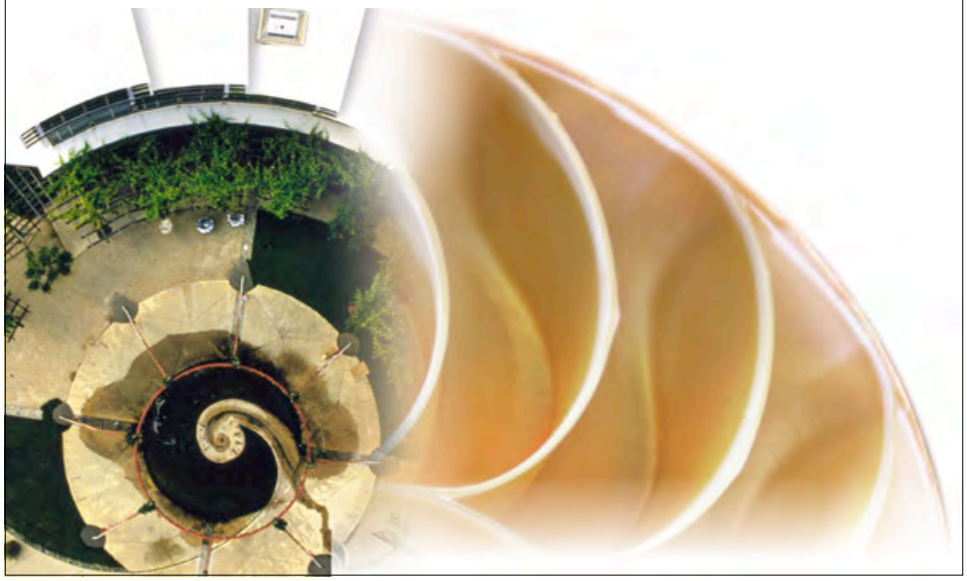
Daylight Models & Design

ARCH 331/431 Spring 2008
Lecture 20



MURCUTT studio PALLASMAA workshop

STUDENT WORK Gould Hall Friday 6 June 2008 3:00 to 7:00 pm

announcements 6/5/08

Final Exam Alternate Time:

Wednesday, 6/11

4:30 - 6:20

Smith (SMI) 304

Final Exam Assigned Time:

Friday, 6/13

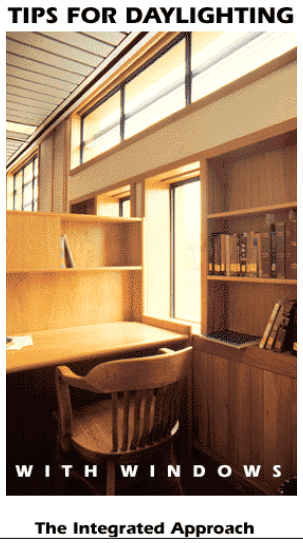
4:30 - 6:20

Gowan 201

Daylighting Design Tips

Tips for Daylighting with Windows

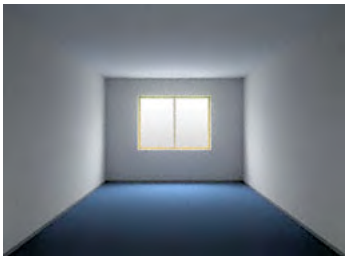
http:windows.lbl.gov/pub/designguide/designguide.html

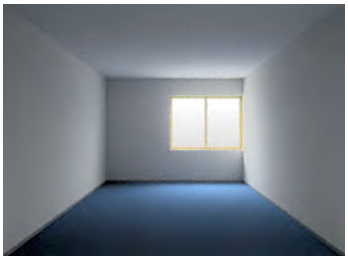


Daylight Design Resources

Daylight Design Variations Book

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





Physical Models and Daylighting

Why use physical models?
How to build daylighting models
How to test daylighting models

Why use physical models?

Light requires no correction for changes in scale: A scaled model behaves exactly as a full size building does.

Easy to construct while providing valuable insight into the quality of a space.

Proof of Concept

By modeling an existing space in detail, we can prove that daylighting models behave exactly the same as a full size building

