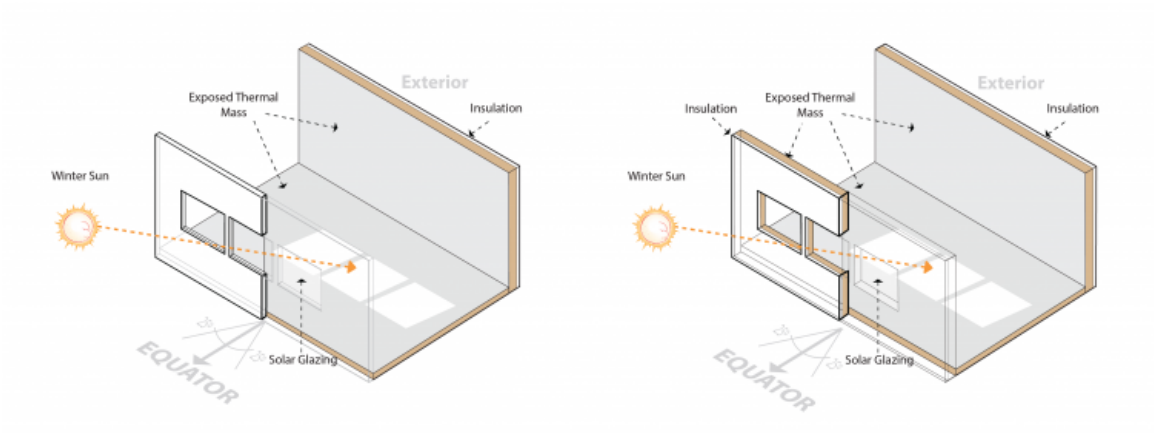
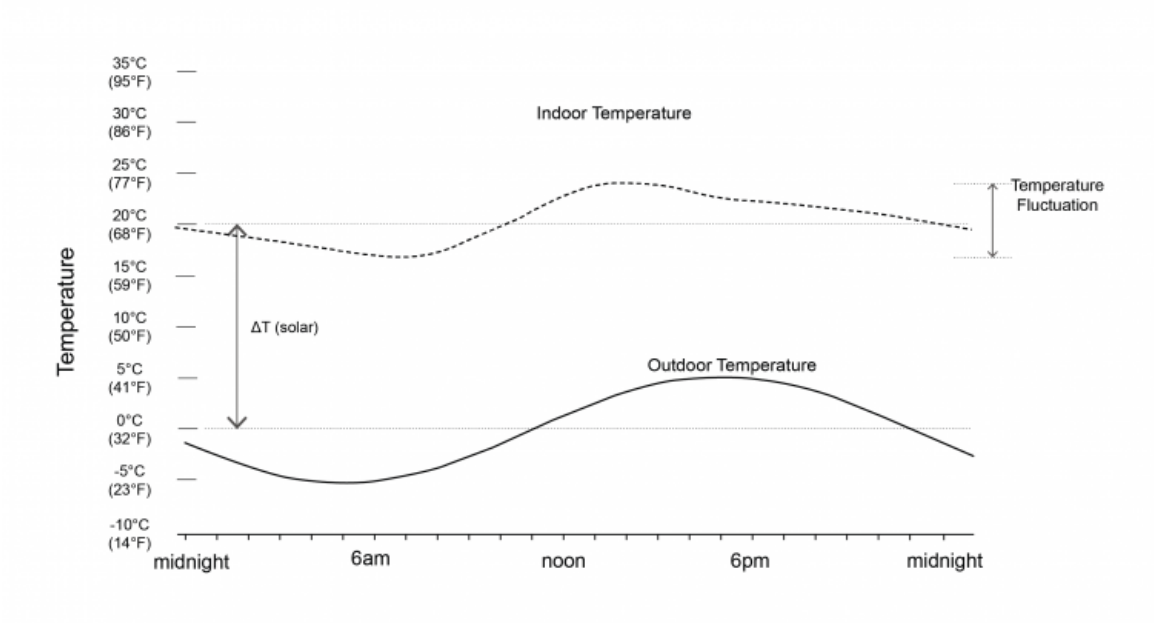
Masonry Thermal Mass

A Direct Gain passive heating system integrates the components of the system, solar glazing (solar collection) and thermal mass (heat storage medium), directly into a building. The most important factor in collecting the sun's energy is the placement and size of glazed openings (see Direct Gain: Glazing). The most important factor in determining indoor temperature fluctuations is thermal mass.



Masonry Thermal Mass and Indoor Temperatures

In a Direct Gain heated building, the amount of sunlight, or solar energy, admitted into a space through solar glazing – windows, skylights, and/or clerestories – in winter, will determine the average temperature in that space over the day. This is referred to as the ΔT (solar), or average indoor temperature increase above the average outdoor temperature. A large portion of this energy must be stored in the thermal mass of a space – usually masonry walls, floors, and/or ceilings – for release for heating at night. The amount, location, thickness and surface area of thermal mass will determine the temperature fluctuation in a space over the day.



