

# Keeping Comfortable

## WITH PRECAST CONCRETE



### Do you understand the thermal properties of precast concrete?

By Claude Goguen, PE., LEED AP

Night and day, precast concrete panels help regulate building temperatures thanks to thermal mass and resistance.

In an era when resiliency and energy efficiency are more important than ever, manufacturers of precast concrete should be able to explain the beneficial properties of their products. This goes beyond compressive strength, air content and watertightness. Thermal properties continue to grow in importance with the increase in development of energy-efficient and net-zero-energy-use buildings. When explaining the thermal properties of precast concrete, it's important to avoid confusion about thermal mass versus thermal resistance. Thermal mass and resistance often get labeled as the same thing but work in very different ways. Together,

they provide the best performance for keeping a building comfortable for its occupants, and that makes precast concrete an optimal choice for a building material.

#### THERMAL MASS

Thermal mass is the property that allows a material to absorb, store and later release significant amounts of heat. A lot of heat energy is required to change the temperature of high-density materials like precast concrete, which is why concrete has high thermal mass. Heating wooden walls, by comparison, is much easier but they store less heat and release that heat faster. Precast concrete walls act



like thermal sponges, absorbing heat during the day and then slowly releasing the heat as temperatures fall at night. As the night air cools the walls, they store it and transfer it back into the building during the day. This cycle repeats itself each day. When outside temperatures are fluctuating throughout the day, the thermal mass of concrete also flattens out temperature changes.

This effect reduces heating and cooling loads on the building's HVAC system, resulting in energy savings. When outdoor temperatures are at their peak, the inside of the building remains cooler. The heat has not yet penetrated the precast concrete mass, which is still releasing the cooler air from the previous evening, producing a time lag as seen in Figure 1. This heat transfer delay is known as damping.

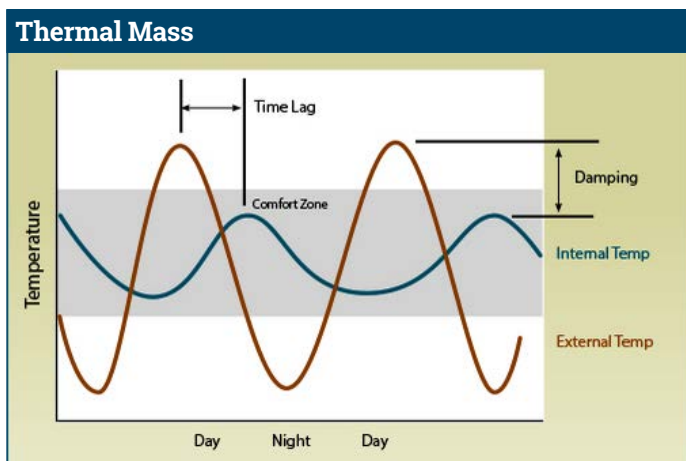


Figure 1

The result of this damping effect is improved energy conservation, which is mandated by the national Energy Policy Act of 1992 for commercial buildings. Can we quantify thermal mass? We can through specific heat, which is a material's ability to store heat energy. Specific heat is defined as the ratio of the amount of heat required to raise the temperature of a unit mass of a material by one unit of temperature to the heat needed to raise an equal mass of water by the same unit of temperature.

### Thermal Conductivity and Resistance

If you're a person who likes to cook, you know the value of a good frying pan. When you are comparing frying pans, you will notice the more expensive a frying pan is, the heavier it is. Concrete is heavy, so why is there no market for precast concrete frying pans? It's all about thermal conductivity.

The thermal conductivity of a material measures how that material absorbs and transmits energy. It is also defined as the quantity of heat transmitted through a unit thickness of a material - in a direction normal to a surface of unit area - due to a unit temperature gradient under steady state conditions. It is measured in SI units by watts per meter Kelvin and in imperial by British thermal units per hour foot Fahrenheit.

When the heat of the stove comes in contact with the pan, the energy from that heat source is transmitted to the pan, which increases the kinetic energy. The heat is then transmitted to nearby materials that are at a lower kinetic energy level. The higher the thermal conductivity of the material, the faster it will heat up and

the faster the heat will spread to unheated areas of the same piece of material. Frying pans made with high thermal conductivity material work best because they transmit heat quickly, resulting in a faster response to thermal changes. This is why many times a frying pan's handle is made from a different material with a lower thermal conductivity. Cast iron has a high thermal conductivity of 50 to 80 watts per meter Kelvin, while concrete has a low thermal conductivity of around 1 watt per meter Kelvin. That may be why your line of precast concrete cookware is not flying off the shelf.

All materials have a thermal resistance value which is a measure of that material's resistance to conductive heat flow. This measure is expressed with an R value. Precast concrete has low R values which vary based on the concrete's density. For 150 pounds per cubic feet of concrete, the R value is approximately 0.7 per inch. As concrete density decreases, the R value increases. Add rigid insulation and you can get an R value of around 5 per inch depending on the type of insulation.


The R value for precast concrete wall panels with insulation typically varies from R-5 to R-50. The types of rigid of insulation generally used with precast concrete wall panels are:

- EPS - Expanded Polystyrene: R values typically 3.8-to-4.4
- XPS - Extruded Polystyrene: R values typically around 5
- Polyisocyanurate: R values typically 6-to-8

### BRINGING THE TWO TOGETHER


To review, thermal mass is the ability of a material to store heat energy and thermal resistivity is the ability of a material to slow


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down the transfer of heat energy. A precast concrete building is good at regulating its own temperature. Precast concrete walls with rigid insulation such as sandwich panels or thin wall panels create an ideal building envelope as they provide high R values while regulating temperature fluctuations. The end result is an energy efficient material that is unmatched.

Energy-efficient and net-zero-energy buildings are popping up everywhere. We even have a net-zero energy precast plant among NPCA's distinguished members. Environmentally conscious construction is no longer restricted to the fringe of the industry. It is mainstream. As the building market recovers, the green construction industry is growing at a rapid pace. According to the United States Green Building Council, total revenue across this industry should grow to \$245 billion by 2016, comprising more than half of all nonresidential building.<sup>1</sup>

Owners, specifiers and builders are more

### THERMAL MASS

is the ability of a material to *store* heat energy.

### THERMAL RESISTIVITY

is the ability of a material to *slow down the transfer* of heat energy.

focused than ever on designing and constructing energy-efficient and durable buildings. Often, this is mandated in order to meet requirements of the following:

- Leadership in Energy and Environmental Design v4
- American Society of Heating, Refrigeration and Air Conditioning Engineers
- International Green Construction Code
- U.S. Federal Government Executive Order 13514

The last ensures that all new government building construction and major renovations meet the Guiding Principles for High-Performance Sustainable Buildings and achieve zero-net energy by year 2030. A zero-net energy building means the total amount of energy used by the building on an annual basis is roughly equal to the amount of renewable energy created on the site.

The thermal properties of precast concrete help improve a building's energy performance. It is an important asset for designers who need to cut heating and air conditioning costs associated with HVAC systems and still keep building occupants comfortable. And, it is an important selling point for your precast products. ■

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<sup>1</sup> www.usgbc.org



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