern is based on the Banner Bank Building in Boise, ID. It includes a 40% window to opaque exterior wall ratio with a window head height at 9'-6", a sill height at 3'-0" and a ceiling height at 10'-0". Interior reflectances are roughly 80%, 50%, and 20% for ceiling, walls, and floors, respectively. Note that a 3'-0" plenum was included for structure and HVAC between floors in the calculation of window to wall area.

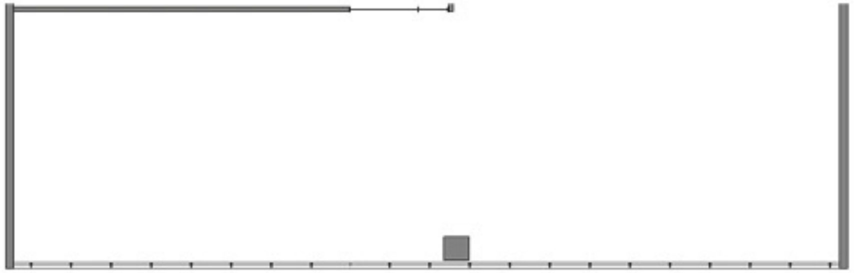
Two orientations of the window wall are explored, north- and south-facing, to better understand the relationship between SDA and ASE as well as the blinds operation.

10% Glass Area
20% Glass Area
30% Glass Area
40% Glass Area
50% Glass Area
60% Glass Area
75% Glass Area

(North & South)



North



South

Annual Sunlight Exposure (ASE)

of floor area at / above 1000Lux for at least 250 hours out of the occupied hours of the year

Preferred	50
Acceptable	100
Nominally acceptable	250
Undesirable	500
Automated blinds should be considered	1000

Spatial Daylight Autonomy (sDA)

% of floor area of floor area at / above 300Lux for at least 50% of the occupied hours of the year above 300 lux

	12
Undesirable	25
Nominally Acceptable Daylight	50
Preferred Daylight	75
Highest Possible Daylight	100

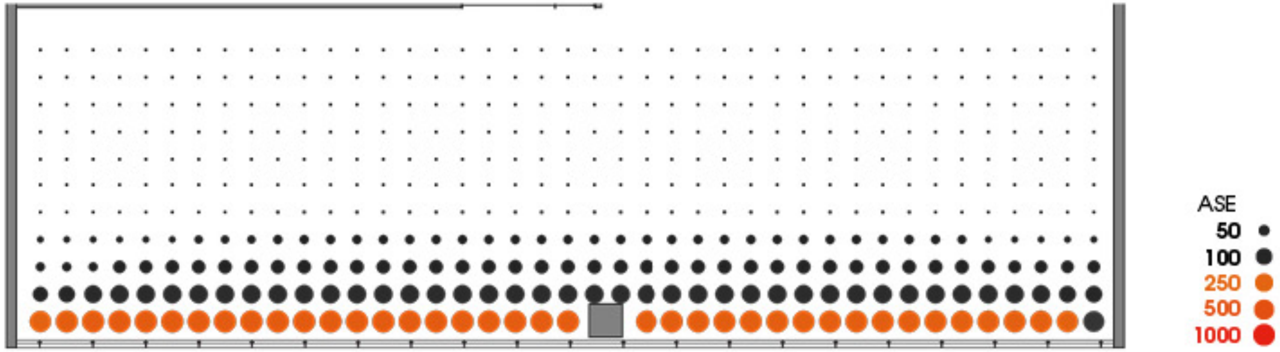
Pattern 2: Window Area (Horizontal Windows)

Sidelit Office

South: 10% Glazing Area

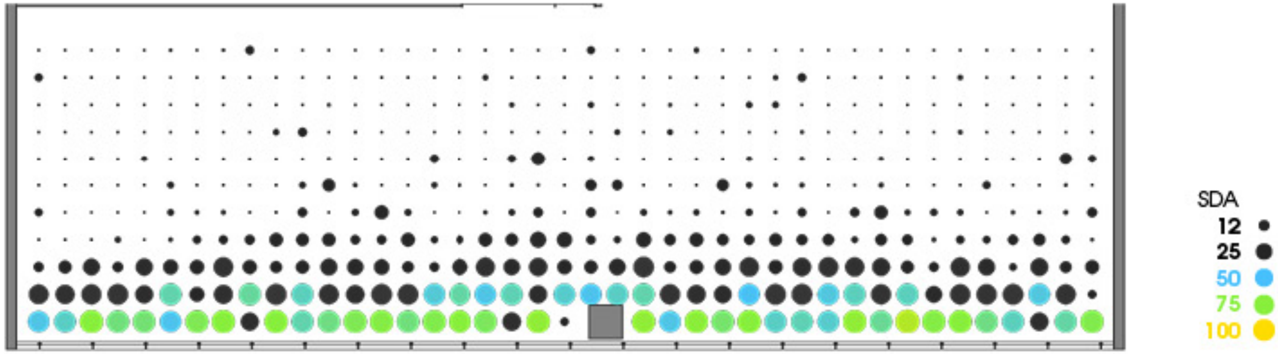
ASE

8.46%
of floor area
above 1000 lux



SDA

11.36%
of floor area
above 300 lux

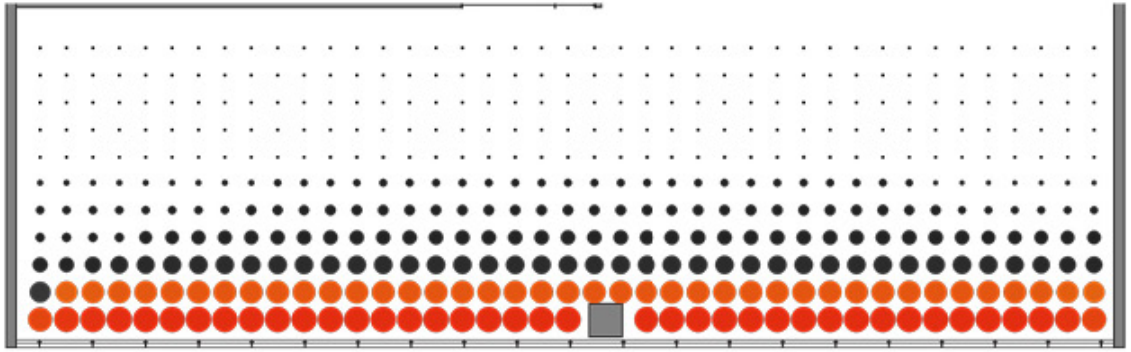


Pattern 2: Window Area (Horizontal Windows)
Sidelit Office

South: 20% Glazing Area

ASE

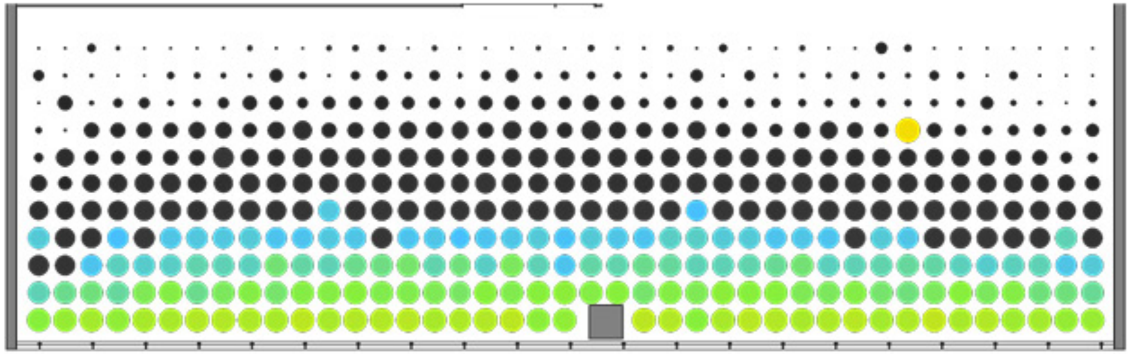
17.59%
of floor area above 1000 lux



ASE
50
100
250
500
1000

SDA

33.18%
of floor area above 300 lux



SDA
12
25
50
75
100

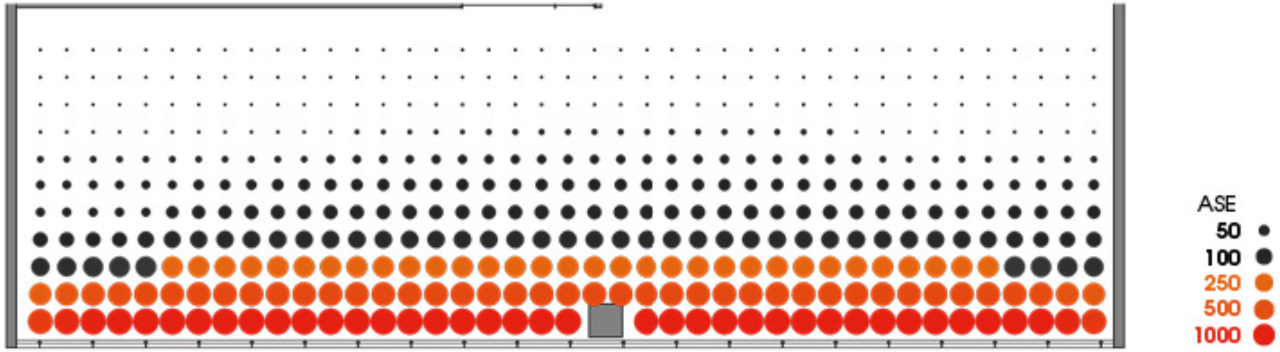
Pattern 2: Window Area (Horizontal Windows)

Sidelit Office

South: 30% Glazing Area

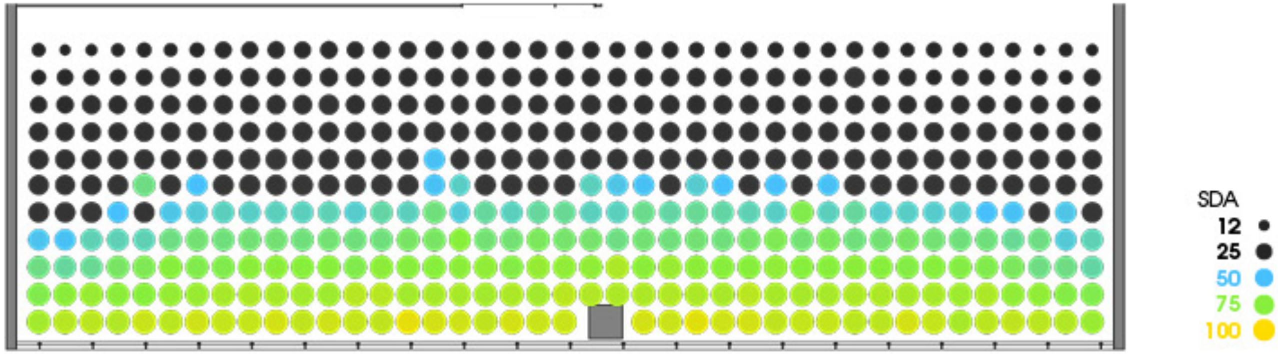
ASE

24.94%
of floor area
above 1000 lux



SDA

46.33%
of floor area
above 300 lux



Pattern 2: Window Area (Horizontal Windows)

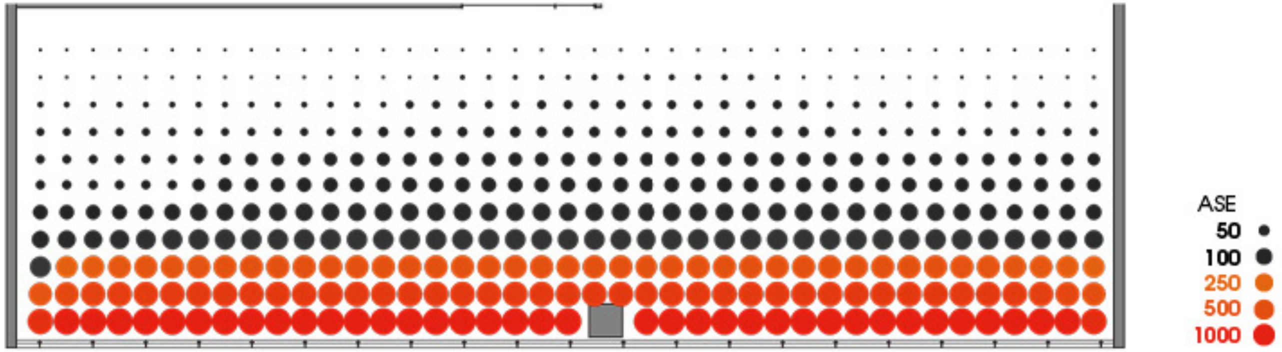
Sidelit Office

South: 40% Glazing Area

ASE

26.73%

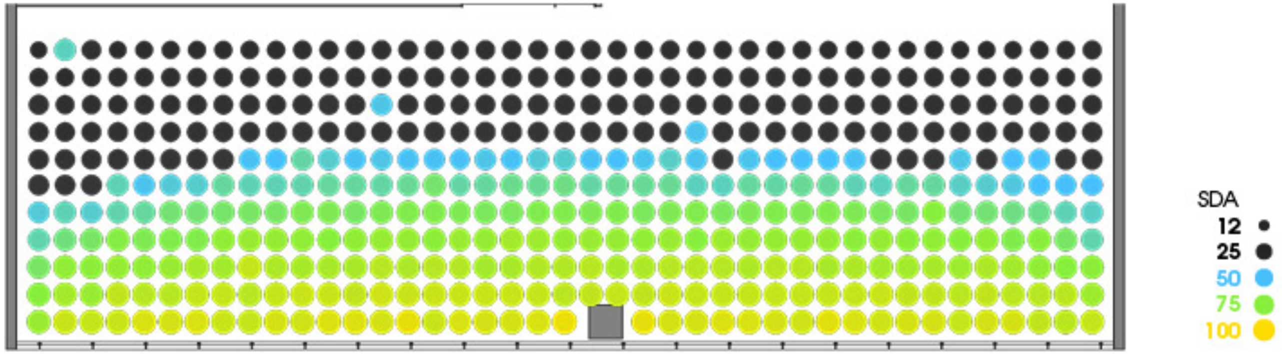
of floor area above 1000 lux



SDA

59.54%

of floor area above 300 lux



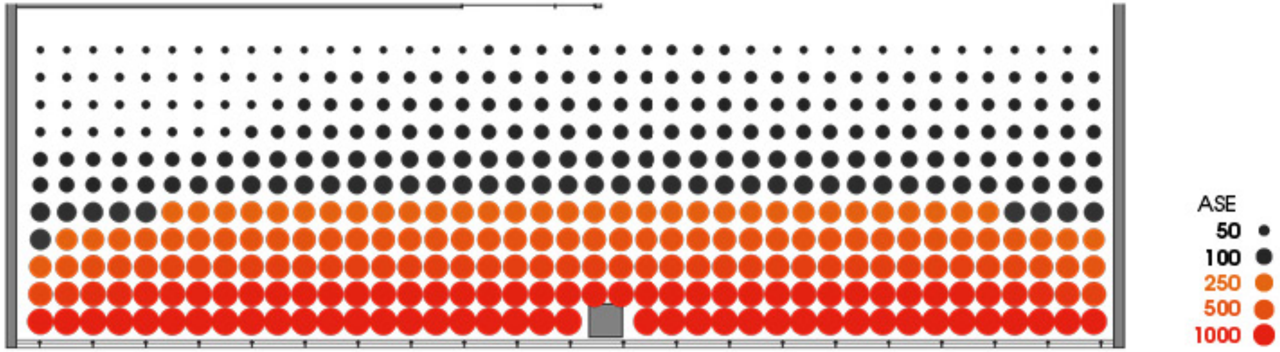
Pattern 2: Window Area (Horizontal Windows)

Sidelit Office

South: 50% Glazing Area

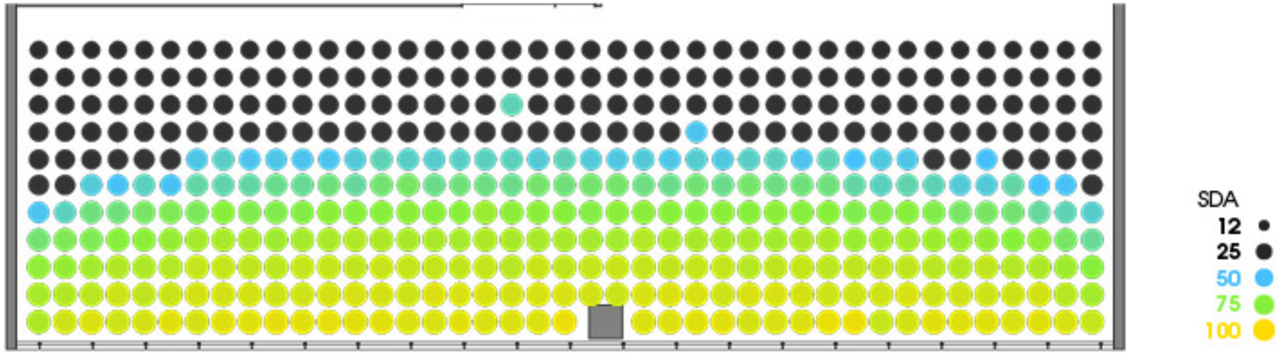
ASE

42.98%
of floor area
above 1000 lux



SDA

60.36%
of floor area
above 300 lux

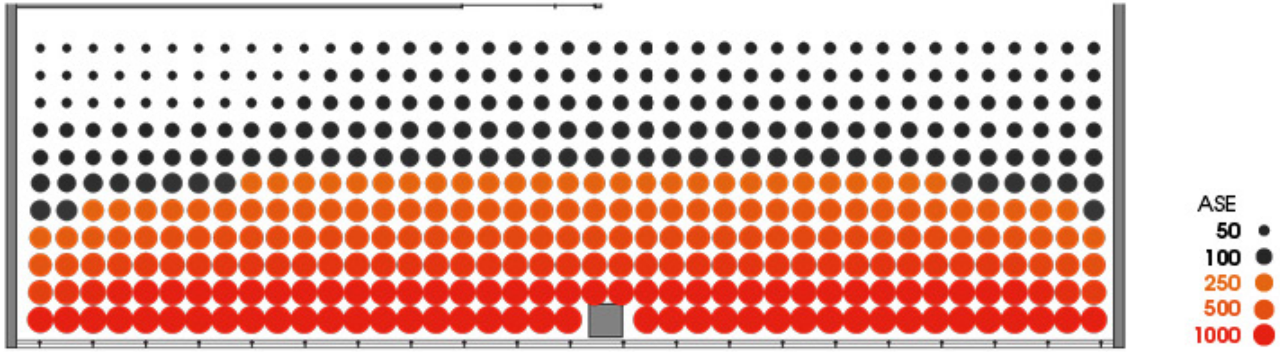


Pattern 2: Window Area (Horizontal Windows)
Sidelit Office

South: 60% Glazing Area

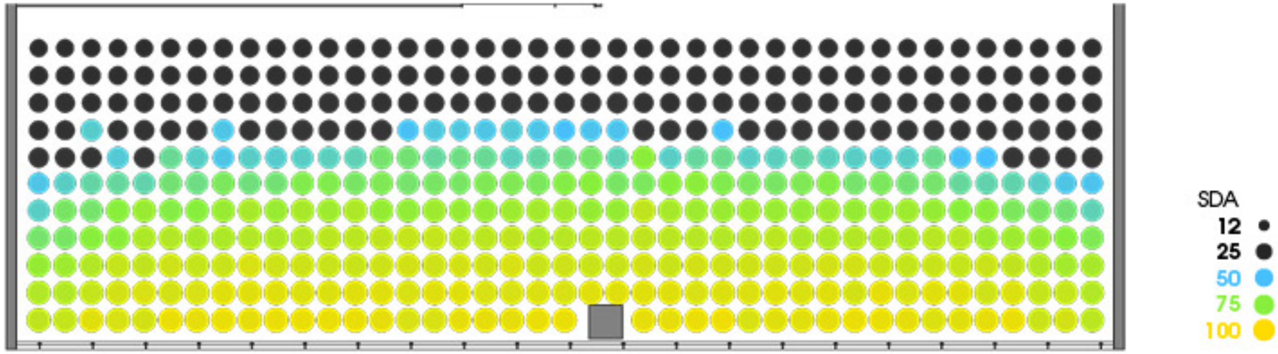
ASE

50.56%
of floor area
above 1000 lux



SDA

64.14%
of floor area
above 300 lux



Pattern 2: Window Area (Horizontal Windows)