In winter, approximately 65% of a buildings heat loss will occur at night; 35% will occur during the daytime. If solar glazing is sized to admit enough sunlight on a clear winter day to heat a space for a 24-hour period (the entire day), then a large portion of this energy must be stored during the daytime and then released back to the space at night. If only a small portion of this energy is stored, then an abundance of heat is available during the day and not enough at night. This condition results in daytime overheating and low nighttime space temperatures, or high temperature fluctuations.

Location, Thickness and Distribution of Masonry Thermal Mass

The relationship between the area of solar glazing, and surface area and thickness of thermal mass, determine temperature fluctuations in a space over a day. Since masonry materials transfer heat slowly from their surface into the material, enough surface area of thermal mass must be located in a space and distributed over a large area to absorb and store daytime solar heat gain. To maintain temperature fluctuations in a space within acceptable levels:

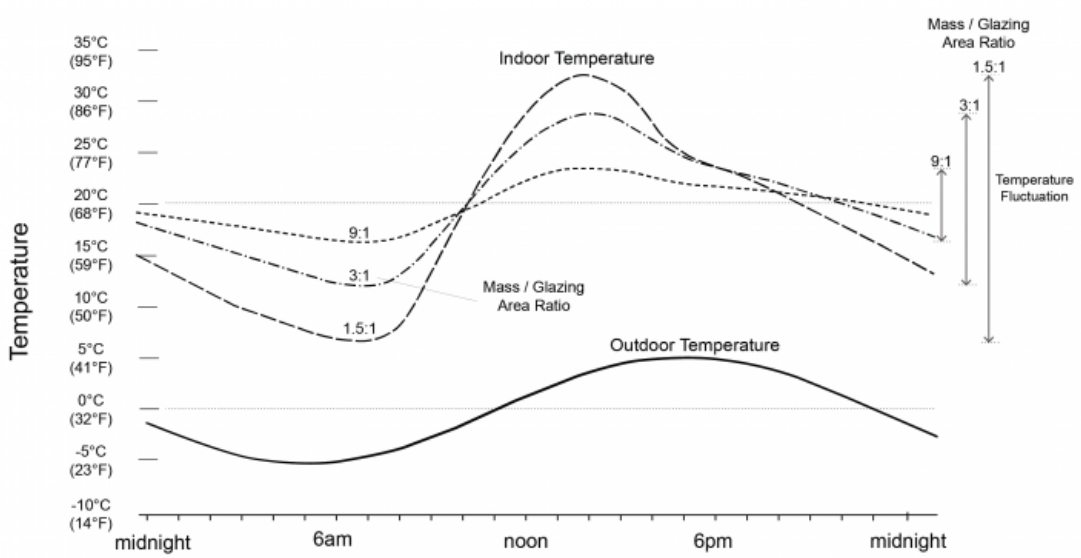
- make interior masonry a minimum of 4 inches in thickness (walls and/or floor and/or ceiling),
- with a minimum masonry surface area to solar glazing area of 3:1; the optimum is 9:1 or greater.

The higher the ratio of thermal mass surface area to solar glazing area (mass/glazing area ratio), the more stable interior space temperatures will be. The magnitude of the indoor temperature fluctuation over the day for various ratios of mass surface area to solar glazing area can be approximately calculated as follows:

Mass/Glazing Area Ratio	Formula for Indoor Temperature Fluctuation
1.5 : 1	1.11 x ΔT (solar)
3 : 1	0.74 x ΔT (solar)
9 : 1	0.37 x ΔT (solar)

The higher the ratio of thermal mass surface area to solar glazing area, the more stable interior space temperatures will be. The indoor temperature fluctuation over the day for various ratios of mass surface area to solar glazing area can be approximately calculated from this table. When sizing solar glazing according to the guidelines in Direct Gain: Glazing, the average indoor clear-day winter temperature will be approximately 21°C (70°F), or the ΔT (solar) will be the difference between 21°C (70°F) and the daily average outdoor winter temperature (for the coldest month).

