A Daylighted Room

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University of Idaho Bookstore
Building Description

Location: Moscow, Idaho
North 46°
West 117 °
Elevation 2556 ft

Design: Northwest Architectural Co. in 1988.

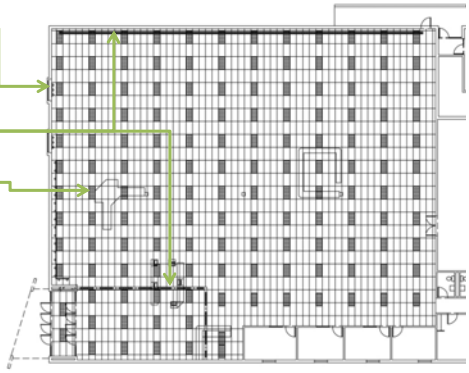
- Concrete masonry construction with flat roof.
- Two relatively small windows on the west façade with intermittent glass block arrangement two feet above the top of the windows.
- Vestibule entrance of five standard glass pane doors with side lights and transoms.
- Four office spaces to the south, each with south-facing windows to the exterior and interior windows overlooking the main retail floor.

Space: Retail & Checkout Spaces

Building Description

Existing lights:

- Wall-mounted track lighting at window displays and Vandal Gear wall
- Suspended direct fixtures with fluorescent lamps and reflector accessories over counter spaces and at back wall
- General 2x4 fixtures, four fluorescent lamps and gridded reflector accessories, flush with ceiling tiles

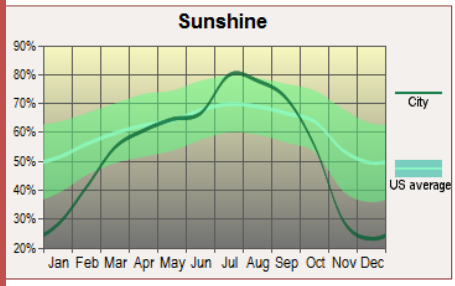


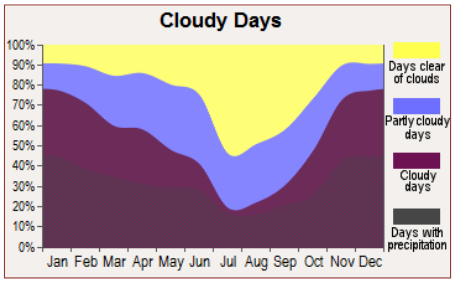
Finishes & Luminance:

- Flat yellow paint on CMU walls : 24 fL
- White acoustical ceiling tiles with white trim :48 fL
- Brown commercial carpet: 24 fL
- 4x4 red-brown ceramic tile: 17 fL
- Light wood finish gondolas & shelves: 74 fL

Climate Data

Estimated daylight hours per season:





Performance Analysis

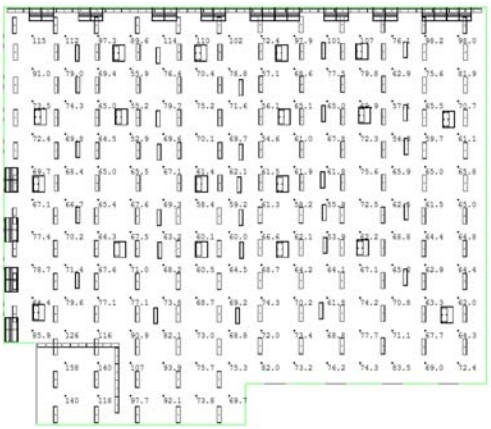
Current Electric/Daylighting Design:
FEB. 8th @ 2:20 pm

Per AGI32 Software:

- Average Illuminance (FC): 74.5
- Maximum Illuminance (FC): 158

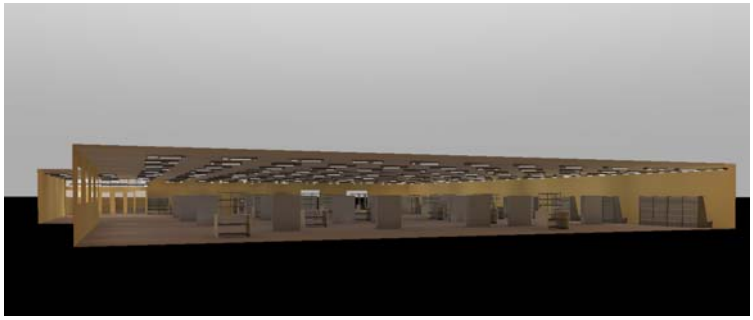
Per Manual Light Meter:

- Average Illuminance (FC): 47.6
- Maximum Illuminance (FC): 95



Performance Analysis

Interior Electrical/Daylighting



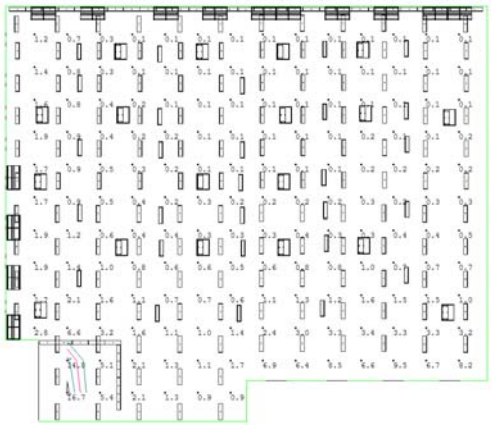
Well distributed amount of light throughout the space:

- Most of light in the space is from the electric light fixtures and lamps
- The front of the store opposite the vestibule suffers from intense glare

Performance Analysis

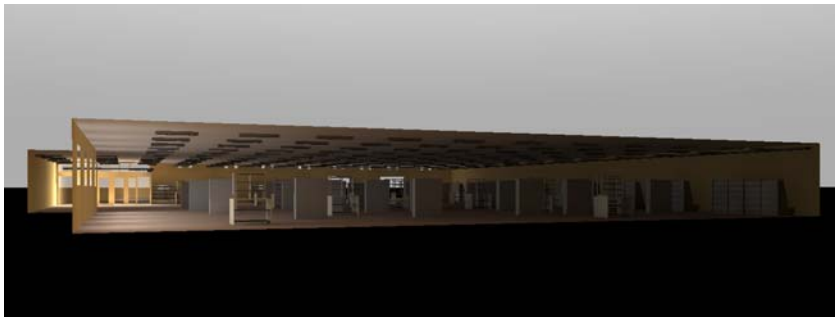
Daylighting Design:
FEB. 8th @ 4:20 pm

Average Illuminance (FC): 1.32
Maximum Illuminance (FC): 16.7



Performance Analysis

Interior Daylighting



Inadequate distribution of daylight throughout the entire space

- The North side is faced with incredible amounts of gloom
- What window openings there are creates intense glare

Performance Analysis

Glare Analysis

- Glare is present on the west side of the structure where there are only two windows
- Most of the display furniture is polished and adds to the glare
- Schiler Glare (yes) with a ratio of 4.71:1

Redesign Proposal

Goals:

- Achieve an adequately daylighted space
- Keep essential wall space for merchandise display
- Keep glare to a minimum
- Limit the amount of heat gain to a space in the summer months

Methods:

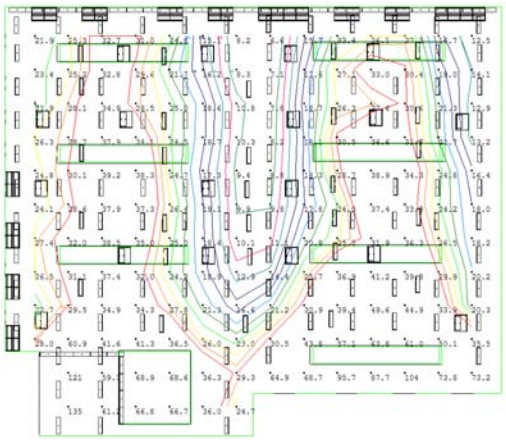
- Create a series of vertical monitors
- Replace the current fixtures and lamps with LED tube lamps

