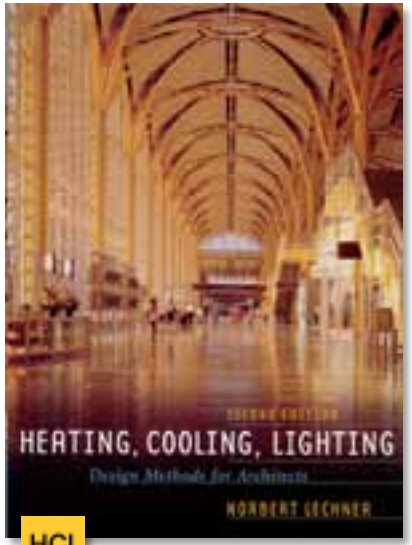
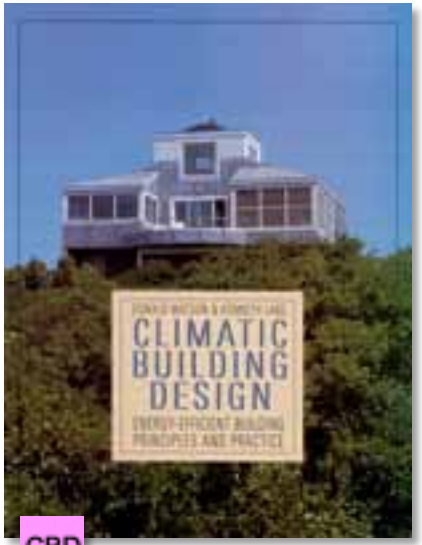
Arch 125: Intro to Environmental Design

SOLAR SHADING

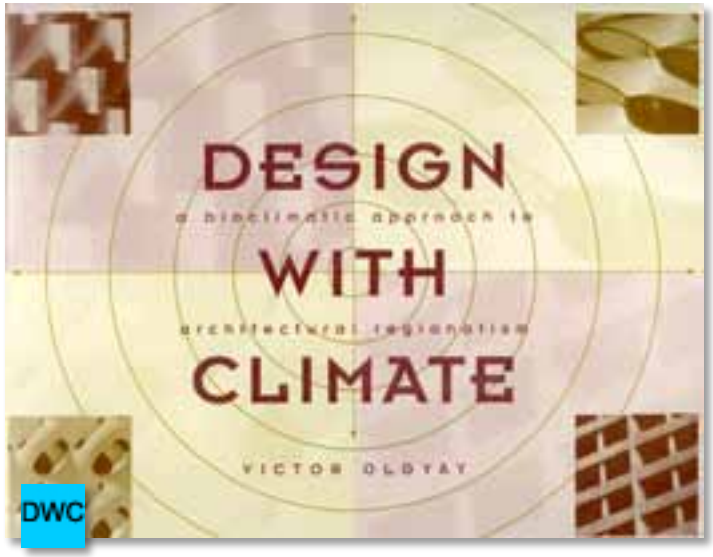


HCL



CBD

SWL



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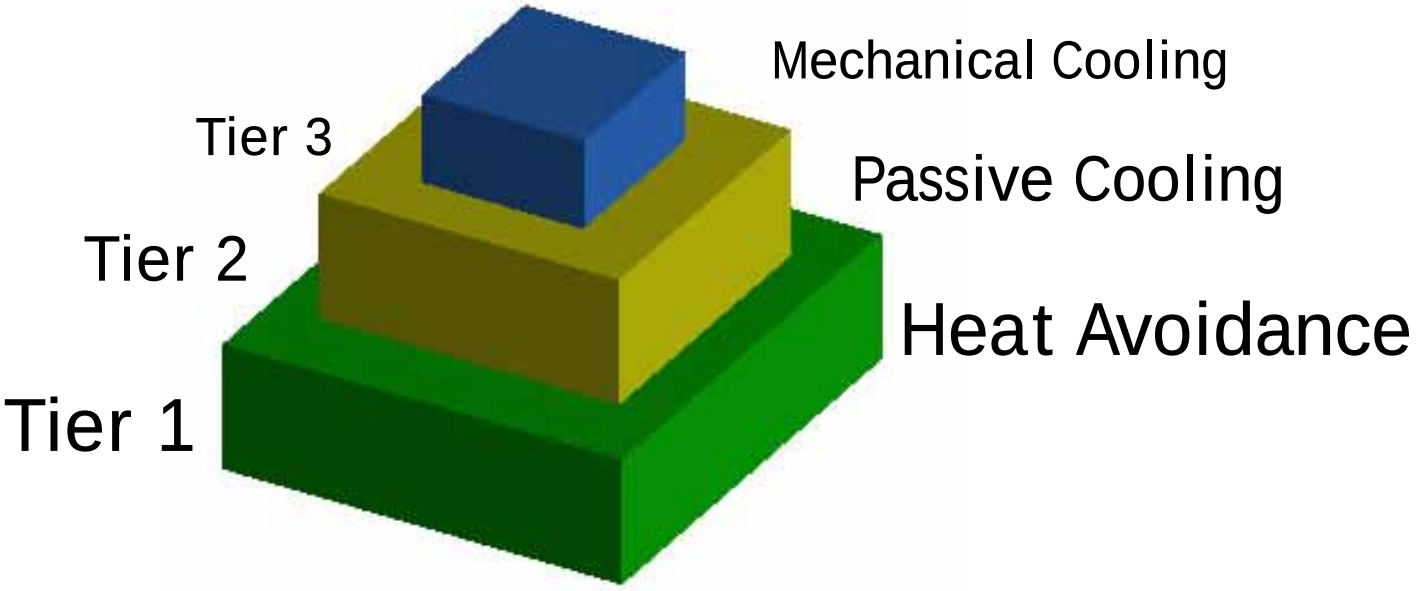
ECS

Texts used in the preparation of this presentation.

Shading is a key strategy of achieving thermal comfort in the summer months.

The tiered approach to reducing carbon for COOLING:



Maximize the amount of energy required for mechanical cooling that comes from renewable sources.

Source: Lechner. Heating, Cooling, Lighting.

HCL

Two main methods of preventing overheating:

1. **Prevent the sun from hitting the glass**: done using roof overhangs, special shading devices or vegetation.

OR

2. **Use special glazing** -- “spectrally selective” -- that filters the harmful rays out of the sunlight striking the glass.

The Function of Glazing

The larger the angle of incidence (steepness of the sun angle), the less transmittance.

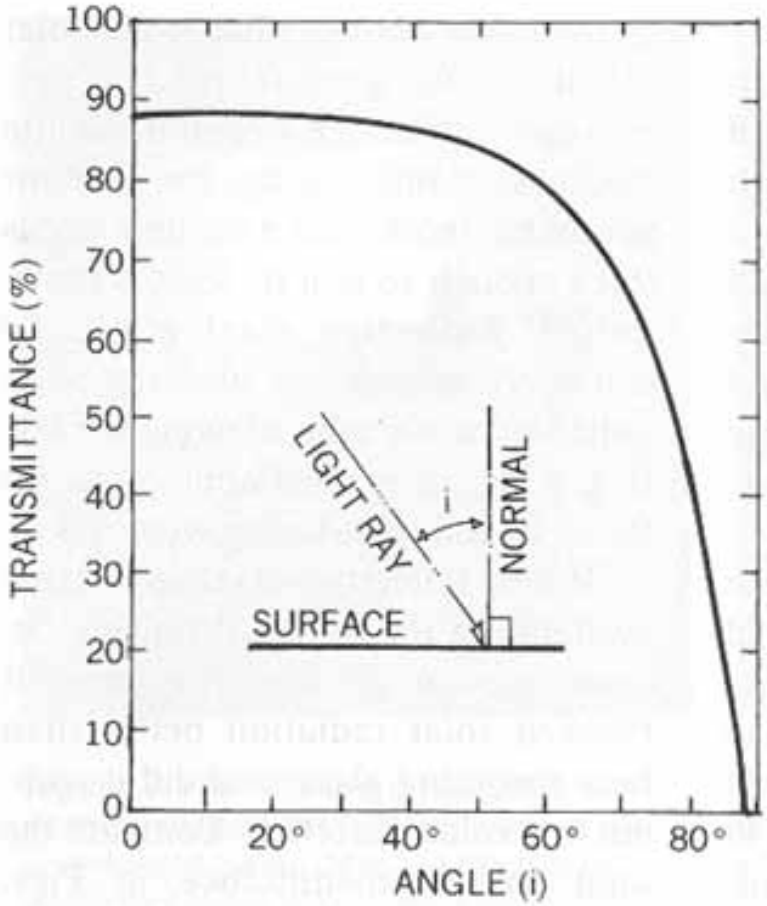
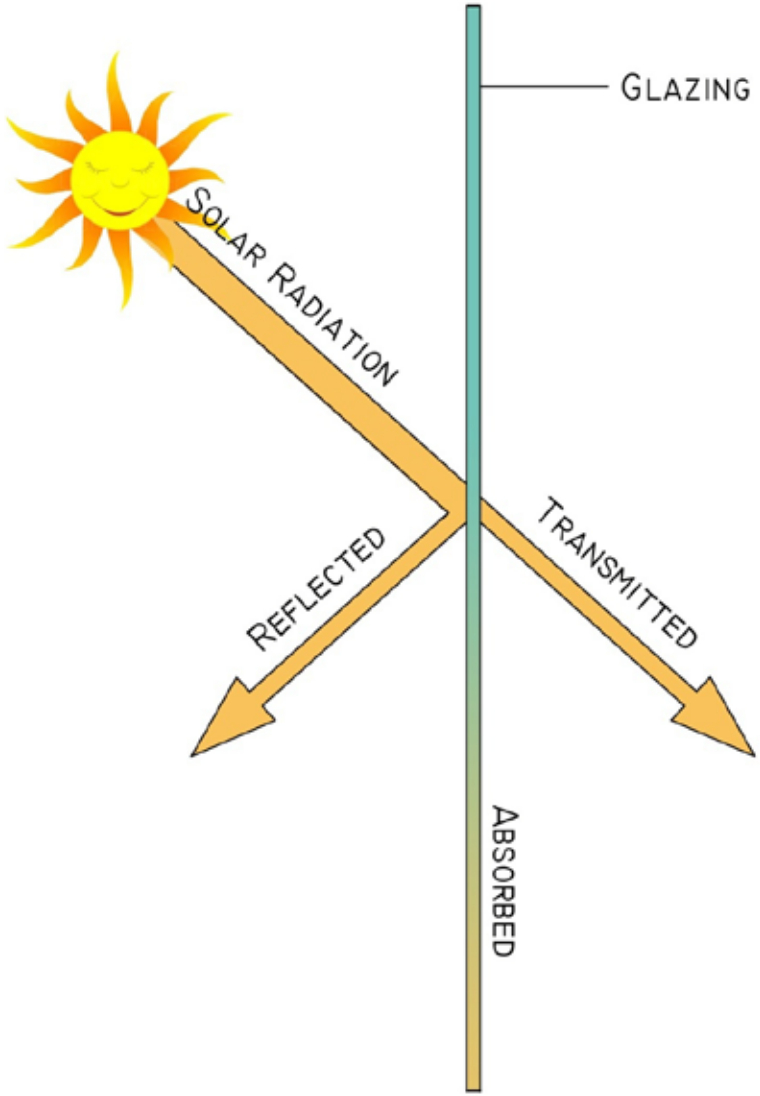
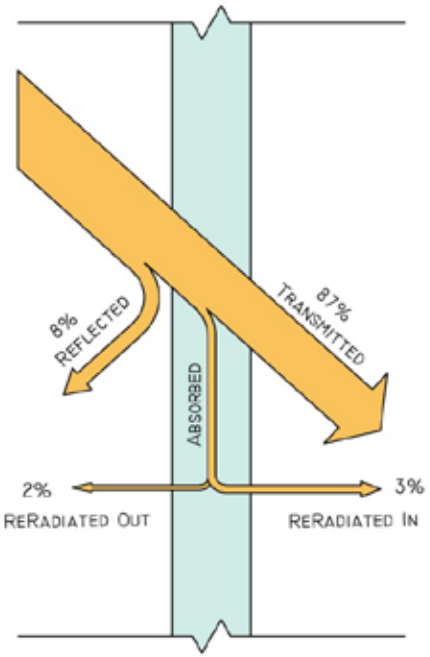


Figure 9.18d The transmittance of solar radiation through glazing is a function of the angle of incidence, which is always measured from the normal to the surface.

HCL


GLAZING
SOLAR RADIATION
REFLECTED
TRANSMITTED
ABSORBED

Clear Glass

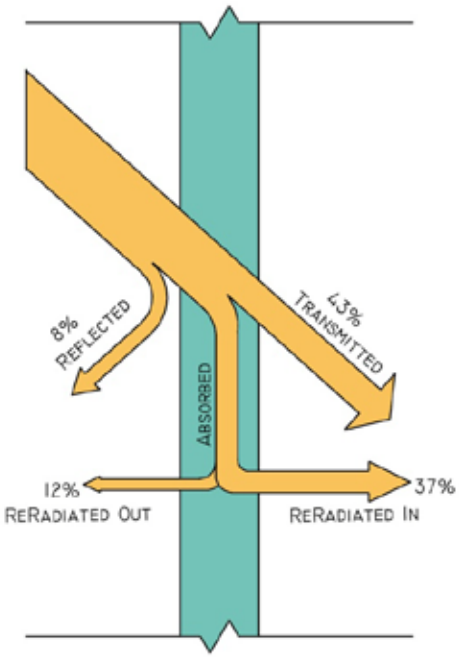


Most of the incident solar radiation is:

Transmitted

Heat Gain:

Heat Absorbing Glass

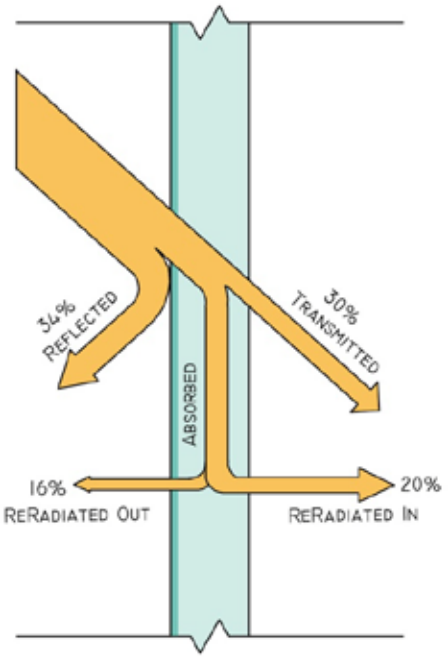


Most of the incident solar radiation is:

Transmitted + Reradiated In

Heat Gain:

Reflective Glass



Most of the incident solar radiation is:

Reflected

Heat Gain:

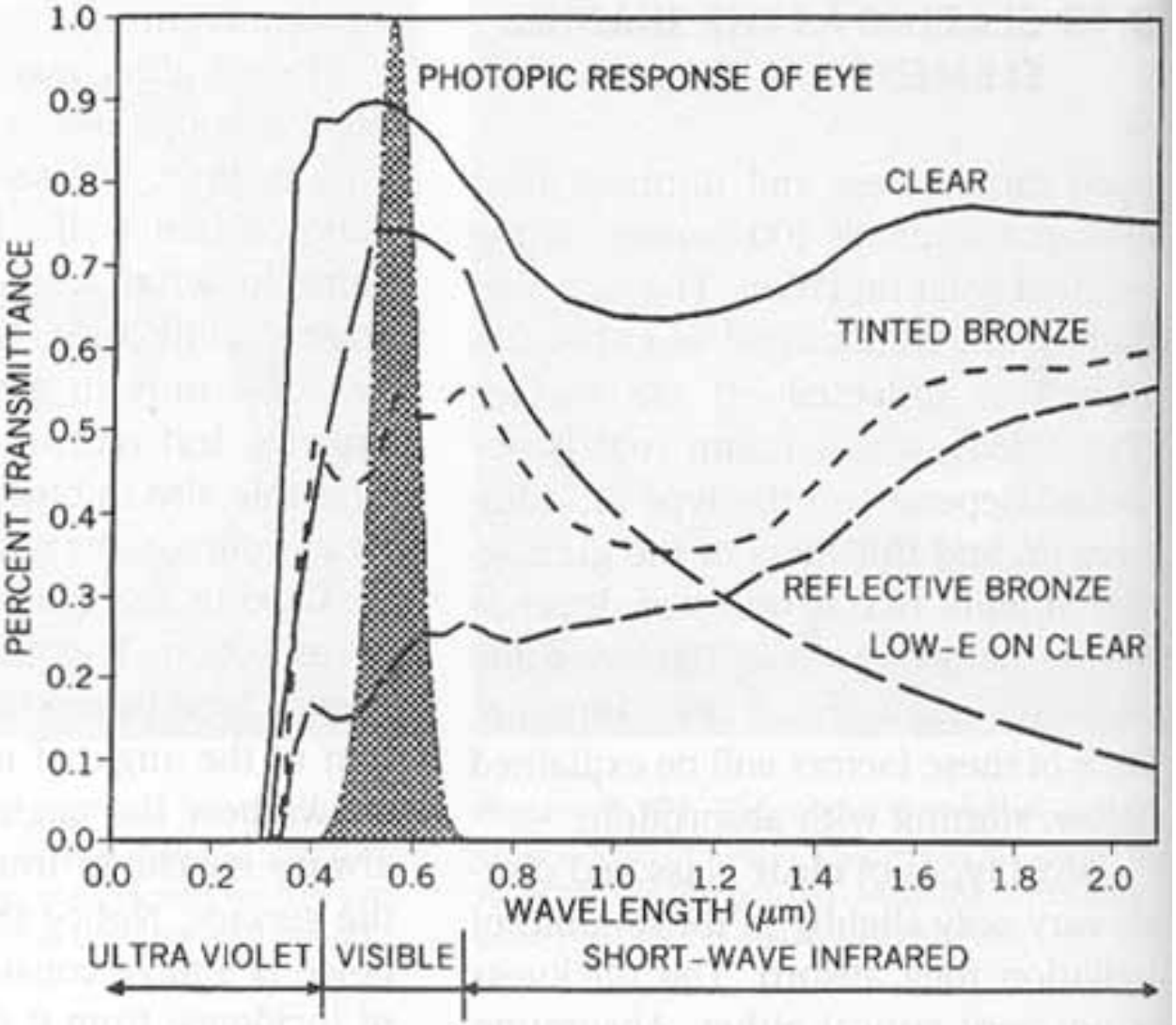
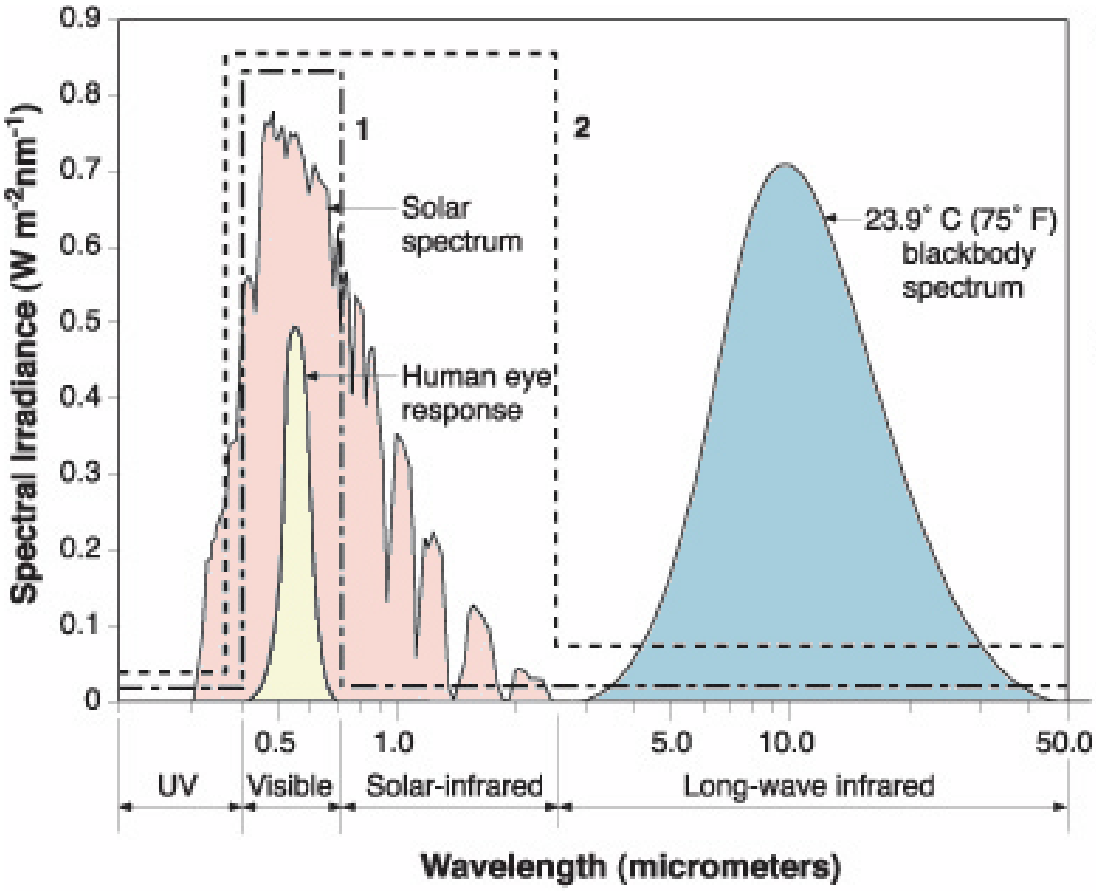


Figure 9.18f Spectally selective low-e glazing transmits cooler daylight because it reflects the short-wave infrared much more than the visible radiation. (From "Effects of Low Emissivity Glazings on Energy Use Patterns," *ASHRAE Transactions*, Vol. 93, Pt. I 1989.)

Green on the Grand in Kitchener uses spectrally selective glazing and no shading devices to control heat gain.

HCL



1 — — Idealized transmittance of a glazing with a low-E coating designed for low solar heat gain. Visible light is transmitted and solar-infrared radiation is reflected. Long-wave infrared radiation is reflected back into the interior. This approach is suitable for commercial buildings in almost all climates.

2 - - - - Idealized transmittance of a glazing with a low-E coating designed for high solar heat gain. Visible light and solar-infrared radiation are transmitted. Long-wave infrared radiation is reflected back into the interior. This approach is more commonly used for residential windows in cold climates.

Note: As shown by the solar spectrum in the figure, sunlight is composed of electromagnetic radiation of many wavelengths, ranging from short-wave invisible ultraviolet to the visible spectrum to the longer, invisible solar-infrared waves.

Figure 2-3. Ideal spectral transmittance for glazings in different climates (Source: McCluney, 1996)

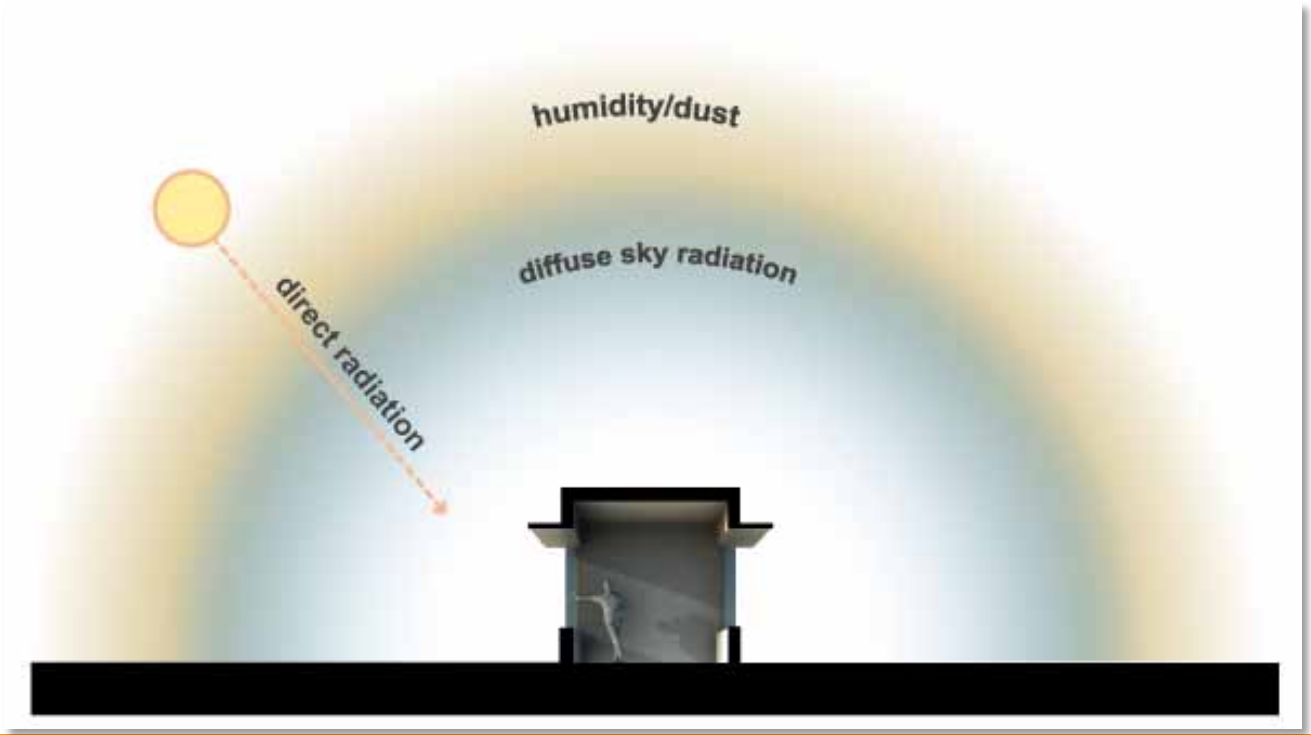
TABLE 9.20 SHADING COEFFICIENTS (SC) AND SOLAR HEAT GAIN COEFFICIENTS (SHGC) FOR VARIOUS SHADING DEVICES

Device	SC	SHGC
Single glazing		
Clear glass, 1/8-inch thick	1.0	0.86
Clear glass, _-inch thick	0.94	0.81
Heat absorbing or tinted	0.6–0.8	0.5–0.7
Reflective	0.2–0.5	0.2–0.4
Double glazing		
Clear	0.84	0.73
Bronze	0.5–0.7	0.4–0.6
Low-e clear	0.6–0.8	0.5–0.7
Spectrally selective	0.4–0.5	0.3–0.4
Triple-clear	0.7–0.8	0.6–0.7
Glass Block	0.1–0.7	
Interior shading		
Venetian blinds	0.4–0.7	
Roller shades	0.2–0.6	
Curtains	0.4–0.8	
External shading		
Eggcrate	0.1–0.3	
Horizontal overhang	0.1–0.6	
Vertical fins	0.1–0.6	
Trees	0.2–0.6	

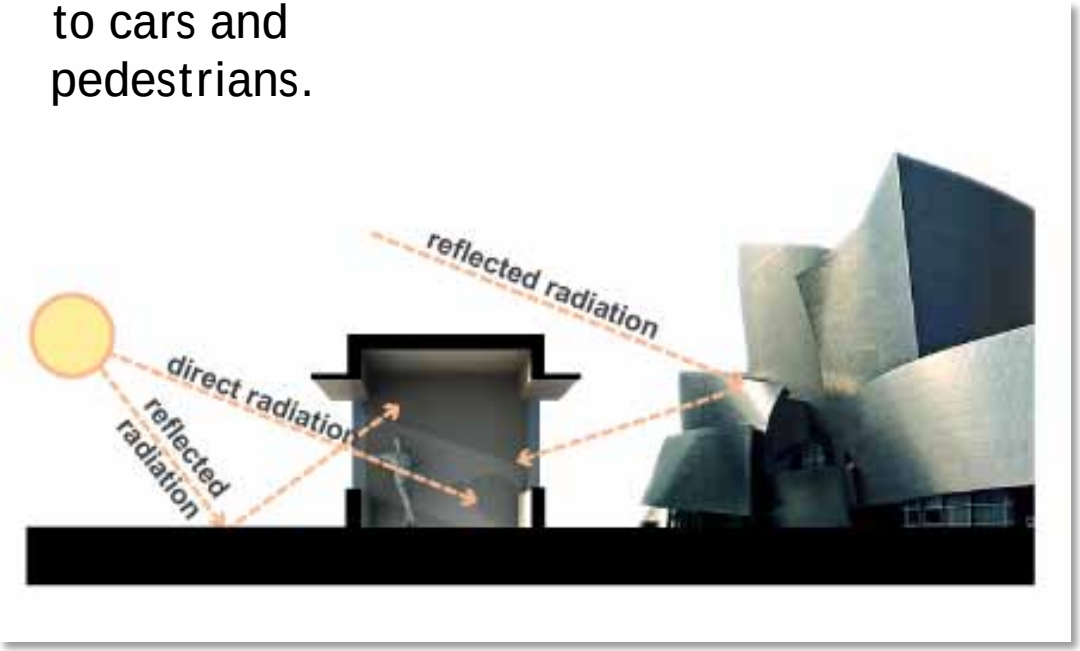
NOTES:
1. The smaller the number, the less solar radiation enters through a window. A value of zero indicates that the window allows no solar radiation to enter either directly or reradiated after being absorbed.
2. Ranges are given either because of the large variety of glazing types available (e.g., slightly or heavily tinted) or because of the varying geometry due to differences in orientation, sun angle, size and type of shading device, and variations in window size.
3. Source: ASHRAE Fundamentals Handbook 1997, Egan, 1975.