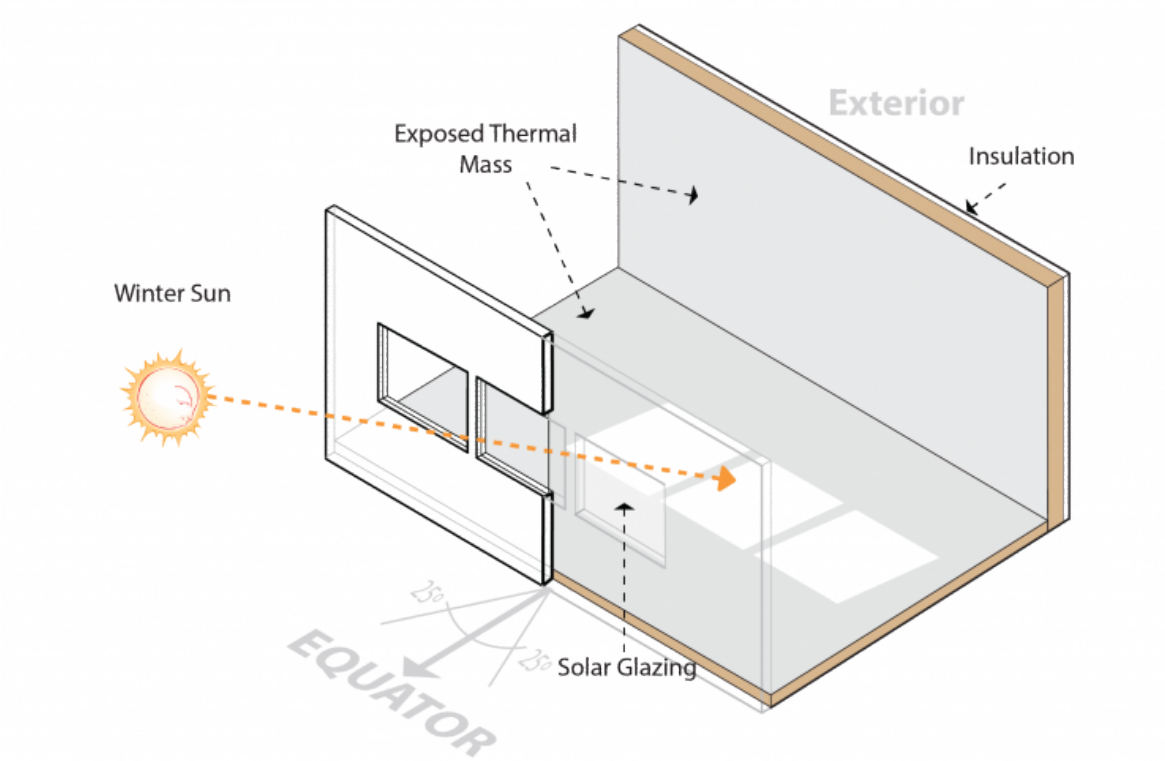
Mass/Glazing Area Ratio Temperature Fluctuation

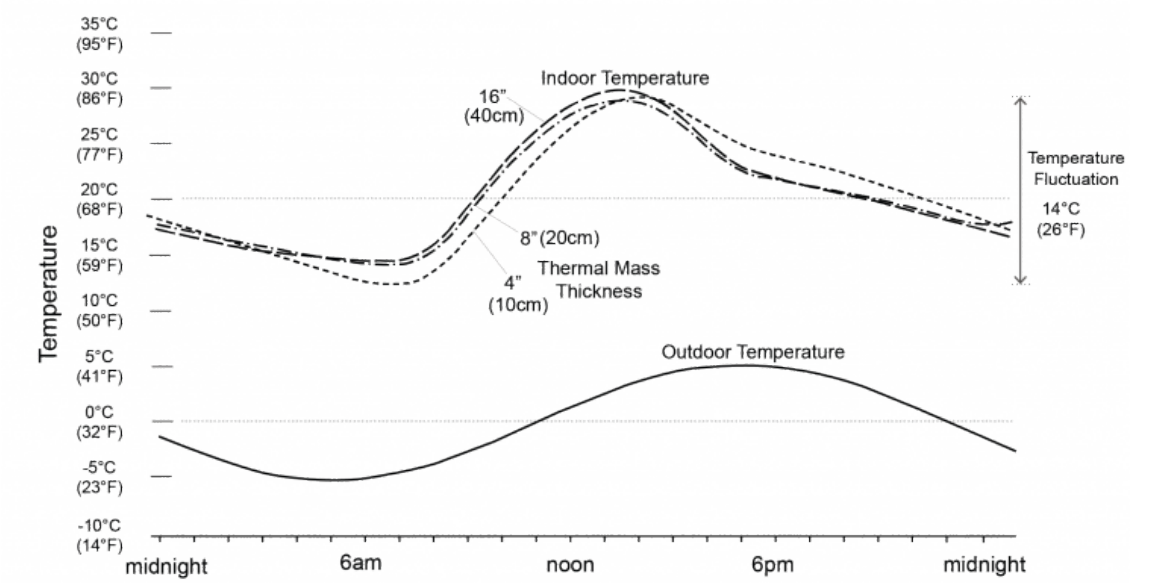


Mass/Glazing Area Ratio of 3:1

for 4" (10cm), 8" (20cm), 16" (40cm) of exposed thermal mass thickness

The surface area of concrete exposed to over the day is 3 times the area of the solar glazing. The illustrations represent a space with glazed openings and light colored interior surfaces and a medium colored thermal mass floor or wall.

