#3950

source
BUILDING SCIENCES LIMITED
Douglas Lawson

Air and vapour barriers

Abstract
In the UK, an air barrier is rarely specified, although this is the key component in the control of unintentional air movement through the building fabric. Such uncontrolled air movement can result in the following: interstitial moisture problems due to condensation from moisture-laden air filtering out through the building fabric, and air-driven rain penetration due to discontinuity of the building envelope pressure plane; higher than necessary heating costs; air quality problems, eg temperature, humidity, fumes, contamination and noise; a comfort problem caused by excessive air movement across working areas. Extreme climatic conditions has forced the Canadian building industry to become increasingly aware not only of the need for effective air and vapour barriers, but also the need for the adequacy of specifications and the "buildability" of the final barrier components.

■ INTRODUCTION

In Canada, confusion over air and vapour barrier design and specification is slowly disappearing thanks to increased attention and debate during the past three years.

Once a requirement for air barriers in buildings had been included in Section 5 of the 1985 Building Code, open discussion and self-education through the provincial Building Envelope Councils has helped lay to rest many of the myths associated with definitions, functions, materials, design and construction supervision of the different kinds of barrier.

Further evidence of concern turning into action is the scheduled publication by Construction Specifications Canada later this Summer (1989) of a TEK-AID on Air Barrier Systems.

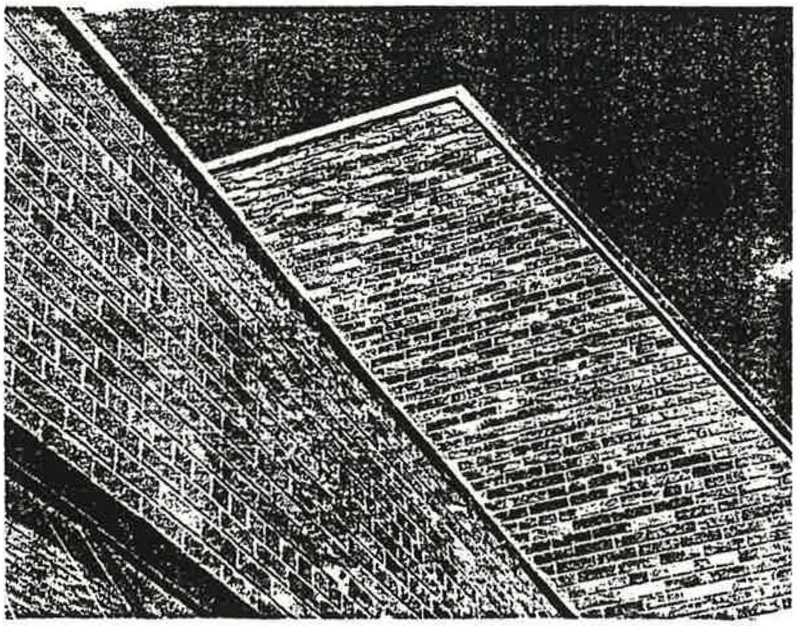
■ PRIME CAUSE

As a result of the large number of prematurely-decaying buildings in Canada, air barrier systems are finally seen as critically important. Not only to stop the air itself moving in an uncontrolled fashion, but to stop its ability to carry the most dangerous element of all: water in all its forms.

Now, the industry is looking for ways to ensure that air barriers and vapour diffusion retarders are installed in buildings so that they perform the functions they are supposed to.

In Canada air leakage is simply the leading cause of exterior wall problems. It has been linked to efflorescence, spalling masonry, ice build-up under the soffits, frozen pipes and condensation in cavities, as well as rain penetration, high energy costs, and poor control over the indoor humidity conditions.

Figure 1
Severe spalling of bricks at both roof/wall junctions.



Having accepted the connection between premature building decay and lack of control of air, water vapour, and water in its other guises, the building envelope fraternity asked itself the question: "Can we contribute to an extended life for buildings by improving air and vapour barriers?" They have answered with a resounding "Yes".