HCL

The Function of the Atmosphere

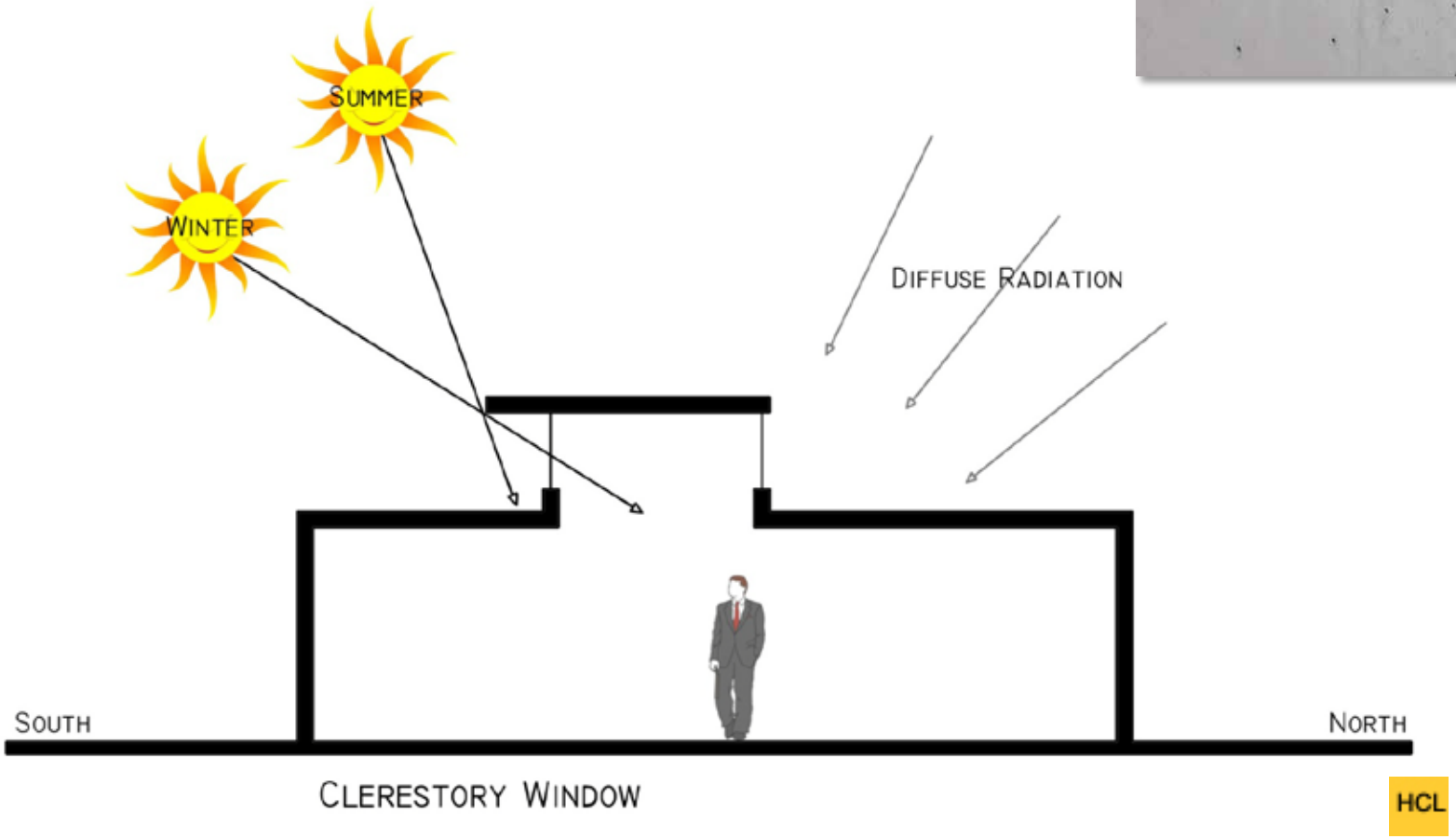


The Disney Concert Hall in Los Angeles required remediation to its shiny skin as the curves were creating hot points in the adjacent streets that were dangerous to cars and pedestrians.



Reflective glazing

A simple roof overhang acts as a shading device.

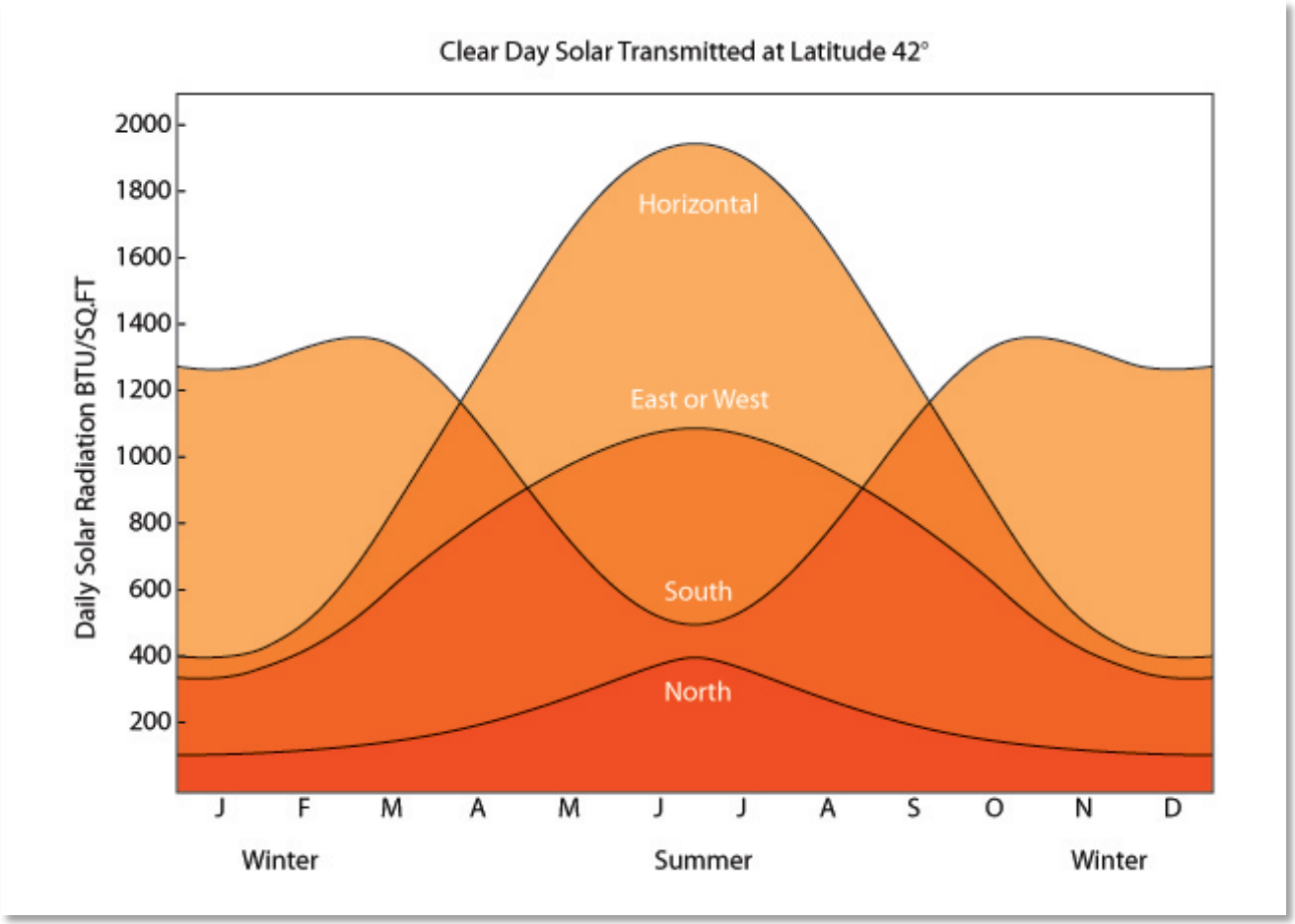


HCL

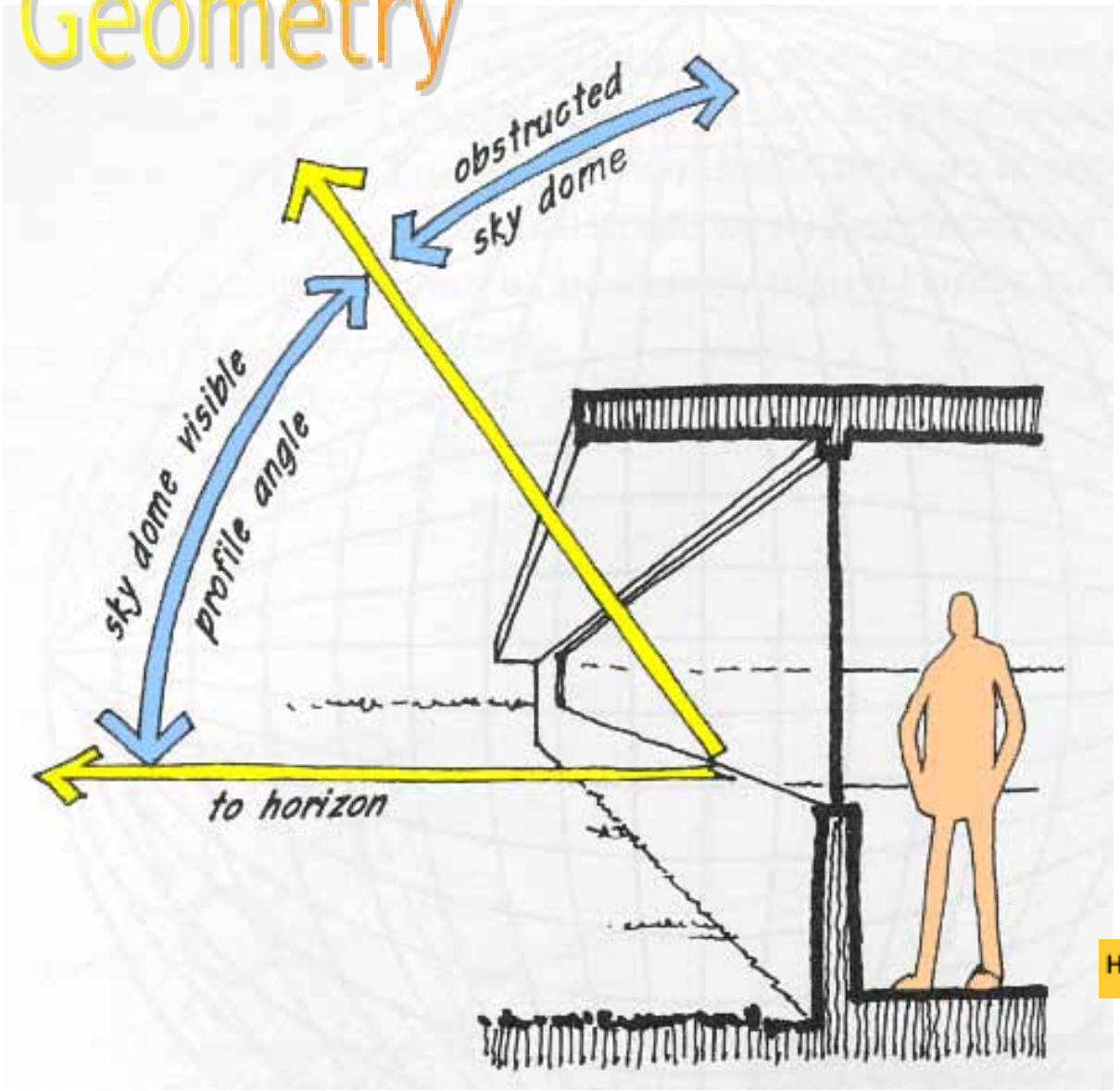
Which orientations get how much??

-A horizontal window (skylight) receives 4 to 5 times more solar radiation than south window on June 21.

-East and West glazing collects almost 3 times the solar radiation of south window.



Shading Geometry



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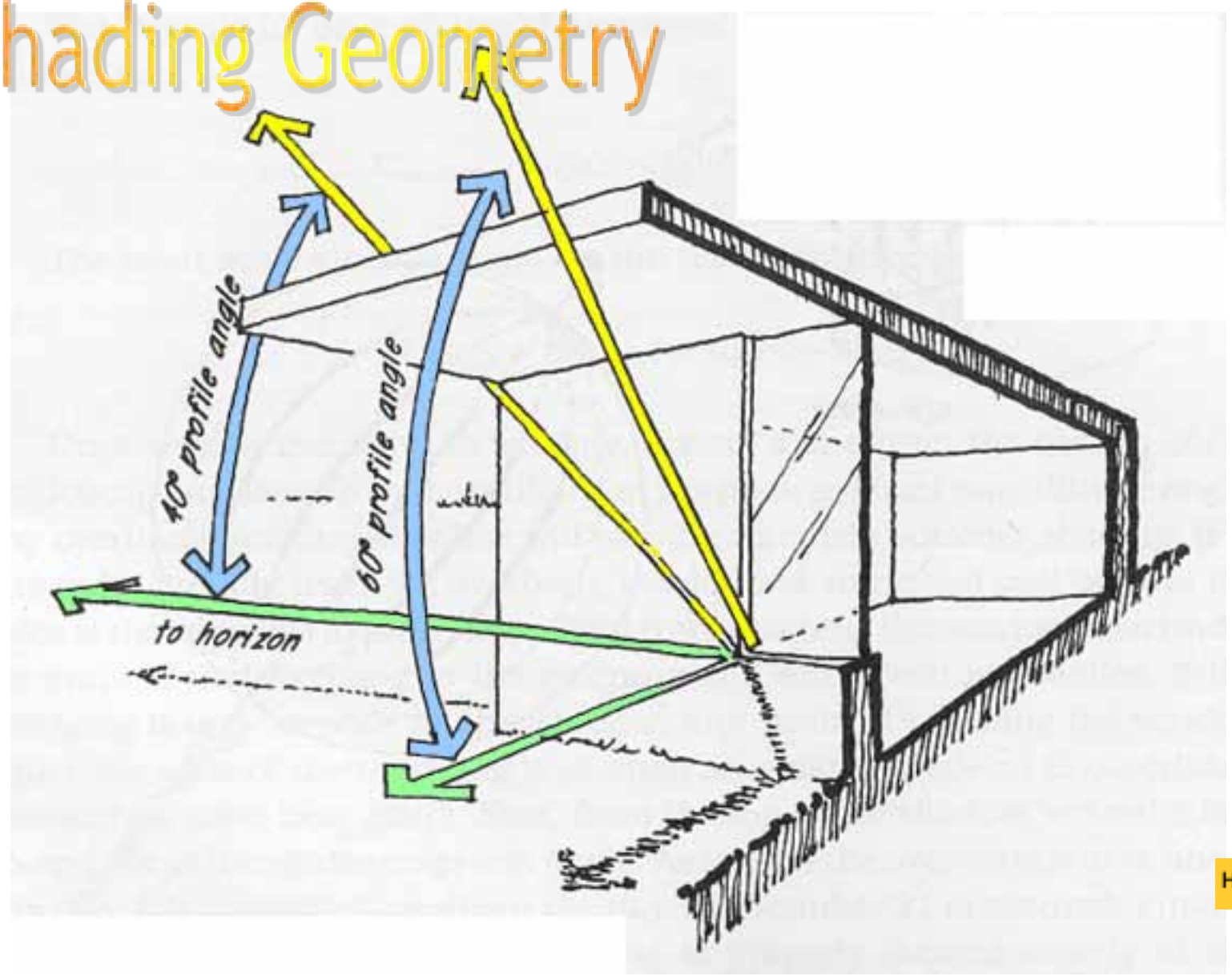
Shading Geometry



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Shading Geometry

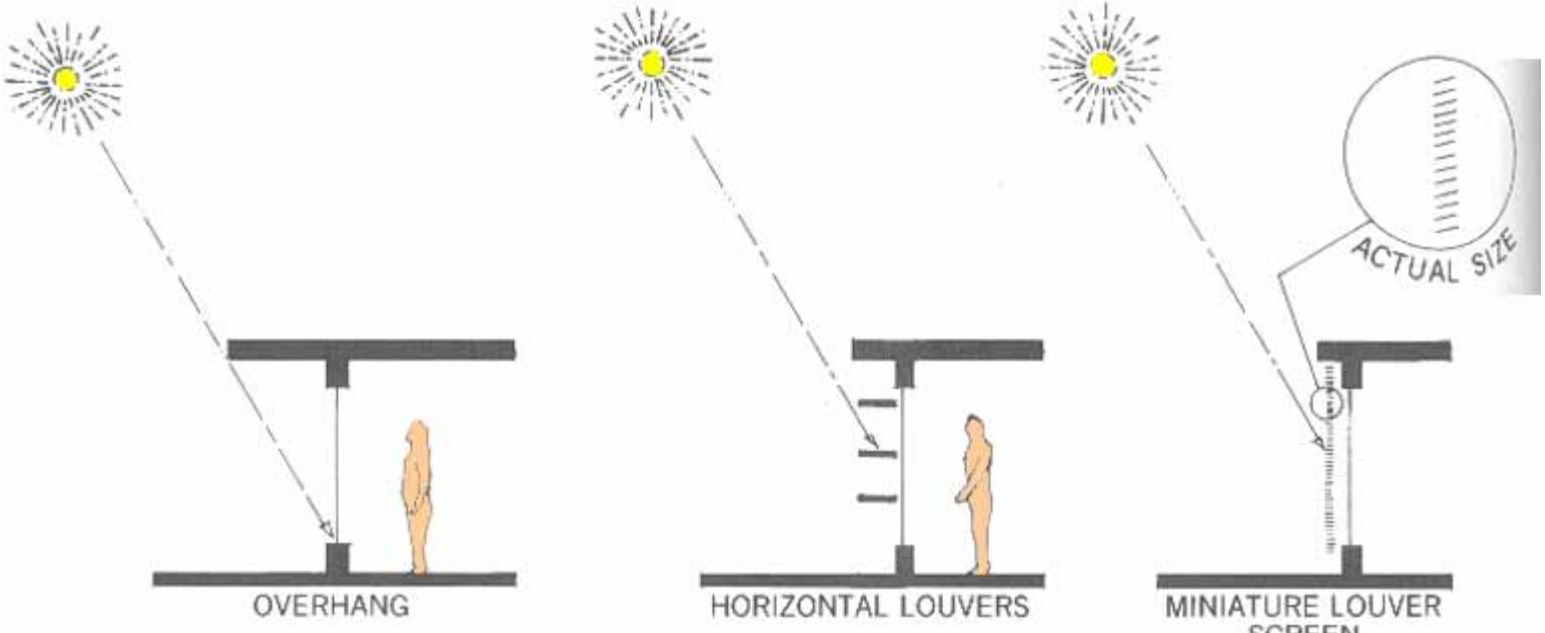
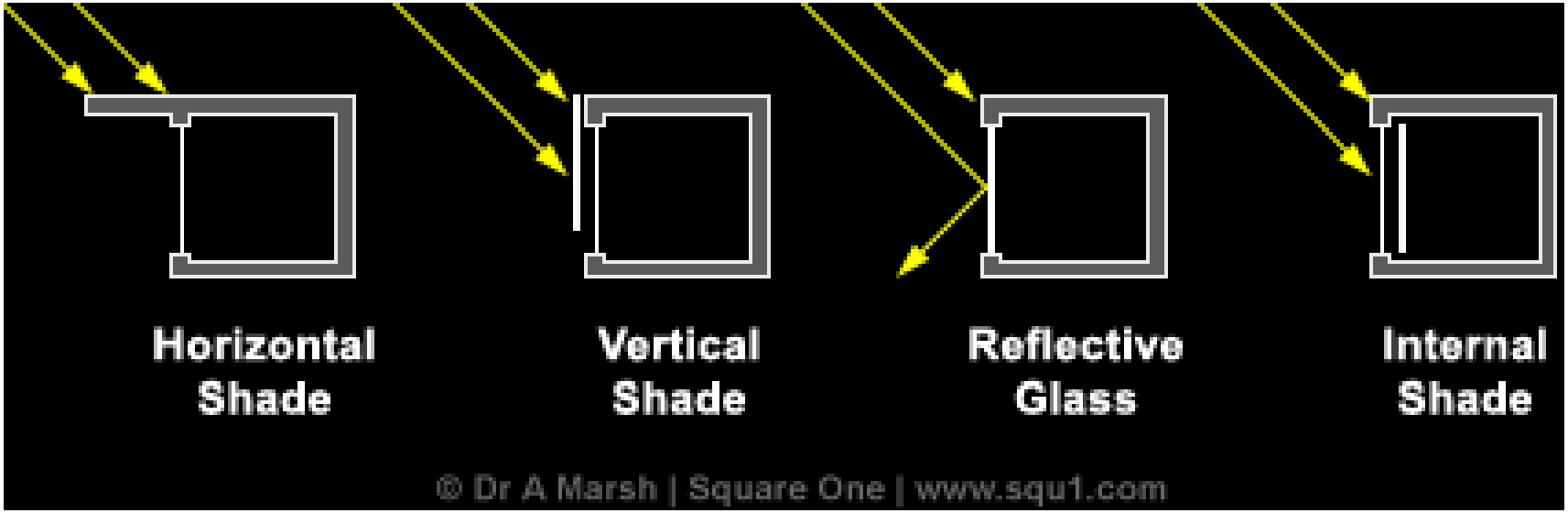


Figure 9.3d Many small elements can create the same shading effect as one large device. However, the view is best with the large overhang.

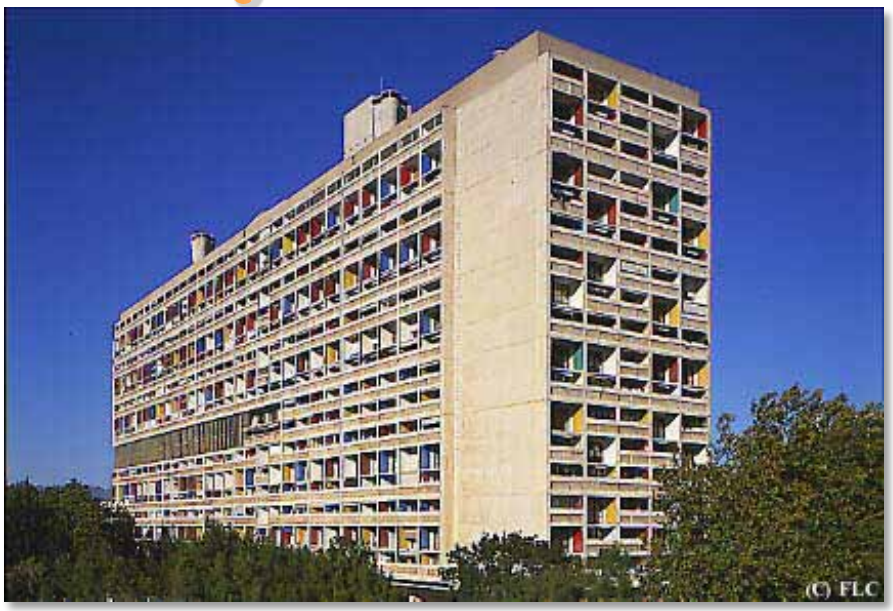
HCL

Basic shading types



Which ones compromise the view? These also compromise daylight and natural light to the room.

Shading Devices are Not "New"…

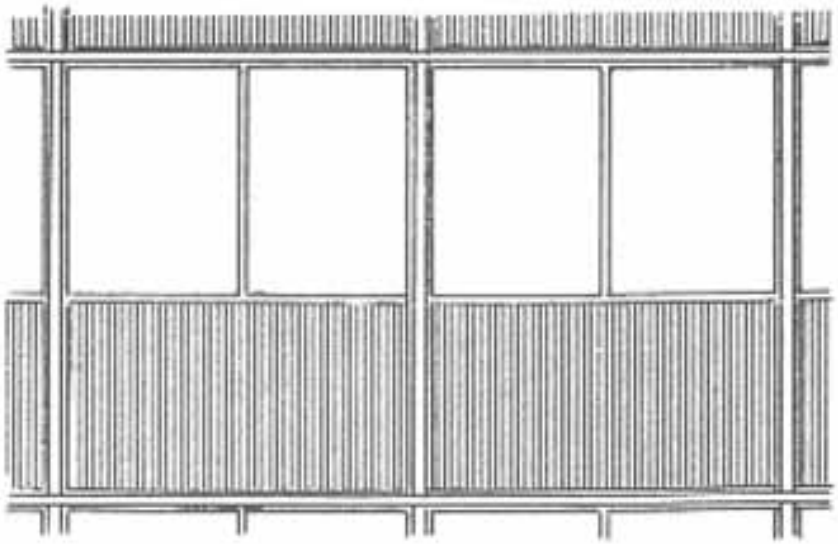


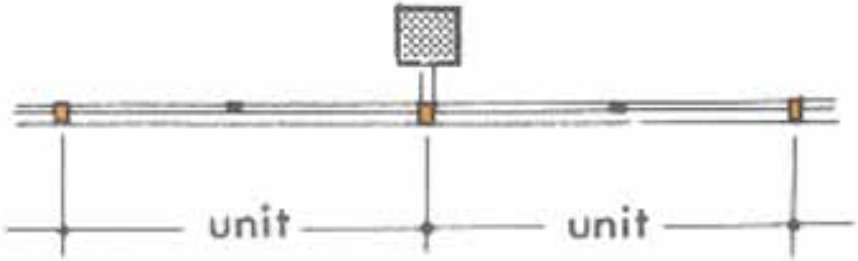
Le Corbusier used his "Brise Soleil" to shade the façades of the Unite d'Habitation (northern hemisphere).

