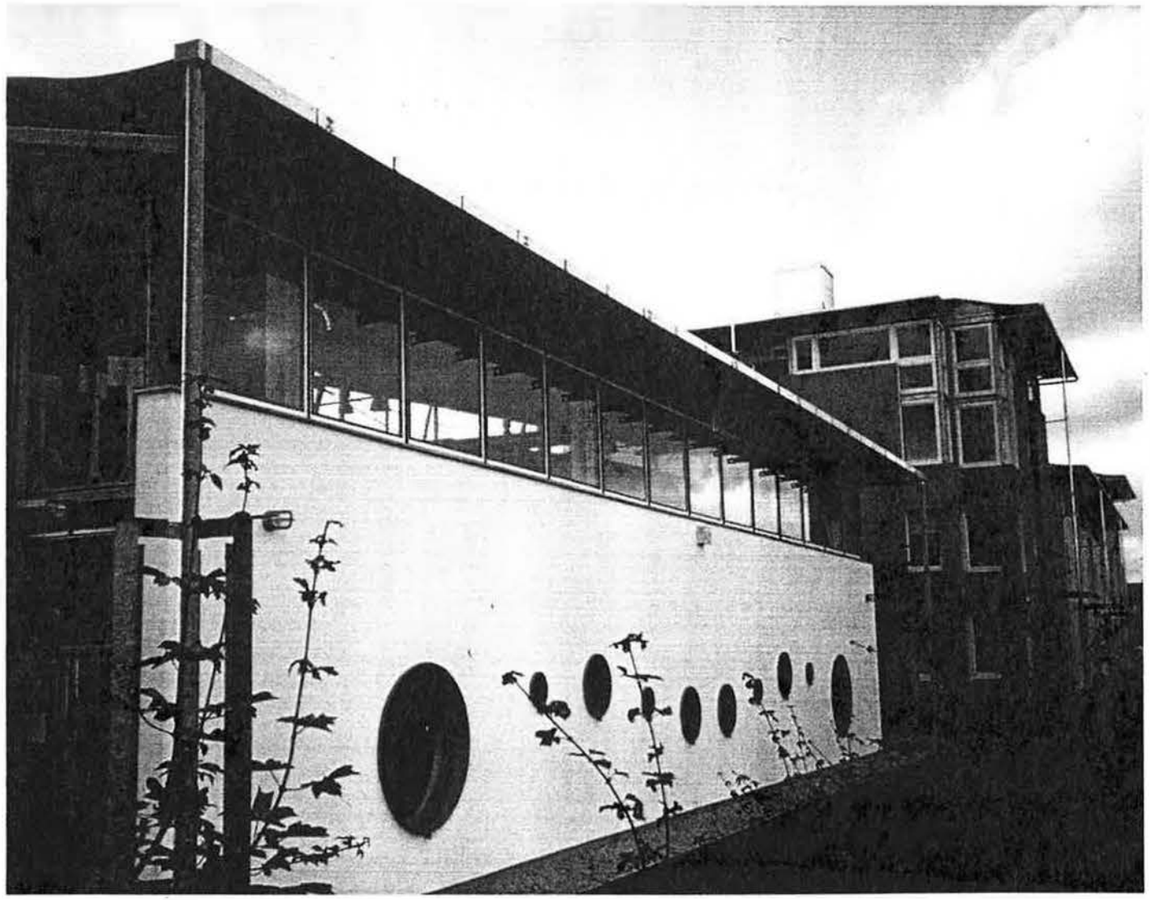
Theme: Insulation and Energy Conservation

There are two factors that are set to dramatically transform the way in which we design and fabricate our buildings in the early twenty-first century – insulation and energy. We need to maximise the insulation levels of our buildings while at the same time rethinking the ways in which we consume and even produce the energy needed to run them. In this article we take a brief look at both subjects and examine projects and ideas which reveal how these aims can be realised.

