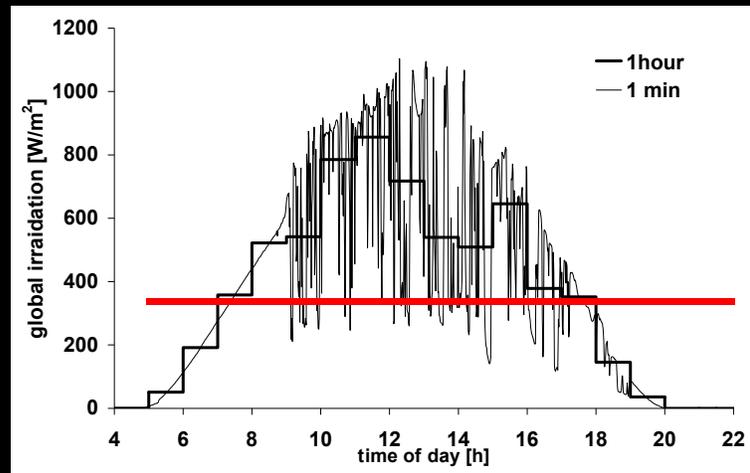


# 4.430 Daylighting

Christoph Reinhart  
4.430 Envelope Design



## Short-Time-Step Dynamics of Daylight

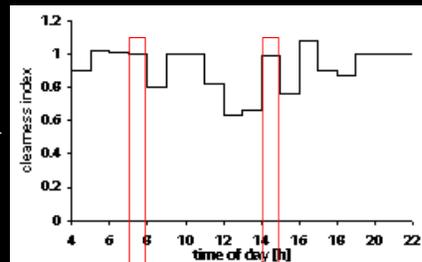
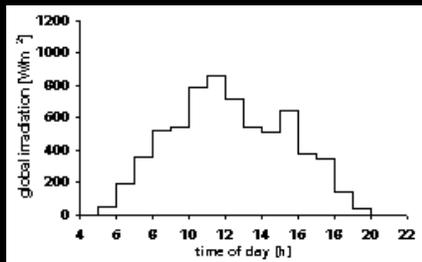


Paper

Walkenhorst O, Luther J, Reinhart C F, Timmer J, Dynamic annual daylight simulations based on one-hour and one minute means of irradiance data. *Solar Energy*, 72:5 pp. 385-395, 2002.

## Short-Time-Step Dynamics of Daylight

Step 1: Normalization



Interval 1 Interval 2

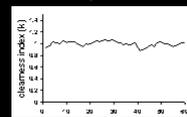
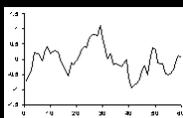
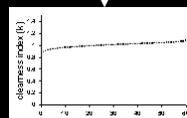
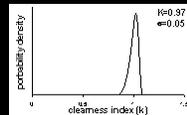


# Short Time Step Dynamics

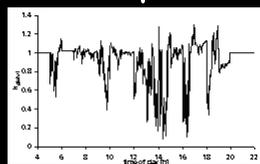
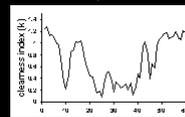
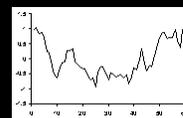
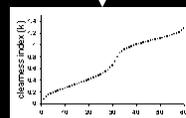


## Short-Time-Step Dynamics of Daylight

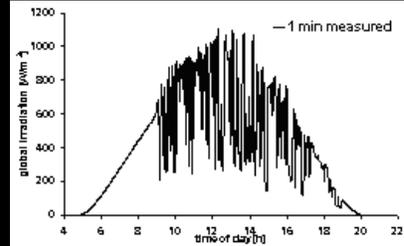
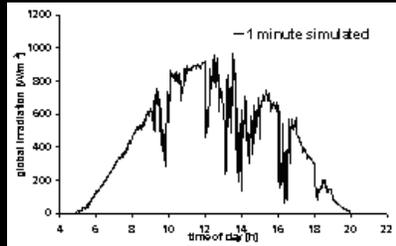
7AM to 8 AM



