DTB040.001

TECHNICAL BULLETIN

SUBFLOOR PREPARATION – SOURCES OF MOISTURE AND DAMP SLAB PROBLEMS

INTRODUCTION & SCOPE

Problems with excessive moisture in both new and old concrete substrates have been around for many years, causing concerns to the contractor, layer, and client. They often result in costly blow-ups and failures which are then compounded by having to take the building out of use for the rectification.

There are many reasons for excessive moisture in concrete substrates, remembering that moisture can travel hundreds of metres sideways through the concrete by capillary action, and not just appear over the exact cause or source.

The first defence of a concrete is a sound sub-slab moisture barrier but is this in place and if so is it still sound?

OLD CONCRETE

In the case of very old concrete, chances are there was never a moisture membrane used under the slab in the first place. The requirement for sub-slab sheets was formalised in AS2870 which first appeared in two parts in 1988-1990. The first version of the Building Code of Australia (now called the National Construction Code) also appeared in the early 1990s. Notwithstanding, the use of plastic sheets was already in place well before these documents were produced.

If a membrane was used, it may have broken down over the years or possibly it was punctured during the installation of reinforcement and placing of concrete, rendering it useless. The problem will be exaggerated if air conditioning has been installed since the flooring was originally laid. The warm ambient temperature above the floor will entice the moisture upwards from the slab. These types of problems are exacerbated in areas of high water table, high humidity, or high rainfall wet seasons, for example tropical Australia, Tasmania or New Zealand.

BELOW GRADE SLABS

Slabs which are 'below grade', for example excavated or cut into the side of a hill can also suffer from severe problems, as there is generally a build-up of hydrostatic pressure forcing the moisture upwards. Even if the membrane were laid correctly under the slabs, the moisture can enter via the sides where the backfill has been done without drainage to take the moisture away, or where water physically runs onto the slab edges.

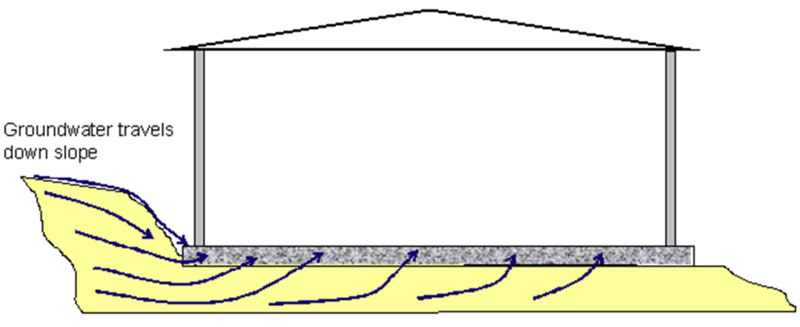
In new buildings, moisture problems can also be caused by water penetration through the sides of the slab, either as the result of heavy rain, or sprinklers on garden beds which have been formed without some sort of drainage, or the lack of a membrane coating up the sides and over top/edges of the slabs or retaining walls below grade.

LEAKING PIPES AND BUILDING ELEMENTS

Leaking pipes or broken underground drainage are common problems in old commercial premises and are sometimes impossible to isolate. Other parts of the building can leak, and the moisture travel throughout the construction, leading to difficult to identify sources. Examples include leaking gutters and downpipes, leaking building facades and curtain walls, leaking door and window frames and leaking roof membranes. Usually the flooring has been installed during the summer of a dry spell. A week of heavy rain can result in an installation with moisture problems, which normally leads to the layer or contractor receiving the blame for something that is beyond their control.

NEW CONCRETE

New concrete is a real problem for the layer today. No one has the time to let the concrete cure properly, bringing the moisture content down to the correct percentage. Pressure is



Below grade slab

always put on the contractor to go ahead prematurely, even though he knows he will be the one taking all the risks.

There are many reasons for concrete taking longer to dry out sufficiently to meet the requirements of the Australian Standards. One of these is due to the speed that modern building techniques can erect buildings (often being to the lock up state with windows in place far earlier these day) not allowing sufficient ventilation and air movement over the concrete. Evidence of this can often be seen by condensation forming on the windows due to evaporation of water during the concrete drying stage giving high humidity readings.

