

1.4 TRAPPED MOISTURE

INTRODUCTION

In addition to designing for the control of moisture vapour generated within the building by occupants and processes, precautions must be taken to prevent excessive moisture becoming trapped during construction and also to allow for the release of vapour pressures which may build up under the waterproof covering as a result. Failure to allow for trapped moisture may lead to blistering of the waterproofing or to residual dampness on the underside of the roof.

CONSTRUCTION WATER

Roofing components such as a poured concrete slab or a wet screed contain quite large quantities of water. For example a dense concrete slab 150mm thick will give up about 10 litres of water per square metre as it dries. The amount of water in the slab will be increased by subsequent wet screeding and also by rainfall if left exposed before the waterproofing is applied. Precast concrete units and other preformed deck and insulation materials may also absorb considerable amounts of water if left exposed to the rain.

Water within the structure is best drained away through temporary weep holes formed at the lowest points of the slab. These can be formed by casting-in blocks of expanded polystyrene for subsequent burning out, by conical timber plugs or cardboard formers or by drilling into the slab from below. The holes are then left open until seepage stops when they can be filled with sand cement mortar before applying the soffit finish. Once the waterproof covering has been laid, drying out of a structural slab will largely take place from the underside of the deck.

In the case of a wet deck construction, trapped air and moisture vapour will, therefore, form pressures which may lead to blistering of the waterproofing unless some form of vapour pressure release is provided.

VAPOUR PRESSURE RELEASE

In the majority of cases when the waterproof covering is applied direct to a wet deck or screed, a part bonded attachment for the first layer will give sufficient vapour pressure release and will prevent cycles of air and water pressure from building up under the waterproofing.

The specific provision of breather vents to the external air is not usually necessary with part bonding because the construction will normally have joints and cracks or permeable sections which will allow sufficient vapour pressure release. Indeed it would be extremely difficult to seal a part bonded membrane round the edges of a roof so that it could hold a significant pressure. Nevertheless, some designers prefer to make quite sure by the addition of breather vents. These should then be installed between the part bonded layer and the substrate, taking care that a free passage of air and water vapour is available from the part bonded interface, into and through the breather vent.

Cork insulation contains a high content of free air

which can expand to form a blistering pressure. Normally the pressure will release at skirtings or other details but if the cork is encapsulated with complete efficiency it may be wise to add occasional pressure release vents.

It would be wrong to rely upon small breather vents to provide a useful contribution to the drying of a screed or deck. Drying out will normally take place from the under surface of the deck and the addition of breather vents will make only the smallest contribution. They disrupt the continuity of the membrane and any subsequent damage to the vents can lead to leakage problems.

BLISTERING

The mechanism of blistering arises from pockets of trapped air and moisture which expand in the sudden heat of the sun and displace the membrane to form a blister.

Disruption of the waterproof covering by vapour pressures takes many forms and it is important that the nature and causes of blisters and similar defects are understood so that built-up roofing and mastic asphalt specifications can be designed and laid to minimise their occurrence.

BUILT-UP ROOFING

Blistering associated with built-up roofing takes three basic forms; full membrane blistering, inter-layer blistering and surface blistering.