BY KEITH HALL

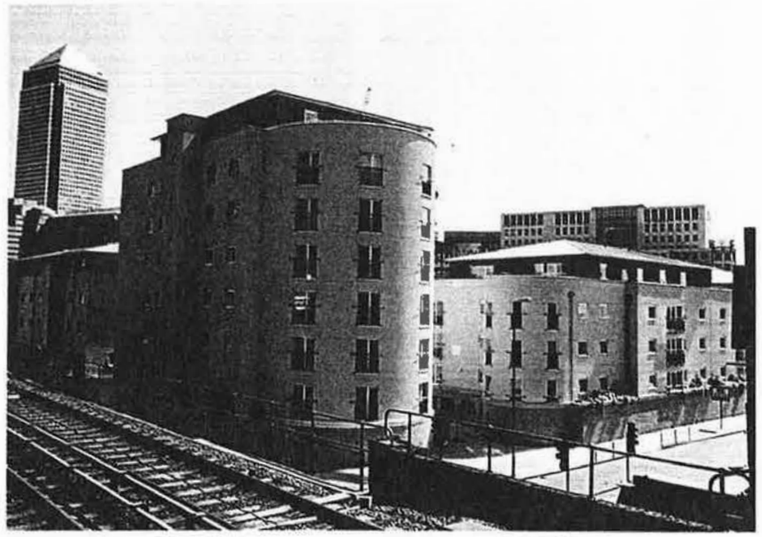


Cheltenham and and Gloucester College of Higher Education, EWIA Awards '98 winner, features a StoTherm Classic external wall insulation system

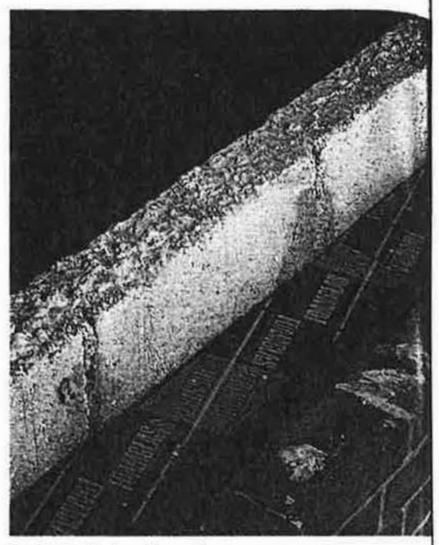
External wall insulation is being used increasingly in the UK for new-build work, and the External Wall Insulation Association (EWIA) offers an annual award to recognise and encourage the development of this building style. In continental Europe, solid wall construction, using this process, has been the predominant form for many years. The winner of the 1998 award was Edward Cullinan and Partners, for its design of student residences and amenity buildings for the Cheltenham and Gloucester College of Higher Education. This involved the use of a StoTherm Classic external wall insulation system, incorporating 100mm of EPS insulation to give a U-value of 0.34W/m²K, mechanically fixed on to 190mm concrete blockwork and finished with a low-maintenance Stolit self-coloured silicone-based decorative render.

A special design feature of the project was to wrap the insulation around the windows, with the insulation and render system forming the sill of the window. The simplicity and flexibility of the jointless system reduces air leakage, while providing an aesthetically pleasing appearance. The system used met all the specifier's requirements with regard to thermal performance, exceeding the demands of current Building Regulations. The architect was looking for a low-cost yet highly energy-efficient building that would be elegant enough to blend in with the Regency environment, for which the Cheltenham landscape is famous. The college's energy manager, John Willoughby, estimates that, since opening, gas consumption for space and water heating is in the region of 105kWh/m²/year, half that of the Higher Education Funding Council benchmark of 200-290kWh/m²/year.

The runner-up for the same award was Phase Two of Premier Place in London. This is a new residential development of 127 flats and houses, designed by Chassay and Last



Premiere Place in London's Docklands, EWIA Awards '98 second place winner



Foamglas Perinsul from Pittsburgh Corning

Celcon 200mm Solar aircete blocks were used with Tektalan-E21 wall insulation boards from Heraklith to achieve a U value of 0.32W/m²K for this recently-built terraced house in Stroud

Architects – a winner the previous year – on behalf of the client, Regalian Properties. The architect specified the StoTherm Classic external wall insulation system. This was achieved by using 140mm blockwork and 80mm polystyrene insulation and the Stolit acrylic through-colour renders, and with the polymer-based silicate Sto paint finish to give increased water-shedding properties and low dirt pick-up.

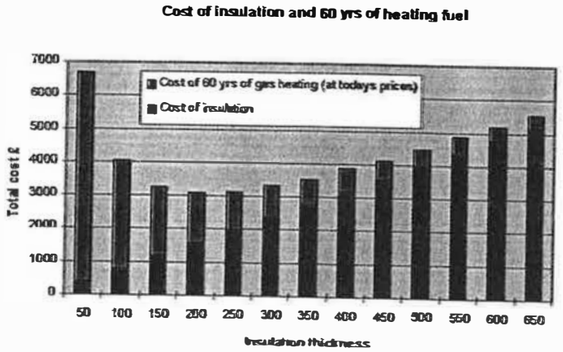
On a smaller scale project, Tektalan E21 wall insulation boards from Heraklith have been used in conjunction with Celcon 200mm Solar aircrete blocks to create a solid wall construction that achieves a total wall U-value of 0.32W/m²k for a terraced house recently built in Stroud, Gloucestershire. Insulation boards (woodwool/mineral fibre composite) 50mm thick were applied directly to the blocks using a simple dowel fastening method and finished using the Heraklith rendering system. Limestone spar chippings were applied as the render finish to complement the Cotswold stone of the adjacent house.