2PM to 3PM



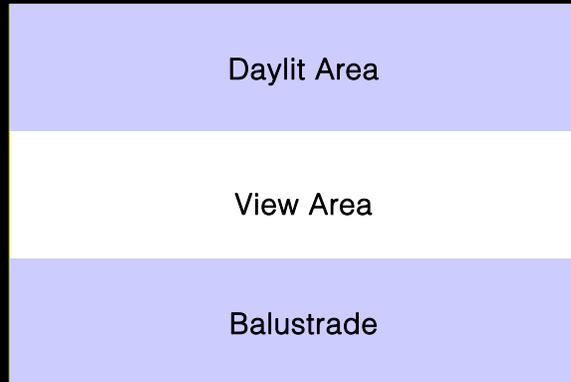
## Short-Time-Step Dynamics of Daylight



## Envelope Design



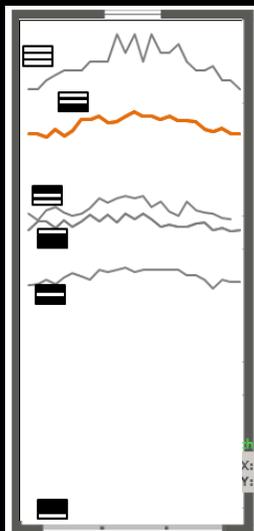
## Daylight - View - Balustrade



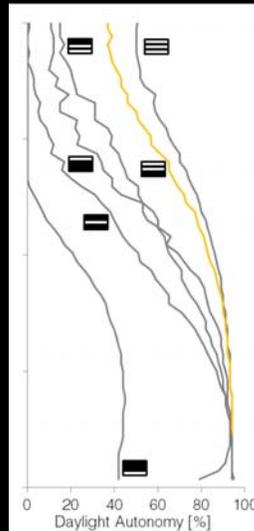
- For daylighting it is useful to conceptually divide a façade into three roughly equally sized areas, a “daylight” top part, a “view” central part and “balustrade” bottom part.
- The daylight area has maximum benefit for admitting daylight deep into a space, the view area mainly serves for “view to the outside” purposes and the balustrade has limited use for daylighting.



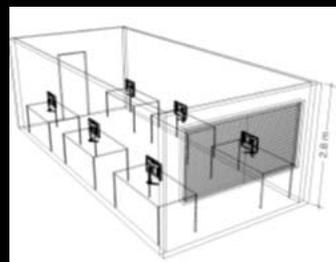
## Daylit Area in the Reference Office for six Façade Combinations



Plan



Section



Perspective View



## Divide the Façade into a View and a Daylighting Area

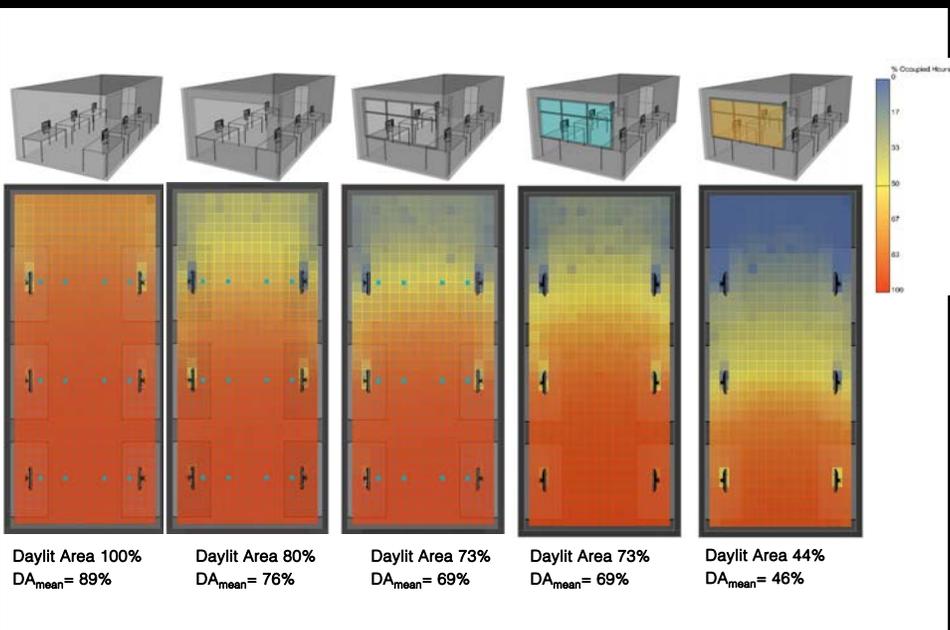


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Fraunhofer Institute for Solar Energy Systems, Freiburg  
 Architecture Dissing and Weitling, Copenhagen  
 Photo: Karsten Voss



## Façade Study



## Fraunhofer ISE - Borrowed Daylight on an Aisle



Photo: Karsten Voss

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Integration of Daylighting with nighttime cooling.

