

4.430 Daylighting

Christoph Reinhart
4.430 Scale Models



Seinäjoki Library



Photo by [Cemre Güngör](#) on Wikimedia Commons.

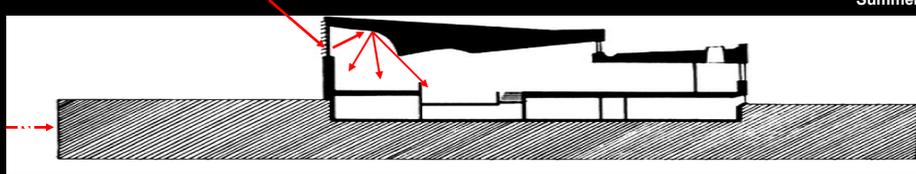
Project: Seinäjoki Library, Finland (1965)
Architect: Alvar Aalto



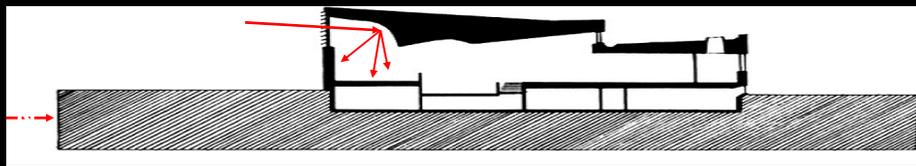
Seinäjoki Library

Latitude 63° N

Summer



Winter



Plan: Donovan Nelson

© The McGraw-Hill Companies. All rights reserved. This content is excluded from our Creative Commons license. For more information, see <http://ocw.mit.edu/fairuse>. Source: Guzowski, Mary. Daylighting for sustainable design. McGraw-Hill, 2000.



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

Different Shading Strategies

- Static vs. dynamic systems*
- Interior vs. exterior systems*
- Manual control, automated control, automated with manual override*



Scale Models



Computer Simulations & Scale Models I

Case Study: Fraunhofer Institute for Solar Energy Systems (1998)



Photo



Computer Model



Scale Model

Computer Simulations & Scale Models II



Scale Model

- costs 10000 Euro
- accuracy under artificial skies within 20%
- provides opportunity to walk around
- used for presentational purposes



Computer Simulations & Scale Models III



Computer Model

- costs ~10000 Euro (including analysis)
- accuracy within 20%
- influenced façade design
- walk around and within



Heliodon

Photographs of manual heliодons from Pacific Energy Center and University of Washington Daylighting Lab, and motorized heliодons from UI-Integrated Design Lab and High Precision devices removed due to copyright restrictions.

SOUTHWEST FAÇADE ANALYSIS

Photographs from heliodon facade analysis of Mixed Use Building in Scottsdale, AZ removed due to copyright restrictions.

Heliodon –Interior Analysis

Photographs of interior of Idaho Central Credit Union in Pocatello, ID with and without shading removed due to copyright restrictions.

Built Reality

Photographs of Idaho Central Credit Union in Pocatello, ID removed due to copyright restrictions.

Artificial Sky – Sky Dome – Sky Simulator

Photographs of Welsh School of Architecture sky dome removed due to copyright restrictions.

Artificial Sky – Sky Dome – Sky Simulator

Photographs of Bartenbach Lichtlabor sky dome and University of Washington daylighting lab removed due to copyright restrictions.

Artificial Sky – Daylight Factor Analysis I

Photograph of model and daylight factor diagram of Ada County Weed and Pest Abatement in Meridian, ID removed due to copyright restrictions.

Artificial Sky – Daylight Factor Analysis II

Photograph of model and daylight factor diagram of Ada County Weed and Pest Abatement in Meridian, ID removed due to copyright restrictions.

Artificial Sky – Visual Analysis

Diagram of control cell and photocell array removed due to copyright restrictions.

Artificial Sky – Visual Analysis

Photographs from case study of Rainier Vista Boys & Girls Club in Seattle, WA removed due to copyright restrictions.

Comparison – Scale model Measurements vs. Reality Gallery

Photographs of Turner House and model of Turner House removed due to copyright restrictions. Source: Figures 2 and 3 in Cannon-Brookes, S.W.A. "Simple scale models for daylighting design: Analysis of sources of error in illuminance prediction." *Lighting Research and Technology* 29 (1997): 135-142.