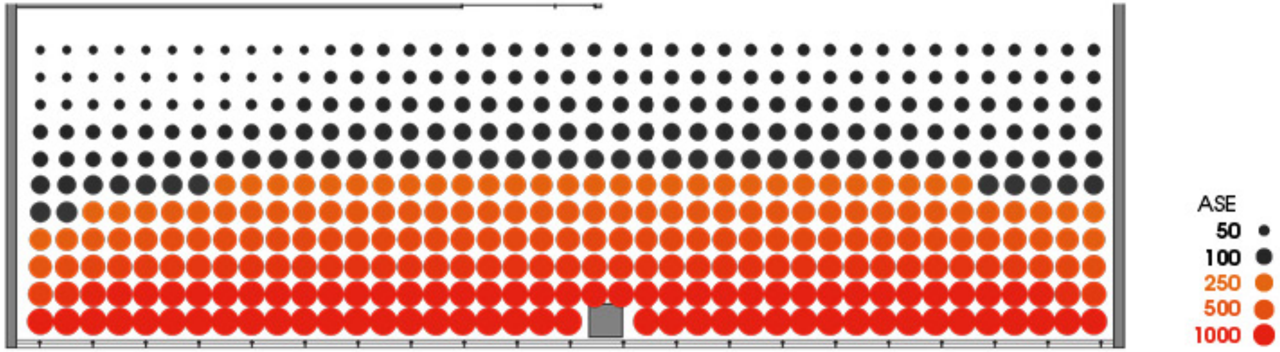
Sidelit Office

South: 75% Glazing Area

ASE

51.22%

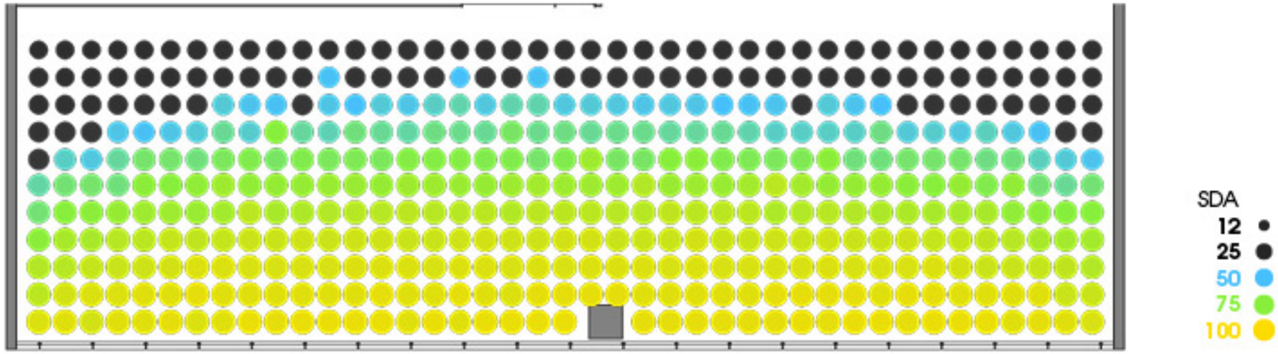
of floor area above 1000 lux



SDA

77.06%

of floor area above 300 lux



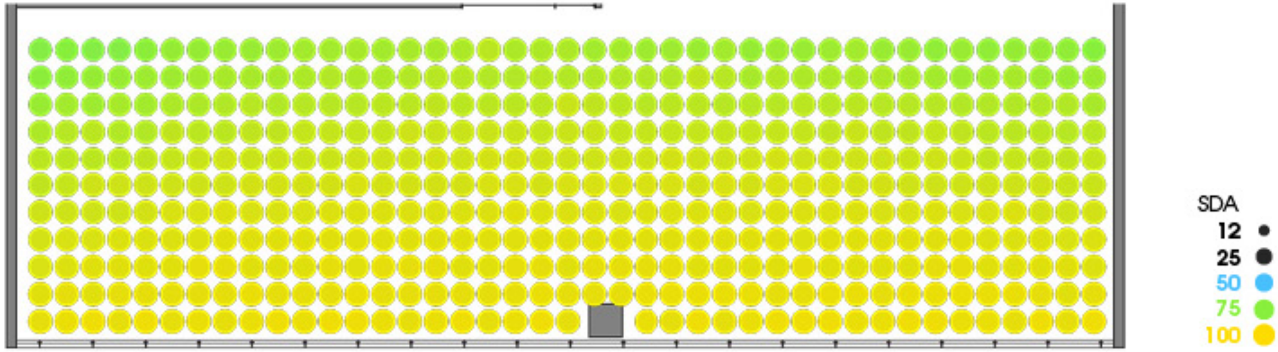
Pattern 2: Window Area (Horizontal Windows)
Sidelit Office

South: 75% Glazing Area

SDA

100%

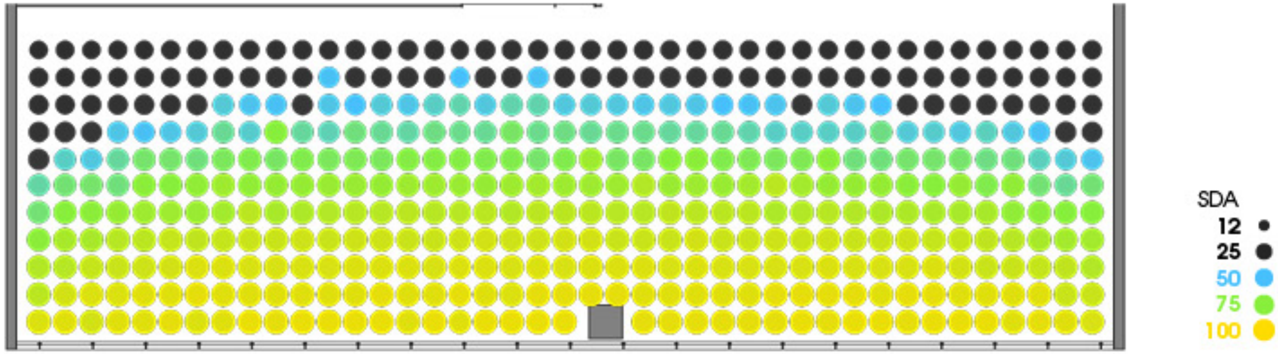
of floor area above 300 lux



SDA

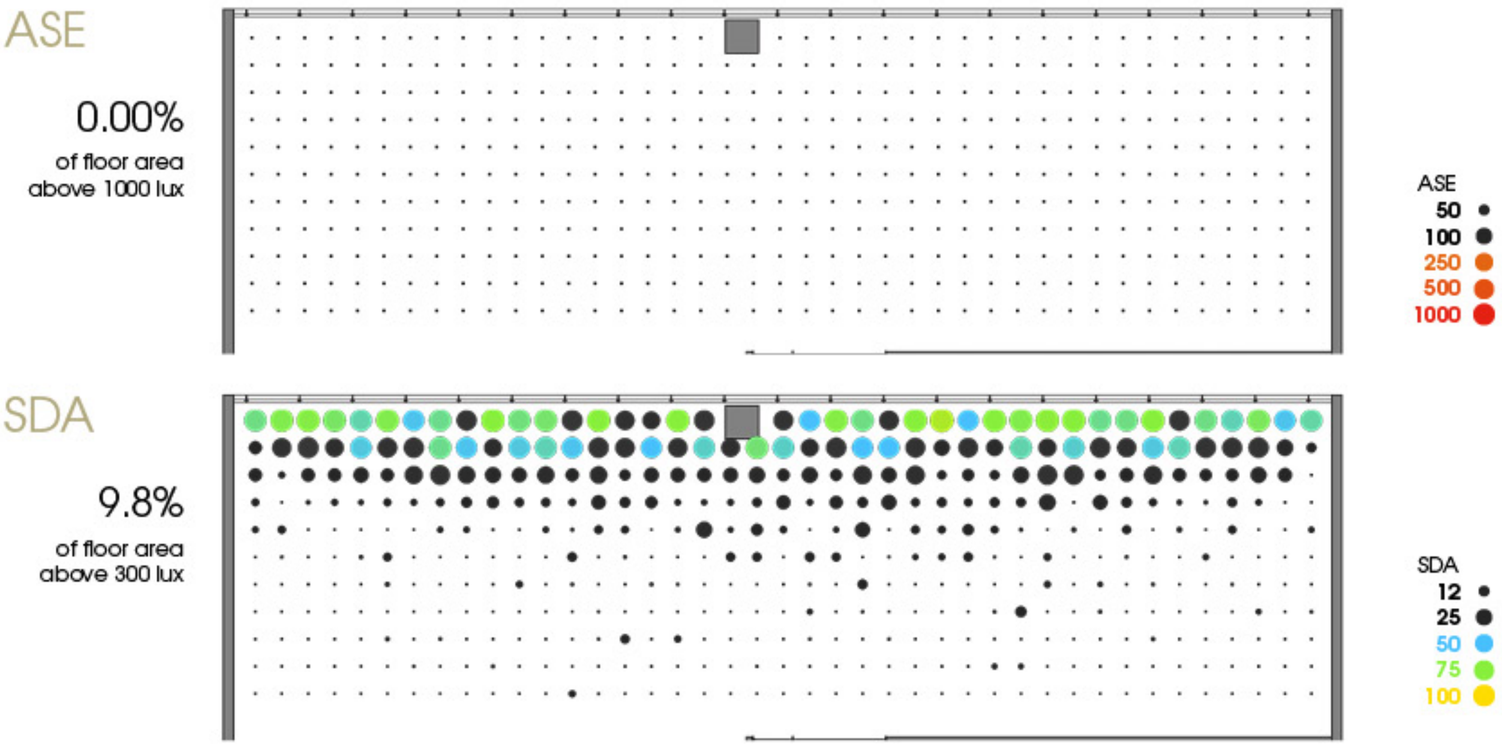
77.06%

of floor area above 300 lux



Pattern 2: Window Area (Horizontal Windows)
Sidelit Office

North: 10% Glazing Area



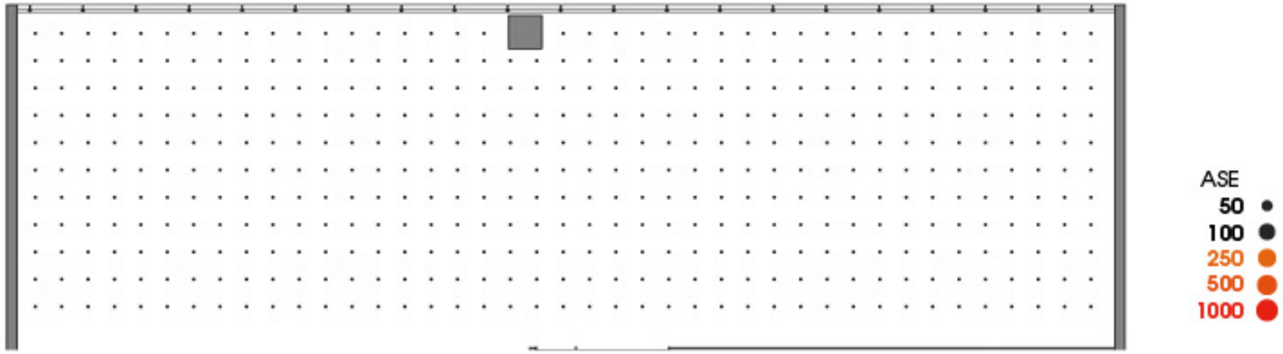
Pattern 2: Window Area (Horizontal Windows)

Sidelit Office

North: 20% Glazing Area

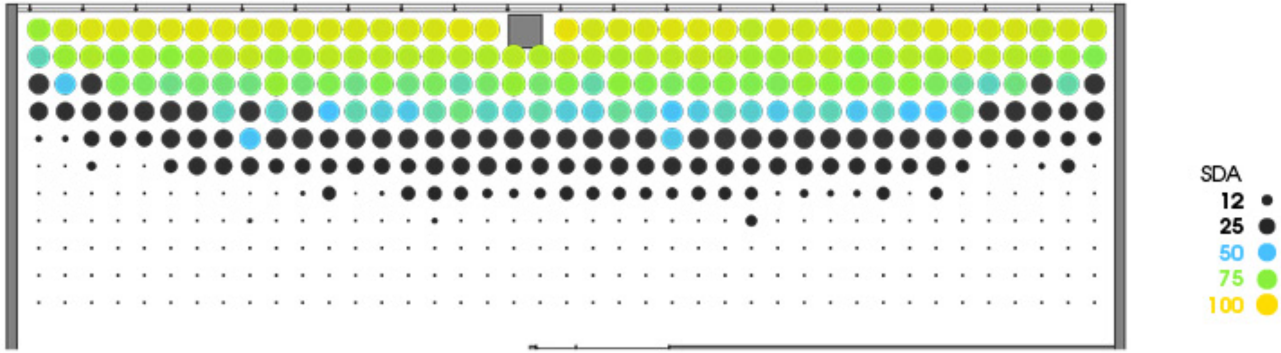
ASE

0.00%
of floor area
above 1000 lux



SDA

32.07%
of floor area
above 300 lux

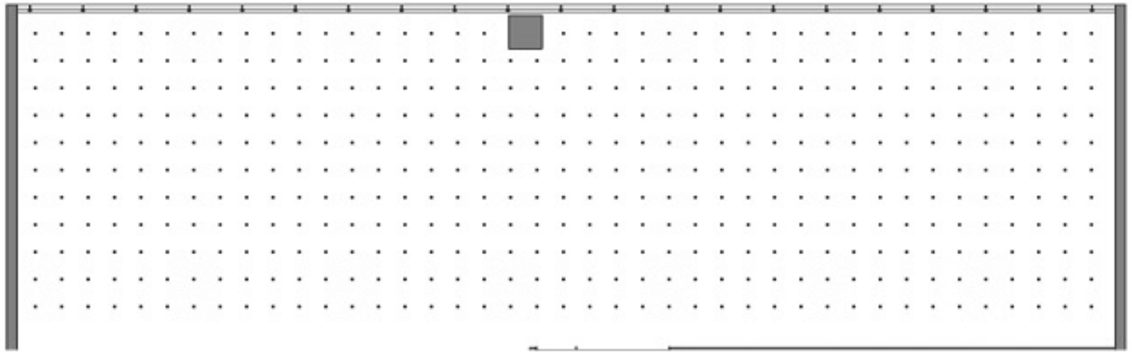


Pattern 2: Window Area (Horizontal Windows)
Sidelit Office

North: 30% Glazing Area

ASE

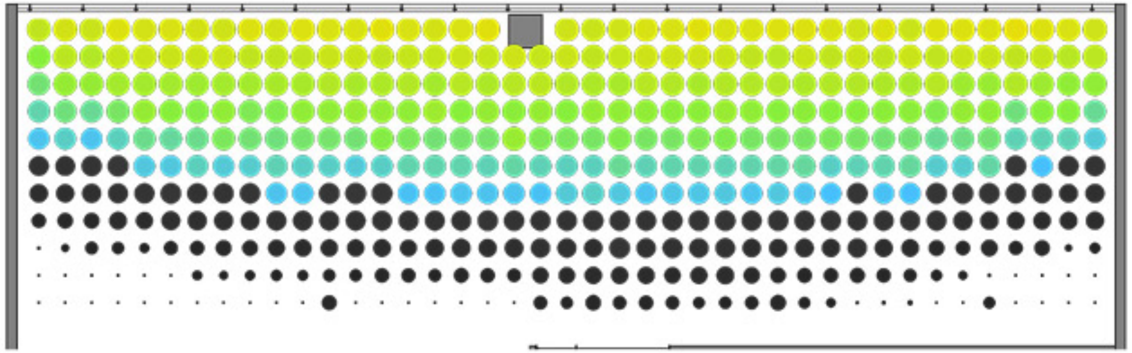
0.00%
of floor area
above 1000 lux



ASE
50
100
250
500
1000

SDA

57.24%
of floor area
above 300 lux



SDA
12
25
50
75
100

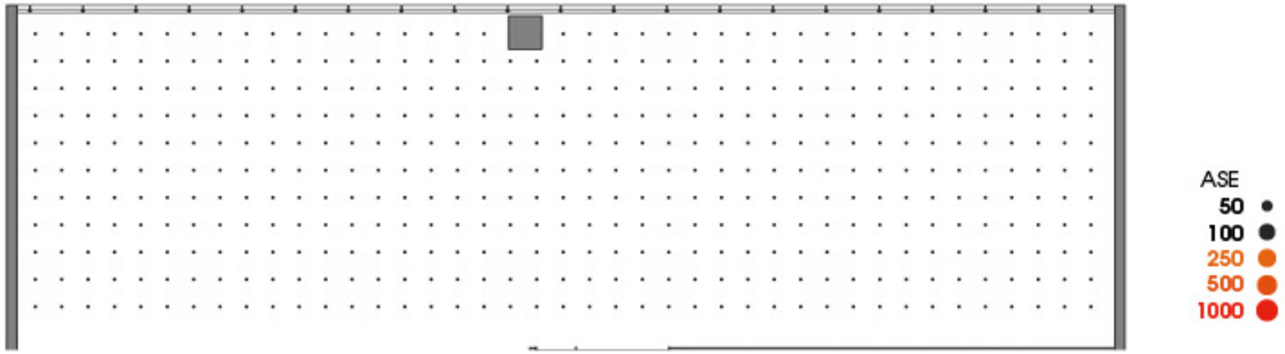
Pattern 2: Window Area (Horizontal Windows)
Sidelit Office

North: 40% Glazing Area

ASE

0.00%

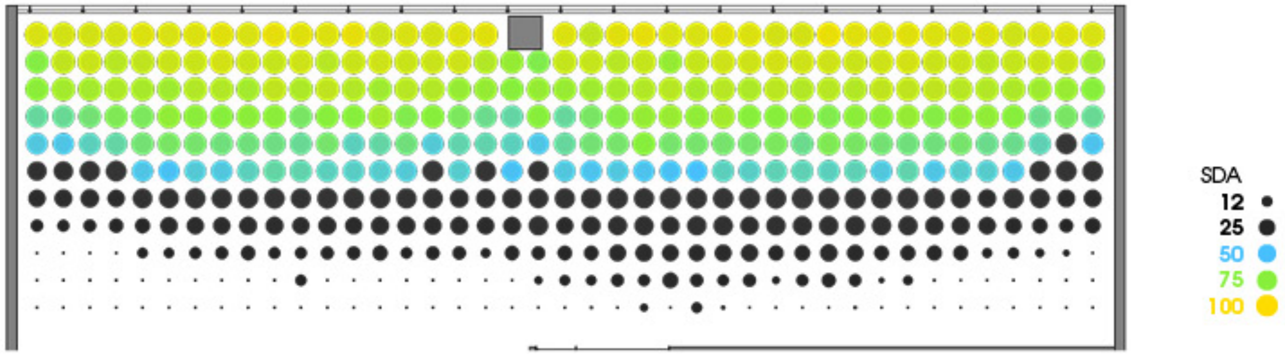
of floor area above 1000 lux



SDA

51.89%

of floor area above 300 lux



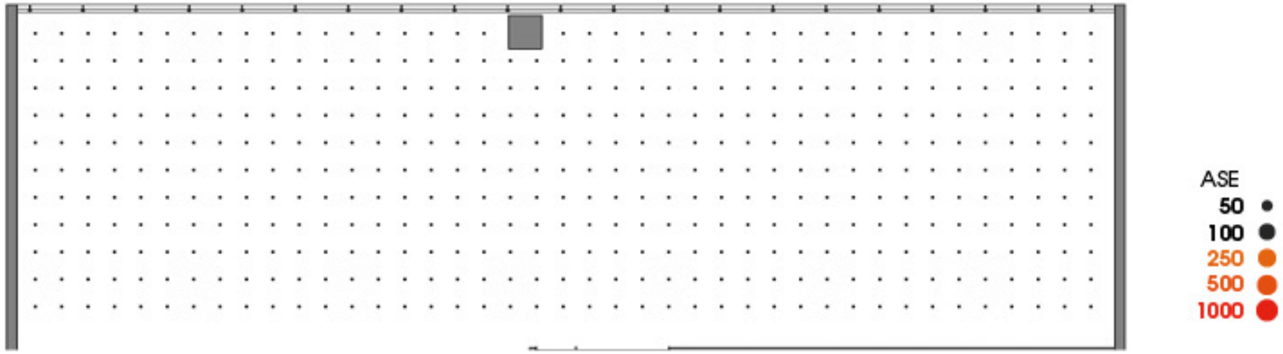
Pattern 2: Window Area (Horizontal Windows)

