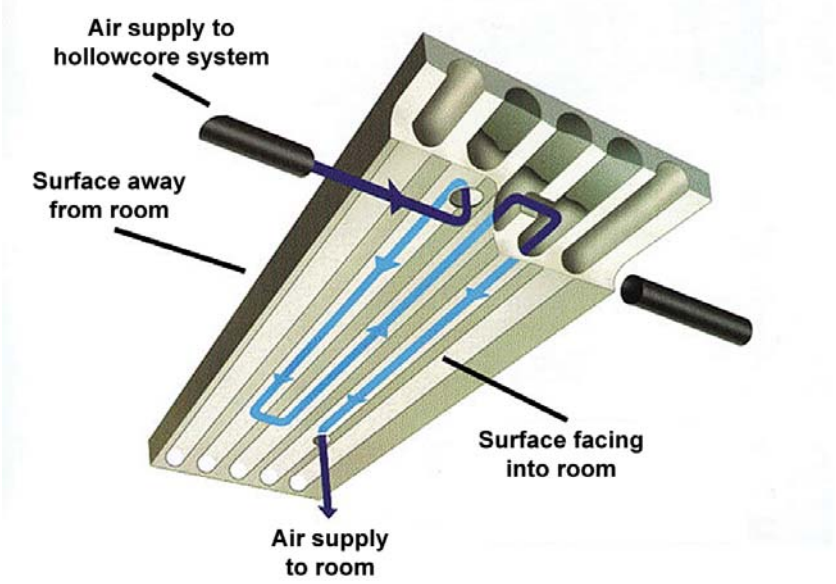
Thermal Mass and Sustainability

The Irish Concrete Federation commissioned the Energy Research Group, University College Dublin to independently produce a publication Thermal Mass & Sustainable Building, improving Energy Performance and Occupant Comfort as a practical guide for designers.

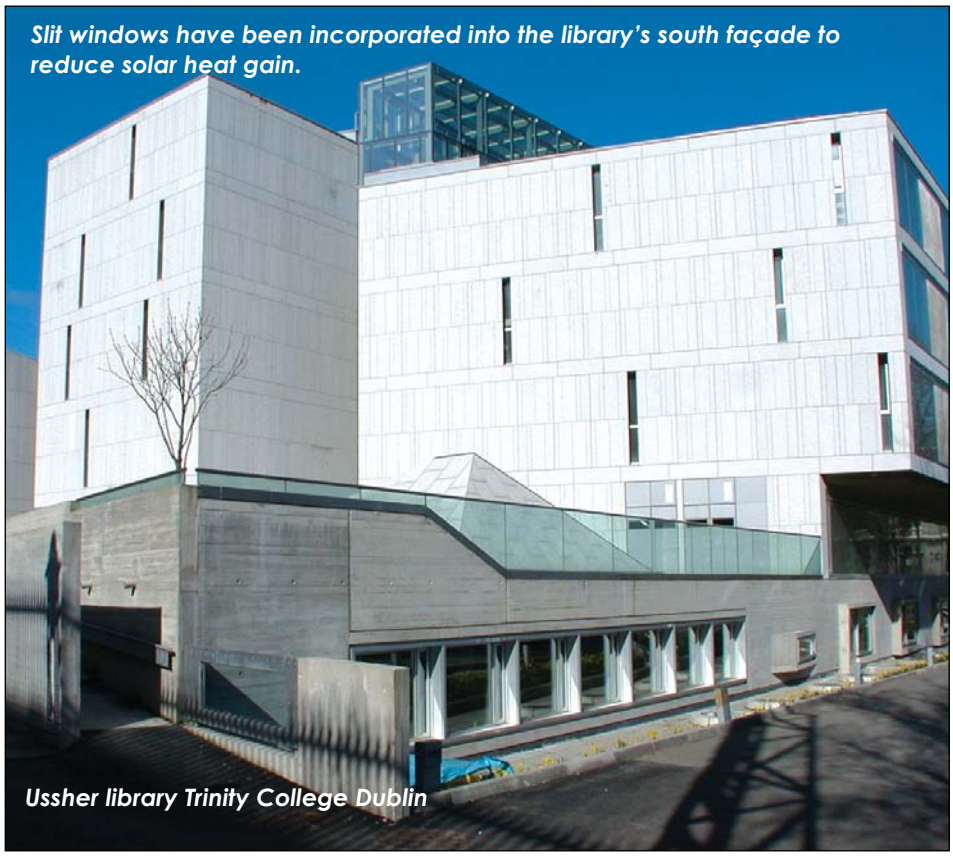
Designing buildings and managing our built environment in an energy efficient way is vital to our future. We believe that this publication proves that concrete will continue to provide the superior product in meeting this challenge.

Energy is currently a 'hot topic' and, that's hardly surprising with the EU Energy Performance of Buildings Directive about to be implemented in Ireland. Apart from the introduction of the Building Energy Rating (BER) for houses, the Government has in many ways prompted the energy discussion with the introduction of the SEI House of Tomorrow and Greener homes schemes.

While it is possible to retrospectively improve the energy performance of any building, it is usually more cost effective to design-in the features, and build them-in at the construction stage. One of the options available, is to use the structural mass of the building to improve thermal performance.



Operation of the proprietary hollow core ventilation system used in the Elizabeth Fry Building. Source: TermoDeck



Slit windows have been incorporated into the library's south façade to reduce solar heat gain.