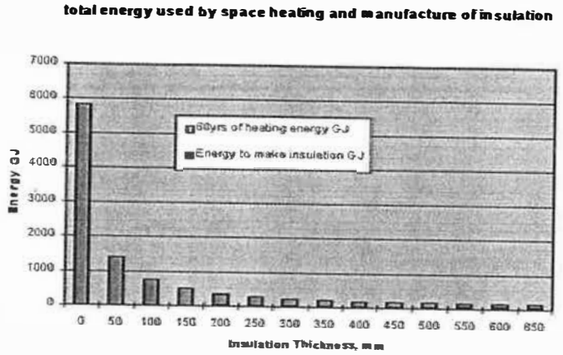
James Muir, Heraklith's UK agent, commented, 'The ease with which our boards can be fixed to Celcon's blocks makes them an ideal partner for our system. The builder involved in the Stroud project found the combination very simple and quick to construct and, as a result, intends to build again in the same way.'

Thermal bridging questions

Any building system that relies on blockwork or concrete as its structure will need careful consideration of heat losses at the junction of wall and floor insulations. The better the insulation levels that are aimed for in the structure, the more attention to detail is needed at these thermal bridging points.

One product that answers this problem, without over-complicated detailing, is Foamglas Perinsul from Pittsburgh Corning. Perinsul, like all of the Foamglas range, is a rigid insulation board (though in coursing sizes) consisting of glass cells with a closed structure, the result of a chemical reaction between oxidised glass and carbon at high temperature. This chemical reaction forms carbon dioxide (CO_2) at temperatures where glass is viscous, so that the CO_2 is imprisoned indefinitely in the glass by forming millions of bubbles. Foamed glass insulation has two unique properties, its strength and its durability, which put it in a category all of its own.



