Weighty arguments

Exploiting the energy-saving potential of thermal mass does not require heavier buildings. More important is how that mass is exposed and utilised.

In reducing the active energy input to achieve comfortable environmental conditions in buildings, thermal mass is generally heralded to be a good thing. Common sense might suggest the greater the thermal mass, the better. But recent research suggests otherwise.

Heat transfer

What is more important than sheer mass on the thermal performance of a building is the correct location of that mass. In particular, for mass to be effective, it has to be available for heat transfer.

Whereas efforts to achieve high thermal mass have tended to favour the use of concrete, that approach appears to have been misguided. One line of research has discovered that there is virtually no difference in the thermal performance of steel-framed and concrete-framed office buildings in terms of thermal capacity. The same research argues that the most significant opportunities for improving thermal storage relate to aspects of building configuration and ventilation, rather than to the choice of structural material.

Thermal performance

British Steel has taken a keen interest in the effect of the physical mass of a building on its thermal performance and recently presented a seminar on the subject.*

"What is more important than sheer mass on the thermal performance of a building is the correct location of that mass"

Two engineers with Ove Arup & Partners, Fiona Cousins and Bob Lang, have used a computer program to examine the effect of thermal mass, and came up with three principal results.

- A building need not be extraordinarily massive to exploit thermal capacity.
- For mass to be effective, it has to be available for heat transfer.
- For normal occupancy patterns, 100 mm of concrete slab is effective.

But why should building-services engineers be concerned with exploiting thermal mass? The answer lies in considering heat gains and losses. Fiona Cousins and Bob Lang explain that in a typical naturally ventilated office with 100% double glazing an internal gain of 35 W/m^2 is sufficient to offset heat loss at an external temperature of 0°C. Good thermal performance during the cooling season, which could cover most of the year, is thus a desirable characteristic. High mass can help, but does not alone guarantee good thermal performance, as a computer simulation demonstrates.

The model was of two South-facing offices, surrounded by other offices and with 20% glazing on the South face and a moderate internal heat gain of 30 W/m^2. Both rooms had concrete walls, ceiling and floor. In the 'high mass' office, this concrete was left exposed. The other office was converted to 'low mass' by the installation of elements with low thermal mass, including a raised floor, suspended ceiling and plasterboard studwork on the walls. The dry resultant temperature (DRT) was analysed, this being an important measure of comfort and defined as the average of air temperature and the area-weighted mean temperature of all the surfaces enclosing the room.

Temperature swings

With the windows left open overnight, the temperature swings in the high-mass office were smaller than in the low-mass office. The high-mass office was warmer at the start of the working day.

"More and more mass does not necessarily

Finding the right renewable software will be easier with Adept

Researchers in Ireland are compiling a database of renewable energy software for the building services profession, accesible via the internet .

A consultant asked to incorporate renewable energy technology into a design has had no easy way of checking the availability of software for simulation and technical calculations. The Adept project is intended to offer independent assessments of programs. There will also be links to other renewable energy web sites.

Technologies covered by Adept include HVAC, passive solar, active solar, photovoltaic, daylighting, site analysis, smallscale wind and biomass CHP.

The database specification for each program covers such sections as user group and uses, hardware and software requirements,

Siebe goes high on groundwater

The biggest project so far in Holland to capitalise on the country's high water table by incorporating underground water storage into a heating and cooling system is nearing completion in the Hague. And the key to the effective operation of the system are controls from Siebe Environmental Systems.

The system serves the refurbished and expanded Palace of Justice in the centre of the city. Water is stored in two sandbanks 80 m deep and 120 m apart. Water passes through the services system at up to 3000 m^3 per day. This groundwater plays an important role in cooling during the Summer. Water is drawn from the cold-water storage and passed through two stages of heat exchangers. In the low-temperature phase (7 to 17°C) cooling is provided by batteries in the air-handling units taking the air down to 9°C. In the high-temperature system (17 to 19°C), the water is used for removing heat from the chiller condensers before returning to the hot storage bank in the ground.

In the Winter, the water is cooled to 7°C before being taken back to the cold-water storage.

There are 1500 VAV boxes installed on a 3.6 m grid throughout the complex. Occupants can control their own environment through intelligent sensors linked to Siebe MicroFlow and MicroNet controllers. All the VAV controllers are linked to an UltiVist head end, which also controls the lighting and monitors and controls three air-handling units, chillers and all associated HVAC equipment, together with the hot-water system.

The large, and growing site, includes a new 19-storey office building of 24 000 m^2, a refurbished 13-storey building comprising 22 000 m^2 of offices and 28 000 m^2 of court rooms, and a further 5-storey extension being built over the 4-lane highway linking the Hague with Utrecht.

Reader Reply No. 114

Water stored in an underground sandbank provides cooling for the Palace of Justice in The Hague, with a little help from an extensive Siebe control system.

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Closing the windows overnight led to a very different temperature regime. Because the rooms cooled only very slightly overnight, the daytime peak indoor temperatures were higher in both types of office. In the low-mass office, the highest temperature was nearly 33°C (2 K higher than if the windows were left open overnight), with nearly 32°C in the high-mass office (3 K higher). The simulated external temperature pattern was the same.

As windows were opened in the morning, the indoor temperatures fell rapidly, and more so in the low-mass office.

Night-time ventilation thus reduces peak indoor temperatures by about 2 to 3 K during the following day. Further, a high mass office with night ventilation has a 4 K advantage over low mass with no overnight ventilation.