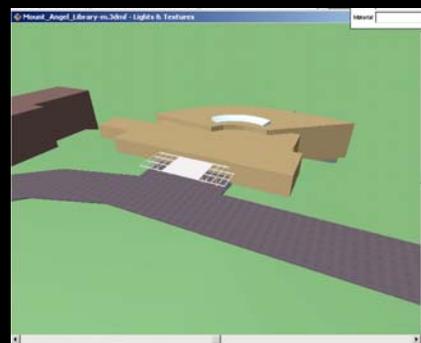


## Mount Angel Library



Photo by [jikido-san](#) on Flickr.

Project: Mount Angel Library, Oregon, USA (1970)  
Architect: Alvar Aalto



Design Workshop

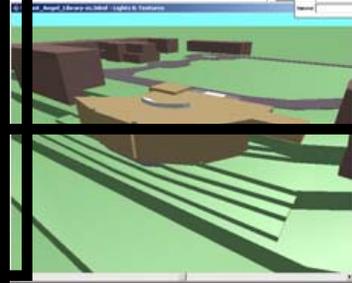
- rectilinear plan oriented east-west with fan-shaped space
- skylight facing North (no louvers)
- probaly due to north-sloping topography + views towards agricultural lands

Example taken from: Guzowski, Mary. Daylighting for sustainable design, New York: McGraw-Hill, 2000



## Mount Angel Library

Photographs of skylight and interiors of Mount Angel Library removed due to copyright restrictions.



skylight with adjacent reflective surface to capture and redistribute daylight  
predominantly overcast skies in Oregon



## General Design Advice for Massing Studies and Envelope Openings

- ⇒ If possible reduce floor plan depth to less than 5-7 times the floor to ceiling height.
- ⇒ Introduce setback on higher floors to increase the sky access for lower levels.
- ⇒ Introduce atria, skylights and clerestories.
- ⇒ Place window as high as possible near the ceiling.
- ⇒ Higher surface reflectances make rooms appear larger.
- ⇒ A vertical/horizontal window near a bright wall/ceiling makes a room appear wider/higher.



## Daylighting Techniques for Sidelit Spaces

- ❑ Provide **movable shading** only for the view area and control the daylighting area either automatically or add a complex fenestration system such as an external or internal lightshelf, a laser cut panel, and overhang, external louvers or a translucent panel.
- ❑ Work with the **ground** immediately adjacent to your façade.
- ❑ **Desirable reflectances** to have a well daylit environment : ceiling > 80%, walls > 50-70%, floor > 20-40%, furniture > 25-45% (avoiding specular surface finishes)



## Occupant Comfort and Well-being

### Design Advice

- ⇒ Use daylight for full spectrum color rendering
- ⇒ Balance a view to the outside with occupants' privacy (perforated shades)
- ⇒ Avoid low solar angles onto facades.
- ⇒ Maintain daylighting levels within acceptable limits
- ⇒ Develop a suitable shading device strategy (Shading from neighboring buildings, Venetian Blinds, Light shelves)
- ⇒ Avoid work places too close the exterior glazings



