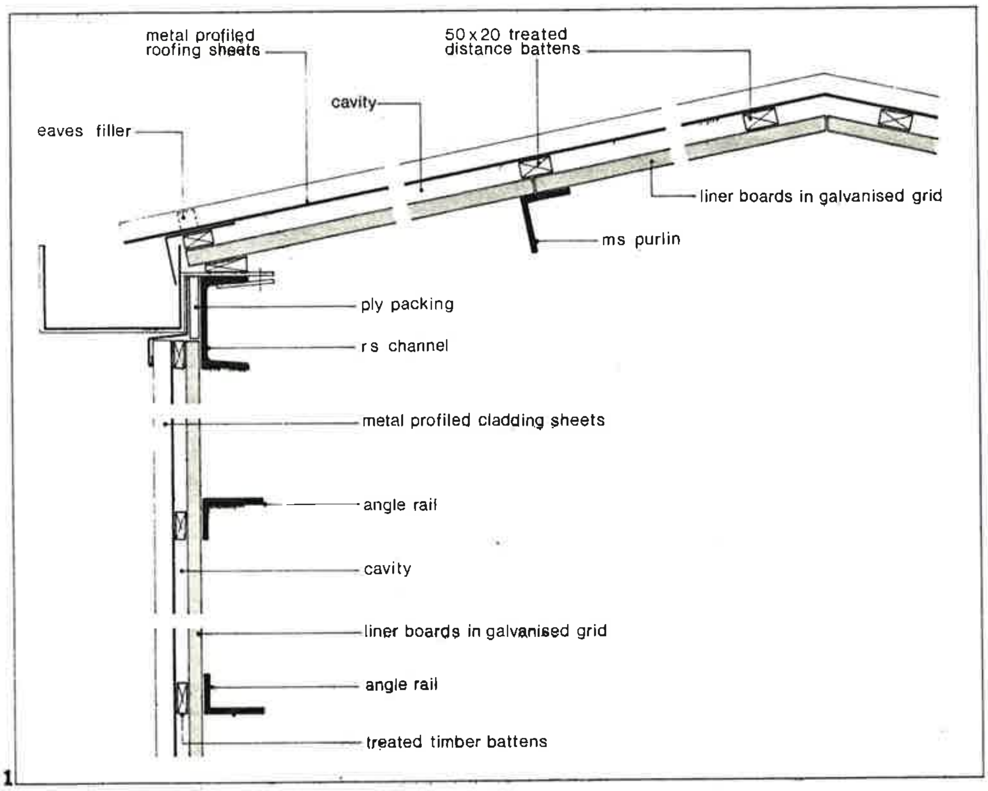
2151

METAL INDUSTRIAL ROOFS MOISTURE PROBLEMS

#1535

2151

Since Peter Falconer first wrote about moisture problems in industrial roofs (AJ 12.6.85 p73) enquiries and cries for help from secret sufferers, some in the throes of litigation have continued unabated. Here he sets out a range of causes, the most unexpected being that ventilation air may be a contributory cause of condensation. And he notes recent developments in cures, including a new design guide.



1 Typical industrial roof in which condensation problems are common.

The previous article, 'Failures of industrial roofs', aroused lot of interest among architects, engineers, contractors, surveyors and occupants who are having problems with interstitial condensation, leaks, cold bridging and corrosion. Problems arise epecially where there is a cavity between the roof sheet and the insulation beneath, *1*.

In August a meeting of interested parties was held in Stroud to discuss industrial roof failures. Among the points made was that the excellent insulating properties of modern foam and glass fibre insulations shield roof sheets from heat rising from the building below. Thus on cold clear nights, roof sheets radiate to this night sky and can drop below freezing when the ambient air temperature is well above that. Condensation and ice can form in the cavity.

Some of those with condensation problems had been advised to seal joints in the ceiling and increase cavity ventilation. But selective attempts had shown no detectable improvement.

The high temperatures of summer 1984 caused exceptional expansion and contraction of roofing sheets. Many low pitched metal roofs were leaking and it was not realised until the long cold dry spells of 1985 that condensation was also taking place.

