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Venting of Flat Roofs

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Please note

Venting in building construction as a technique of cooling by air flow and of controlling or removing moisture has been in use for many years. Air-cooled roofs were used by primitive tribes in warm climates and modern buildings often take advantage of the principle, known also to campers who employ two layers of canvas with air flow.between to obtain cooler tents. Where wood is a usual material for structural framing and cladding, architects and builders have also found that ventilation of underfloor spaces and spaces in walls and roofs is necessary to prevent rotting[1,2].

There are recommended standards governing the type and amount of venting required, but although it is quite generally used the principle involved is often misunderstood. Sometimes, indeed, existing problems are aggravated or others introduced because of venting. The typical sloping residential roof is of the attic type with roofing on the sloping deck, insulation between horizontal ceiling joists, and the attic space ventilated to the outside. This has generally been eminently successful, but problems have sometimes developed where there has been inadequate ventilation. A common requirement is that such a roof space be ventilated, with openings to the exterior to provide an unobstructed vent area of not less than 1/300 of the insulated ceiling area. Where this has been provided in addition to other normal design requirements there has generally been no problem.

Flat Roofs

The typical flat or near-flat roof, with no intentional air space, is used mainly for commercial and industrial buildings. It is the principal concern of this Digest for it is often plagued by moisture problems. From the inside outward it consists of a structural roof deck, in most cases a near-impermeable vapour barrier, insulation, and an impermeable roofing membrane. A water and vapour trap can be created by such a system with insulation sandwiched between two membranes. If any water is present in the materials from which the roof is constructed or enters through the top by leaks, or from below as vapour, it may be trapped. Such moisture will reduce the thermal resistance of the insulation and may contribute to its physical degradation and that of the membranes if they are moisture sensitive. Better performance can be assured if the designer recognizes the possibility of wetting and makes allowance for the escape of moisture from all possible sources. He can usually encourage this by drainage and venting.

Unfortunately, such allowance is often not made, and an owner can be faced after a few years of service with a roof where the insulation is wet and the water leaking into the building. Even if it is not, the wet insulation no longer provides adequate heat flow resistance. The owner has the drastic and expensive option of complete removal and replacement with a new system, or he may leave the roof as it is and make repairs to prevent further wetting. In this case he must attempt to dry the wet insulation in some manner.

Breather Vents

It has been common practice in recent years to install breather vents in an attempt to remove moisture from wet insulation. Such vents usually consist of vertical pipes or stacks, open to the outside air, shielded from the rain by a cover and penetrating the roofing membrane to provide a path for moisture to reach the outside. Where a rigid type of insulation is involved it is usual to cut it away below the vent and replace it with a loose form. This is intended to facilitate lateral movement of moisture through the insulation to the vents. Usually a number of such vents are aligned in one or more rows.

Reports on the effectiveness of stack venting vary widely. Some roofers and consultants claim great success in drying wet roofs; others have experienced little if any beneficial effect, and some owners insist that breathers make a bad situation worse.

Moisture Movement

Two transport mechanisms can be in effect in moving moisture through breather vents (Figure 1): convective movement of air carrying vapour; and vapour diffusion. In addition, wicking along fibres may help to move moisture laterally through some types of insulation. For drying to occur by either of the transport mechanisms outside air must be drier than that in the roof.

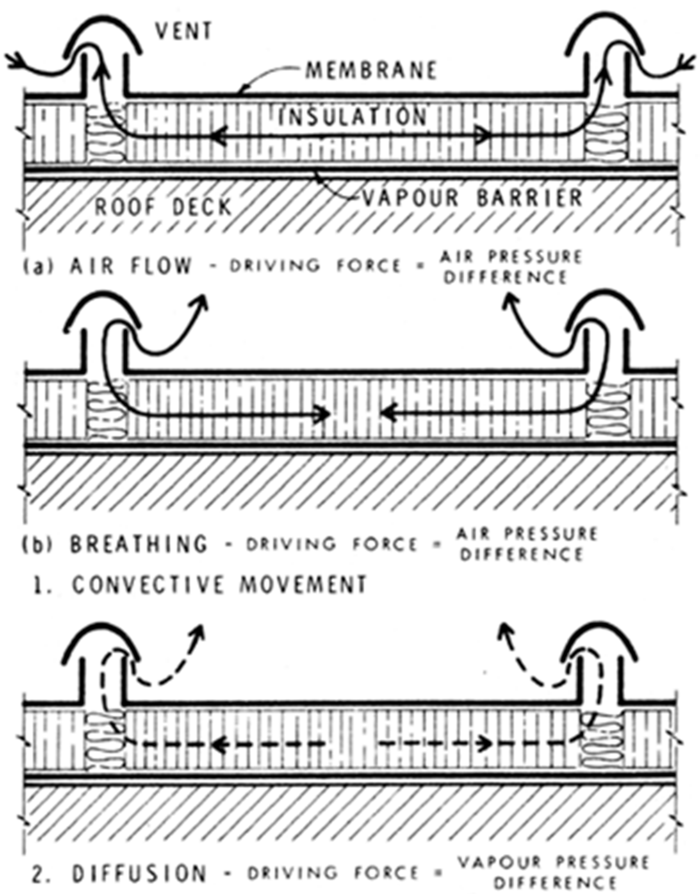

Figure 1. Removing moisture from insulation by venting.