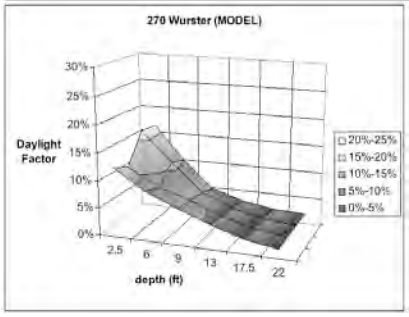
Proof of Concept

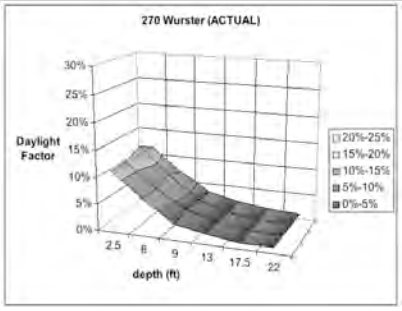
parametric analysis

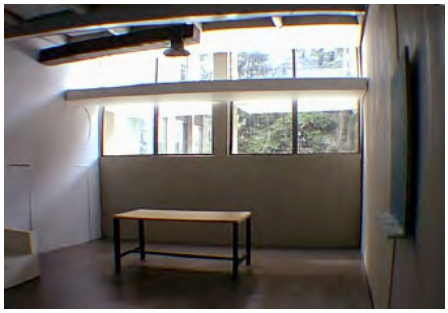
Proof of Concept

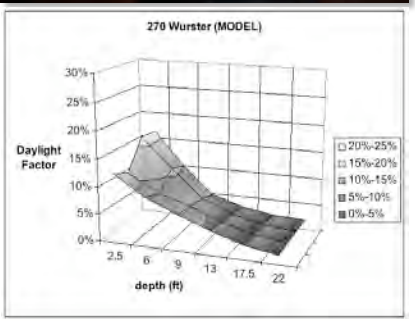

Proof of Concept

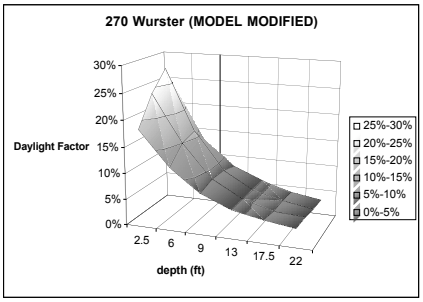

Proof of Concept



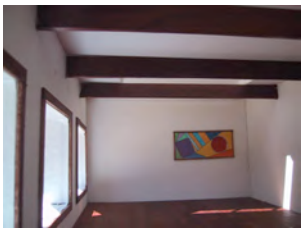


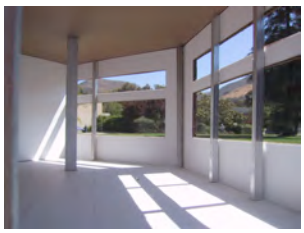


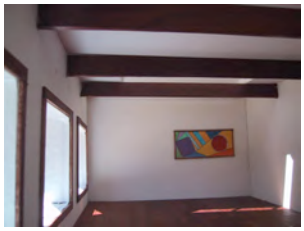


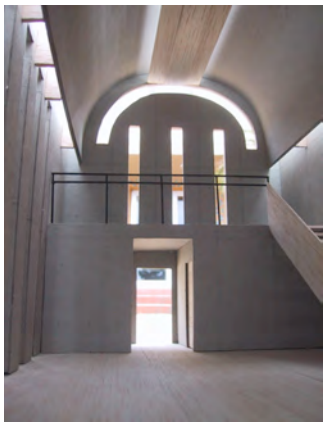


Student Study Models









Student Study Models

Daylighting Study Models

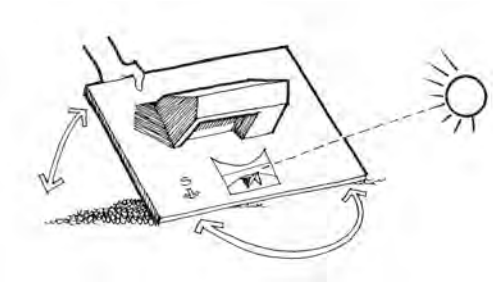
Surface materials are approximated

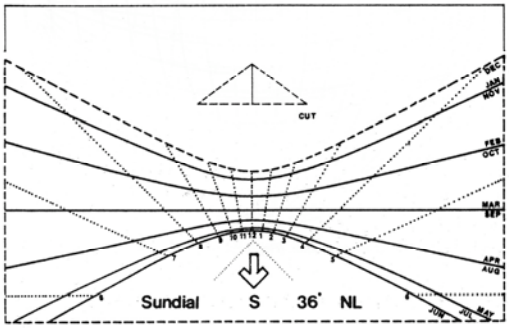
Quick model construction allows for multiple variations to be tested

Good for both qualitative and quantitative studies

Exploring Daylight Models:

Real Sky Studies



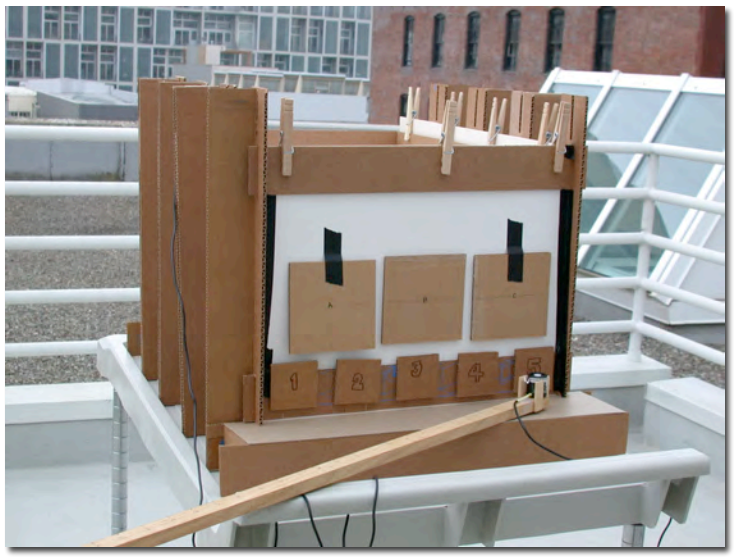


Advantages:

*Best for **Qualitative** Analysis*

- *Full Spectrum Light - good color*
- *Dynamic lighting conditions*
- *Both clear sky and overcast sky conditions - and everything in between*

How to build physical models



How to build physical models

Scale 3/4" = 1'

Wall thickness

Light leaks

Materials

- Why cardboard and paper?
- Tape?
- The window glazing?
- Translucent materials?

