RETROFITTING LIBRARIES FOR DAYLIGHTING WORK ENVIRONMENTS/TRANSITION SPACES

case study: Harvard Cabot Science Library
MIT 4.430: Daylighting
DESCRIPTION OF THE PROJECT

_DAYLIGHT IN LIBRARIES

HELSINKY PENSIONS INTITUTE

SEINAJOKI PUBLIC LIBRARY
**Table 1. IES Recommended Light Levels for Libraries** (Foot-candles)

<table>
<thead>
<tr>
<th>Space</th>
<th>Recommended Illuminance (Foot-candle Level)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active (occupied) Book Stacks</td>
<td>See table footnote a below</td>
</tr>
<tr>
<td>Inactive Book Stacks</td>
<td>5&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Book Repair and Binding</td>
<td>30</td>
</tr>
<tr>
<td>Cataloging</td>
<td>30</td>
</tr>
<tr>
<td>Circulation Desk and Reference Desk</td>
<td>30&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Computer Areas</td>
<td>30</td>
</tr>
<tr>
<td>Audiovisual Areas</td>
<td>30</td>
</tr>
<tr>
<td>Audio Listening Areas</td>
<td>30</td>
</tr>
<tr>
<td>Reading (normal size and contrast: newsprint, magazines, keyboard)</td>
<td>30</td>
</tr>
<tr>
<td>Reading (very small size and low contrast: fine detail items, small print)</td>
<td>50&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>For book stacks, use vertical foot-candle levels. See the discussion immediately below.

<sup>b</sup>At 30 inches above the finished floor level.

<sup>c</sup>Although this is the IES standard, lighting designers typically prefer 40-50 foot candles at these desks.

<sup>d</sup>This should not be used as an excuse to light the whole library to 50 foot candles, just because there are always some low contrast tasks interspersed throughout the library. The higher light level would apply only in specific areas, such as collections of phone books.

1 foot candle (ftcd, fcd) = 1 lumen / sq ft = 10.752 lux
DESCRIPTION OF THE PROJECT
_LIGHT TRANSITION IN LIBRARIES

VIIPURI PUBLIC LIBRARY
Alvar Aalto
1935
DESCRIPTION OF THE PROJECT
LIGHT TRANSITION IN LIBRARIES
DESCRIPTION OF THE PROJECT
LIBRARIES CONTEXT

WHY LIBRARIES?

IMPORTANCE OF DAYLIGHTING INHERITED FROM TRADITIONAL
LIBRARY, BECAUSE OF A HIGH REQUIREMENT FOR READING.
DIGITAL MEDIA AND INFORMATION PRODUCED A
DOUBLE SHIFT

RETROFIT PROCESS

Day-lighting in library retrofitting_ Transition spaces: Harvard SCIENCE CENTER_ Carlos Cerezo | Natalia Escobar | Amaia Puras
SUSTAINABILITY GOALS

'College Library Offices Meet Green Office Challenge.'

Harvard Gazette, 12 Feb 2011

'Harvard is making public the information on more than 12 mil. books inside its 73 libraries.'

Day-lighting in library retrofitting: Transition spaces: Harvard SCIENCE CENTER_ Carlos Cerezo | Natalia Escobar | Amaia Puras
CASE STUDY: THE SCIENCE CENTER LIBRARY

THE BUILDING
**CASE STUDY: THE SCIENCE CENTER LIBRARY**

_The Building_

<table>
<thead>
<tr>
<th>Existing:</th>
<th>291,000 sq. ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additions:</td>
<td>26,814 sq. ft.</td>
</tr>
</tbody>
</table>

**History of Science**
- Addition 2005

**Library + Reading**
- Original 1970

Day-lighting in library retrofitting: Transition spaces: Harvard SCIENCE CENTER, Carlos Cerezo | Natalia Escobar | Amaia Puras
CASE STUDY_THE SCIENCE CENTER LIBRARY

READING ROOMS PLANS

FLOORPLAN 2
Main reading room, study and stacks

FLOORPLAN 1
Access, stacks, reading and office
CASE STUDY_THE SCIENCE CENTER LIBRARY

FLOORPLAN 2
Main reading room, study and stacks

FLOORPLAN 1
Access, stacks, reading and office
CASE STUDY: THE SCIENCE CENTER LIBRARY
READING ROOMS

SECTION AA

FAÇADE READING AREA
18 MARCH 2012, 17:00 h
CASE STUDY THE SCIENCE CENTER LIBRARY

READING ROOMS

INTERIOR READING AREA 2
18 MARCH 2012, 17:00 h
Day-lighting in library retrofitting: Transition spaces: Harvard SCIENCE CENTER. Carlos Cerezo | Natalia Escobar | Amaia Puras
CASE STUDY_THE SCIENCE CENTER LIBRARY

OBJECTIVES

INTRODUCE DAYLIGHT TO THE DEEP PLAN

Obtain a minimum illuminance of 500 lux for the whole reading room area, and distribute uses accordingly.

