Intelligent membranes and airtightness

Uncontrolled air leakage from buildings is a major cause of energy loss and increasing CO2 emissions. It has long been established that airtightness is an essential part of creating a healthy, comfortable, energy efficient living environment. This has been acknowledged by the relatively recent introduction of airtightness standards to Technical Guidance Documents Part L in the UK and with the introduction of Energy Performance Certification for new buildings. Niall Crosson explains.

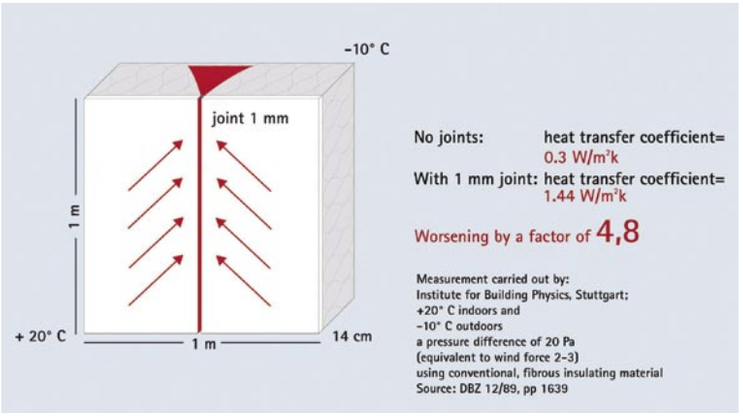


Fig 1. Air leakage = energy leakage.

While this is to be welcomed, the maximal permissible air permeability of buildings in the UK is still relatively weak, compared to our continental neighbours. Air leakage is one of the most significant contributors to inefficiently heated buildings. While controlled ventilation is desirable and a requirement for healthy construction, studies confirm that air leakage can account for up to a third of all heat losses in modern buildings. Air leakage also significantly increases the potential for condensation to occur within building elements. This may lead to insulation and structural degradation and mould growth, particularly in lightweight construction (i.e. timber or steel frame).

Airtightness

Approximately 43% of the energy consumed in the UK goes into the servicing of buildings, of which 60% is used for water/space heating and cooling. In the past the majority of heat loss through the fabric of the building envelope was as a result of little or no insulation and a very low level of airtightness. One of the most cost effective means of reducing heating bills, increasing the energy efficiency in homes and ensuring that the insulation can perform effectively, is to use a quality insulation while making sure the structure is as airtight as possible. The UK is not exposed to extremes in low temperatures, such as that found in Scandinavian countries, however, it is a climate which is exposed to extremes in wind pressure, particularly in coastal and exposed areas. In this way addressing air leakage can be pinpointed as one of the most effective means of increasing the energy performance of modern buildings.

An insulation layer is as effective as it is airtightly sealed. Many studies have been conducted in this area. One such study conducted by the Fraunhofer Institute of Building Physics measured the effects of air leakage in relation to both insulation performance reduction and moisture penetration into the building fabric. When investigating the thermal performance of 14cm thick thermal insulation with a seamless vapour barrier/check, the measured U-value was 0.30W/m²k. The thermal insulation performance was then measured with leakages of various widths in the vapour check/barrier, at various pressure differences. Even with the smallest leakage width of 1mm, there was a reduction in insulation performance by a factor of 4.8 (see Fig 1). This means that the insulation value of the 14cm thick thermal insulation with a slight leak is no longer 0.30W/m²K but only 1.44W/m²K. Consequently, leaks at the airtightness level – such as in the vapour barrier/vapour check – lead to a reduction in the performance of the thermal insulation. The heating energy demand and, consequently, CO_2 emissions, increase many times over.

This clearly demonstrates that when we install insulation in a building we should also consider the airtightness of the external envelope as a priority.

Addressing air leakage and moisture management

In lightweight construction, particularly timber elements of masonry and timberframe constructions, the airtightness layer (i.e. the vapour barrier/check) typically has a dual function. A vapour barrier/check acts as a vapour control layer which retards the transfer of the warm, potentially moisture laden air from the habitable space, penetrating the external fabric and coming into contact with cooler elements within the construction. In the UK, with increased insulation standards in modern buildings, the average internal temperature has risen over the last 10 years by approximately 3.5°C. This temperature rise implies that air in the habitable space can maintain more moisture than ever before. In this way the vapour control layer has a critical role. A 'leak' in the vapour barrier/check, therefore, not only becomes important from an energy perspective, but also from a moisture management perspective.