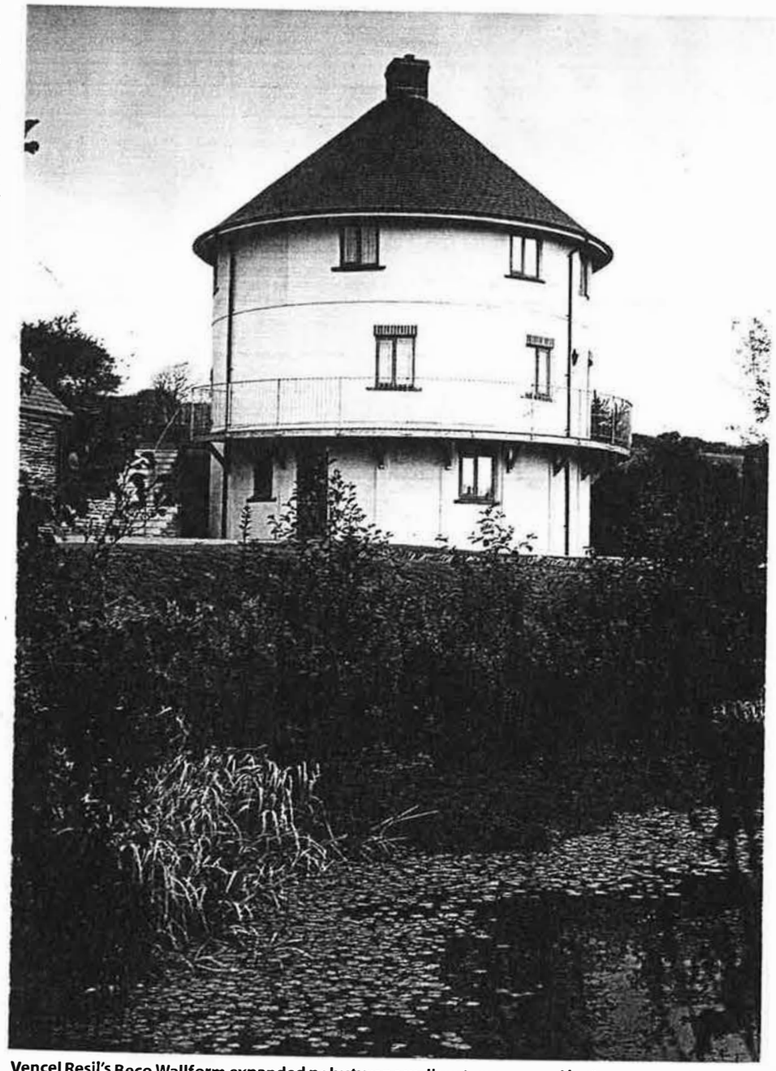


Thickness of insulation

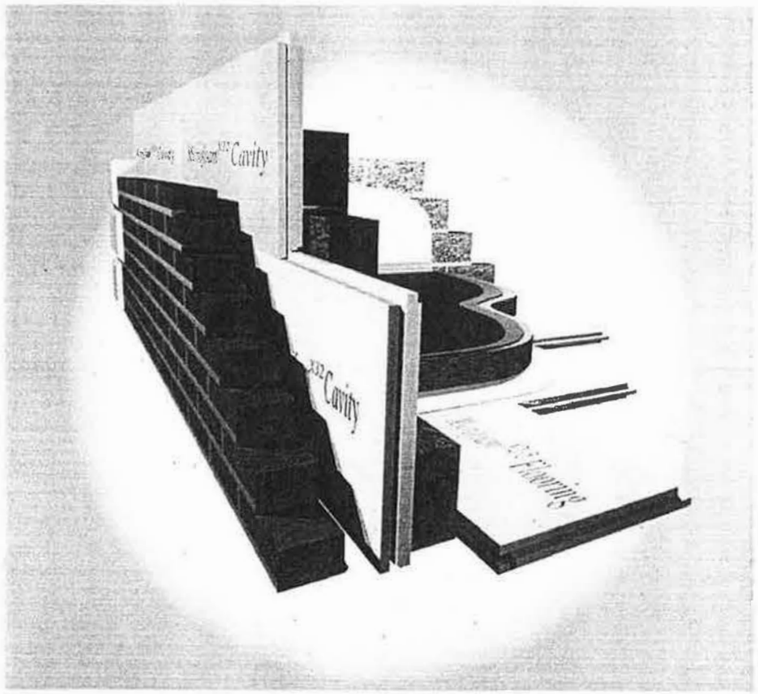
In a report for *Building for a Future* magazine last year, energy consultant Peter Warm outlined the optimum thickness of insulation on a cost payback scenario over 60 years, using the cheapest air-based insulant available and based on current prices. The report concluded that when fully insulated (floors, walls and roof) at a thickness of below 200mm in a typical semi-detached home, the heating fuel has a far more dominant cost when compared to the insulation. When insulating around or above these levels, the cost of the insulation becomes more significant (*see Fig 1*).

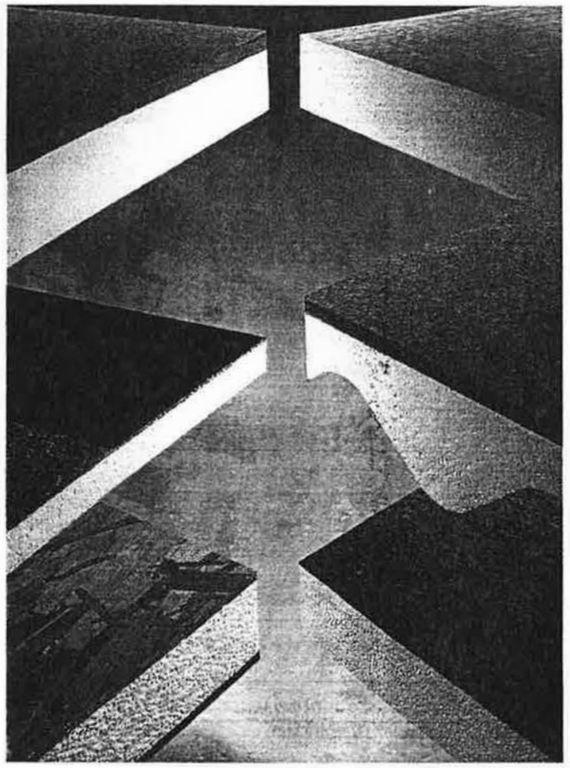
A second comparison the report makes is to compare the energy consumed in the manufacture of the insulation to the energy it saves over the same 60-year period (*see Fig 2*). This shows just how insignificant the embodied energy of the mineral fibre insulation is compared to the consumption of fuel used in heating the building. From this comparison you can see the thickness in energy terms is more than 650mm. Heating system efficiency or different insulation types might have a small effect on this chart but is unlikely to change the conclusion. It would seem, then, that the only constraints are practical – just how can we incorporate such high levels of insulation into our buildings? This confirms that much of what the insulation manufacturers tell us is common sense and, providing we follow this common-sense approach through to its logical environmental conclusion, we can be confident of having made the best environmental choice.