Daylighting Tools – Sky Simulator

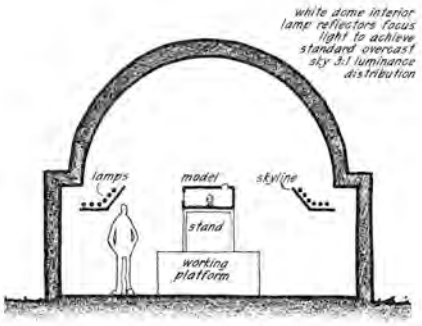
Replicates an overcast sky (diffuse daylight)

Primarily used for quantitative studies

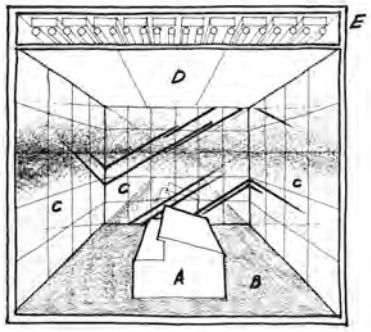
Measures the amount of daylight hitting a specific part of an interior space

This is then compared to the amount of daylight available (daylight factor)

Exploring Daylight Models
Sky Simulator



Sky Dome Simulator

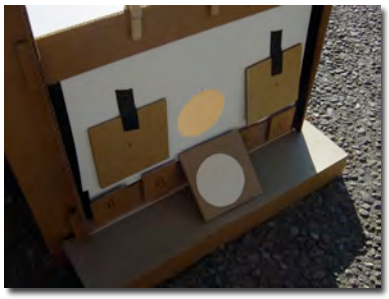


Mirror Box

Advantages: *Best for* ***Quantitative*** *Analysis*

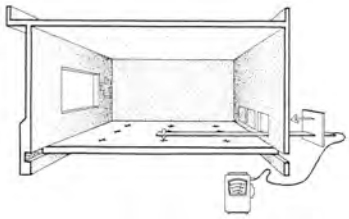
- *Consistent, reproduceable conditions for parametric studies*
- *Simulation of uniform overcast sky conditions only*

Openings



Li - Cor light meter

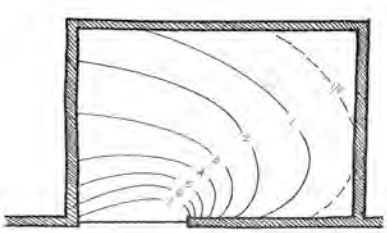
Quantitative Analysis of Daylight Models



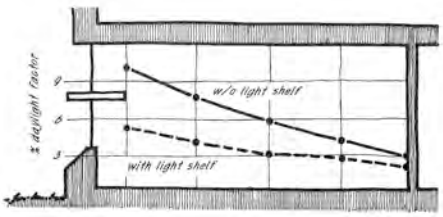
Use Daylight Factor:

$$\frac{\text{Light at Points Inside}}{\text{Light Available Outside Window}}$$

1 footcandle ~ 10 lux

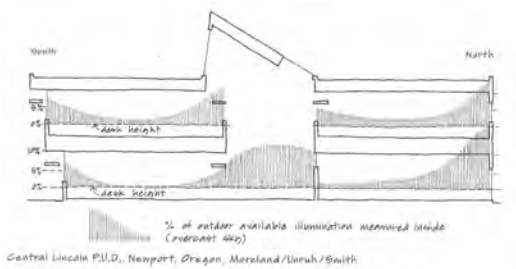


isolux plans



daylight sections

daylight factor graphs



Central Lincoln P.U.D., Newport, Oregon, Moreland/Unruh/Smith

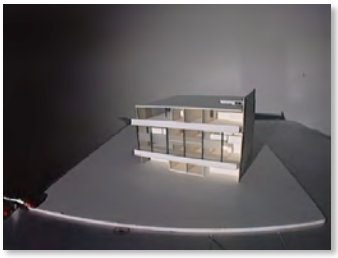
Central Lincoln P.U.D., Newport, Oregon, Moreland/Unruh/Smith

Daylighting Tools – Heliodon

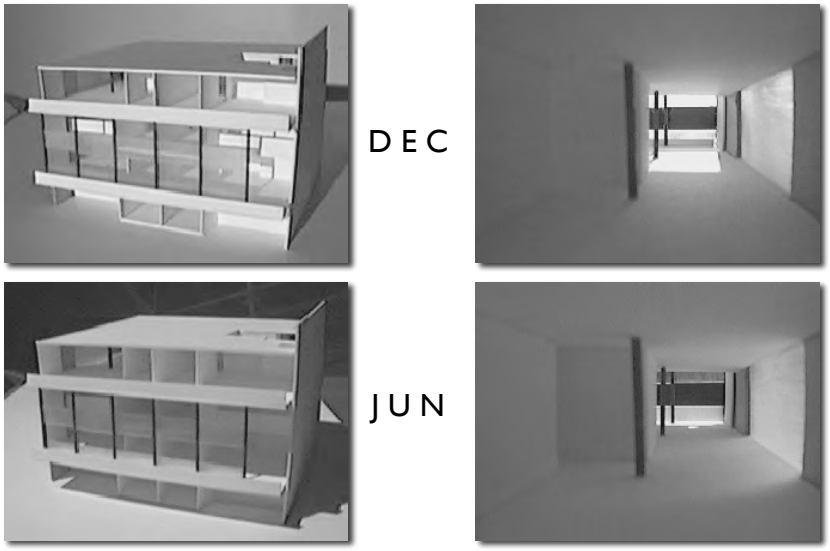
Models direct beam (sunlight) penetration and shading

Models different locations, times of day and year

Not an accurate tool for studying daylighting



Heliodon Images



Four goals for designing with daylight

1. Use as much daylight as possible to replace electric lighting; bring it deeply into the space.
2. Provide adequate illumination levels for the given tasks and purpose of the space.
3. Avoid creating visual discomfort.
4. Consider *light as formgiver of architecture*; make use of all the visual and experiential qualities of daylight possible.