The study by the Fraunhofer Institute of Building Physics also measured moisture penetration into the structure in conjunction with the thermal insulation

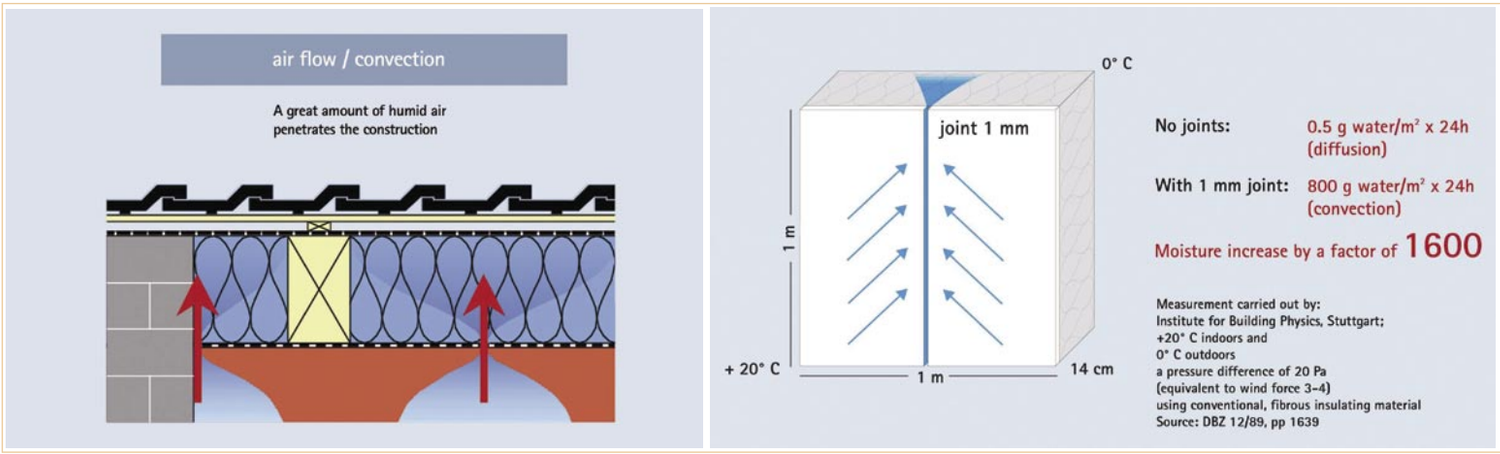


Fig 2. A study by the Fraunhofer Institute of Building Physics measured moisture penetration into a structure in conjunction with the thermal insulation performance. The measurement confirmed a theoretical moisture penetration rate of 0.5g/m² into the structure. This volume of moisture poses no problems for structures.

