UNIT 3

BUILDING ENVELOPE

General, Mandatory requirements - Fenestration - Opaque construction - building envelope sealing, Prescriptive requirements - Roofs - cool roofs - opaque walls - vertical fenestration - skylights.

GENERAL, MANDATORY REQUIREMENTS

BUILDING ENVELOPE

- ✓ Building envelope refers to the exterior façade, and is comprised of opaque components and fenestration systems.
- ✓ Opaque components include walls, roofs, slabs on grade and opaque doors.
- ✓ Fenestration systems include windows, skylights, ventilators and floors that are more than one-half glazed.

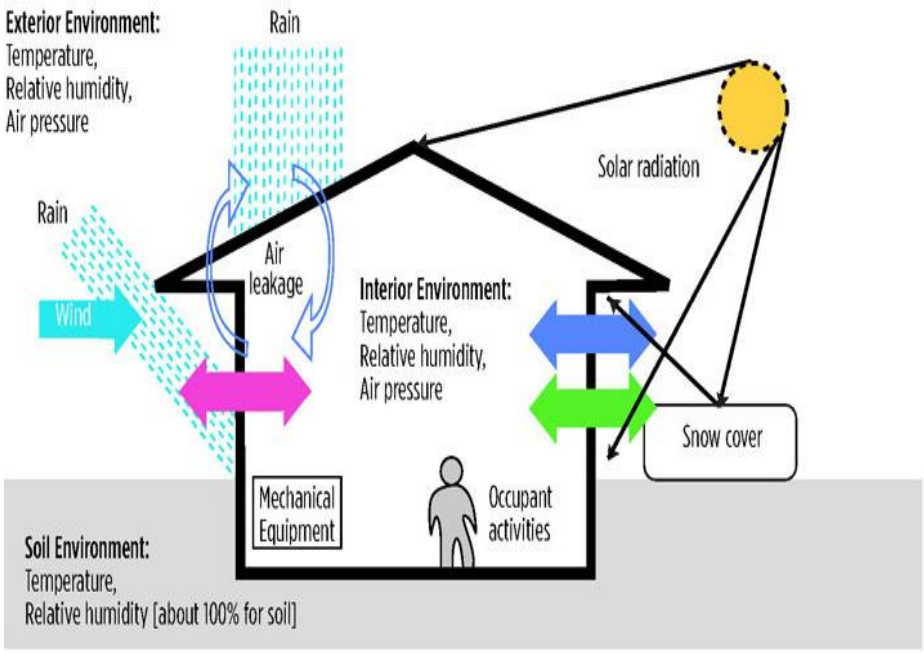


Figure 2 Environmental loads of building envelope

Load: Vapour pressure difference Load: Air pressure difference Load: Temperature difference

MANDATORY REQUIREMNTS OF BUILDING ENVELOPE

(A)Fenestration

- U – factor
- SHGC
- Air leakage

(B) Opaque construction

(C) Building envelope sealing

FENESTRATION

Definition

- The arrangement, proportioning, and design of windows and doors in a building
- An opening in a surface (as a wall or membrane)
- The operation of cutting an opening in the bony labyrinth between the inner ear and tympanum to replace natural fenestrae that is not functional

Introduction to fenestration

Majority of heat transfer in the tropics is through thermal radiation

Solar radiation incident on building apertures is in the form of

- Beam
- Diffused (i.e. skylight)
- Reflected radiation

Visible light is a component of solar radiation

The national building code of 1983 requires habitable rooms to have one or more windows or skylights, not otherwise provided with light and ventilation.

Size of apertures

The building code further requires the combined area of a room's skylights and windows to be no less than 10% of its floor area, at least half of which should be operable to facilitate ventilation.

Apertures should be uniformly distributed throughout a room for good daylighting,

- ✓ Skylights provide more uniform lighting than windows.
- ✓ Locating windows as high as possible within a room improves distribution

In the humid tropics, solar heat-gain (SHG) increases as apertures get larger, even if natural lighting is used to supplement electric lighting.