Goal Two:
Provide adequate illumination levels

Dining	5 - 10 fc
Reading	30 - 50 fc
Conferring	20 - 50 fc
CRT screens	5 - 10 fc

from the IES Lighting Ready Reference

Daylight Factor

MEEB Table 14.2, pg. 593

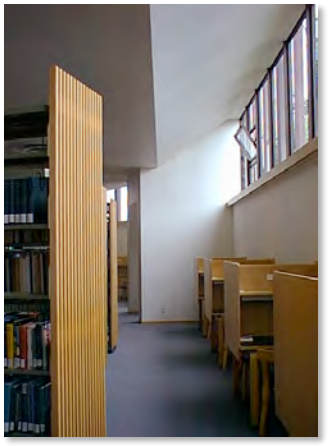
$$DF = \frac{\text{indoor illumination from daylight}}{\text{outdoor illumination at window plane}} \times 100\%$$

Recommended Daylight Factors

TASK	DF
Ordinary seeing tasks, such as reading, filing, and easy office work	1.5 - 2.5%
Moderately difficult tasks, such as prolonged reading and normal machine tool work	2.5 - 4.0%
Difficult, prolonged tasks, such as drafting, proofreading poor copy, fine machine work, and fine inspection	4.0 - 8.0%

Rule of Thumb for adequate illumination

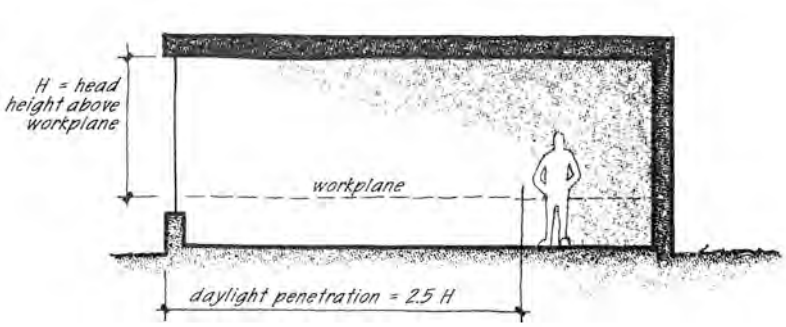
For daylighting, the room depth (distance from the window wall) should be less than 2.5 times the height of the window head to maintain a minimum level of illumination and an even distribution of light.



Daylight Rule-of-Thumb

2.5 x H Rule

MEEB Fig. 14.21, pg. 594

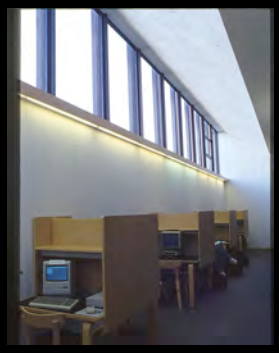


The portion of a space that can be considered "daylit" is the area located 2.5 times the height of the window head above the workplane, from the window into the room.

Sidelighting

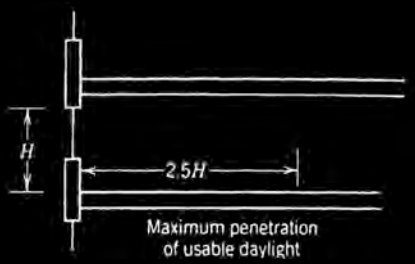
Rule-of-thumb

MEEB Table 14.4, pg. 595



$$DF_{av} = 0.2\left(\frac{\text{window area}}{\text{floor area}}\right)$$

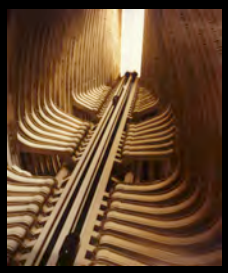
$$DF_{min} = 0.1\left(\frac{\text{window area}}{\text{floor area}}\right)$$



Toplighting

Rule-of-thumb

MEEB Table 14.4, pg. 595



Vertical monitors:

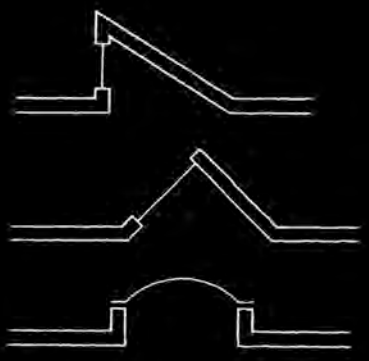
$$DF_{av} = 0.2\left(\frac{\text{skylight glazing area}}{\text{floor area}}\right)$$

North-facing sawtooth:

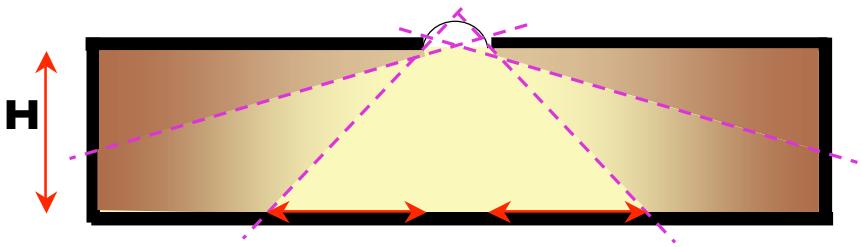
$$DF_{av} = 0.33\left(\frac{\text{skylight glazing area}}{\text{floor area}}\right)$$

Horizontal skylights:

$$DF_{av} = 0.5\left(\frac{\text{skylight glazing area}}{\text{floor area}}\right)$$



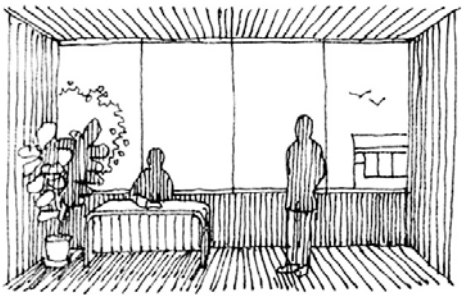
Skylights: Light Distribution



Effective daylight distribution ~ 1 times the floor to ceiling height in each direction from the skylight

