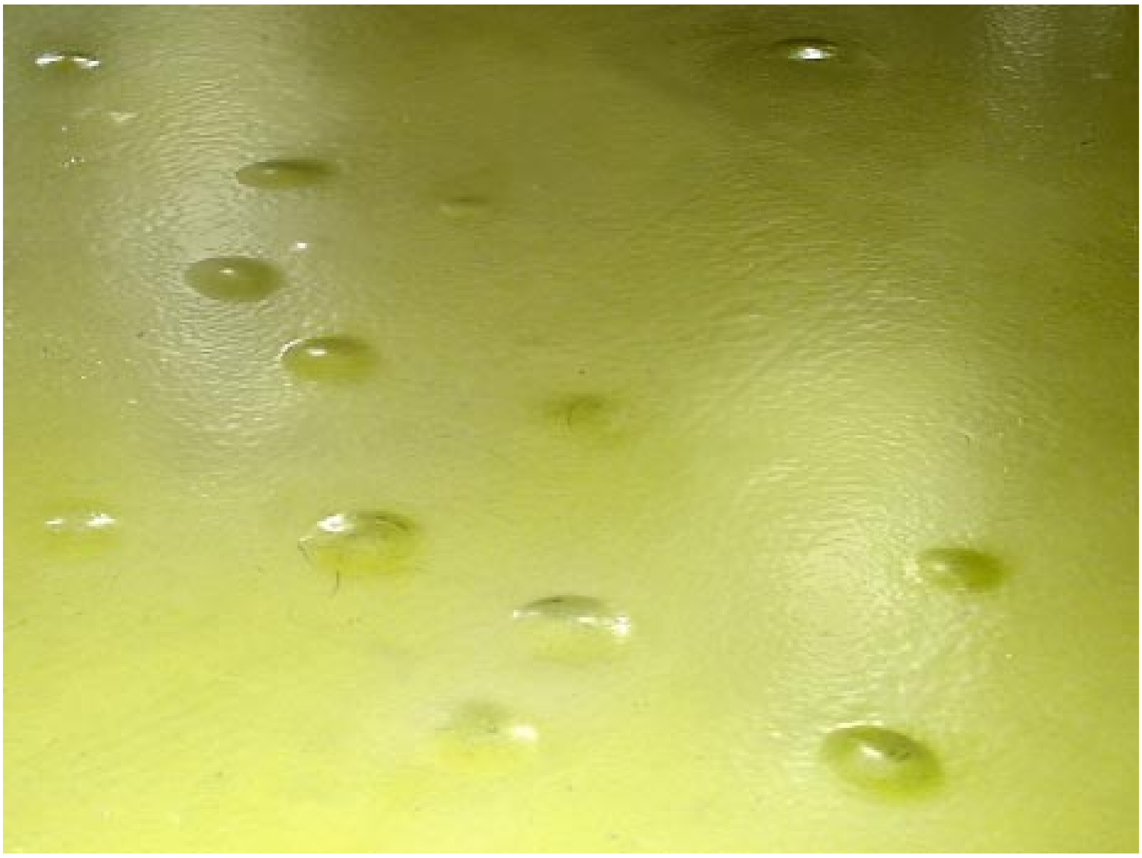
GUIDANCE

The Resin Flooring Association

OSMOSIS IN RESIN FLOORING



FeRFA Guidance Note: No. 2

INTRODUCTION

The original Guidance Note on the problem of Osmosis in flooring was published by FeRFA in 1989. Since that time the document has been invaluable in helping those whose floors have been affected by blistering, to understand the uncertain nature of the problem. The problem has inevitably attracted an air of mystery and this has intrigued investigators and led to an increasing number of scientific studies in recent years. These are shedding increasing light on the problem. Although the position has not yet been reached where the problem can be said to have been completely eradicated the likelihood of it occurring should have been reduced if the precautions described here are taken.