# Daylighting Techniques



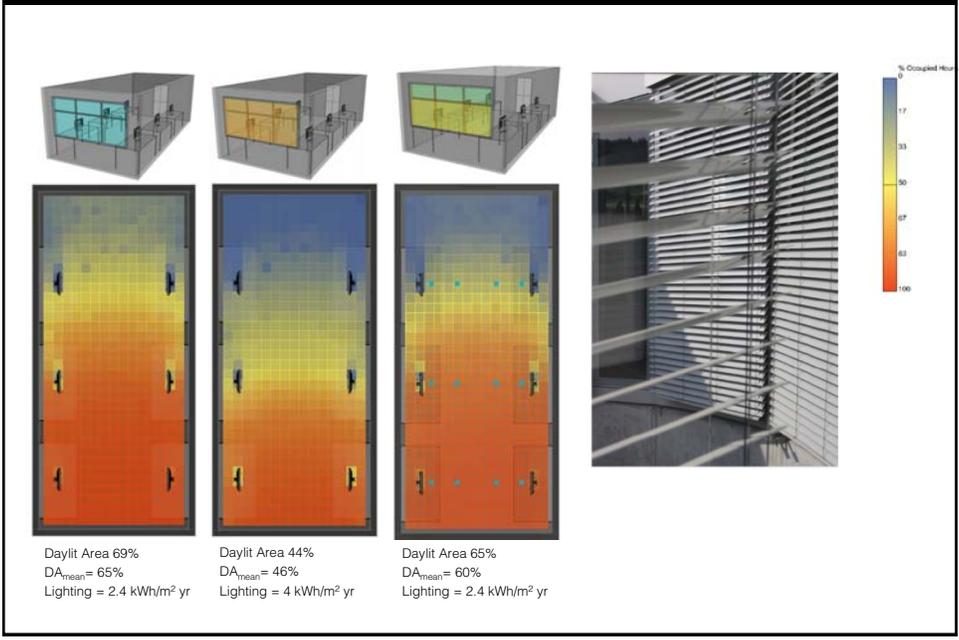
## Split Blind Study



7 cgY11 d UbX ]bhf]cf j ]Yk 'cZU'gd ]hV]bX grghra ]b 'h.Y @Ja dUrhYf CZZVrf '6i ]X]b[ 'bYUf Gh Hf Ufhz; Yfa Ubrrf



# Split Blind Study



# Bauhaus Dessau

moullions: outside black, inside white



Photo: Karsten Voss

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Project: Bauhaus Dessau, Germany (1925)  
 Architect: Walter Gropius



## German Reichstag



Photo by Michael Stephens on Flickr.

Project: Reichstag, Berlin, Germany (constructed 1894; renovated 1999)  
Architect: Paul Wallot, Norman Foster (renovation)

- sunlighting vs. daylighting (daylight redirecting cone)
- powerful symbolism of 'the people' walking on top of their parliament



## Arthelio - Lightpipe



Courtesy of Alexander Rosemann. Used with permission.

Photo: Alex Rosemann

Project: demonstration project in the Semperlux Building, Berlin, Germany (2000)  
Project management: Technical University of Berlin

Integration of daylighting and electric lighting (sulphur lamp).



## Butterfly System



Courtesy of Alexander Rosemann. Used with permission.

Photo: Alex Rosemann

Research Project: University of British Columbia, Canada (2005)

Prototype of a new light-redirecting daylighting system.



## National Art Gallery



Project: National Art Gallery, Ottawa, Canada (1988)  
Architects: Moshe Safdie

Photos: A. Rosemann

Courtesy of Alexander Rosemann. Used with permission.



## New York Times

Rendering of the NYTimes headquarters removed due to copyright restrictions.

Project: New York Times headquarters Building (under construction)  
Architects: Renzo Piano, Fox & Fowle  
Research Project: Lawrence Berkeley National Laboratory

Largest installation of automated lighting and dimming controls in North America.



## NY Times Design Goals

**“There should be no place where an employee does not see natural light and a view.”**

Floorplan of NY Times Headquarters removed due to copyright restrictions.

Cruciform shape of the building brings more light into the space and gives employees near-panoramic views.

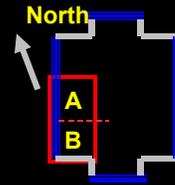
Open plan offices near the windows, private offices against the core.

Generous floor to ceiling height of 9'-7" with 10'-4" height in the five foot band by the windows.

Floor-to-ceiling clear low-iron glass (SHGC=0.39, Tv=0.75) made possible by the exterior ceramic rods



## Research Project: Energy/Comfort Performance in a Full-Scale Mockup



Furniture, daylighting, employee feedback and constructability: ~450 m<sup>2</sup>, 4500 sf mockup