As with so many problem-solving exercises, it was no surprise to find that the basic answers of air and vapour barrier function were not only well-known 15 or 20 years ago, but also well-documented.

■ DEFINING THE TERMS

Uncertainty over building envelope design has been seen on Canadian architectural drawings over the past few years, where terms are regularly used such as vapour barrier, vapour retarder, air/vapour barrier, elastic air barrier, wind barrier, pressure barrier and air barrier preservative.

The most common term, which has regularly appeared on drawings, is "vapour barrier", with sometimes a specification for "air/vapour barrier", and, less often, "air barrier". Confusion is apparent, and seems to centre on the functions of the different barriers.

A vapour barrier must stop or, more accurately, retard the passage of moisture as it diffuses through the assembly of materials in a wall. Sometimes the vapour barrier is called a vapour diffusion retarder - in order to better explain its function.

An air barrier must stop outside air from entering, and inside air from filtering through the building envelope to the outside. This applies whether the air is humid or dry, since air leakage can result in problems other than the deposition of moisture in cavities. Outgoing air carries away heating and cooling energy, while incoming air may bring in pollution as well as disable a rain screen wall system.

A vapour barrier is any material which offers a higher resistance to the diffusion of water vapour than most other materials. In Canada, polyethylene film of sufficient thickness is the material most commonly used for this purpose. However, other materials such as aluminium foil, some paint products, some insulation adhesives (mastics), metal, glass, exterior grade plywood, and even concrete of sufficient thickness may be quite suitable.

Figure 2
Unsealed joints in foil backed insulation shows severe dust build up due to infiltration.

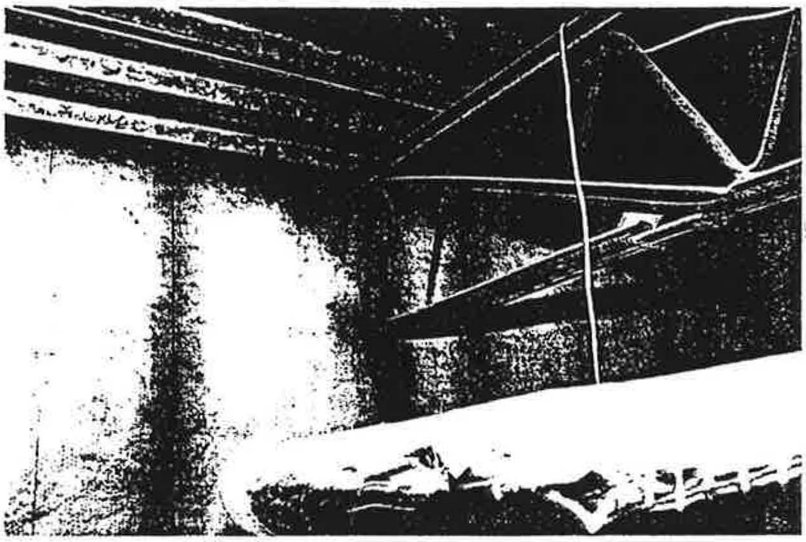
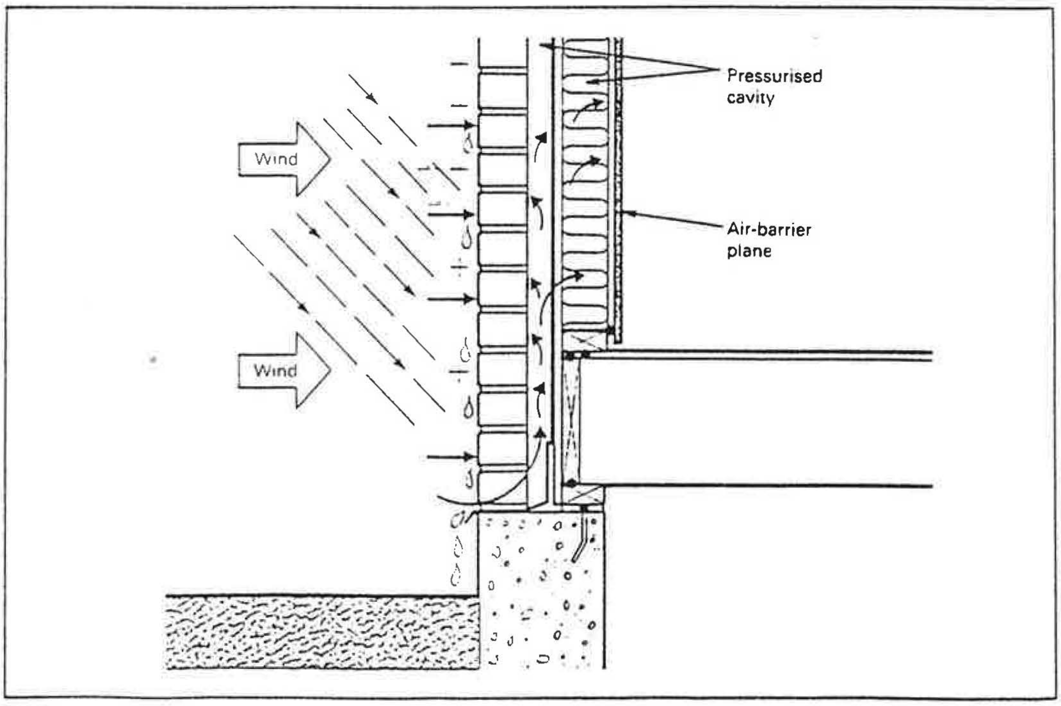