Goal Three: Avoid Visual Discomfort

- Insufficient light
- Shadows or patterns
- Veiling reflections
- Contrast Glare



shadows / patterns

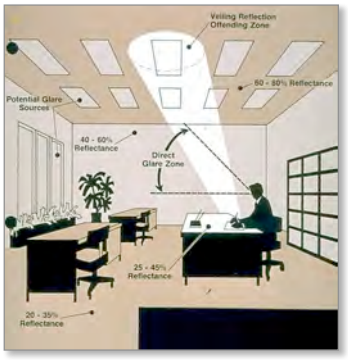
reduce contrast glare

Discomfort Glare

- 3 : 1 for Task to Surround (10 : 1 max.)
- 20 : 1 for window to adjacent surfaces

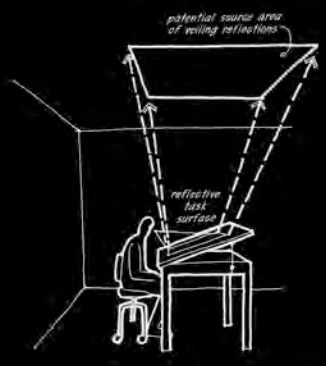
contrast levels • luminance ratios

Task to adjacent surfaces	**1:3**
Task to surfaces within a 30 degree cone of vision	**1:10**
Anywhere in the room	**1:40**



Disability Glare

- Reduce puddles and splashes of light
- Minimize veiling reflections

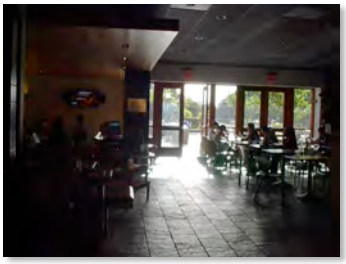


Veiling Reflections

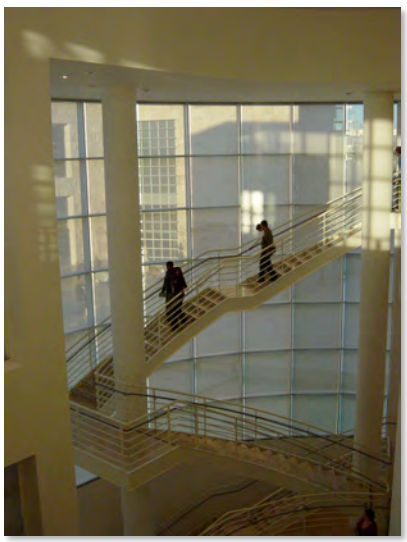
Minimize light that is too directional

Reducing Glare

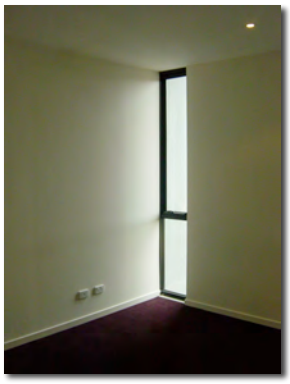
- *light* window frames
- wall washing
- windows on two sides of a room
- thick or splayed window frames
- clerestory windows
- lightshelves
- indirect daylighting

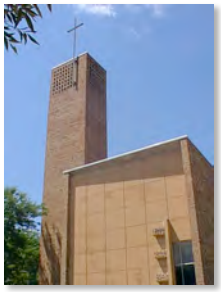
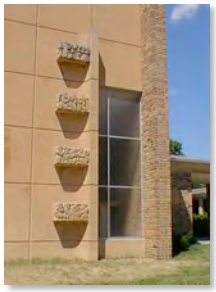