Typical glazing characteristics

The transmission, absorption and reflection of solar radiation by glass depends on

- The angle of the beam
- Thickness
- Refractive index
- Absorption/extinction coefficient (K) of the glass

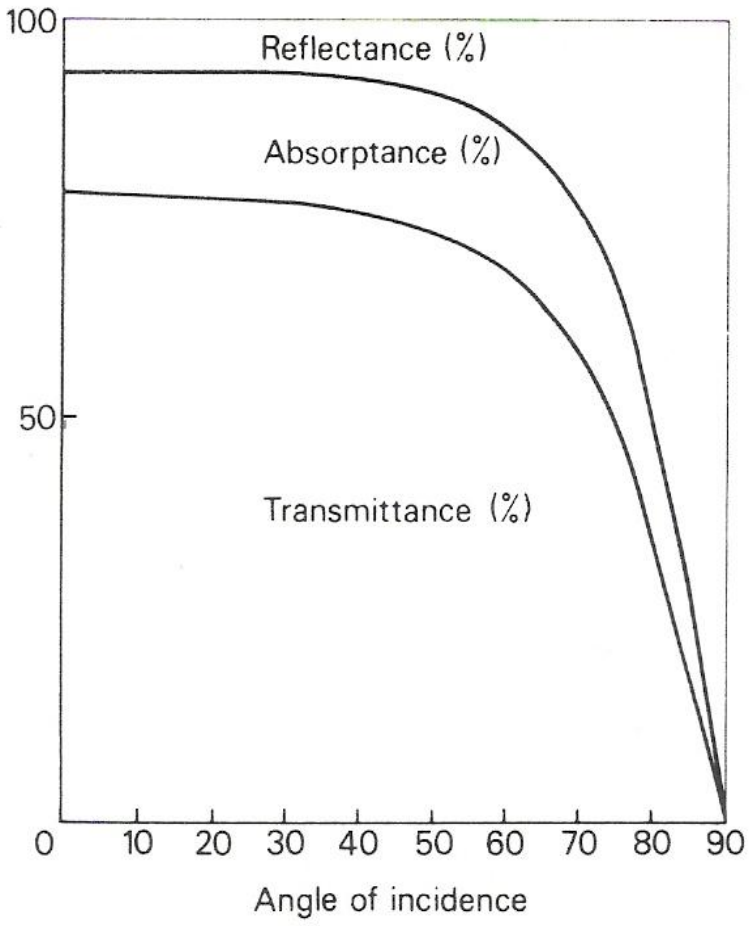


Fig. 1. T, A, R characteristics for 4-6 mm clear glass: KL = 0.16, μ = 1.52.

Figure: Glazing Characteristics of Clear Glass

Special glazing

Double glazing is not cost – effective in the humid tropics

Solar control glasses are classified as

- ✓ Heat-absorbing
- ✓ Heat -reflecting
- ✓ Heat- reflecting polyester film over clear glass
- ✓ Photo- chromatic glasses

Glazing which transmits more heat than light should be avoided in the tropic

TABLE: SOLAR OPTICAL PROPERTIES AND HEAT – TO – LIGHT RATIOS OF DIFFERENT GLASSES.

Solar optical properties and heat:light ratios of different types of glasses

Type of glass	Solar optical properties			Total solar heat gain (%)	Daylight transmission (%)	Heat:light ratio
	reflectance (%)	absorptance (%)	transmittance (%)			
Clear glass						
3-mm sheet glass	7	8	85	87	90	0·97
6-mm float glass	8	12	80	84	87	0·96
6-mm wired glass	6	31	63	71	85	0·83
Coloured pattern glass						
3-mm green	6	55	39	56	49	1·14
3-mm blue	6	32	62	72	31	2·32
3-mm amber	6	40	52	66	58	1·14
Heat-absorbing glass						
6-mm grey glass	5	51	44	60	41	1·46
6-mm blue–green glass	5	75	20	43	48	0·85
6-mm green	6	49	45	60	75	0·80
6-mm bronze glass	5	51	44	60	50	1·20
6-mm spectral float glass (bronze)	10	34	56	66	49	1·35
Heat-reflecting glass (laminated; 6-mm gold-coated glass)						
heavy-density coating	47	42	11	25	20	1·25
medium-density coating	33	42	25	41	38	1·08
light-density coating	21	43	36	53	63	0·84

Shading

Operable shading is more effective than fixed shading, if used to reduce glare and intense solar radiation.