Sidelit Office

North: 50% Glazing Area

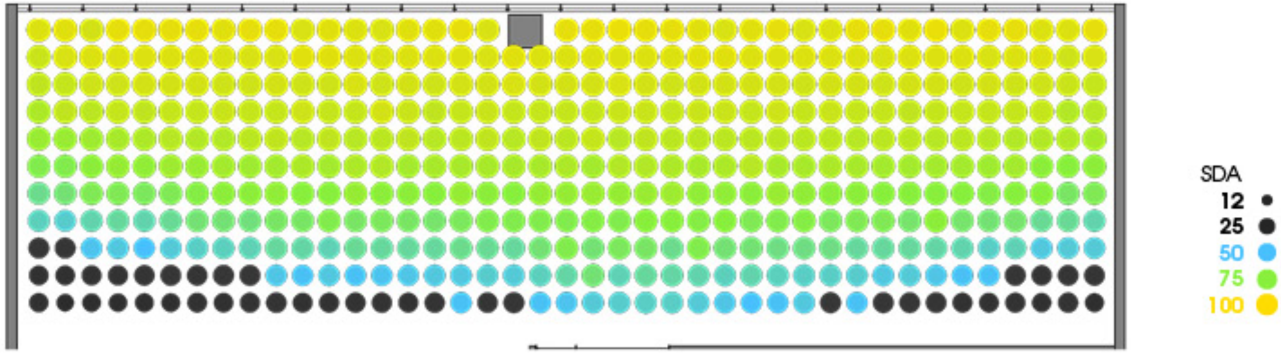
ASE

0.00%
of floor area
above 1000 lux



SDA

90.42%
of floor area
above 300 lux



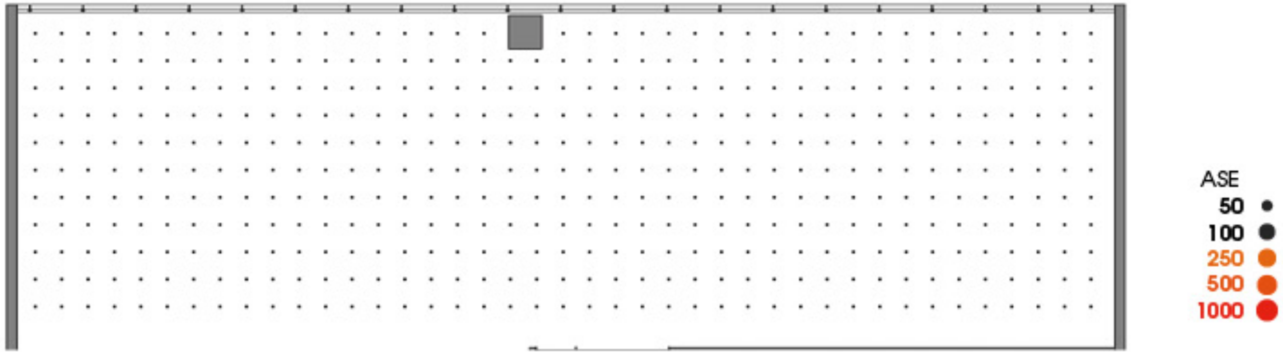
Pattern 2: Window Area (Horizontal Windows)

Sidelit Office

North: 60% Glazing Area

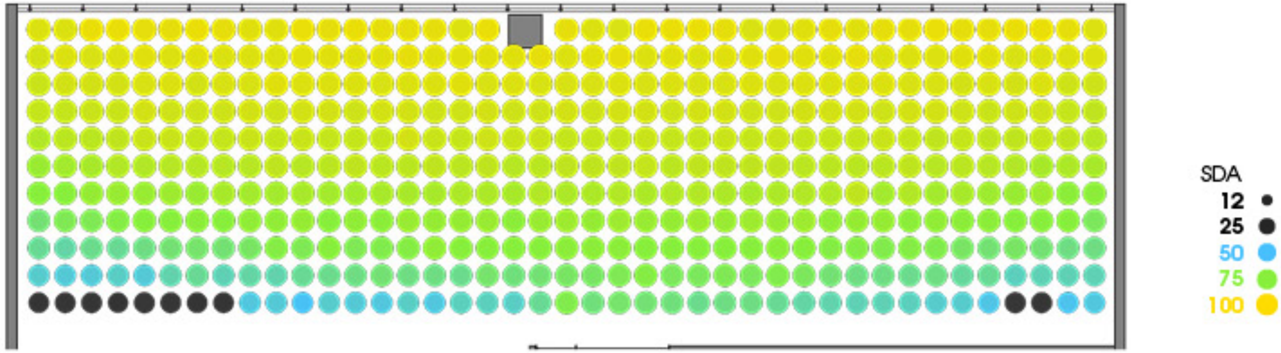
ASE

0.00%
of floor area
above 1000 lux



SDA

97.77%
of floor area
above 300 lux



Pattern 2: Window Area (Horizontal Windows)

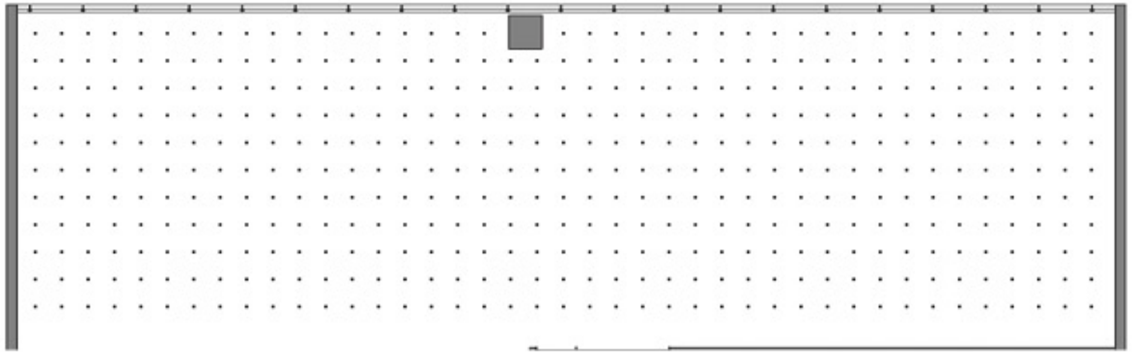
Sidelit Office

North: 75% Glazing Area

ASE

0.00%

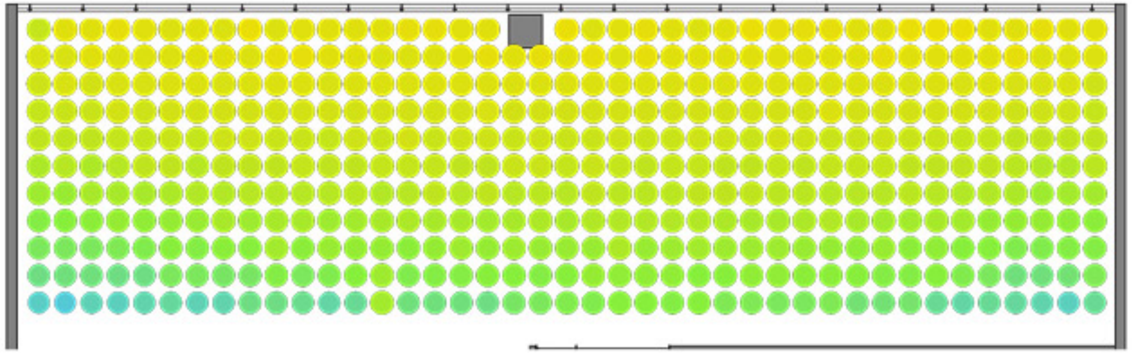
of floor area
above 1000 lux

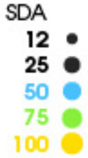


SDA

100%

of floor area
above 300 lux

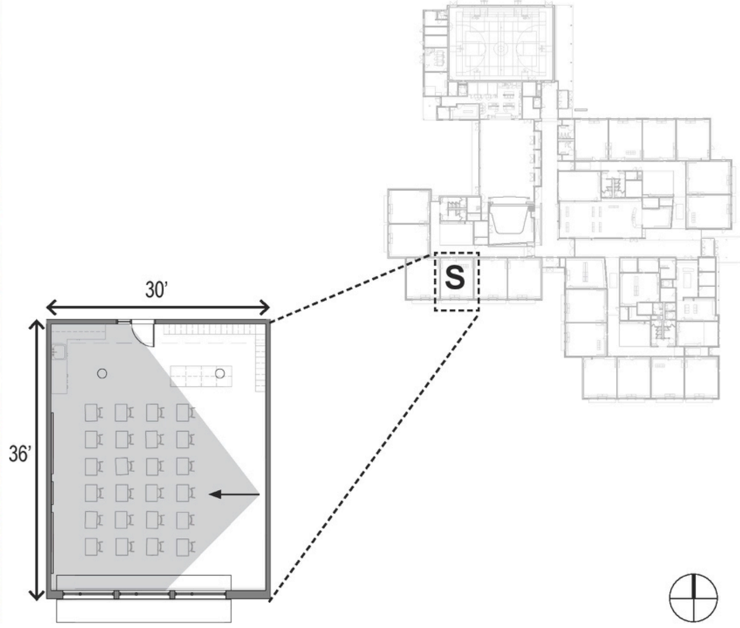


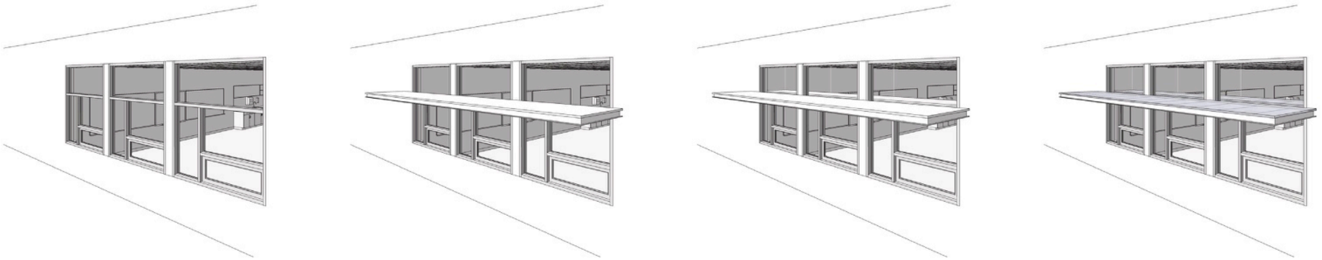


Pattern 18: Fixed Building Shading

Fixed Classroom Shading - South Facade

Ash Creek Elementary: Monmouth, OR





No Shading

Horizontal Shading Device

Horizontal Shading Device + Light Shelf (As Built)

Translucent Horizontal Shading Device + Translucent Light Shelf

Overview

In almost every climate, control of direct sun penetration is a key design criterion in order to avoid unwanted heat gain and excessive glare. While operable blinds can be very effective at minimizing glare if used properly, they are only marginally effective at minimizing heat gain. Furthermore, blinds are often simply left closed far more than is necessary if they are not motorized. External motorized blinds, operated with some form of automation system can be extremely effective at minimizing both heat gain and glare, however including these devices is often not feasible due to cost or other limitations. Fixed architectural shading strategies, such as exterior overhangs, vertical fins and interior lightshelves can serve to minimize both heat gain and glare and greatly reduce the number of hours per year that manually operable blinds are required.

This pattern analysis explores the effect of basic fixed architectural shading strategies on glare, daylight availability and very high illumination levels. The case study used to examine these design alternatives is Ash Creek Elementary School in Monmouth, OR. It is a one-story school building designed by BOORA Architects. This pattern sequence highlights simulations under sunny sky and overcast sky conditions during September at noon with workplane illumination data represented in lux. Classroom ambient lighting criteria range from 300-500 lux and 300 lux was selected as one of the daylighting design criterion examined herein. The percentage of floor area above this value is presented for each permutation. For permutations shown under a sunny sky, the percent of the floor area above 2,000 lux is also noted as a means of illustrating the amount of direct sun penetration and potential for unwanted heat gain. It is important to note however, that illuminace values often have very little to do with heat gain. Furthermore illuminace values have little to do with human perception of glare, and the luminance maps are more useful in this assessment.

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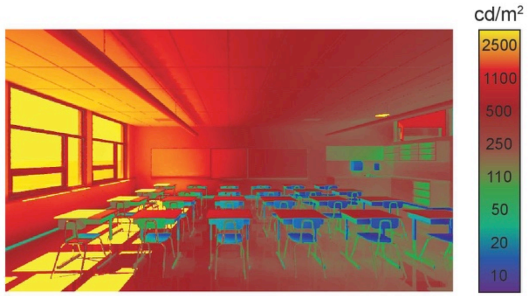
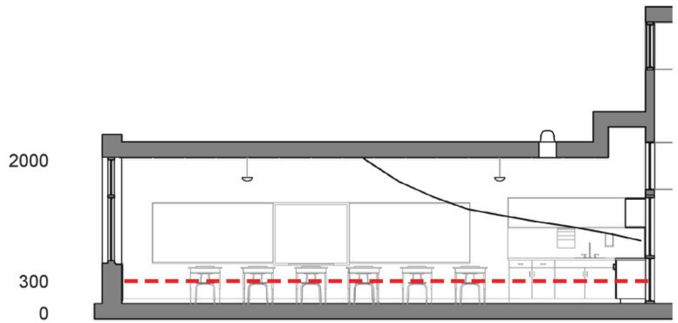
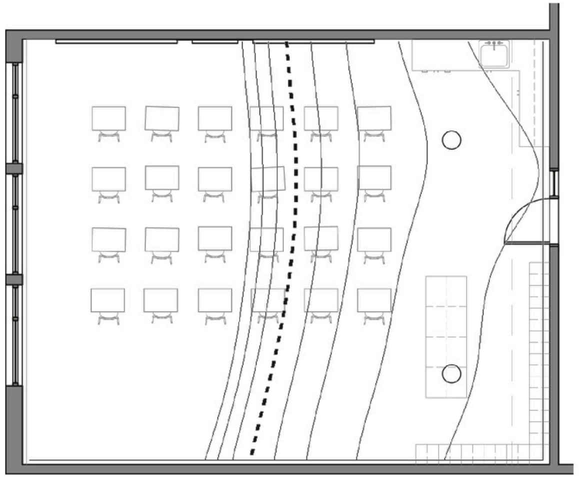
Pattern 18: Fixed Building Shading

South Sunny: No Shading

This sequence uses a south classroom under a sunny sky at noon in September. In this step there is no shading shown and the sun penetrates onto the floor and onto the first row of desks near the perimeter. This would likely result in all blinds being closed and unwanted heat gain. It is also likely to mean that a seated student would see the disc of the sun causing glare. Furthermore, In the morning, the sun would strike the white board and cause veiling glare for all students in the room. Almost the entire floor area (99%) is above 300 lux and over 40% is above 2,000 lux.



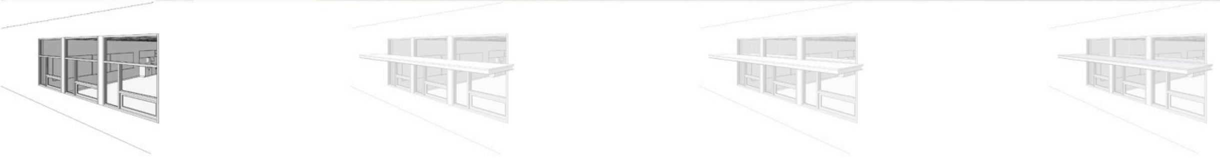




41%
of floor area is above 2000 lux

99%
of floor area is above 300 lux

LUX	
black dashed line	2000
red dashed line	300
	200
	100
	0



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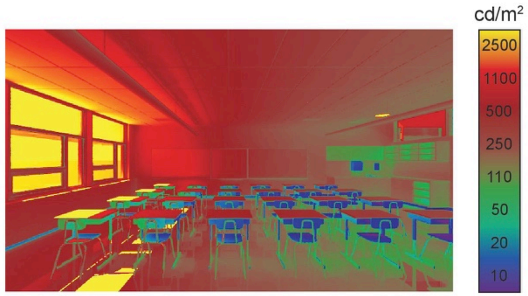
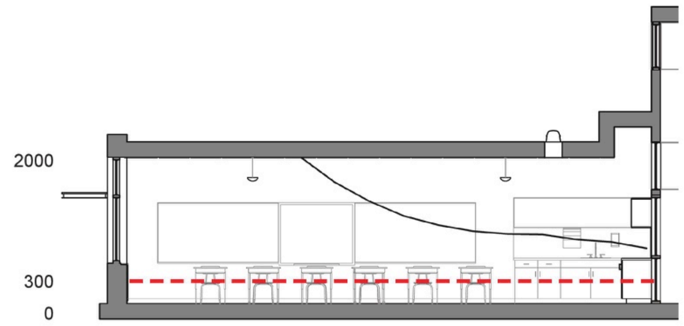
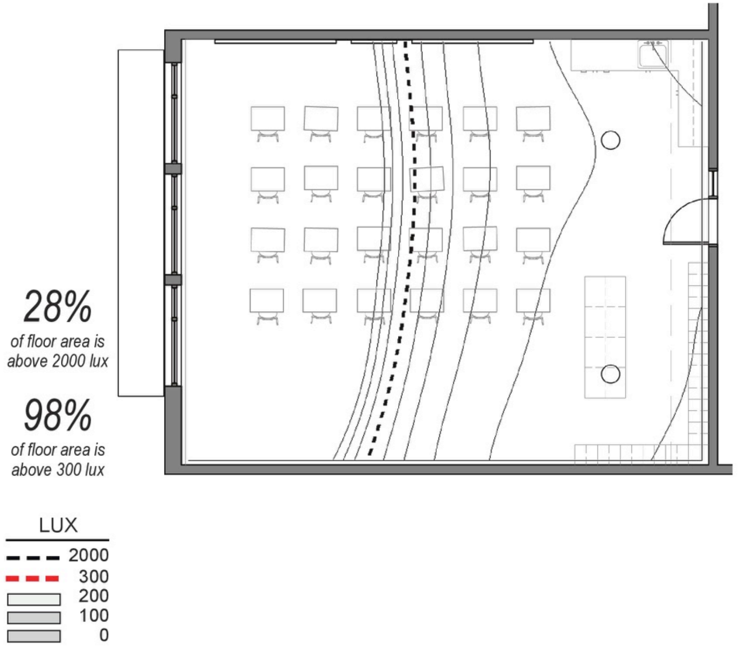
Pattern 18: Fixed Building Shading

South Sunny: Horizontal Shading Device

In this step an opaque exterior overhang is added and was sized to be about as deep as the window it is trying to shade is tall. This 1:1 ratio is a good rule of thumb for shading windows on the south façade located near 45-degrees latitude from March through September. The sun nearest the south façade is no longer on the floor, however the same problem persists on the desks as the previous step. Almost the entire floor area (98%) is above 300 lux and the area above 2,000 lux dropped from 41% to 28%, a marked improvement.







