Thermal Mass

Key facts

1. **In buildings, thermal mass is a property of medium and heavy weight construction that enables heat to be stored in the fabric of the building, providing "inertia" against temperature fluctuations.**

2. **Thermal mass is used to enhance year-round building performance, reducing overheating risk and cooling demand in summer, and helping capture/recycle heat from the sun in winter.**

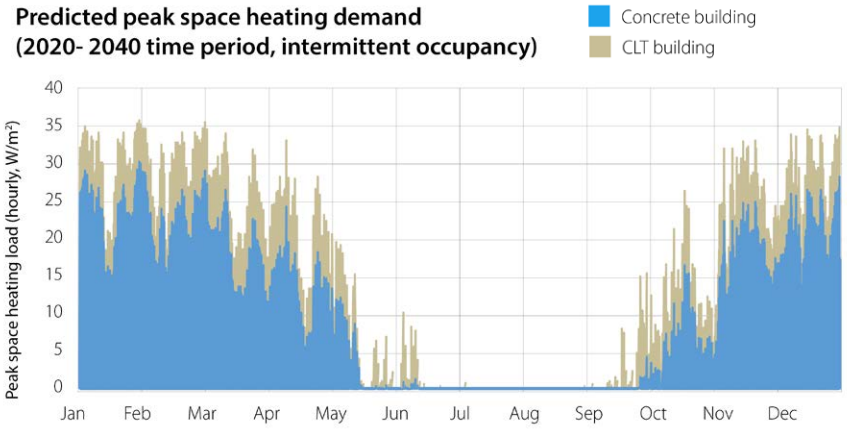
3. **Concrete provides a high level of thermal mass, which can improve a building's energy performance.**

4. **A new role is emerging for thermal mass, in which its ability to store/release heat is used to help balance a building's energy loads with energy grid demand; a vital feature of low carbon buildings as it helps facilitate decarbonisation of the grid.**

Thermal mass in summer

The main use of thermal mass in buildings is to naturally absorb excess heat during the day, helping flatten out daily temperature fluctuations and provide more comfortable conditions, particularly during warmer weather. This is called passive cooling. The heat stored in heavyweight floors/walls is later removed, by ventilating the building using the cool night air. This technique can be used alongside other design measures, such as shading, to reduce overheating risk. The combination of thermal mass and night-time ventilation is commonly used in southern European homes and can also provide effective climate resilience to UK homes as hotter seasons become more frequent [1,2].

For building types such as offices and schools, this technique is already widely used in the UK where it helps reduce or avoid the need for air conditioning, saving energy and carbon. Guidance from The Concrete Centre "Concrete floor solutions for passive and active cooling" includes buildings that have achieved the highest environmental assessment (BREEAM) ratings. Thermal mass also reduces the peak electrical demand for heating and cooling demand, which is a vital part of a net zero carbon future as it helps facilitate decarbonisation of the national grid (see box out).



Thermal Mass in Action

1. **Reducing peak electrical demand**
This graph shows the comparative peak space heating load of a six-storey apartment building constructed using concrete compared to the same design using Cross Laminated Timber (CLT), which has lower thermal mass. On average the peak load is about 25% lower when concrete is used. Limiting peak electrical demand helps facilitate decarbonisation of the national grid. Details of the study can be found here.

2. **Saving cooling and heating energy**
Energy savings provided by thermal mass are project specific and depend on the way it is being used, but for passive cooling, research has shown that high thermal mass office buildings coupled with night-time ventilation can reduce the energy needed for cooling by up to 50%[3], and with around 10%[4] of UK energy consumption related to air conditioning, the significance of this saving is apparent. Add in the predicted growth in European air conditioning of 185% by 2050[5] and the maximum potential UK energy savings by 2050 is up to 14% of UK energy consumption, assuming thermal mass was to be incorporated in all new air-conditioned buildings going forward.

3. **Savings from Demand Side Response**
A study by 3E Consulting Engineers[6] has shown that using thermal mass in combination with a residential space heating system, controlled in response to grid demand, can reduce wastage of renewable energy supplying the grid by 35-40%.
A report by UK Fires says that domestic smart controls that make small adjustments to temperature settings to reduce peak electricity demand can save 5-10% on heating costs[7]. This is likely to be higher in homes with a useful level of thermal mass as they offer greater scope for temperature adjustment without unduly impacting occupant comfort. Their peak heating demand profile also tends to be flatter, which helps support a net zero carbon future.
The government's Heat and Buildings Strategy[8] states that flexible energy systems that use smart technologies, such as storage and smart heating systems, could save the energy generation and supply network as much as £10 billion per year by 2050. The use of thermal mass would be one of many technologies contributing to this.