Whilst the flooring standard AS1884 was revised in 2012, the **old** standard AS1884-1985 - Appendix A contains this interesting paragraph in Determination of Dryness of Concrete Subfloors A3, Approximate Drying Times of Concrete:

> *"As a general "rule of thumb" it has been found that under average conditions in Melbourne, and with good ventilation, a typical 100mm thick slab of normal concrete, drying from one face only, will take about four months to dry to a moisture content in equilibrium with the surrounding air. If ventilation is poor, the humidity high, or the temperature low, drying will naturally take longer; on the other hand, with good ventilation in hot weather, drying will speed up. It should also be noted that occasional wetting of the concrete surface will reverse the drying process, because dry concrete absorbs moisture rapidly. Consequently, drying time should be calculated from the time when the slab was last wetted by rain or dew. Even scrubbing of the surface before the floor layer commences work, should be voided as far as possible".*

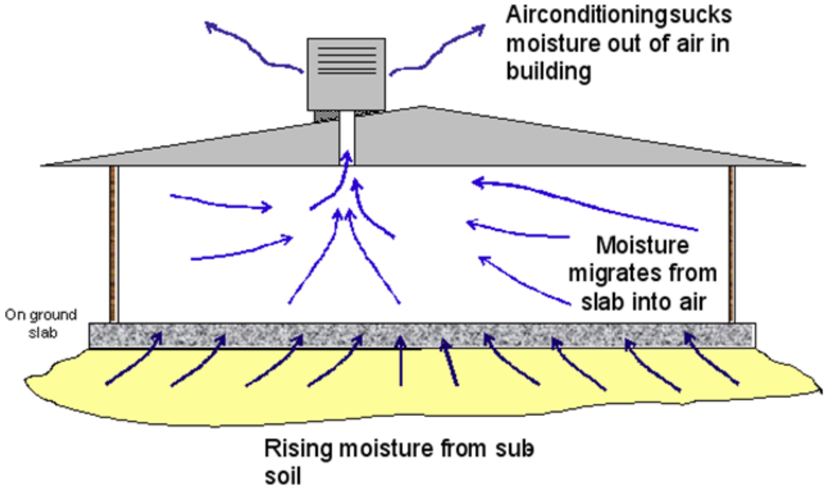
The basic measure here is that the required drying time approximates to 1 day per millimetre concrete thickness from each exposed face to reach equilibrium with the surrounding air. Whilst much of this useful information still holds *generally* true, more recent research has shown the numbers are not always *strictly* true and the drying rate is not necessarily a linear relationship for slab thickness vs time.

So many times when the client is asked when the slab was poured, the answer is "months ago". One would think this would normally be sufficient time for curing, however maybe the roof did not go on then, or the windows were not installed, therefore in theory the drying time should be adjusted from the last time the slab was wetted by rain.

AIR-CONDITIONING

Air conditioning appears to be playing a major part in moisture related blowups, especially in new construction work. Clients will notice that most problems occur a short time after the air conditioning is commissioned, which is sometimes up to three months or more after the flooring has been installed.

Most installation procedures are done in a fairly stable ambient temperature, which does not initially lead to any problems. However, a combination of little things can accumulate to cause problems: the slab moisture content was fractionally outside the recommended tolerance, the levelling compound was mixed with more water than recommended, the adhesive was applied before correct cure of the levelling compound and wasn't allowed to tack off correctly, this leaves us with excess moisture. Another situation



that can occur is high ground moisture levels which may not have enough pore pressure to cause rising damp, but provide a latent source of moisture which can penetrate the slab.

This may be okay at the ambient temperature during construction, but when the air conditioning is commissioned, the dehumidifiers in the plant remove the moisture from the air. This can result in an unbalanced situation with relatively dry air above a source of moisture and so any excess moisture is drawn upwards causing problems.

A similar effect can result from slow combustion stoves which tend to dry out the air and also encourage water vapour formation, which when the environment cools down, forms liquid water which can accumulate under impervious surfaces.

The Australian and New Zealand Standards

We bring the reader's attention to the fact that AS1884-2012 and NZS1884-2013 are NOT the same, even though the NZS was based on the earlier AS document. Therefore, you need to refer to the standard that is relevant in your country.

Flooring contractors are strongly advised to obtain copies of the Australian or the New Zealand Standards for floor covering installation. However, there are those who do have copies but never seem to read them and they see them as a handicap rather than a benefit.

The standards are an excellent guide and a selling tool, which can be used to qualify prices and procedures relating to quality installations. They are also an excellent form of protection and assistance in discussions with customers when the contractor is instructed to proceed with work practices, which contravene those Standards. Contractors need to protect themselves by not agreeing questionable installations. DUNLOP strongly recommends that contractors familiarise themselves with the provisions of the relevant Australian or New Zealand Standards.

The following excerpts are taken from AS1884-2012 and AS/NZS2455.1-2007 (together with the two excerpts already discussed above) and define two **'golden rules'** for installers in relation to moisture.