Redesign Performance Analysis

Daylighting Redesign:

Average Illuminance (FC): 29.50

Maximum Illuminance (FC): 134



Redesign Performance Analysis

Interior Daylighting:

Performance Analysis

Glare Analysis:

- Glare is greatly reduced in the re-design of the bookstore
- Schiler glare (maybe) with a ratio of 2.48:1

Performance Analysis

Total exterior illumination (FC_{ext}) required to achieve recommended Daylight Factor:

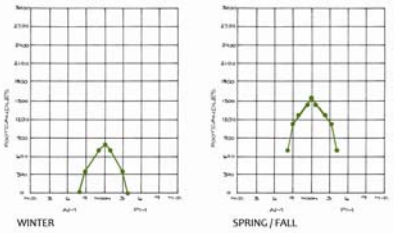
Task/Space	Illumination (FC_{int})	Hours of Operation	Recommended Daylight Factor (DF)
Counters/Entry	500 Lux or 47 FC	8am-9pm	1% or 0.01
Retail Floor	750 Lux or 70 FC	8am-9pm	5% or 0.005

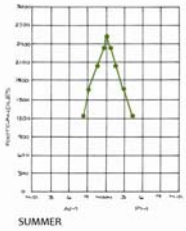
$FC_{ext} = FC_{int} / DF$

- For Counters/Entry: FC_{ext} = 47 / .01 = 4700 FC
- For Retail Floor: FC_{ext} = 70 / .005 = 1400 FC

Performance Analysis

Available Illumination @ 46° Latitude





- Highest illumination from 10am-2pm
- Top-lighting allows for maximized illumination throughout the year

Table B2.2.1 Cloudy Sky Illuminance Data

Equivalent sky luminance in footlamberts--average overcast day

Latitude (°N)	December 21						March 21 or September 21						June 21					
	8 a.m. 4 p.m.	9 a.m. 3 p.m.	10 a.m. 2 p.m.	11 a.m. 1 p.m.	Noon		8 a.m. 4 p.m.	9 a.m. 3 p.m.	10 a.m. 2 p.m.	11 a.m. 1 p.m.	Noon		8 a.m. 4 p.m.	9 a.m. 3 p.m.	10 a.m. 2 p.m.	11 a.m. 1 p.m.	Noon	
30	420	740	1020	1210	1270		910	1300	1710	2010	2140		1270	1730	2250	2350	2350	
32	350	700	960	1150	1200		880	1290	1650	1940	2070		1280	1730	2240	2340	2340	
34	305	650	910	1100	1140		860	1250	1600	1870	1980		1290	1730	2220	2220	2220	
36	260	600	840	1020	1070		840	1220	1580	1800	1900		1290	1730	2200	2960	2960	
38	230	550	790	940	1000		800	1200	1500	1740	1840		1290	1720	2160	2840	2840	
40	190	500	740	900	930		790	1140	1460	1670	1760		1290	1700	2120	2650	3060	
42	150	460	660	820	860		760	1120	1410	1600	1690		1300	1690	2080	2540	2960	
44	100	380	600	760	790		740	1080	1340	1540	1620		1190	1670	2050	2430	2960	
46	40	340	530	690	730		710	1030	1290	1470	1560		1290	1640	2010	2330	2850	
48	40	290	470	630	650		690	990	1240	1410	1480		1290	1630	1960	2250	2400	
50	0	240	420	580	580		650	940	1180	1330	1400		1260	1590	1900	2160	2260	

Reprinted, by permission, from Kaufman (editor), IES Lighting Handbook, 5th edition, 7-6.