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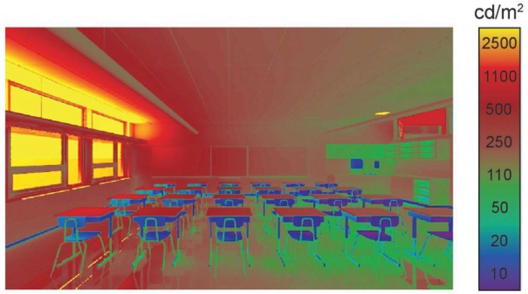
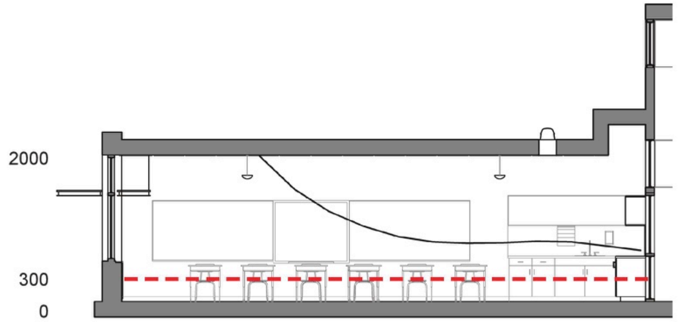
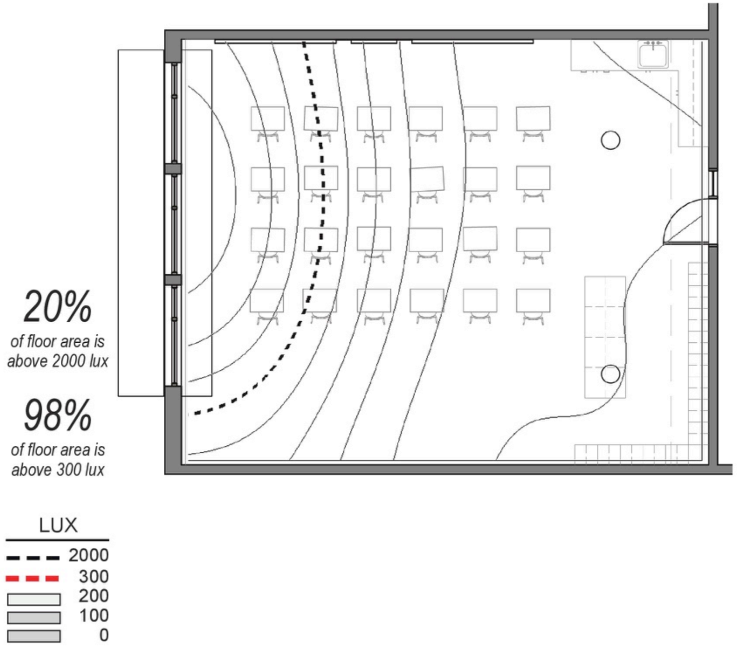
Pattern 18: Fixed Building Shading

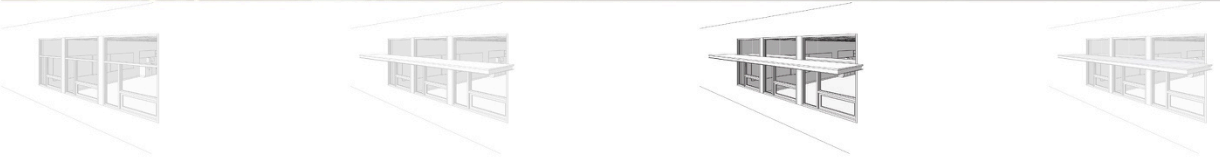
South Sunny: Horizontal Shading Device + Light Shelf

In this step an opaque interior lightshelf is added was sized to be about as deep as the window it is placed beneath is tall. This 1:1 ratio is a good rule of thumb for shading windows on the south façade located near 45-degrees latitude from March through September. The sun that was falling on the desks is now eliminated and there is no sun penetration in the room. Note that the heat gain from the upper 'daylight' window, below which the lightshelf is placed, still enters the room, however glare is greatly reduced throughout the space. The lightshelf bounces light onto the ceiling and reduces the contrast at the perimeter window. Almost the entire floor area (98%) remains above 300 lux and the area above 2,000 lux dropped from 28% to 20%.









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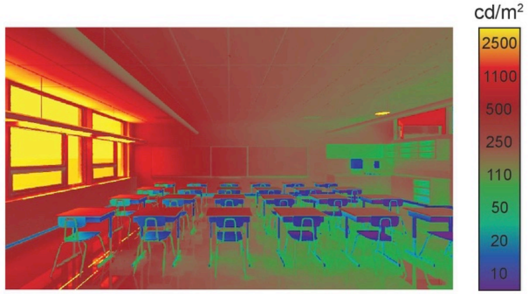
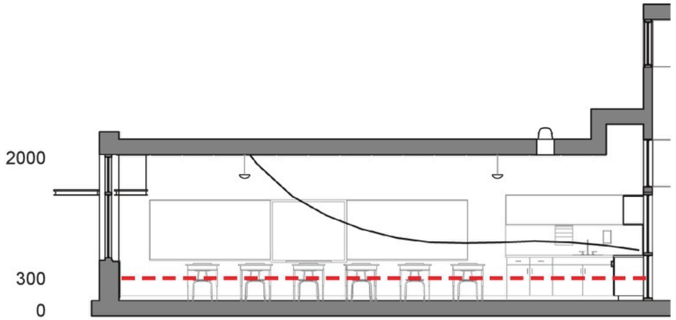
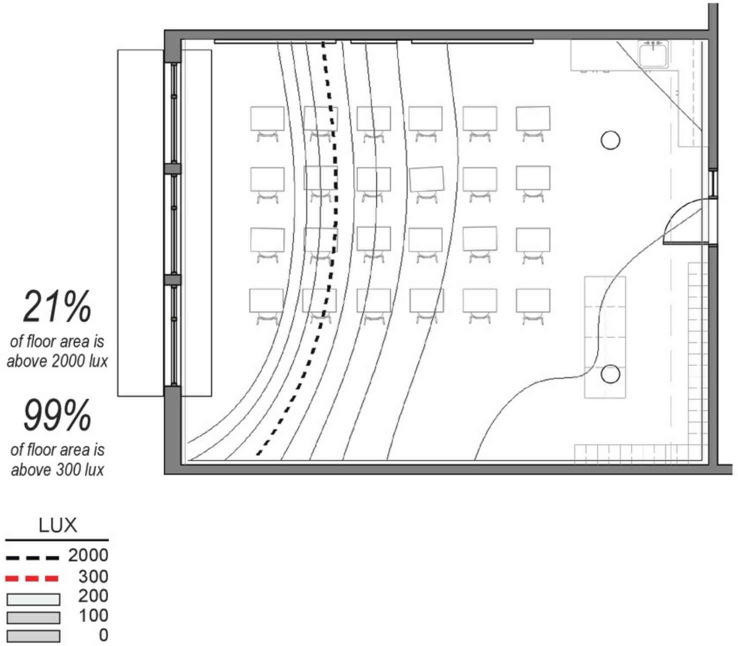
Pattern 18: Fixed Building Shading

South Sunny: Translucent Horizontal Shading Device + Translucent Light Shelf

In this step the overhang and lightshelf are changed in material from opaque to translucent. This has almost no effect on the illumination values (99% above 300 lux, 21% above 2,000 lux) but improves the balance of brightness across the space. In particular, note the increased brightness below the overhang and lightshelf on the perimeter opaque walls around the windows as compared to the previous step. The brightness on the ceiling is very slightly diminished since more light is passing through the shading elements.







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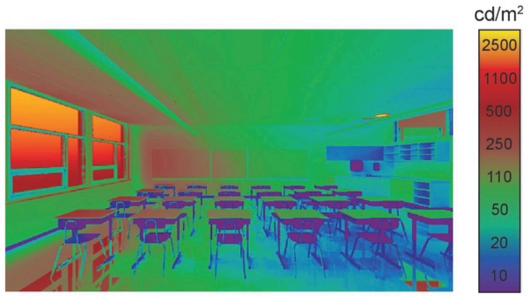
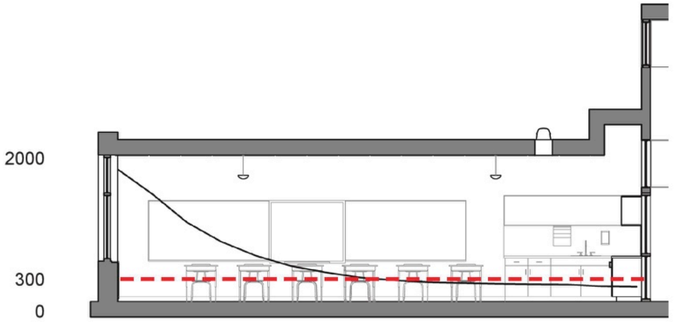
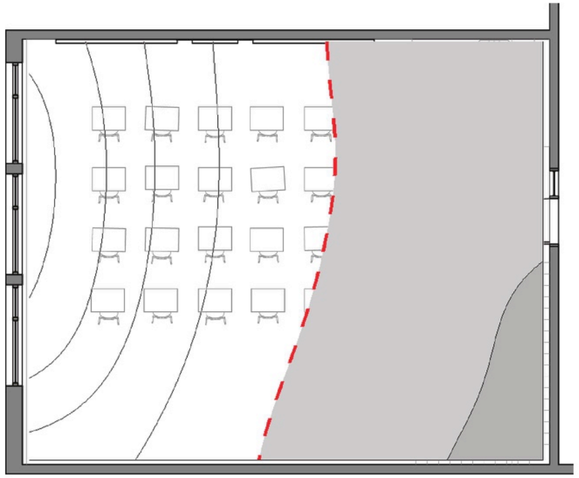
Pattern 18: Fixed Building Shading

South Overcast: No Shading

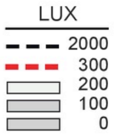
Since fixed shading devices are usually permanent, it is important to understand effects under overcast sky conditions as well. The same permutations are now repeated under an overcast sky at noon in September. Note that the illumination area above 300 lux is substantially reduced due to the lower outdoor illumination levels, irrespective of the shading devices. The floor area above 300 lux is 48%.







48%
of floor area is above 300 lux



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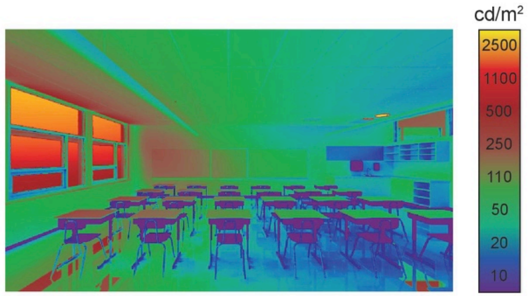
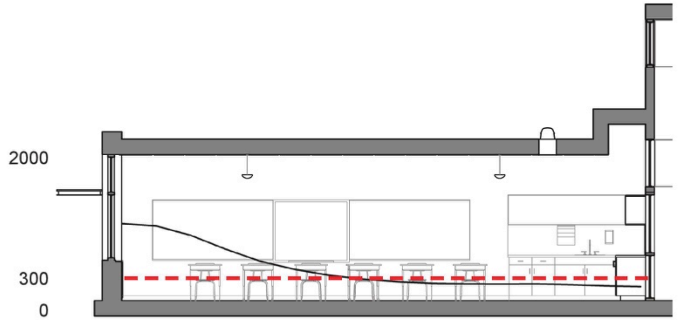
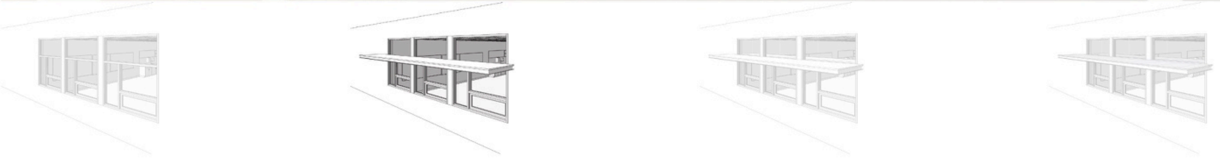
Pattern 18: Fixed Building Shading

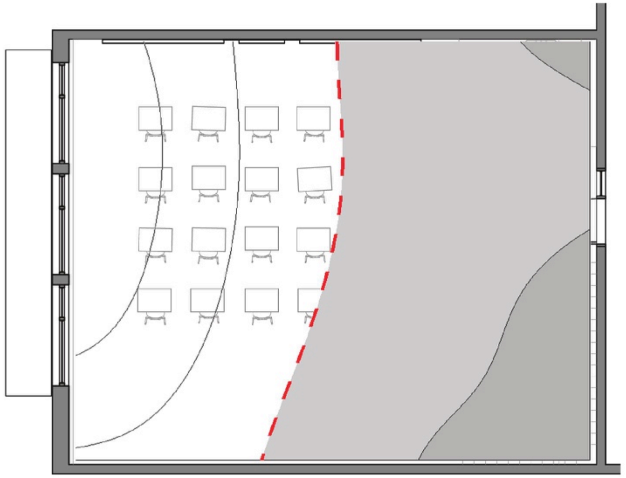
South Overcast: Horizontal Shading Device

In this step, the opaque overhang was added. This reduced the floor area above 300 lux from 48% to 42% representing just over a 1/10th illumination reduction from the baseline without shading. This is a modest penalty to pay in order to provide the improved comfort and energy benefits associated with shading elements.



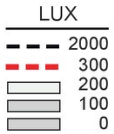






42%

of floor area is above 300 lux



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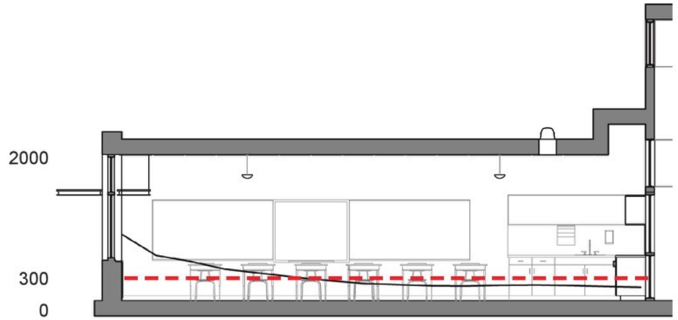
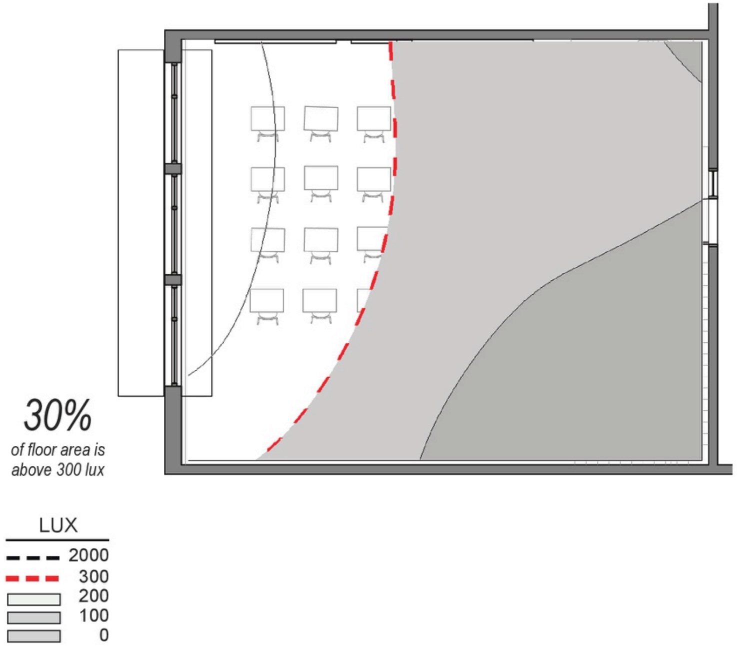
Pattern 18: Fixed Building Shading

South Overcast: Horizontal Shading Device + Light Shelf

In this step, the opaque lightshelf was added. This reduced the floor area above 300 lux from 42% to 30% representing just over a 1/3rd illumination reduction from the baseline without shading. This is not insignificant; however it may be a useful tradeoff in order to provide the improved comfort benefit during sunny conditions.





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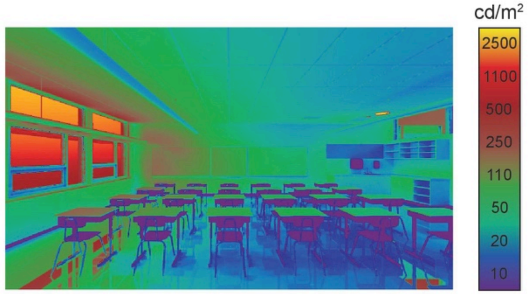
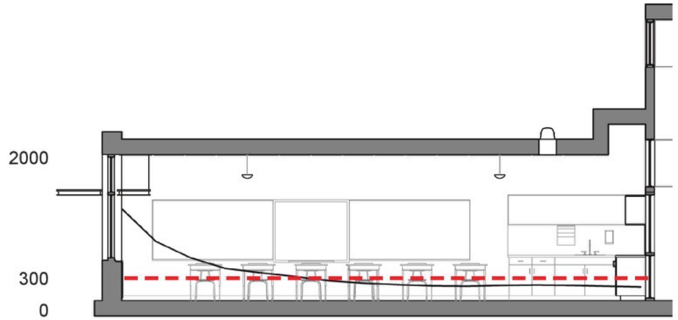
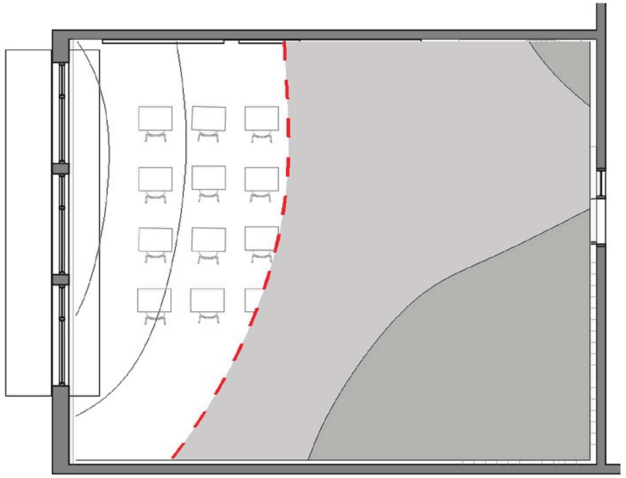
Pattern 18: Fixed Building Shading

South Overcast: Translucent Horizontal Shading Device + Translucent Light Shelf

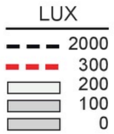
In this step, the opaque overhang and lightshelf were changed to a translucent material. This slightly improved the floor area above 300 lux from 30% to 31% compared to the previous step.







31%
of floor area is above 300 lux



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Pattern 18: Fixed Building Shading

Fixed Classroom Shading - South Facade

Ash Creek Elementary | Monmouth, OR | BOORA Architects

No Shading

Solatubes

Horizontal Shading Device

Horizontal Shading Device and Light Shelf

Horizontal Shading Device and Translucent Light Shelf, no Solatubes

Horizontal Shading Device and Translucent Light Shelf

Annual Sunlight Exposure (ASE)

of floor area at / above 1000Lux for at least 250 hours out of the occupied hours of the year

Preferred	50
Acceptable	100
Nominally acceptable	250
Undesirable	500
Automated blinds should be considered	1000

Spatial Daylight Autonomy (sDA)

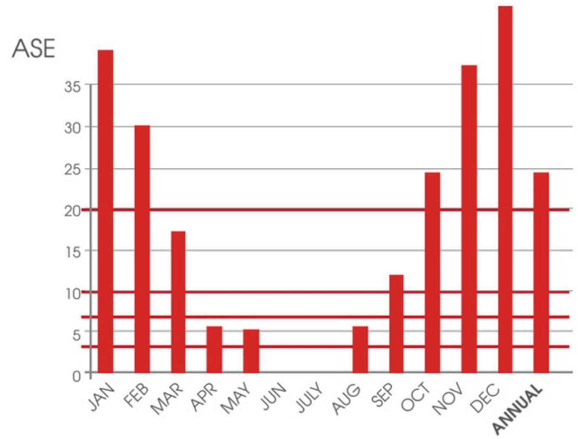
% of floor area of floor area at / above 300Lux for at least 50% of the occupied hours of the year above 300 lux

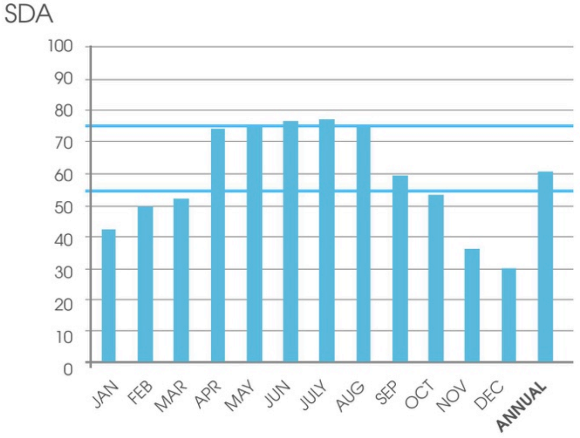
	12
Undesirable	25
Nominally Acceptable Daylight	50
Preferred Daylight	75
Highest Possible Daylight	100