Please note that NZS/AS1884-2013 has some variations in the Appendix A to suit the local New Zealand conditions and so the results are slightly different to the parent AS version.

AS1884/NZS1884

3.1.1.2 Dryness

Before subfloor preparation is performed and a floor covering is laid on a concrete subfloor, the dryness of the concrete shall be determined as described in Appendix A.

AS1884 - Appendix A - A3.1 Concrete subfloors

A3.1.1 Test methods

Wherever possible the relative humidity in-situ probe test in accordance with ASTM F2170 shall be carried out on the subfloor as, even though the surface may record an acceptable moisture content reading, this may not be the case beneath the surface. The only exception to using this test is where there is in-slab heating, a security system, an anti-static wiring installation or where slabs have been treated with a penetrative moisture suppressant. In these cases the surface mounted insulated hood test in accordance with ASTM F2420 shall be performed.

A3.1.2 Relative humidity in-situ probe test

Concrete subfloors shall be considered sufficiently dry when measurements taken in accordance with ASTM F2170 do not exceed 75% relative humidity. Three tests shall be performed for the first 100 m^2 and at least one additional test for each additional 100 m^2 and other recommended positions in accordance with ASTM F2170. Refer to the adhesive manufacturer's recommendation for acceptable relative humidity levels for their product.

NZS AS 1884-2013

The New Zealand version of the standard does not specify the use of specific external test methods for measuring humidity, but uses the generic process of either an in-slab moisture measurement or the surface test, with a recommended process. This is similar to the processes used in the older version of AS1884-1985.

The NZS1884 version of the standard also allows for the use of capacitance testing in section A2.3 as a secondary standard method, and also does not exclude the use of Calcium Chloride (i.e. ASTM F1869 type tests) or anhydrous Copper Sulphate moisture testing.

AS/NZS2455

The textile floor covering figures are less stringent.

> ***AS/NZS2455***
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> ***2.4.2 c) Subfloor preparation***
> ***(i)*** *All subfloor surfaces shall be dry, smooth, plane sound and clean (see Appendix A). Dryness shall be considered satisfactory when relative humidity by the hygrometer test does not exceed 70% in Australia or 75% in New Zealand.*
>
> *NOTE: For the determination of subfloor dryness, methods detailed in Appendix B are recognised procedures.*

% Relative Humidity vs % Moisture Content

It is important to recognise that the moisture figures are very different to the older AS1884 with removal of the 5.5% moisture content measured with an electrical probe. Research showed that when the surface was covered over with impervious flooring, moisture rose from below to restore equilibrium rendering surface measurements less reliable.

Because of the way measurements were shown in AS1884-1985, the local industry seemed to develop the perception that 5.5% MC and 70% RH were the same measurement. There was no empirical data to back this up, it was purely a case of that is what the standard said. What tended to happen was that most measurements were made using electrical meters and the results % MC was used.

However, as a result of more detailed research, it was found that 5.5% moisture content equalled $\approx^{3}$85%+ RH, and 70% RH at the surface was equivalent to around 3% moisture content. The newer requirement of 75% RH at 0.4x slab depth is a tighter specification and is approximately equal to 2% moisture content (similar to the DIN standard requirements) and 60% RH at the surface.

The problems of correlating the moisture contents suggest that in effect the industry had been laying floor coverings over subfloors considered to be damp for a long time when defined under the new regimes. This must say something either for the accuracy of the test methods employed (c.f. the floors were drier than measured) or that the adhesives had more reserves of resistance than was considered to be the case.

Measurements

The in-slab hygrometer method based on ASTM F2170 is intrusive and requires the use of probes which are placed into holes drilled in the slab to a depth of 0.4x the slab thickness. The method measures residual moisture and depth and avoids problems where surface drying could lead to the low moisture figure being measured.

The continued use in the NZS1884 of electronic type methods (capacitance), or the potential use of hygroscopic materials to directly measure the moisture give other possible options around this problem. However as that standard notes, these methods required experience to use effectively, and in the case of the hygroscopic chemicals, the answers provided need to be correlated with the US usages of moisture emission rather than humidity. Also, the use of Calcium Chloride has been questioned in the US (hence the prevalence of recent reference to in slab measures) so this further complicates the whole matter.

Remember that once a contractor has accepted the contract he is deemed to have tested (amongst other things) the substrate for moisture.

Surprisingly, many contractors do not have testing equipment, although it is relatively low priced. If you haven't this facility to buy or hire this equipment then there are reputable people who offer a field-testing service which includes a written report.