Figure 3
Rain screen wall without an effective air barrier wind driven moisture can penetrate the inner wall cavity.



The moisture diffusion control property of a material is its "water vapour permeance". This is usually expressed as the weight of moisture that will diffuse through a given area and thickness of material, over a specified period of time at a unit vapour pressure difference. Any material having a rating of 15 or less may be suitable as a Type 1 Vapour Barrier, provided it meets the other conditions of the standard (CAN 2-51.33 M80).

■ MATERIALS USED IN BARRIER DESIGN

Finding materials with practically zero leakage is easy, but assembling a total air barrier system (main area plus joints) and keeping the structure virtually airtight is where problems occur.

As the object of an air barrier is to stop air movement through a building envelope, it can be made from anything that is air-impermeable, or virtually so. No value for maximum permeability has been determined from Canadian buildings, but as a rough guide, materials which would qualify include polyethylene, several single-ply roofing membranes, gypsum, board, cast-in-place concrete, metal or glass.

On the other hand, concrete block, acoustic and fibrous insulations, open-cell foam insulations and fibreboards do not qualify.

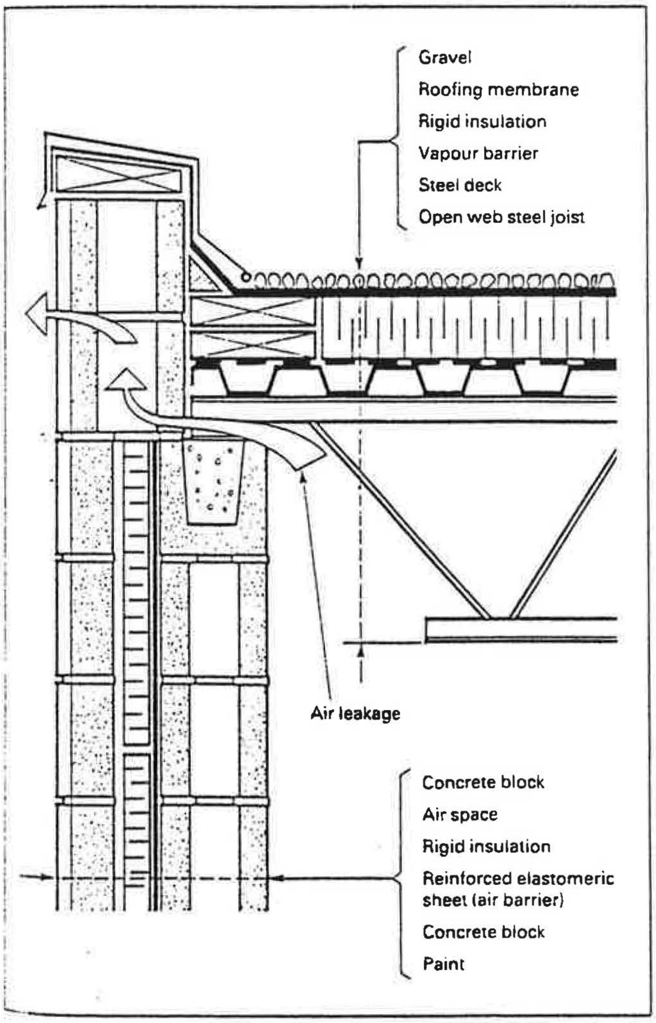
For a barrier to control condensation resulting from vapour diffusion, it must be placed on or near the warm side of the insulation, which is normally the high-vapour-pressure side. Contrary to popular belief, it need not be perfectly continuous. Unsealed laps and pin holes, minor cuts, etc, do not increase the overall moisture diffusion rate into a wall or roof cavity appreciably.