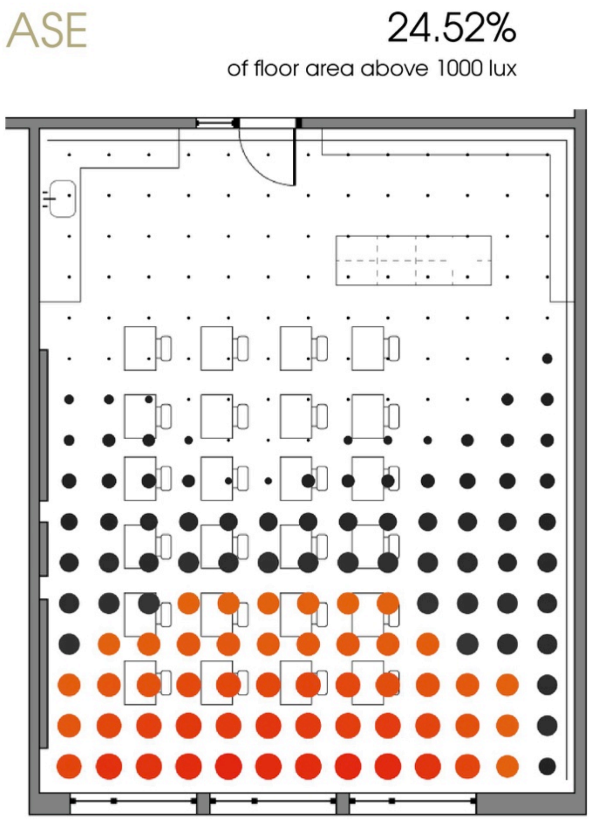
Pattern 18: Fixed Building Shading

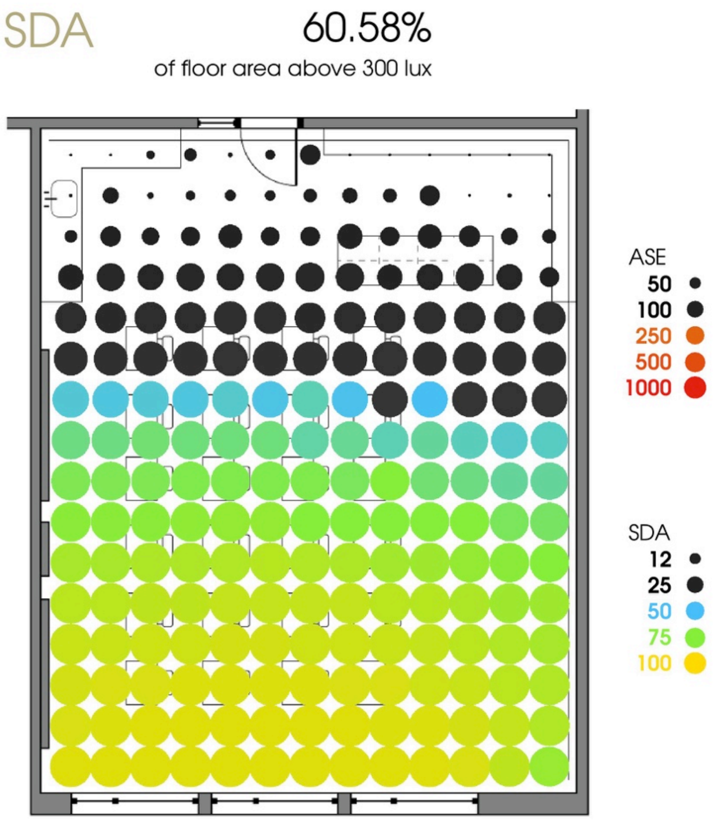
Fixed Classroom Shading - South Facade

Boise, ID: No Shading





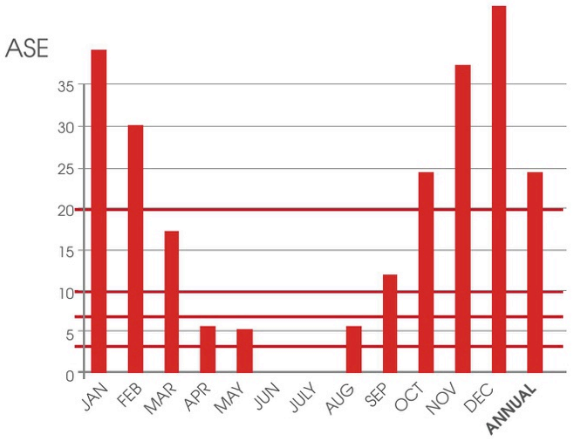




Pattern 18: Fixed Building Shading

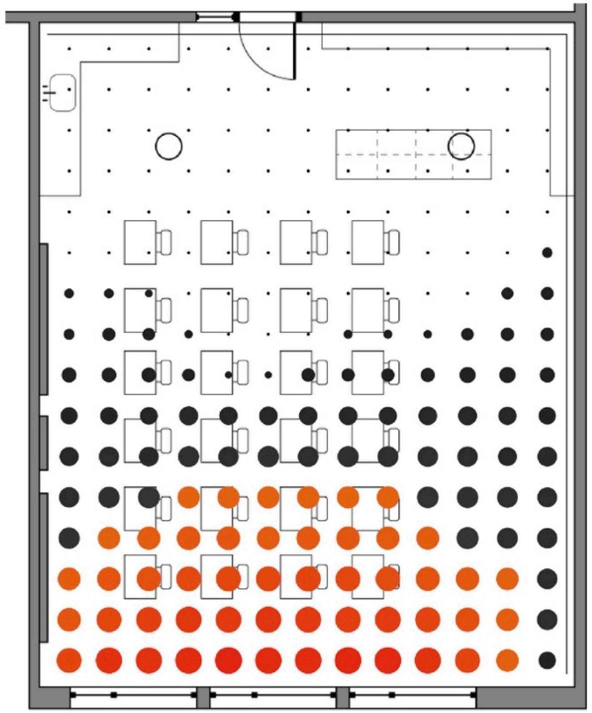
Fixed Classroom Shading - South Facade

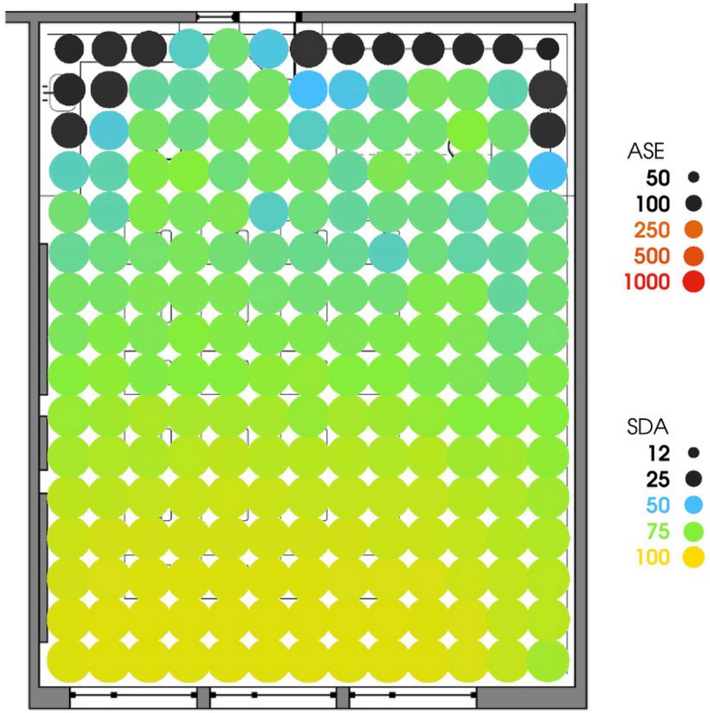
Boise, ID: No Shading, with Solatubes



ASE 24.52%
of floor area above 1000 lux

SDA 92.31%
of floor area above 300 lux

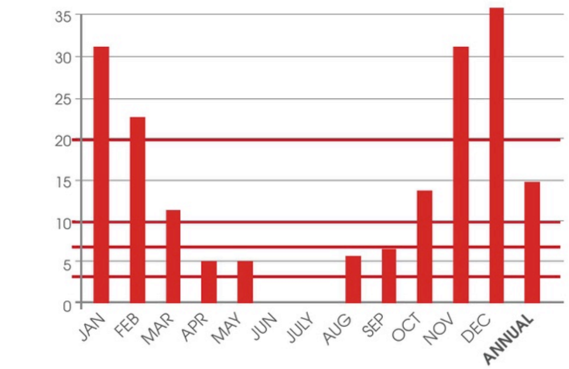




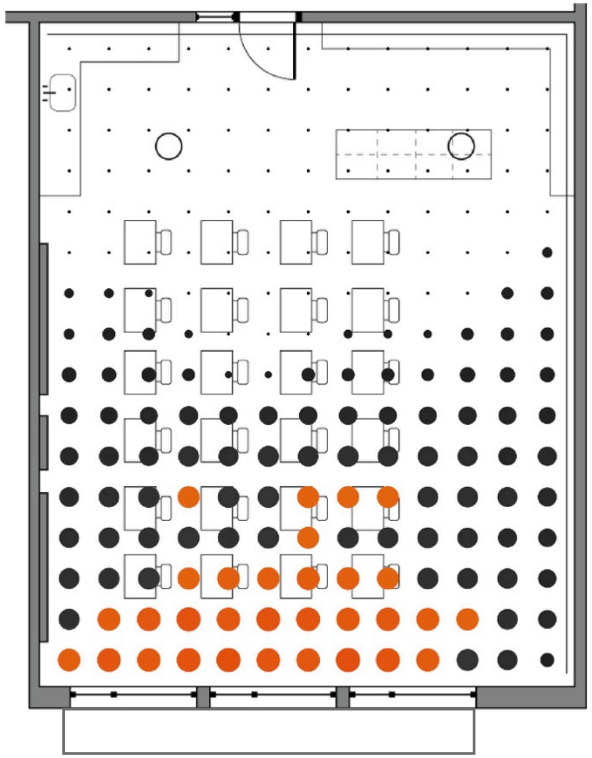
Pattern 18: Fixed Building Shading

Fixed Classroom Shading - South Facade

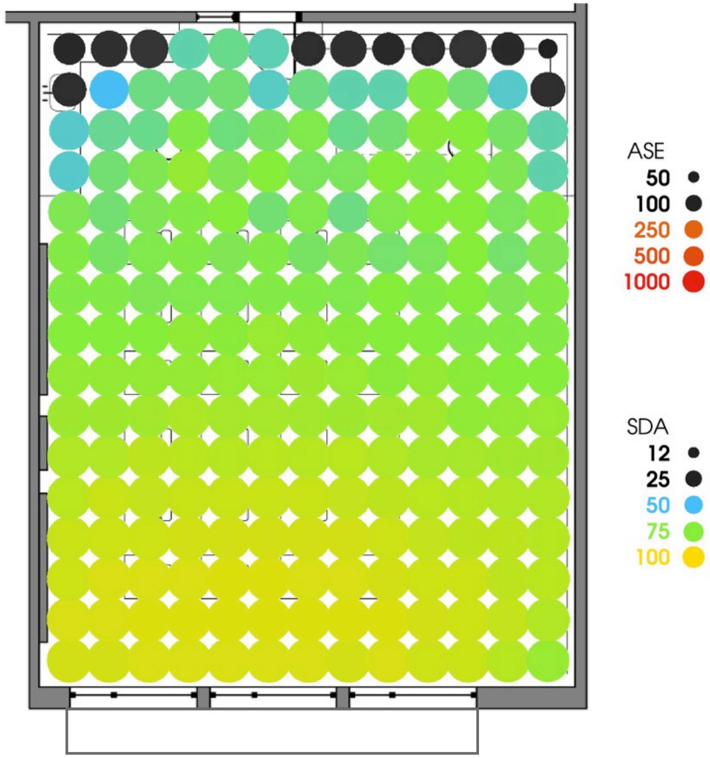
Boise, ID: Horizontal Shading Device



ASE 14.90% of floor area above 1000 lux



SDA 94.23% of floor area above 300 lux

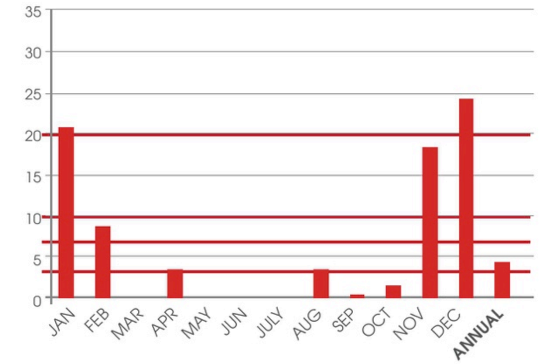


Pattern 18: Fixed Building Shading

Fixed Classroom Shading - South Facade

Boise, ID: Horizontal Shading Device and Light Shelf

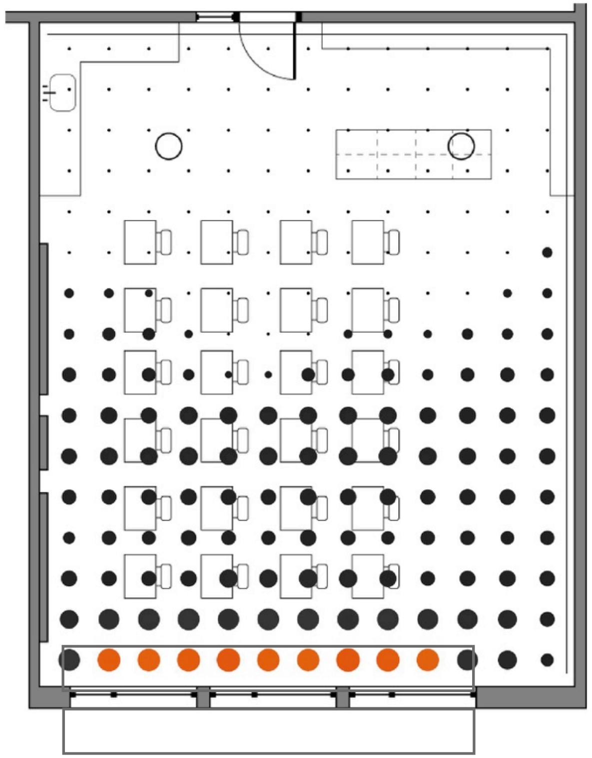
ASE



SDA

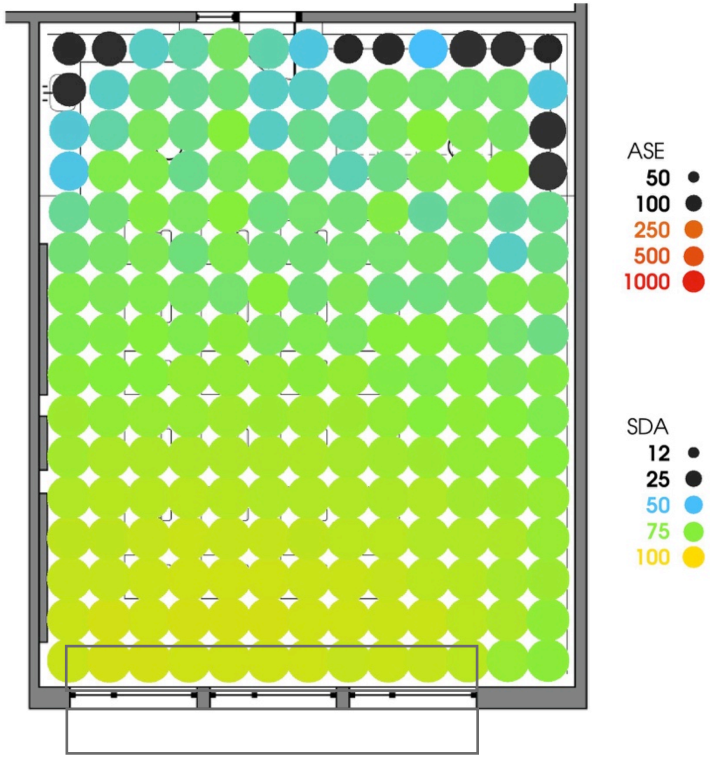
ASE 4.33%

of floor area above 1000 lux



SDA 95.19%

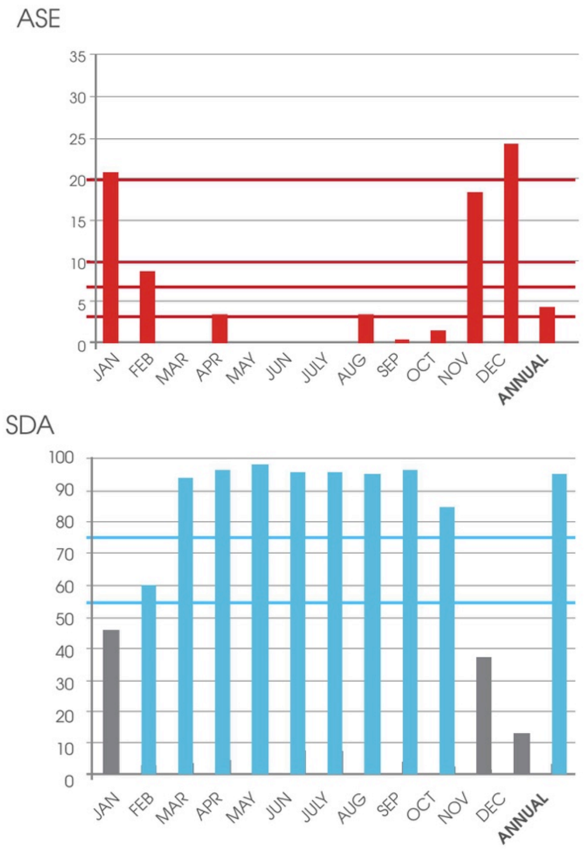
of floor area above 300 lux

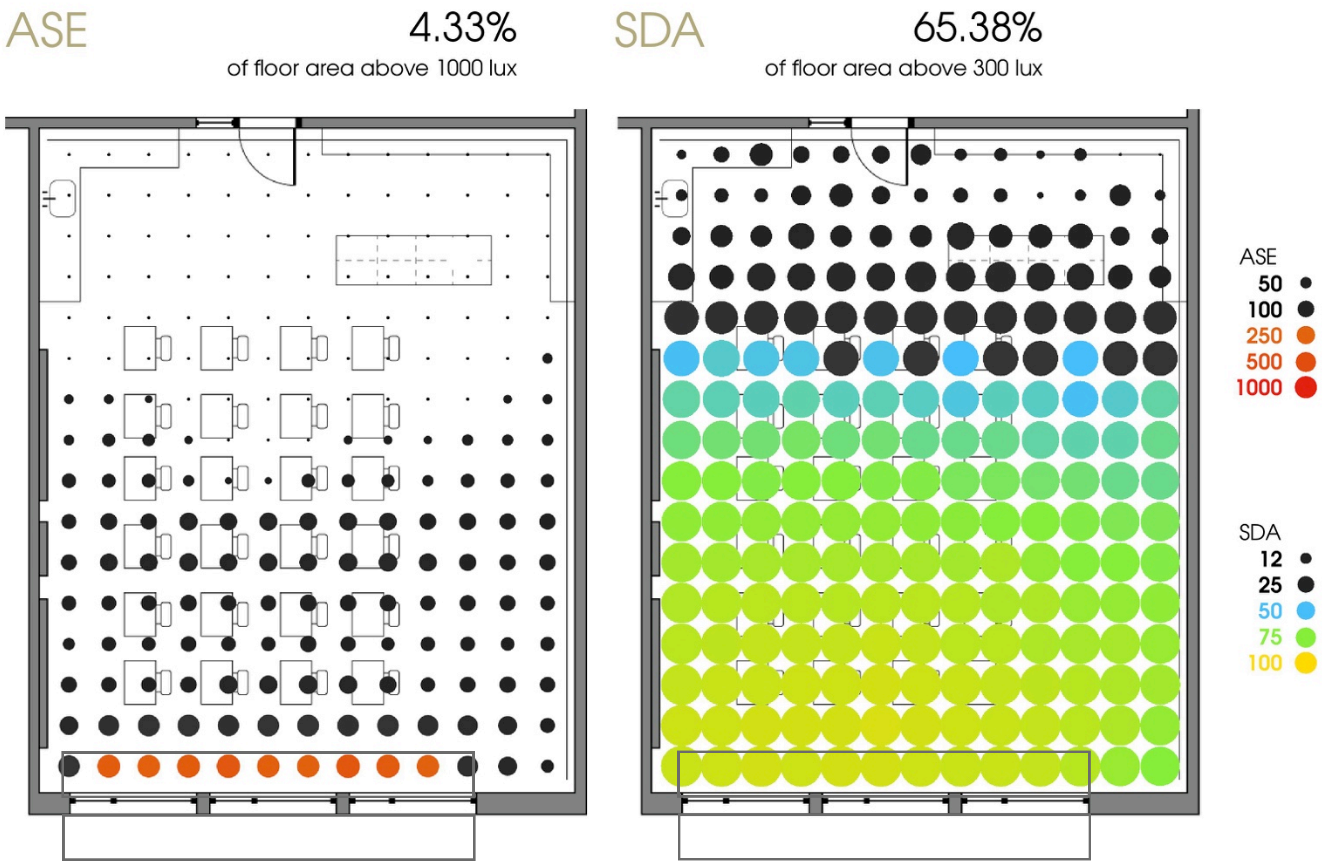


Pattern 18: Fixed Building Shading

Fixed Classroom Shading - South Facade

Boise, ID: Horizontal Shading Device and Translucent Light Shelf, no Solatubes

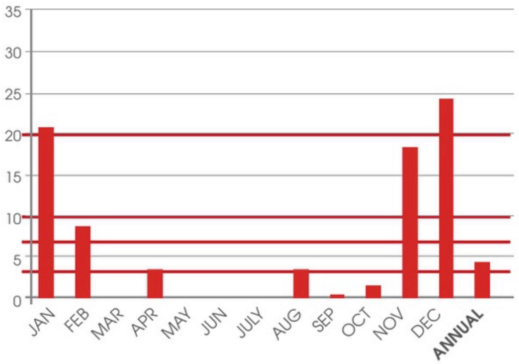


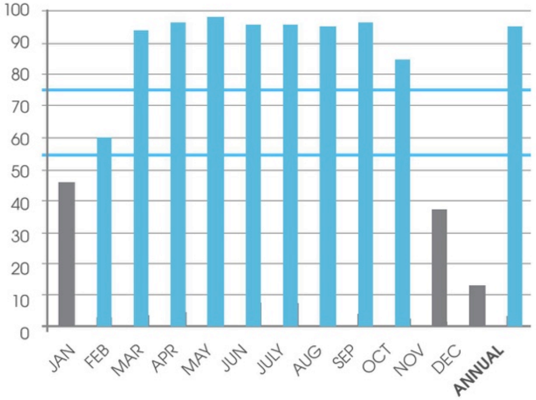


Pattern 18: Fixed Building Shading

Fixed Classroom Shading - South Facade

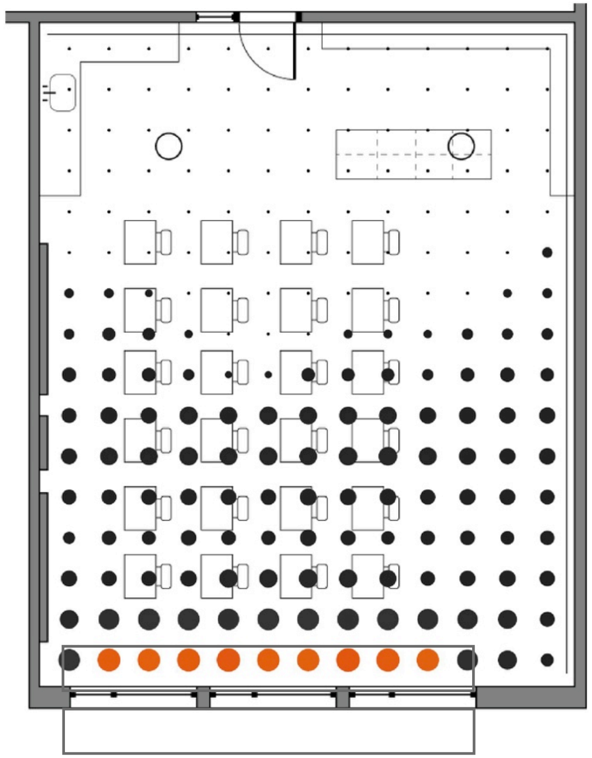
Boise, ID: Horizontal Shading Device and Translucent Light Shelf

