For High Performance Radiant Heat
... Conductivity, Not Mass, is King

Often, when people are talking about radiant floor heating, the term “Thermal Mass” comes up. Thermal mass in this context is a term that refers to the ability of a high mass radiant floor assembly to store heat. The concept originally made sense in the design of passive solar homes back in the 60’s and 70’s. A dark colored high mass slab made of Portland cement concrete or gypsum concrete was often positioned under south facing windows. The heat from the sun would soak into the slab all day. Once the sun went down, the slab would give up its heat to the habitable space, in essence delaying the release of the sun’s heat by about 12 hours. The delay of the release of heat was a benefit in these systems precisely because the sun gave off its greatest amount of heat about 12 hours before it was needed.

Because passive solar could rarely supply all of the heat needed for a home, these slabs were often poured with tubing embedded in them so that hot water could heat the slab when there was insufficient heat from the sun stored in them. In other words, they were combination radiant floor heating systems and passive solar systems. Because these systems were prevalent during the infancy of radiant and solar, the terms thermal mass and radiant heat became linked in people’s minds.

But the same thermal mass that is so essential to a passive solar home causes one of the more common complaints with radiant heat ... that it’s slow. In high mass systems, because heat loads change upward or downward more rapidly than a high mass slab can respond, it is not uncommon for the inhabitants of a high mass radiant heated home to be too cold in the morning and too hot in the afternoon. Or if they are returning to a cold home after an absence, they might have to wait a day or more for their home to come back up to a comfortable temperature.

As interesting as the history of the association of passive solar with radiant heat may be, given a blank sheet of paper, no one would design a radiant system to be a storage device. It's the job of a radiant system to deliver heat not store it. Homes lose heat because heat flows from the warm interior to the cold outside. It's the job of a radiant floor system to cause heat to flow into the conditioned space at close to the rate that heat is flowing out. The property of a material that allows heat to flow through it is called conductivity. Yet concrete is an inherently mediocre conductor. Aluminum is 240 times as conductive as concrete! So concrete, by its very nature, is a mediocre choice for a radiant panel material.

Because the quantity of heat that must be supplied by a radiant panel is constantly changing for any number of reasons, the ideal radiant system is able to adjust its heat output upward or downward, in real time, as is needed to create a constant temperature environment. Paradoxically, the quality most often touted as the advantage of radiant systems based on high mass slabs, namely, that they don’t vary much in their output, is precisely their Achilles heel. The slab itself may maintain a constant temperature, but the conditioned space they serve doesn’t maintain a constant temperature simply because heat loss varies throughout the day.

Boiled down to its essence, a high mass system is really a control system, not unlike a flywheel. But it is not a very bright control system. It is about as intelligent as a lump of concrete. This means that sometimes it will accidentally get it right and sometimes it will, by equally random accident, get it wrong. Like a stopped clock, it's guaranteed to be right at least twice a day.

The point is, if we are not getting our heat from an uncontrolled source such as the sun, but instead, get it from a controllable fuel source or, for example, from some of the emerging ultra high efficiency technologies such as ground source heat pumps, it makes a lot more sense to control the heat supplied, by use of an intelligent control system ... a thermostat. Such a smart control system can merely turn on a pump in response to a call from thermostat, which can direct that heat to a highly conductive low mass radiant panel, which can deliver that heat in real time as is needed.

This is especially true for modern, active solar systems. These systems do not store heat in an uncontrolled slab but instead store the Sun's heat in a mass of water held in a well insulated tank. A pound of water will store 3 times as much heat as a pound of concrete. This means that not only are concrete slabs mediocre conductors, they are a mediocre means of storing heat as well. In a well engineered active solar system, heated water can be pumped as needed to a highly conductive low mass panel, controlled in real time by a simple thermostat.

High mass systems are being relegated to the dustbins of history. Low mass, fast response systems are the future of radiant simply because they are better engineered relative to the laws of thermodynamics. Because the best low mass systems employ a thick aluminum plate to conduct heat, they are inherently more conductive than concrete. Highly conductive radiant panel assemblies allow the use of lower water temperatures than high mass slabs, which saves energy (i.e. money). Fast responding low mass systems also save energy by avoiding the waste of under-shooting or over-shooting the desired interior temperature, and by allowing night setback and vacation setback. But most importantly, low mass systems are better able to maintain the desired interior temperature on a constant basis. Constant temperature at the desired set point, the essence of heating comfort after all, is the primary mission of a modern, energy efficient, well controlled, radiant floor heating system.