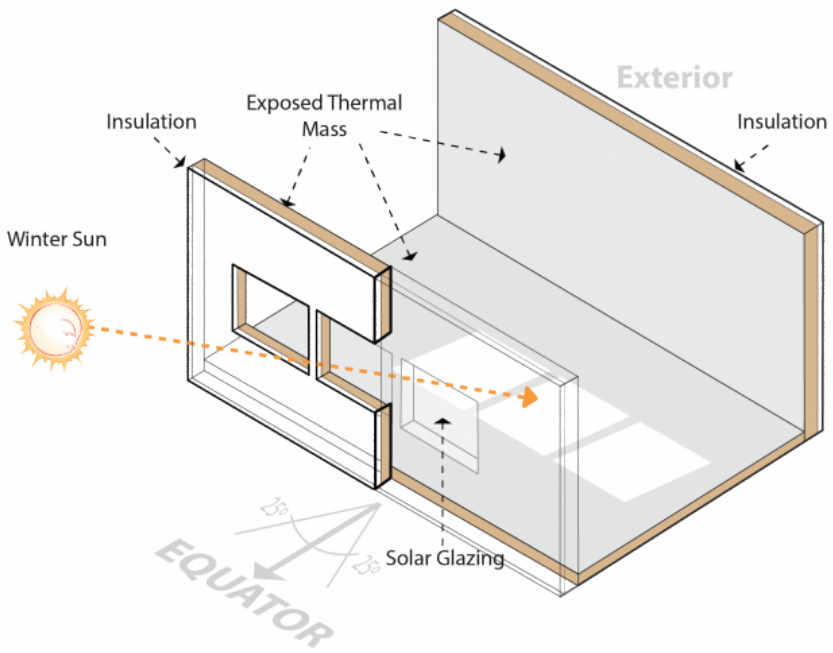


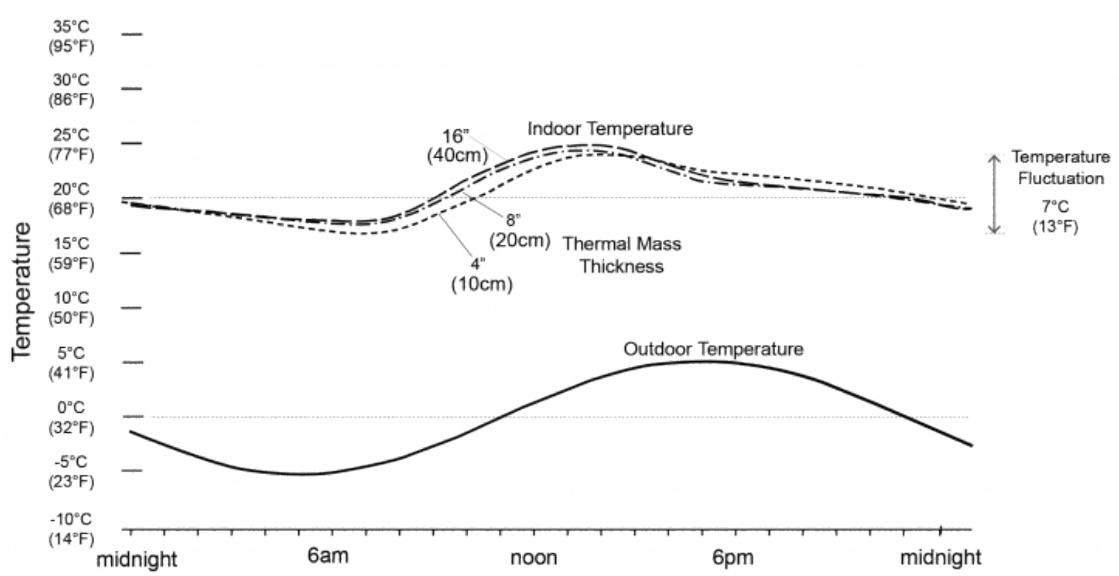


Mass/Glazing Area Ratio of 9:1

for 4" (10cm), 8" (20cm), 16" (40cm) of exposed thermal mass thickness

The surface area of concrete exposed to over the day is 9 times the area of the solar glazing. The illustrations represent a space with glazed openings and masonry walls and floor. The walls are a light color and the floor a medium color.





Insulate on the Outside

While good at storing heat, a masonry wall that also faces the exterior will readily pass this heat to the outside. When using an exterior masonry wall for heat storage, place insulation on the outside face of the wall. This keeps the heat stored in the wall inside the space. Incorporate perimeter insulation along the edge of all masonry floors and extend insulation down to the top of footings.

When heating unconnected spaces, each space requires its own glazing and exposed interior thermal mass.