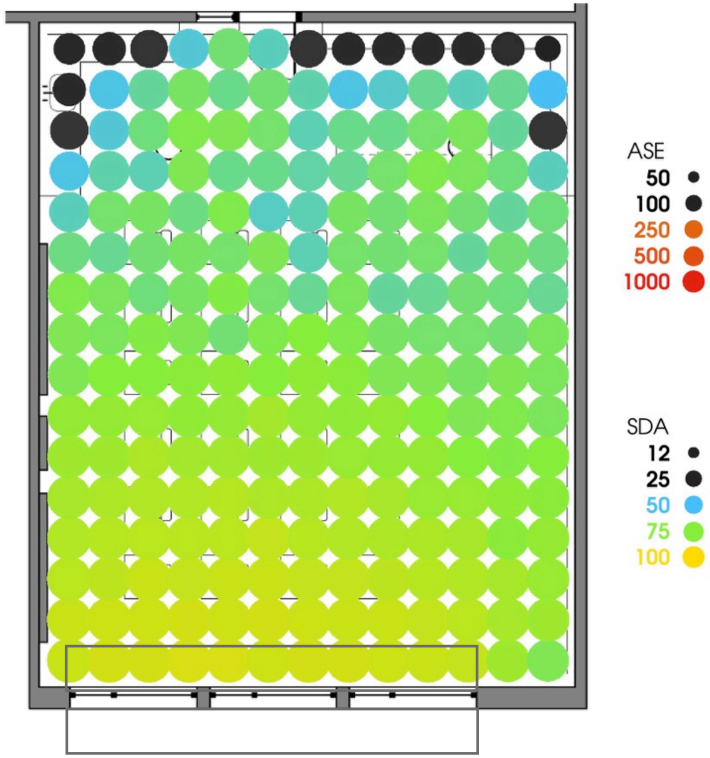




ASE 4.33%
of floor area above 1000 lux

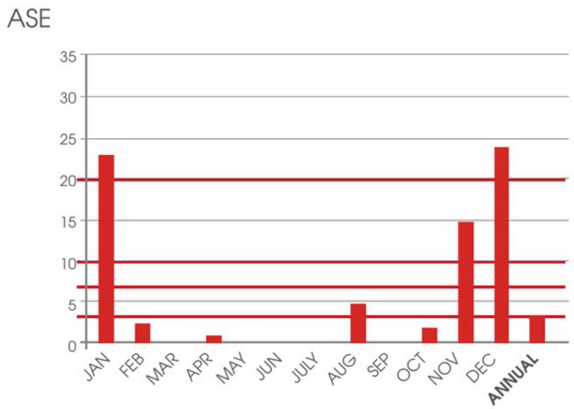
SDA 93.75%
of floor area above 300 lux

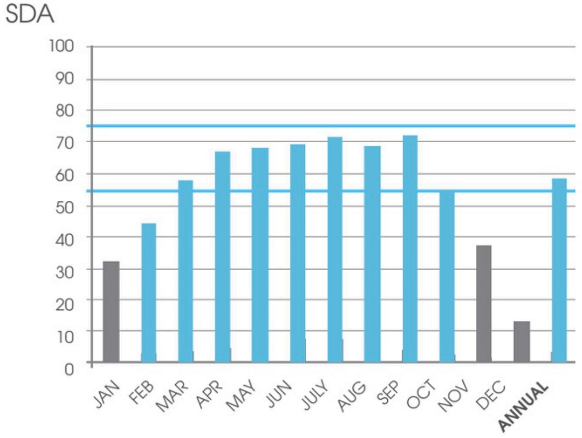


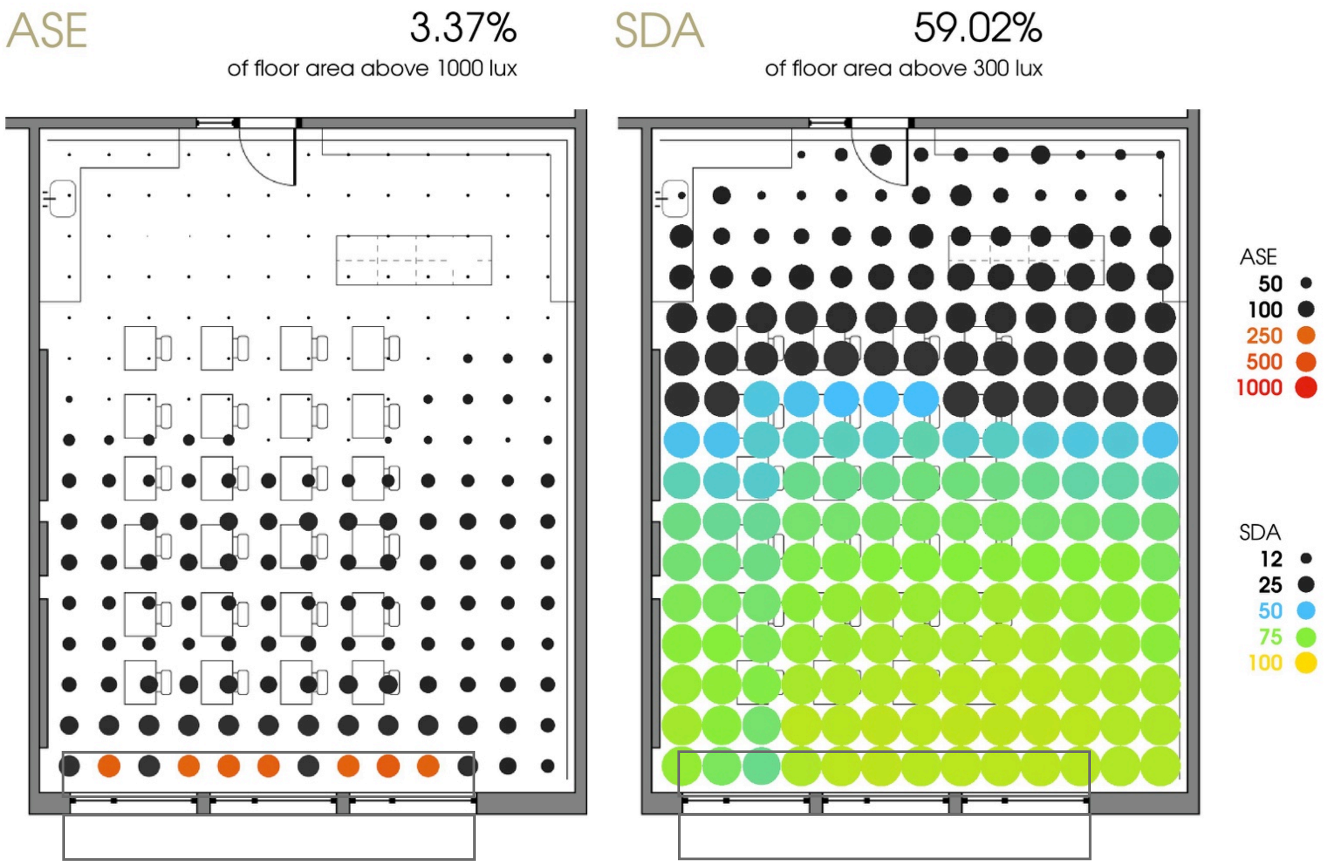


Pattern 18: Fixed Building Shading
Fixed Classroom Shading - South Facade

Salem, OR: Horizontal Shading Device and Translucent Light Shelf, no Solatubes



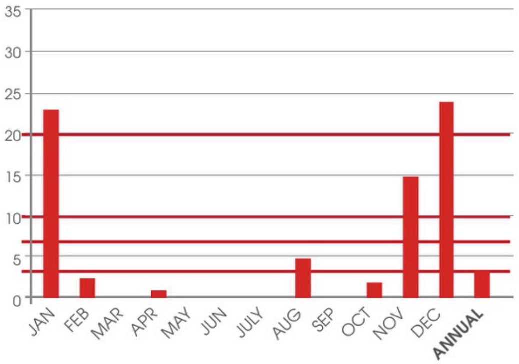


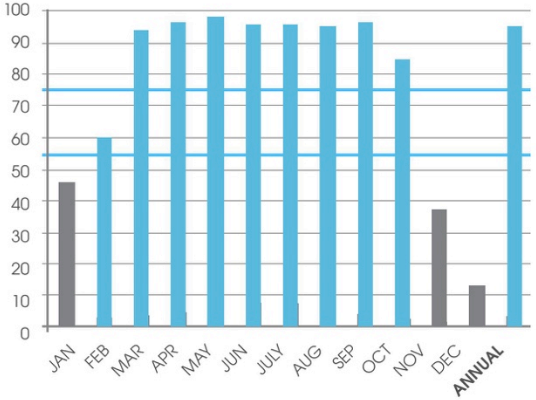


Pattern 18: Fixed Building Shading

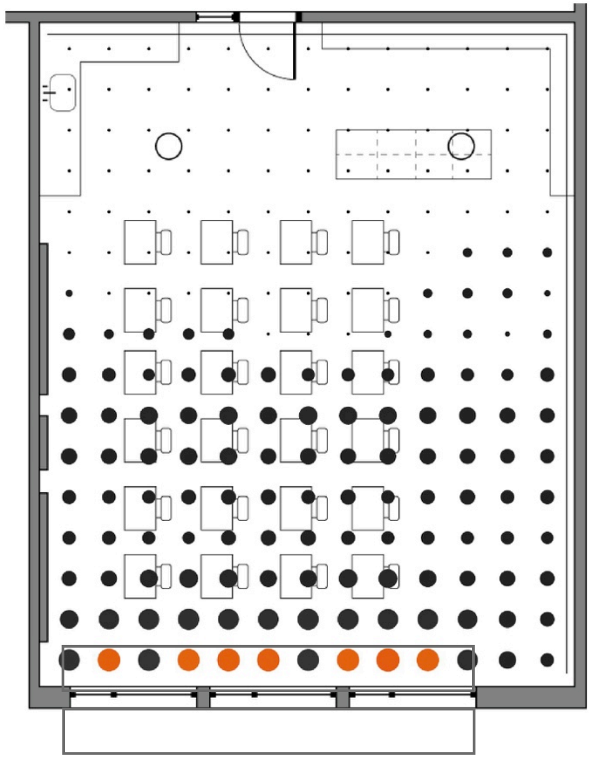
Fixed Classroom Shading - South Facade

Salem, OR: Horizontal Shading Device and Translucent Light Shelf

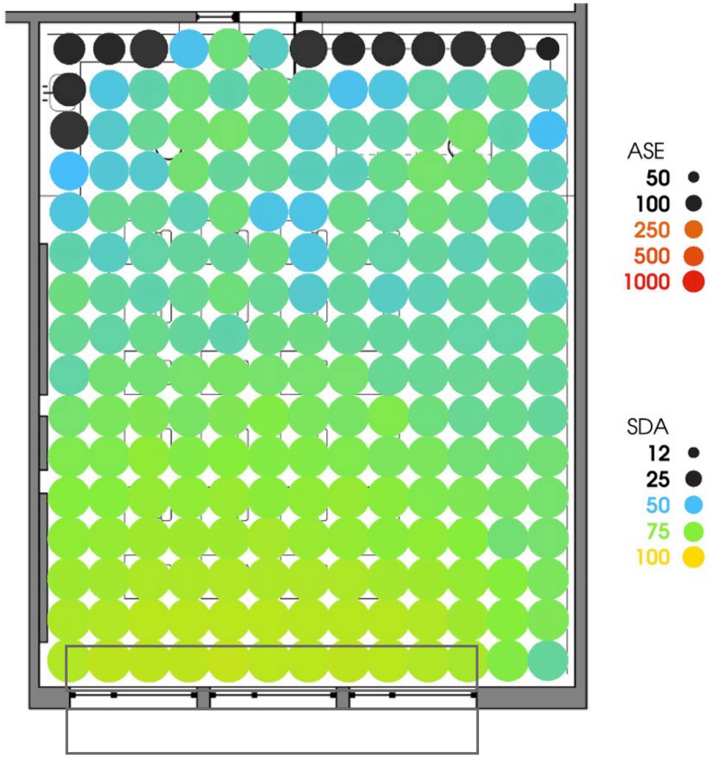




ASE 3.37% of floor area above 1000 lux



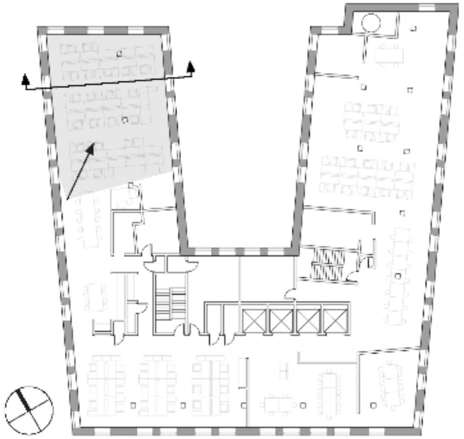
SDA 94.23% of floor area above 300 lux



Pattern 5: Glass Area Ratios

Fenestration Patterns From Two or More Sides

NBBJ Office: New York, NY



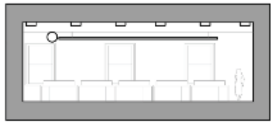
Overview

Successful daylight from the side begins with maintaining a relationship between window head height and section depth. Generally speaking the effective distance of daylight penetration is no more than two times the head height of the perimeter window. In buildings with traditional floor to ceiling heights (~10') this translates to about 20'-0" of section depth that can be daylit from one side. It should be noted that the configuration and size of interior furnishings, and the presence and use patterns of blinds may substantially reduce this distance.

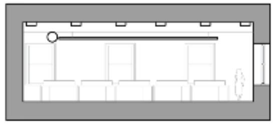
Once an interior section depth exceeds about 25'-0" (assuming traditional ceiling height) the contrast between perimeter zone and core of the building begins to increase substantially during daylight hours. Since the human eye tends to adjust to the brightest location within a space this can cause the perception of darkness in the interior section, and glare due to the lack of luminous uniformity across the section.

There are two primary strategies to address this condition. First, section depths can be kept narrow to ensure both daylight performance and relative uniformity. Alternatively, additional sources of daylight can be added to provide supplemental illumination. In this case additional sources are provided in the form of daylight apertures on multiple sidewalls.

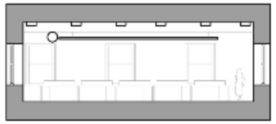
The case study example is the 2 Rector Street building in New York City. This pattern sequence highlights simulations under sunny sky conditions during September at noon with workplane illumination data represented in lux. Typical ambient office lighting criteria range from 300-400 lux and 300 lux was selected as one of the daylighting design criteria examined herein. The percentage of floor area above this value is presented for each permutation.



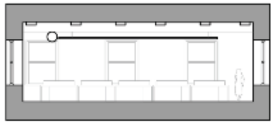
20% Glass Area (1 Side)



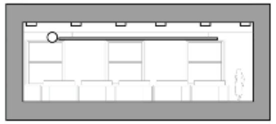
20% Glass Area (2 Sides)



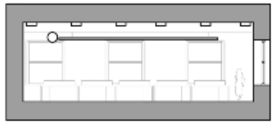
20% Glass Area (3 Sides)



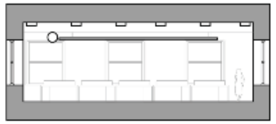
26% Glass Area (3 Sides)
As Designed



30% Glass Area (1 Side)



30% Glass Area (2 Sides)



30% Glass Area (3 Sides)

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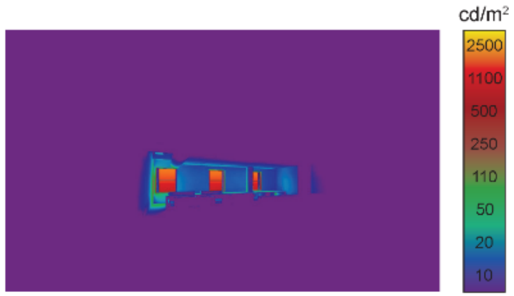
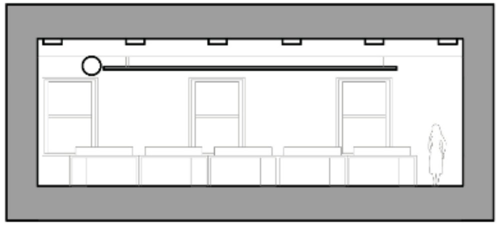
Pattern 5: Glass Area Ratios (2 or more sides)

20% Glass Area (1 Side)

These data illustrate discomfort glare from three perimeter windows comprising 20% of the wall area on the end wall. The daylit zone is restricted to the area within the first 15'-20' from the windows and the majority of the open office space is subject to glare. In a space such as this, blinds would be drawn closed to reduce glare, even on these north-facing windows, much of the time. Approximately 7% of the floor area meets the targeted lighting criteria from daylight alone.