Ministry of Education, Rio De Janeiro (southern hemisphere)

Basic Shading Types

A CURTAIN WALL

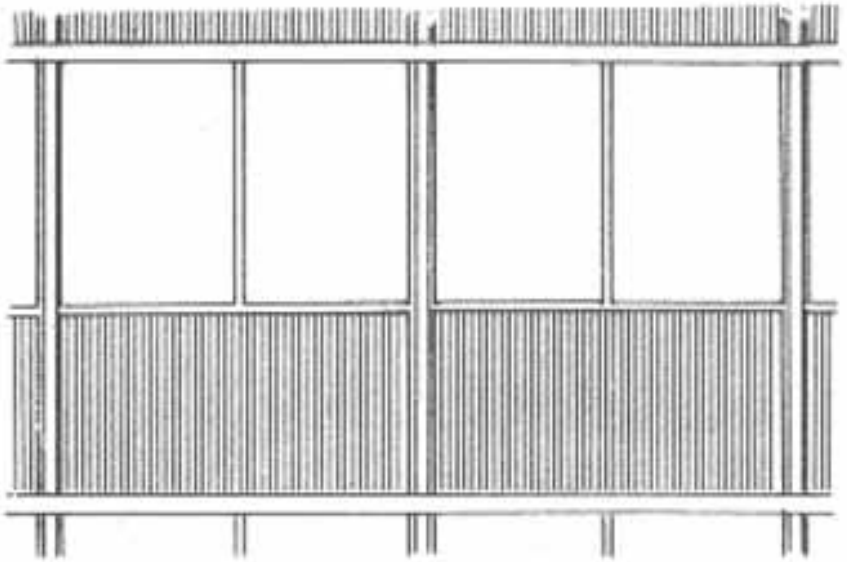


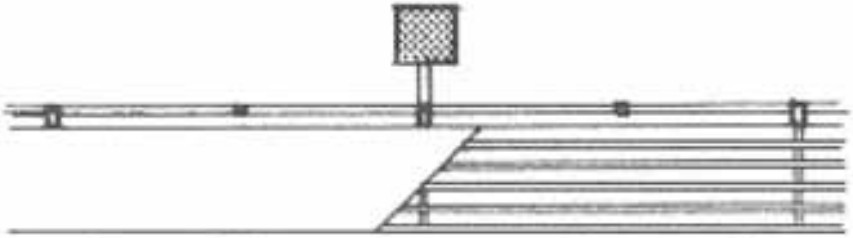


DWC

Basic Shading Types

B HORIZONTAL DEVICE





1 = solid 2 = louvered

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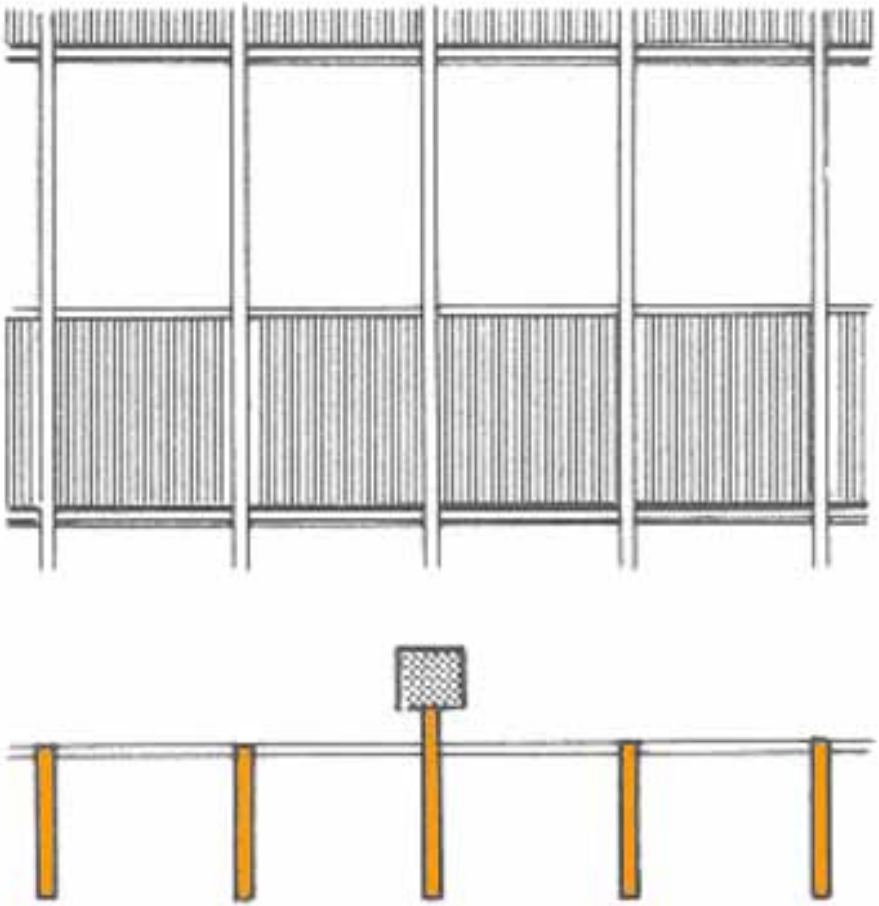
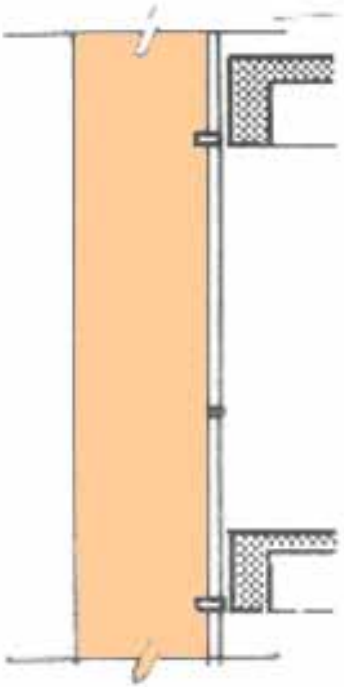
Basic Shading Types

C VERTICAL FIN





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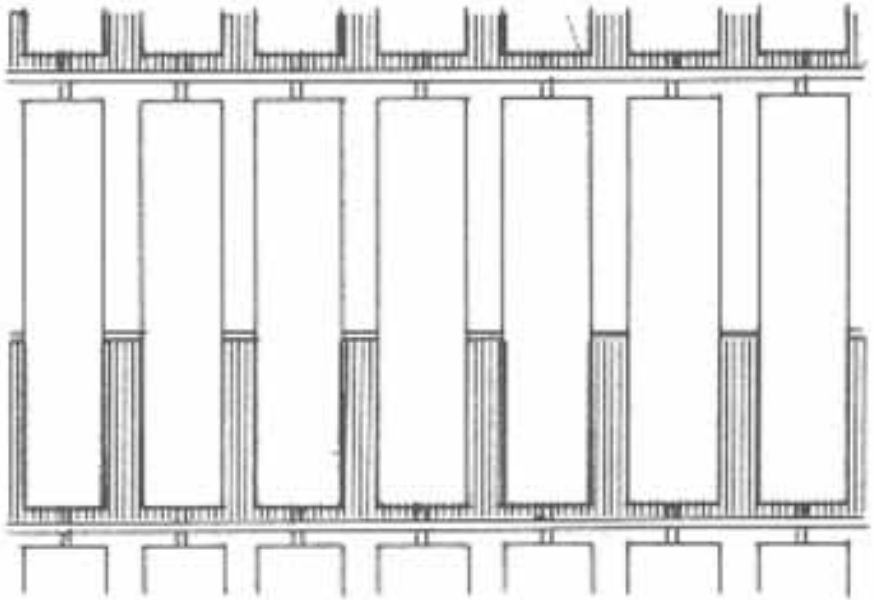
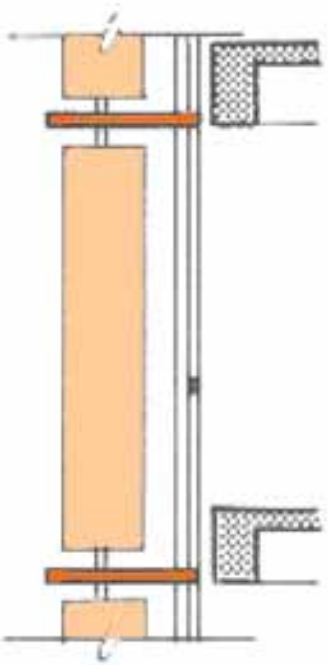
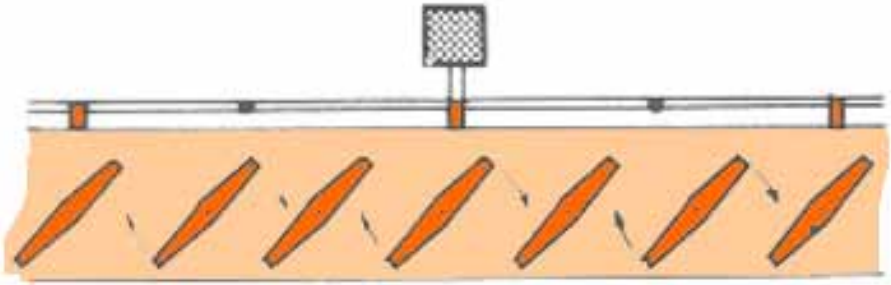
Basic Shading Types

D VERTICAL MOVABLE







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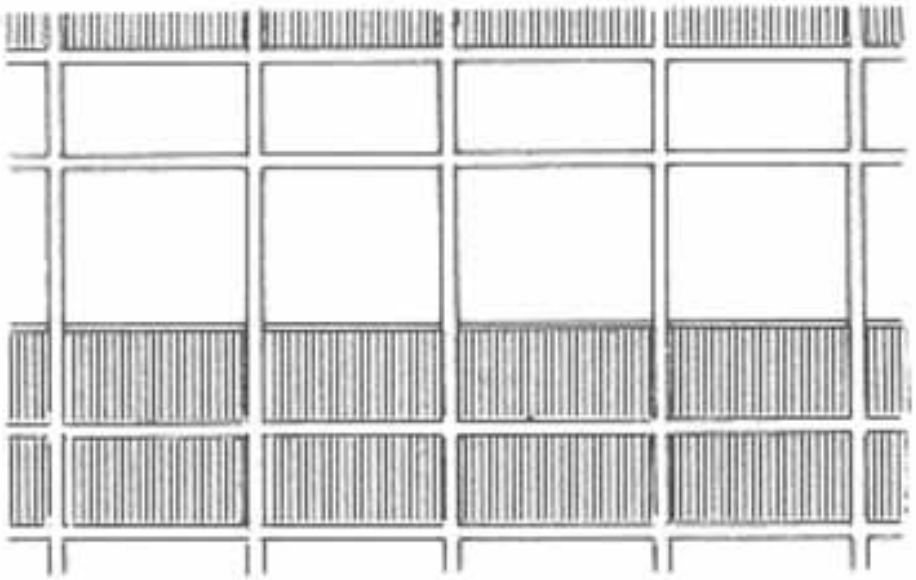
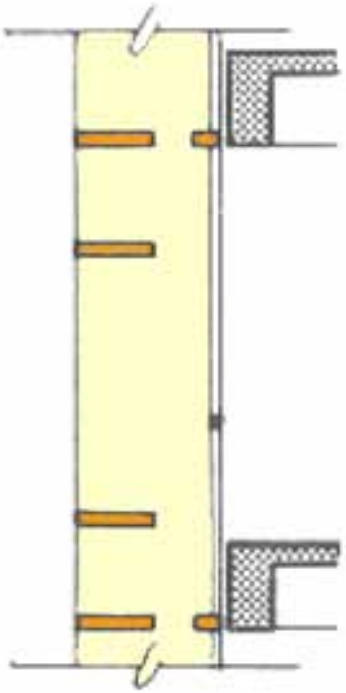
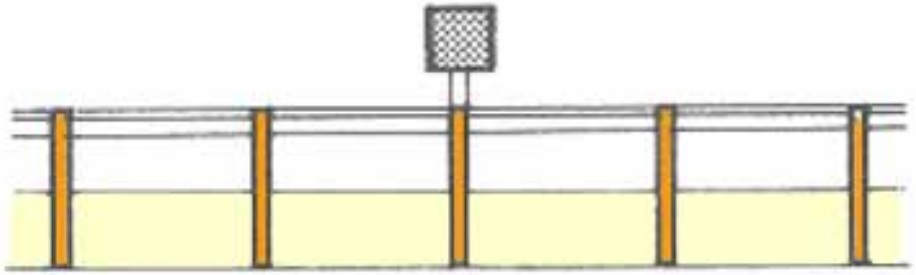
Basic Shading Types

E FIXED EGGCRATE







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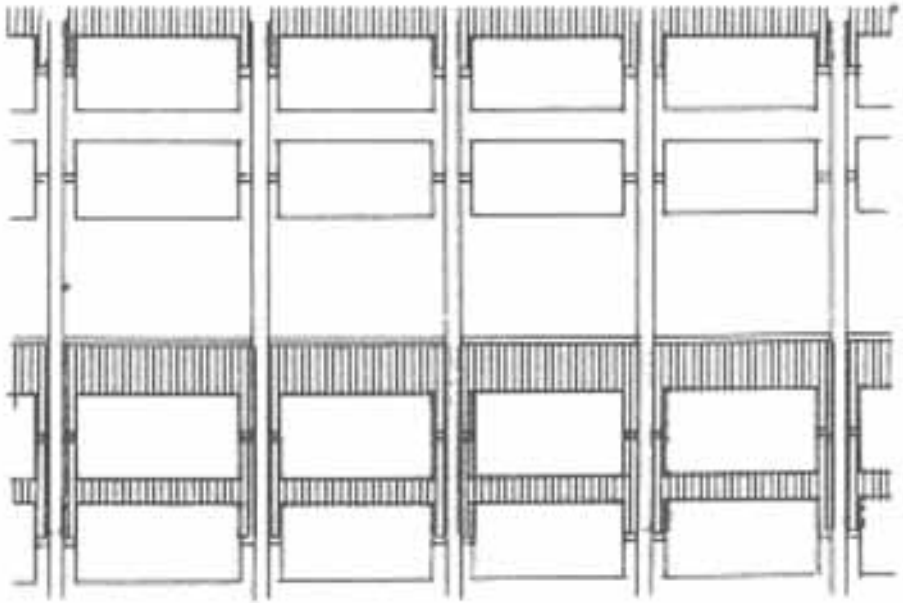
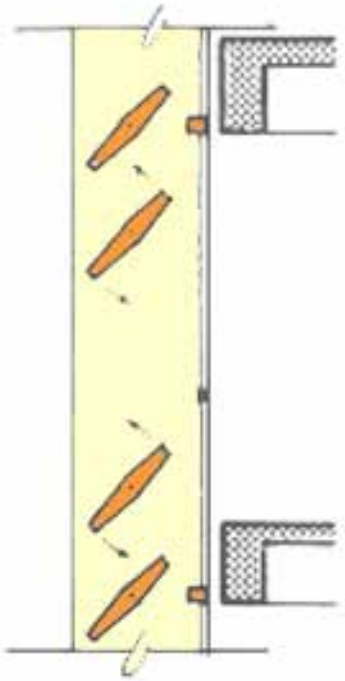
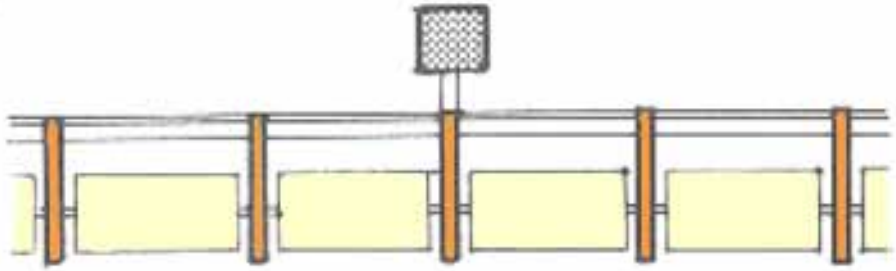
Basic Shading Types

F MOVABLE EGGCRATE







DWC

Even though the grate is removed from the building face, its net effect is somewhat the same.

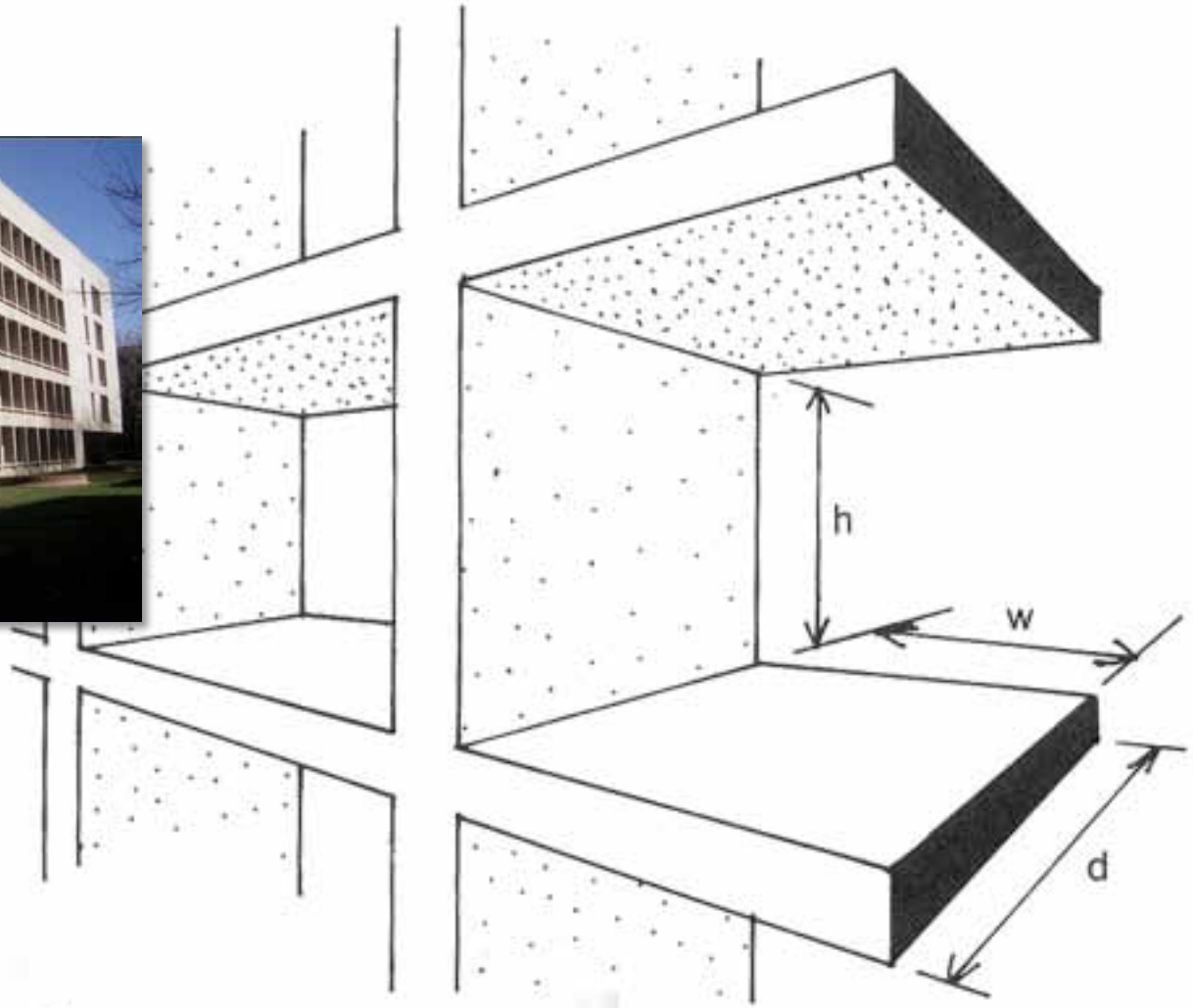
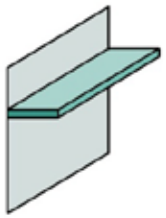
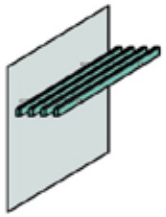
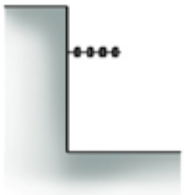
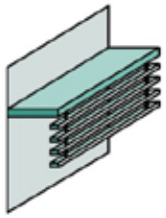
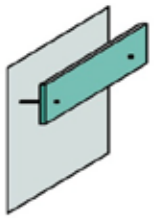
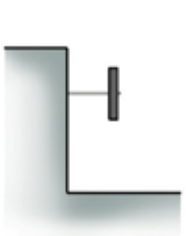
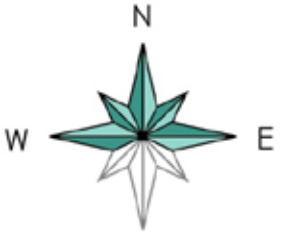
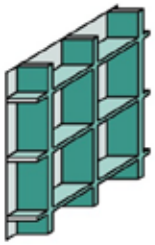
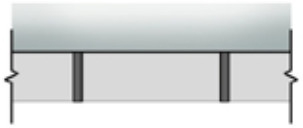
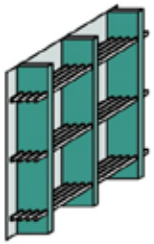


Figure 9.14d The shading effect is a function of the ratios h/d and w/d. It is not a function of actual size.

HCL

	Section	Ideal Orientation	View Restriction
Horizontal Panel			
Horizontal Louvres in Horizontal Plane			
Horizontal Louvres in Vertical Plane			
Vertical Panel			

		Plan	Ideal Orientation	View Restriction
Vertical Fin				
Slanted Vertical Fin				
Eggcrate				
Eggcrate with Horizontal Louvres				

A variety of approaches is possible.

Louvered shades are commonly used to:

- **prevent snow build up**
- allow for **ventilation** at the façade
- lighter when it comes to loading and support than solid shades

Solar Geometry tells us that we need different shading strategies for each facade …

Differentiated Shading Strategies

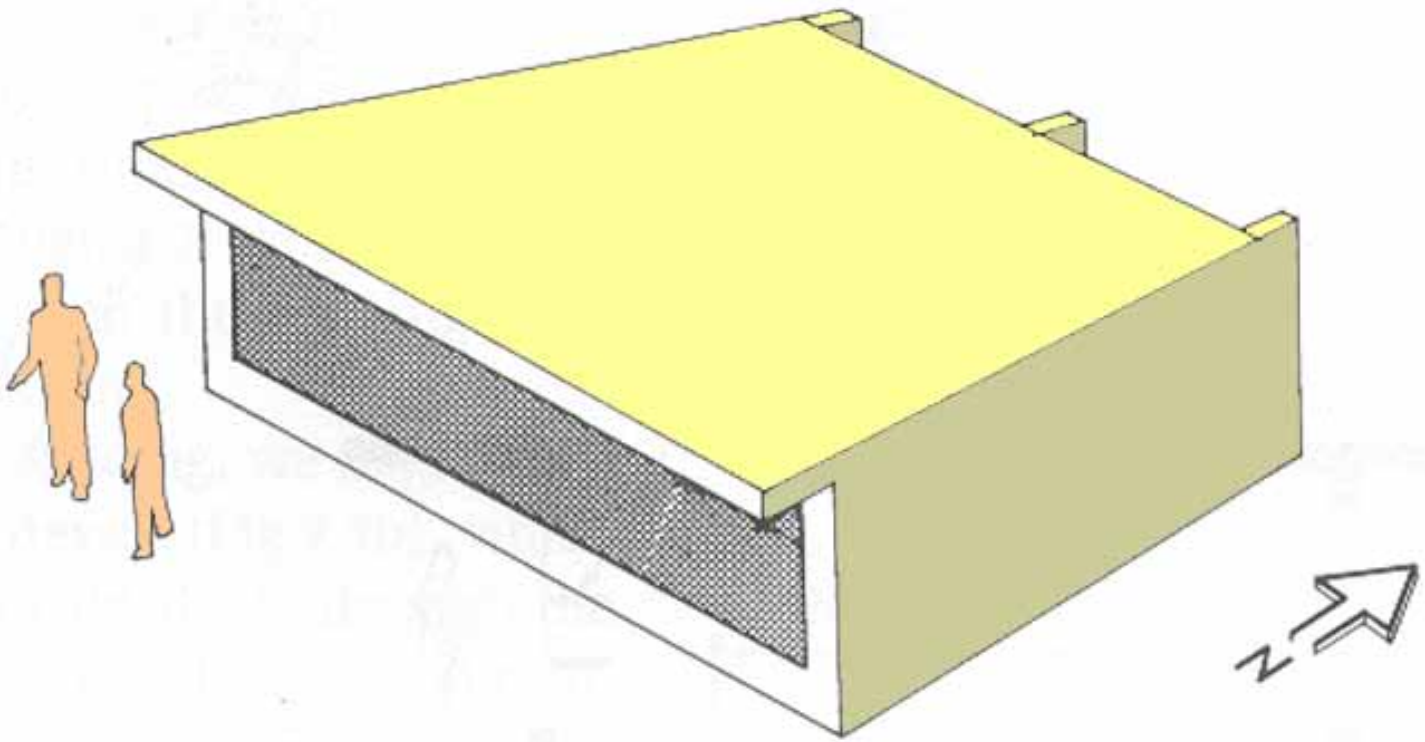


Figure 9.3a Each orientation requires a different shading strategy.

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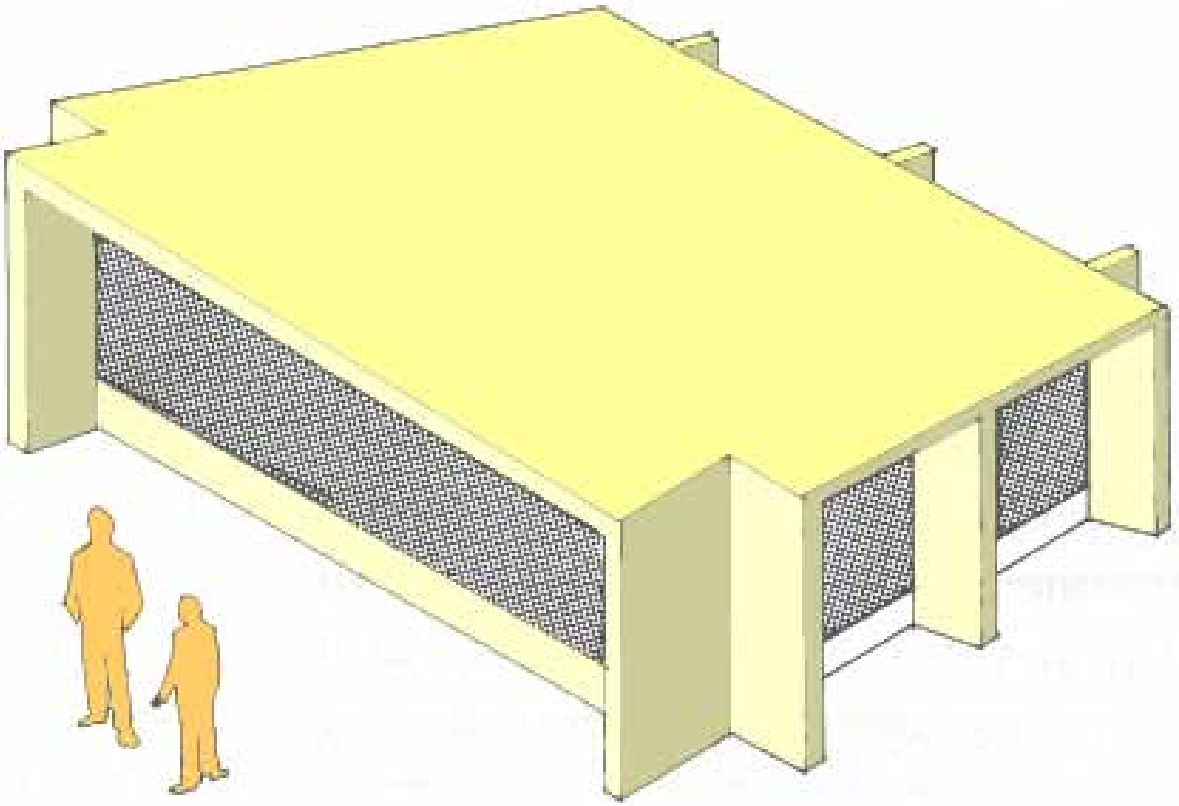


Figure 9.3c Shading is improved when a combination of vertical and horizontal elements is used.

HCL

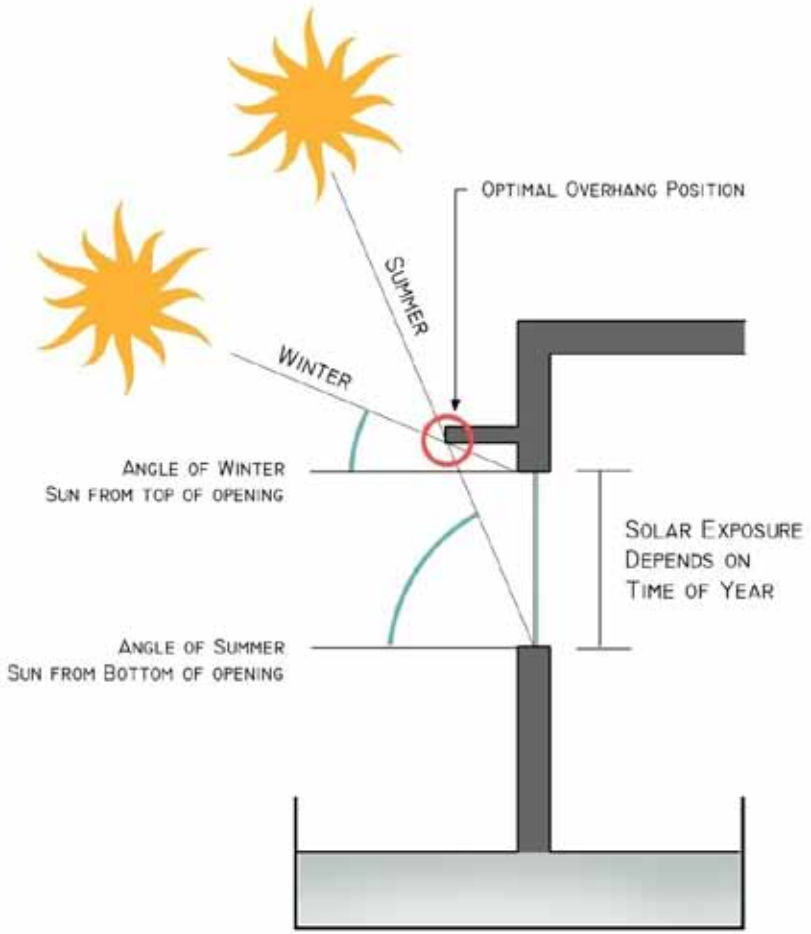
South Facing Shading Strategies

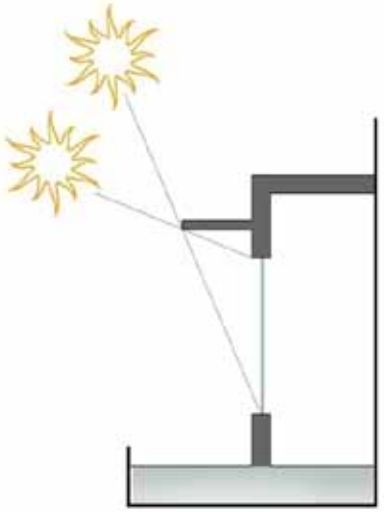
Solar Exposure of Window is a Function of:

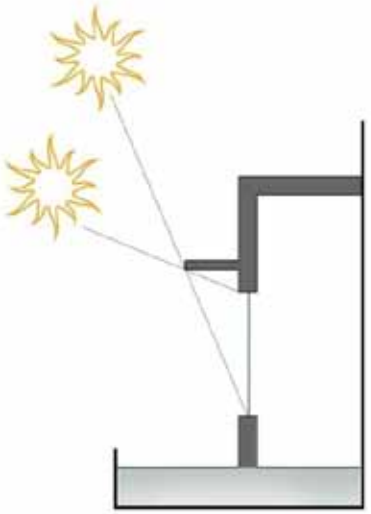
Time of Year

vs.