4. **Reducing embodied carbon**
A recent whole-life carbon study of a six storey apartment block found that the use of concrete did not have a significant whole-life carbon impact; the difference between using concrete and cross laminated timber (CLT) for the apartment block was only around 6% over a 60 year building life cycle. Similarly, for low-rise housing, a study by the NHBC Foundation found the difference to be around 1 to 4% over a 60 year lifecycle when comparing masonry and timber construction.

Thermal mass in winter
Thermal mass can also be used during the colder months to reduce the energy needed for heating through its ability to store and release solar gains from south facing windows. This is known as Passive Solar Design and is another proven technique that continues to be highly relevant as energy bills increase. More information is included in guidance from The Concrete Centre "Thermal Mass Explained".

Smart thermal mass
Using thermal mass as a short-term thermal store, in combination with smart controlled heating/cooling systems can reduce a building's costs through time-of-use tariffs and help manage the peak energy demand. Controlling the daily heating/cooling demand in response to the grid's carbon intensity and/or cost is called **Demand Side Response** (DSR). DSR helps to reduce energy use when the grid is under stress and maximise the use of renewable power at times when it may otherwise be wasted. For more information see: Thermal Mass and Demand Side Response.

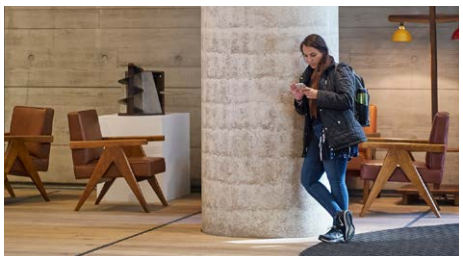
Thermal mass – building regulations and government policy
The contribution thermal mass can make towards a net zero carbon future has been outlined here and no fundamental changes to the building codes and regulations are needed to facilitate this. There is a need however, for government to uphold its neutrality on building materials and construction systems, so a level playing field is maintained. It is also important that the use of whole-life assessment continues to be encouraged as good practice and is central to any future regulations on embodied carbon.

From a technical perspective, it is important that the next update to the Standard Assessment Procedure (SAP) takes proper account of Demand Side Response, including the use of thermal storage systems; as outlined in the BRE/Robust Details SAP report. There is also a need for the measurement of thermal mass (when used in SAP and SBEM) to be updated as it is no longer sufficiently accurate. This requires a move from the basic method currently used, to the full method, both of which are detailed in BS 13786[9] . At present, the simplified method can significantly overestimate the thermal mass provided by lightweight materials.

Finally, there is a need for greater recognition of the role thermal mass can play in overheating mitigation. More specifically, the next update to Part O of the Building Regulations needs to account for thermal mass in both the simplified method for achieving compliance, as well as the dynamic method; at present it is only included in the latter.

Key policy enablers:

1. **Uphold government neutrality on building materials and construction systems; design options must continue to be performance based.**
2. **Introduce thermal mass into the next update to the 'Simplified Method' of compliance in Part O of the building regulations, which deals with overheating mitigation.**
3. **Ensure the government's stated intention to incorporate flexibility and smart technologies in the next update to the Standard Assessment Procedure (SAP) are upheld.**
4. **Ensure the government's stated intention to investigate building energy storage and flexible heating systems as part of the Future Homes and Buildings Standards, are upheld.**
5. **Ensure any new regulatory requirements for embodied carbon are based on a whole-life building assessment.**
6. **Update the way thermal mass is currently measured in respect of the building regulations.**



[1] https://www.theccc.org.uk/publication/updating-an-assessment-of-the-costs-and-benefits-of-low-regret-climate-change-adaptation-options-in-the-residential-buildings-sector/

[2] https://www.theccc.org.uk/publication/risks-to-health-wellbeing-and-productivity-from-overheating-in-buildings/

[3] Hietmaäki, T., Kuoppala, J. M., Kalema, T., & Taivalantti, T. Thermal mass of buildings–Central researches and their results. Tampere University of Technology, Instititue of Energy and Process Engineering. Report, 174.

[4] Dr Andy Lewry, BRE, article in Modern Building Services, March 2017 - UK energy use of air-conditioning reaches alarming levels.

[5] International Energy Agency.

[6] Structural thermal energy storage in heavy weight buildings – analysis and recommendations, 3E Consulting Engineers, 2016.

[7] Energy Sector Innovation within Absolute Zero, UK FIRES, April 2022.

[8] Heat and Buildings Strategy, HM Government, October 2021.

[9] BS EN ISO 13786 :2017 (Thermal performance of building components - Dynamic thermal characteristics - Calculation methods)

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