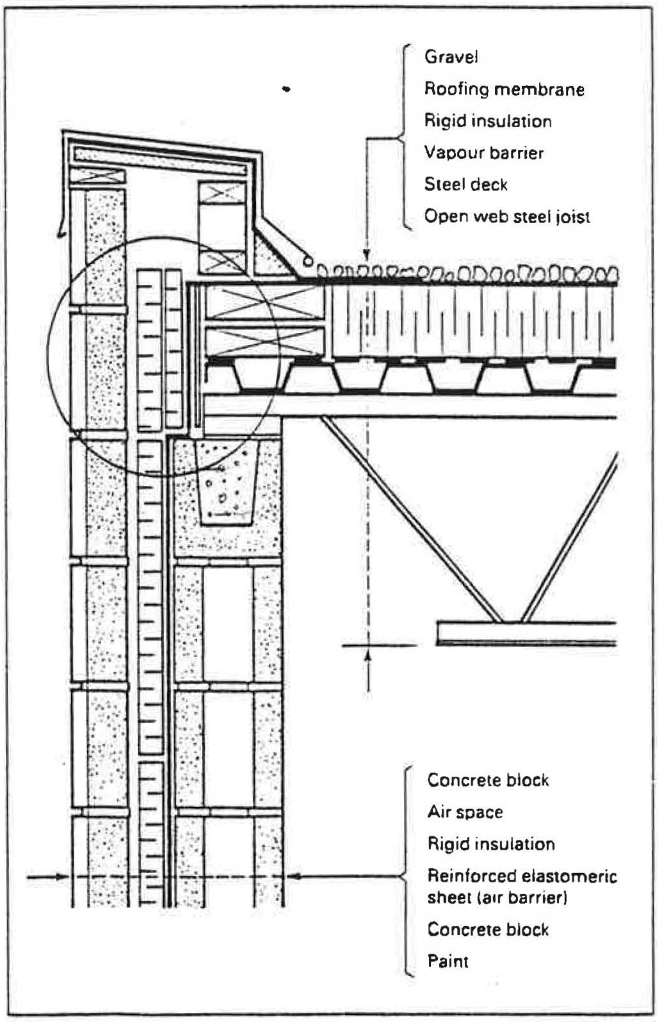
Often forgotten is that an air barrier must be as durable as the building itself, and materials with a long service life should be specified and assembled and positioned in such a way as to make repair and maintenance possible.

Continuity is the by-word. Air barrier material in the wall, unlike vapour barriers, must be continuously linked with air barrier material in the roof, and must be connected to the air barrier of the window frames.

Figure 4 (below left) Non-continuous air barrier results in significant air leakage at roof/wall junction.

Figure 5 (below right) Roof and wall air barriers made continuous.





The system must be structurally capable of resisting displacement. It must be fastened to a supporting structure in order to resist a peak wind load, a sustained stack effect, or pressurisation from ventilation equipment.