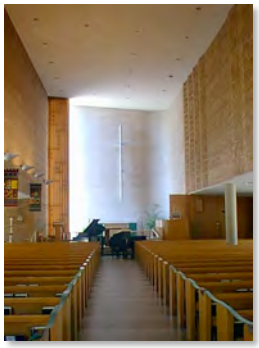
light window frames



wall washing



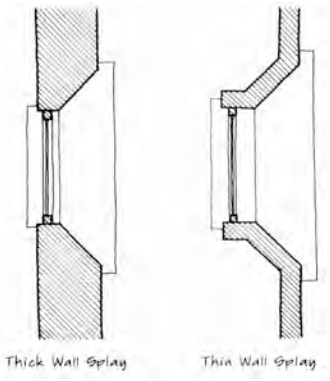



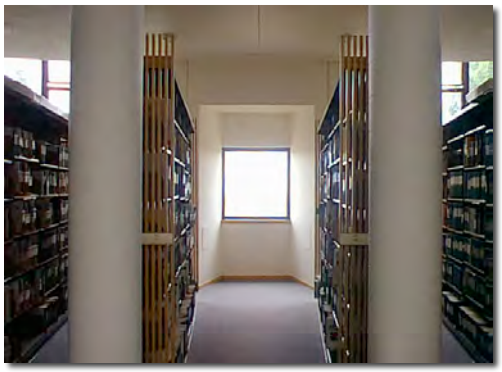
windows on two sides

windows on two sides + wall washing

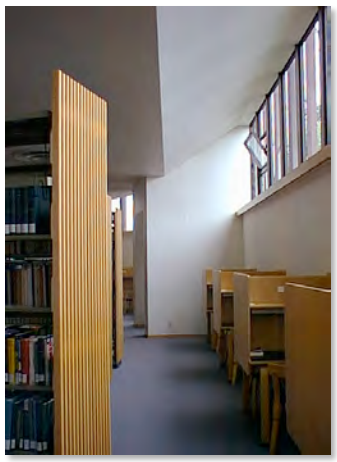
thick or splayed frames

thick or splayed frames



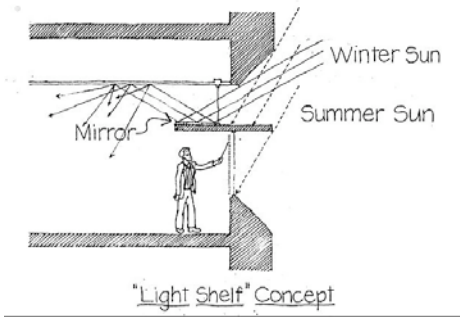


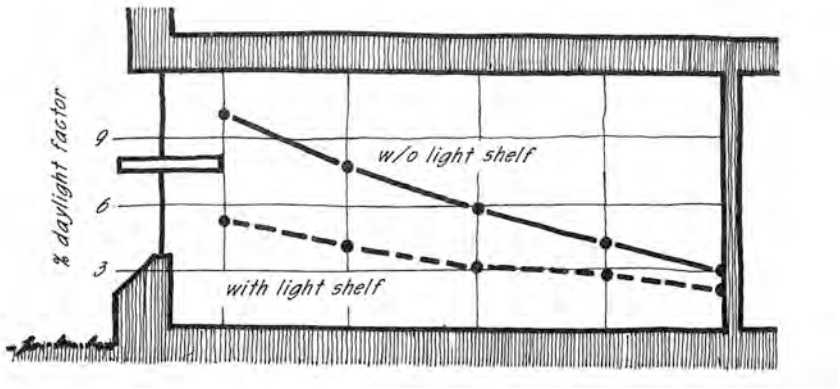
clerestory windows



lightshelves

- reduce glare by blocking view of the bright sky
- wash ceiling with daylight
- create a more even distribution of daylight
- if extended outside past the window, they act as shading devices – brise soleil – blocking glare-causing direct sunlight

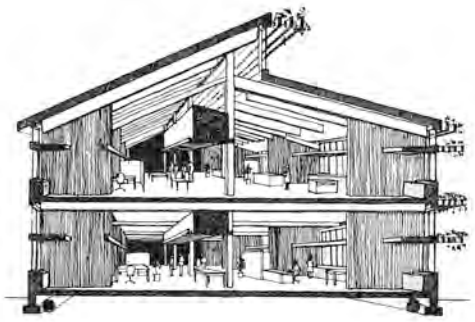


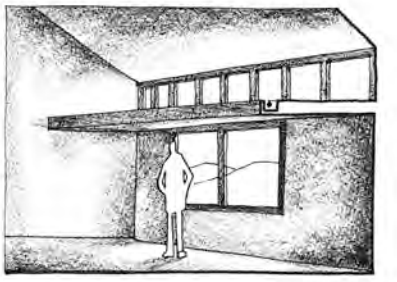


Light shelves rarely produce higher illuminance levels away from the window; however, they often improve the quality of illumination and perceived lighting levels by providing more even daylighting and reducing glare for room occupants.

Emerald Peoples Utility District Building Eugene, Oregon

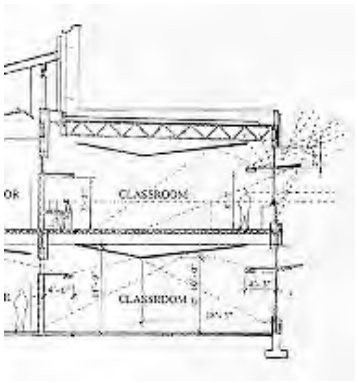
John Reynolds and G.Z. Brown





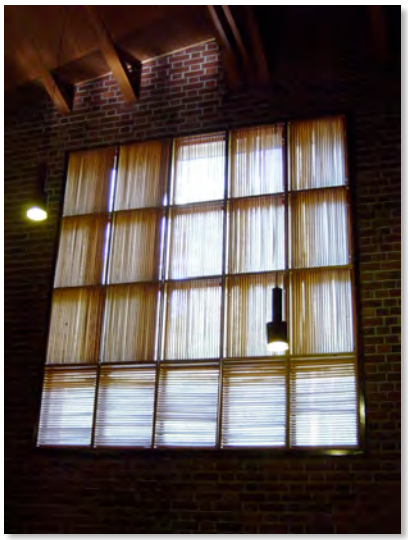
Clackamas High School

Clackamas High School



indirect daylighting

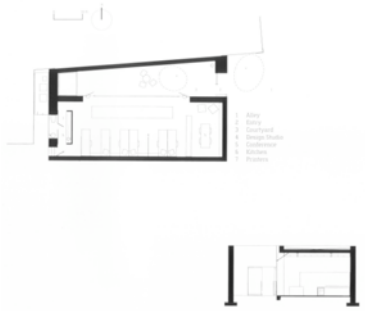
- borrowed daylight
- reflected daylight
- daylighting *fixtures*
- effective skylights



borrowed daylight

reflected daylight

reflected daylight



Rubio Avenue Studio, Tucson, Arizona

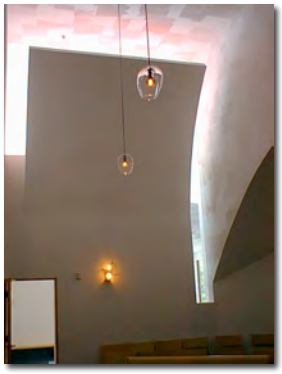
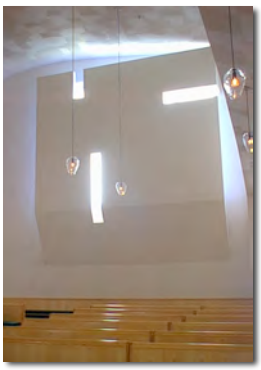
Rick Joy Architects

reflectivity of materials

Material	*Reflectance*
Flat black paint	.05
Brown concrete	.15
Red bricks	.30
Uncolored concrete	.35
White semi-gloss paint	.70
Polished aluminum reflector	.88