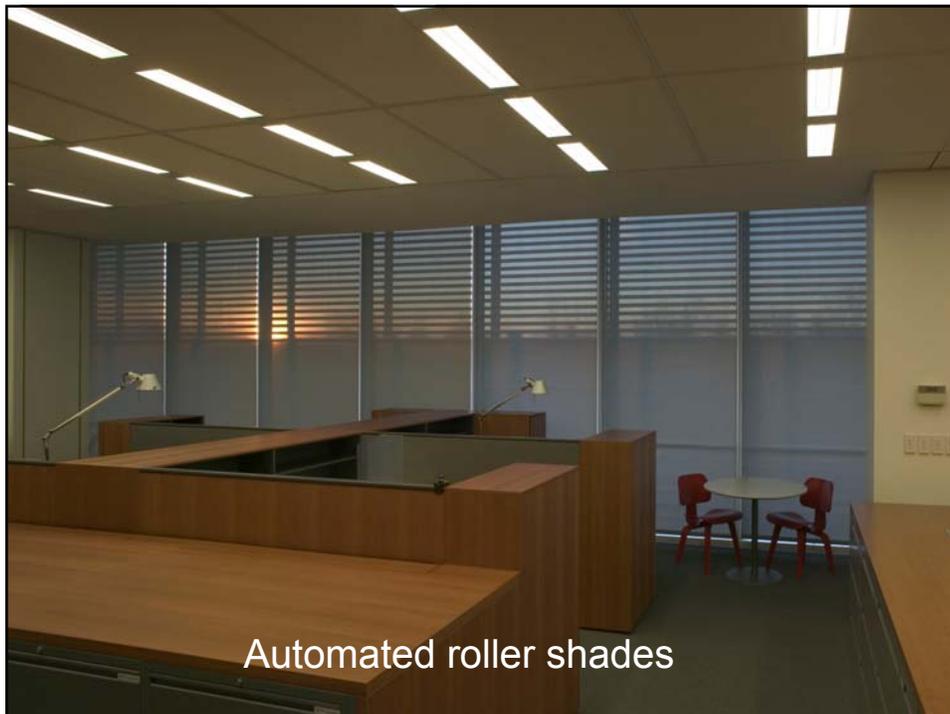
Core Concerns:

- Window glare (Tv 0.75)
- Daylight harvesting potential

Northwest Southwest corner of a typical floor

Investigate diverse technological solutions by multiple vendors

more info under: [http://windows.lbl.gov/comm\\_perf/newyorktimes.htm](http://windows.lbl.gov/comm_perf/newyorktimes.htm)



Automated roller shades

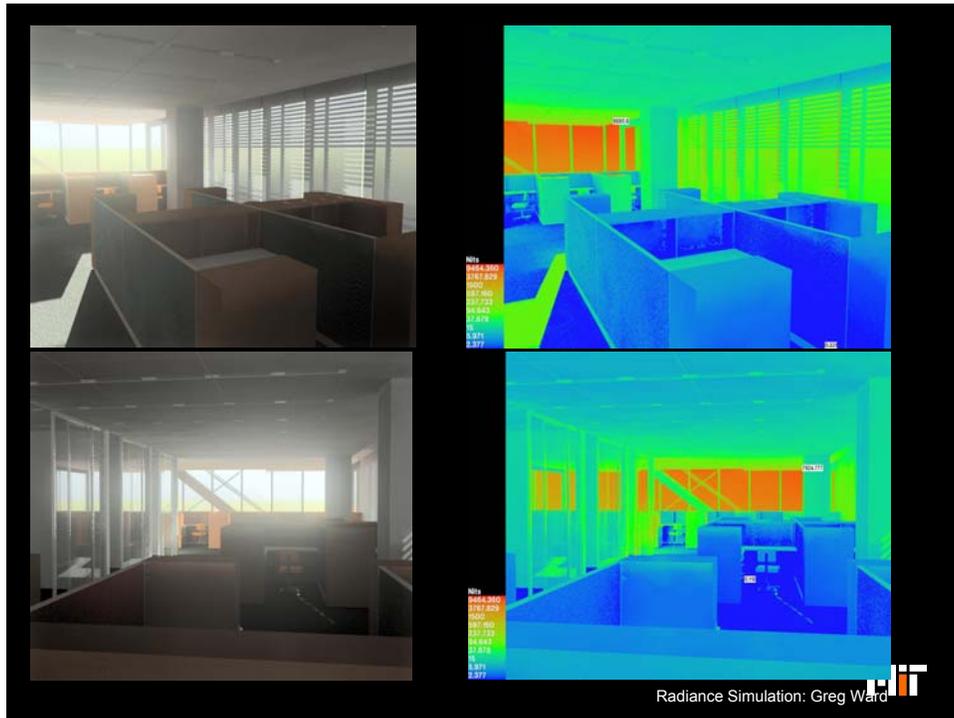
Courtesy of Gregory Ward. Used with permission.



Courtesy of Gregory Ward. Used with permission.



Courtesy of Gregory Ward. Used with permission.