Ussher library Trinity College Dublin

Thermal mass is the term used to describe the materials in a building's construction which can store and release large quantities of thermal energy. These materials are normally the dense structural elements that form the inner shell, or fabric of the building. Building materials with good thermal mass include, block, brick, stone and concrete.

The heat storing capacity of thermal mass has two separate effects on a building. It delays the time that peak temperatures occur and it averages day and night extremes. This behaviour is known as *thermal inertia*. The thermal mass of a building can store energy during times of surplus supply, and release this energy later, when supply is scarce. A report, *Thermal Mass & Sustainable Building*, by the University College Dublin, Energy Research Group, prepared for the Irish Concrete Federation, claims that "by moderating internal temperatures, thermal mass can reduce the heating requirements of residential buildings and can offset the need for air conditioning in office buildings."

The performance of the thermal mass of a building is dependent on the materials

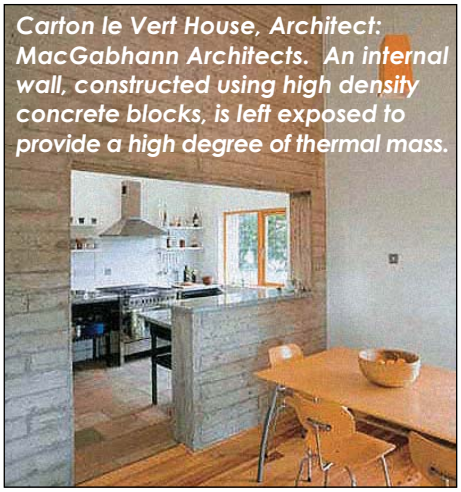
used in its construction, their location and orientation. The amount of heat a material can store is determined by its volumetric heat capacity. The UCD expert group show concrete with a capacity of 1940 kilo Joules Kelvin at 20°C. The base material in this case is air measured at 1 kJ K. at the same temperature. Water is at the top end, at 4180 kJ K and wood at 187 kJ K. is at the lower end. Concrete, glass, sandstone and brick, all have good volumetric heat capacity.

The total area of exposed mass is critical to the thermal mass of a building. Increasing the surface area of exposed mass is the most effective way to increase the performance of thermal mass. But storing the heat in the material isn't much use if it can't be released to the desired area. For effective thermal coupling to take place, the internal surface treatment of the building must be favourably disposed to heat transfer. Carpets, plasterboard and ceiling tiles all insulate the mass of a building's structure from the internal environment.

Maximum performance is achieved where the internal surfaces of the building fabric remain exposed. The challenge here for building designers wanting to take advantage of thermal mass and provide thermal coupling, is to specify finishes which facilitate heat transfer. Dense plaster and ceramic tiles are options that will achieve successful implementation of Thermal Mass. Insulation does have a big part to play in thermal performance however, as the thermal mass needs to be protected from the influence of external air temperature.

Interior view showing the exposed concrete soffits and the fin shaped up stand posts. Source: Christian Richters

Ussher library Trinity College Dublin



Carton le Vert House, Architect: MacGabhann Architects. An internal wall, constructed using high density concrete blocks, is left exposed to provide a high degree of thermal mass.

Convective heat transfer can be achieved by increasing the airflow over a thermal mass surface or by introducing turbulence into the air stream. Designers and occupiers too, need to take into account the fact that buildings deploying thermal mass heat up and cool down slower than other buildings. This phenomenon is well documented and debated where under-floor heating is used in concrete floors. Because of the thermal mass of the floor, the heating has to be switched on earlier than with traditional radiators, but can be switched off sooner too, as the heat stored in the concrete will be released, after the heating source has been switched off. Buildings deploying the thermal mass of external walls will behave similarly, and this delay or inertial has to be factored in when setting the heating controls.

The sun can contribute significantly to a building's space heating requirements. When locating buildings, designers and their clients should consider solar access and orientation. The use of large windows in south facing elevations will help trap the heat of the sun, and the use of taller windows will allow the sun to penetrate deeper into the building. Designers should also locate thermal mass in rooms that will receive generous amounts of light.

Thermal mass in commercial buildings is referred to as Fabric Energy Storage (FES.) Thermal mass can be used to cool commercial buildings at night, and thereby reduce the need for energy intensive air conditioning. Cooling a building by 1°C using air conditioning, requires three times as much energy as it would to heat a building by the same amount.

The above topics are discussed in detail with practical examples of buildings utilising the benefits of thermal mass in a new publication entitled 'Thermal Mass and Sustainable Building' – available on request from the Irish Concrete Federation. Tel: 01 4640082.

Thermal Mass

The U.K. Concrete Centre has welcomed the Government's recognition of the role that the high thermal mass of masonry and concrete construction can play in reducing the energy consumption of our homes and so combat climate change.

Speaking at the recent House Builders Federation summit to determine the most effective way to deliver the Government's environmental vision, Yvette Cooper MP, the Minister for Housing and Planning said: "Last summer there were reports of big increases in people buying portable fans and air conditioning units just to keep cool. The homes of the future need to be designed for hot summers as well as cold winters. We should be building green houses not greenhouses for future generations". She cited Mediterranean house construction, which is typified as being of heavyweight construction with high thermal mass, as an example of the type of houses that should be built in the UK.