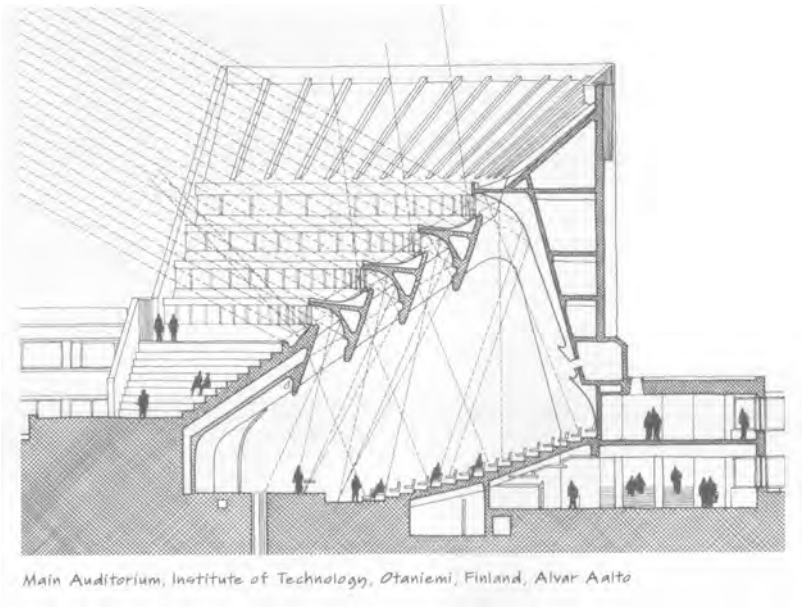
from SWL, pp. 218-219

daylighting fixtures

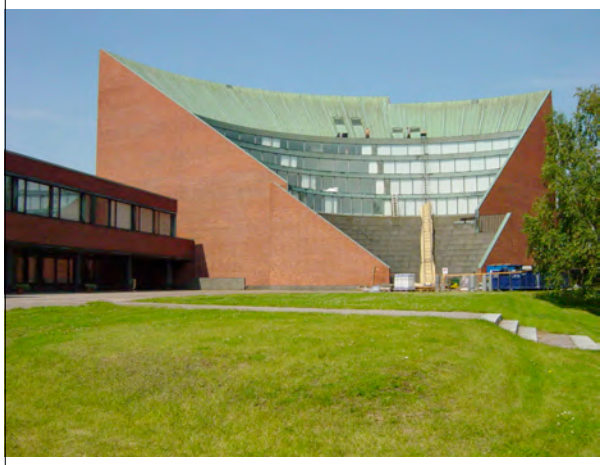




Architectural elements in combination with windows or skylights that reflect, diffuse, distribute or otherwise control how daylight enters a space.

daylighting fixtures

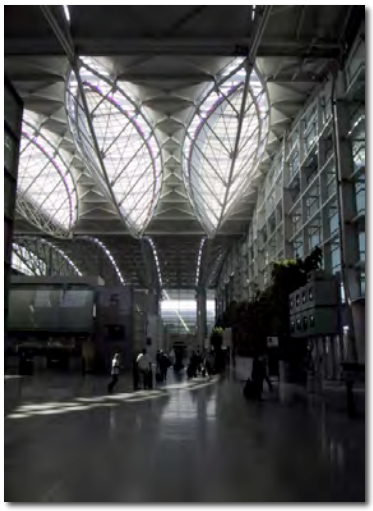


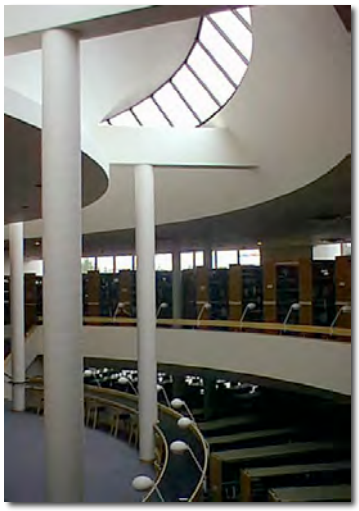
Main Auditorium, Institute of Technology, Otaniemi, Finland, Alvar Aalto



Institute of Technology, Otaniemi, Finland

Alvar Aalto





effective skylights

Skylights must be deep enough to minimize direct beam radiation (sunlight) from entering the space

Skylights can also double as electric lighting fixtures at night

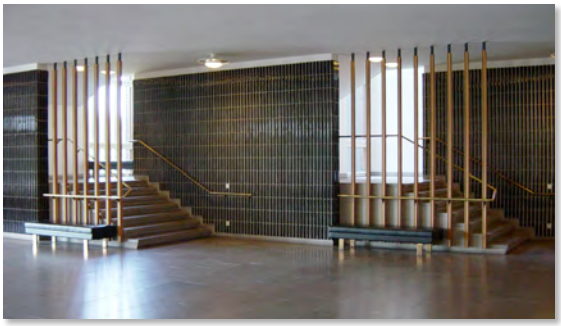
Goal Four: Architectural Spacemaking

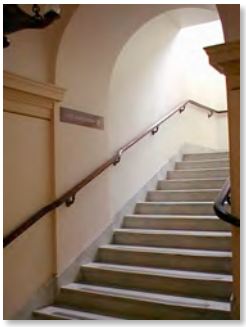
Daylight can be used as an architectural element as fundamental as structure, material or form.