Performance Analysis

Daylighting Aperture Sizing:

- Existing Side Lighting – Windows and Vestibule
  - 308 SF of Existing Glazing
- New Top Lighting – Vertical Monitors
  - 1032 SF of Glazing Added

Daylight Factors Calculations:

- Total Daylight Factor for Redesign: 12%
  - $DF_{Average} = 0.2\ (A_{Glazing} / A_{floor})$
    - Existing Glazing: $DF_{Average} = 0.2\ (308/616) = 10\%$ DF
    - New Top-Lighted Glazing: $DF_{Average} = 0.2\ (1032/10{,}121) = 2\%$ DF

Energy Savings

- By replacing the 600+ fluorescent lamps with high efficiency LED tubes the savings will be great over the lifetime of the building.

Energy Savings Calculator

Energy efficient lighting isn't just a bullet point in a mission statement, it's a lifestyle that makes your life and the world around you better. Click through the boxes below and see what a difference we make.

Energy Efficient Lamps vs. Incandescent Bulbs

Enter Your Information

Current Lamp Wattage:	110
Current Cost per Lamp:	2.03
Current Lamp Hours:	5000
kWh Cost $:	13
Number of Lamps:	600
New Replacement Lamp Wattage:	20
Cost of New Energy Efficient Lamp:	126
Lifetime of New Energy Efficient Lamp:	50,000
Hours per Day Usage:	10
Labor Cost for Replacement:	

Your Results:

Investment Cost to Switch:	$74382.00
Payback Period in Months:	35.32
New Lamp Replacement Cost:	$126.00 ea.
Current Electrical Cost:	$2574.00 per month
Electrical Cost using Energy Efficient Lamp:	$468.00 per month
Savings Based on Switching:	$2106.00 per month
Energy Savings Over the Life of the Energy Efficient Lamp:	$351000.00
Labor Cost Savings:	$0.00
Total Long Term Savings:	$213198.00

High Initial Cost

Total Long Term Savings

Energy

According to the LBL Nomograph there should be a savings of 63% per year with the addition of sky lighting

An annual savings of over 15,000 due to daylighting

ENERGY SAVINGS DUE TO DAYLIGHTING

(based on Selkowitz, S., and Gabel, M., 1984, "LBL Daylighting Nomographs," LBL report 13534. Berkeley, CA: Lawrence Berkeley Laboratory.)

Spreadsheet by Fuller Moore, Architecture Department, Miami University, Oxford OH 45056 (e-mail efmoore@aol.com)