If the air barrier system is made of flexible materials, it must be supported on both sides by materials capable of resisting peak air pressure loads; or it must be made of self-supporting materials, such as board products adequately fastened to the structure.

■ A COMBINED OPERATION

Recent experience has proved the viability of combining the functions of the air barrier and the vapour diffusion retarder in one assembly. Provided the properties required of the materials, and the functions defined above are satisfied, this is acceptable.

If the air barrier is located on the cold side of the insulation, it should be several times more permeable than the vapour barrier in order to allow the escape of vapour on its way out from the wall assembly. (The air barrier and the insulation must be in intimate contact to prevent convection within the cavity seriously altering the thermal performance of the insulation).

More than a decade ago, building science experts wrote that "efforts should be made to develop construction details, arrangements of materials and construction methods that will result in walls, windows, floors and roofs being more airtight, with provision made for intentional and controll-

Figure 6
Single component foam being used to seal top of window frame to concrete lintel.

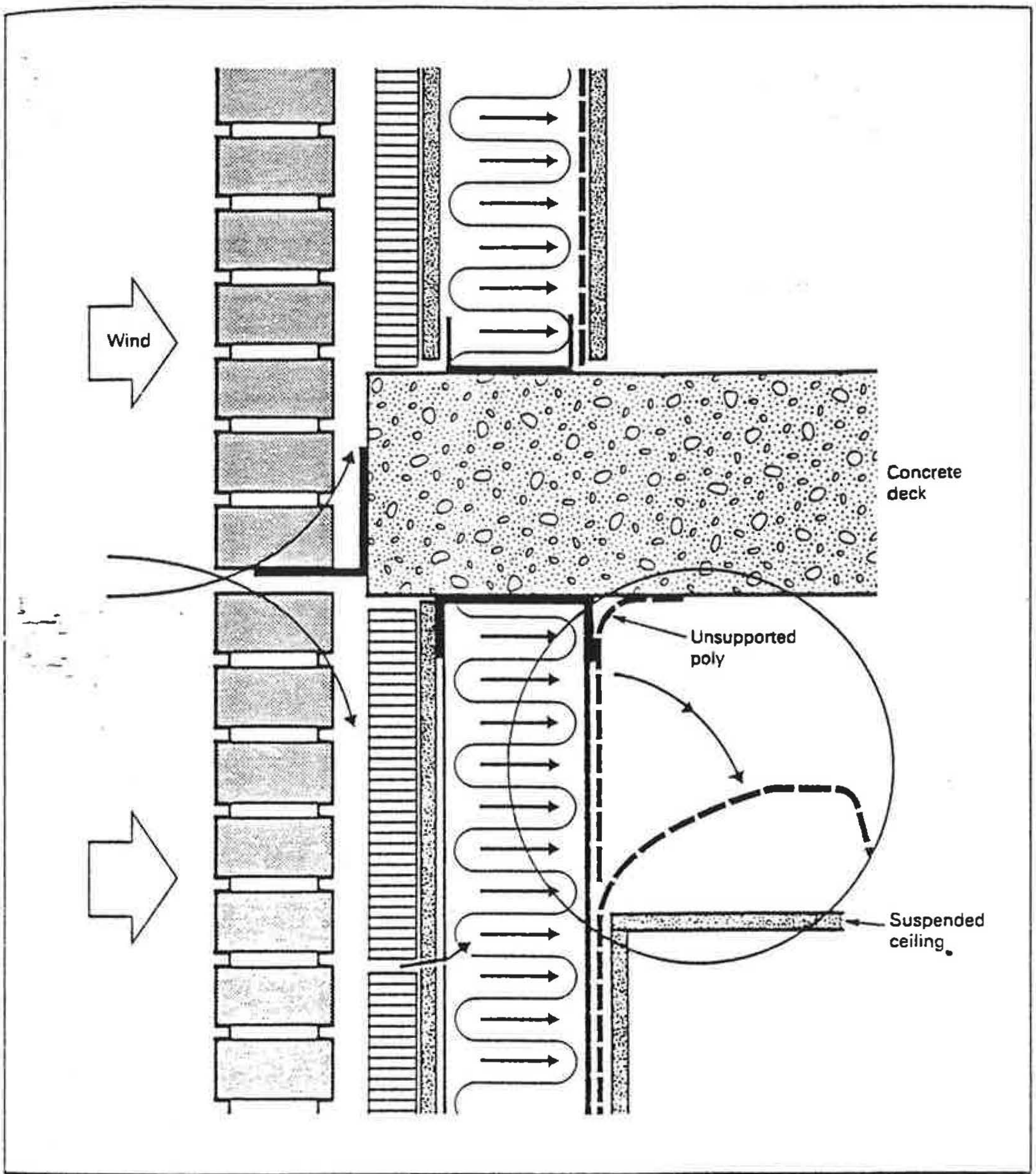


Figure 7
Wind pressure disconnects polyethylene film from deck.

able ventilation openings through the components where necessary".

Detailed drawings are the key to making these experts' wishes a reality. Large scale details of air barrier systems are essential, if the reader is to really understand what the designer wants. With these, contractors can price more fairly if they know what material, where, and how installed, rather than trying to interpret costly clauses such as "by other", "performance specification", "as per manufacturer's recommendations", or "shall provide an effective air barrier".

■ INSTALLATION AND MAINTENANCE

Success of a vapour barrier or an air barrier system in new construction depends on the combined correct approach of the designer, the specifier, and the installer. When dealing with an existing building, however, it is often not possible to fully repair poor barriers to achieve monolithic construction.

Significant progress has, however, been made in developing retrofit solutions. Not only in identifying the areas of the envelope requiring attention, but also the use of materials which have the properties of low air permeability and the ability to retard moisture diffusion, while possessing necessary structural qualities. In situ polyurethane foams have really come into their own recently in this area.

■ CONCLUSION

In order to be effective, air and vapour barriers must not only be designed and specified correctly but must be readily buildable. With the expertise and materials now available such demands should no longer be a deterrent to better air and vapour barriers.

Figure 8
Roof/wall junction above suspended ceiling. Gaps around beams and in metal deck flutes stuffed with insulation. Significant air leakage occurring.

