# Thermal Mass

*This article is composed of two parts.*

*The first "*Using and activating thermal mass in buildings*", is based on an extract from* New Steel Construction*, vol. 18, no. 6, June 2010 and is followed by answers to some relevant questions it might raise.*

*The second "*A local perspective on thermal mass*", by Nigel Howard, Managing Director of Edge Environment, presents an Australian view on the subject*.

## Using and Activating Thermal Mass in Buildings

Creating an environmentally friendly building, contributing to lower running costs and keeping the carbon footprint as low as possible, is going to become a major criterion in Australian building design.

When a building type has been selected, there may be the option to use the building's thermal mass to help regulate temperature. Natural ventilation and activating a building's thermal mass can be used to drive reduced running costs.

In a UK building at Seaham in Durham County, the floor design for the library and county offices has resulted in floors that are able to absorb heat during the day and radiate it out again during the night.

The architects and engineers used a steel frame to construct natural ventilation and thermal mass to control building temperatures. Together with a much quicker construction timetable, the solution dramatically cut the running costs of the building.

The main engineer Capita Symons said that natural ventilation was achieved by a series of stacks which penetrate the metal decking and floor slabs culminating at roof level in louvred boxes and at roof level; roof lights also aid the ventilation.

### Thermal mass: exposing the myth

Thermal mass is the ability of the fabric of a building to absorb excess heat and as such it can reduce cooling loads and, in some cases, completely remove the requirement to provide air conditioning and its associated energy consumption.

Over a typical 24 hour cycle, the maximum value of admittance for a slab exposed from underneath only, may be achieved with just 75-100mm of concrete. This means that, where heating and cooling takes place over a daily cycle, a floor thickness of 100mm (typical of steel composite construction) will provide the maximum amount of fabric energy storage possible. If more mass is provided, it will not be utilised and is a waste. (Ref Corus UK)

## Some questions and answers

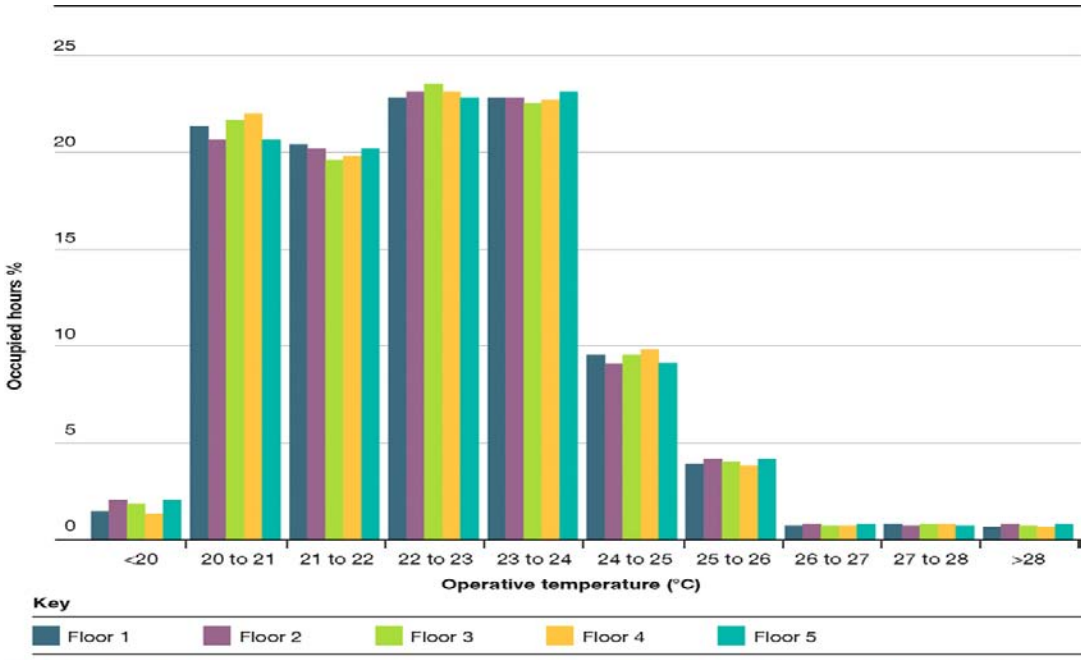
Q. Is it correct to say that the more mass is in a building, the more thermal capacity is available?