An innovative walling system, Beco Wallform from Vencel Resil, offers buildability beyond traditional cavity construction. The CFC-free, HCFC free and Zero ODP Beco Wallform EPS wall system has been used in the construction of a unique three-storey, four-bedroom 'round house'. Built on sloping ground beside a lake at Roserrow Golf Course, it is of a rendered



Vencel Resil's Beco Wallform expanded polystyrene wall system was used in the construction of this three-storey, four-bedroom 'round house' at Roserrow Golf and Country Club in Cornwall





Above: Microfoam® Eps² cavity and flooring insulation, new from Springvale EPS. Left: Combat Polystyrene's 1999 Roofshield range of expanded polystyrene for flat and pitched roof insulation

construction to contrast with the natural stone of adjacent properties. The system is of hollow, lightweight blocks that simply lock together, providing a formwork into which concrete is poured in-situ to form a structural wall with high levels of thermal insulation. This method of construction offers a U value of just 0.28w/m²K combined with sound insulation of 45dB, and is claimed to eliminate many of the problems associated with the weatherproofing of cavity wall construction on exposed sites.

Telling markets a product called Unilit 20. Unilit 20 is a lightweight hydraulic lime/perlite insulating render system that was actually developed for use on historic buildings, where its lightweight and natural properties are sympathetic to the structure. This system, however, is used commonly as a complete insulation/render solution in thicknesses up to and beyond 200mm. Spray-applied in two, three or four coats it can achieve U values far in excess of the current building regulations. The system was recently used at a thickness of 200mm on a project in London. The beauty of the Unilit system is that it is totally hygroscopic and needs no mechanical fixings or other components.

Springvale Insulation has launched a new line of modified expanded polystyrene insulation systems. The Microfoam EPS building solutions system has improved EPS performance, and therefore a reduced thickness is needed to achieve the required (current) building regulations standards.

The Roofshield T-Board from Combat Polystyrene is a 'between and over the rafter' polystyrene insulation block which can provide good thermal values due to the thickness achievable. Standard board thickness up to 175mm is available, offering U values of 0.20W/m²K.

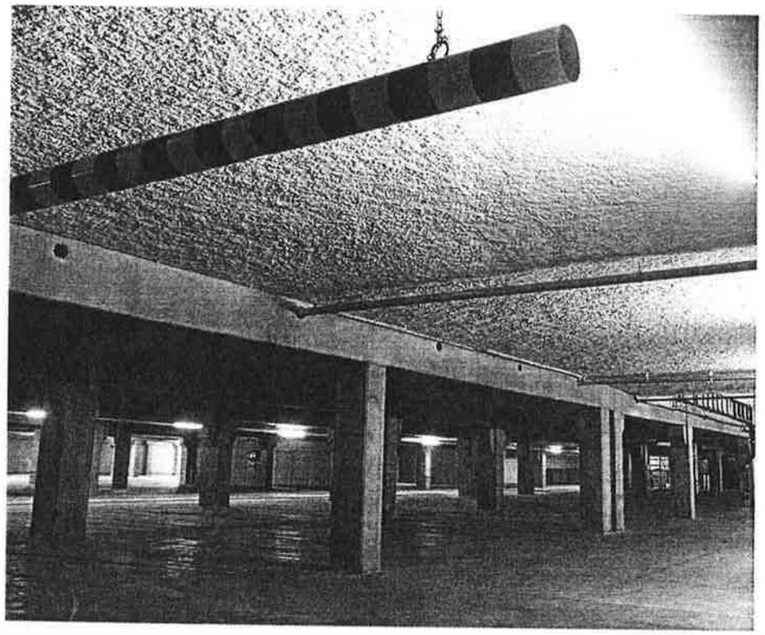
Thicker still?