ADAPT SPACE FOR COMPUTER USE

Avoid all direct sunlight coming from the façade by redesigning the shading system. Reduce space contrast and glare for work spaces using a dynamic facade.

DESIGN A-transition SPACE

Use the existing library distribution to generate a sequence of exposures to daylighting from the dark entrance to the extremely bright reading areas.

REDUCE THE ENERGY USE FOR LIGHTING

Quantify the reduction of electricity use with the introduction of daylighting.
CASE STUDY_THE SCIENCE CENTER LIBRARY

METHODOLOGY

METHODOLOGY PROCESS FOR LIBRARY REDESIGN

A. SPACE ASSESSMENT OF THE READING ROOM

1. Illuminance levels simulation (DIVA for Rhino)
2. Shading system study (Ecotect, DIVA for Rhino)
3. Glare DGP analysis (DIVA + Evaglare)
4. User behaviour survey

B. NEW READING ROOM PROPOSAL

1. Façade shading redesign
2. Skylight design
3. Physical model heliodon study

C. ILLUMINANCE AND GLARE QUANTITATIVE ANALYSIS

1. Façade shading illuminance study (DIVA for Rhino)
2. Dynamic façade and glare study (DIVA for Rhino + Evaglare)
3. Skylight variation performance (DIVA for Rhino)
4. Daylight autonomy study for new design (DIVA for Rhino)

D. TRANSITION SPACE PROPOSAL

E. ENERGY SAVING ESTIMATION
A. SPACE ASSESSMENT
_ILLUMINANCE LEVELS SIMULATION

CASE0:
ORIGINAL STATE
Description space

FLOOR PLAN (2nd room)

GLAZING
Double clear
85%

INTERIOR WALL
White Paint
0.65, 0.65, 0.65

BOOK SHELF
Dark Grey plastic
0.4, 0.4, 0.4

STRUCTURE
White Paint
0.7, 0.7, 0.7

FURNITURE
Wood Clear
0.30, 0.25, 0.16

FLOORING
Grey Carpet
0.12, 0.11, 0.09

LOUVERS AND FIN
White Reflecting
0.75, 0.75, 0.75

MULLIONS
White Paint
0.7, 0.7, 0.7
A SPACE ASSESSMENT
_ILLUMINANCE LEVELS SIMULATION

CASE0:
ORIGINAL STATE

DIVA simulation
ab 4 ad 1000 as 20
ar 100 as 0.1

20-35%

300
2500

12:00 21DEC
12:00 21SEP
12:00 21JUN

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Carlos Cerezo | Natalia Escobar | Amaia Puras
A. SPACE ASSESSMENT

_SHADING SYSTEM STUDY_

CASE0: ORIGINAL STATE

Shading analysis with addition of shading status along line parallel to facade

A. SPACE ASSESSMENT

GLARE ANALYSIS IN WORK SPACES

CASE 0:
ORIGINAL STATE

DGP glare study with DIVA
ab 4 ad 1000 as 20
ar 100 aa 0.1
A SPACE ASSESSMENT

WHERE DO PEOPLE SIT?

Close to windows  70%
Far from windows  30%

WHY THERE?

Views  50%
More light  70%
Less distraction  30%
More privacy  20%
Less glare  20%

DISCOMFORT CLOSE TO WINDOWS?

Lack of light  40%
Excess of light  45%

TYPES OF USERS

DURING THE SEMESTER

Laptop  Notes, books

EXAM PERIOD

Laptop  Notes, books  L + N/B

• PEOPLE SITTING CLOSE TO THE WINDOWS LEAVE FASTER
• SMALL AMOUNT OF TASK LIGHTS AVAILABLE USED
• COMPLAINTS CLOSE TO WINDOWS ABOUT EXCESS/LACK OF LIGHT
B. NEW READING ROOM PROPOSAL

_PROPOSAL DESCRIPTION

FLOORPLAN 2
Main reading room, study and stacks

MEZZANINE
New reading/working area
B. NEW READING ROOM PROPOSAL

PROPOSAL DESCRIPTION

SECTION A

SECTION B

SECTION C
B. NEW READING ROOM PROPOSAL

PROPOSAL DESCRIPTION
B. NEW READING ROOM PROPOSAL
_SKYLIGHT DESIGN

**FINAL SKYLIGHT DESIGN**

- Tilted surface to optimize the light capture, according to the summer solar angle
- Interior parabolic reflective surface to improve the channel of the sunlight to the interior space
- Optimized exterior operable louvers in distance and size, to avoid the direct sunlight

*Horizontal louvers* Still direct sunlight in winter with low angles

*Louvers at 45°* Avoid direct sunlight with low angles
B. NEW READING ROOM PROPOSAL
_HELIODON ANALYSIS

