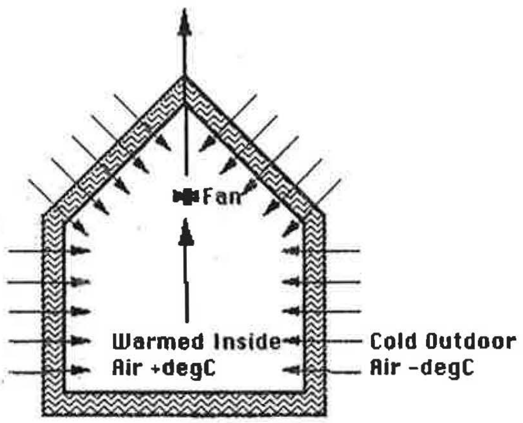
CI/SfB (M2)

Dynamic insulation, in which the whole fabric acts as a heat exchanger, can cut energy use and improve ventilation of small buildings

Exploiting the fabric

BY HELEN MULLIGAN



The basic principle of dynamic insulation is straightforward. Conduction heat loss through the external skin of a building is reduced by drawing ventilation air through porous insulation material, rather than through conventional openings such as windows and doors. By doing so, heat energy that would normally be lost by conduction to the outside of the building is returned to the inside via the incoming ventilation air. Essentially, the external insulated fabric of the building is used as a large heat exchanger.

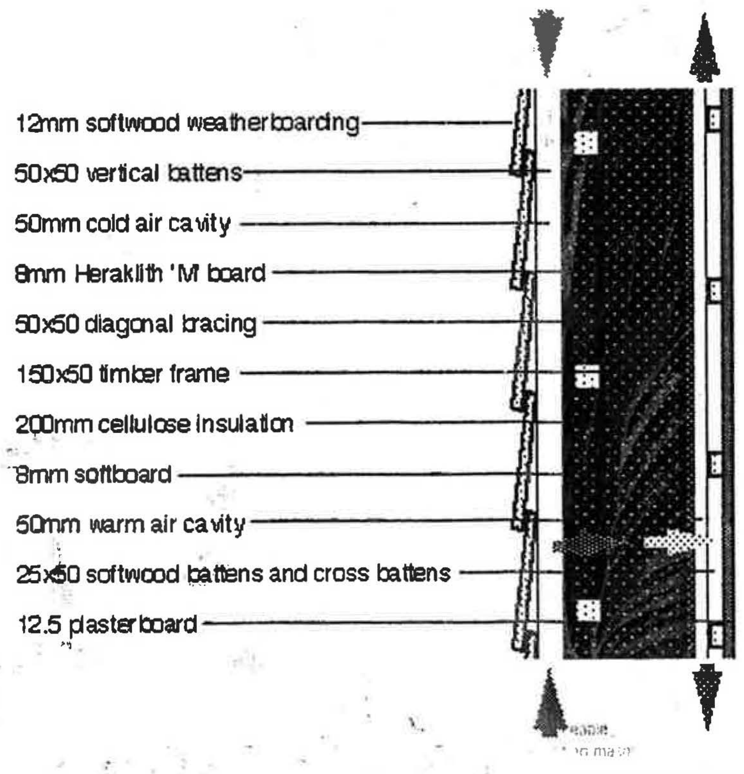
Of course, since ventilation air is entering the building, it also has to leave. This is done by means of a fan/heat exchanger system where the heat energy in the outgoing ventilation air is extracted for re-use. This can be used to pre-heat incoming ventilation air through the insulation or to pre-heat cold water for the hot water system. In this way the overall energy consumption of the building can be reduced.

This is a concept that has been investigated for a number of years in other parts of the world, notably Canada, Scandinavia and Japan. A Japanese study in 1993 showed that in a single family house, approximately 50 per cent of the transmission heat loss from the building envelope can be eliminated by using dynamic insulation. This was achieved with an insulant thickness of 150mm and an exterior-to-interior pressure difference of about 5Pa, giving an air-flow velocity through the building envelope of less than 0.5m/hour. This was found to provide preheated ventilation air which was well distributed and draught free.