Temperature





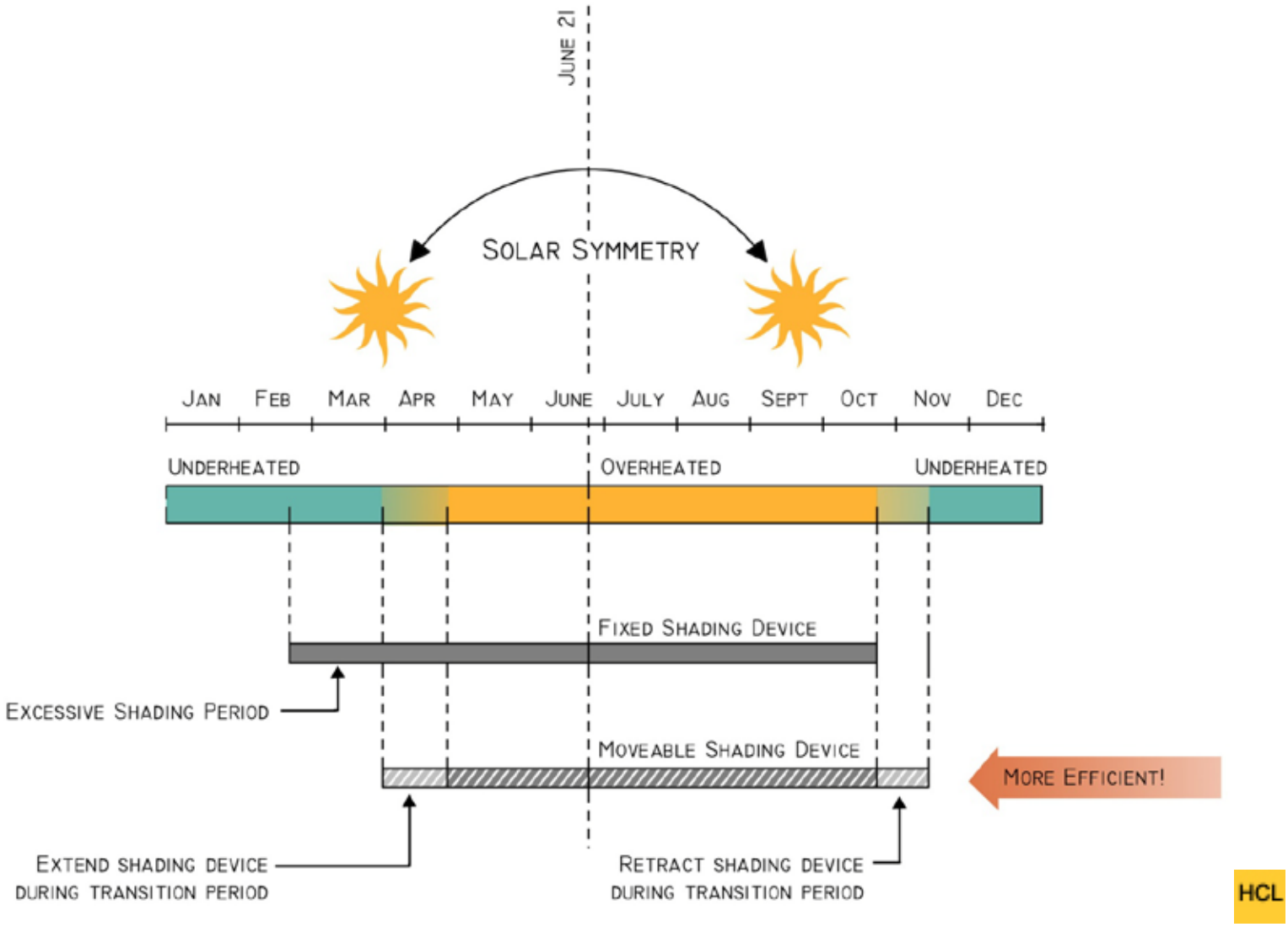


Preventing overheating

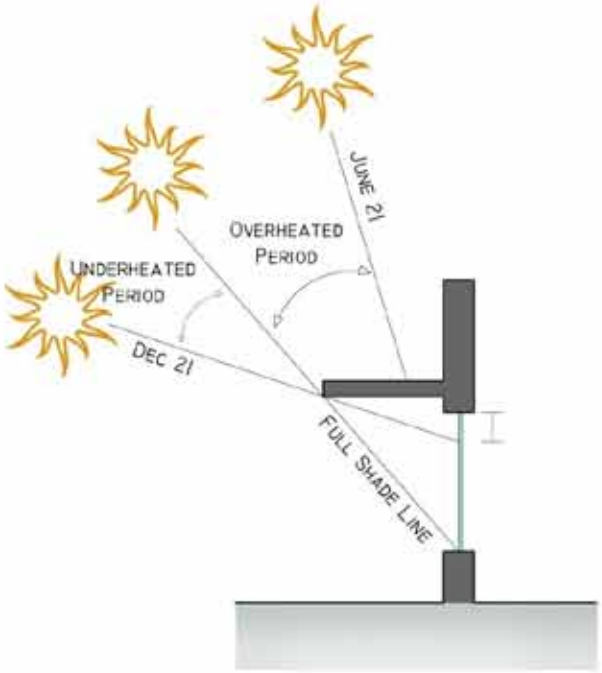
A problem inherent in any fixed overhang is its inability to respond to seasonal lag. The warmest period of the summer occurs in early August about 5 or 6 weeks after the summer solstice (June 21 when the sun is highest in the sky). A fixed overhang designed to provide complete shading on June 21 allows unwanted sunlight to enter the window when the daily temperatures are warmest five weeks later.

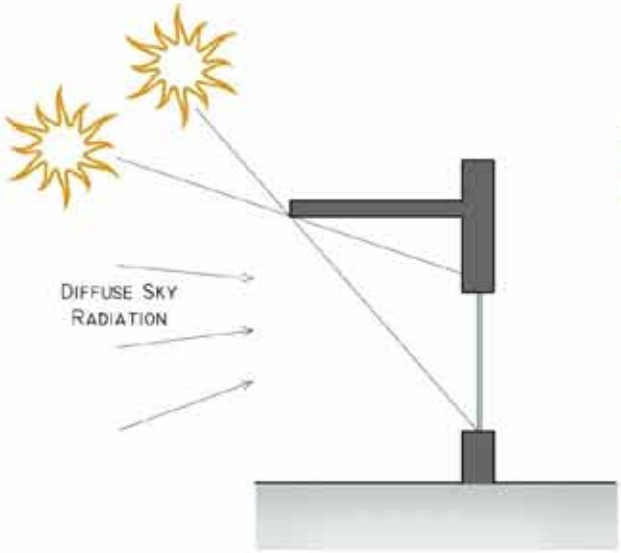
Conversely designing to provide complete shading during the warmest period (in early August) also results in similar complete shading from mid-May when solar heat may still be desirable.

Preventing overheating

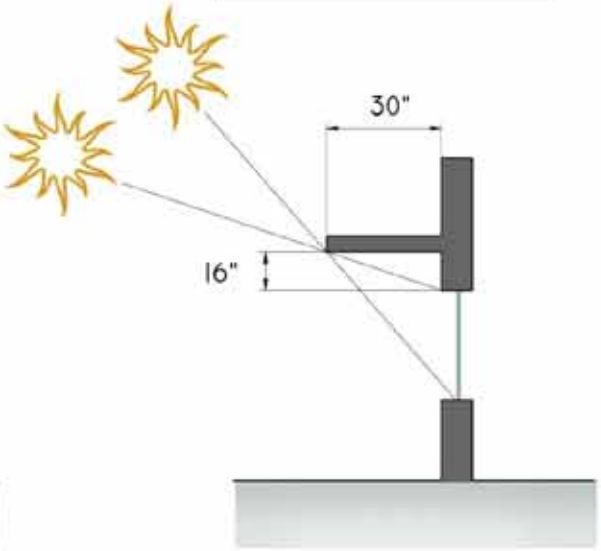


HCL





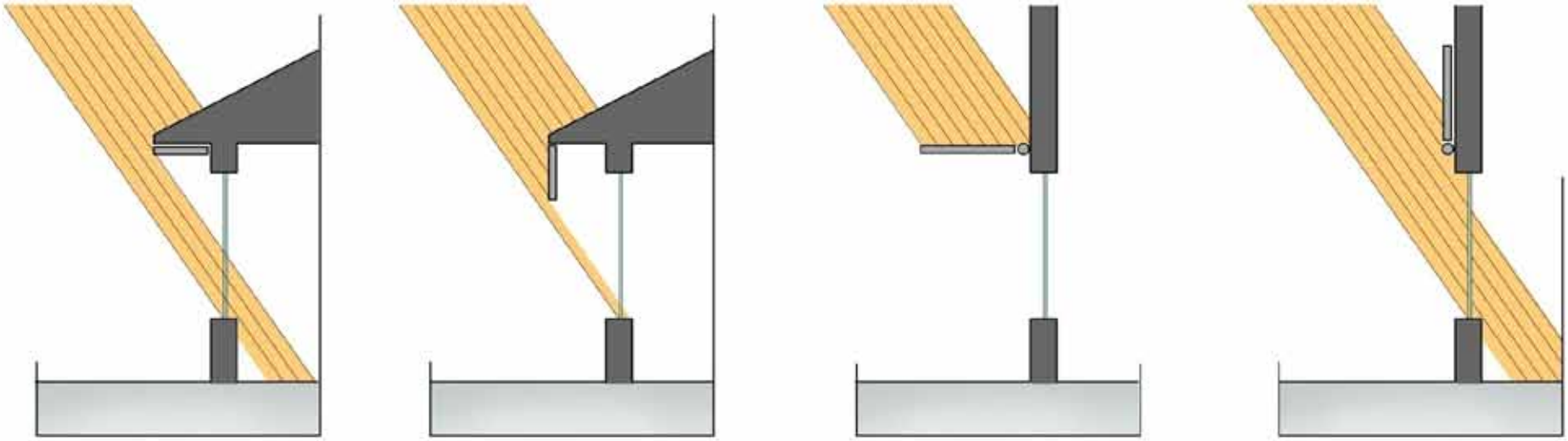
IDEAL CONFIGURATION FOR SOUTH ELEVATIONS 30-50 LATITUDE



- HIGH OVERHANGS ARE NOT RECOMMENDED FOR HUMID CLIMATES BECAUSE OF THE EXCESS OF DIFFUSE SKY RADIATION

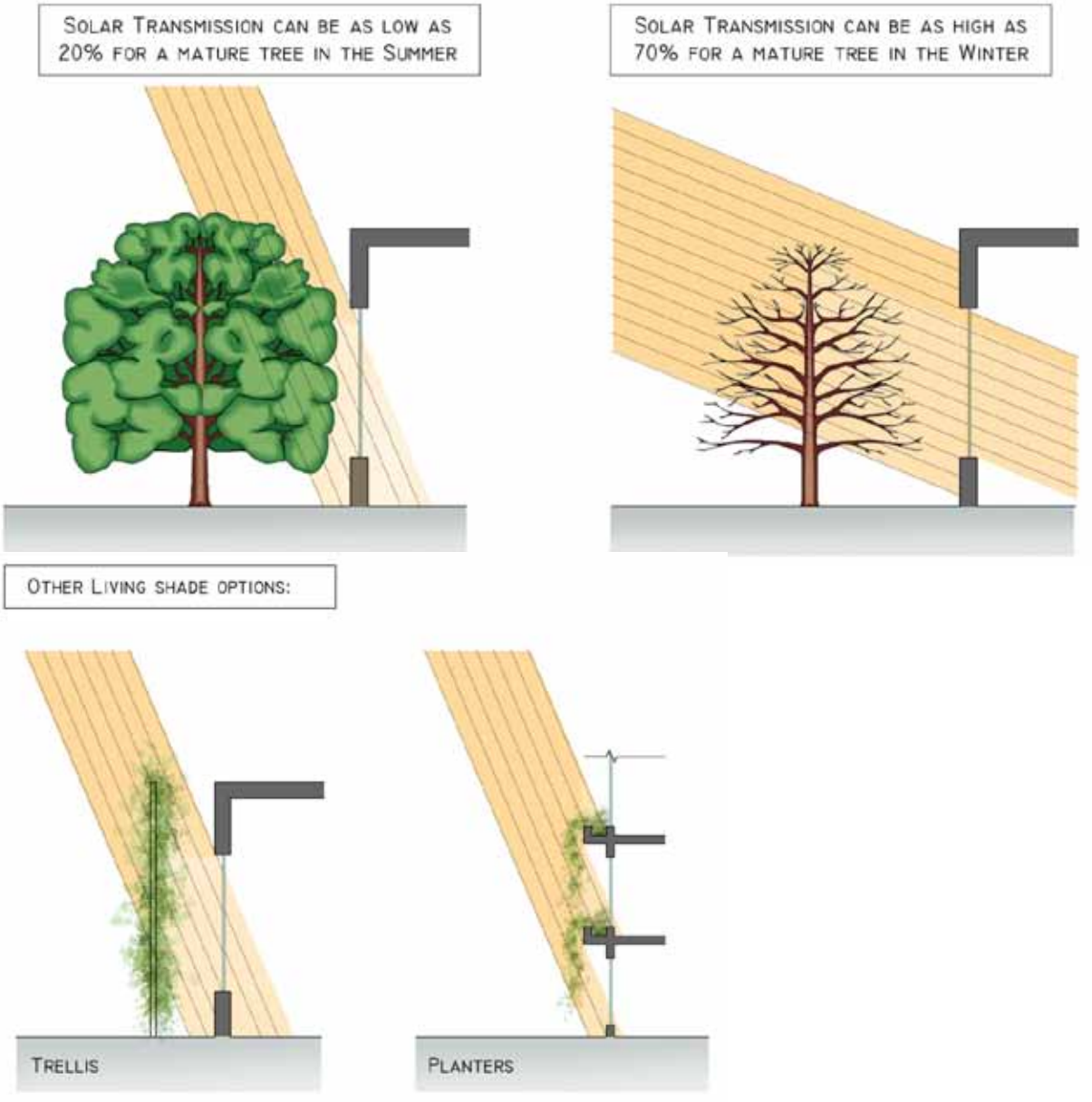
Adjustable overhangs provide a solution to seasonal lag.

Some ideas might work well “in a drawing”, but think carefully before you use any devices that require hinges or motion in climates where snow and ice will cause wear.



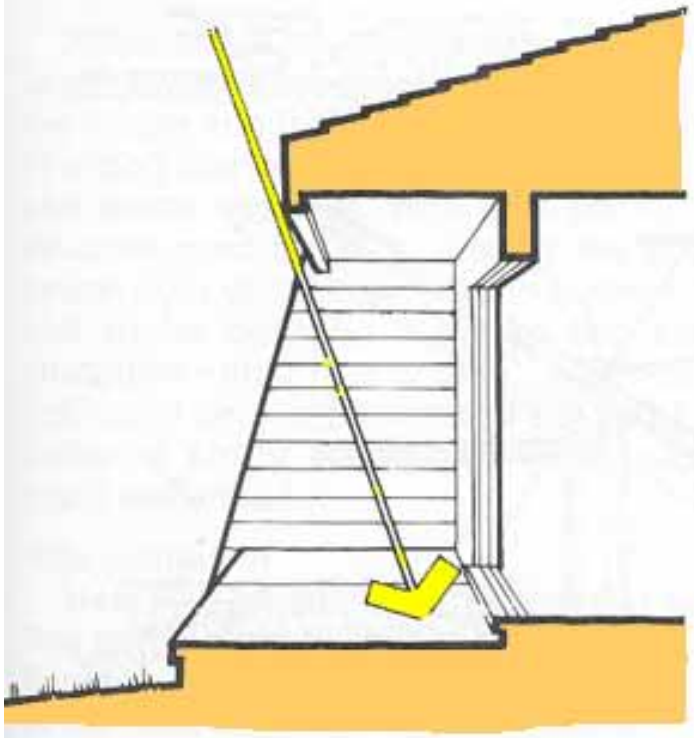
IN THEORY, A HINGED, TWO-POSITION SHADING DEVICE AN EFFECTIVE SOLUTION.
... BUT CONSIDER ITS PRACTICALITY.

Living Awnings such as deciduous trees and trellises with deciduous vines are very good shading devices. They are in phase with the thermal year – gain and lose leaves in response to temperature changes.

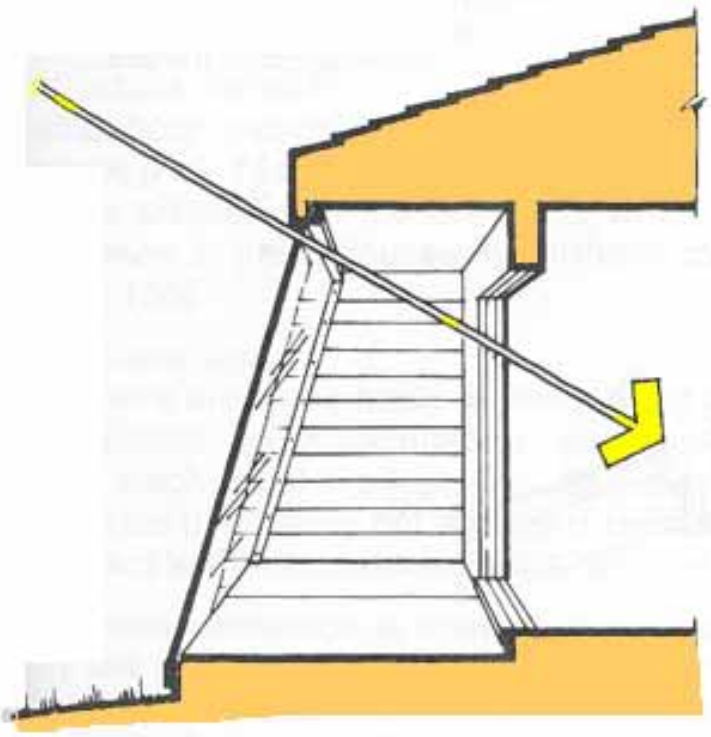


Ketchum Residence, ON,
Sustainable EDGE Inc.

Center for Regenerative
Studies, Cal Poly Pomona



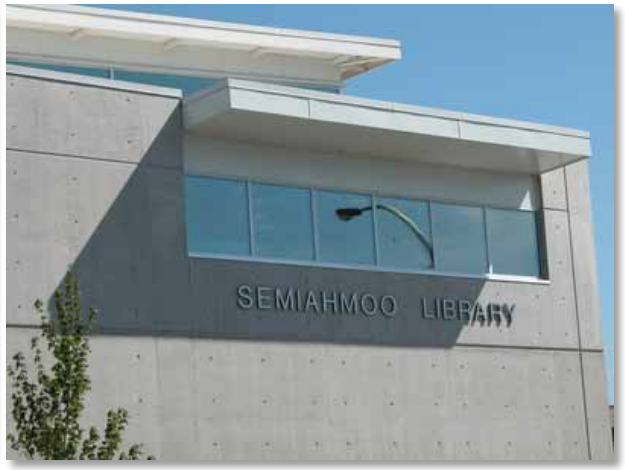
SIZE OVERHANG FOR SUMMER SUN PROTECTION



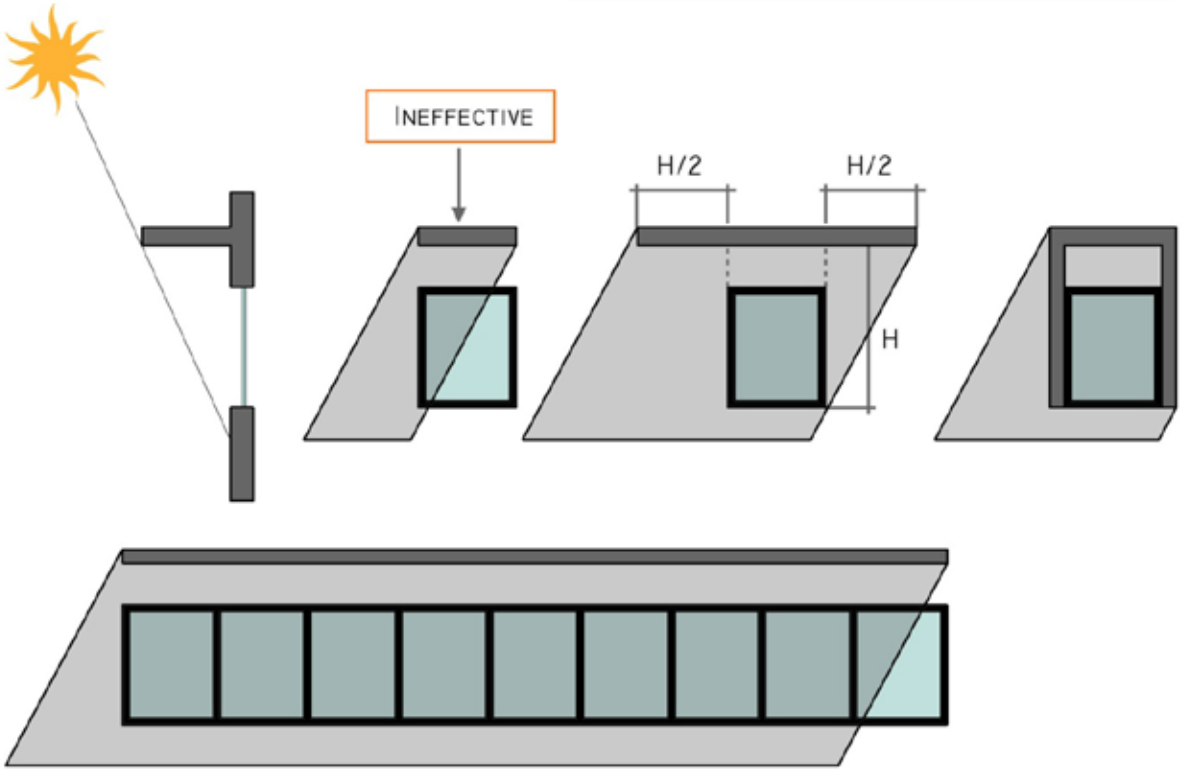
IF PROPERLY PLANNED IN ADVANCE, A SEASONAL GREENHOUSE CAN BE ADDED BY "STITCHING" IN A PLASTIC FILM TO SOFFIT, CURB, AND WINGWALL NAILING STRIPS.

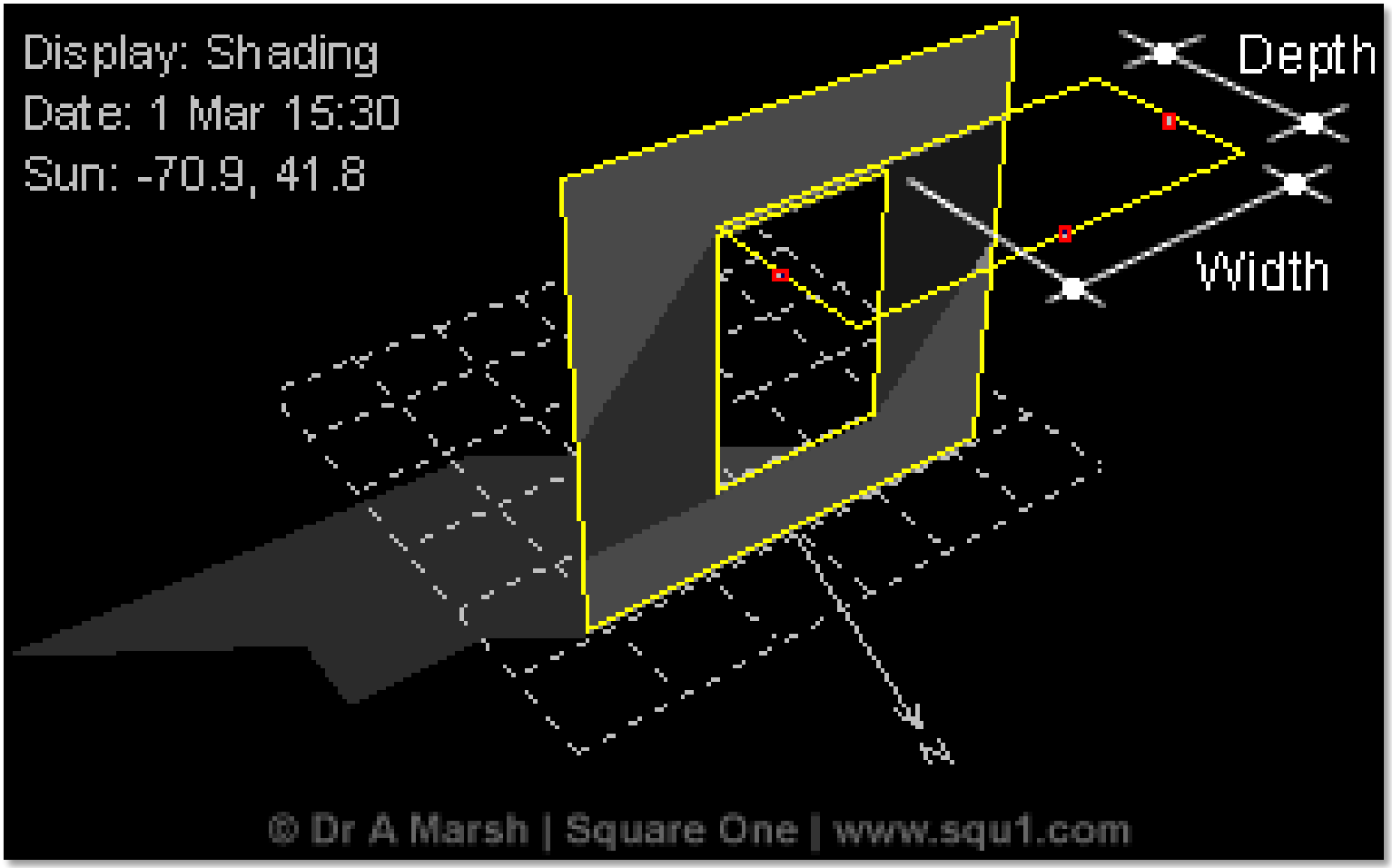
FIG. 14 **Outdoor spaces can be designed for both summer sun protection and winter sun collection with demountable glazing panels or films.**

CBD

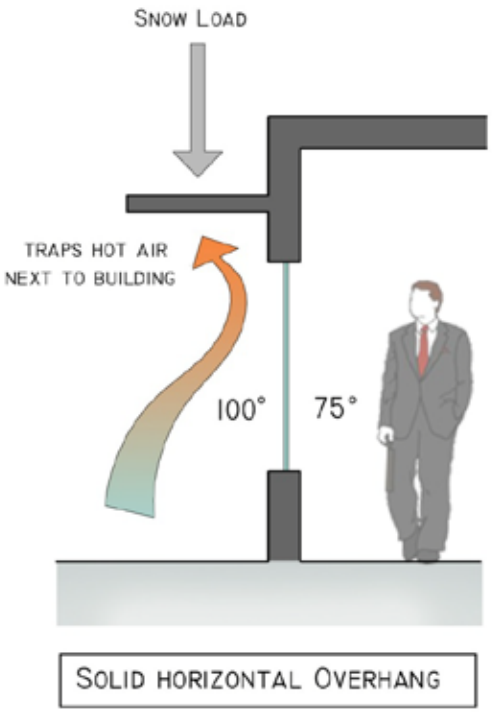


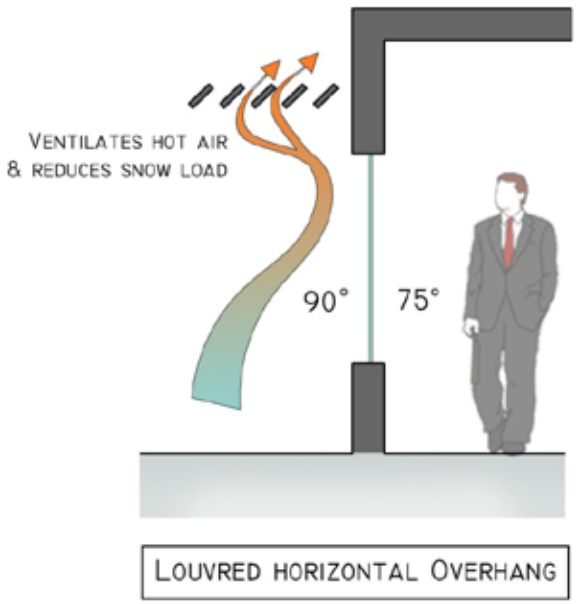
…extend device for full shading




Display: Shading
Date: 1 Mar 15:30
Sun: -70.9, 41.8
Depth
Width
© Dr A Marsh | Square One | www.squ1.com

This one uses ceramic fritted glass that is sloped, to allow some light but shed rain and wet snow.





The above two use louvers or grates that will let snow, rain and wind through.

