UTILIZING Thermal Mass in Concrete Residential Construction to Reduce Energy Demand

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Increasing the thermal mass of a building can provide cooler summer indoor temperatures, a shift in the peak energy load leading to possible monetary savings and an overall reduction of energy up to 10%

It is estimated that 2007 will be the hottest year in recorded history! The British Meteorological Office reported in January that a resurgent El Nino and an increase in greenhouse gases will result in a 1.2-degree Fahrenheit increase over the long-term average. The increase in temperature results in higher energy prices, greater CO_2 emissions from residential and other heating and cooling units and an overall reduction in available fossil fuels[1]. Developing a balanced design approach for residential homes, including a structure with a high thermal mass, would help reduce energy consumption. This will reduce the dependence on air-conditioning systems, thus reducing the dispersion of CO_2 and the increase in global greenhouse gas emissions.

Thermal mass in the most general of forms is any mass that absorbs and stores heat energy. In the building system, it is the mass of the building elements that stores heat during the hottest periods of the day and releases the heat during the cooler evening hours[2], as shown in Figure 1. Concrete is one of the primary building materials that provide advantages of thermal mass in building systems. In the winter season, the high thermal mass concrete home absorbs radiant heat from the sun and is gradually released back into the home during the night when the outdoor temperature drops. Concrete is an ideal building material for residential structures desiring high thermal mass due to its high specific heat, high density and low thermal conductivity. The distinct benefits to the thermal mass of concrete construction in residential design are[3]:

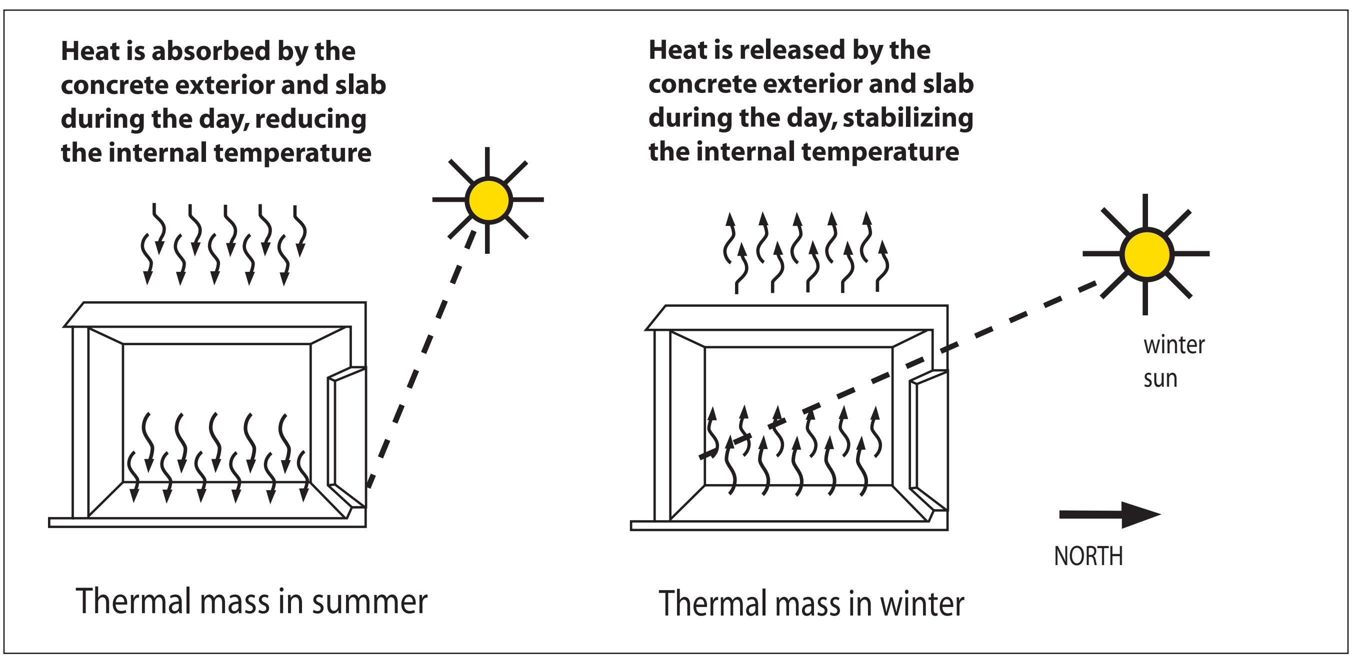

Figure 1. Benefit of high thermal mass during summer and winter seasons.

- Moderate shifts in peak loads of energy requirements due to the reduction in high fluctuations between indoor and outdoor temperatures.
- Heat transfer through a high thermal mass home, one constructed of concrete, is reduced, therefore, less energy is used to heat and cool the home.
- The thermal mass of concrete delays peak temperatures and reduces and spaces out peak energy loads, therefore, may shift the energy demand to off peak periods when utility rates may be lower. The damping and lag effects of a high thermal mass building are shown in Figure 2.