Shading is more efficient when located outdoors

Large overhangs reduce indoor lighting levels, through lighting levels are more uniform.

The size and configuration of shading devices should be determined with use of sun charts.

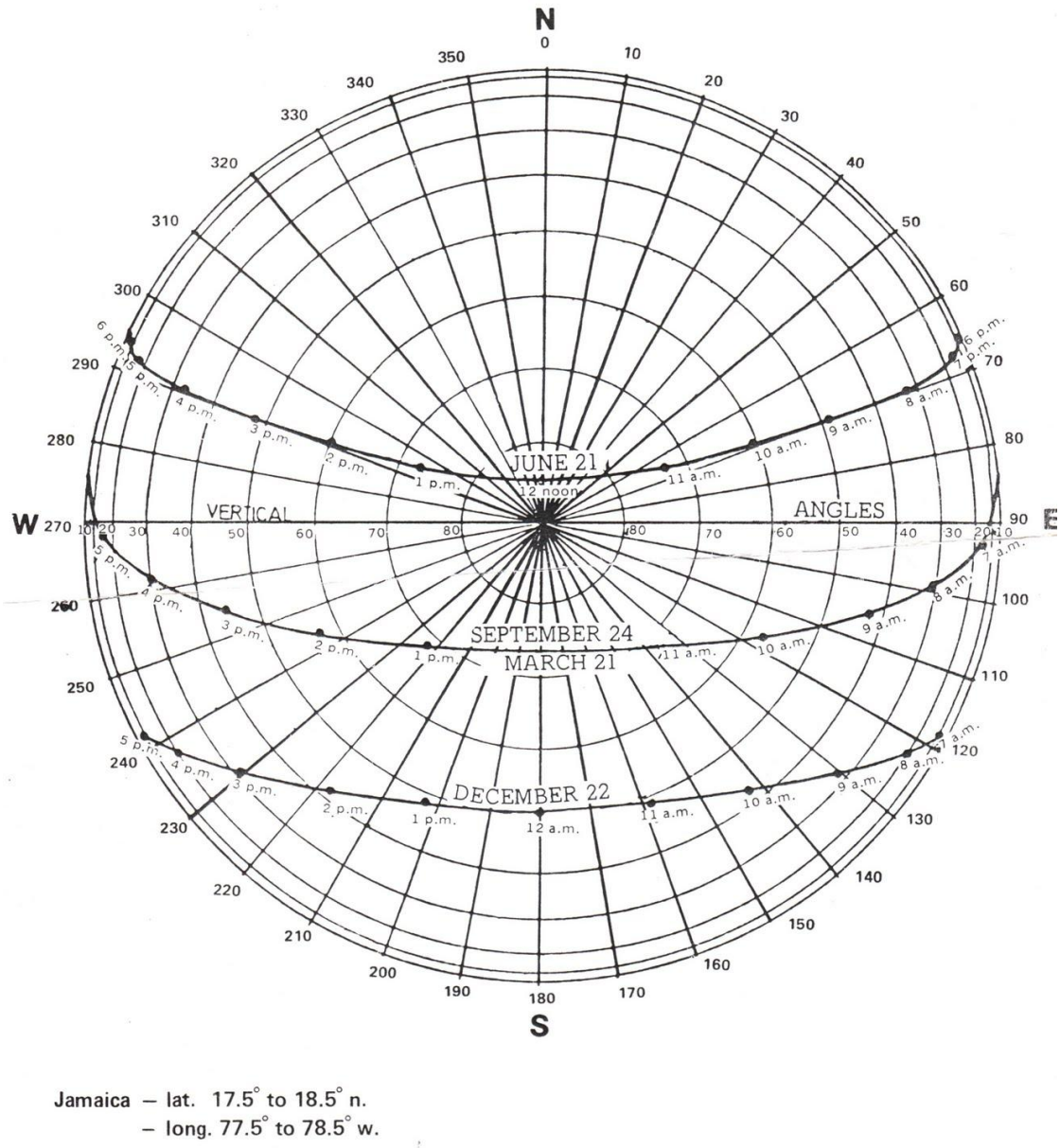


Figure: Sunchart of Jamaica

Shading masks are two dimensional representation of shading available from a shading device or adjacent structures.