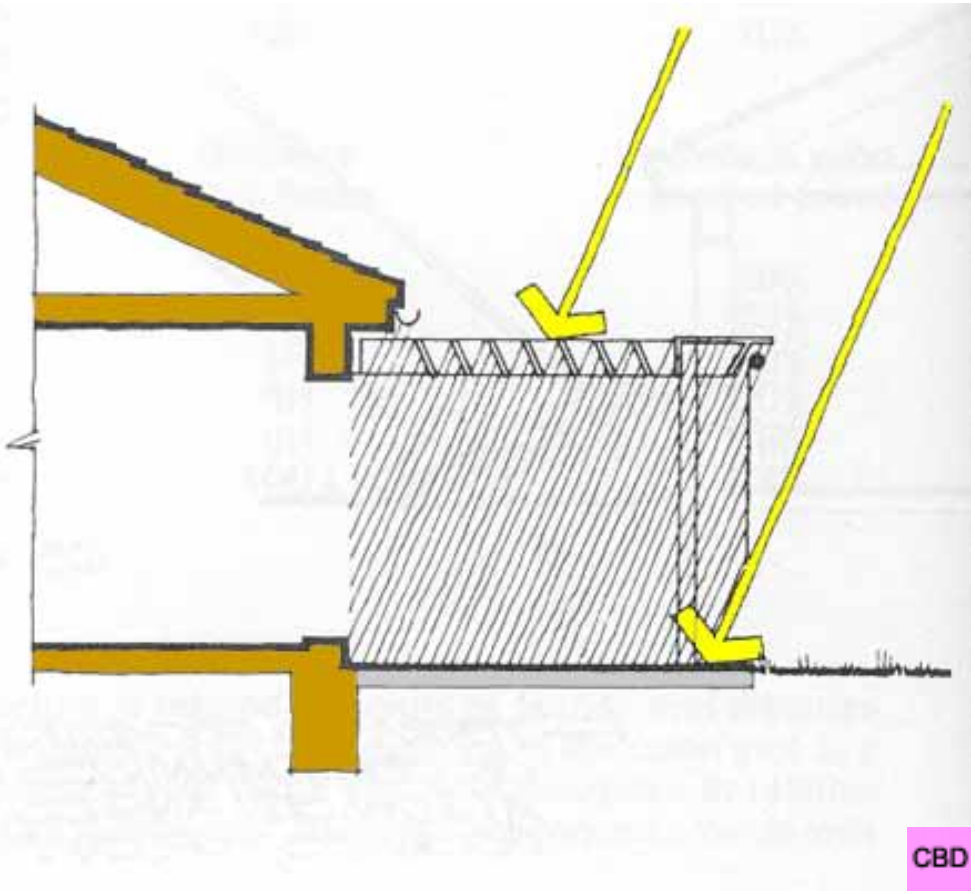
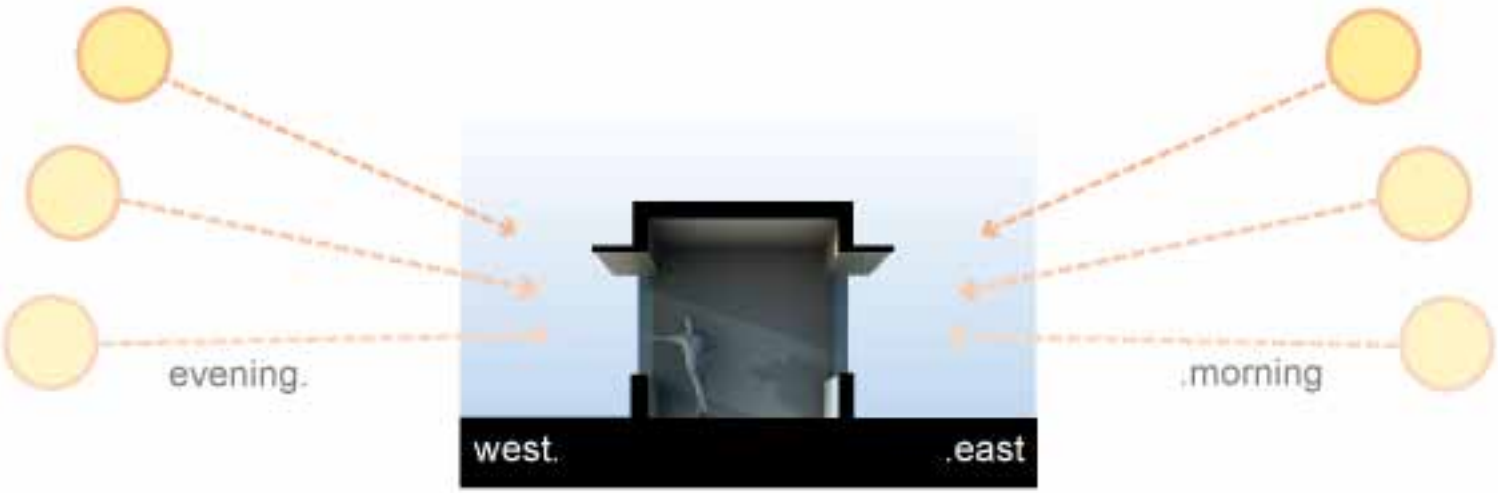


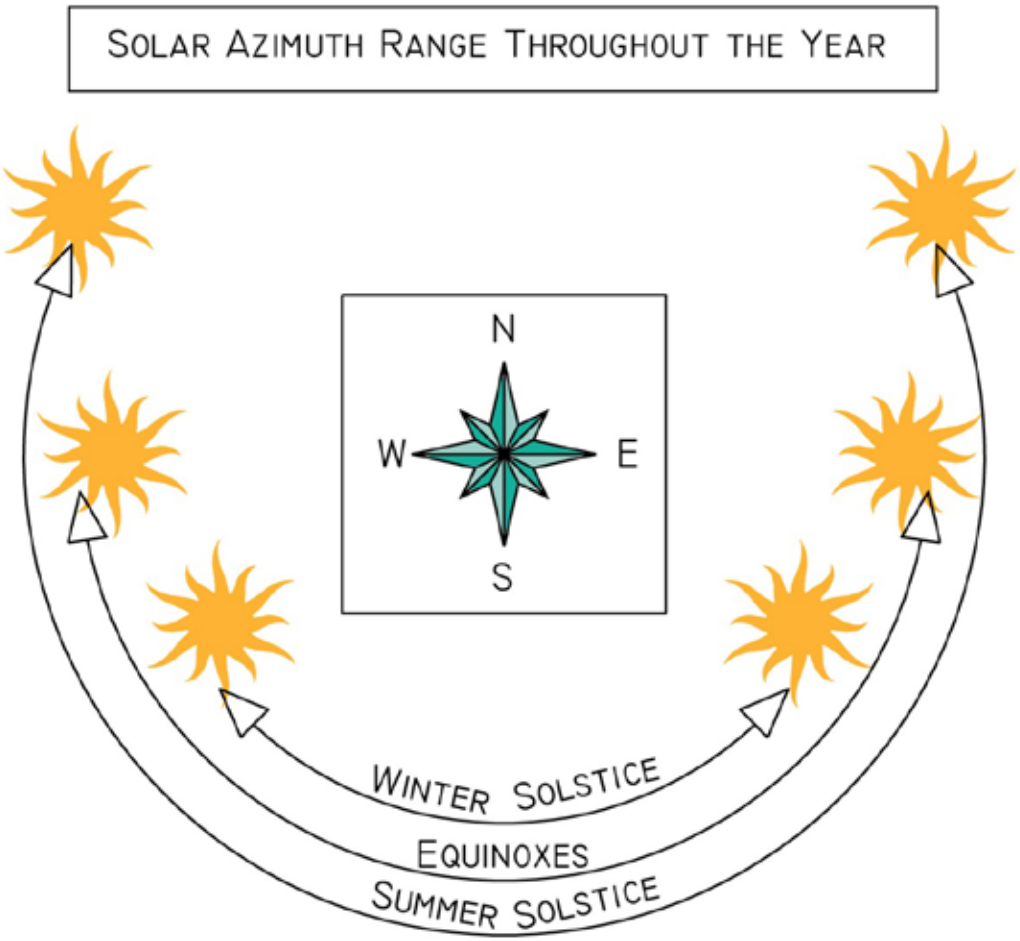
FIG. 4d. Attached overhead shading structures can provide multiple benefits. Not only does this patio cover shade the wall, it also reduces reflected gain from loading on the wall.

CBD

Shading Strategies for West and East Elevations

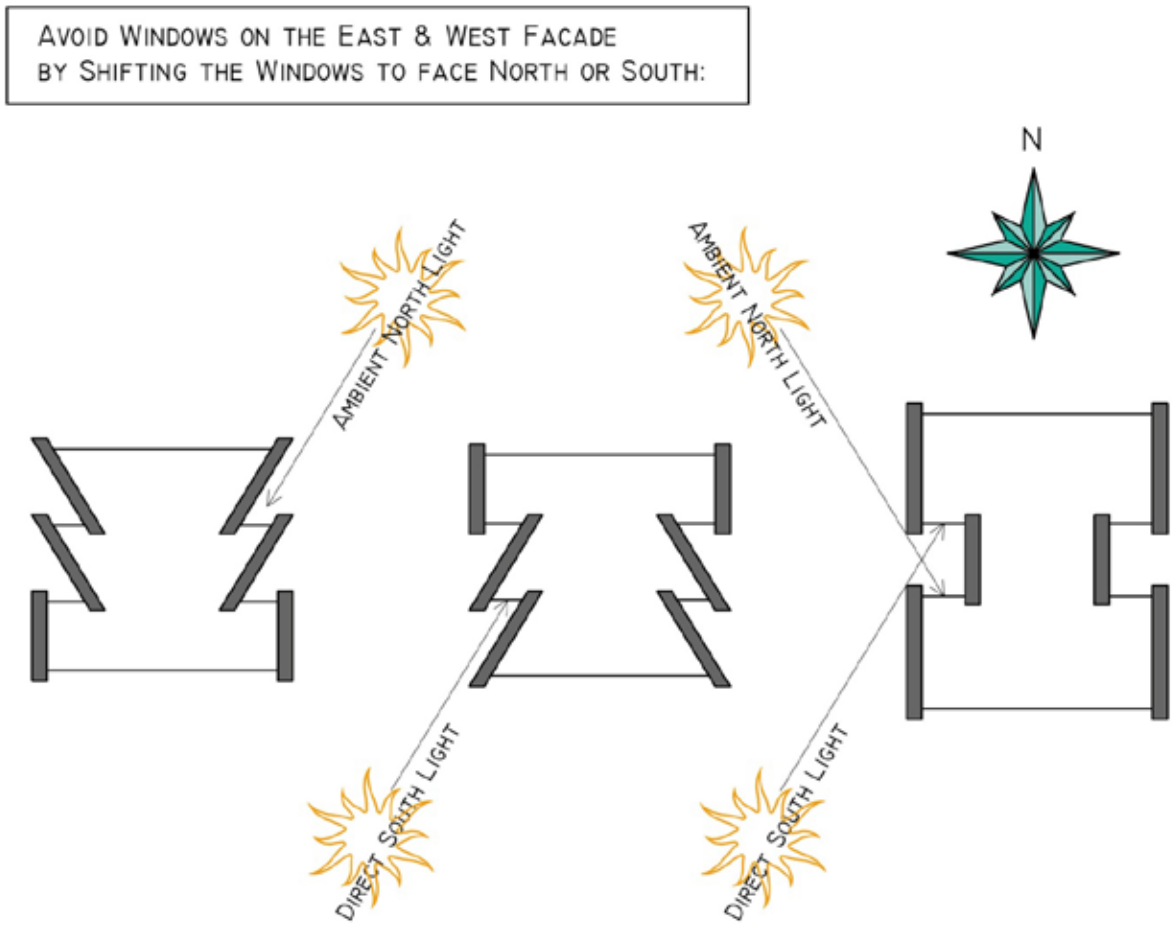


Horizontal overhangs DO NOT work on east & west facades.



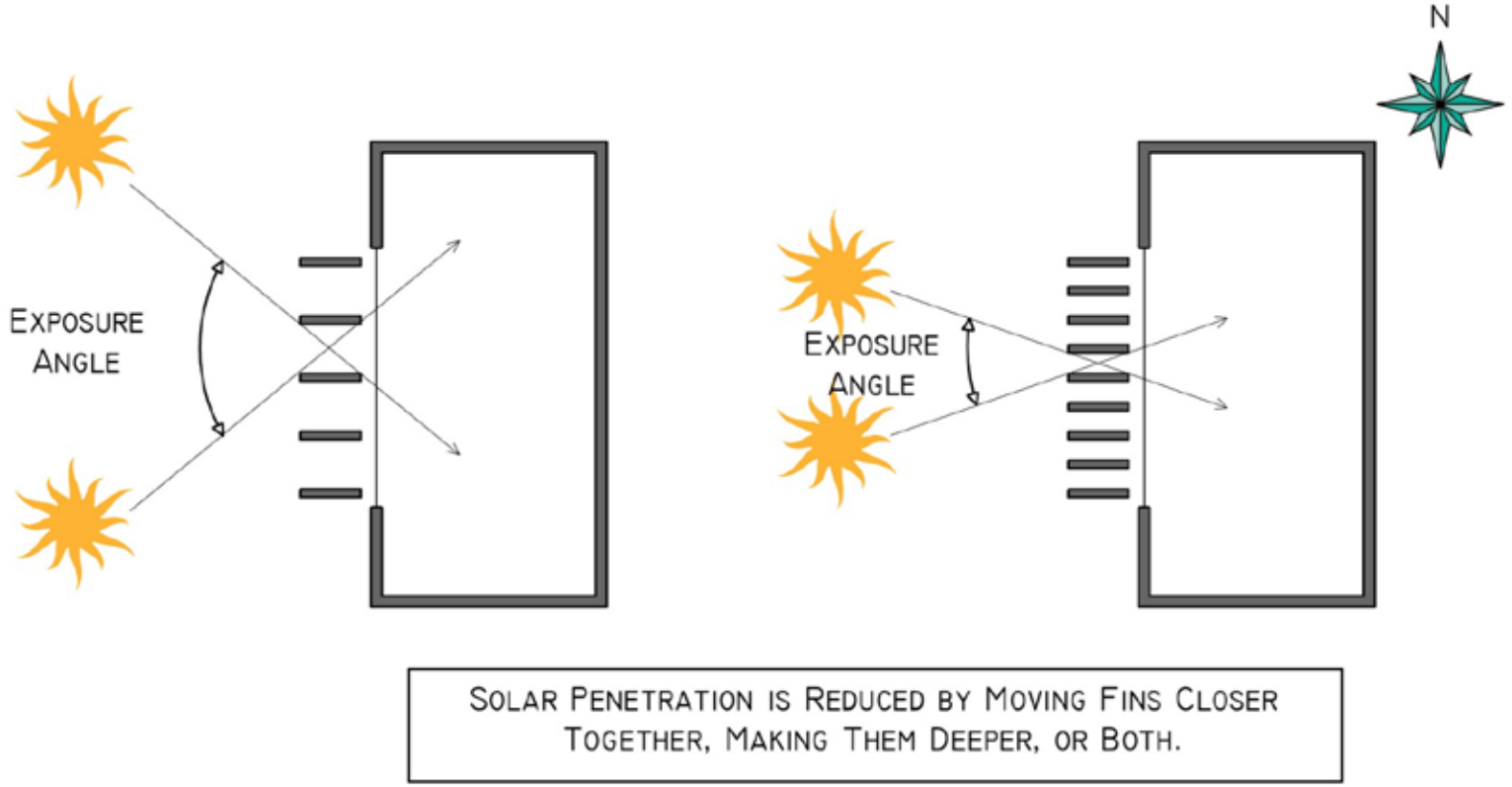
Since little winter heating can be expected from east and west windows, shading devices on those orientations can be designed purely on the basis of the summer requirement.

1. The best solution by far is to limit using east and especially west windows (as much as possible in hot climates)



2. Next best solution is to have windows on the east and west façades face north or south

Shading Strategies for West and East Elevations



SOLAR PENETRATION IS REDUCED BY MOVING FINS CLOSER TOGETHER, MAKING THEM DEEPER, OR BOTH.

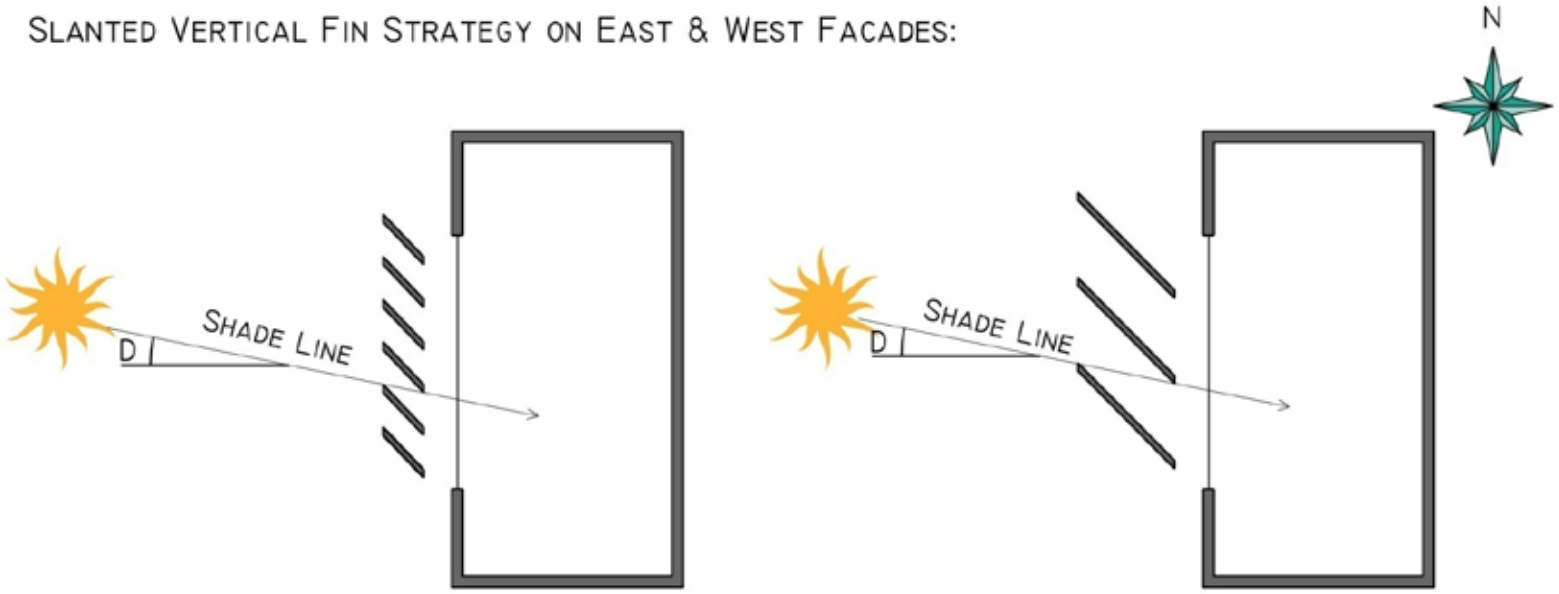
3. Use Vertical Fins. Spacing is an issue, as well as fin length. Must be understood that if to be effective, they will severely restrict the view.

TABLE 9.12
SHADE LINE ANGLE FOR SLANTED VERTICAL FINS*

Latitude	Angle "D"
24	18
28	15
32	12
36	10
40	9
44	8
48	7

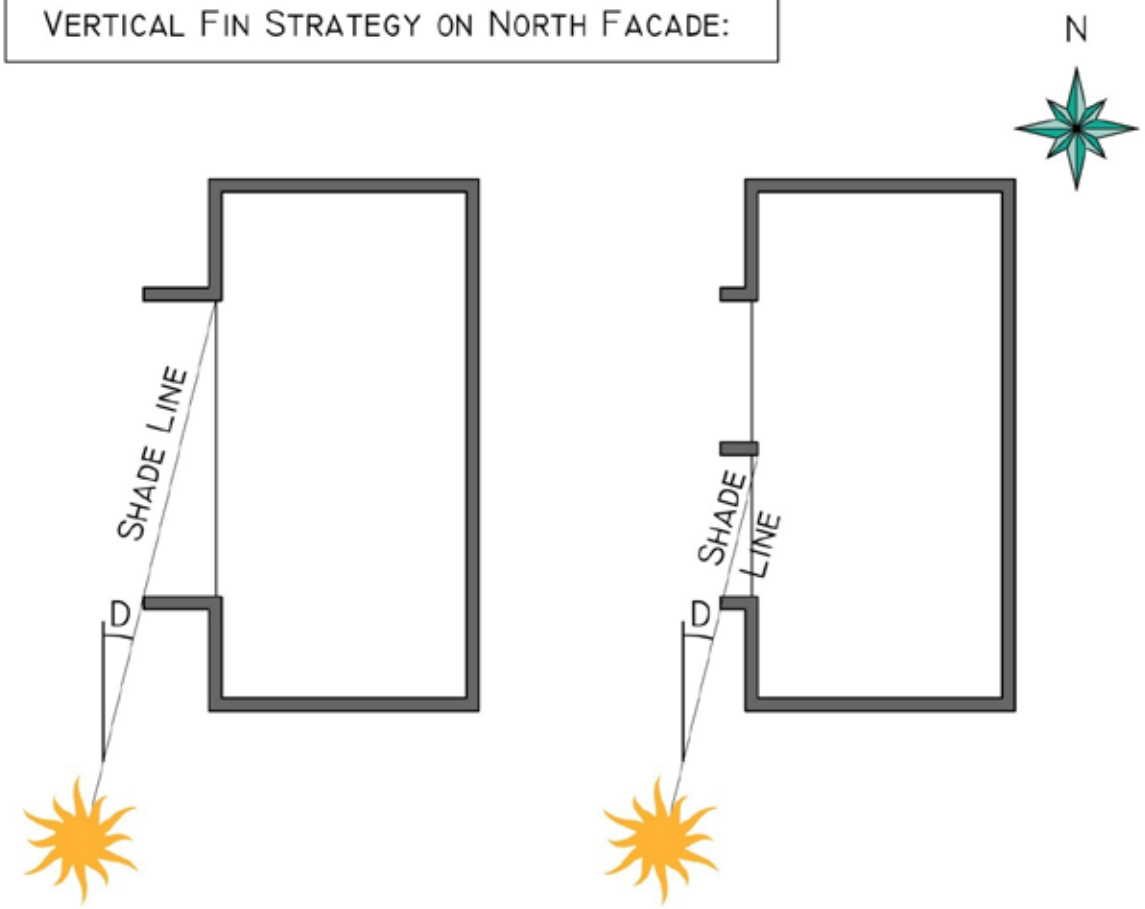
* This table is for vertical fins slanted toward the north on east or west windows. Designs based on this table will provide shade from direct sun for the whole year between the hours of 7 A.M. and 5 P.M. (solar time). This table can also be used to design vertical fins on north windows for the same time period.

SLANTED VERTICAL FIN STRATEGY ON EAST & WEST FACADES:



THE "SHADE LINE" AT ANGLE "D" DETERMINES FIN SPACING, DEPTH & SLANT

VERTICAL FIN STRATEGY ON NORTH FACADE:



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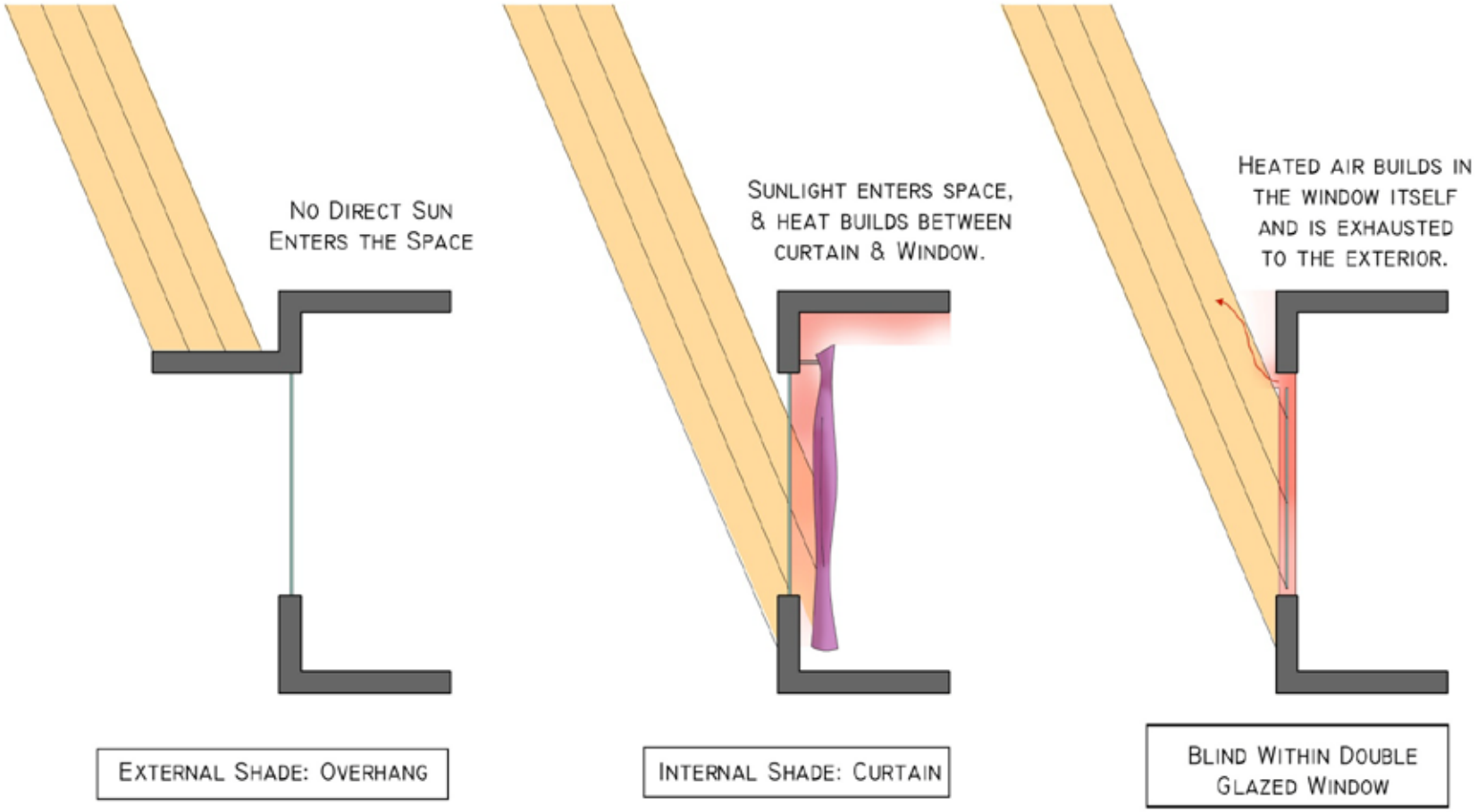
HCL

The sun also hits the façade from the north east and north west during the summer. Fins can be used to control this oblique light as well. It is a function of the latitude, window size and fin depth/frequency.

Interior vs. Exterior Shades



Once the heat is IN, it is IN!

Interior Shading Devices

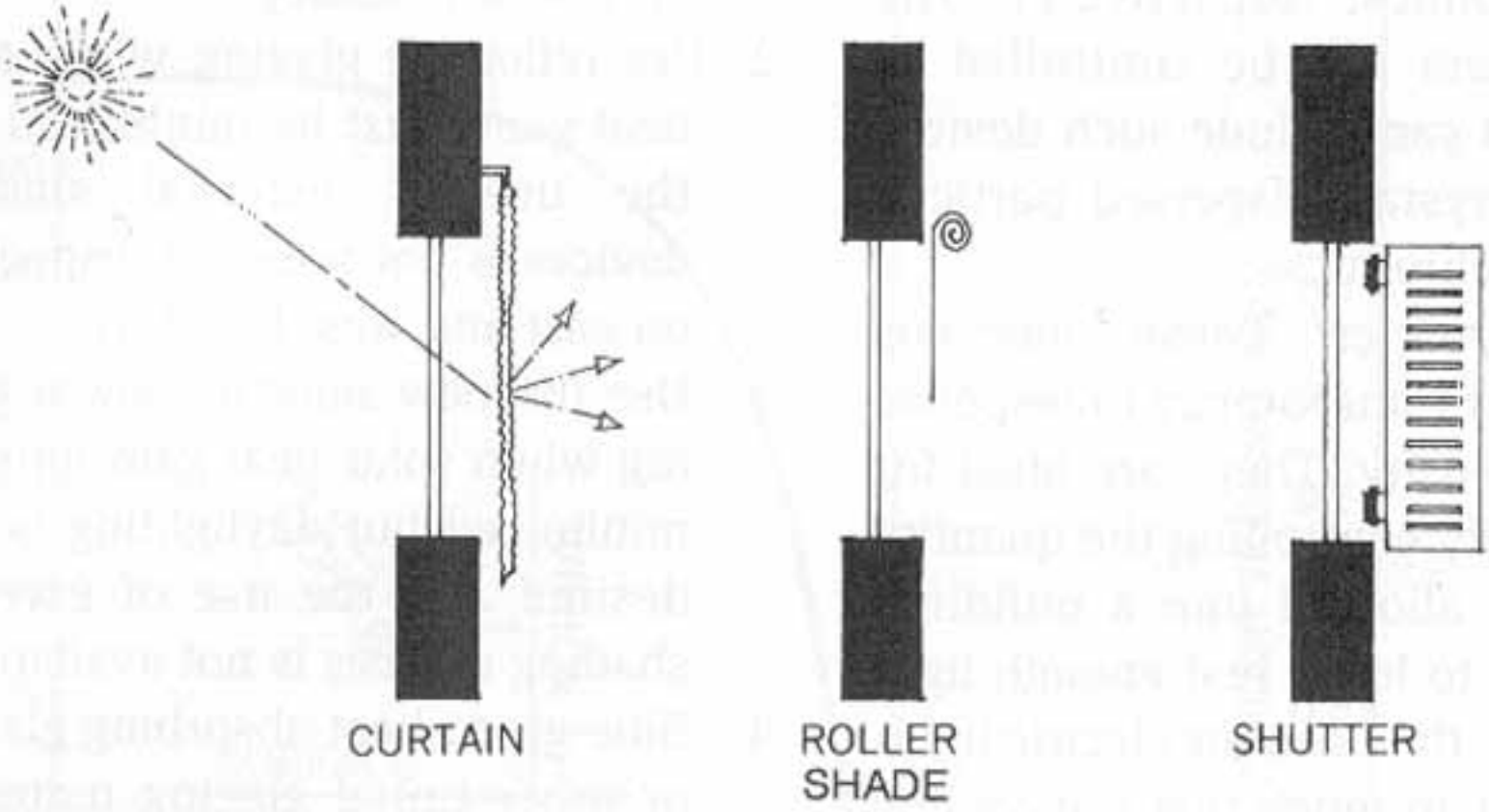
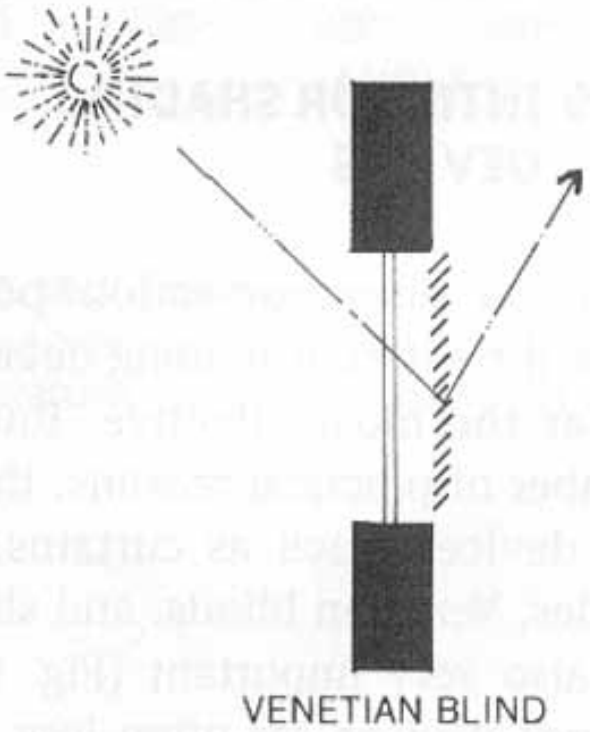


Figure 9.19a Interior shading devices for solar control.