Convective movement of air may occur as a result of either "breathing" (pumping action) or air flow through the insulation. Heating and cooling of the roof and changes in air pressure expand and contract the air in the insulation, producing exhalation and inhalation through any openings (Figure 1, see Part 1(b)). Under favourable conditions it is the mechanism with the greatest potential for moving moisture out of the insulation. There is often fear expressed that the inward breathing can also deposit water, but this is very unlikely. Even when outside air is saturated (that is, at its dew-point temperature) it will be warmed as it is drawn in so that the temperature will rise above the dew-point and condensation will not occur. Moisture on its way out during freezing conditions, on the other hand, may condense on the inside of uninsulated metal stacks to produce an ice build-up. This may melt and drip back in warmer weather to cause a wet spot at the vent.

For air flow to take place, air must move in at some vents and out through others, requiring a difference of pressure between the vents (Figure 1, see Part 1(a)). Wind can cause such a difference, as can stack effect, which can be created if some vents are higher than others. On most flat roofs, however, stack effect will be ruled out since all vent openings will be at approximately the same level and there will generally be only small pressure differences from wind. Air flow between vents will also be affected by the resistance to lateral flow. Some insulations offer high resistance except at the joints, and if flow is to be assured it will be necessary to provide intentional flow passages.

Diffusion, the second transport mechanism, is the movement of water vapour through the insulation to the outside under a vapour pressure difference (Figure 1, Part 2). Resistance to diffusion through the insulation and through the column of air in the vent tube will be very high owing to the long paths involved. During the summer, with warm outside conditions, vapour movement will be mostly downward throughout the insulation thickness, with condensation at the surface below the insulation. During the winter there will probably be upward movement, with condensation at the surface on top of the insulation. Lateral movement tends to be small.

Venting Effectiveness

Some small-scale testing of the effectiveness of venting has been carried out at Saskatoon for the past several years. Four types of rigid insulation were used, in test panels 2 by 4 ft by 2 in. thick, with three different configurations of the insulation below the vent. A vent was placed directly on the centre of the insulation surface for one group of panels, at the point of intersection of butt joints formed by cutting the insulation into four equal pieces for a second group, and over a 1-in. diameter hole directly on the centre of the insulation surface for the third group. The single vent allows for diffusion and breathing only. The insulations were wetted with measured amounts of water and each panel was sealed in polyethylene except for the hole under the vent. The panel cover was of plywood with the exposed surface painted black The twelve panels were placed on the roof of a heated outdoor experimental building and weighed at intervals to determine changes in moisture content.

Loss of moisture varied considerably from panel to panel, but in all cases steady, slow drying appeared to have taken place (Figure 2). Measurements on some panels had to be rejected during the test because of rain leakage into the system or because of physical degradation, but most, except those with wood fibre insulation, were continued for six years.