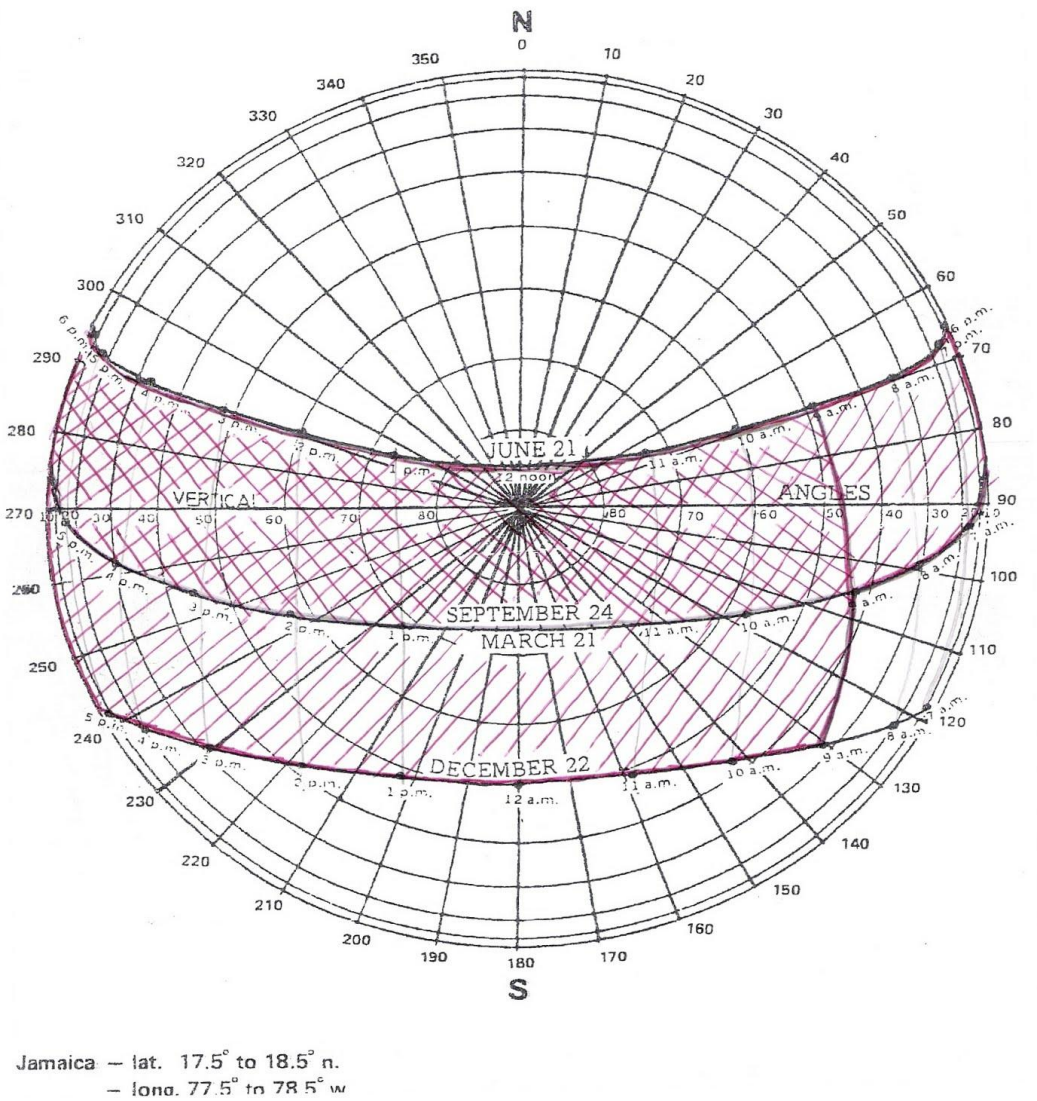


Figure: Sunchart of Jamaica with overlay showing need for (A) 50% and (B) 100 % shading

Shading devices can be categorized as

- ✓ overhangs
- ✓ Fins
- ✓ Baffles
- ✓ Combinations of two or more

Shading devices do not have to be monolithic.

OPAQUE CONSTRUCTION

BUILDING ENVELOPE SEALING

Air sealing

- Air will leak through a building envelope that is not well sealed

Leakage of air (causes)

- Decreases the comfort of a residence by allowing moisture, cold drafts, and unwanted noise to enter lower indoor air quality by allowing in dust air borne pollutants.
- 25% to 40% of the energy used for heating and cooling in a typical residence

Amount of air leakage

Depends on two factors

1. Number and size of air leakage paths through the building envelope
2. Difference in air pressure between the inside and outside
    - Wind
    - Indoor
    - Outdoor temperature differences (stack effect)
    - Chimney and flue exhaust fans
    - Equipments with exhaust fans (dryers, central vacuums etc)
    - Ventilation fans (bath, kitchen etc)

To prevent air leakage

Best to seal the building envelope during construction prior to installation of the dry well

Test: a “blower door” test (good way of to identify air leakage paths)

Materials used: caulks, foams, weather stripping, gaskets, door sweeps.

Advantages

- Improved comfort
- Improved indoor air quality
- Increased construction quality
- Lower energy bills
- Fewer condensation problems
- Reduced obsolescence

PRESCRIPTIVE REQUIREMENTS

1. Exterior roofs and ceilings
    - ✓ Insulation
    - ✓ Substantial contact
    - ✓ Insulation above suspended ceilings
    - ✓ Insulation protection
2. Cool roofs
    - ✓ Reflectance
    - ✓ Absorptance
    - ✓ Emissivity
3. Opaque walls
4. Vertical fenestration