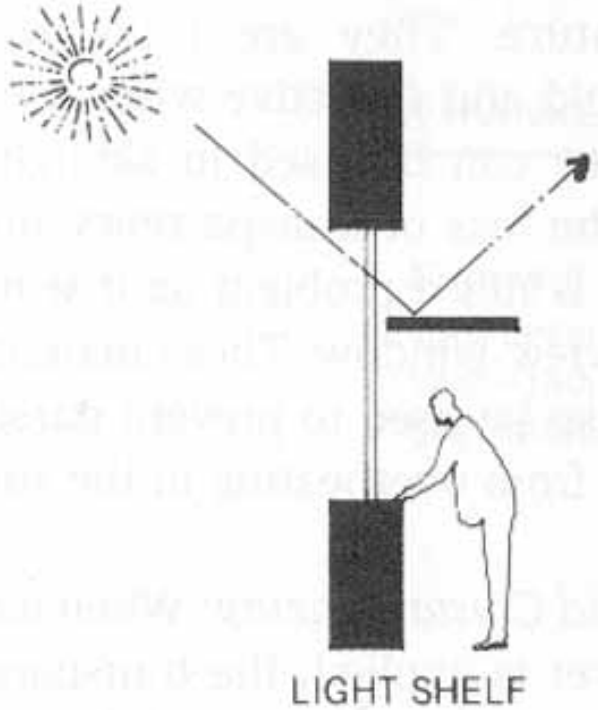
HCL

These do NOT control heat gain -- only issues of glare.

Interior Shading Devices



VENETIAN BLIND



LIGHT SHELF

Figure 9.19b Interior shading devices that contribute to quality daylighting.

HCL

Interior blinds CAN be used to assist in daylighting and light distribution within the space. *They do not control heat from solar gain.*

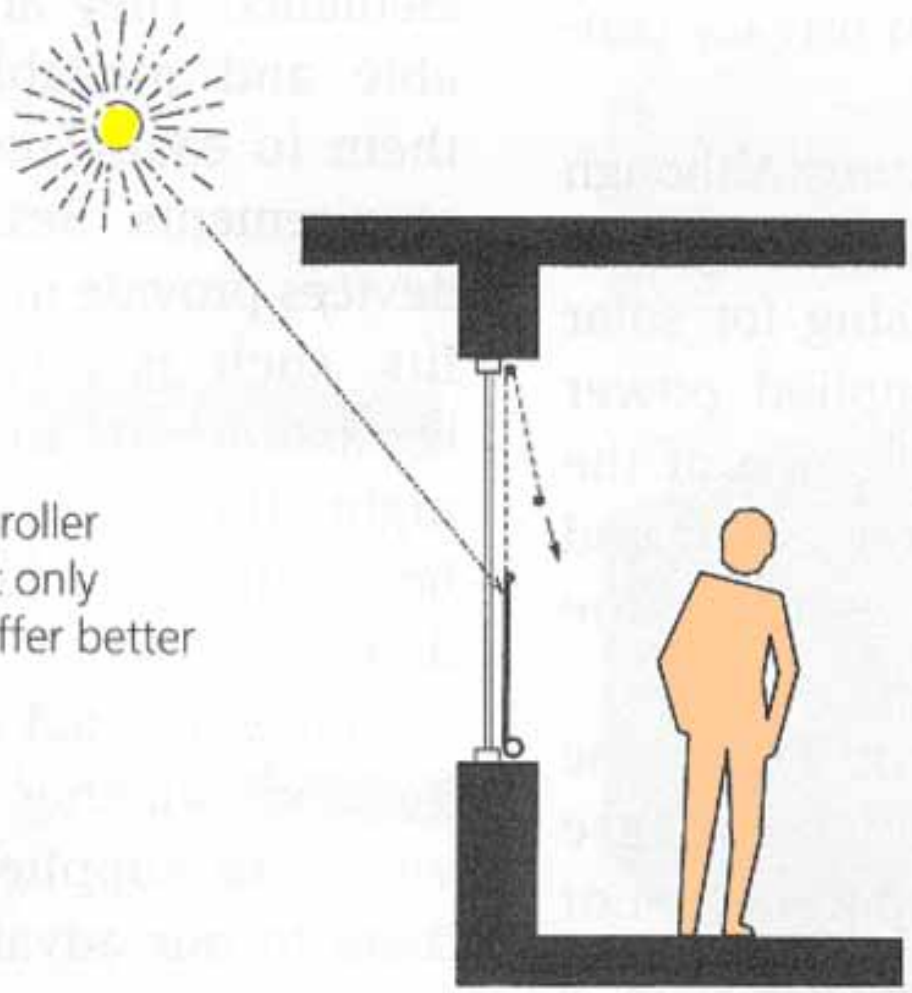
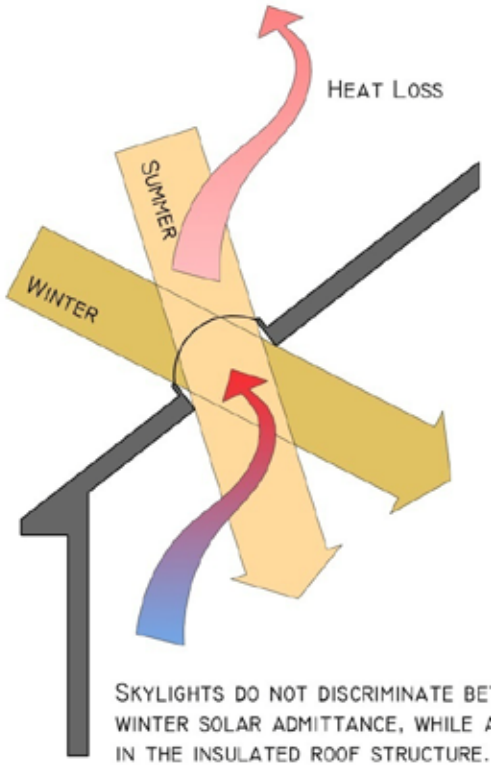


Figure 9.19c When roller shades roll up, they not only shade better but also offer better privacy.

HCL

Skylights vs. Clerestories

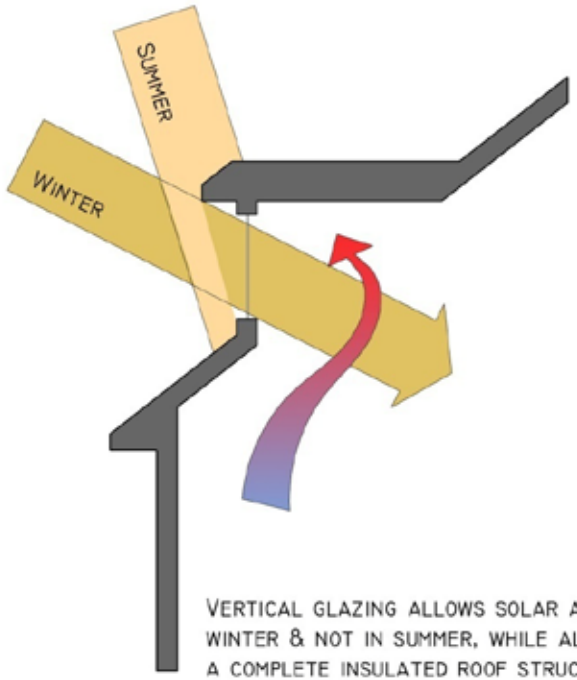
Sloped/Horizontal Glazing: Skylight



Skylights do not discriminate between summer & winter solar admittance, while also creating a hole in the insulated roof structure.

- Result = Overheating in Summer & Excessive Heat Loss in Winter

Vertical Glazing: Dormer/Clerestory



Vertical glazing allows solar admittance in winter & not in summer, while also maintaing a complete insulated roof structure.

- Result = Natural Daylighting & Thermal Comfort Year-Round

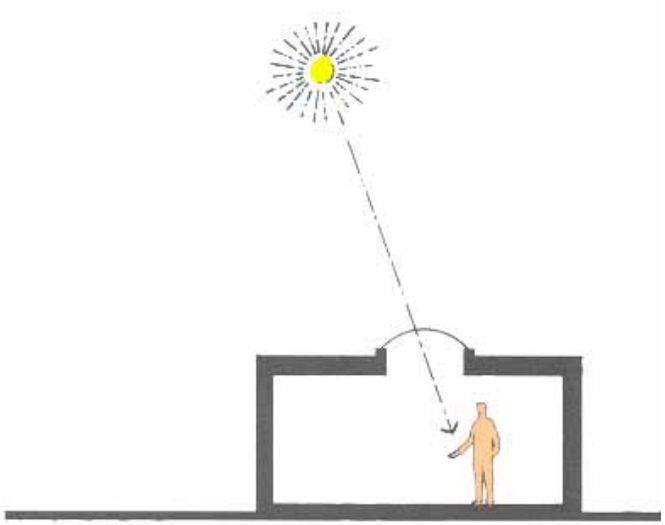


Figure 9.3e Skylights (horizontal glazing) should usually be avoided because they face the summer sun.

HCL

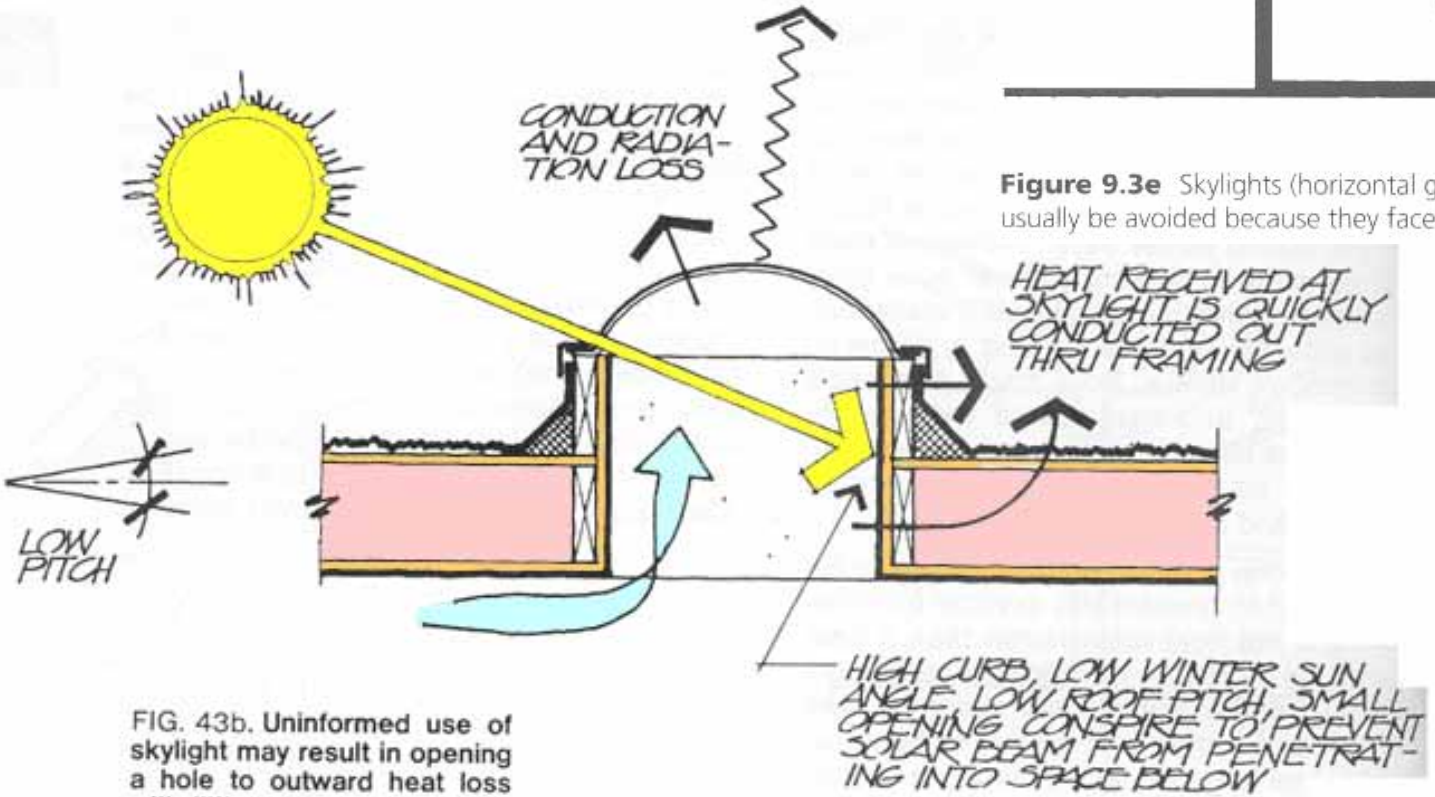


FIG. 43b. **Uninformed use of skylight may result in opening a hole to outward heat loss with little compensating gain. The result may be summer overheating and winter net heat loss.**

CBD

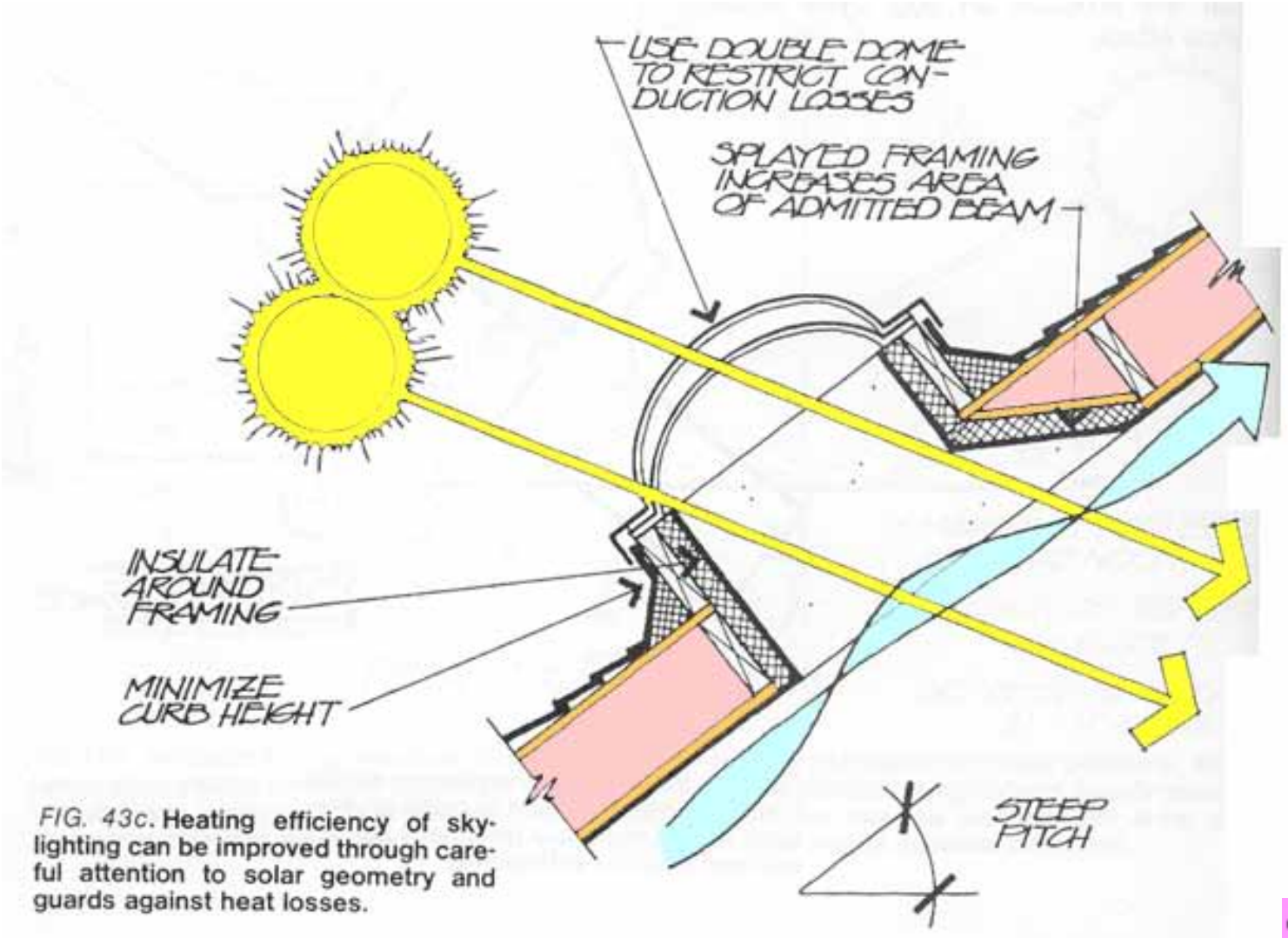
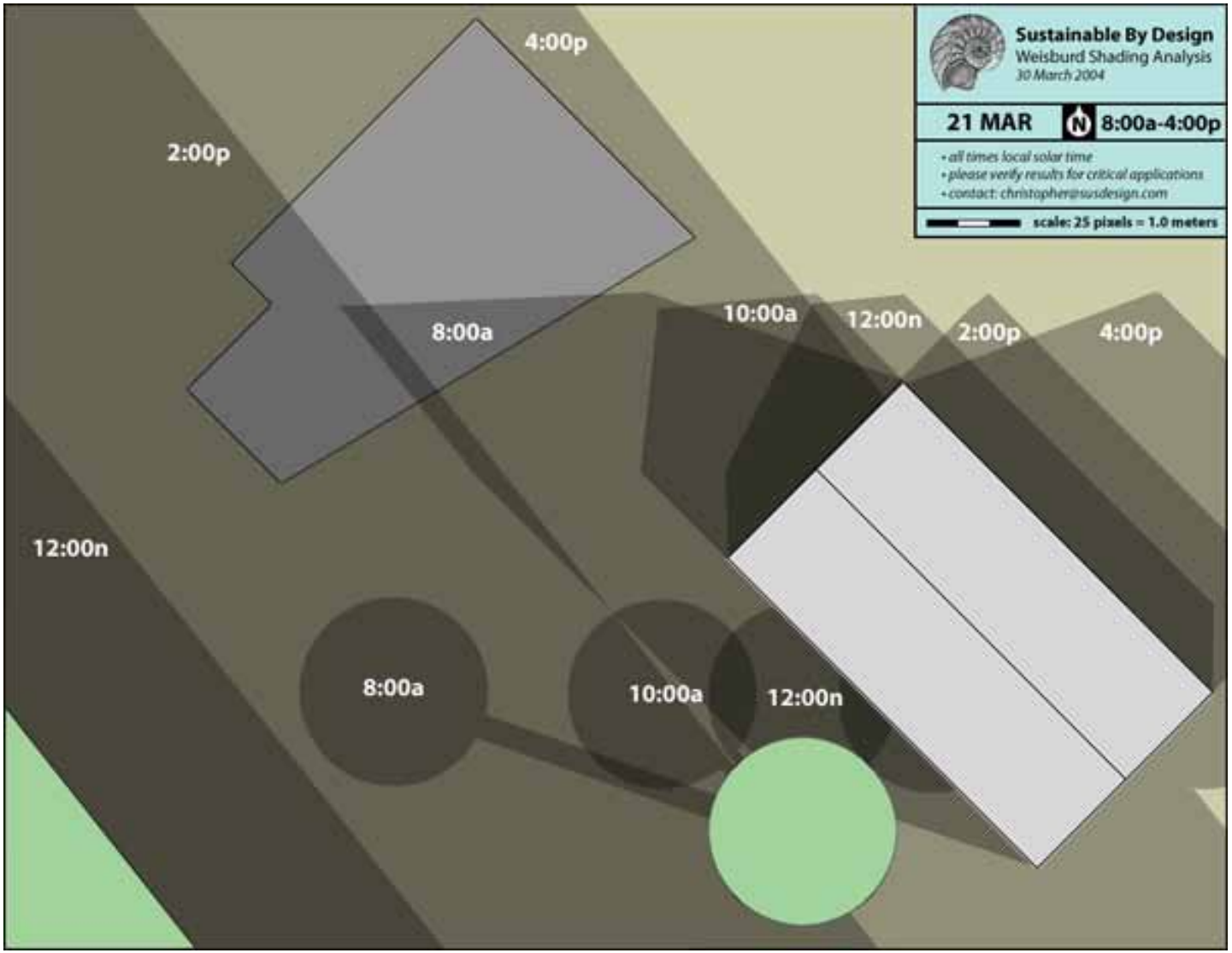


FIG. 43c. **Heating efficiency of skylighting can be improved through careful attention to solar geometry and guards against heat losses.**

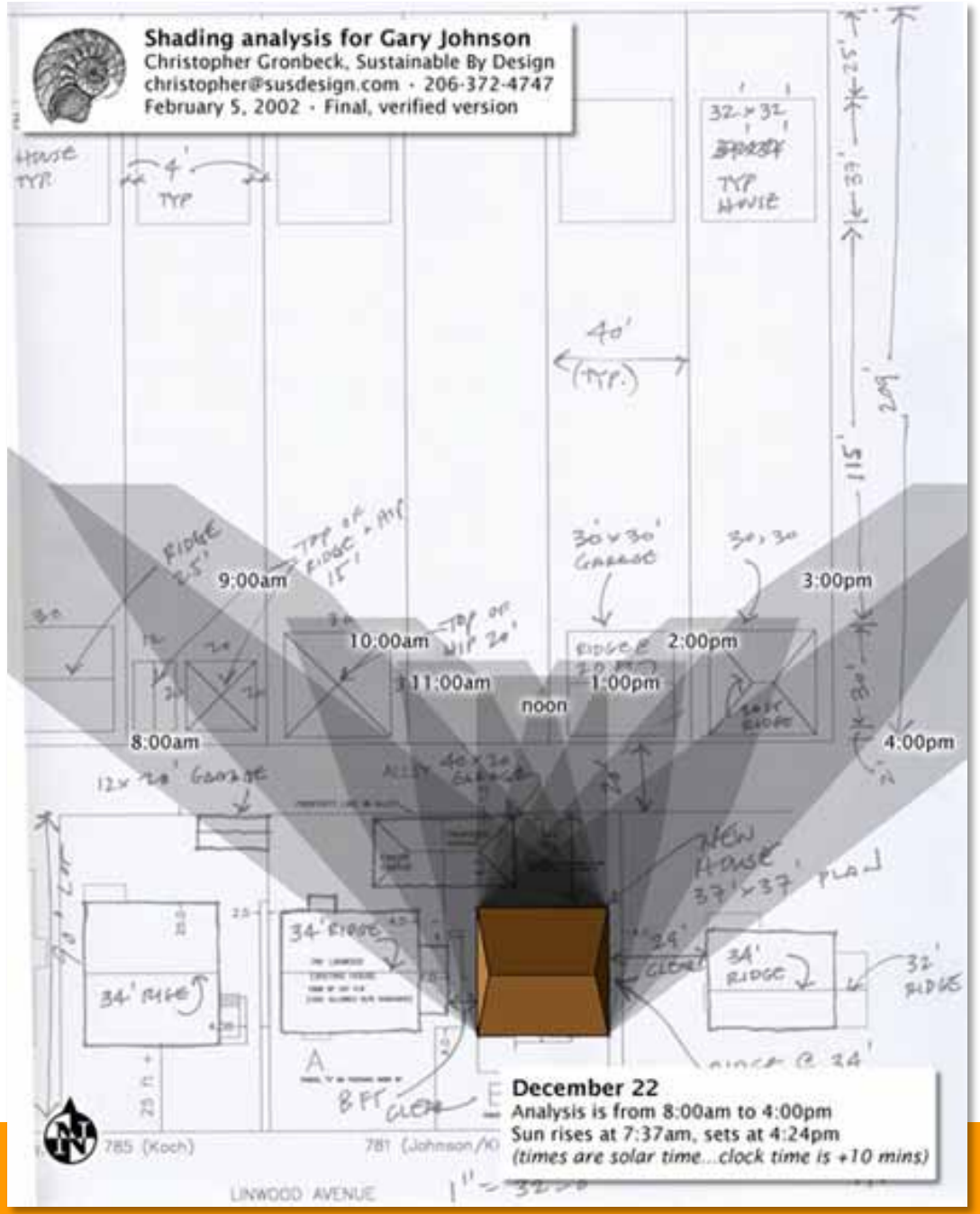
CBD

Learning how to plot shadows…

- important to get a quick and dirty understanding of your building and its shadow patterns (both INTERIOR and EXTERIOR)
- need to do this BEFORE you commit to extensive designs
- can use computers to simulate
- can do sun angle diagrams
- can build a quick massing model and model it on a HELIODON



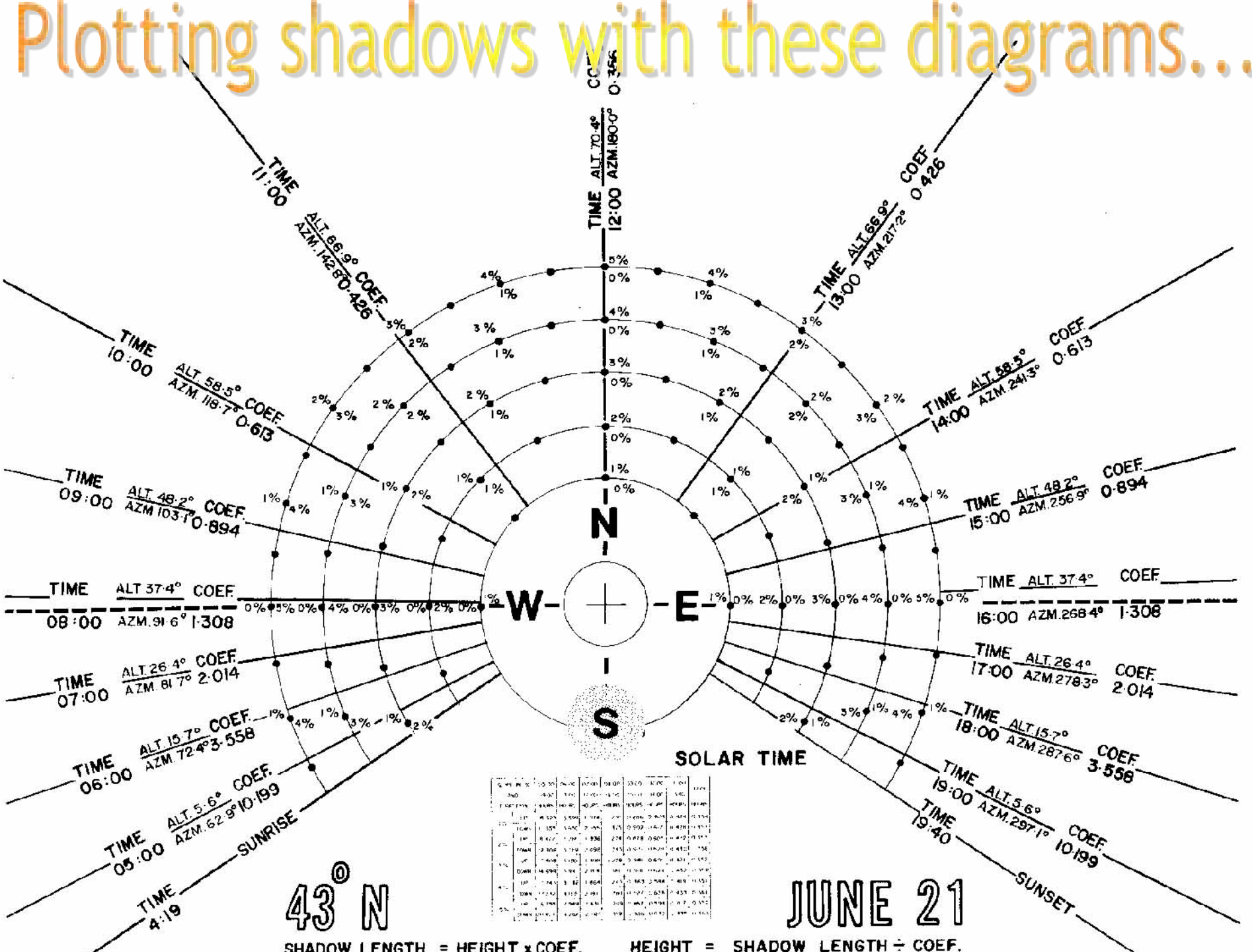
Plotting shadows allows you to understand your site and the effects of the sun on your site at different times of the day and year.



