

## Tromb  Walls

Tromb  walls (see Fig. 1) can be used to maximize the benefits of thermal mass and solar thermal collection. The radiant energy of the sun passes through glass, striking a dark, high mass wall. A large portion of the energy is absorbed by the wall, while some is transferred to the air within the tromb  wall assembly. The glass keeps this warm air from escaping. Strategic venting and fans can be used to circulate air through the air space and direct it inside or outside when temperature adjustments are needed. This passive solar heating concept is called the indirect gain.

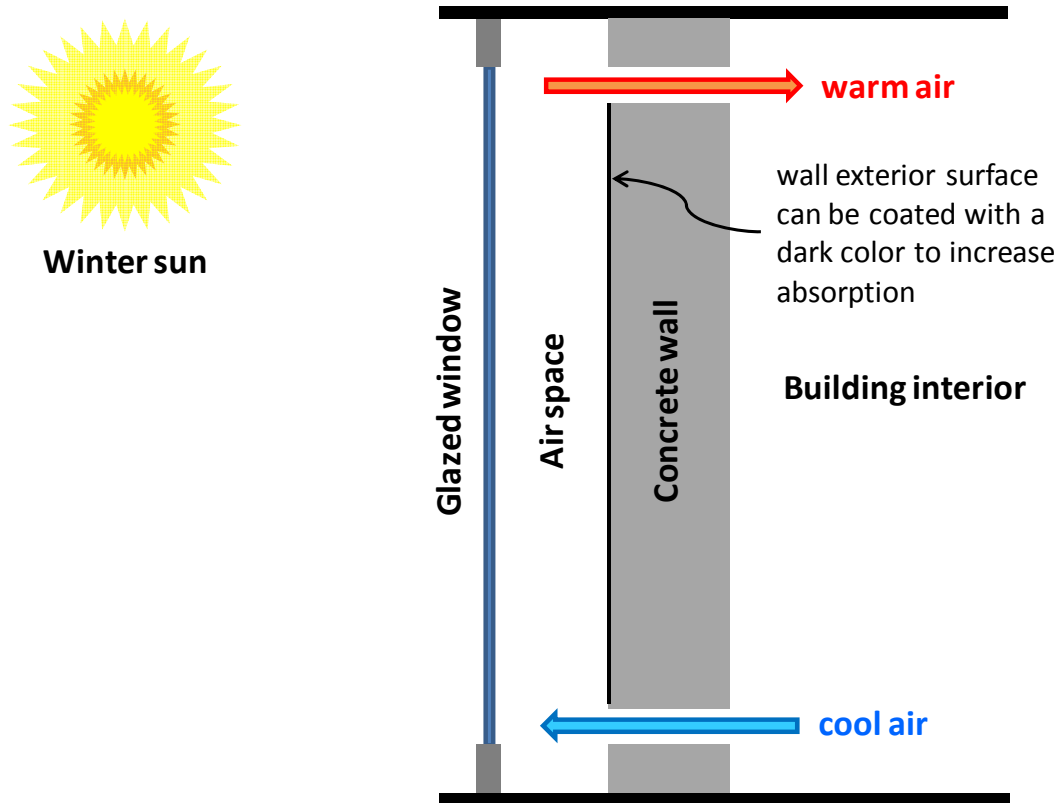
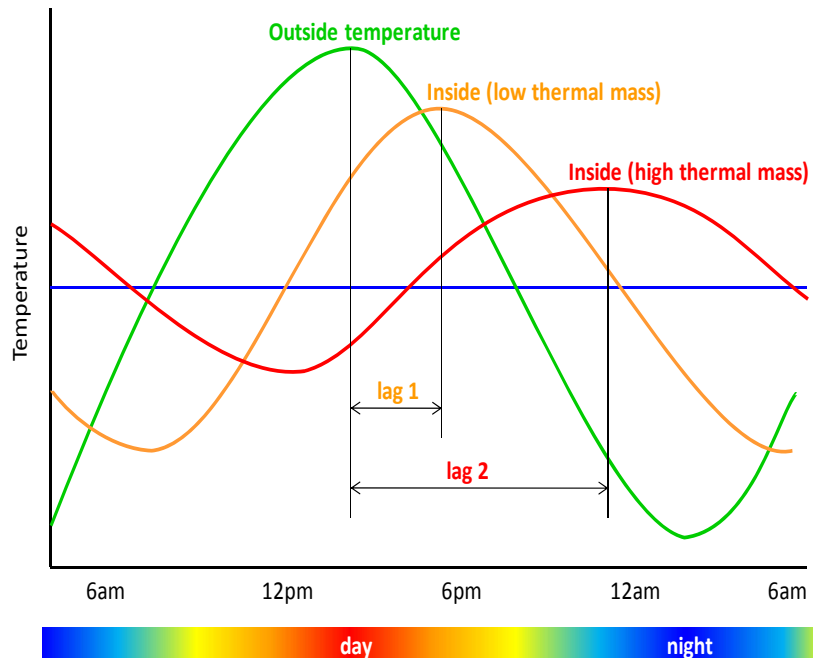


Figure 1—Tromb  wall (*The Sustainable Concrete Guide-US Green Concrete Council*)

## **Thermal Mass and Temperature Lag**

The effect of temperature lag associated with low and high thermal mass is shown in Fig. 2; and Table 1 shows some values of time lag and amplitude reduction for various materials. On a hot summer day, thermal energy (heat) absorbed and stored in walls and other elements delays the peak-heat of the day and thus keeps the interior of the building cooler and saves energy. For an office building, this delay alone can have a major influence on tempering the heat generated from lighting and computers. For an occupied residence in warm months, the absorption and delayed release of peak-heat reduces the energy needed to keep a house cool during the day. At night, the process is reversed. Energy absorbed during the daytime is released from the walls into the cool night. Cooling for the interior can be hastened if windows are opened, particularly if the structure has been designed for good air flow and ventilation.