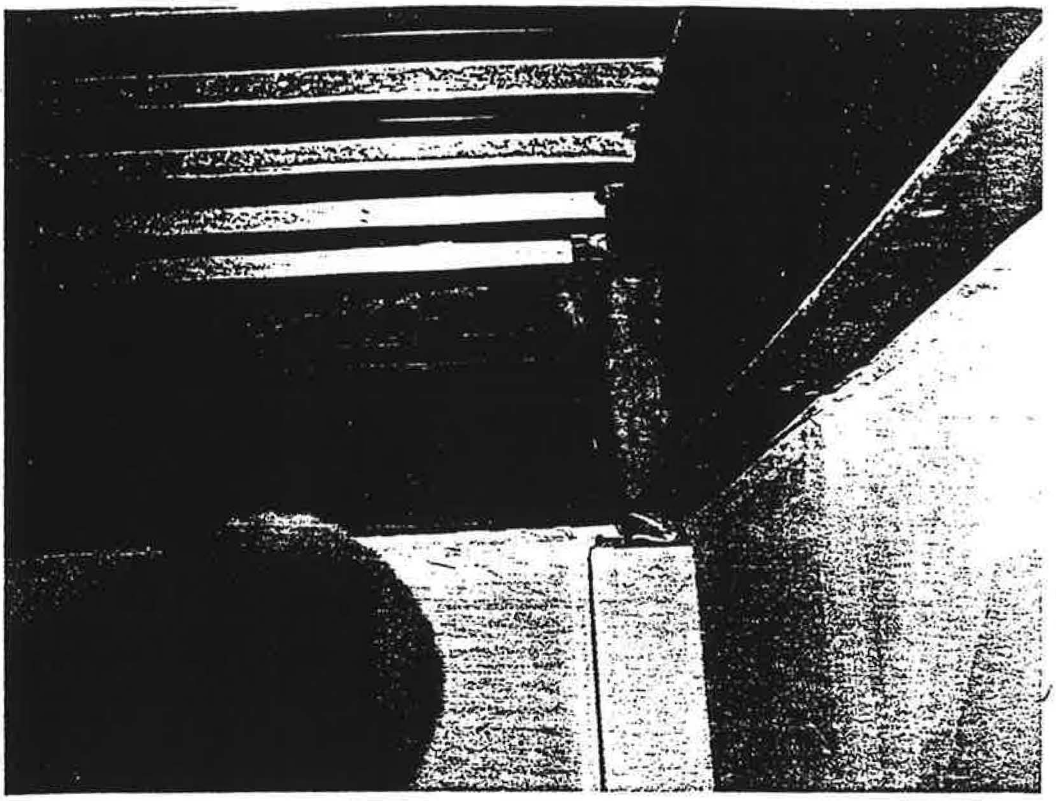
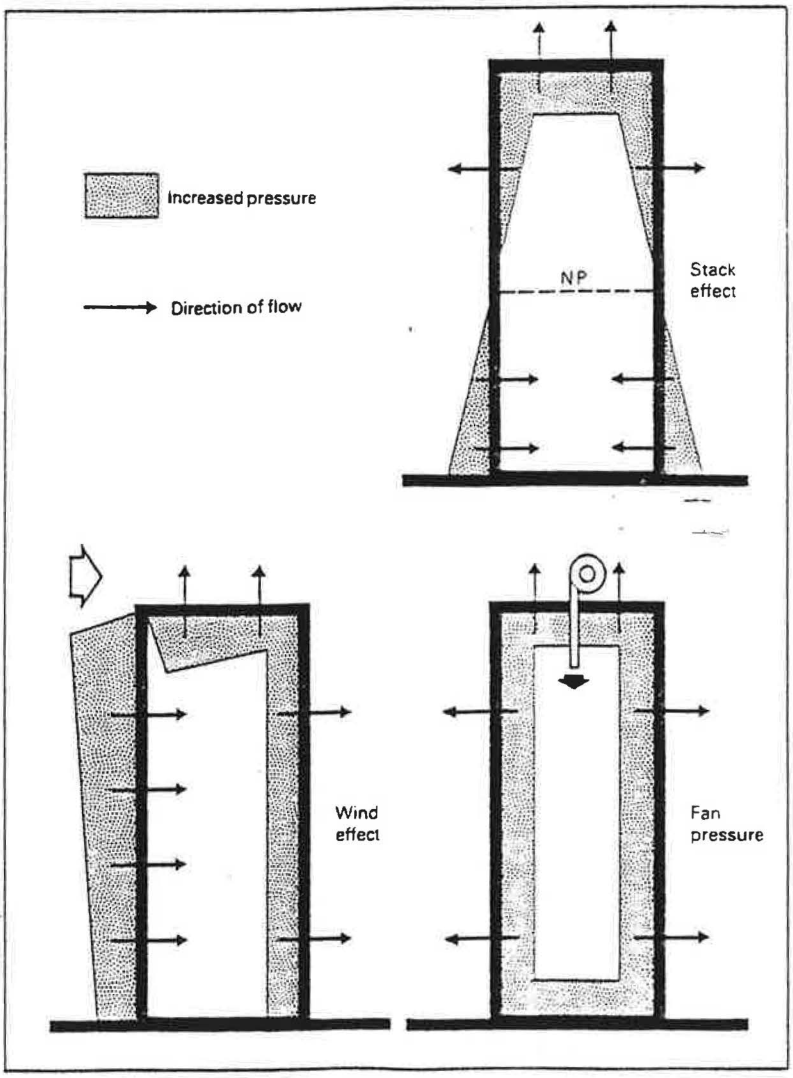


Figure 9
Air leakage through building envelopes is caused by air pressure differences from one or more of three sources.