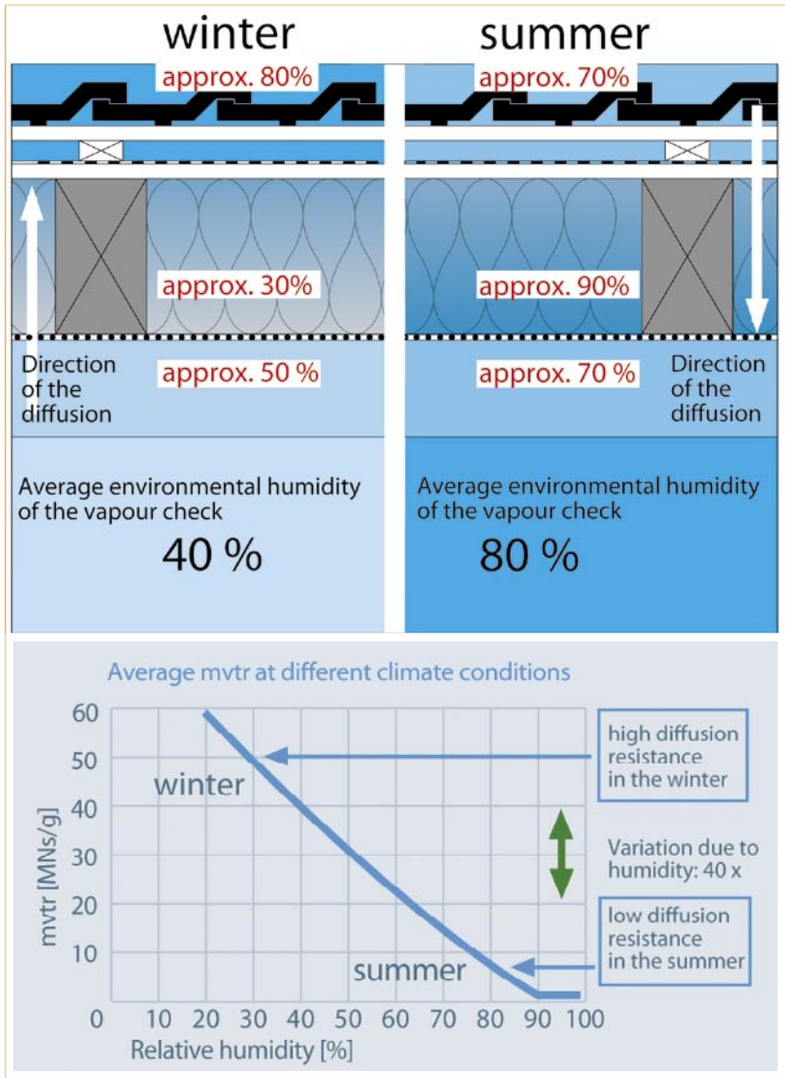
performance. The vapour barrier had a diffusion resistance sd of 30m (vapour resistance of 150MNs/g). With a perfect seal the measurement confirmed the theoretical moisture penetration rate of 0.5g/m² into the structure (See Fig 2). This volume of moisture poses no problems for structures. The moisture penetration through the leakages was determined in the second test. The results were alarming and explained many cases of structural damage. The moisture penetration by convection (air flow) was 800g of moisture/m² per day with the smallest slit of only 1mm.

In this way a vapour check/barrier has a critical role to play, not only from an insulation perspective, but also from a moisture management perspective. It is impossible to completely rule out potential moisture entry into building components over the life of a building. It is always attractive to design buildings which, in the event of unforeseen moisture entry, can allow this moisture to dry out as rapidly as possible. It is with this in mind, that intelligent airtightness membranes provide constructions with high levels of protections against unforeseen moisture entry, even in the most challenging constructions, from a condensation risk perspective.

What are 'intelligent' membranes and 'vapour checks'?

An intelligent membrane is completely air impermeable and can alter its vapour resistance/permeability depending on the direction of heat flow and the average relative humidity between both sides of the membrane. It allows vapour to diffuse through it when humidity is high within structural elements, either due to seasonal change or unexpected moisture intrusion. When the average humidity is low (winter condition), the membrane resists the penetration of vapour into structural elements, preventing interstitial condensation. If the average humidity at the membrane is high (summer conditions), the membranes vapour resistance decreases substantially (see Fig 3). This permits drying to occur in summer months if required and decreases moisture accumulation within the construction over seasonal periods, something traditional vapour barriers/checks cannot do. In this way, these membranes are characterised as Intelligent.

Fig 3. Summer and winter performance of inteligent membranes and vapour checks.



In focus: intelligent membranes

An intelligent vapour check controls the moisture which may otherwise become trapped within structural elements, even after the building is sealed airtightly and complete. Intelligent vapour checks are characterised as having humidity variable properties. When installed in conjunction with suitable tapes and adhesives this functions as a durable airtight layer with maximum safety against unanticipated moisture entry.

In terms of construction physics, an intelligent vapour check may provide a vapour resistance ranging from 1.275MNs/g in summer conditions (diffusion open), to over 70MNs/g (diffusion tight), in winter conditions (see Fig 3). As a result, in winter the intelligent vapour membrane's higher diffusion resistance value of over 70MNs/g, protects the building fabric from interstitial condensation.

In summer, an intelligent membrane adapts and allows for over 40 times more vapour transfer (vapour resistance value of less than 1.275MNs/g), hence providing a high potential for drying out. This means that the construction has the ability to allow up to 560g of moisture per m^2, per week, to dry towards the inside in summer, removing the possibility of moisture accumulation (sweating), behind the vapour check, (see diagrams below). This dramatically reduces the risks associated with interstitial condensation, thereby eliminating the threat of mould growth and insulation degradation as a result of moisture saturation, and damp rot.