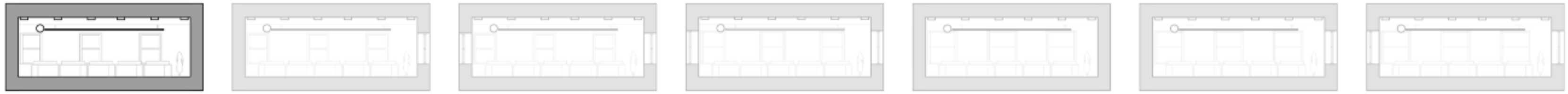




7%

of floor area is above 300 lux

LUX
2000
300
200
100
0



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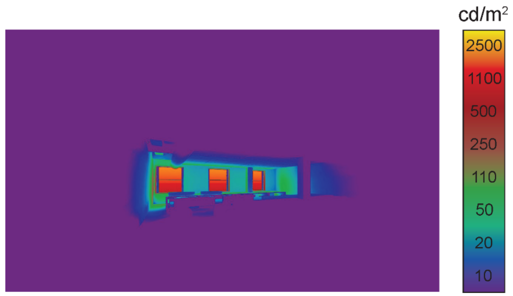
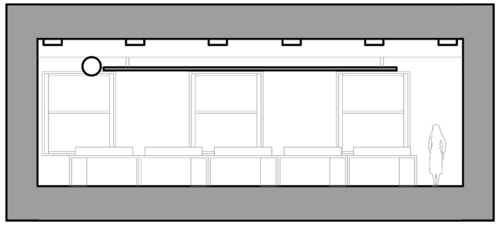
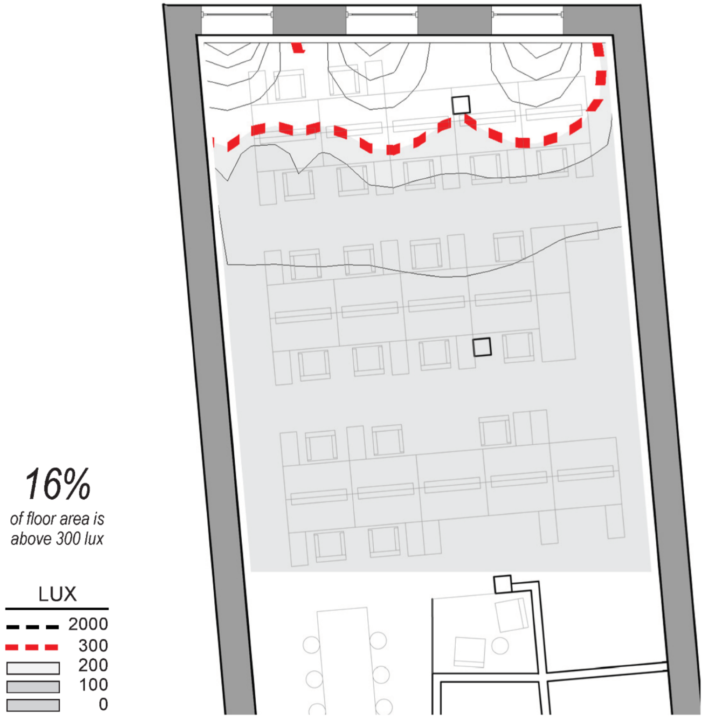
Pattern 5: Glass Area Ratios (2 or more sides)

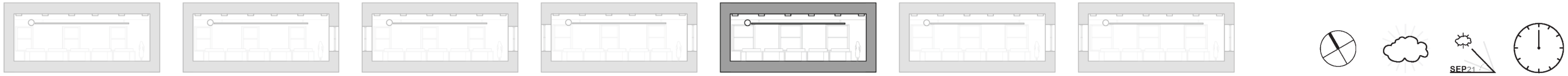
30% Glass Area (1 Side)

These data illustrate discomfort glare from three perimeter windows comprising 30% of the wall area on the end wall. The daylit zone is restricted to the area within the first 15'-20' from the windows and the majority of the open office space is subject to glare. In a space such as this, blinds would likely be drawn closed to reduce glare, even on these north-facing windows, much of the time. Approximately 16% of the floor area meets the targeted lighting criteria from daylight alone.









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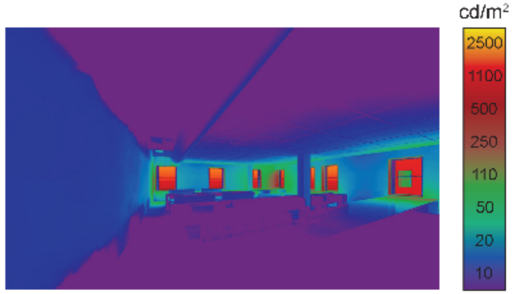
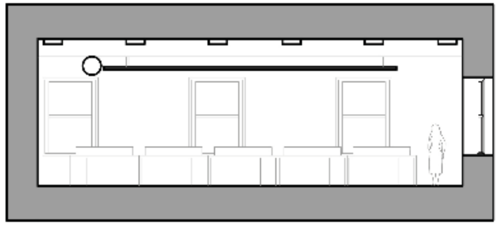
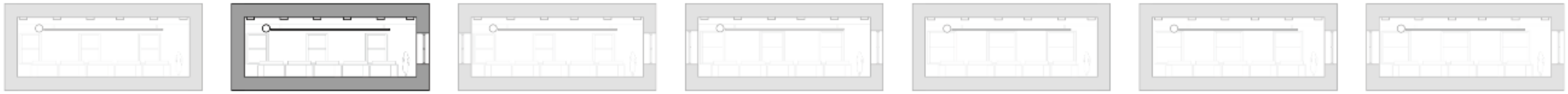
Pattern 5: Glass Area Ratios (2 or more sides)

20% Glass Area (2 Sides)

Windows comprising 20% of the wall area are added to one of the long walls and dramatically reduces the perception of glare experienced. Providing daylight from two directions is an important strategy to create spaces with both functional daylight illumination and with lower contrast. Here, the light from the windows on the long wall can be seen illuminating the third wall opposite it. Approximately 28% of the floor area meets the targeted lighting criteria from daylight alone.







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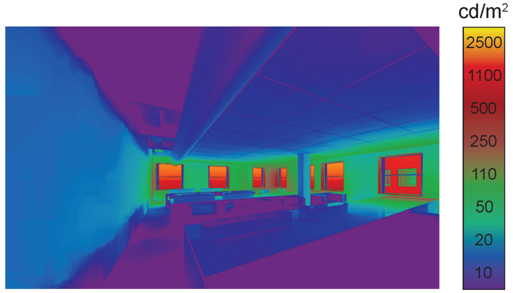
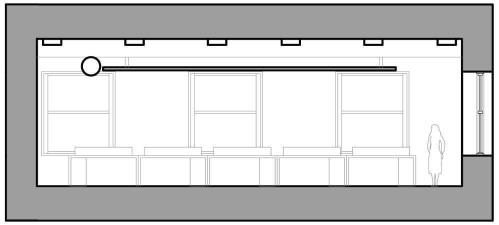
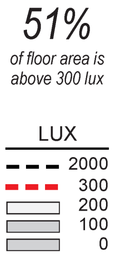
Pattern 5: Glass Area Ratios (2 or more sides)

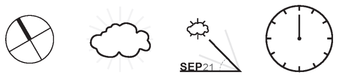
30% Glass Area (2 Sides)

Windows comprising 30% of the wall area are added to one of the long walls and dramatically reduces the perception of glare experienced. Providing daylight from two directions is an important strategy to create spaces with both functional daylight illumination and with lower contrast. Here, the light from the windows on the long wall can be seen illuminating the third wall opposite it. Approximately 51% of the floor area meets the targeted lighting criteria from daylight alone.









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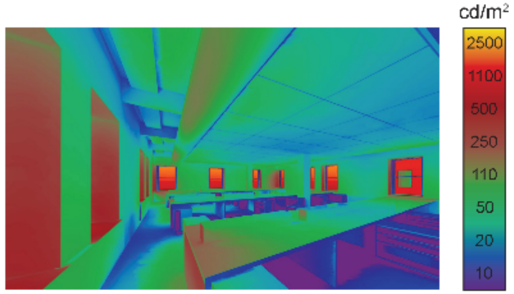
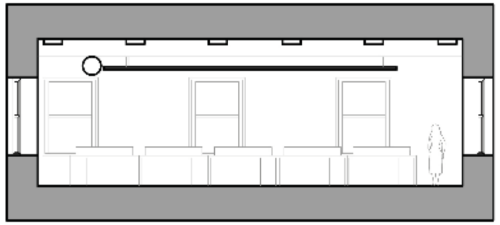
Pattern 5: Glass Area Ratios (2 or more sides)

20% Glass Area (3 Sides)

Windows comprising 20% of the wall area are utilized on all three major walls (N, E, W) within this space. Contrast is reduced because there is light from three sides and walls are painted white to increase inter-reflection. Furthermore, deep window reveals, orientation and building self-shading (atrium at east) serve to minimize direct sun penetration.

Approximately 53% of the floor area meets the targeted lighting criteria from daylight alone.



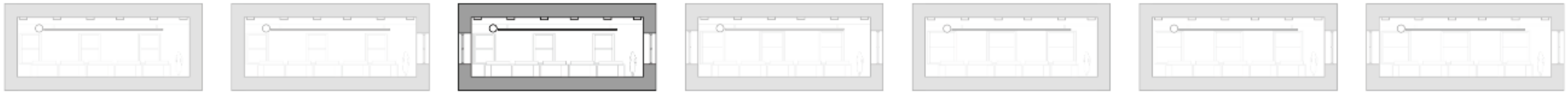


53%

of floor area is above 300 lux

LUX

- - - 2000
- - - 300
200
100
0



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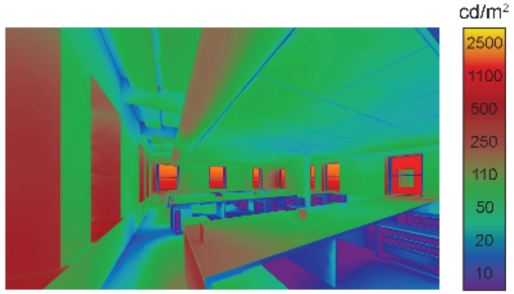
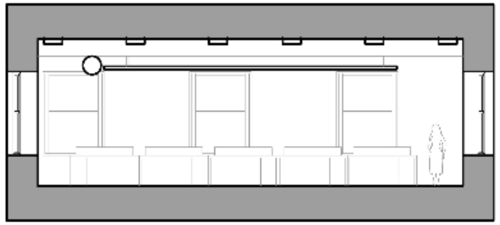
Pattern 5: Glass Area Ratios (2 or more sides)

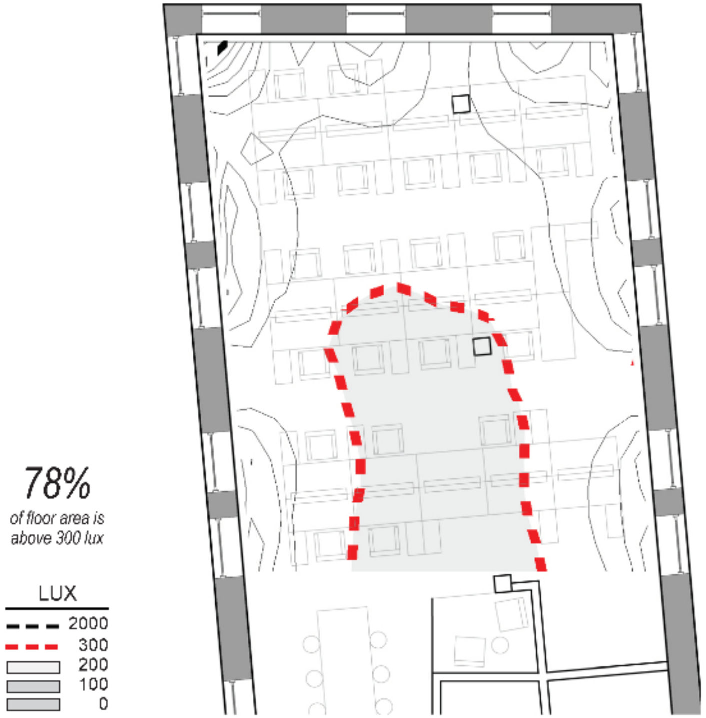
26% Glass Area (3 Sides): As Designed

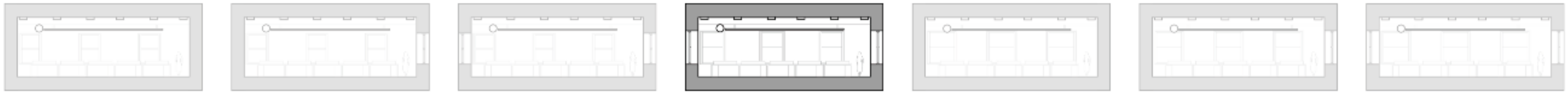
Windows comprising 26% of the wall area are utilized on all three major walls (N, E, W) within this space. This is the simulation that matches the as designed condition. Contrast is reduced because there is light from three sides and walls are painted white. Deep window reveals, orientation and building self-shading (atrium at east) serve to minimize direct sun penetration. The workstations are pulled back from the perimeter of the space, ensuring windows are considered to be 'owned by all', and also reducing the likelihood of direct sun on work surfaces. Partitions between workstations are essentially eliminated, maintaining free line of sight to both windows and well-illuminated vertical surfaces for all occupants. Approximately 78% of the floor area meets the targeted lighting criteria from daylight alone.





78%
of floor area is above 300 lux





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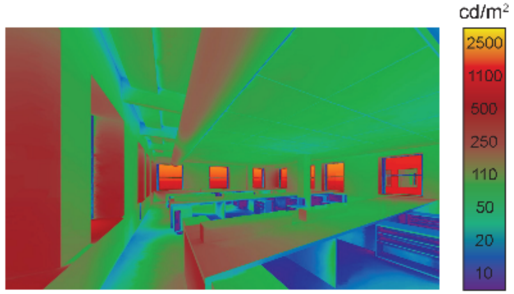
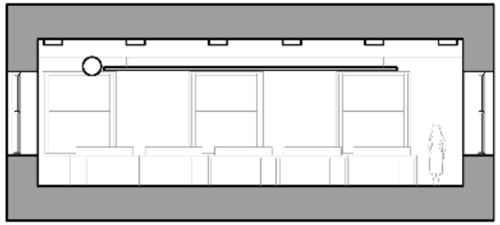
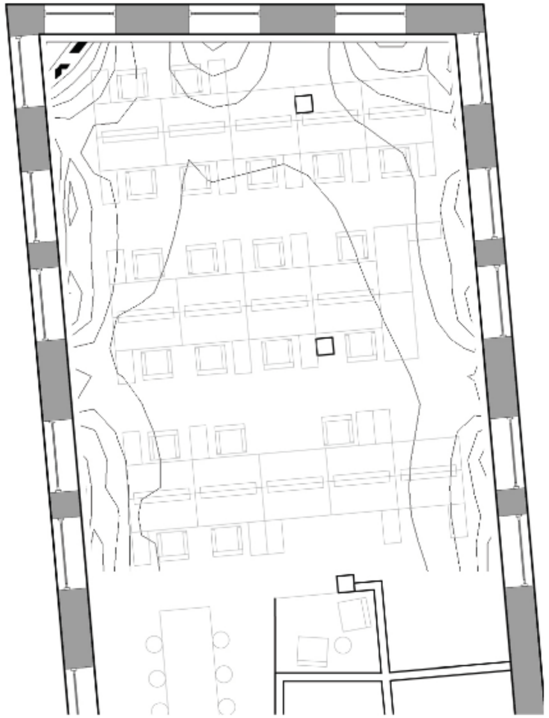
Pattern 5: Glass Area Ratios (2 or more sides)

30% Glass Area (3 Sides)

Windows comprising 30% of the wall area are used on all three major walls (N, E, W) within this space. Contrast is reduced because there is light from three sides and walls are painted white to increase inter-reflection. Furthermore, deep window reveals, orientation and building self-shading (atrium at east) serve to minimize direct sun penetration. The workstations are pulled back from the very edges of the space, ensuring windows are considered to be 'owned by all', and also reduce the likelihood of direct sun on work surfaces. Partitions between workstations are essentially eliminated, maintaining free line of sight to both windows and well-illuminated vertical surfaces for all occupants. Approximately 100% of the floor area meets the targeted lighting criteria from daylight alone.

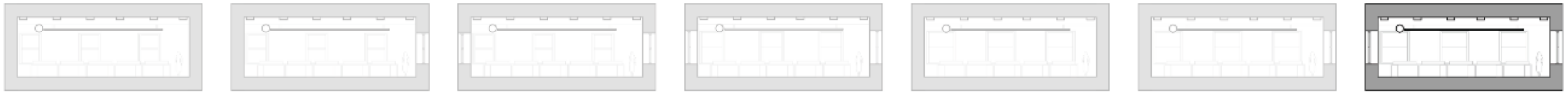






100%
of floor area is above 300 lux

LUX
2000
300
200
100
0



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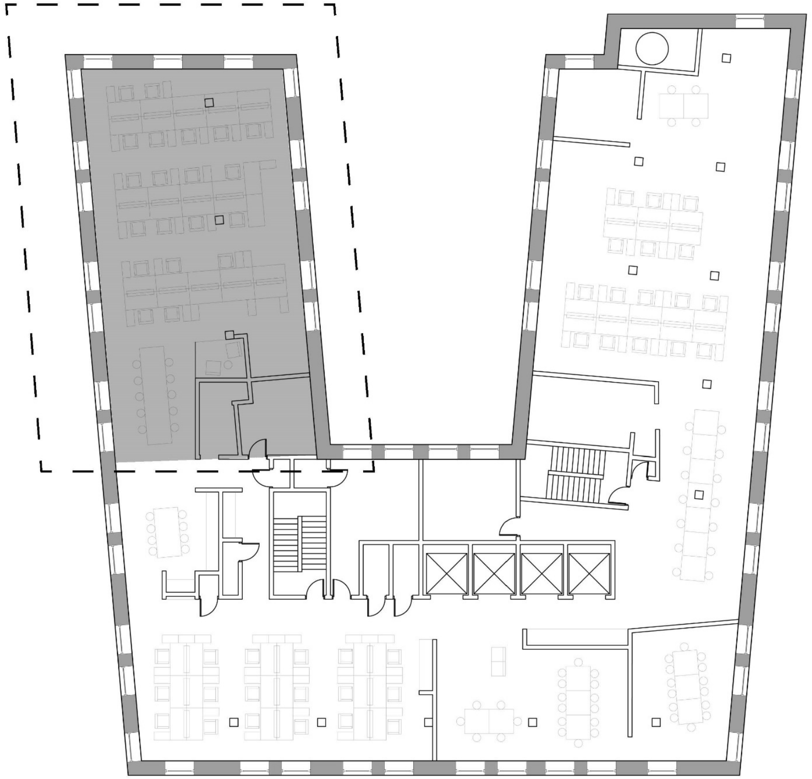
Pattern 5: Glass Area Ratios

Fenestration Patterns From Two or More Sides



20% Glass Area (1 Side)
30% Glass Area (1 Side)
30% Glass Area (2 Sides)
20% Glass Area (2 Sides)
20% Glass Area (3 Sides)
26% Glass Area (3 Sides) *as-built
30% Glass Area (3 Sides)

Annual Sunlight Exposure (ASE)

of floor area at / above 1000Lux for at least 250 hours out of the occupied hours of the year

Preferred	**50**
Acceptable	**100**
Nominally acceptable	**250**
Undesirable	**500**
Automated blinds should be considered	**1000**

Spatial Daylight Autonomy (sDA)

% of floor area of floor area at / above 300Lux for at least 50% of the occupied hours of the year above 300 lux

Undesirable	**12**
	25
Nominally Acceptable Daylight	**50**
Preferred Daylight	**75**
Highest Possible Daylight	**100**

Pattern 5: Glass Area Ratios

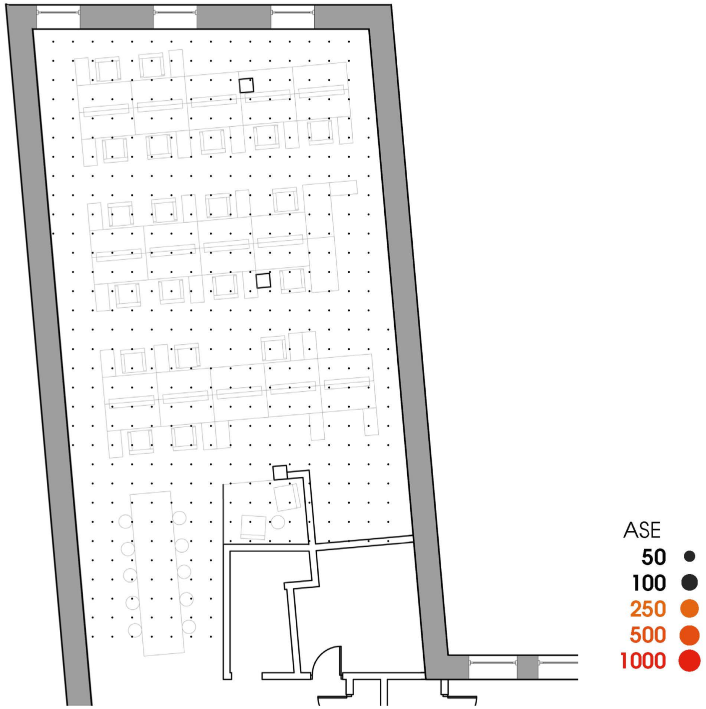
Fenestration Patterns From Two or More Sides

20% Glass Area (1 Side)