On a cold day, thermal mass works particularly well with a passive solar design. Daytime occupants experience light and warming from windows that reduce the energy load for heating. Energy stored in walls and floors from daytime warming (direct gain) carries over into the night to delay cooling of interior and to temper the effect of temperature drops.



*Figure 2—Effect of temperature lag from thermal mass*

Wall no.	Thermal lag, h	Amplitude reduction, %
1. 8 x 8 x 16 (200 x 200 x 400 mm) masonry	3.0	18
2. 8 x 8 x 16 (200 x 200 x 400 mm) masonry, with insulated cores.	3.5	28
3. 4-2-4 masonry cavity wall	4.5	40
4. 4-2-4 insulated masonry cavity wall	6.0	38
5. Finished 8 x 8 x 16 (200 x 200 x 400 mm) masonry wall	3.0	51
6. Finished 8 x 8 x 16 (200 x 200 x 400 mm) masonry wall with interior insulation	4.5	31
7. Finished 6 x 8 x 16 (150 x 200 x 400 mm) masonry wall with interior insulation	3.5	10
8. Finished 8 x 4 x 16 (200 x 100 x 400 mm) masonry wall with interior insulation	4.5	27
9. Structural concrete wall	4.0	45
10. Structural lightweight concrete wall	5.5	53
11. Low-density concrete wall	8.5	61
12. Finished, insulated 2 x 4 (38 x 89 mm) wood frame wall	2.5	-6
13. Finished, insulated 2 x 4 (38 x 89 mm) wood frame wall	1.5	7.5
14. Finished, insulated 2 x 4 (38 x 89 mm) wood frame wall	1.5	-4
15. Insulated 2 x 4 (38 x 89 mm) wood frame wall with a masonry veneer	4.0	-6

*Table 1—Thermal Lag and Amplitude Reduction Measurements from Calibrated hot box tests (ACI 122R-02, Guide to Thermal Properties of Concrete and Masonry Systems)*

**Effect of wall thickness on storing heat energy**

Tests indicate that the thicker the concrete wall the more energy it can store – see Table 2. However, as a rule of thumb for concrete walls greater than 8 in. (200 mm) thick, the practical ability to use the full heat capacity of the wall in a 24-hour period tapers off rapidly, as shown in Fig. 3.

Wall thickness (in.)	Heat Capacity per ft <sup>2</sup> (btu/ft <sup>2</sup> ·°F)	
	145 pcf	110 pcf
3	7.2	5.5
4	9.6	7.3
5	12.0	9.2
6	14.4	11.0
7	16.8	12.8
8	19.2	14.6
9	21.6	16.5
10	24.0	18.3
11	26.4	20.2
12	28.8	22.0

Table 2—Heat Capacity of Concrete for Varying Wall Thickness  
(Adapted from Designer’s Notebook, Energy Conservation, PCI, 2006)

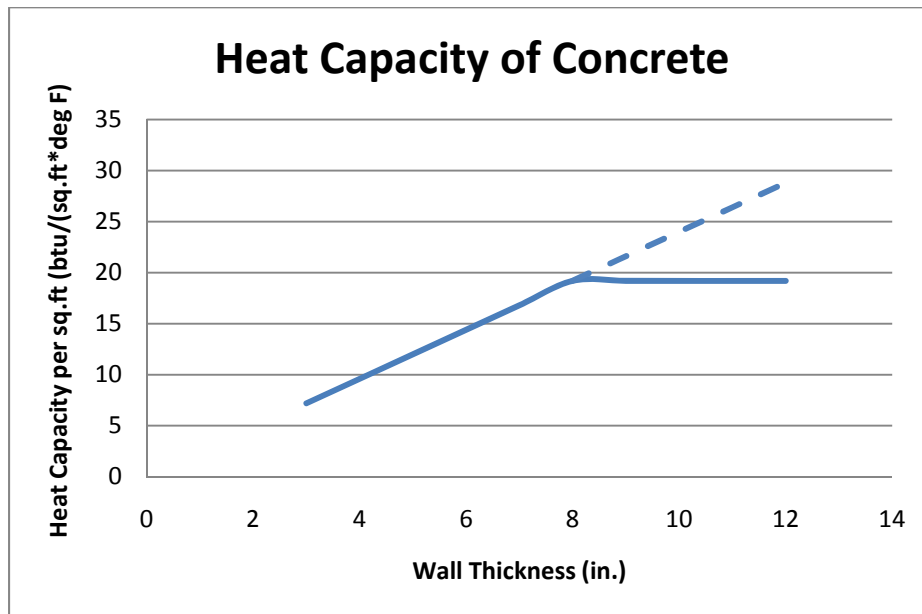


Figure 3—Heat Capacity versus Concrete Wall Thickness

### **Summary of Thermal Mass**

#### Potential advantages/benefits

- Reduction of effects of outside temperature spikes on building occupants
- Time delay in peak temperature effect
  - Cooler inside when warmer outside, and vice versa
  - Shift to off-peak energy use
- Radiant heat benefits from exposed surfaces
- Contributor to using passive solar system
- Energy savings for heating and cooling (level dependent on climate)
- Downsizing (or removal) of HVAC systems

#### Potential disadvantages/limitations

- Openings (windows and doors) need to be carefully sealed for full benefit
- Difficult to model true energy use incorporating thermal mass
- Storage wall can block view and daylight
- Additional cost associated with the design of the mass wall and its foundation.

Reference: The Sustainable Concrete Guide, Andrea Shokker, U.S. Green Concrete Council, 2010.