INTERIOR MODEL

FACADE PROPOSAL
B. NEW READING ROOM PROPOSAL

_HELIODON ANALYSIS

Measurements - 22nd June

NORTH 09h

NORTH 12h

NORTH 15h

SOUTH 09h

SOUTH 12h

SOUTH 15h
C. ILLUMINANCE AND GLARE QUANTITATIVE ANALYSIS

_FAÇADE SHADING AND ILLUMINANCE ANALYSIS

CASE1: 
OPEN LOUVERS

CASE2: 
CLOSED LOUVERS

1.5 m
Line A

5.0 m
Line B

1.5 m
Line A

5.0 m
Line B
C. ILLUMINANCE AND GLARE QUANTITATIVE ANALYSIS

ILLUMINANCE LEVELS SIMULATION

CASE 1:
FAÇADE + HORIZONTAL LOUVERS

DIVA simulation
ab 4 ad 1000 as 20
ar 100 as 0.1

15-25%
C. ILLUMINANCE AND GLARE QUANTITATIVE ANALYSIS

_ILLUMINANCE LEVELS SIMULATION

CASE 2:
FAÇADE + LOUVERS
45 DEGREES

DIVA simulation
ab 4 ad 1000 as 20
ar 100 aa 0.1

10-20%

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C. ILLUMINANCE AND GLARE QUANTITATIVE ANALYSIS

SKYLIGHT VARIATION PERFORMANCE

CASE 1: NORTH SKYLIGHT

DIVA simulation
ab 4 ad 1000 as 20
ar 100 as 0.1

C. ILLUMINANCE AND GLARE QUANTITATIVE ANALYSIS

SKYLIGHT VARIATION PERFORMANCE

CASE 2A:
SOUTH SKYLIGHT 00

DIVA simulation
ab 4 ad 1000 az 20
ar 100 as 0.1
C. ILLUMINANCE AND GLARE QUANTITATIVE ANALYSIS
SKYLIGHT VARIATION PERFORMANCE

CASE2B:
SOUTH SKYLIGHT 45

DIVA simulation
ab 4 ad 1000 as 20
ar 100 as 0.1
C. ILLUMINANCE AND GLARE QUANTITATIVE ANALYSIS

_DYNAMIC FAÇADE AND GLARE STUDIES
C. ILLUMINANCE AND GLARE QUANTITATIVE ANALYSIS

_DYNAMIC FAÇADE AND GLARE STUDIES

CASE2A. BACK TABLE:
ANNUAL GLARE DGP
DIVA simulation
ab 4 ad 1000 as 20
ar 100 aa 0.1

CASE2B. BACK TABLE:
ANNUAL GLARE DGP
DIVA simulation
ab 4 ad 1000 as 20
ar 100 aa 0.1

CASE2 A+B. BACK TABLE:
ANNUAL GLARE DGP
DIVA simulation
ab 4 ad 1000 as 20
ar 100 aa 0.1
C. ILLUMINANCE AND GLARE QUANTITATIVE ANALYSIS

_DYNAMIC FAÇADE AND GLARE STUDIES

CASE2A. FRONT TABLE:
ANNUAL GLARE DGP
DIVA simulation
ab 4 ad 1000 as 20
ar 100 aa 0.1

CASE2B. FRONT TABLE:
ANNUAL GLARE DGP
DIVA simulation
ab 4 ad 1000 as 20
ar 100 aa 0.1

CASE2 A+B. FRONT TABLE:
ANNUAL GLARE DGP
DIVA simulation
ab 4 ad 1000 as 20
ar 100 aa 0.1
C. ILLUMINANCE AND GLARE QUANTITATIVE ANALYSIS

_DAYLIGHT AUTONOMY STUDY FOR NEW DESIGN

80% (over 50% DA)

DYNAMIC SHADING

2 STATE: 0deg/45deg

DIVA simulation
ab 4 ad 1000 as 20
ar 100 as 0.1
9 hours
C. ILLUMINANCE AND GLARE QUANTITATIVE ANALYSIS

_DAYLIGHT AUTONOMY STUDY FOR NEW DESIGN

99\%  \textit{(over 50\%DA)}

DYNAMIC SHADING

3 STATE: 0\textdegree /40\textdegree /50\textdegree

\textbf{DIVA simulation}

ab 4 ad 1000 as 20
ar 100 as 0.1
15 hours
D. TRANSITION SPACES

MEAN ILLUMINANCE

21 JUNE 12pm

1018 lux/m² (0–1000)

71 lux/m² (0–500)

674 lux/m² (0–1000)

177 lux/m² (0–500)

199 lux/m² (0–500)
E. ENERGY SAVING ESTIMATION

A. ORIGINAL. NO DIMMING
B. ORIGINAL. DIMMING
C. NEW. DIMMING

<table>
<thead>
<tr>
<th>kWh/year</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>9000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>800</td>
<td></td>
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</tbody>
</table>

E. ENERGY SAVING ESTIMATION

ZONE 1: WINDOW AREA
1200 W installed (15 W/m²)

340 kWh year

ZONE 2: BELOW PLATFOM
540 W installed (15 W/m²)

280 kWh year

ZONE 3: INTERIOR
810 W installed (15 W/m²)

193 kWh year
Thank you

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