5. Skylights

ROOFS

A roof is part of a building envelope.

It is the covering on the uppermost part of a building or shelter which provides protection from animals and weather, notably rain or snow, but also heat, wind and sunlight.

The word also denotes the framing or structure which supports that covering.

The characteristics of a roof are dependent upon the purpose of the building that it covers the available roofing materials and the local traditions of construction and wider concepts of architectural design and practice and may also be governed by local or national legislation.

In most countries a roof protects primarily against rain.

A verandah may be roofed with material that protects against sunlight but admits the other elements.

The roof of a garden conservatory protects plants from cold, wind, and rain, but admits light.

A roof may also provide additional living space, for example a roof garden

COOL ROOFS

- Roofs are covered with a reflective coating that has a high emissivity property that is very effective in reflecting the sun's energy away from the roof surface.
- These "cool roofs" are known to stay 10 C to 16 C cooler than a normal roof under a hot summer sun.
- This quality greatly reduces heat gain inside the building and the needs to be met by HVAC system
- A cool roof reflects and emits the sun's heat back to the sky instead of transferring it to the building below.
- "Coolness" is measured by two properties, solar reflectance and thermal emittance.
- Both properties are measured from 0 to 1 and the higher the value, the "cooler" the roof

BENEFITS OF COOL ROOFS INCLUDE:

- Energy savings and global warming mitigation
- Reduction in urban heat island effect and smog
- Improved occupant comfort
- Comply with codes and green building programs