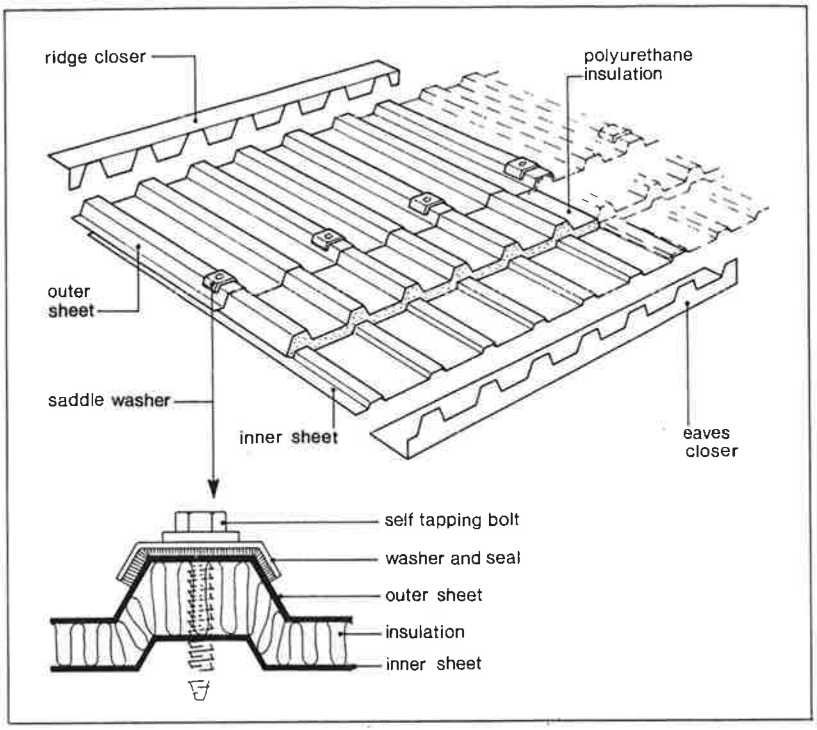
Condensation—the traditional picture

A major part of what is happening arises from a change (or lack of it) in designers' expectations about condensation in roofs. In building roofs generally the traditional remedial approach has combined moisture control and ventilation.

As a minimum measure, obvious gaps are plugged at ceiling level; at the most ambitious, attempts are made to create an impervious vapour barrier. And above the vapour check, whatever its quality, there has been through ventilation. Apparently, belt and braces.

It has long been accepted that this approach is not easy to follow in industrial buildings. Creating vapour barriers with long life joints, sealed from eaves to eaves including penetrations and fixings, is difficult to achieve.

Draining any condensate formed to the eaves rather than allowing it to waterlog insulation or collect in the roof structure is also problematic. And though moisture flow from the occupied space may be inhibited by



2

2 Proprietary system in which closed cell foam insulation is preformed to fill the gap completely between the roof sheets and lining sheets (Trinsul).

the vapour check there are other moisture sources within the roof construction.

Industrial roofs typically hold significant quantities of moisture. It lies in the laps of sheets and often on ledges and the like, around imperfectly waterproofed penetrations such as rooflights and flues. Another source is past condensate which may have waterlogged the insulation.

Achieving through ventilation from eaves to ridge or opposite eaves is often not easy to do effectively, especially where there are curved eaves or rooflights or box gutters between multiple roof slopes. The ventilation of roof cavities by natural means in low pitches cannot be achieved on calm cold evenings; mechanical ventilation is difficult and expensive to provide.

It was assumed that the current mass of condensation problems was due to the sort of moisture sources and constructional difficulties noted above. Some may be. But problems—on site or still on the drawing board—also need looking at with respect to other mixes of cause and effect.

Ventilation air as a moisture source

More unexpected, ventilation air itself may also be a moisture source contributing to condensation. In late autumn and early spring especially, skies can be clear and outdoor relative humidities very high—90 per cent or more. Where daytime temperatures are relatively high the air contains a lot of moisture at high humidities.

At night, metal roof sheets radiate to cold, clear night skies. Being well insulated from the warmer building below, the sheets can be 5°C or more colder than the surrounding air. Used for ventilation, this air can be cooled enough through proximity to the colder sheets to result in condensation on their undersides. Condensate may then run into the roof structure, or freeze only to start dripping through to the building below by mid-morning as the structure warms up.