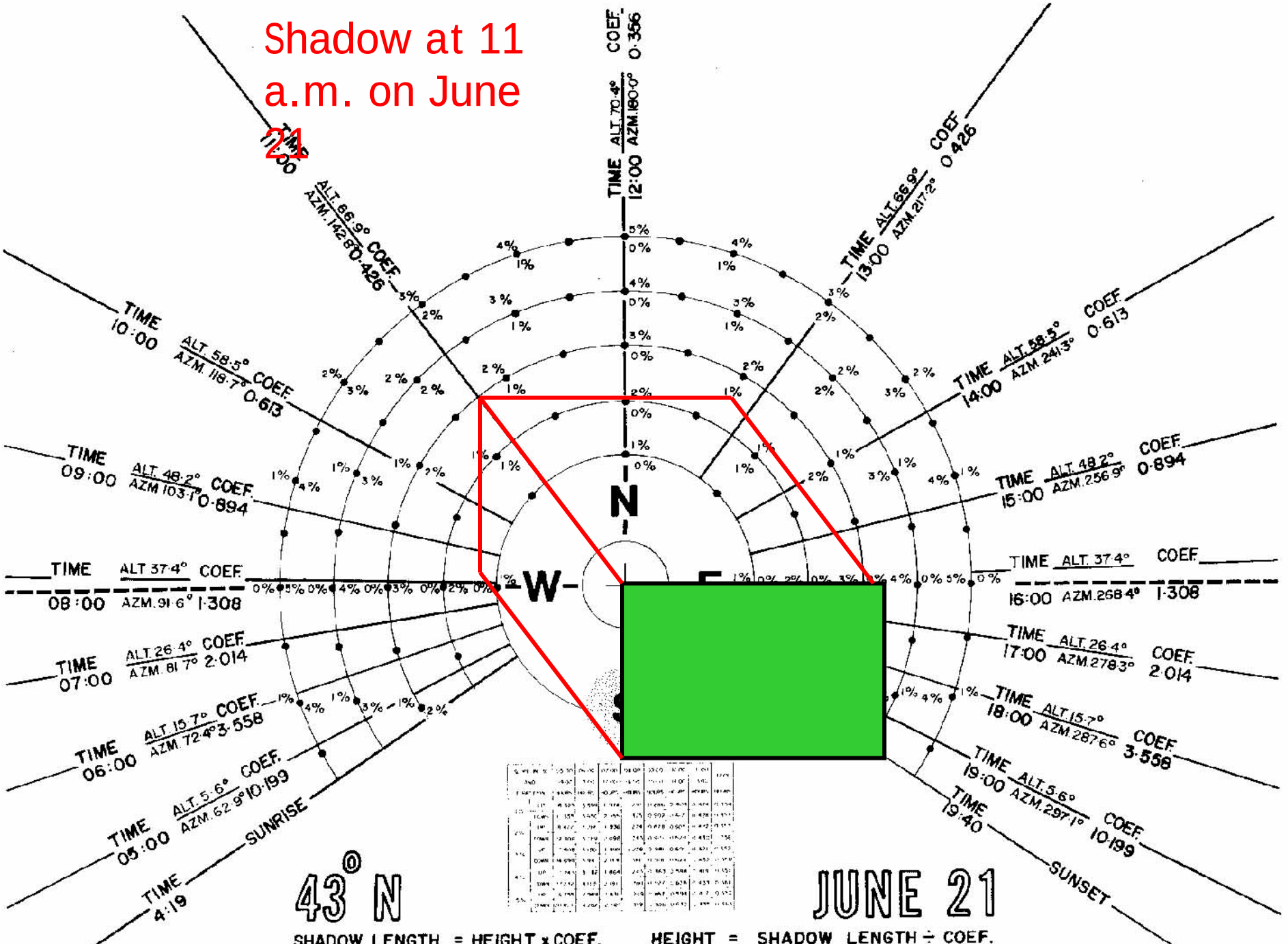
This type of analysis is a "must do" for every building that you design.

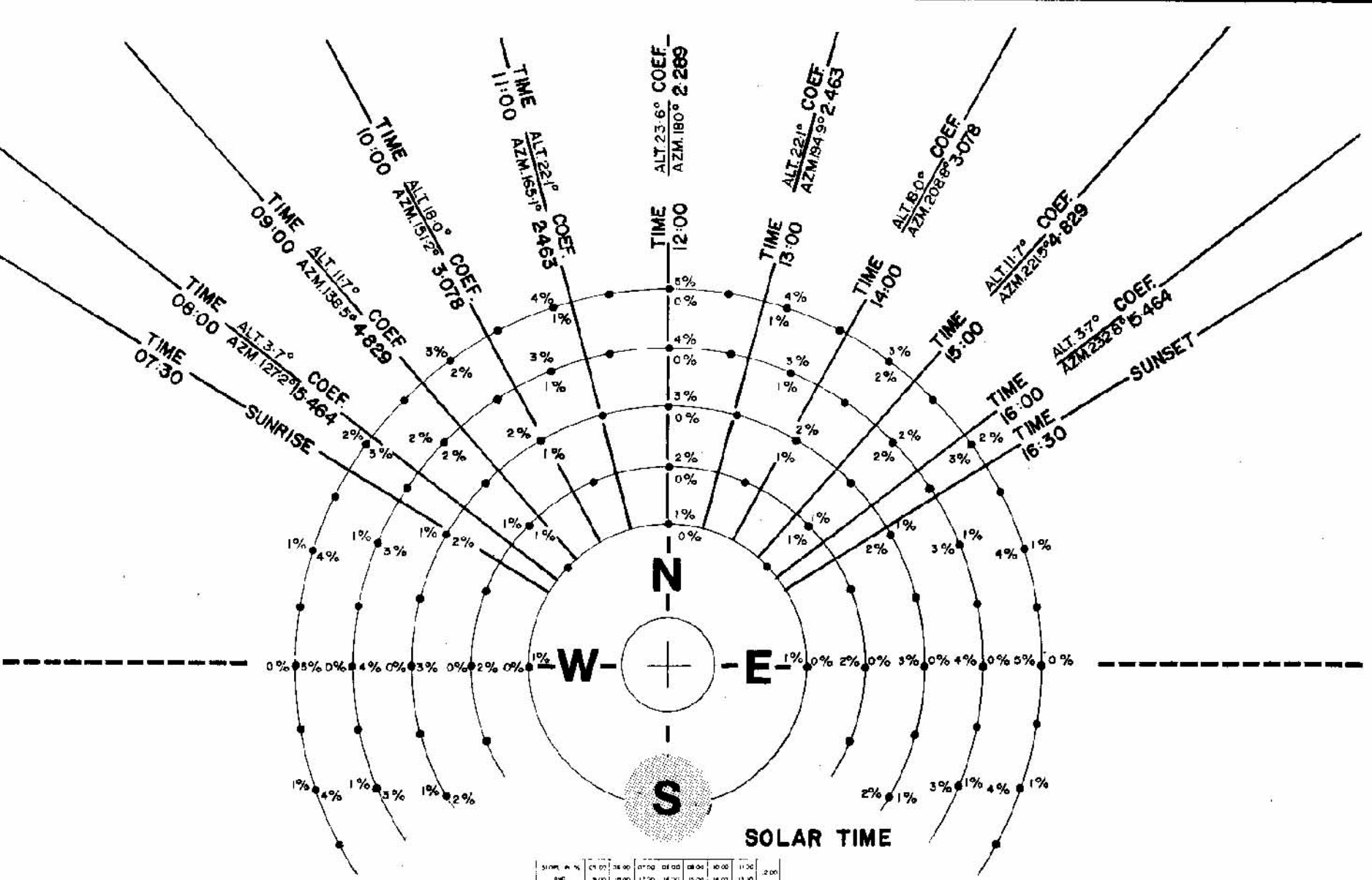
What is MISSING here, is the shading diagrams from the neighbouring properties (all sides). Their shadows will impact your building too.

Plotting shadows with these diagrams…



Shadow at 11 a.m. on June 21



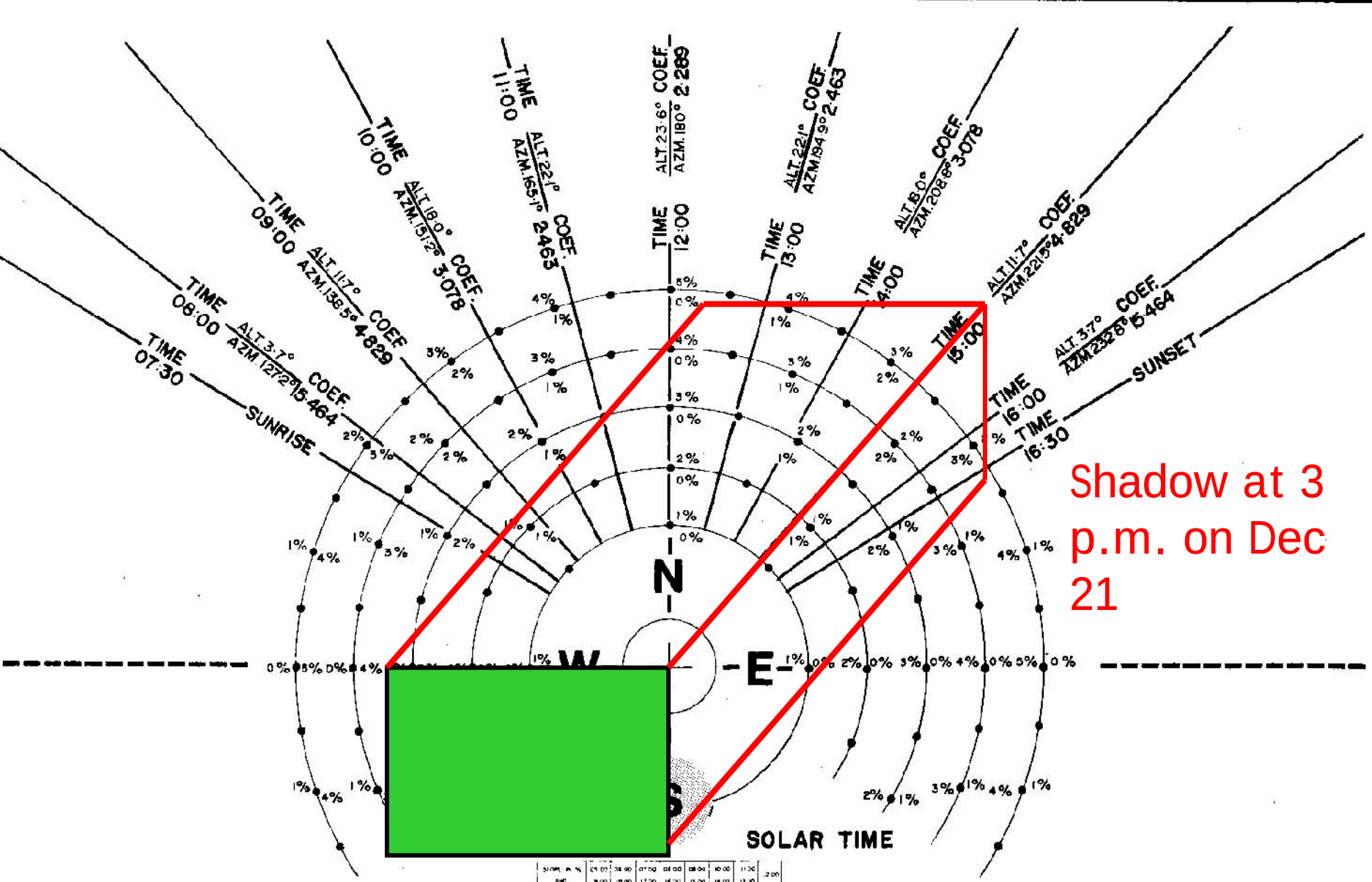


43° N

DEC. 21

SHADOW LENGTH = HEIGHT x COEF.

HEIGHT = SHADOW LENGTH ÷ COEF.



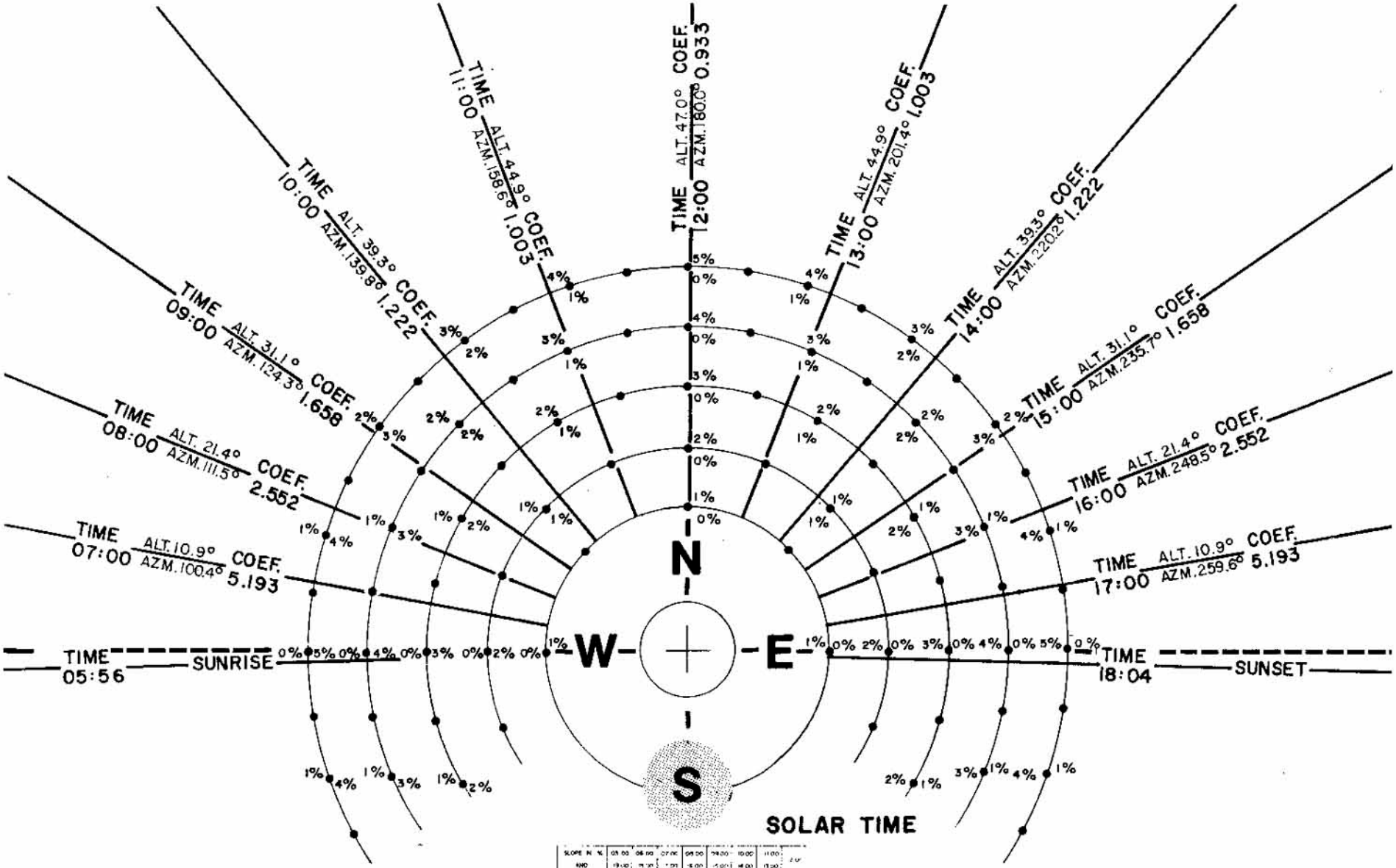
Shadow at 3 p.m. on Dec 21

43° N

DEC. 21

SHADOW LENGTH = HEIGHT x COEF.

HEIGHT = SHADOW LENGTH ÷ COEF.

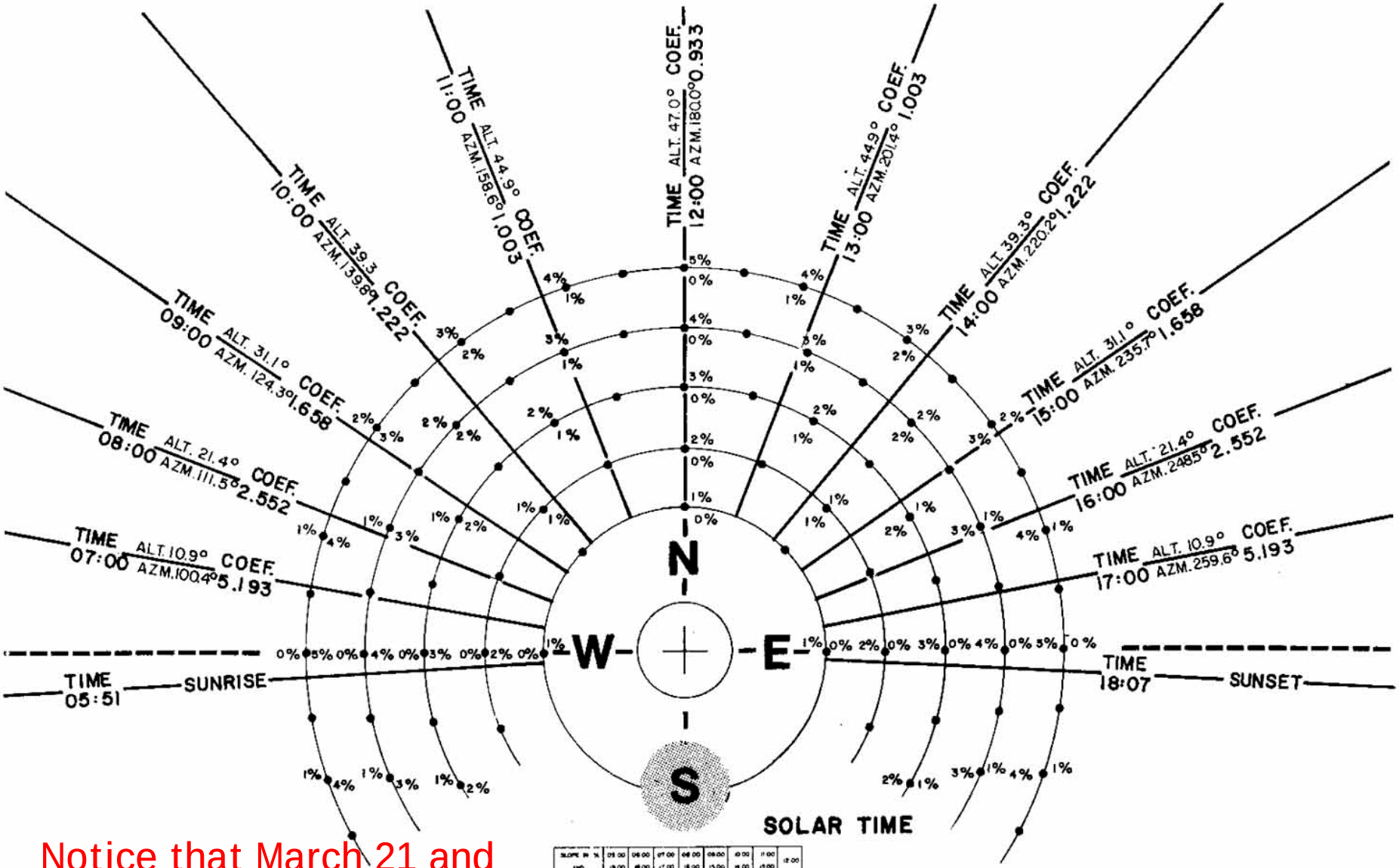


SLOPE N °E AND DIRECTION		05:00 19:00 HOURS	06:00 18:00 HOURS	07:00 17:00 HOURS	08:00 16:00 HOURS	09:00 15:00 HOURS	10:00 14:00 HOURS	11:00 13:00 HOURS	12:00 HOURS
1%	UP			6.916	2.886	1.670	1.207	0.995	0.926
	DOWN			5.477	2.618	1.646	1.227	1.015	0.941
2%	UP			4.704	2.429	1.605	1.193	0.983	0.913
	DOWN			5.794	2.669	1.714	1.252	1.026	0.950
3%	UP			4.493	2.320	1.579	1.178	0.974	0.917
	DOWN			6.151	2.765	1.748	1.268	1.044	0.959
4%	UP			4.296	2.225	1.554	1.164	0.965	0.899
	DOWN			6.553	2.863	1.785	1.283	1.045	1.965
5%	UP			4.121	2.231	1.530	1.152	0.955	0.891
	DOWN			7.015	2.929	1.827	1.298	1.066	0.974

43° N

MARCH 21

SHADOW LENGTH = HEIGHT x COEF. HEIGHT = SHADOW LENGTH ÷ COEF.



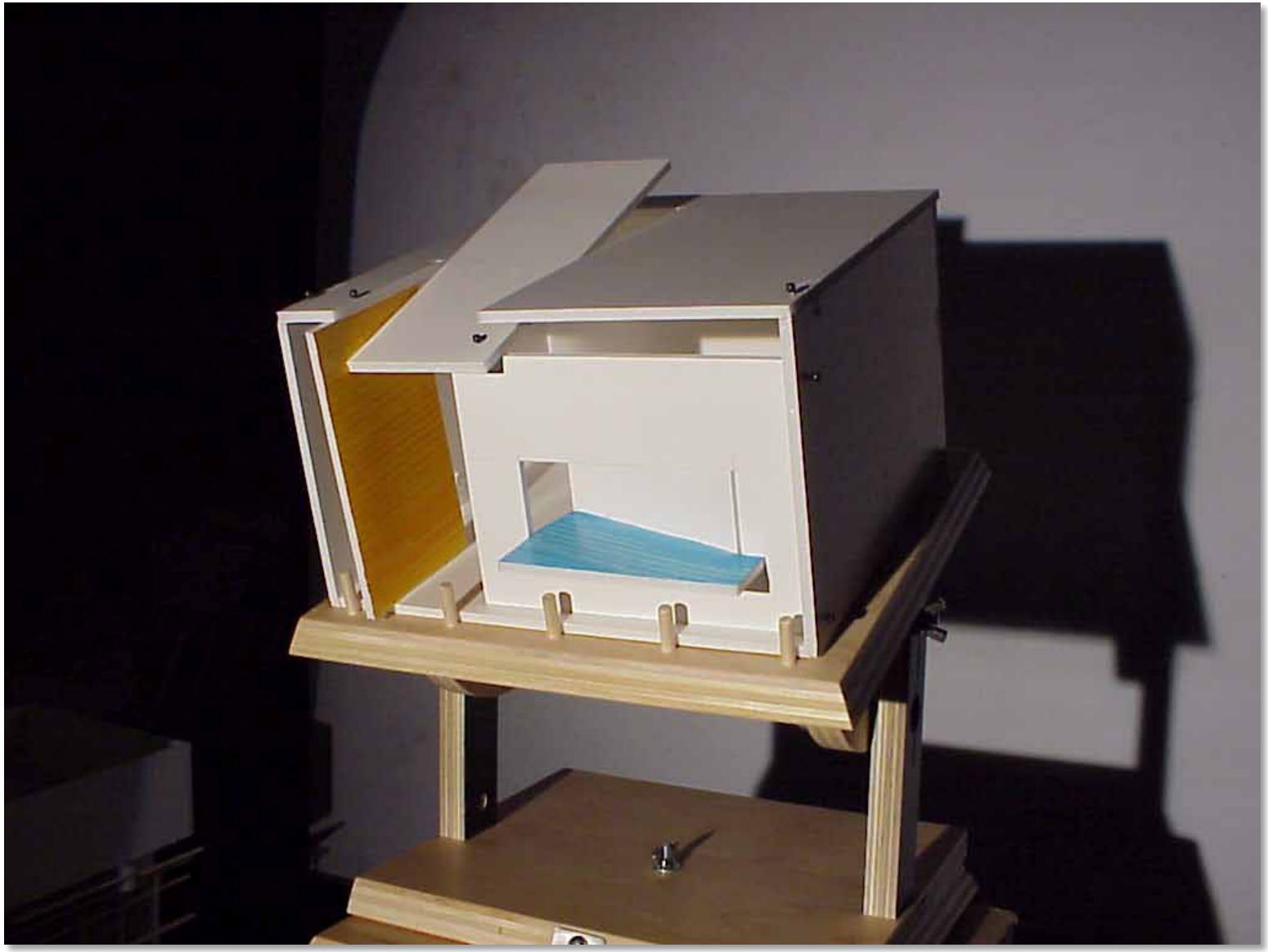
Notice that March 21 and Sept 21 are identical

43° N

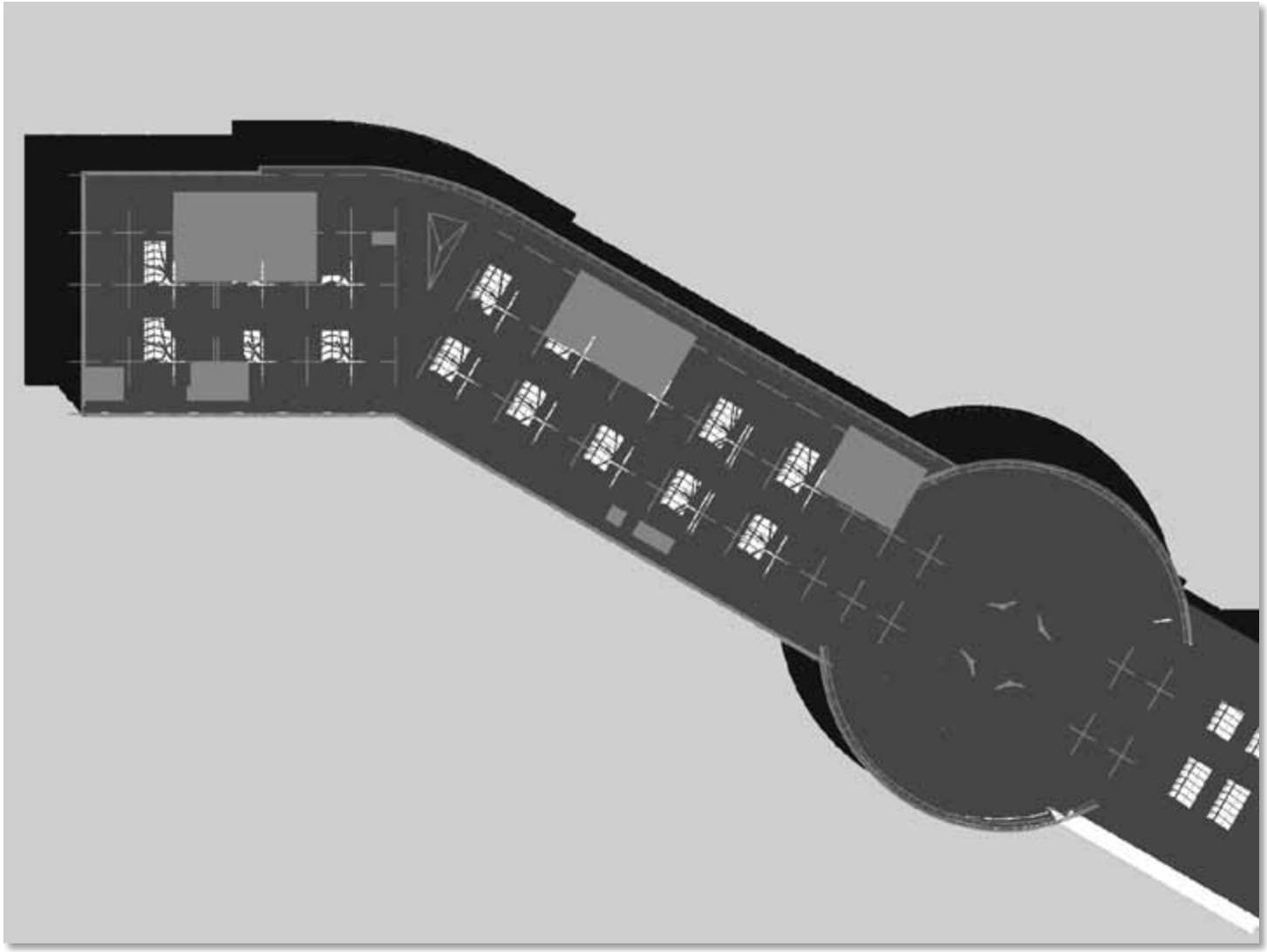
SEPT. 21

SHADOW LENGTH = HEIGHT x COEF. HEIGHT = SHADOW LENGTH ÷ COEF.