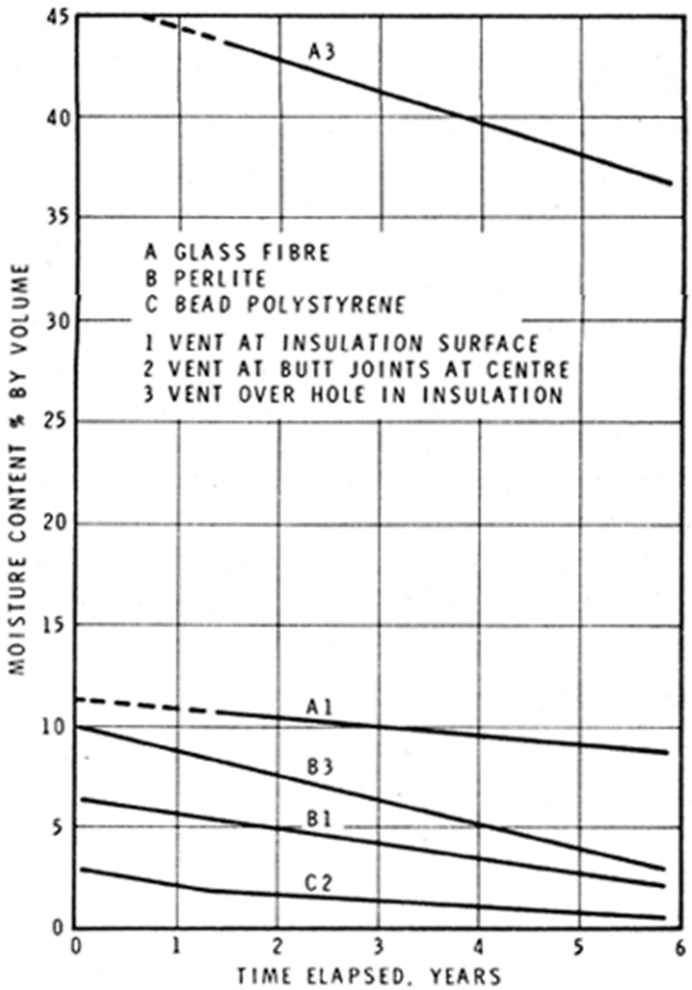

Figure 2. Change of moisture content of vented test panels.

Two field problems were encountered that could also be a problem with vents on an actual roof. Considerable difficulty was experienced in securing a good seal between the vent and the panel to prevent water leakage into the system; and in the first winter of operation snow drifted into the vents. The amount of wetting from snow did not appear to be large, but caps were constructed to provide a stilling chamber surrounding the vent to eliminate the problem. With modifications to the vents and top cover, the panels were reweighed and the study begun again. It should be noted that the panels do not accurately simulate a roof situation where there is a large expanse of roof surface and usually a number of vents installed in some regular pattern. They do, however, indicate that drying by stack venting is possible, although it tends to be a slow process.

New Roofs

For a new roof with insulation sandwiched between a vapour barrier and a roofing membrane to form a sealed system, stack venting is logical, particularly if combined with perimeter venting and intentional venting passages through the insulation. This may well take care of small quantities of construction moisture that would otherwise be trapped in the system as well as small quantities that might get past the vapour barrier. In addition, such vents will relieve vapour pressure generated under a heated roof surface and this will help in relation to some types of membrane blistering. For insulating fills placed over cast-in-place structural concrete decks, box vents are usually advisable to provide for drying of wet fill even if there is no vapour barrier.

It should be recognized that projecting vents are potential sources of leakage and that they are vulnerable to damage. Every projection through a roof is a source of leakage if flashing is improperly done, opens up due to building or flashing movement, or is damaged by traffic over the roof. A suggestion for venting without stacks is contained in **CBD 99**[3]; in this double-drained and vented system, vents are provided at the drains and building perimeter, with channels through the insulation for venting and drainage.

Existing Roofs

Where insulation is wet in existing, conventional roofs, it is unlikely that stack venting will be successful if the source of wetting is leakage around flashings or through the roofing membrane. If the source of wetting can be eliminated and the insulation has not deteriorated, it may in some instances be possible to dry a roof over a number of years. It may well be the logical procedure, preferable to replacing the roof. It may even be the only course of action for some process-type buildings where the owner does not wish the roof opened for replacement. It should be recognized in this case, however, that it may be extremely difficult on weathered roofs to achieve a seal around stack penetrations. Most roofers will be aware of the difficulties introduced by dirt, moisture, and deteriorated bitumen and will take steps to assure proper adhesion of flashing materials, but the very real hazard involved cannot be overemphasized.

On roofs where there is no vapour barrier the installation of breathers through the roofing membrane might create air leakage paths from inside the building directly to the outside through the insulation and vents. In such cases, large quantities of water might be deposited in the insulation to increase the wetting as moist air moves outwards and reaches its dew-point somewhere in the insulation. Generally, where there is no vapour barrier, vents to the outside from the roof system should not be used unless it can be definitely established that no air leakage paths will be created.

Size and Spacing

The size and spacing required for stack vents probably relate mainly to lateral moisture transfer potential in the system, although the Division is not aware of any testing or calculation methods that would indicate what this should be. Commercially available stack vents are generally 2-in. diameter pipe, and the spacing recommendation by the suppliers about one every 1000 sq. ft. Custom-made vents are usually larger in diameter, frequently 6 in. or more. Insulated box vents used for drying lightweight aggregate concrete fills may be even larger and spaced further apart. If the full benefit of a venting system is to be achieved it seems essential that stack venting should be combined with perimeter venting, and that intentional venting passages through the insulation should be provided.

Conclusion

Moisture traps in roof systems should be avoided. Where a double membrane system is to be provided this can be accomplished by designing a vented system. Breather vents can relieve vapour pressure and provide for drying of small quantities of moisture over a relatively long period of time. They tend to be unsuccessful in drying wet roofs unless wetting can be eliminated at the source and the venting system designed to facilitate drying. venting can be achieved without stack vents[3], or systems can be used that do not need vents[4].

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