When the debate regarding insulation gets to a point where thicknesses of 300mm or more become a serious consideration, then a rethink of common building practices pertaining to walls and, to some extent, roofs is probably needed. The best performing buildings will be those that have fast shedding of water with little more moisture absorption into the fabric beyond a level that is soon dissipated by drying winds between showers. To satisfy this criterion for heavyweight structures, external insulation with a render or similar rainscreen could well be the best answer. Lightweight buildings, however, have the added advantage of being able to maximise the thickness of insulation, although there are presently limitations on the scale of such structures.

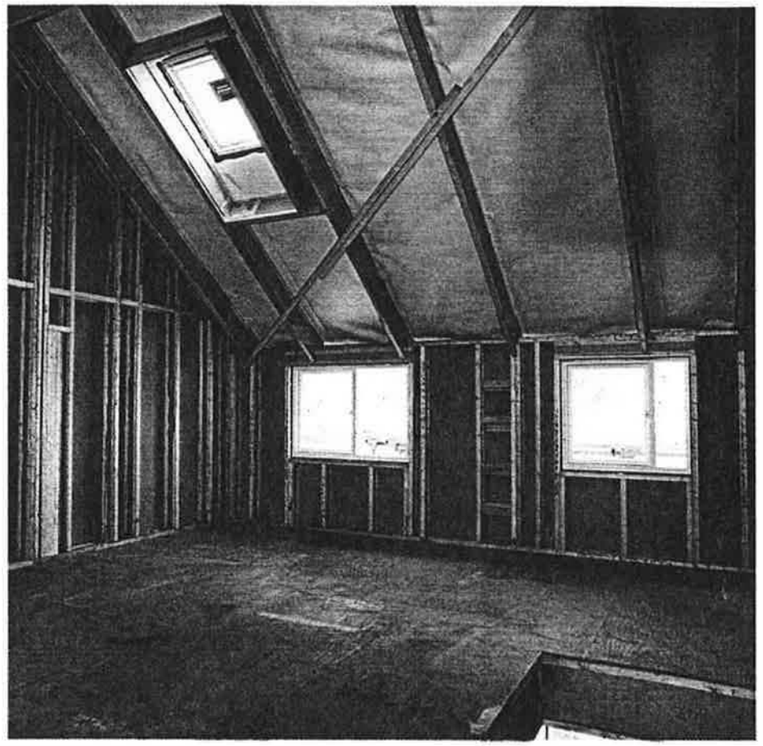
Insulation for use in protected applications such as within a timber frame, loft space or suspended flooring, can be sheep's wool, flax, cellulose fibre and corkboard. These products are becoming increasingly popular due to their naturalness and user-friendliness. For the specifier they offer an opportunity to reinforce the 'healthy' aspects of the indoor environment when integrated with such measures as natural ventilation, untreated wood, natural paints etc. Because of the increasing awareness of the public regarding health issues we are likely to see far more use made of these products in the future.

Cellulose fibres

A closed panel Breathing Wall solution from Fillcrete has been specified for the construction of 23 new homes for CDS Housing in Harlow Park, Liverpool, by the specialist social housing and public-sector architect Architype, whose designs focus strongly on energy efficiency and sustainability. Among the key criteria leading to the selection of the Fillcrete system were excellent insulation properties, the requirement for materials to be from recycled or sustainable sources and the need for 'risk-free' construction.



Available from Oscar Acoustics, Sonatherm features expanded polystyrene oversprayed with SonaSpray K13 cellulose fibre, achieving a class O fire rating and Rc 2.5W/m²K when 70mm polystyrene is used with 20mm of K13



Fillcrete's closed panel Breathing Wall in use in 23 new homes for CDS Housing in Liverpool

Jon Broome of Architype explained the background to the project: 'Our overall aim was to minimise the impact on the environment, not only in the energy consumed in running the houses, but also in terms of the embodied energy in the materials we used – ie, the amount of energy that goes into producing the products themselves.'

The houses at Harlow Park have less than half the embodied energy of similarly sized, conventional houses. It is estimated that these houses will cost 30 per cent less than conventional houses to heat. The Fillcrete Breathing Wall will play a fundamental part in this, delivering a U value of only 0.19W/m²K while delivering a high level of breathability and enhanced vapour transfer, which means that moisture inside a building can safely migrate through the structure to the outside. The air-tightness of the Breathing Wall system assists in producing the enviably low U values, as does the use of masonite beams, which are able to provide the required structural performance for the walls, while minimising cold bridging. The closed panel Breathing Wall comprises masonite beams, Warmcel 500 cellulose fibre insulation and Panelvent® sheathing on the cavity side of the frame.