ASE

0.00%

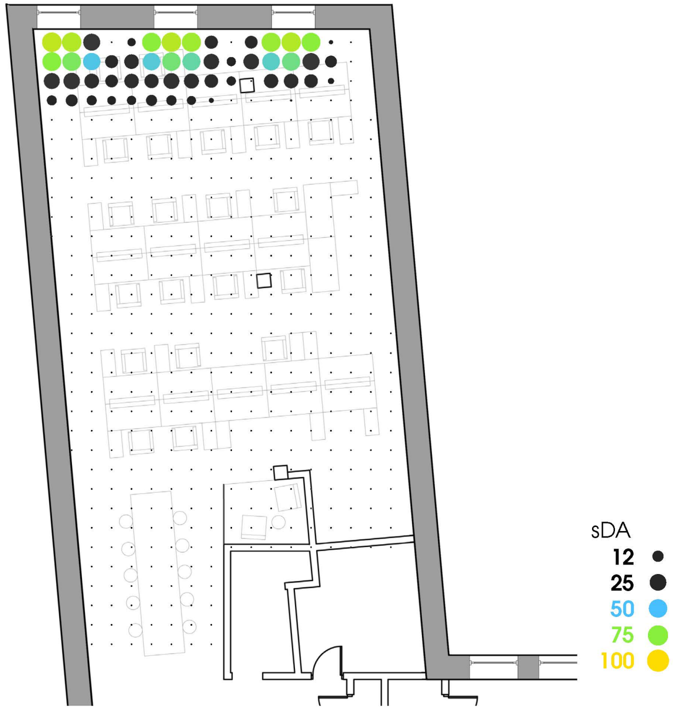
of floor area above 2000 lux



sDA

3.33%

of floor area above 300 lux



Pattern 5: Glass Area Ratios

Fenestration Patterns From Two or More Sides

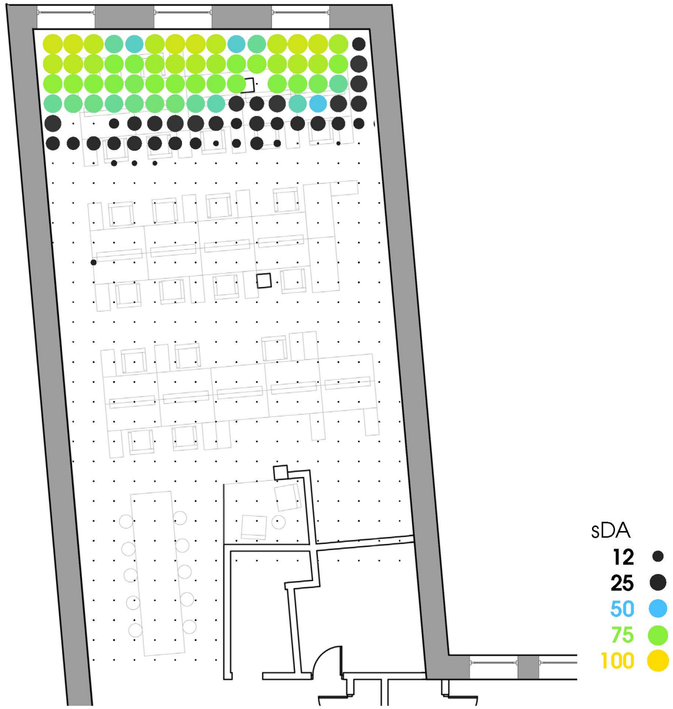
30% Glass Area (1 Side)

ASE 0.00%

of floor area above 2000 lux

sDA 11.43%

of floor area above 300 lux

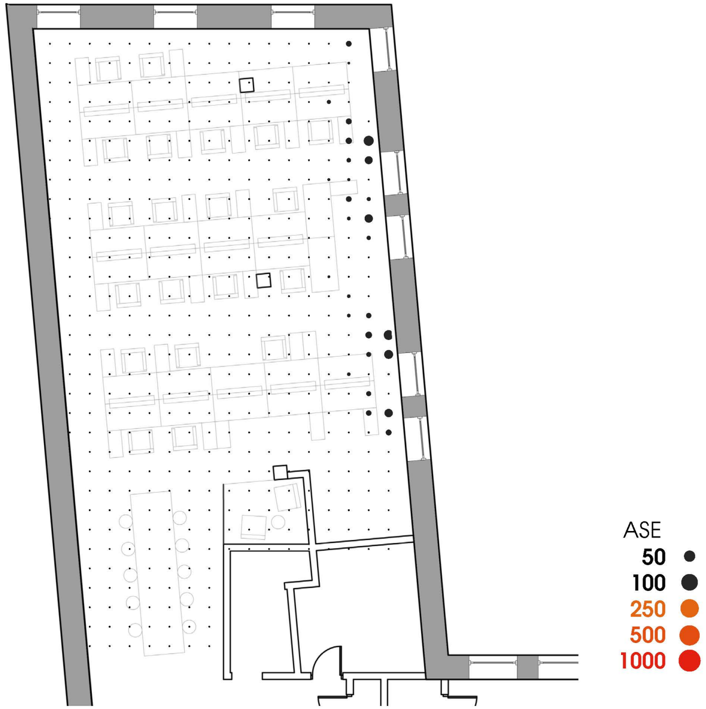


Pattern 5: Glass Area Ratios
Fenestration Patterns From Two or More Sides

20% Glass Area (2 Sides)

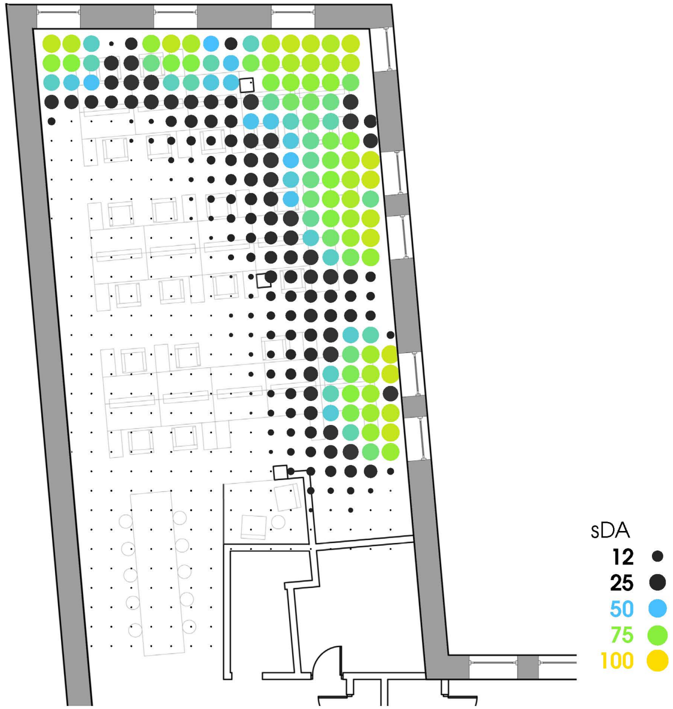
ASE

0.00%
of floor area above 2000 lux



sDA

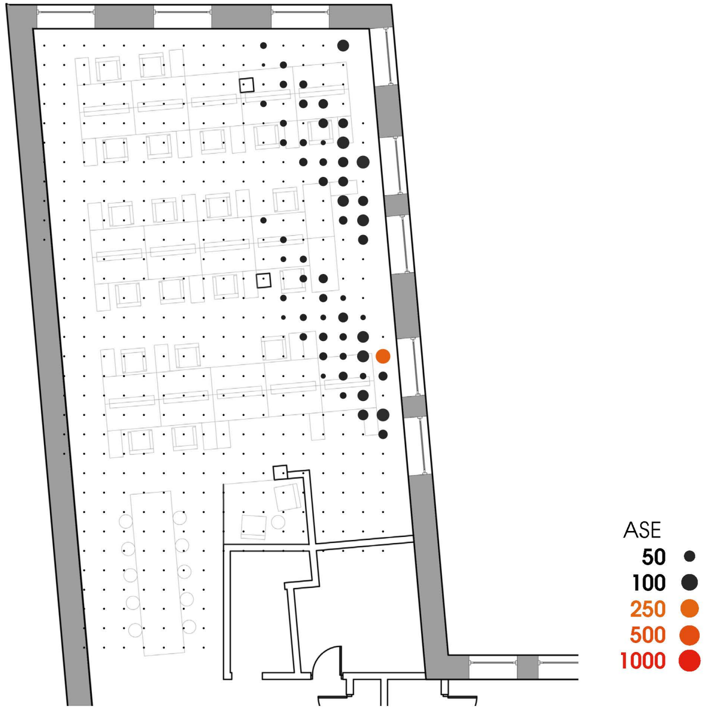
20.37%
of floor area above 300 lux



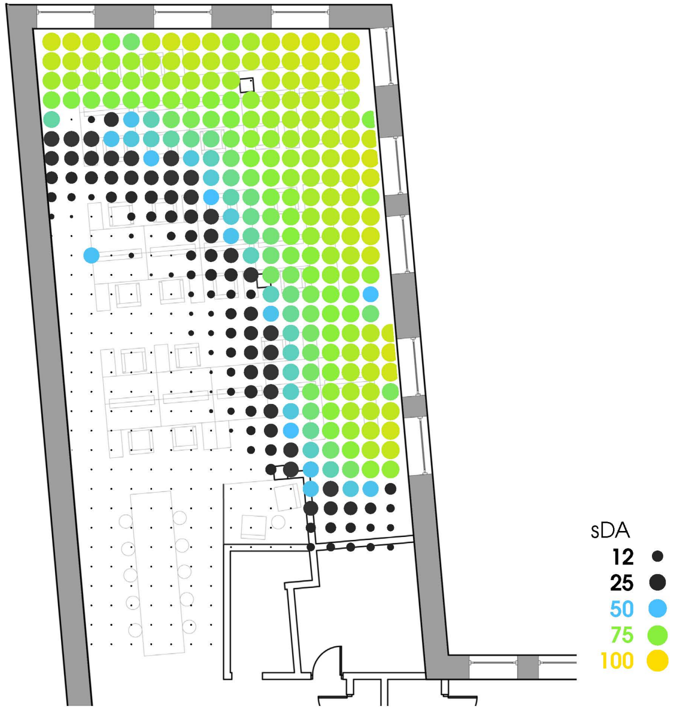
Pattern 5: Glass Area Ratios
Fenestration Patterns From Two or More Sides

30% Glass Area (2 Sides)

ASE **0.21%** of floor area above 2000 lux



sDA **43.24%** of floor area above 300 lux



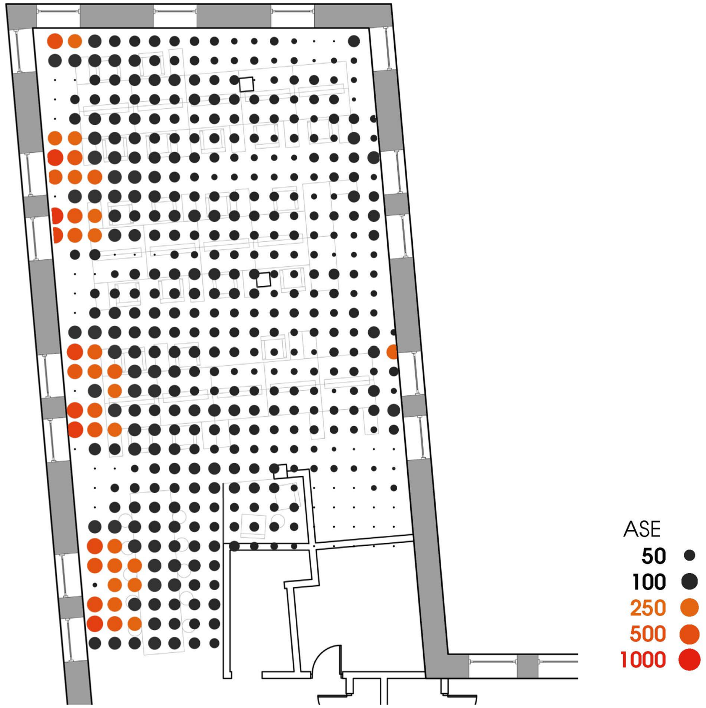
Pattern 5: Glass Area Ratios

Fenestration Patterns From Two or More Sides

20% Glass Area (3 Sides)

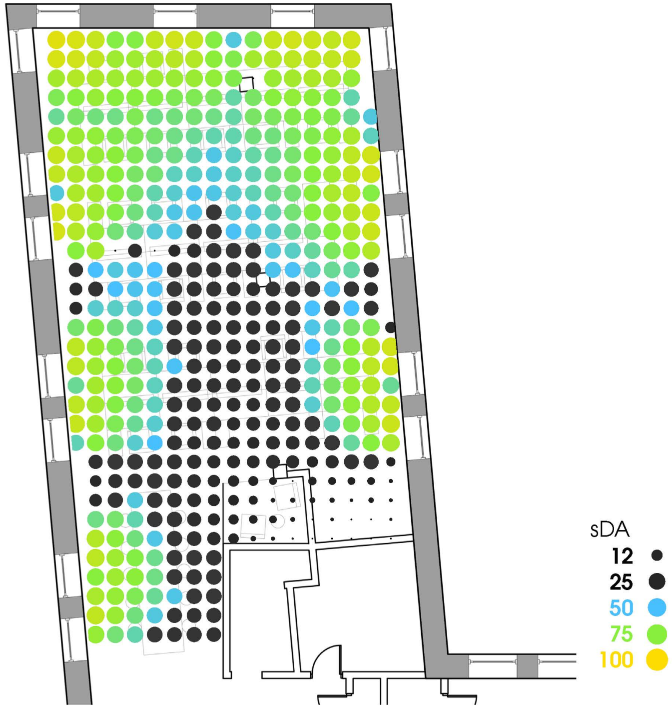
ASE

8.11%
of floor area above 2000 lux



sDA

61.54%
of floor area above 300 lux

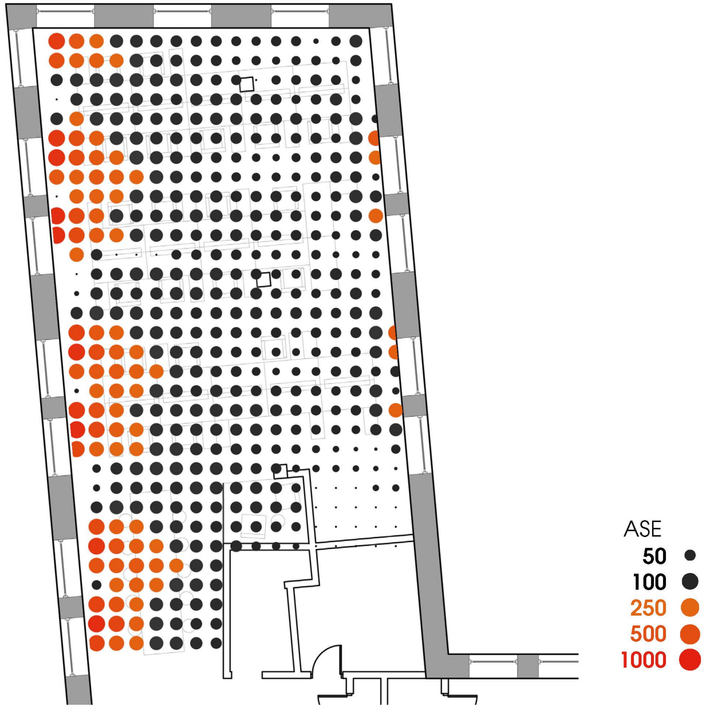


Pattern 5: Glass Area Ratios
Fenestration Patterns From Two or More Sides

30% Glass Area (3 Sides)

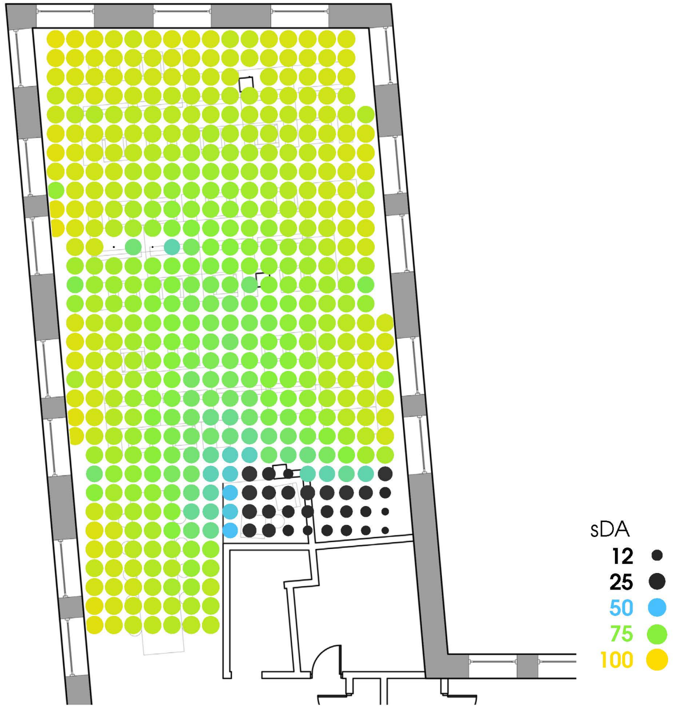
ASE

18.09%
of floor area above 2000 lux



sDA

93.56%
of floor area above 300 lux



Pattern 5: Glass Area Ratios

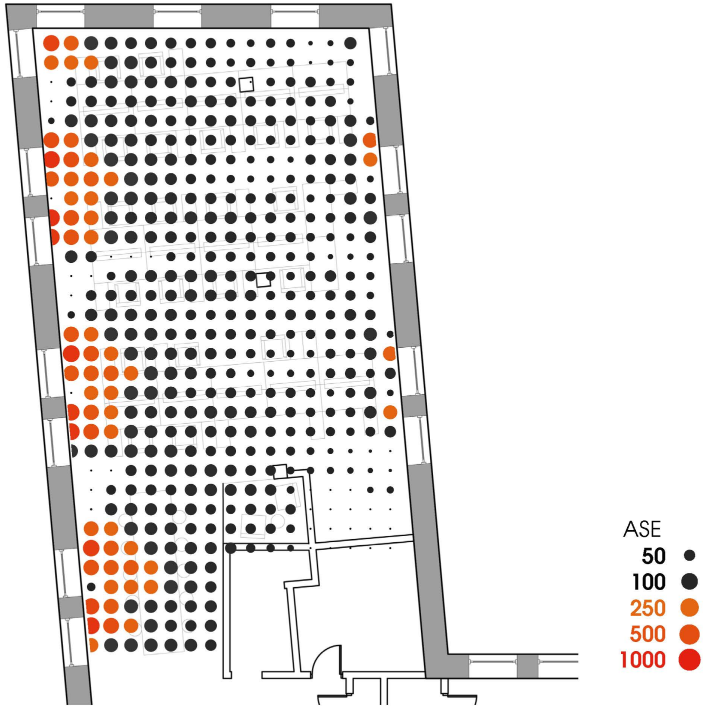
Fenestration Patterns From Two or More Sides

26% Glass Area (3 Sides) - *as-built*

ASE

12.68%

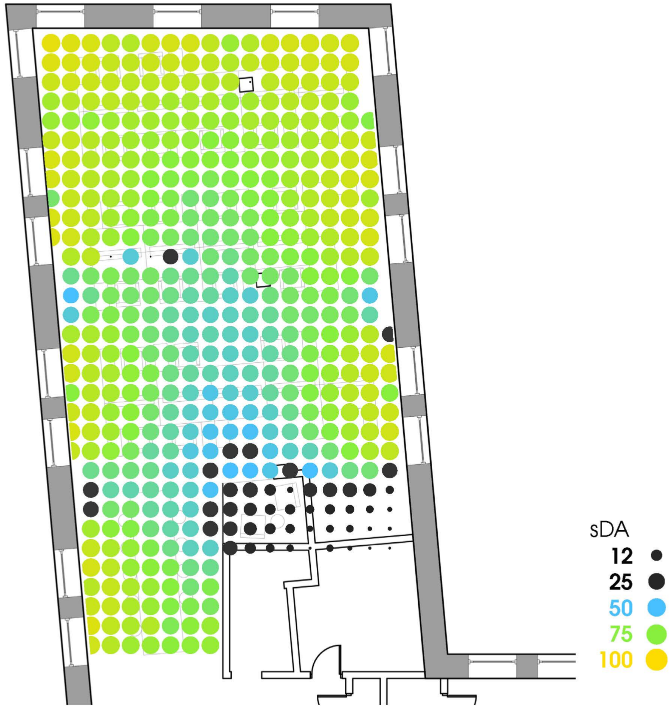
of floor area above 2000 lux



sDA

88.98%

of floor area above 300 lux



Takeaways

Annual data v. point-in-time discrepancies

LM83 was designed to balance ASE and sDA

Design decisions v. LEED compliance

Further investigation

LM83 integration

Computation time

Improved workflow

Tilted model

Window group optimization

Is ASE the right metric?

Thank you.

Kevin Van Den Wymelenberg

Alen Mahic

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INTEGRATED DESIGN LAB University of Idaho

nbi new buildings institute