			Base	Case 1
1.	Enter LATitude of building location	LAT =	46.73	46.73
2.	Enter the Daily Occupancy Period Code from box below (1-11):	DOPC =	5	5
	1=7a3p, 2=7a4p, 3=8a4p, 4=8a5p, 5=8a6p, 6=8a7p, 7=8a8p, 8=9a5p, 9=9a6p, 10=9a7p, 10=9a8p, 11=9a9p			
3.	Enter Typical Floor Width (ft):	FL =	118	118
	Enter Typical Floor Length (ft):	FW =	102	102
		Typical Floor Area (f) = FL * FW = FA =	12036	12036
4.		Typical Floor Shape (Length ÷ Width) = FS =	1.15686275	1.15686275
5a.	Enter Lighting Control Type (1 = on/off; 2 = dimming):	LCT =	1	1
5b.	Enter Design Illuminance Level (30, 50, or 70 fc) =	DIL =	50	50
5c.	Enter window area per floor above the workplane (sf)	WAAW =	116	116
	Enter typical ceiling height above floor (ft)	CH =	10	10
		Floor Perimeter (ft), FP =	440	440
		Side-Lighting Glass Area Fraction = WAAW ÷ (CH * FP) = SLGAF =	0.026	0.026
	Enter skylight or monitor glazed area (sf):		0	1444
		Top-Lighting Glass Area Fraction: glazed aperture area ÷ floor area = TLGAF =	0	0.11997341
5d.	Enter Side-Lighting Glass Visible Transmittance (0-0.8)	= SLGVT =	0.8	0.8
	Enter Top-Lighting Glass Visible Transmittance (0-0.8)	= TLGVT =	0	0.8
	Enter Well Factor (0.2 to 1.0; depends on well depth and reflectance)	WF =		
6.	Enter Annual Hours of Occupancy (hr)	AHO =	3100	3100
7.	Enter Installed Lighting Load (watts/sf; typically 1.0 to 3.0)	ILL =	2.5	2.5
8.	Electricity Cost ($/kWh; typically 0.10 to 0.25)	EC =	$0.31	$0.31
9.	Enter No. of Floors:	NF =	1	1
	Enter daylighted width (ft; 15 is typ. for conventional windows)	DW =	15	15
		Gross Total Building Area = NF * GAPF = GTBA =	12036	12036
10.	Enter Non-Lighting Electric Load (watts/sf; 3.0 is typical for office buildings)		3.0	3.0
11.	Peak Electric Utility Demand Rate ($/kW-month; 2.50 is typical for office bldgs):	PDR =	$1.70	$1.70
12.	Daylighted Hours (determined from DOS)		93.0%	93.0%
13.	Total Daylighted Area (% of total; based on entered depth for sidelit; 100% for top):	TDA =	47%	100%
14.	Control Effectiveness (determined by LCT, side or top-lighting, and DIL):		64%	68%
15.	Enter Dimming Factor (0 - 1.0; typically 0.8 for dimming systems, 1.0 for on/off)	DF =	1	1
16.	Annual Energy Savings Due to Daylighting		28.2%	63.0%
17.	Peak Load Savings Due to Daylighting		47.4%	100.0%
18.	Non-Daylighted Lighting Energy Consumption (kWh/sf-yr)		7.75	7.75
19.	Non-Daylighted Lighting Consumption Cost ($/sf-yr)		$2.40	$2.40
20.	Daylighting Energy Savings (kWh/sf-yr)		$1.76	$3.94
21.	Daylighting Consumption Savings ($/sf-yr)		$0.55	$1.22
22.	Annual Electric Consumption Cost Savings Due to Daylighting for Building ($*1000)		$6.6	$14.7
23.	Non-Daylighted Peak Demand (kW)		66.198	66.198
24.	Non-Daylighted Monthly Demand Charge ($/kW-month)		0.0043	0.0043
25.	Non-Daylighted Annual Demand Charge ($/kW-yr)		$0.051	$0.051
26.	Daylighted Peak Demand Savings (kW)		14.3	30.1
27.	Daylighted Annual Demand Savings ($/sf-yr)		0.0020	0.0043
28.	Daylighted Monthly Demand Savings ($/sf-month)		0.02415254	0.051
29.	Total Annual Savings Due to Daylighting (Consumption and Demand $/sf-yr)		$0.570	$1.271
30.	Building Annual Savings Due to Daylighting (Consumption and Demand, per yr)		6,964	15,29
31.	Enter Extra Construction Cost Due To Daylighting ($/bldg)	DC =	100000	100000
32.	Simple Payback Period (Extra Const Cost ÷ Bldg Annual Savings)		14.5688919	6.53734069
33.	Simple Return on Daylighting Investment (Bldg Annual Savings ÷ Extra Const Cost)		7%	15%

Annual Daylighting Occupancy Lookup Table

Conclusion

Upon entering the space, we observed that it was not adequately daylighted. There is enough daylight at the entrance, but the retail floor was primarily lighted by electric fixtures.

In the original design, energy was being wasted. Because the electric lights were the main source of illuminance during the daytime, energy was being used not only for lighting but also for cooling and ventilation.

Providing the space with top lighting allows for daylight without occupying the wall space needed for merchandise. It also allows for ventilation in the summer months and solar heat gain in the winter.

Thank You

¿Questions?

"Day man, fighter of night man"