Construction Resources of London market a similar cellulose fibre product to Warmcel – Ekovilla, which is suitable for similar applications. Both Warmcel and Ekovilla can be damp-sprayed between the studs of timber-frame walls or blown in dry under pressure between roof rafters. The thermal conductivity of cellulose fibre insulation is 0.0375W/mK and the products typically contain recycled newspaper (pre-consumer waste), with added boric acid/boron as a fire retardant and fungicide.

Cork

Cork originates from the bark of the cork tree (*Quercus suber*) which is grown extensively in Portugal and Spain. The cork (outer bark) is stripped from the tree at nine-year intervals without harming the tree, while the ground beneath the trees can be used for other agricultural practices such as grazing sheep. The 90 million hectacres of cork forests in Portugal appear to be meticulously managed. Cork is a highly ecological choice for sustainable building as there are no added substances. The cork is granulated and steam-baked under pressure, bonding the granules together using its own inherent natural resin. Applications for cork are increasing rapidly. Cork is much more chemically inert than other materials and is therefore capable of withstanding deterioration through age, and it is resistant to the penetration of moisture. Cork has a thermal conductivity value of 0.042 W/mK.

Western Cork, British Cork Mills and Construction Resources market rigid cork boards for partial fill cavity wall, loft insulation, cut to falls and external cladding applications.

Sheep's wool

Hailed by some as the ultimate eco-insulation, sheep's wool certainly satisfies all of the criteria thought to be necessary for an eco-insulation product: breathability, low embodied energy, low toxicity, etc. For the installer, it is said to be an absolute pleasure to use, with no associated dust, fumes or gases. The raw wool used in the SFPL wool insulation from Construction Resources is bought direct from small-scale farms in Austria, where chemicals and pesticides are used on neither the land nor the sheep. Samples are regularly tested by the Austrian Institute for Building Biology.

The production process couldn't be simpler. After shearing it is washed and combed to shape (to form dense batts) before natural borax is added for fire resistance and as an insect repellent. Klober UK has also launched a competitively priced sheep's wool insulation batt from New Zealand that has already found favour in many domestic installations. Its pure wool mix is available in thicknesses of 50mm and 100mm.

A feasibility study partnership has recently been established, with European funding, between the Centre for Alternative Technology and CYMAD to study the potential for the establishment of a sheep's wool insulation manufacturing plant in North Wales, using Welsh fleeces.

Flax

Flax insulation is a high-grade insulation made from the stem of the plant grown for linseed oil. Heraflax insulation batts are marketed in the UK by Heraklith, and have an extremely low embodied energy. The flax plant takes three to four months to grow to maturity, which is followed by a four-to-six-week drying period during which time the stems of the flax plant are allowed to die back before it is harvested. The long fibres are separated and used for linen making and the short fibres are used for making insulation. The fibres are interwoven and bound with polyester, which helps to form the insulation batt. Heraflax is available in two standard thicknesses of 60mm and 80mm. Klober UK

markets a similar product, also in batt form but with a 20 per cent sheep's wool content. Flax insulation has a thermal conductivity value of 0.042 W/mK.

Hemp

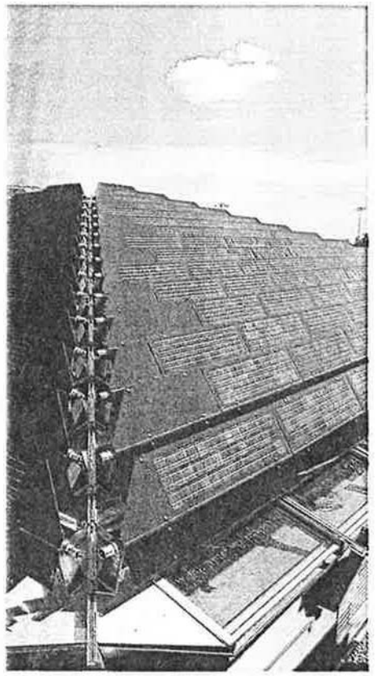
The Hemp Union has begun distributing a new hemp insulation batt called 'Thermo Hemp'. Grown in Germany, this eco-insulation has (like all natural insulations) superb breathing properties and is totally non-toxic. It is available in thicknesses from 40mm to 160mm. The Hemp Union was established a few years ago to promote the growing of hemp as an industrial agricultural crop in the UK. Unfortunately UK legislation severely restricts it as a commercial crop in this country, which in turn hampers the development of hemp products.