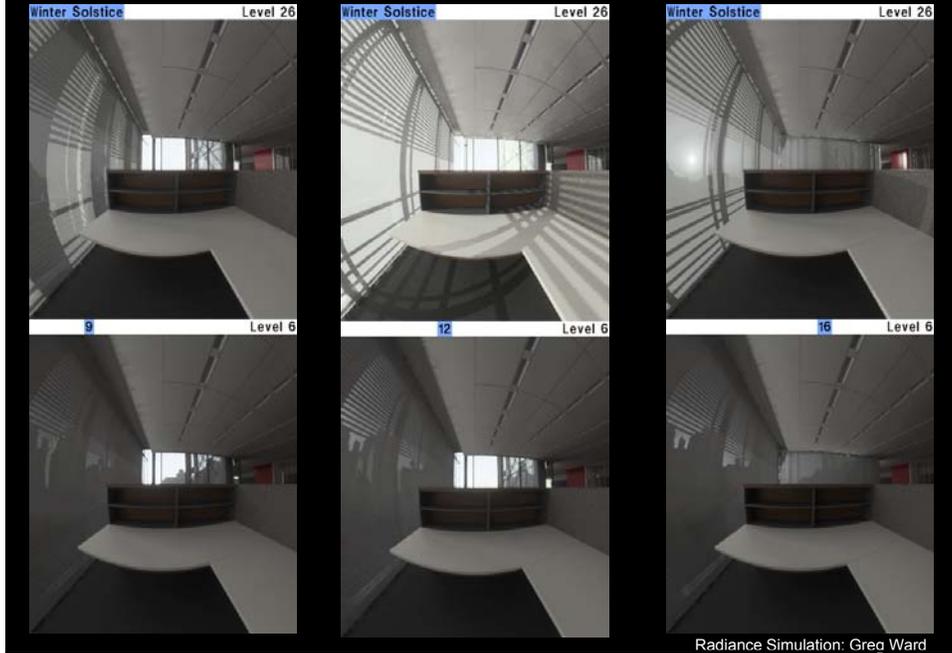


Courtesy of Gregory Ward. Used with permission.



Courtesy of Gregory Ward. Used with permission.

# Radiance Simulation – different floors



Radiance Simulation: Greg Ward

Courtesy of Gregory Ward. Used with permission.

# Daylighting Pattern Guide

**Advanced Buildings** Daylighting Pattern Guide

Home **Patterns** Using this Guide About DFG+E Development

Patterns

Filter by

<p><b>Pattern 1: Floor Plate Geometry</b> Multiple Buildings Courtyard/Skullion Plate Depth</p> <p><a href="#">View Pattern</a></p>	<p><b>Pattern 2: Window Area</b> Skullion Office Window Area Window Height Window Patterns</p> <p><a href="#">View Pattern</a></p>	<p><b>Pattern 3: Section Depth</b> Skullion Office Plate Depth</p> <p><a href="#">View Pattern</a></p>	<p><b>Pattern 4: Work Station Partitions</b> Skullion Office Interior Furnishing Interior Reflectances</p> <p><a href="#">View Pattern</a></p>	<p><b>Pattern 5: Glass Area Ratios</b> Fenestration Patterns From Two or More Sides Window Area Window Orientation Window Patterns</p> <p><a href="#">View Pattern</a></p>
<p><b>Pattern 6: Courtyard Depth and Width</b> Courtyard/Skullion Plate Depth</p> <p><a href="#">View Pattern</a></p>	<p><b>Pattern 7: Blinds and Shades</b> South Sun Penetration Sun Penetration Time of Day Time of Year</p> <p><a href="#">View Pattern</a></p>	<p><b>Pattern 8: Blinds and Shades</b> Blind Types Interior Furnishing Lower Blinds <b>Static Blinds</b> Shading Dynamics Sky Condition</p> <p><a href="#">View Pattern</a></p>	<p><b>Pattern 9: Toplighting Gymnasium</b> Toplighting Design Clerestory Windows Glass Diffusion Interior Reflectances Skylighting Skylighting Area Type of Glazing</p> <p><a href="#">View Pattern</a></p>	<p><b>Pattern 10: Toplighting Warehouse</b> Toplighting Design Glass Diffusion Interior Reflectances Perimeter Orientation Skylighting Skylighting Area Type of Glazing</p> <p><a href="#">View Pattern</a></p>

<http://patternguide.advancedbuildings.net/>



# Daylight Design Variations Book

Cover image of book removed due to copyright restrictions.

<http://sts.bwk.tue.nl/daylight/varbook/index.htm>



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