Daylight is dynamic, changing the perception of a space throughout the day and year.

daylight as highlight

leading daylighting



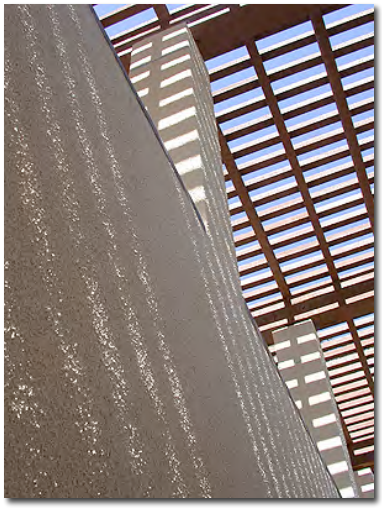


Alvar Aalto • Seinajoki Town Hall

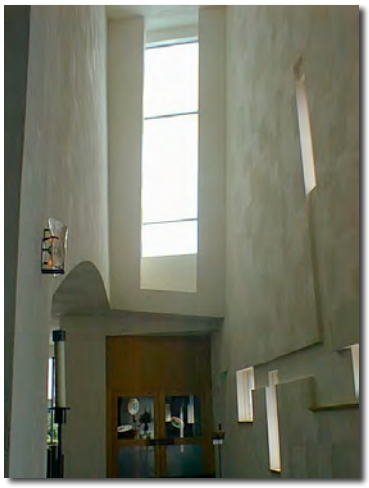
Daylight can be used to highlight certain paths or ways of moving through a space

rhythmic daylighting

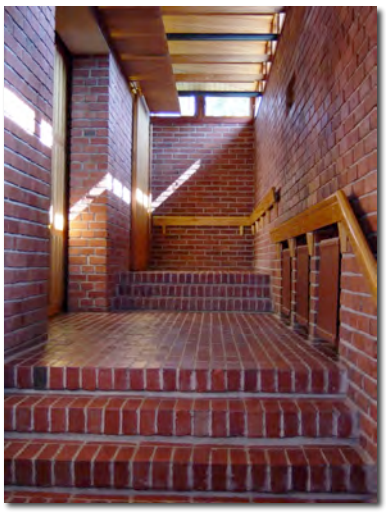
material textures revealed by daylight

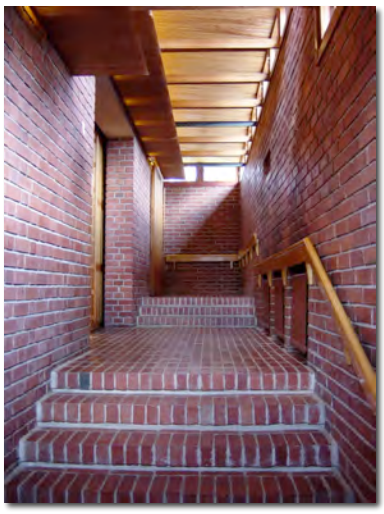


material textures revealed by daylight



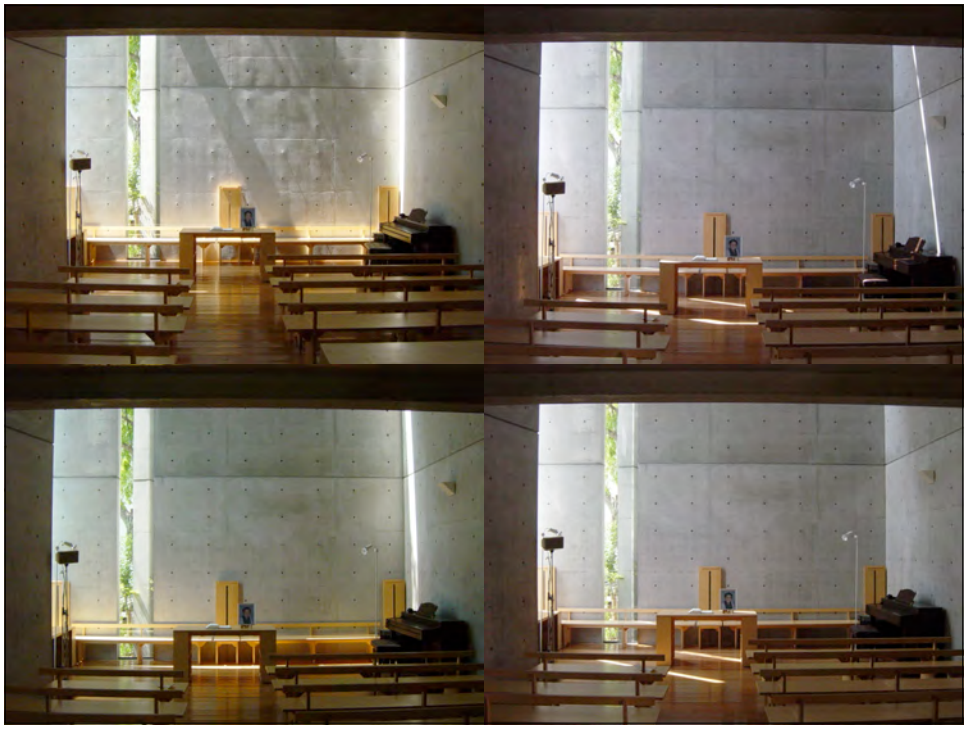
dynamic daylighting

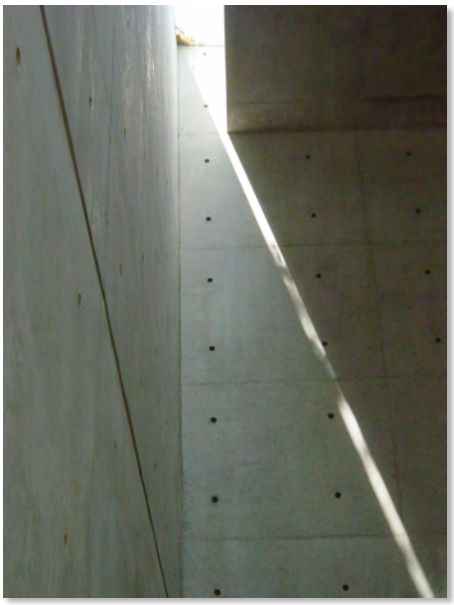




Church of the LightOsaka, Japan

Tadao Ando





Myyrmäki Church, Finland

Juha Leiviskä