Energy

Photovoltaic cell arrays mounted on buildings are likely to lie behind the greatest architectural changes to buildings in the early twenty-first century. According to a recent report from the Worldwatch institute, sales of solar cells expanded by more than 40 per cent in 1997, making it the world's second fastest-growing energy source (next to wind).

The sun bathes the earth with 1900 times the energy that mankind presently consumes, and this is only one of the free renewable resources available to us. ETSU (Energy Technology Support Unit) spent much of the 1980s researching the passive solar potential for the heating and cooling of buildings. The results were not conclusive enough to encourage the widespread uptake of the concept, but projects that are able to and have taken advantage of solar positioning and passive solar design have, in the main, proved successful.

Passive solar design is a site-specific issue, which may be of limited advantage to inner-city developments where over-shading often occurs and orientation of buildings is limited. Office buildings commonly overheat from too much sunshine, and vast quantities of energy are subsequently consumed in cooling plant. To answer this problem one company, Colt International, has come up with a double trump card: shading and power generation in one unit – Shadovoltaic Wings which are actually photovoltaic louvres, ideal for large glazed (roof or facade) buildings. They are assembled on frames that lie on a joint torsion tube turned by an electric actuator so that they are aligned at right angles to the sun's rays. The wings perform two main functions: the shading of the building and the generation of electricity.



Shadovoltaic Wings from Colt International combine solar shading with photovoltaic cells

This is surely the future for commercial buildings of the next millennium: they will become autonomous power stations, boasting their own power supplies and, coupled with intelligent management systems, controlling the functions of integrating renewable power which can be generated on the building fabric, where any excesses are exported to the grid, and the best performers actually profit from their designs.

Domestic autonomy

At a domestic level, power generation and energy autonomy is set to boom, providing that the heat energy requirements of the house (space and water heating) are reduced far beyond the current building regulations expectations. Off-the-grid homes even where a grid exists will soon become an everyday sight. Although Redland's launch of a roof-integrated PV roof tile in the UK has met with a slow start, as prices fall and other products enter the market this is certain to become more popular.

The much publicised David's' House near Monmouth, designed by Eco-Arc Architects of York, combines many of the ideas I have discussed in this article. In the garden is a self-contained power generation set-up: 28 BP Solarex photovoltaic panels provide a 2.1kW peak rating. These are mounted on a simple garden timber trellis. This arrangement permits optimum solar orientation without compromising the building. The array's performance is improved by avoiding excess heat build-up on the panels. The trellis allows the panels to be easily cleaned and maintained without roof ladders, and the system can be extended if, after the first year's monitoring, this appears necessary.

Due to the seasonal and day-to-day fluctuations in any solar array output, the system is complemented with a matching 2.5kW Scottish-made Proven wind turbine. The combined wind and solar provision will give a more consistent and steady supply of renewable energy with the ability to adapt to seasonal variations.

To ensure a continuous electrical supply when there is no sun or wind, a 48-volt DC battery bank stores up to 17kW hours of energy. An inverter converts this power to normal AC voltage electricity for running conventional domestic appliances. The system is capable of providing up to 4.5 kW of load at any one time. In the event that the battery runs low or load exceeds inverter capacity, then the supply is automatically transferred to the grid and at the same time the batteries are recharged. When more power is being generated than is being used and the batteries are full, surplus power is diverted to a multi-stage immersion heater element in the domestic hot water cylinder. A conservatory pre-heat (passive solar) buffer zone, coupled with super-insulation levels of Warmcel 500, combined with limited thermal mass, creates considerable thermal inertia, thus eliminating the need for a central heating system.

Keith Hall has spent all his working life (over 25 years) in the construction industry. In 1989 he founded the Association for Environment Conscious Building (AECB) and is currently editor of its magazine, Building for a Future. *The AECB is an independent organisation which promotes sustainable building. An information pack about this organisation can be obtained by sending an A4 sae (93p) to AECB, Nant-y-Garreg, Saron, Llandysul SA44 5EJ, or visit its web site on http://www.aecb.net*

READER ENQUIRIES

BP **1300**
British Cork Mills **1301**
Celcon **1302**
Colt International **1303**
Combat Polystyrene **1304**
Construction Resources **1305**
EWIA **1306**
Fillcrete **1307**
The Hemp Union **1308**
Heraklith **1309**
Klober **1310**
Oscar Acoustics **1311**
Pittsburgh Corning **1312**
Redland **1313**
Telling **1314**
Springvale EPS **1315**
Sto/CCS Scotseal **1316**
Vencel Resil **1317**
Western Cork **1318**