The Weidmuller hq at West Malling, built in 1994, uses the Swedish passive cooling system Termodeck. We examine the results of in-use system performance tests.

DR ROBERT WINWOOD REPORTS

What's in store for Termodeck?

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References
[1]Bunn R, "Slab and trickle", *Building Services Journal*, February 1994, pp30-32.
[2]Winwood R, "The application of advanced fabric energy storage within UK commercial buildings", PhD Thesis, University of Manchester Institute Of Science and Technology, October 1995.
[3]Bunn R, "Teaching low energy", *Building Services Journal*, April 1995, pp19-23.
[4]"Cambridge calling", *The Architects' Journal*, December 1994, pp29-38.

[1]The monitoring results will be used to produce a set of guidelines for the design of advanced fabric energy storage buildings. The results will be presented at the joint CIBSE/ASHRAE Conference in October, and at a seminar to be hosted by EA Technology during the spring of 1997. For details telephone Dr Robert Winwood on 0151-347 2588.

Weidmuller's prototype hq, located on the site of an old RAF airfield at the Kings Hill Business Park in West Malling, Kent, was the first of a trio of UK buildings to be built using the Swedish passive cooling system Termodeck[1].

The Termodeck system uses the thermal storage capacity of a building's structural mass to regulate its internal temperatures. By making use of hollow core concrete slabs, the building's 'effective' thermal mass is enhanced by passing ventilation air through the centre of the slab before it enters the room.

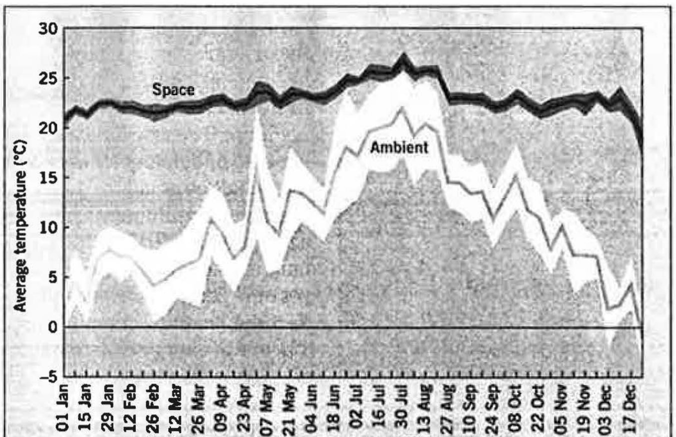
This bond and the slab's high thermal inertia produce stable space temperatures which, so long as it is properly controlled, provides consistent, robust and comfortable working conditions.

Monitoring tests

Throughout 1995, EA Technology carried out independent monitoring tests of the temperatures and energy consumption levels experienced at the Weidmuller offices.

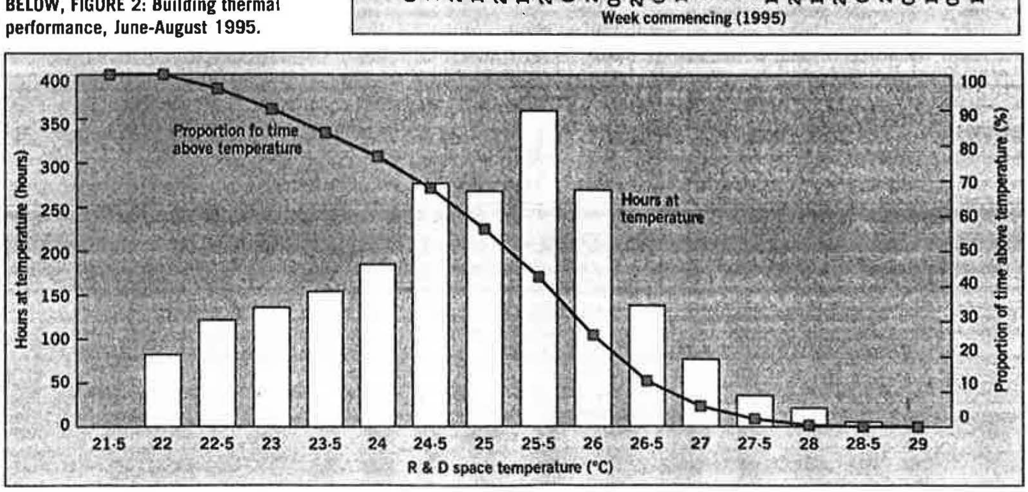
Although the other UK buildings equipped with the Termodeck system – namely the Elizabeth Fry building, University of East Anglia and the Ionica building in Cambridge – were monitored to some extent during 1995, only at the Weidmuller building has it been possible to present the complete picture.

Figure 1 shows the weekly average space temperature in the west-facing r&d office, alongside the weekly average ambient temperature. The dotted lines indicate the standard deviation of each point.



RIGHT, FIGURE 1: Weekly average space and ambient temperatures in the west-facing r&d office, January-December 1995.