If you conduct your own reading and the results are border-line, DUNLOP highly recommends that you have another test done with calibrated equipment from a professional company to save any demarcation problems

down the track.

There are many other reasons for damp slab problems, such as cutting penetrations and trenches through the slab, breaking the membrane, bad drainage and ventilation under above-ground slabs – the list can go on and on. However, by using correct procedures, there is usually a way to prevent these problems before they arise.

Procedures to Overcome Moisture Problems

Concrete slabs laid on ground need to have a below slab moisture/ vapour barrier applied over the subsoil, sand or gravel base. Typically in Australia these barriers are made from heavy duty plastic sheets 0.2mm thick (c.f. 'Forticon' sheeting). This type of material is defined in AS2870 as we have noted.

Silicate treatments

The issue of reactive silica based materials is an interesting point of consideration. These materials are strictly speaking, neither membranes nor moisture barriers under the conventional definition of these technical terms. They are intended to react with the cement matrix to create a new mineral phase, as opposed to topical coatings or physical sheets. The major purpose of these materials is to close the concrete pores and block the movement of water. The test data we have seen indicates that the barrier effect is related to liquid water rather than water vapour. We have not seen any data to show what sort of vapour permeability reductions these materials create when applied to concrete. As a sealing material these treatments can arguably have some effect on reducing hydrostatic pressure (as indicated in their test data), but performance for rising damp related vapour is unclear.

Greens Slabs & Constant moisture

In all the majority of situations in Australian and New Zealand conditions including new slabs and old damp slabs, the DUNLOP system uses DUNLOP Damp-Proof. The system is based on a single component polymer paste which is simply rolled on in two separate coats, allowed to cure, then a levelling compound such as DUNLOP Ardit Floor Leveller is applied as a normal floor preparation.

This system is for internal applications only.

NOTES:

Always refer to the product data sheets for specific usage details.

The information contained herein is to the best of our knowledge true and accurate.

No warranty is implied or given as to its completeness or accuracy in describing the performance or suitability of the product application.

Users are asked to check that the literature in their possession is the latest issue.

It is the responsibility of the users to confirm that all products are suitable for the application and system, and are compatible with products in the application.

More detailed technical advice can be obtained by ringing DUNLOP on free call using the numbers shown below or via email from the contact us page at the DUNLOP DIY website.

ARDEX AUSTRALIA PTY LTD,

ABN 82 000 550 005

7/20 Powers Road, Seven Hills, NSW. 2147.

References

AS1884-1985. Australian Standard. Floor coverings—Resilient sheet and tiles—Laying and maintenance practices.

AS1884-2012. Floor coverings - Resilient sheet and tiles - Installation practices.

ASTM F2170-2011. Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes.

NZS AS 1884-2013 (AS1884-2012 MOD) New Zealand Standard. Floor coverings - Resilient sheet and tiles - Installation practices.

For a more detailed discussion on this topic, we refer the reader to ARDEX Technical Bulletin TB040.009 (from which this DUNLOP bulletin was derived), and also ARDEX Technical Paper TP007.

Glossary

Constant damp– The moisture in the concrete substrate is permanent and does not reduce with time. This is the same as rising damp.

Construction water– This is water added to concrete to allow it to be mixed, poured or pumped. It is around 40% of mix, but concrete only requires around 11% to react, and the rest has to be evaporated out of the concrete.

Green slab– A concrete slab that has been freshly poured. Typically a green slab is considered to be 28 days old or less. However, it can also be loosely used to describe concrete older than 28 days, but not dry.

Moisture barrier– This term is normally used to refer to waterproofing that is intended to stop rising damp. It can be liquid water or vapour barrier.

Moisture content- Literally this means the weight percent of water in the concrete. The short hand is % MC.

Reactive silicates & silica sols– These are a type of treatment which relies on the reaction between the silicate component in the treatment and free lime in the concrete. They can be either an applied liquid or an additive mixed into the concrete.

RH– Short hand for relative humidity, which is the normal measure for concrete moisture contents and is expressed as a percentage.

Substrate-the surface on which the product will be applied. Can be concrete, sand-cement screed, stone, or tiles.

Vapour barrier– A type of moisture barrier with very low permeability intended to retard the movement of water vapour.

Waterproof membrane-This has two separate definitions

Membrane-A barrier that is impervious to moisture.

Waterproof-The property of a material that does not allow moisture to penetrate through it when tested in accordance with AS/NZS 4858.

The usual usage of the term waterproof membrane refers to materials intended to stop water from the top, as opposed to rising damp or water vapour.