THE PROBLEM

In a very small proportion of installations, (far less than 1%), severe blistering of thin synthetic resin floorings or coatings occurs unexpectedly between three months and two years after laying. These blisters commonly vary in size from a few mm in diameter up to 100 mm, with heights up to 15 mm. When drilled into or otherwise broken an aqueous liquid is expelled under very high pressure. The mechanism of their formation is still not fully understood but the most likely explanation on account of their physical characteristics is that it is by a process of 'osmosis'. Certainly the level of pressure contained within the blisters could not be explained by direct hydraulic pressure from ground water, but is consistent with osmotic pressures.

The problem is not confined solely to flooring: similar blistering can occur with other coatings such as used in roofing or marine applications.

Blistering can also be caused in ways other than by osmosis such as by direct hydrostatic pressure if the concrete base is below the water table or by water vapour trapped within the concrete slab. Such blisters generally occur within a day or so of application. Water in the concrete can exert sufficient pressure to debond a partially cured synthetic resin flooring and force it away from the surface forming a blister. The trigger is usually a temperature differential; such as caused by exposure to localised sunlight or draughts or by radiant heat from ovens or other equipment.

Osmotic blistering is distinguished by not becoming apparent for many weeks, or even months, time being necessary for the internal pressure to build up to the level necessary to deform a fully cured synthetic resin flooring. It is unlikely that the whole floor will be affected, blistering generally being confined to a small proportion of the coated area.

Correct diagnosis of osmosis is important if a blistering problem is to be rectified correctly. As a general rule, osmosis has occurred only if the blisters:

a) do not appear until several months after the original application, and

b) are filled with liquid under very high pressure

Because of its unpredictable nature, osmotic blistering has been invested with a degree of mystery akin to that surrounding crop circles. However the implications of its occurrence are far from a joke. Due to the time interval involved, the floor will have generally been brought into full commission and any problems cannot be easily rectified without considerable expense and inconvenience, arising from the very extensive disruption to production.

Fortunately experience has built up in recent years indicating which types of flooring are more resistant to osmotic blistering. Where a floor or production process is particularly critical it is now feasible to specify flooring systems which have been found to be unaffected by osmosis. Inevitably such floorings are of higher cost but this can be accepted in many instances because of the degree of assurance provided for a trouble-free life!

HISTORY

During the early 1970's the first cases of blistering of resin flooring were reported to the then Building Research Station. They mainly concerned epoxy and polyester coatings of the self-levelling type. Many cases have since then been investigated at BRE or by other organisations. These cases have also included some rubber and PVC flooring stuck down with epoxy adhesives.

A wider survey indicated that the problem was relatively rare affecting only a very small proportion of floors laid. In 1974 a limited amount of work was done at BRE to show that cement paste could behave as a semi-permeable membrane and the hypothesis was put forward by Warlow and Pye that the blistering phenomenon was caused by osmotic pressure. More recently experimental studies in Germany by Siegfried Wisser of the Hoechst laboratory, Hamburg and independently by Reinhold Stenner of the Polymer Institut, Wicke have demonstrated by model experiments that osmosis can cause blisters in resin coatings.

Other work has shown that osmosis can lead to blisters in paints applied into immersed metal structures, although in such cases the moisture is not originating in the substrate.

A survey of reported problems in floorings indicates that osmotic blisters occur only with the thinner types of resin flooring (Types 1 to 5) up to about 6 mm in thickness. The problem has not generally been observed with trowelled resin mortar floorings, possibly because of their higher resistance to deformation and greater lateral permeability.