Importance

A consideration of applying air conditioning to bring the indoor temperature down to 22°C shows the importance of night-time ventilation in the high-mass office. The lowest sensible cooling load was for the high-mass office with overnight ventilation, whereas the highest load was for the same office without overnight ventilation. This is because the mass is only able to help reduce the load when its temperature is allowed to vary. The peak load without overnight ventilation was over 25% higher than if the office had been ventilated overnight.

Four factors

Further more detailed analysis by Fiona Cousins and Bob Lang showed that more and more mass does not necessarily improve the benefits of thermal mass. More important is how and where mass is incorporated into buildings. There are four factors to consider:

- U value;
- decrement factor;
- surface factor;
- admittance factor.

A low U value reduces the rate at which heat from the Sun shining on it is conducted to the inside, and a light surface can reduce the temperature gain of the external wall compared with a dark colour, so there is less heat to be conducted. A low U value is good, and this points to a thick wall.

The decrement factor depends on how long heat takes travel through the wall. He
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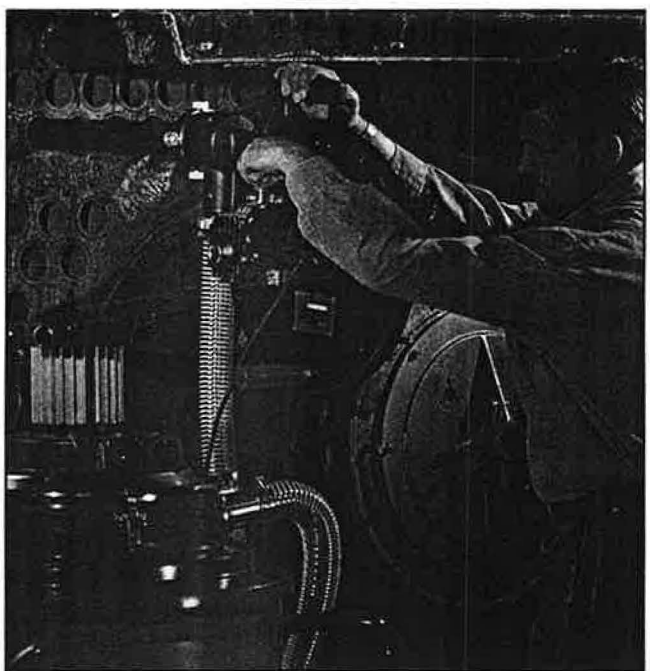

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concrete on the outside improves the admittance. However, interior insulation reduces the admittance drastically.

For best performance, U value, surface factor and decrement factor should all be low, and the admittance should be high. Surfaces with these properties include externally insulated concrete, brick and block. However, for these benefits to be exploited, it is essential that the mass is exposed and that the temperature of the interior of the building be allowed to vary overnight.

Finding mass

There is likely to be plenty of mass available in a building. According to Fiona Cousins and Bob Lang, structure, partitions and finishes may weigh 150 to 250 kg/m^3. Much of the structure, however, is hidden behind cladding, ceilings and false floors, which act as insulation so that it is not available for thermal capacity.

Partitions have considerable potential as a climate moderator, ranging from 50 to 150 kg/m^2 or more of developed floor area.

Floors and ceilings also provide potential thermal capacity. It is not necessary to attempt to supply a lot of mass, since only the outside 10 cm or so of concrete mass is effective on the temperature cycles and usage profile associated with a modern office.

Dynamic modelling

Two other researchers at the British Steel seminar confirmed these findings. They are Dr Raymond Ogden of Oxford Brookes University and Nick Barnard of Oscar Faber Consulting Engineers. They used thermal dynamic-modelling techniques to assess the passive thermal performance of equivalent buildings with steel and concrete frames. These buildings had various structural and ventilation systems and exploited thermal mass to reduce daily temperature variations within them. Dr Ogden comments, 'We found that high physical mass is not necessary to achieve high levels of fabric thermal storage and that steel-framed buildings, despite being generally lighter than equivalent concrete-framed buildings, have nearly identical thermal performance on grounds of thermal capacity.

'It is our view that the most significant opportunities for improving thermal storage would appear to relate to aspects of building configuration and ventilation, rather than the choice of structural material.'

Opportunity

Robert Latter, marketing manager for structural steels with British Steels, summarises, 'These research projects highlight that you do not need heavy mass or thick floor slabs, such as *in-situ* reinforced concrete, to achieve an energy-conscious building. There is now every opportunity to design "lean", light and thermally efficient steel buildings.'

'Thermal mass — a new perspective' was organised by British Steel (Sections, Plates & Commercial Steels), Steel House, Redcar, Cleveland TS10 5QW.

Sun of air conditioning

Gaia Research of Edinburgh is to examine the technical and economic feasibility of solar-powered air conditioning in UK climates. The research will set out to determine if dessicant cooling, using solar thermal heating for regeneration, might offer a reliable and cost-effective alternative in the UK to other methods of air conditioning.

Sandy Halliday, the project leader, explains, 'There are many applications where mechanical cooling is necessary, and solar air conditioning may prove to be an elegant exemplar of a clean, sustainable technology consistent with Government commitment to sustainable development.'

At present, there is no working demonstration project in the UK, but this venture will identify a suitable site for a demonstration project and provide information to assist in the cost and technical assessments which will encourage its widespread application in the longer term.

Gaia Research is seeking to create a steering group. Details from 0131-661 1589.

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Using the sun to cut greenhouse gases

Although solar collectors have never become mainstream products in the UK, they can provide up to 60% of the energy required by domestic hot water systems in both residential and commercial buildings.

Viessmann introduced

greenhouse gas emission levels,' said UK managing director John Rigby.

The collectors can be mounted on the side of a building as well as on flat or pitched roofs, and up to six can be connected in series to give a surface area