Note that most methods of condensation calculation, based on psychrometric charts, make no allowance for such radiation to cold night skies and so fail to predict this ensuing condensation.

Foam filling the cavity

One general approach to a cure described in the earlier article was to exclude ventilation air by filling the cavity with non-waterlogging insulation that is resistant to air movement. Typically this would be a closed cell foam.

As described in that article, proprietary systems are available for new-build where preformed insulation fits closely between lining sheets and roofing sheets. The insulation is a loose element rather than being bonded to either sheet to avoid the risk of delamination and sagging, *2*.

There are problems in closing ventilation spaces in existing buildings. Very careful work is needed with rigorous supervision as described in the previous article. Cures are also costly. But this response to condensation is valid in principle and has worked in practice.

Recent experience of applying these cures offers the following points to watch:

● *Glass fibre insulation*
Where existing insulation is glass fibre above a metal lining sheet, it will often be waterlogged. When foam is injected to fill the ventilation cavity this water pours through the ceiling for some days before dripping ceases. However the foam appears to effect a cure.

Foam filling will typically compress existing glass fibre, say by 25 mm for a 100 mm thickness. The volume of foam needed can be substantial, contributing to high costs.

● *Existing leaks*
If a roof is inclined to leak, foam filling can aggravate the trouble. Sheets may expand more from solar heat gain with insulation rather than a cavity immediately below, pulling at fixing holes and flashings.

● *Existing damage*
When cold bridging is taking place between roof sheets and ceiling through purlins or other metal framing, foam fill makes little difference.

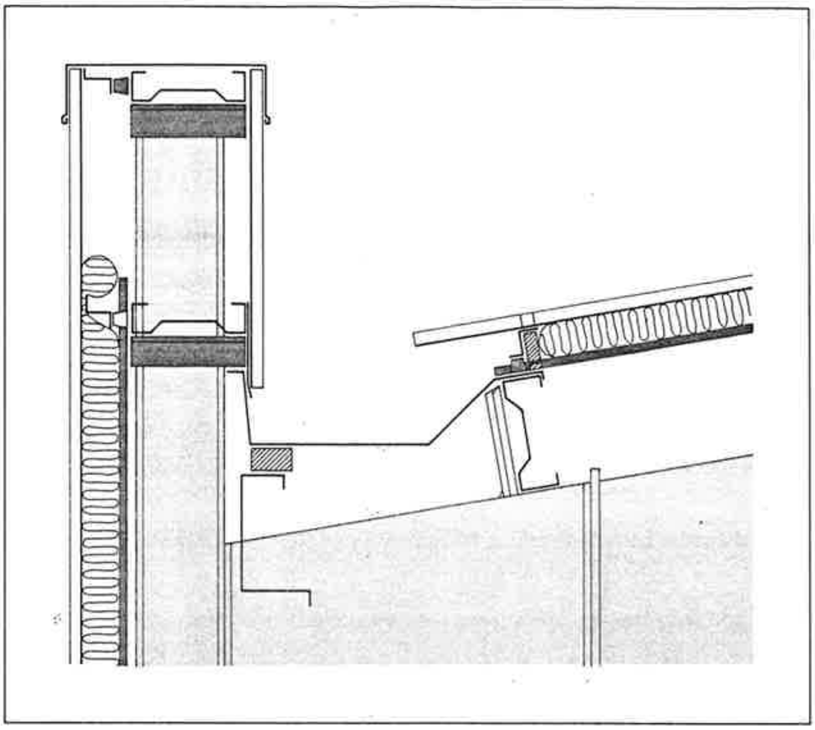
● *Existing corrosion*
Moisture, epecially in waterlogged insulation, may already have caused significant corrosion in steel roofing and lining sheets.

● *Delamination and compatibility of foams*
Roofing systems consisting of flat rigid polystyrene insulation board bonded to steel roofing sheet have been found to suffer bond failure on southern roof slopes where the expansion and contraction of sheets was not followed by the insulation. When the bond is broken the insulation sheet drops slightly between purlins, creating a gap which presents problems if the profiles have to be foamed to prevent condensation. It appears essential to prop the insulation from below.

Generally, before foaming over an existing foam board, check with the contractor or supplier that the two are compatible.