OSMOSIS

Osmosis is an important and well-known thermo dynamic property of solutions. The term is used to describe the spontaneous flow of water into an aqueous solution, or from a more dilute solution to a more concentrated one when the two are separated by a semi-permeable membrane. A semi-permeable membrane is one that will allow the passage of water but not the dissolved substance. If the side of the membrane containing the higher concentration is enclosed then the passage of water through the membrane will cause a pressure to develop. Water continues to pass until the resultant pressure prevents further movement. This pressure, the osmotic pressure, may be very high. Three conditions are required for osmosis to occur:

1: A concentration of water-soluble material

2: The formation of a semi-permeable membrane

3: A source of water

OSMOSIS IN FLOORING:

Concentration of Water Soluble Material:

If a concentration of water-soluble material and a semi-permeable membrane occur at the surface of a cementitious screed or concrete base which is subsequently covered by an impervious material then, provided a source of water is available on the underside of the semi-permeable membrane, osmosis can occur. The osmotic pressure generated by movement of water through the semi-permeable membrane is sufficient to cause blistering of flooring. Such blisters will be found to be full of aqueous liquid usually under pressure although if they are opened after some years they may be dry because water has returned to the base through an imperfect semi-permeable membrane. The size of the blisters formed will depend on a number of factors such as the initial concentration of water soluble material, the quality of the semi-permeable membrane formed, how well the flooring is bonded to the concrete or screed and the type and thickness of flooring.

Water-soluble material may comprise either inorganic or soluble organic materials. In either case these may derive from the resin ingredients of the flooring, from the concrete base, or from contamination. Inorganic salt concentration can be formed at or near the surface of concrete in a number of ways such as acid etching in substrate preparation, or the application of surface hardening agents. Moreover, contamination from sources outside of the concrete or screed need not be involved. Salts derived from the Portland cement can migrate to the surface and concentrate there when the concrete is drying after laying. This is similar to the formation of efflorescence on bricks. It is known that there can be a significant increase in the soluble salt concentration at the surface of a concrete slab from which moisture is evaporating. Local high concentration of alkali sulphates have been found in a number of cases, samples of liquid from blisters have been taken and analysed for soluble salts. Total dissolved solids ranging from 3% to 13% have been found. However, it should be remembered that original concentrations would have been much higher before dilution by way of osmosis occurred.

Water-soluble organic material may derive from the resin ingredients or from existing contamination of the concrete. Concentrations of water-soluble materials can therefore arise from a number of factors: -

- Previous contamination, e.g. cutting oils, food stuffs, de-icing salts, chemicals etc
- Residues from acid etching;
- Detergent residues from cleaning process - salts from cement;
- Salts from poorly washed concrete aggregates;
- Some cement admixtures;
- Indirectly from inadequate curing of the concrete;
- Incorrect proportioning or blending of resin components leading to leachable quantities of soluble material;
- Resin materials with leachable soluble components;
- Resin materials that have deteriorated or segregated due to prolonged or unsatisfactory storage.

Semi-permeable membrane:

A semi-permeable membrane or layer is one that will allow the passage of water size molecules, but will not allow the passage of larger molecules. The pore size found in good quality concrete can be of a suitable size ($1 - 2 \times 10^{-5}$ mm). Even if the pore size in the concrete is not sufficiently small to form a semi-permeable membrane, it is conceivable that the application of a primer coat could reduce the diameter of the pores in the surface to a size where the surface layer could act as a semi-permeable membrane. Some research work in Holland has shown that epoxy films can by themselves behave as a semi-permeable membrane. Other resin types such as polyurethane, polyester or methacrylate would behave similarly in this respect to epoxy resins.

Source of water:

Even when concrete or a screed is said to be nominally 'dry', it will contain about 3 to 5% of free water by weight. This is sufficient water for osmosis to occur and no other source such as water from the ground is necessary. At least one case has occurred on a suspended floor several stories above ground level. Generally blistering of floorings caused by osmosis is usually noticed and reported after an average period of six months. The formation of blisters often continues for about two years after which no further blistering is noted. It can be expected that the increase in size of blisters will slow down and stop when the ionic activity on either side of the semi-permeable membrane becomes equal due to dilution of the dissolved material by transfer of water and/or leaking back into the screed or concrete slab of dissolved material across an imperfect membrane. Clearly osmosis can be made more likely by the presence of free water. This can arise from a number of sources:

- Inadequate, damaged or missing damp-proof membrane
- Leaking drains passing through the floor
- Water leakage through walls into a ground floor
- Water used in acid etching or preparatory cleaning process on a concrete slab
- Condensation onto prepared concrete base before application of flooring