Model

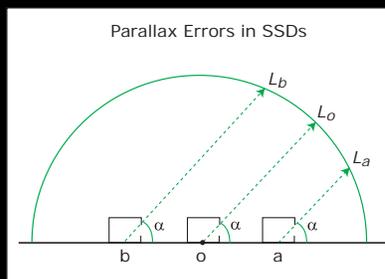
Reality

'Scale models tend to overestimate interior illuminances by about 20%'

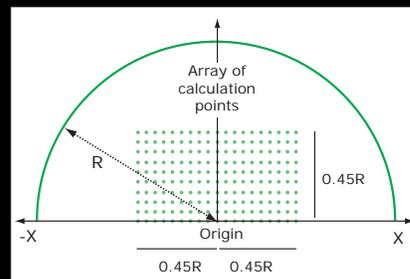
Reference: S W A Cannon-Brookes, Simple scale models for daylighting design: Analysis of sources of error in illuminance prediction", *Lighting Research and Technology* 1997 29(3) 135-142



Parallax Errors in Sky Simulators



Parallax Error



Determination of a Parallax Bound Volume

Low accuracy ($\pm 50\%$): > tested area

Mid accuracy ($\pm 25\%$): 0.5R long and wide and 0.2R high

High Accuracy ($\pm 10\%$): 0.15R long, 0.05R wide and 0.05R high

'...on the basis of a credible design goal for the sky simulator dome, high accuracy illuminance predictions ($\pm 10\%$) are practically unattainable ...'

Reference: J Mardaljevic, Quantification of parallax errors in sky simulator domes for clear sky conditions", *Lighting Research and Technology* 34,4 (2002) pp. 313-332



Discussion

- ❑ Costs of simulations vs. physical models. Comparable if the infrastructure already exists.
- ❑ Different tools for different objectives: Physical models shine when it comes to complicated materials with 'imperfections'. Another application are getting a sense for massings and proportions.
- ❑ Simulations can look at all sky conditions of the year.



Material Selections

INTERIORMATERIALS



Materials Used

- EXTERIOR WALL
- WINDOW FRAME
- FLOOR
- CEILING
- WALLS
- DESKS
- DESK LEGS
- WHITEBOARD
- DOOR

Chipboard + Foamcore
Museum Board
Laser Printed Wood Pattern
Coated Paper
Bristol Paper
Foamcore Board
Wood
Foamcore Board
Laser Printed Wood Pattern

Grey Wall Concrete, Ref#0	White Wall Plaster, Ref#0-90	Whiteboard/Desks Porcelain, Ref#0-83	Wood Flooring Light Oak, Ref#25-35	Ceiling Panels PVC, Ref#90-95
↓	↓	↓	↓	↓
Chipboard	Bristol/Museum Board	Foamcore	Printed Wood Pattern	Glossy Paper

Interior Criteria

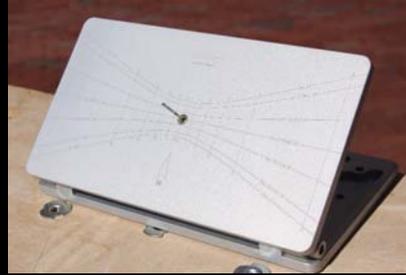
- Effect of different wall color
- Effect of different material reflection

Material Reflectance Source:
<https://forums.autodesk.com/4046-making-convincing-materials-choices-use.html>

T Dogan & N Yoon



Using the Heliodon



Adjust 3 angles:

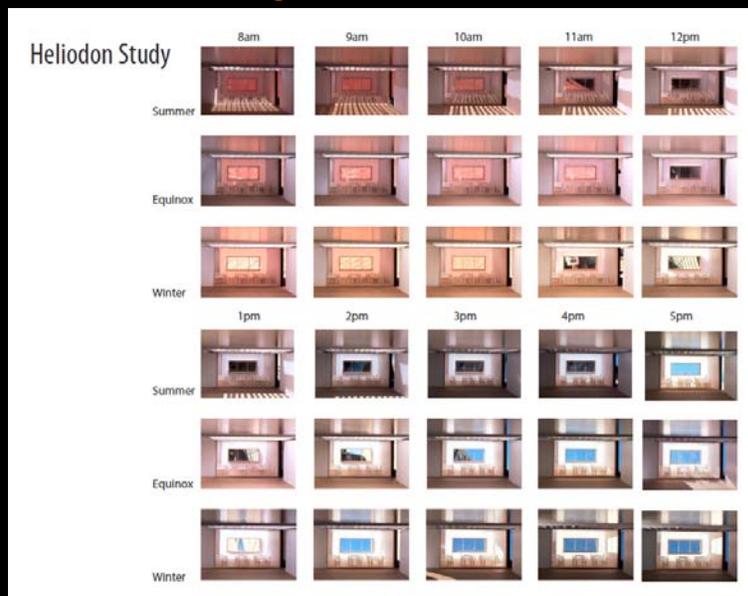
$\theta = 90^\circ - \text{site latitude}$

α = stand should directly face the sun

β = rotate until the sun's shadow corresponds to the desired day of the year



Modes of Analysis



T Dogan & N Yoon



Modes of Analysis



D Pal & A Payne



MIT OpenCourseWare
<http://ocw.mit.edu>

4.430 Daylighting
Spring 2012

For information about citing these materials or our Terms of Use, visit: <http://ocw.mit.edu/terms>.