OPAQUE WALLS

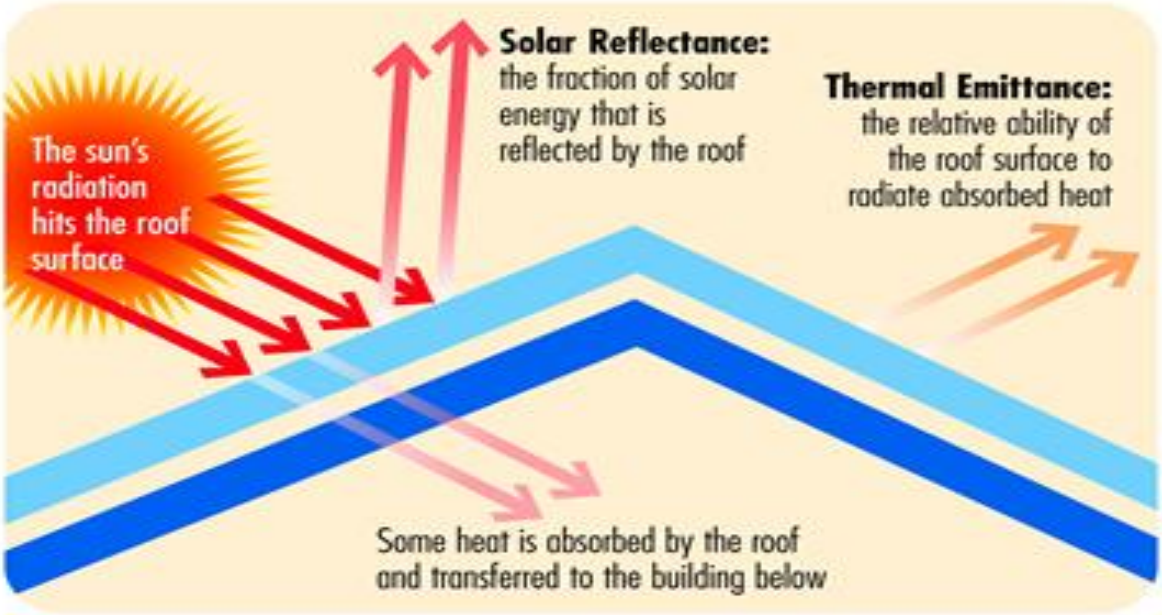
Defined as all other constructions by their individual material layers and the thermo physical properties (eventual from standard libraries) of the material-layers.