FULL MEMBRANE BLISTERING

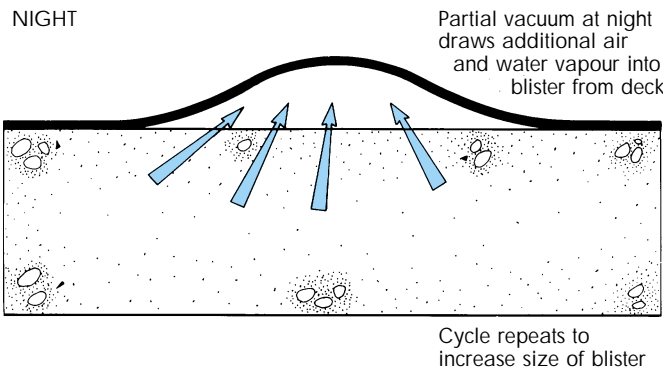
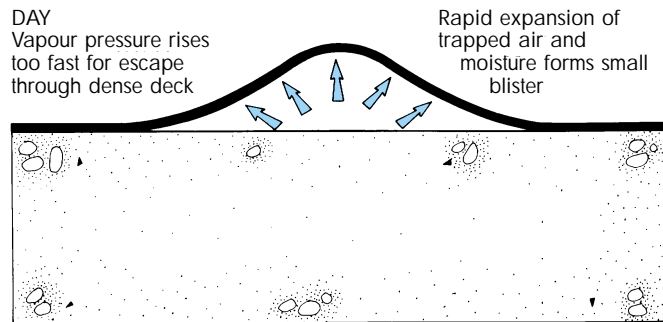
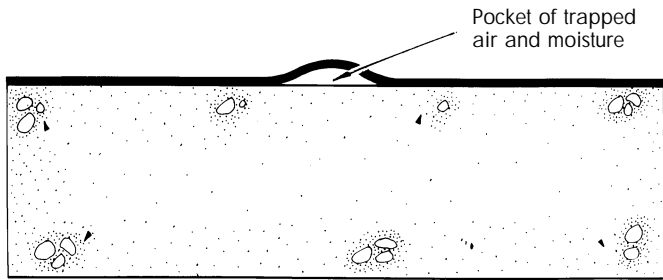
This refers to the blistering of the total waterproof covering from the substrate without separation between the individual layers of roofing.

Full membrane blistering starts from the expansion of trapped pockets of air and moisture. The blister will only be formed when dense substrate materials allow air and moisture to pass through them at a slow rate of flow. Under these circumstances, temperatures from the heat of the sun can rise too quickly for trapped air and water vapour to escape back through the substrate. Pressures will then develop in air pockets and cause an expansion which drives the beginning of a blister.

If the waterproofing suffers an irreversible stretch during the process, subsequent cooling will not cause the air pocket to return to the original size and a partial vacuum occurs in the now partly developed blister. Air and water vapour may be drawn slowly through the substrate to re-fill the original pocket of air, now slightly increased in size and ready to start another cycle of development of the blister when the sun appears again. The amount of expansion possible in a single cycle is calculable and is in the order of a 35% increase in volume, for a temperature change of 50°C.

With oxidised bitumens it is not usually possible to achieve such a good bond that blistering can be entirely prevented. Specification design therefore relies on part bonding to prevent full membrane blistering occurring.

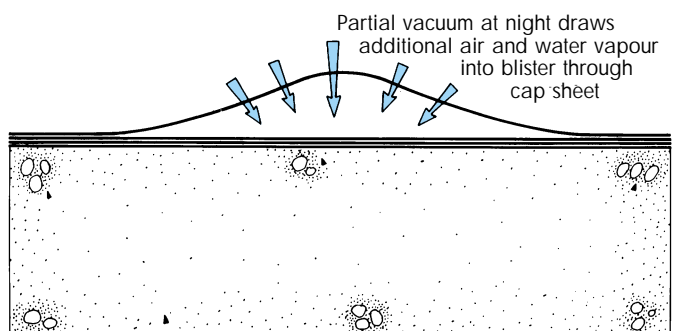
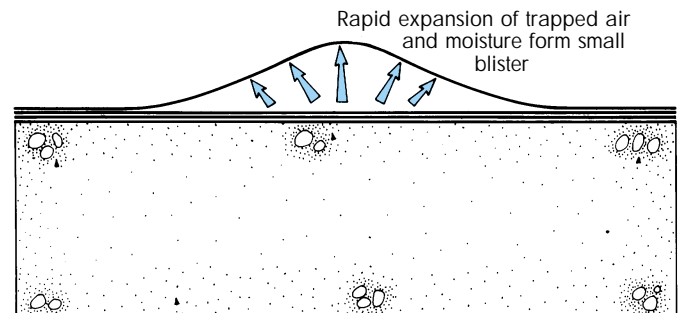
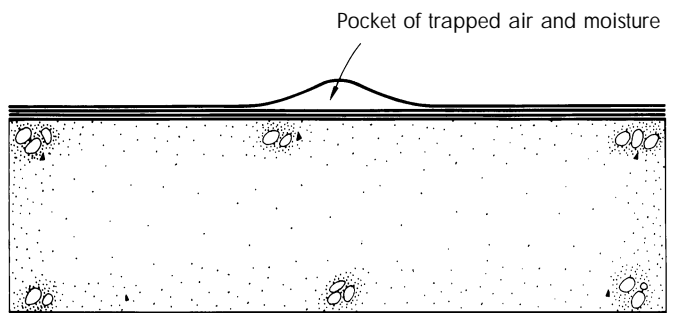
Certain torch-on materials with APP modified