Nature and

In the UK remedial sealing is usually confined to the weatherstripping of the opening parts of windows and doors. While on some buildings this can be a significant element of leakage, in many cases this would represent only a minor portion.

Depending on the building construction, air leakage can occur at the following additional areas: door and window frames (in one recent instance the metal jointing in the window frames of a large office accounted for 75% of the building's estimated rectifiable air leakage); roof/wall and floor/wall junctions (in an hotel recently audited, this area amounted to over 45% of the estimated rectifiable air leakage); beam/truss penetrations; columns and walls; vertical shafts for services; junctions between different wall materials; and duct, cable and plumbing penetrations.

There is clearly significant confusion on the nature and impact of air leakage. Some building owners'/users' reactions to the question of air leakage have been:

☐ "We have already tackled the problem as we have insulated." Most insulating materials are not air barriers and will simply act as filters, ie the air

ONTARIO BUILDING ENVELOPE COUNCIL

Aims and objectives

Aims
To promote the pursuit of excellence in the design, construction and performance of the building envelope.

Objectives

☐ Create a forum at which everyone concerned with building envelope improvement can exchange ideas and information.

☐ Accumulate technical information and make it easily accessible.

☐ Broadcast information and create educational programmes for the benefit of the building community.

☐ Promote and guide research and development to accomplish the aims.

☐ Make recommendations to appropriate legislative bodies for improvements to codes and standards.

There are four provincial envelope councils, also a national council and there is a move to form an international building envelope council.

Ontario Building
Envelope Council
c/o Faculty of
Architecture
University of Toronto
230 College Street
Toronto M5S 1A1
Ontario
Canada

impact of air leakage

will be cleaned as it is moving through the building envelope. In addition to this, the air movement will signficantly reduce the effectiveness of the insulation, and is likely to deposit moisture within the fabric.

☐ "We have mechanical systems with heat recovery so leakage will not cost us money." With conditioned air exfiltrating through the building fabric there is obviously a misunderstanding of the mechanics of air leakage.

☐ "We do not need leakage control as our problem is cooling rather than heating." Again, a lack of awareness that the conditioned air could be escaping in large quantities and thus significantly increasing the cooling load.

☐ "We have tackled the problem as we have fitted double glazed windows." As already stated, windows are only a part of the problem. Also, new windows may reduce air leakage but there is still confusion between double glazing, which is a form of insulation, and the sealing of window perimeters, which is weatherstripping. Effective weatherstripping is now available for almost all windows and the same effectiveness of sealing can usually be achieved on existing leaky single-glazed windows.

☐ "Our building is pretty tight and air leakage is insignificant." There are indeed a few fairly tight buildings but for many air leakage can account for up to 40% of space heating costs. An experienced air leakage control company would expect to identify and effect remedial sealing on about half of this with a resultant reduction of up to 20% in space heating costs.

It is clear that the nature ~~and~~ impact of air leakage has been widely misunderstood and the problems ignored or tackled in a very limited manner. It is also clear that the cost of air leakage can be significant in respect of energy, comfort and building structural integrity. The know-how now exists to identify cost-effectively and estimate rectifiable air leakage.

This technology can be applied to industrial and commercial buildings both mechanically and naturally ventilated. On buildings where some comfort or interstitular problem exists there is the double benefit of the reduction or elimination of this problem, plus the resultant savings in space heating costs.

REFERENCES

1.TEK-AID is being prepared by a consultant team including Ontario Building Envelope Council c/o Faculty of Architecture University of Toronto 230 College Street Toronto M5S 1A1 Ontario, Canada. W2 Consultants Ltd, of Sherwood Park, Alberta, JC Perrsault & Sons, Edmonton, Alberta, and the National Research Council, Saskatoon Institute for Research and Construction.

BIBLIOGRAPHY

The Difference Between a Vapour Barrier and an Air Barrier, RL Quirouette. Building Practice Note BPN 54, Division of Building Research, National Research Council Canada, 1985.

The Need for Improved Airtightness in Buildings, GO Handegord. Building Research Note, Division of Building Research, National Research Council Canada. November 1979.