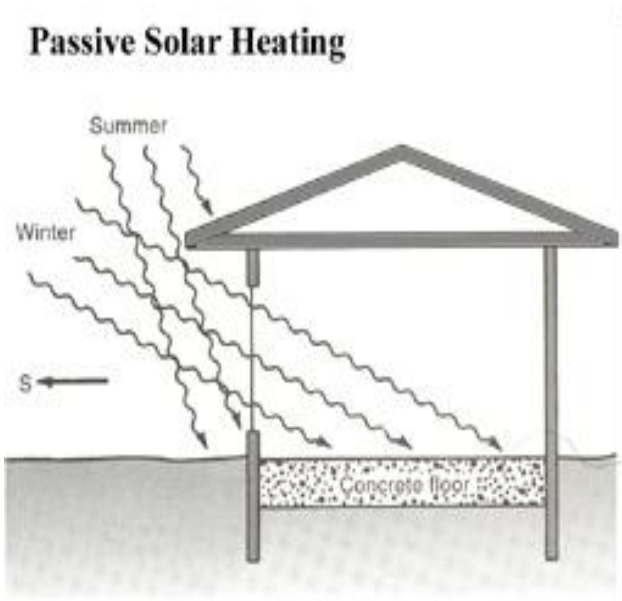
VERTICAL FENESTRATION

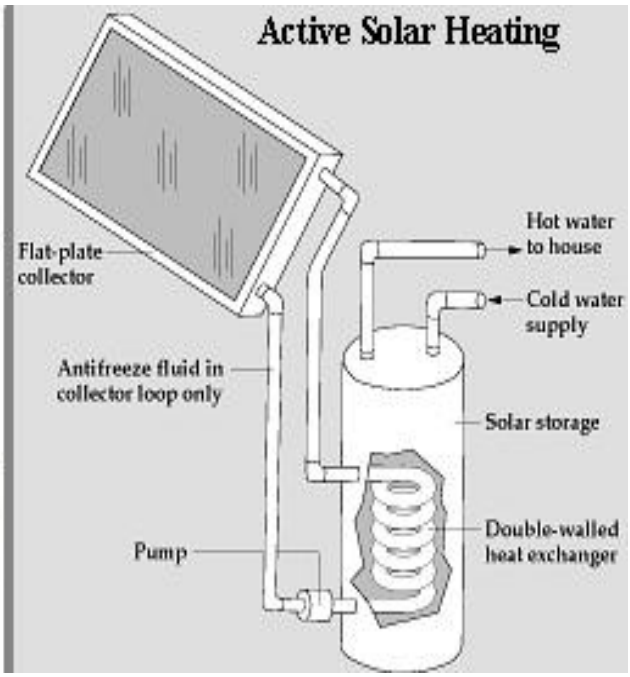
SKYLIGHTS

- Skylights admit harsh direct overhead sunlight and glare either horizontally (a flat roof) or pitched at the same angle as the roof slope.
- In some cases, horizontal skylights are used with reflectors to increase the intensity of solar radiation (and harsh glare), depending on the roof angle of incidence.
- When the winter sun is low on the horizon, most solar radiation reflects off of roof angled glass (the angle of incidence is nearly parallel to roof-angled glass morning and afternoon).
- When the summer sun is high, it is nearly perpendicular to roof-angled glass, which maximizes solar gain at the wrong time of year, and acts like a solar furnace.
- Skylights should be covered and well-insulated to reduce natural convection (warm air rising) heat loss on cold winter nights, and intense solar heat gain during hot spring/summer/fall days
- The equator-facing side of a building is south in the northern hemisphere, and north in the southern hemisphere.
- Skylights on roofs that face away from the equator provide mostly-indirect illumination, except for summer days when the sun rises on the non-equator side of the building (depending on latitude).
- Skylights on east-facing roofs provide maximum direct light and solar heat gain in the summer morning.
- West-facing skylights provide afternoon sunlight and heat gain during the hottest part of the day.
- Some skylights have expensive glazing that partially reduces summer solar heat gain, while still allowing some visible light transmission. However, if visible light can pass through it, so can some radiant heat gain (they are both electromagnetic radiation waves.
- Partially reduce some of the unwanted roof-angled-glazing summer solar heat gain by installing a skylight in the shade of deciduous (leaf-shedding) trees, or by adding a movable insulated opaque window covering on the inside or outside of the skylight.

- This would eliminate the daylight benefit in the summer. If tree limbs hang over a roof, they will increase problems with leaves in rain gutters, possibly because roof-damaging ice dams, shorten roof life, and provide an easier path for pests to enter your attic.
- Leaves and twigs on skylights are unappealing, difficult to clean, and can increase the glazing breakage risk in wind storms.
- "Saw tooth roof glazing" with vertical-glass-only can bring some of the passive solar building design benefits into the core of a commercial or industrial building, without the need for any roof-angled glass or skylights.
- Skylights provide daylight. The only view they provide is essentially straight up in most applications. Well-insulated light tubes can bring daylight into northern rooms, without using a skylight. A passive-solar greenhouse provides abundant daylight for the equator-side of the building.
- Infrared thermography color thermal imaging cameras (used in formal energy audits) can quickly document the negative thermal impact of roof-angled glass or a skylight on a cold winter night or hot summer day.




Passive Solar Heating
Summer
Winter
S
Concrete floor


Active Solar Heating
Flat-plate collector
Hot water to house
Cold water supply
Antifreeze fluid in collector loop only
Solar storage
Pump
Double-walled heat exchanger