If air and water are trapped together the water will keep the air 100% saturated with moisture vapour and the increased vapour pressure will cause additional expansion. When the temperature rises to 80°C, the increased air and vapour pressure will expand the cavity and if the pressure is allowed to expand the cavity freely, the volume increase will be 140%. If the temperatures rise were only 40°C, the volume increase would be 23%.

Large blisters are, therefore, not explained by the expansion of trapped air and water alone. It should be appreciated that the mechanism depends on a feed of additional air and water vapour through the top layer of the felt. This is possible because of the vacuum effect which will develop inside the space formed by blistering action during the cooling process when the walls of the blister are stiff enough to resist returning to their original position.

The vacuum effect which draws air and moisture through the cap sheet into the blister is a slow action but when exposed to sunshine the temperature will increase rapidly causing a rapid expansion of the air and moisture which will not have time to escape through the cap sheet. This will cause an increase in pressure and further development of blistering.



bitumen coatings achieve a bond which is an improvement on that obtained using unmodified bitumen and these materials exhibit an increased resistance to flow or stretching. All of these properties help the formation of specifications which are more resistant to blistering pressures.

An application of chippings helps to keep the membrane cool and the weight of the chippings helps to hold down the membrane against blistering.

INTER-LAYER BLISTERING

Inter-layer blistering usually takes the form of a blister formed under the cap sheet of the membrane.

To understand the process, it is necessary to consider the mechanism of air and moisture movements in a little more detail. The blister will start at a pocket of trapped air, and there may well be some such pockets as it is impossible to achieve total continuity of bond. In practice only thin layers of air can be trapped during the course of application of roofing materials. Taking a simple case where a local 1mm thickness of dry air is trapped in a cavity between two impermeable layers at 0°C (273° absolute). If the temperature rises on a hot day to 80°C (353° absolute), the volume of air would increase by the ratio 353:273 or about 30% provided there is no force to restrain the expansion. The 1mm layer of air cannot therefore increase to more than 1.3mm and would not form a noticeable blister.

Observations of inter-layer blistering on site confirm that trapped water is not necessary to initiate the mechanism. Such blisters can occur on roofs which have been installed in entirely dry weather but the scale and frequency of blistering will tend to increase with roofs which have been installed in wet weather. Working in dry and warm weather is clearly desirable but the ideal conditions are not often experienced in the UK climate.

Modern felts are far more resistant to blistering than the old rag base and asbestos base felts, which were very dependant on a covering of stone chippings. Glass base mineral surfaced roofing is resistant as are most polyester base mineral surfaced roofings. Felts made with SBS or APP modified bitumen are very resistant.

On flat roofs, blisters are almost entirely prevented by the application of a layer of 10mm stone chippings; smaller chippings are less effective. Mineral surfaced polyester base roofing is proving satisfactory with little risk of blistering. In the event of inter-layer blistering it is usually wise to leave the blisters in place. Aesthetically this may be unfortunate but it is extremely unlikely that leakage will result.

SURFACE BLISTERING

Certain felts can exhibit a miniature surface blistering of the coating bitumen and this has been most marked with the old and superceded rag and asbestos mineral surfaced felts. It is composed of small blisters in the order of 1mm to 3mm and is unsightly if widespread.

The small blisters can be formed by air and moisture trapped in the base during the course of manufacture.

Alternatively an incompatibility of the bitumens, referred to as Oliensis, causes oils from the oxidised coating bitumen to separate as a result of contact with an incompatible saturant bitumen. An oily layer may develop at the interface and rise to the surface through pin holes in the coating to cause a spread of oily material on the surface, or miniature blisters in hot sunshine.