BELOW, FIGURE 2: Building thermal performance, June-August 1995.



The relatively flat profile and the small standard deviation of the space temperature indicates the building's smoothing effect upon both seasonal and daily temperature swings. The dip in the space temperature during the last week of the year was due to the combination of exceptionally cold weather and the Christmas week, when the building was unoccupied and no daytime heating was used.

Winter and summer performance

During winter, comfortable temperatures were maintained throughout the season, the only disappointment being that insufficient heater sizing made it impossible to shift the entire heating load to off-peak periods.

Figure 2 summarises the building's thermal performance throughout June, July and August. Peak internal air temperatures reached 28·5°C, although computer modelling suggests that the corresponding dry resultant temperatures would have been between 0·5°C and 1·0°C below this, due to the slab's radiant cooling effect[2].

The high summer temperatures were due to a combination of warm nights (1995 was the hottest summer for 20 years) and uncontrolled heat gains in the ventilation system which, during August, eliminated 67% of the available cooling before the air reached the slabs.

Energy consumption levels

The building has two air supply zones – the ground and first floors – each of which is split into two heating zones corresponding to the west and east-facing offices.

Fans are sized at 9·5 kW per ahu, while the heater batteries are rated at 15 kW. Specific fan powers are about 3 W/l/s, but the Elizabeth Fry building[3] has shown that this can be reduced by at least 1 W/l/s.

Heater sizing is another significant issue. During March

BELOW, FIGURE 3: First floor energy consumption due to fans and heater batteries, January-December 1995.

BOTTOM, FIGURE 4: Energy use by operational mode.

BELOW RIGHT, FIGURE 5: Energy consumption and cost by end use.

1995, only 29% of the energy consumed during night-time heating reached the concrete slabs, with the remainder directed to overcome uncontrolled heat losses in the ventilation system.

Larger heaters would have resulted in an increased proportion of the supplied energy reaching the slabs, reducing daytime operation.

Energy performance

Figure 3 highlights the first floor energy consumption of the fans and heater batteries. The total was 106 kWh/m², slightly disappointing but corresponding well with the energy target of the Ionica building (103 kWh/m²)[4].

The Weidmuller building's higher-than-anticipated energy consumption was mainly due to the relatively high specific fan power and initial commissioning problems. For example, 7·5 kWh/m² can be attributed to the bems calling for night cooling while leaving the air handling unit in heat recovery mode, resulting in 730 h of wasted fan operation.

Figure 4 shows a breakdown of the 1995 plant operation at the Weidmuller building in hours run, energy consumed and energy cost. The energy cost figures have been calculated on an assumed 9p/3p peak/off-peak tariff.

Moving all of the heating to the daytime – therefore eliminating the need for night-time fan operation – would have cut the building's energy consumption by 10% to 95 kWh/m², however it would have increased the energy cost by 16% to £7.71/m² due to the poorer peak/off-peak split.

Had the heater batteries been larger, and therefore able to shift to the night the heat which was supplied during the day, the energy cost would have been reduced by 18% to £5.46/m².

Energy use by function

Energy consumption and cost by end use is shown in figure 6. It can be seen that the fans accounted for 65% of the energy consumed and 72% of its cost, highlighting the crucial importance of maximising fan efficiency. Had the fans had a specific efficiency of 2 W/l/s, as at the Elizabeth Fry building, then the energy consumption and cost would have been reduced by 22% to 83 kWh/m² and 24% to £5.05/m².

At a fan power of 1W/l/s, these figures would have become 60 kWh/m² and £3.50/m² respectively.

Figure 5 clearly indicates the benefits of demand shifting and the penalties of failure. For example, night operation accounted for 46% of the building's energy consumption yet only 22% of its cost, while daytime heating accounted for 12% of the energy consumption and 18% of its cost.

Analysis of the Weidmuller data suggests that, with more efficient fans and improved night heating, a Termodeck building should be able to attain an energy target of between 50 and 70 kWh/m², depending upon heat gains, heat loss characteristics and local weather conditions.

Improvements for 1996

The Department of the Environment is providing the necessary funding for EA Technology to continue monitoring the Weidmuller building for another year, which will allow several improvements to be closely monitored[†].

An improved control schedule is to be implemented which should reduce energy consumption and improve thermal performance.

Work will also be carried out to reduce the uncontrolled heat gains to the ventilation system, and the heater batteries may be upgraded to allow fully off-peak operation.

Advanced fabric energy storage offers the potential to combine low energy, environmentally friendly buildings which have low running costs and a pleasant internal environment with the benefits of controlled temperatures and ventilation rates while avoiding the vagaries of natural ventilation or using refrigeration plant.

However, monitoring has shown that, for optimum performance, an advanced fabric energy storage building must be considered as an integrated whole with particular attention paid to the maximisation of fan efficiency, minimisation of uncontrolled ventilation heat gains, correct sizing of heater batteries and selection of an appropriate control strategy.

Continued monitoring will provide design guidelines which should help to achieve this.