PREVENTION

It has not proved possible so far to research the subject of osmotic blistering completely because of the unpredictable nature of its occurrence. However some general precautions can be identified which should minimise the potential risk. A degree of risk will nevertheless still exist. At the same time, ignoring one or more of these factors will not inevitably lead to blistering problems. These precautions include the following:

- Identify the structure of the base onto which the resin flooring is to be applied, taking care to determine its moisture content;
- Where a dpm is absent from an existing concrete base, it is preferable to specify a flooring system that is water vapour permeable throughout, including the primer;
- Investigate previous use of the floor to determine whether soluble contaminants might have been absorbed into the surface;
- Specify a synthetic resin flooring of Types 6 to 8;
- If the situation is particularly critical, specify a flooring system that is designed to be water vapour permeable to allow any osmotic pressure to dissipate;
- In new construction ensure base concrete has low soluble salts, by avoiding poorly washed aggregates and by curing the concrete well immediately after laying, to prevent premature drying out, e.g. cover with plastic sheeting for 7 days;
- Allow the concrete to dry out after curing, preferably for at least 21 days;
- Thorough, dry, mechanical preparation of concrete bases in preference to chemical methods. Avoid acid etching;
- Do not wash the base concrete with detergent;
- Ensure complete removal of all contamination on existing floors;

- Any levelling screeds should be polymer modified to minimise permeability and potential salt movement;
- Ensure resin compounds are accurately proportioned (by weight or volume as specified).

RECTIFICATION

Where osmosis has occurred, different techniques for rectifying which have proved successful to date include, after cutting out the affected area and mechanically cleaning the concrete base:

1 Replacing the affected area with a synthetic resin flooring known to be resistant to osmosis. This may not be an acceptable option if there is a need to match the thickness and texture of the adjacent unaffected floor.

2 Double priming the base to ensure complete coverage and maximum adhesion when replacing the flooring.

3 HCA (Hot compressed air) treatment of the concrete base coupled with a penetrating primer before replacing the flooring.

THE FUTURE

This document has been produced in order to stimulate further interest in this particular problem and to summarise the technical information and guidance currently available. FeRFA would welcome details of any experience of such problems so that a more detailed picture can be built up, thereby furthering our knowledge of ways of preventing osmosis occurring.

BIBLIOGRAPHY

"Osmosis as a cause of blistering of in-situ resin floorings on wet concrete": W J Warlow & P W Pye: Mag. Concrete Research (1978) 30, No. 104, 152-156

"Behaviour of solvent-free epoxy resin systems on water absorbent concrete surfaces": Siegfried Wisser: Kunstharz Nachrichten (Hoechst)

"Defects in epoxy resin flooring": BRE Technical File, (July 1986), No. 14, 32-34

"Blistering of in situ thermosetting resin floorings by osmosis": P W Pye: International Colloquium, 'Industrial Floors', Esslingen 1995

"Influence of moisture from substrate to blistering", R Stenner & J Magner: International Conference on Polymers in Construction, 1995

"Osmotic blistering of epoxy coatings on concrete", F A Pfaff & F S Gelfant, (December 1997), J. Protective Coatings & Linings, 52-64

"Osmose – Theorie und praktische bedeutung": K Littmann: International Colloquium, 'Industrial Floors', Esslingen 1999

The Resin Flooring Association

FeRFA

FeRFA, the Resin Flooring Association is the UK Trade Association for Manufacturers and Contractors of specialist resin floorings. Originally established in 1969, FeRFA now represents over 60 U.K. based major companies in this specialist market sector.

For a list of other publications or further information, contact FeRFA at:

Association House, 99 West Street, Farnham, Surrey, GU19 7EN
T: 01252 739141 F: 012525 739140
E: info@associationhouse.org.uk

or

visit the FeRFA website at www.ferfa.org.uk for a list of members, publication downloads and other useful information.

ISBN: 0 9538020 5 1

Edition: July 2003

G U I D A N C E