This can be a general property of dynamic insulation. As well as potentially increasing energy efficiency, it can allow relatively high rates of air change within a building at relatively low air velocities, since the incoming air is distributed over a large surface area. This may:

- allow much higher rates of air change than would be possible by conventional means of ventilation, thus contributing to improved indoor air quality. Furthermore, whole-fabric ventilation can reduce the incidence of stagnant pockets, where with conventional ventilation air movement is minimal
- with windows and doors sealed, the uncomfortable draughts often associated with winter ventilation may be avoided. Thus dynamic ventilation may assist in improving occupant comfort, and thereby allow a lower indoor air temperature for the same perceived occupant thermal comfort, so saving heating energy.

Dynamic insulation on these lines has been used since 1968 in Scandinavia, in a few buildings with a rather high and constant demand for ventilation air and which have a relatively high moisture production. These include swimming pools, sports halls and animal houses for pigs and poultry. In these buildings the ventilation air is taken in through an air-permeable wall or ceiling construction and exhausted through a fan-assisted, vertical flue.



Above left: dynamic insulation in principle – the building fabric acts as a heat exchanger, where ventilation air entering through the entire fabric picks up heat from the inside. Right: the Morvenette house for the Camphill Trust in Aberdeen. Air is extracted by a fan unit in the roof space, assisted by the ventilator on the roof. Below right: a wall detail from the Morvenette house's timber-frame construction. Cold air is drawn from the cold side of the insulation to the warm side in the opposite direction to the heat flow. The cold air is heated as it passes through the porous insulation material

The UK experience

In 1995/6 the first dynamically insulated building in the UK, the Morvenette house, was constructed in Aberdeen for the Camphill Trust. A small, two-bedroom, timber-frame house insulated with 200mm of blown cellulose insulation, it was designed to allow air flow through the walls and ceiling into all the rooms of the house – see photograph and wall section. Air extraction is via a series of 110mm tubes at skirting board and ceiling level through a fan unit in the roof space to the outside. Monitoring results indicate that air leakage through the cracks and joints in the building (which is constructed to higher than normal standards) has a significant influence on the effectiveness of the dynamic insulation. A very high standard of construction is therefore required for the potential of the technique to be realised.

Scotland is continuing to lead the rest of the UK in the development of dynamic insulation. A study on the application of the technique for the Scottish Sports Council has resulted in a design for a school and sports centre which is now on site in Callander.

The current research

Cambridge Architectural Research has been funded by the DoE to look at the potential of dynamic insulation under British conditions. The project is supported by a range of major companies from the construction industry who form an advisory group.

Beyond the simplicity of the basic concept of contra-flux dynamic insulation, there lie rather more complex inter-relationships which affect the magnitude of potential heat recovery and the acceptability of conditions of operation. The study carried out by Cambridge Architectural Research has looked at the applicability of the technique to a range of building types, taking account of differences in building geometry and patterns of use. The study indicates that an energy saving of at least 25 per cent can be realised for suitable building types.

From an architectural viewpoint, the critical factors are the need for shallow plan depths and small volume:surface area ratios, characteristic of domestic-scale buildings. For example, a typical UK house has a volume:surface area ratio of around 0.8, while the ratio for an office block is typically five times greater. So the study concludes that the potential for energy saving in housing is very much greater than in office and similar-scale commercial buildings, since the UK housing stock is characterised by a large number of small buildings.

However, the experience of the Morvenette house indicates that conventional domestic framed construction is perhaps intrinsically difficult to seal to a sufficiently high standard. Our project is exploring the potential for whole-building construction methods which are inherently less leaky. Planar glazing technologies are an example, though one which has to date seldom been applied in the housing sector. The development of translucent dynamically insulated panels, based on advance glazing technology, is a promising area of exploration. It would have the added advantage of enabling windows and doors made from these panels to be included in the assessment of building surface area available for dynamic insulation.

As a conclusion to the project, a prototype house scheme has been proposed – see sketch and section. This would give the opportunity to test the performance of differing types of construction at full scale. The possibility of constructing it is being explored with members of the project advisory group. □

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Below and right: suggested prototype house. It would use a range of different fabric types which could embody dynamic-insulation techniques. Gabion walls link the building to its landscape setting. Dynamically insulated glazing units provide diffuse natural lighting at clerestory level