A. No, this is incorrect. The concept that more mass is good arose from a fundamental misunderstanding of how fabric energy storage works. The origin of the theory lay in observations that large, monolithic buildings such as the Radcliff Camera never overheated, even in the warmest weather. The assumption then made was that this was because the large, thick walls absorbed the excess heat in the building. The actual reason is that these buildings did not overheat because they sheltered relatively low levels of activity, and therefore generated little internal energy, and also because small windows limited solar gain.

More recent studies have demonstrated that relatively small amounts of mass are mobilised in maximising the available thermal capacity in a modern building.

Q. What studies have been carried out to assess the difference in fabric energy storage potential between different types of flooring systems?

A. In 2007 AECOM (a global provider of technical support services) carried out a study on a four storey, naturally ventilated office block using five different flooring systems. The results are summarised below:




| Floor Construction | Construction | Thermal Mass | |
|---|---|---|---|
| | Modelled concrete thickness (mm) | Admittance (W/m²K) | Decrement factor |
| [1] Slimdek | 137 | 6.93 | 0.454 |
| [2] Composite flat slab – ComFlor70 | 104 | 6.35 | 0.547 |
| [3] Pre-cast concrete | 200 | 5.87 | 0.268 |
| [4] Reinforced concrete | 300 | 5.64 | 0.146 |
| [5] Hollow core pre-cast | 200 (with circular cavities; 145mm diameter at 189mm pitch) | 5.15 | 0.398 |

The results are presented as percentages of occupied hours in which temperatures lay within certain limits. As can be seen, there is little difference between the systems.

Q. How much mass is mobilised in a building to optimise the available thermal capacity?

A. The quantity of mass in a building which can be linked to the internal atmosphere to provide fabric energy storage is governed by the admittance of the material of which the construction, usually the ceiling, is manufactured. The admittance is a measure of the ability of a material to exchange heat with its surroundings. The admittance is limited by the rate of heat transfer between the material and its environment.

Lightweight building materials, such as dry lined partitions, have a low admittance or a low ability to store and release useful amounts of energy. By contrast, exposed structural elements such as floor slabs have a high admittance.

On a daily 24 hour cycle, the maximum value of admittance for a slab exposed from underneath only may be achieved with only 75-100mm of concrete. This means that, where heating and cooling takes place over a daily cycle, a floor thickness of 100mm will provide the maximum amount of fabric energy storage possible. If more mass is provided, it will not be utilised.

# A local perspective on thermal mass

**Nigel Howard, Managing Director, Edge Environment**

The thermal mass of a building must be accessible to the air-flow it cools, meaning that, elements such as suspended ceilings, raised floors, carpet and even wallpaper reduce this accessibility. The larger the thermal mass, the more energy is absorbed/released, but more significantly, the LONGER it will take to both absorb and release heat to the air.

Normally we want to stabilize temperatures over the diurnal swing of day to night so we need a thermal mass which creates a time-lag of 6-12 hours which is where the 100mm thickness of concrete comes in. If we have more thermal mass than this, then it will time average over longer periods and this can be a problem as much as a benefit, perhaps taking longer to heat or cool to comfortable temperatures. In some cases this may lead to having to use external heating early in the day to get the building to temperature for the occupants, only to have to externally cool the building later in the day once fully occupied – exactly the opposite of what was intended.

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Thermal mass is not needed everywhere – if the average of day and night temperatures is either too cold or too hot for comfort then thermal mass is a problem not a benefit, requiring excess energy to get buildings to temperature when they become occupied from empty.

For intermittently occupied buildings – for example a young person's accommodation such as a back packers' hostel, short term stay situation thermal mass may not be desirable. These buildings need to be heated and cooled quickly with the minimum energy needed to get them to temperature.

Heating and cooling controls therefore need to be matched to the thermal mass of the buildings and their occupied periods – high thermal mass buildings need the heating/cooling on longer before occupancy and off long before occupancy is due to finish, if energy is to be conserved.

We always think concrete when it comes to thermal mass, but what is important is matching the thermal mass to the building use requirements.

For a multilevel commercial building, generally the amount of concrete in the composite floor is sufficient to produce the level of thermal mass required for efficient heating and cooling in the Australian capital city environment.