Foaming over the roof

Another treatment offered by several large contractors is to foam finish the whole roof



3

3 Typical problem of trade literature—focusing on one aspect of detailing and neglecting the rest. This diagram shows no insulation beneath the gutter, no vapour check, vague fixings and an indeterminate path for ventilation air. There are no notes or caption. (This diagram has been redrawn from the original. Linework is an exact replica, but the two tones, wall sheets, roof sheets, packings and insulation appear in the BSC document as six solid areas of coloured tones.)

on the outside (with a 10-year guarantee). This can only be carried out in good weather and programming is a major problem.

There are also the disadvantages of loss of appearance, loss of rooflights and possible increasing corrosion in the existing roof system. When re-roofing is eventually necessary, it could be a difficult and expensive job to remove the foam and sheets.

British Steel Corporation design guide

British Steel (BSC) has recently issued a new edition of *Roofing and cladding in steel: a guide to architectural practice**. It is interesting to review this in the light of current concerns about roof failures in industrial buildings.

It is a well produced 32-page guide covering function, appearance, colour, durability of fixings and maintenance. The information is better than that previously given by BSC. The colour photography of the buildings and coloured diagrams are excellent.

Three pages are devoted to cold bridging and condensation. But the troubles now being experienced with ice formation and moisture in cavities immediately under the steel roofing sheets in cold, sunny, and calm weather are not mentioned.

There is reference to the fact that where air is excluded from the space between the two skins there is no possibility of condensation forming, but 14 of BSC's diagrams show cavities which make condensation likely in critical weather conditions.

It is a pity that BSC did not take this opportunity to stress the need to completely fill all roof cavities with an insulating material that does not shrink or absorb water.

On top of this, fixings are omitted from one diagram, and insulation and purlins are not clearly shown on two. Similar criticisms can be made of nearly all technical information available from manufacturers and trade associations, *3*.

It is admitted that condensation forms within some roofing systems where there is a cavity under the steel roofing sheet. But justly discredited theories about the possible causes of condensation are once again resurrected: that condensation within industrial roofs can always be cured by ventilating the cavity and having an efficient vapour barrier, or that the condensation can be guided down on top of the under sheet into the gutters or out of the building at curved eaves.

Vapour barriers are referred to but the polythene sheets commonly used are usually punctured by fixings and the taping is unlikely to be effective after a few months. The natural ventilation of cavities referred to in the guide does not work on a cold, windless evening even where the profiles are open at the eaves on both sides of the building and there is ventilation at the ridge.

The question of cold bridging is dismissed as not presenting any serious problems. But where heavy steel sections have been used for purlins or where the frame passes from inside the building to the exterior, cold bridging can be a very serious problem in periods of sustained cold weather.

Remedial work of filling with foam is touched on in just eight lines. It is said to be entirely effective.

Several other points relevant to roofing should also be noted. The newly recognised problems of noisy metal roofs are mentioned, apparently caused by the roofing sheet rubbing against the ceiling board as it expands and contracts from the sun. A cure has yet to be found for existing buildings. Designers are warned of the pitfalls of roofing over quiet areas where silence is required for telephone calls and important conversations. The use of steel spacer bars is rightly recommended in cavities as these allow for the expansion of the roofing sheets. It is pointed out that timber spacers shrink and loosen fixings. There is no reference in the guide to the corrosive effect on steel sheets if they come into contact with damp timber that has been pressure impregnated with salts.

Conclusion

The magnitude of the problems facing the industry where there is a cavity under the roofing sheets has now become clear. Costs of claims and litigation are already mounting. Those concerned are reluctant to discuss their troubles and this, in the end, makes the problem even more costly to remedy.

Very few cures have been effected and the advice so far given by academics and consultants has often proved wrong. Building owners are infuriated by the lack of interest shown by the manufacturers, fixers and designers who appear to hope that the whole thing will fade away as the building dries out, or that the sort of long, cold, sunny, calm periods of weather of 1985 will not be repeated.

It is now vital to the whole building industry that the offending roofs are put right and that claims are kept to a minimum. After expensive litigation, remedial work still has to be carried out and paid for. This can entail complete new roofs which, like lawyers, don't come cheap.

Peter Falconer is an architect and a member of the Falconer Partnership.

**Roofing and cladding in steel: a guide to architectural practice* British Steel Corporation. 32pp. November 1985. Free.