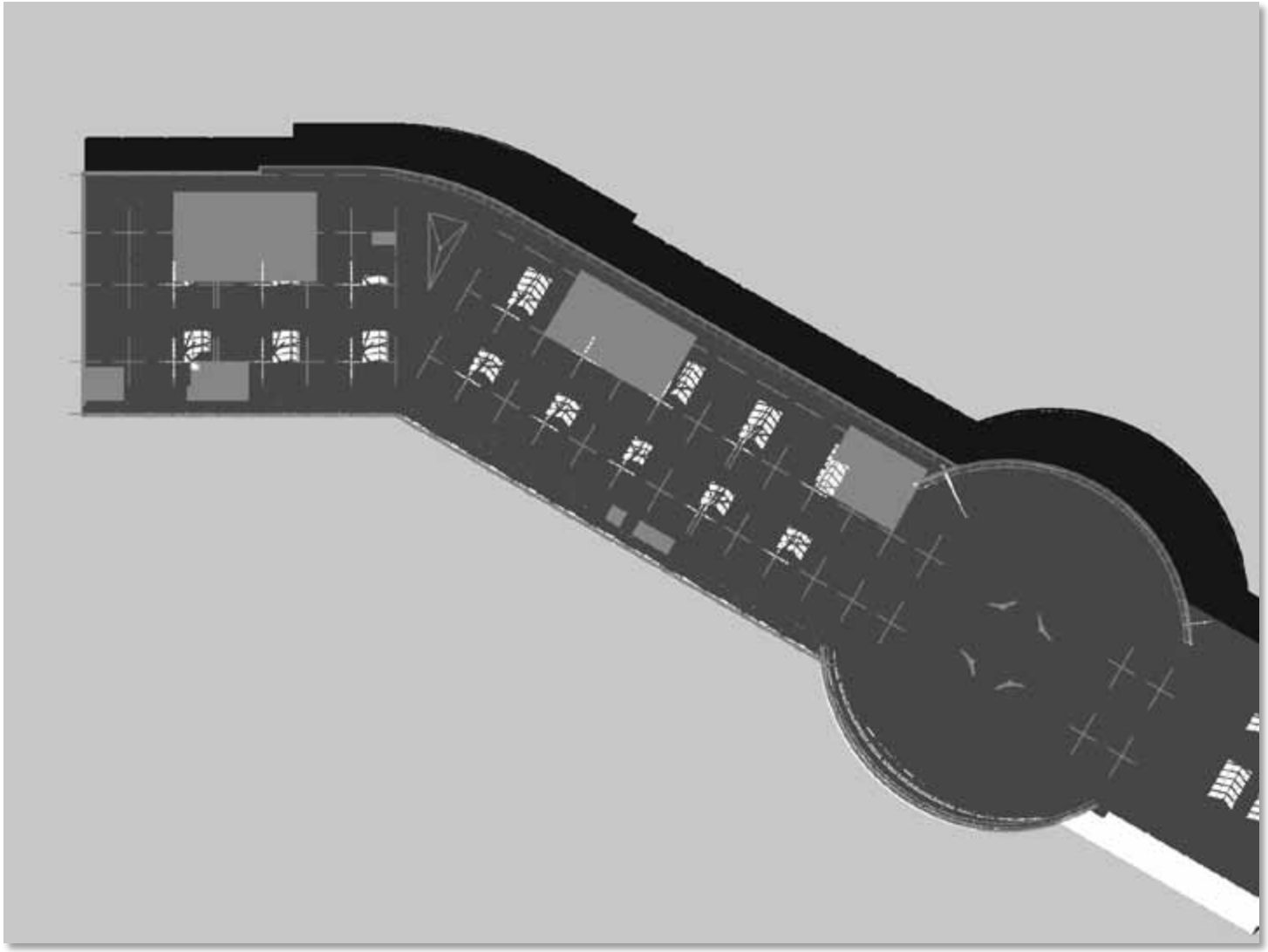
Modelling with a Heliodon…



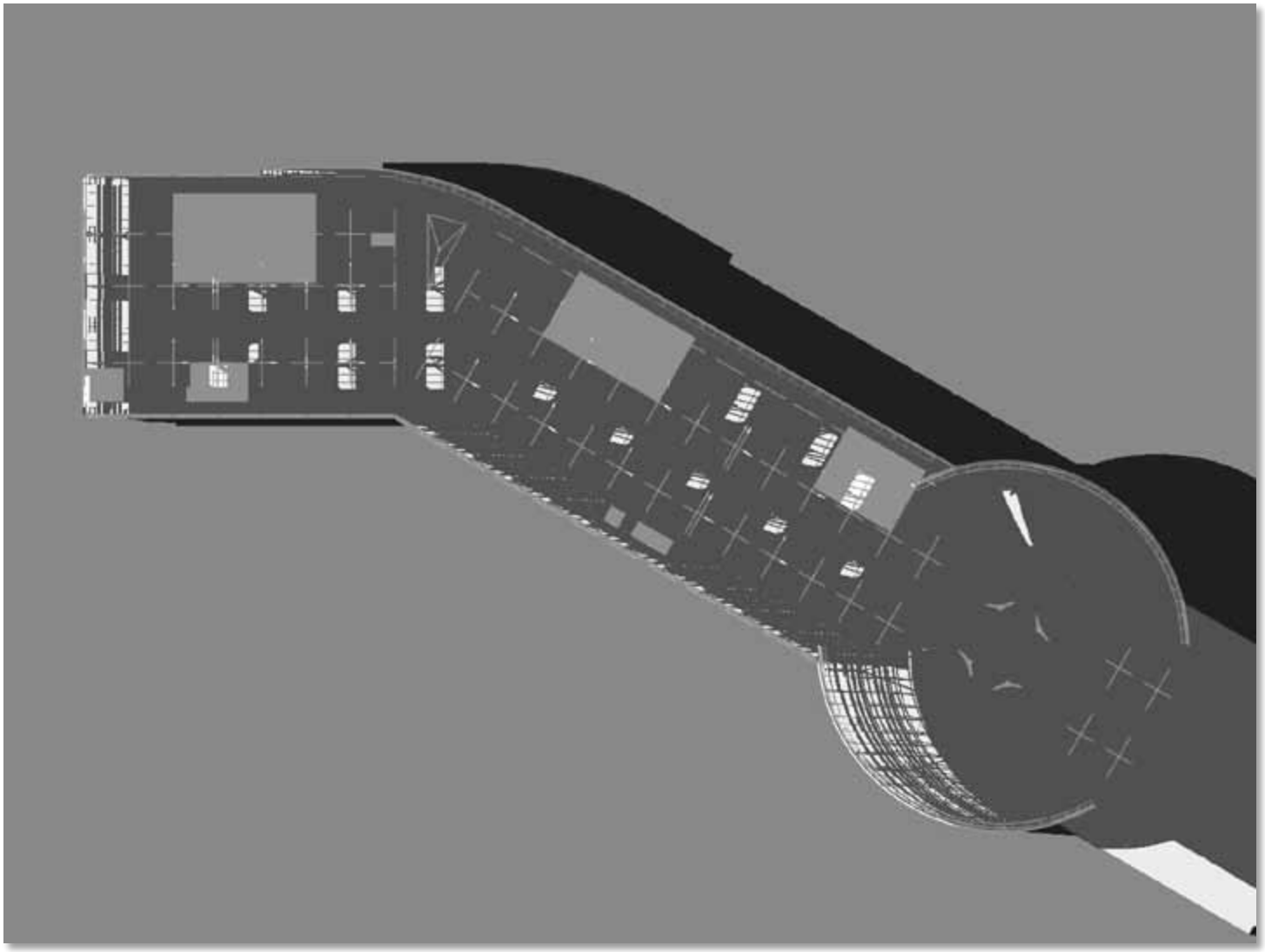
Vancouver Airport Authority: summer solstice noon



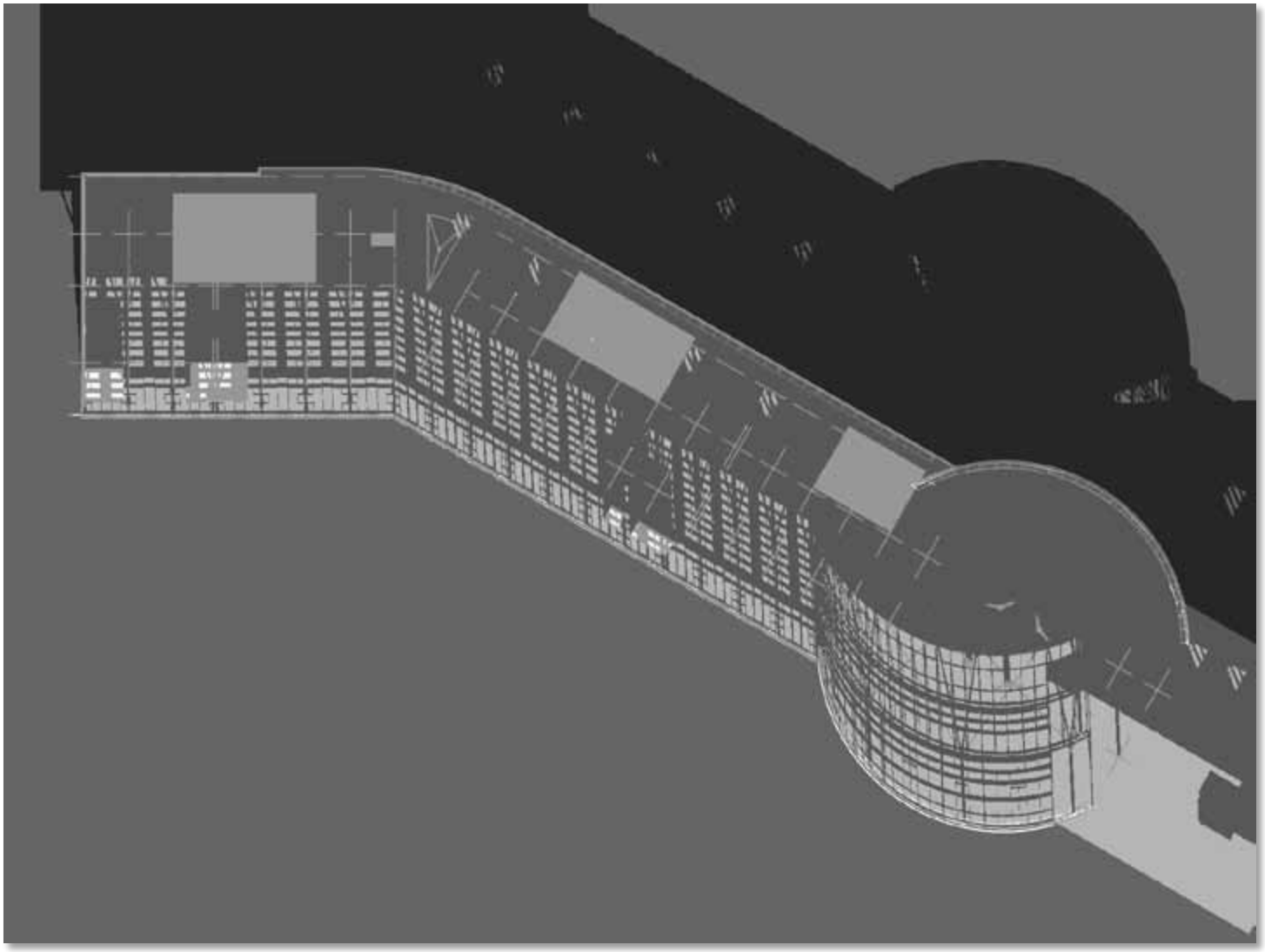
YVR: summer solstice 3pm



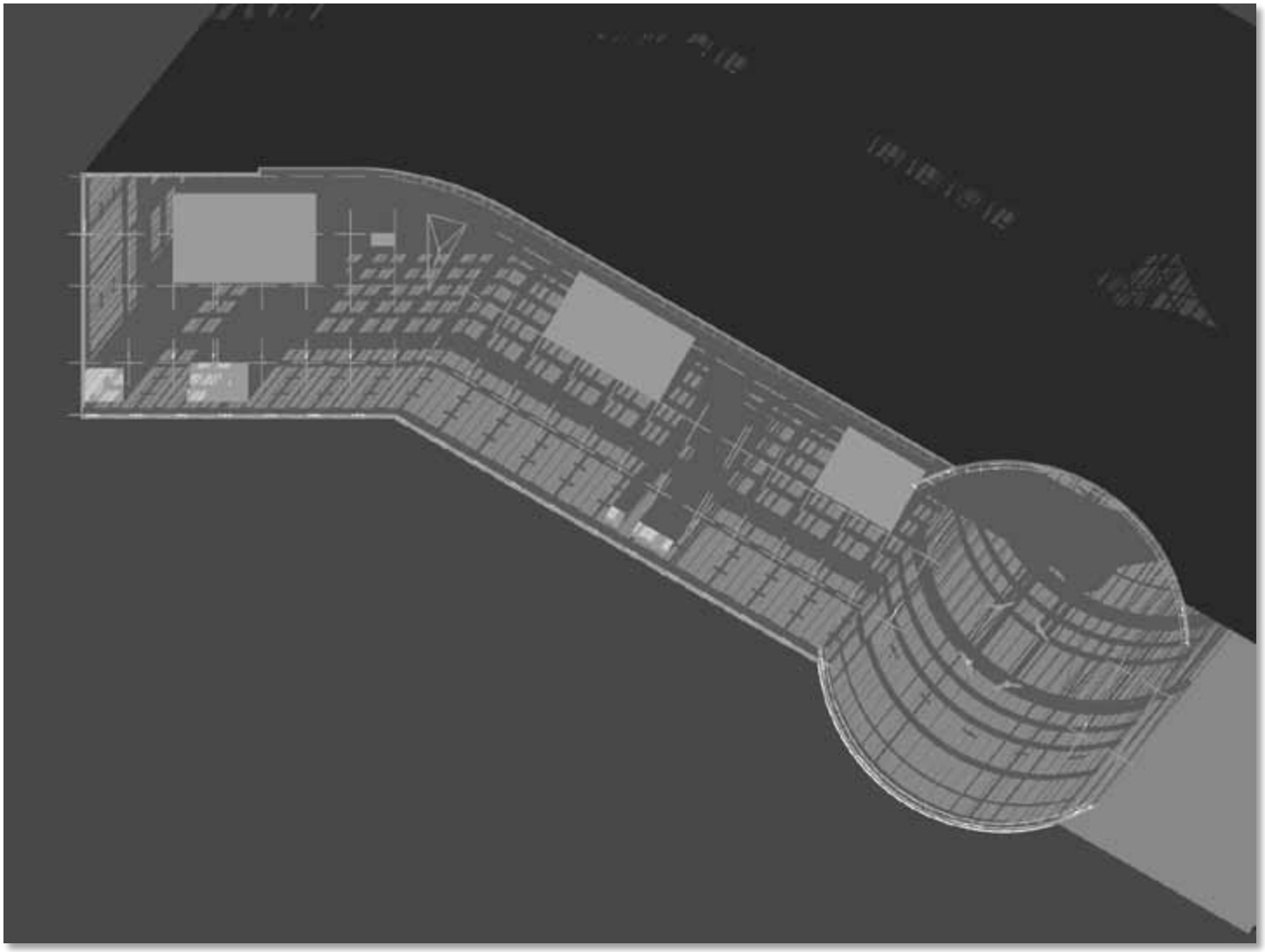
YVR: summer solstice 6 pm



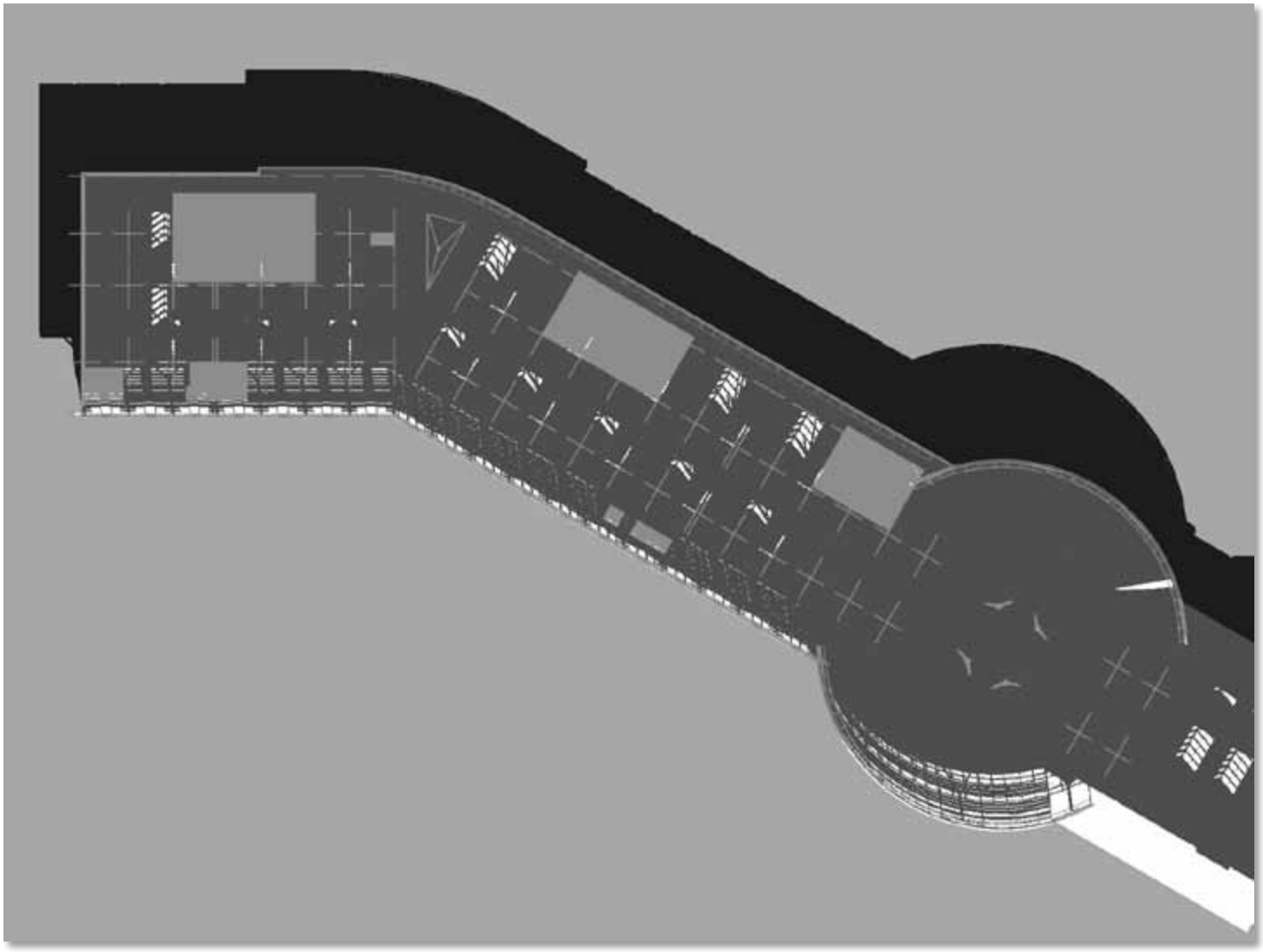
YVR: winter solstice noon



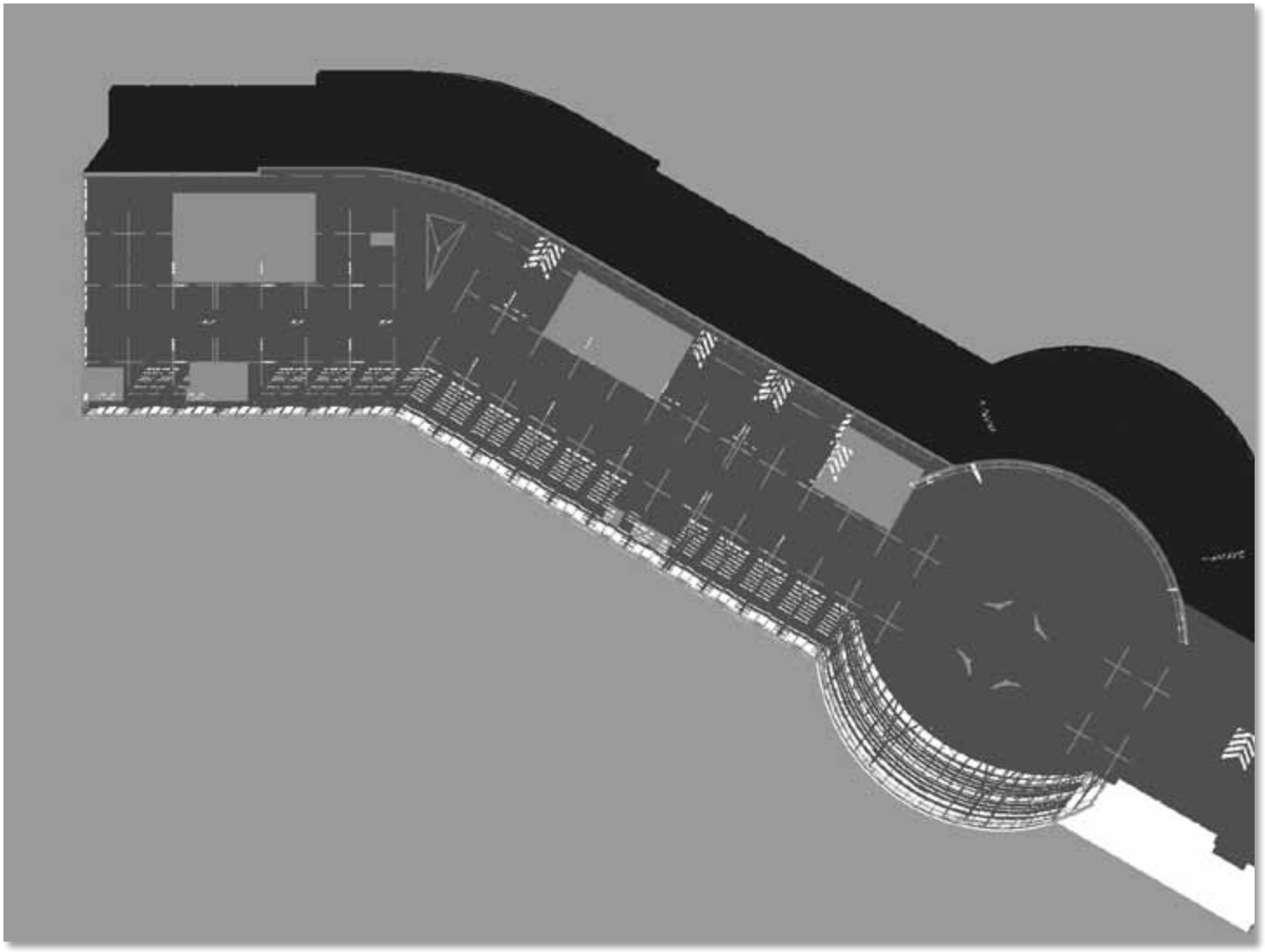
YVR: winter solstice 3 pm



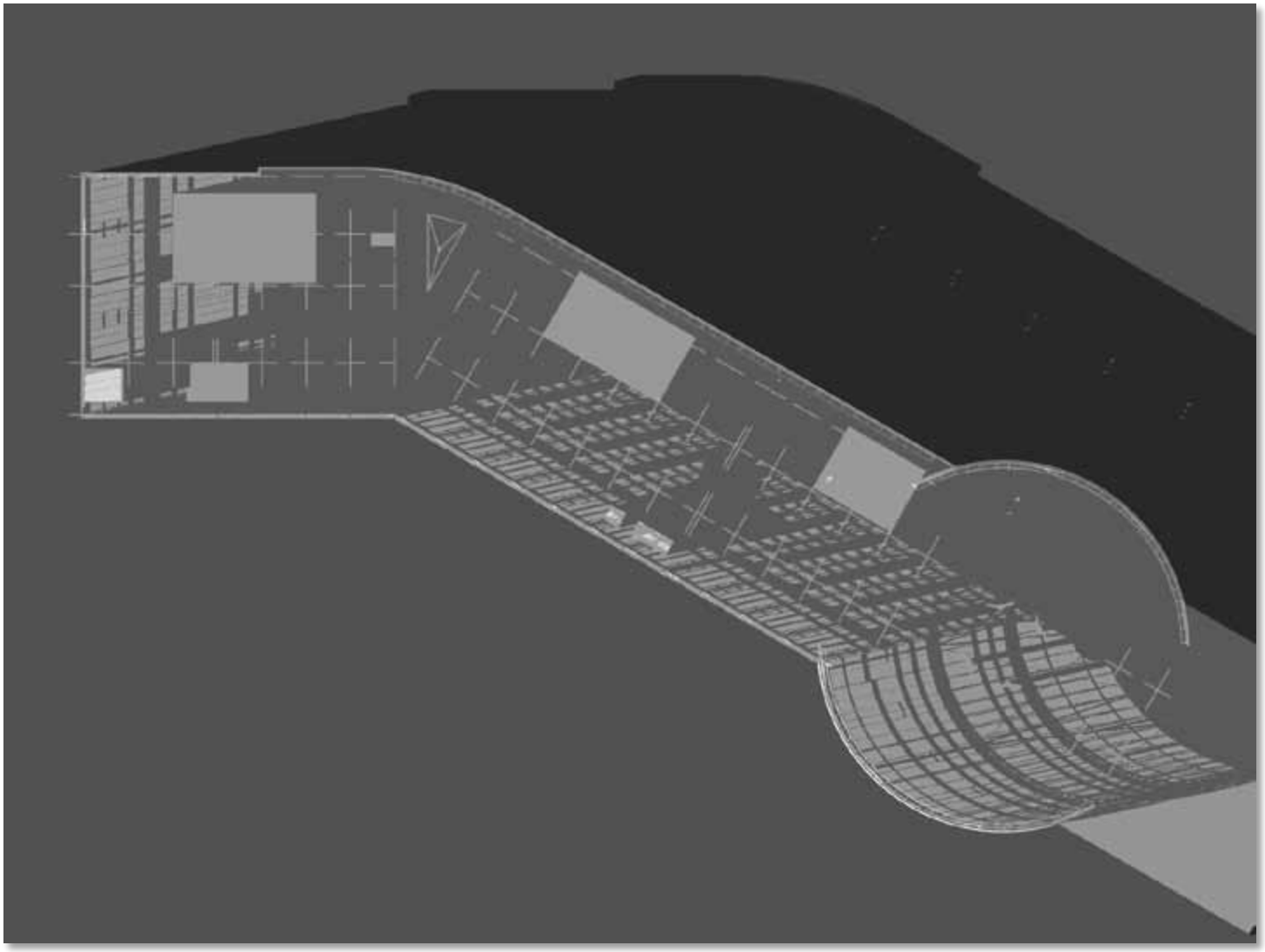
YVR: spring/fall equinox noon

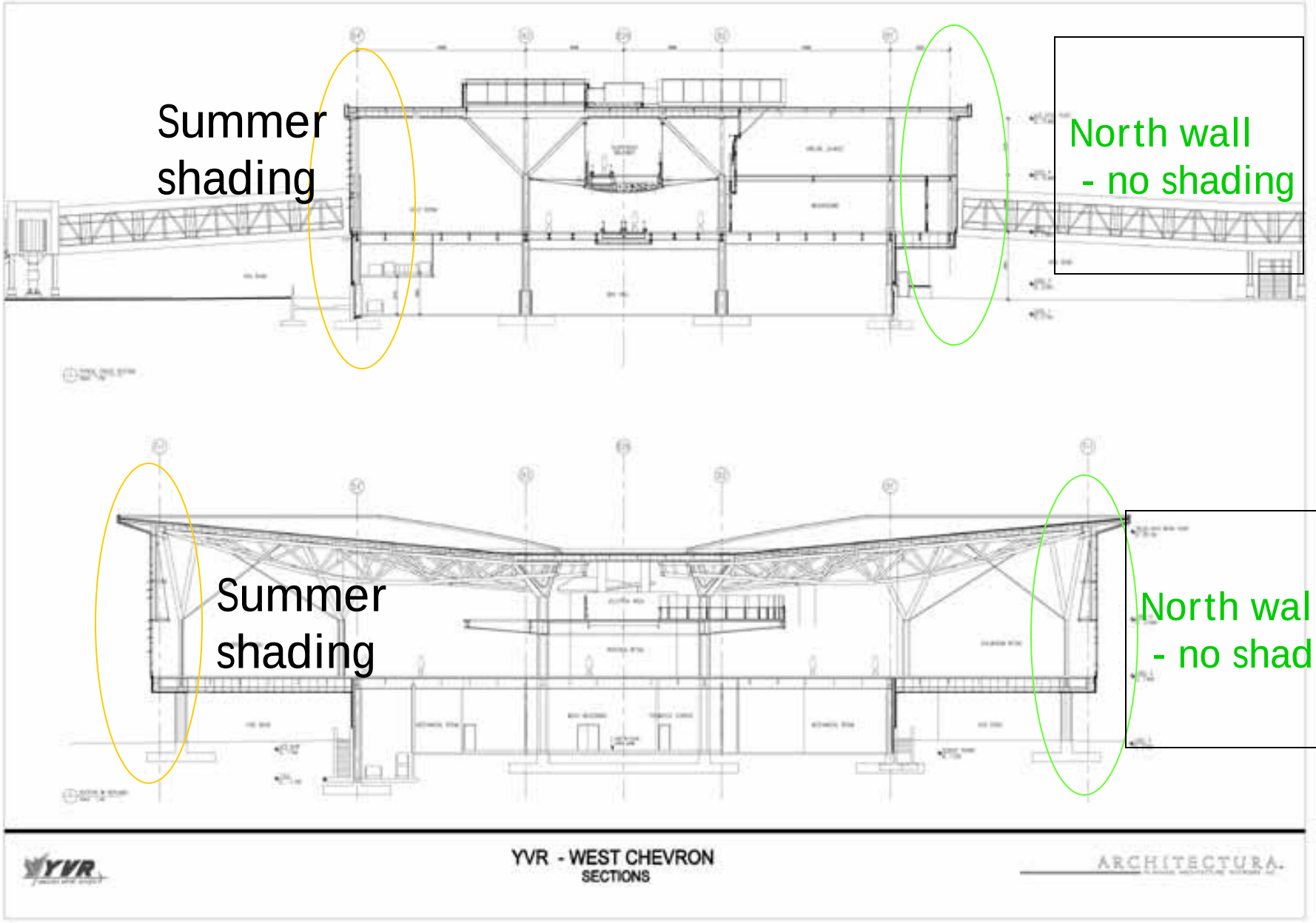


YVR: spring/fall equinox
3 pm



YVR: spring/fall equinox
6 pm




Summer shading
North wall - no shading
Summer shading
North wall - no shading
YVR - WEST CHEVRON
SECTIONS
ARCHITECTURA

Exterior shading devices (horizontal fins) are proposed for the south side of the terminal wall to cut down on solar gain in the highly glazed space during the summer months. Solar gain is still permitted during the winter.