A sufficiently airtight home is one of the key factors in ensuring that insulation and the heating system can actually perform as efficiently as possible. An intelligent airtight system, lends itself to an efficient energy performance certificate with the health of the homeowner at the forefront through a significant reduction in risks associated with mould growth and structural degradation due to interstitial condensation.

A case in-point of the successful application of intelligent membranes was a project carried out for Powys County Council when intelligent membranes[1] were specified for use in a recent office build for the Dyfi Valley Pathfinder project in Machynlleth. Designed and built to Passivhaus and BREEAM standards by Passivhaus specialist's, JPW Construction Ltd, the building has achieved an air leakage test of 0.37m^3/m^2hr @ 50Pa, an amazing result well beyond Passivhaus and national standards. JPW has also recently achieved a result of 0.25m^3/m^2hr on a residential Passivhaus design and build project.

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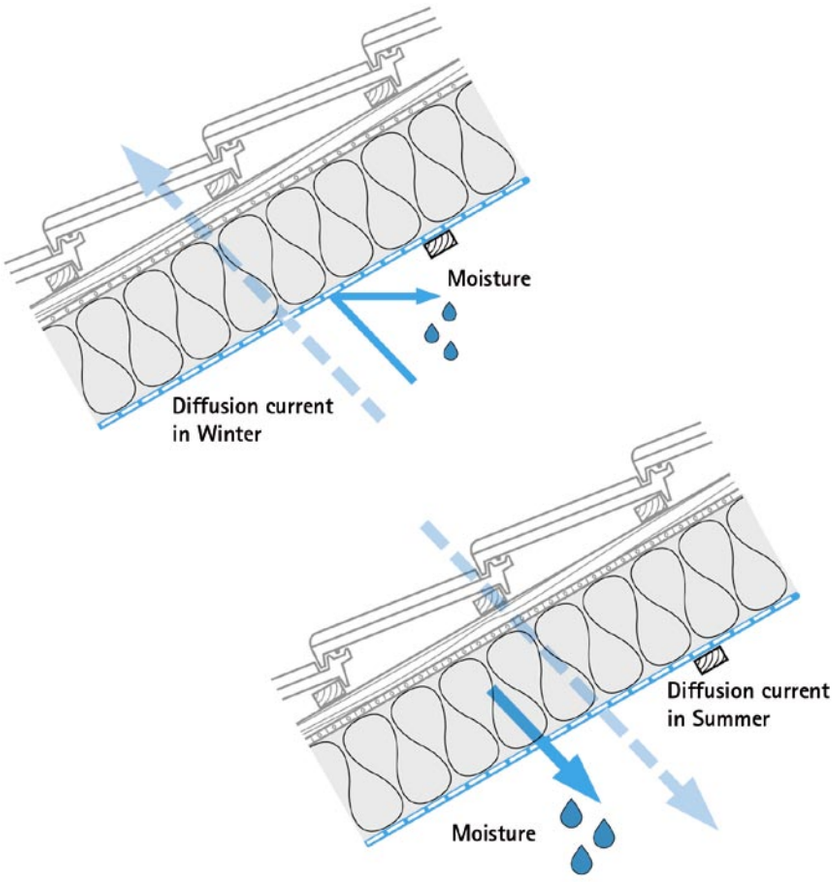
Refs:

1. The Pro-Clima system from Ecological Building Systems
WWW.ECOLOGICALBUILDINGSYSTEMS.COM

Niall is technical engineer with Ecological Building Systems. He holds a degree as a bachelor of technology (1st class hons) and a masters Eng. Sc. from the National University of Ireland, Galway. Ecological Building Systems has pioneered the introduction of natural building materials and airtightness to the construction industry in Ireland and the UK. Niall has particular expertise in the area of energy conservation, airtightness and vapour diffusion open constructions. He has provided technical guidance to architects, timberframe manufacturers and on-site personnel regarding low energy construction, airtightness and active moisture management. Niall has provided guidance to some of the most prestigious low energy projects in Ireland and the UK and his expertise is much sought after.



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