Several studies have researched the impact of high thermal mass concrete residential structures on energy savings. The Oak Ridge National Laboratory (ORNL) published a study comparing the energy performance of high thermal mass wall technologies with the typical residential light-weight wood-framed technologies [4]. The ORNL report detailed a residential home constructed of Insulated Concrete Form (ICF) construction, the use of foam forms, which are filled with ready mixed concrete at the site. The ICF walls provide a high thermal mass when compared to a typical wood framed construction home. The results of the study indicated that the average potential whole building energy savings (ICF house vs. conventional wood-framed house) for all U.S. locations is approximately 8%. Figure 3, reproduced from the ORNL report, shows the energy savings from a high thermal mass construction for various U.S. cities.

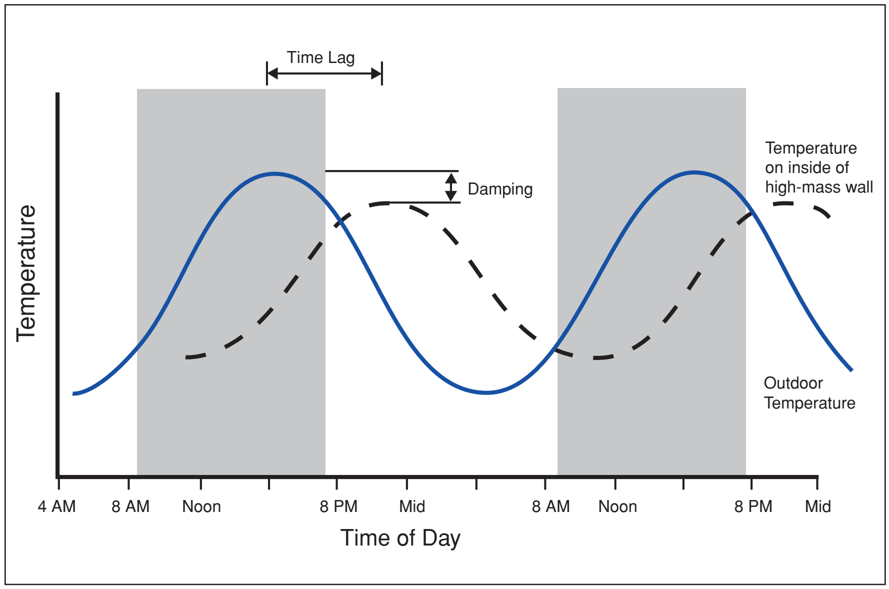

Figure 2. Damping and lag effect of thermal mass.

With the inevitable rise in outdoor temperatures leading to higher energy use, additional CO_2 emission and more expensive heating and cooling bills, increasing the thermal mass of residential homes through the use of concrete construction is a viable option for sustainable design. Increasing the thermal mass of a building can provide cooler summer indoor temperatures, a shift in the peak energy load leading to possible monetary savings and an overall reduction of energy up to 10%. ■

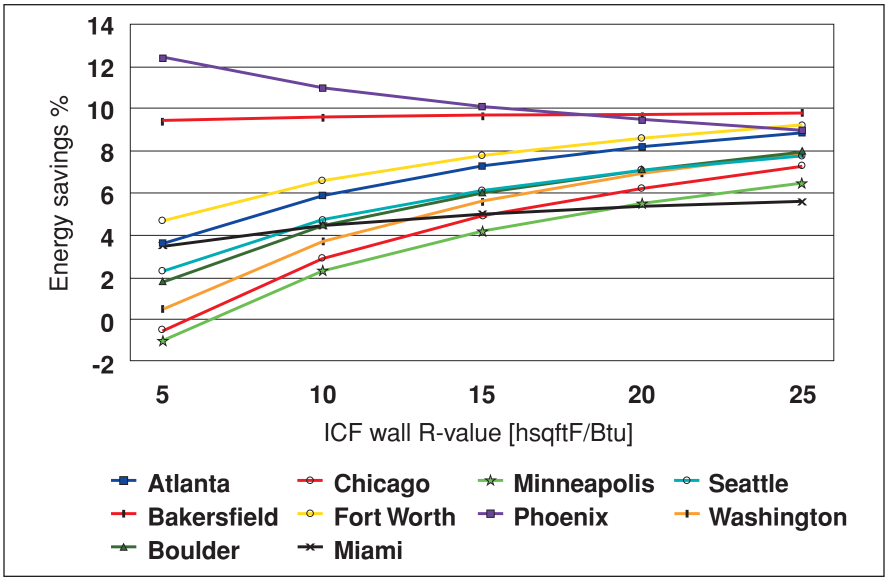

Figure 3. A potential whole building energy which can be saved in 10 U.S. locations by the replacement of conventional wood frame walls by ICF walls.

1. The Associated Press. www.ap.org – accessed, January 8, 2007
2. "Thermal Mass for Housing," The Concrete Centre, 2006
3. www.concretethinker.com – accessed, January 8, 2007
4. Kosny, J. "Thermal Mass," Oak Ridge National Laboratory and Polish Academy of Sciences, 2001

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