As with other blistering, there is no need to fear for the efficiency of the waterproofing and no remedial treatment is recommended for surface blistering.

MASTIC ASPHALT

Asphalt is relatively stiff and heavy compared to built-up roofing. It is less prone to blistering, but the action of trapped moisture and air must be allowed for in the application of the asphalt.

BLOWING

During the initial application of mastic asphalt the extreme heat of the asphalt expands the air quickly and raises the temperature of any moisture above boiling point. The result is the formation of blows or bubbles on the surface as the gas forces its way through the asphalt, which increases the difficulty of achieving a satisfactory adhesion of the asphalt.

For the main horizontal roof areas, mastic asphalt is applied on top of sheathing felt or sometimes on a glass tissue separating membrane. This allows the air and water vapour pressures to escape laterally beneath the asphalt as it is applied. Any formation of blows which remain are noted by the asphalter, and the situation is rectified as it occurs by piercing the blows and working over the asphalt to prevent voids.

On vertical brick or concrete the asphalt is applied direct, without sheathing felt, in order to achieve a soundly bonded interface. Again, blowing is controlled by the asphalt spreader and adhesion is improved by the application of a high bond primer to the concrete or brick surface before application of the asphalt.

Most blowing occurs during the application of the first coat of asphalt and although it can be expected that imperfections of bond or permanent air pockets will occur, they should be small in scale. The first coat will form an ideal dry smooth surface for the second coat which will be largely free of problems during application and free of significant imperfections.

It is important that the second coat is applied as soon as possible after the first coat preferably on the same day, in order to minimise deposits of dirt and dust or contamination from foot traffic which could prevent the formation of a full adhesion between the coats.

The majority of blows are visible and easily corrected but some small scale blows can stop short of showing on the surface of the asphalt but leave a small hidden void. This may not be immediately visible after the asphalt has cooled but gradual settlement of the unsupported asphalt above will take place to leave a depression on the surface, known in the trade as a 'sinker'. Sinkers are not a defect likely to lead to leakage but remedial action will normally be taken to make good the surface of the asphalt if the incidence is widespread.

FULL MEMBRANE BLISTERING

Sheathing felt is a fully efficient separating layer for the flat areas of a roof. Air and vapour pressures in service will be released by lateral escape under the membrane. Asphalt which is bonded to concrete or sand and cement rendering or screeds, however, gives no escape routes for trapped air and moisture other than through the concrete itself. In these cases the cyclic formation of blistering can be set up with the same mechanism previously described for full membrane blistering of built-up roofing on a wet deck.

As a full adhesion will only be formed on details or vertical or sloping surfaces, it is only in these situations where the mastic asphalt is at risk of blistering. At detail work it is likely that air and vapour pressures will disperse through the concrete fast enough to prevent a build-up of enough pressure to cause the asphalt to blister. Concrete surfaces should be wood float finished to provide a coarse texture which allows a measure of pressure release. Smooth surfaces should be avoided.

The sides of gutters or large areas of vertical or sloping work are more likely to contain local pockets of increased pressure and these situations are rather more likely to blister, unless protected with a solar reflective finish.

As with any blistering the process must start from a small nucleus of unbonded material and the incidence of blistering will be reduced by a positive and continuous adhesion of the asphalt to the concrete. Unfortunately building construction can never be so accurate that 100% adhesion is achieved and even though blistering is not very likely with asphalt, it is always possible for a certain amount to take place on large bonded areas which are exposed to the sun. A solar reflective finish will minimise this effect.

INTER-LAYER BLISTERING

Inter-layer blistering is not a common occurrence on mastic asphalt roofs but it can take place between coats under exceptional circumstances. Again the blister must start at a nucleus of unbonded material and this may occur where the second coat has not fully adhered, usually due to dirt or dust on the first coat. If this results in a blow, a cavity will be formed during the application of the asphalt but may remain unobserved. The second coat above the cavity will be thinned and conditions may occur where air and moisture can penetrate slowly into the cavity to feed the cyclic growth of the blister until a significant blister is formed. Finally, the blister erupts or cracks to the extent that it will no longer hold a pressure.