TECHNICAL BULLETIN – TB040

SUBFLOOR PREPARATION – SOURCES OF MOISTURE AND DAMP SLAB PROBLEMS

Date, Friday, 5 February 2021

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?

We will in this bulletin examine a range of topics concerning moisture and damp slabs. Further information can be found in ARDEX Technical Papers TP007 Alkalinity and Moisture in Subfloors, and also TP006 Reactive Silica based Waterproofing, Effects on ARDEX Systems.

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.

A typical example of a problem faced by layers up to the mid 2000s was dealing with old slabs where an existing floor covering, for example vinyl floor tiles bonded with old bitumen adhesive ("black jack") was removed. It was replaced with a welded sheet vinyl, but the old vinyl tile installation had shown no apparent signs of moisture problems; however, the sheet vinyl soon started to show signs of bubbles and lifting. In fact there may always have been a slight moisture problem. Although the tiles may have been laid when the ground and concrete were dry, subsequent changes in the moisture content of the ground beneath have penetrated the porous concrete. While no hydrostatic pressure was present, the concrete was like a sponge and the adhesive and tiles just held on, retaining most of the moisture. As well, the gaps between the tiles have allowed water vapour transmission (WVT) to occur. When you remove the old tiles and "black jack" adhesive, you get a "taking the plug out of the bath" effect. When an impervious membrane like welded sheet vinyl was installed, totally locking in the moisture vapour, the new flooring has to give.

Whilst the number of installations involving these older tiles and bituminous adhesives that need to be replaced have faded with time, the problem still exists with old slabs that are subject to damp.

Whilst the newer adhesive materials can be more resistant to dampness, even they have a limit of performance which cannot be exceeded.

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.

Figure 1

Moisture can rise from the base of the slab and build up over time beneath the impermeable vinyl covering resulting in bubbling of the floor covering. Where the subsurface is permanently damp the moisture then travels into the slab and upwards.

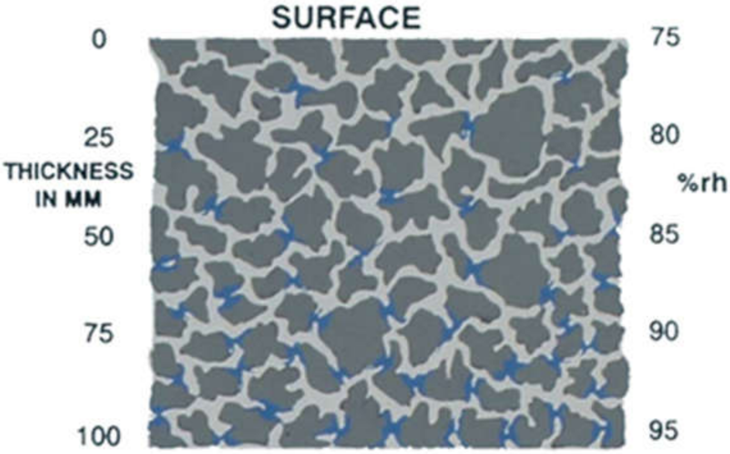


Figure 2

The adjacent floor was in a supermarket and had vinyl tiles laid over an existing slab. In this case the membrane has either failed, or none was installed and so moisture was penetrating to the base of the tiles.

After the tiles were removed, the dampness pattern where moisture was rising to evaporate through the tile joints was revealed.

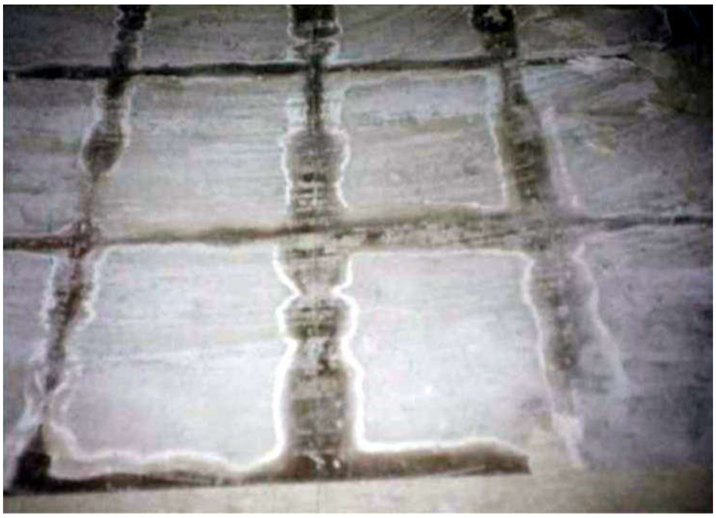
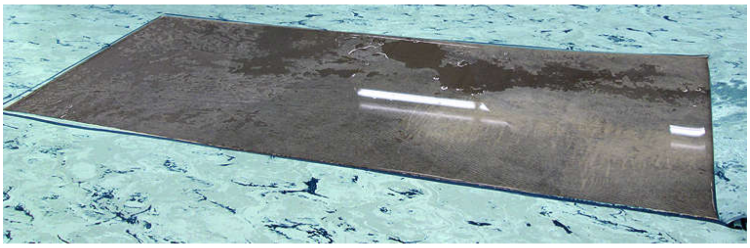


Figure 3

Another example in a commercial building where the concrete barrier system has not performed adequately and moisture has risen to the surface.



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.

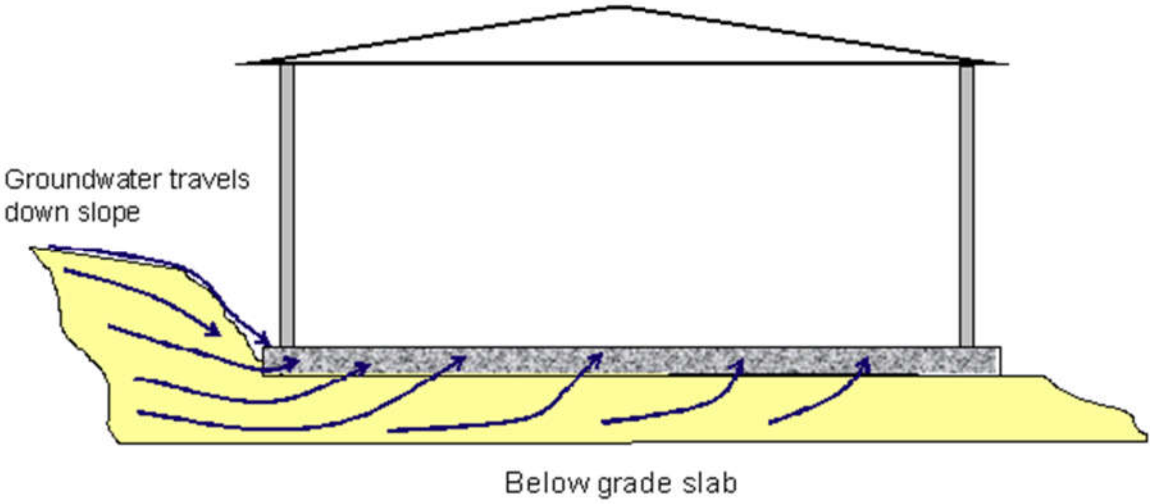


Figure 4. This schematic shows an example of a below grade slab and how moisture can travel into the concrete. The picture below shows an example of a below grade slab.

Figure 5

The site shown is a dwelling with a below grade slab which was subject to a moisture complaint.

Water due to surface run off onto the slab, and also percolating ground water in through the base and edges have penetrated the slab and resulted in high moisture contents in the concrete inside the building.

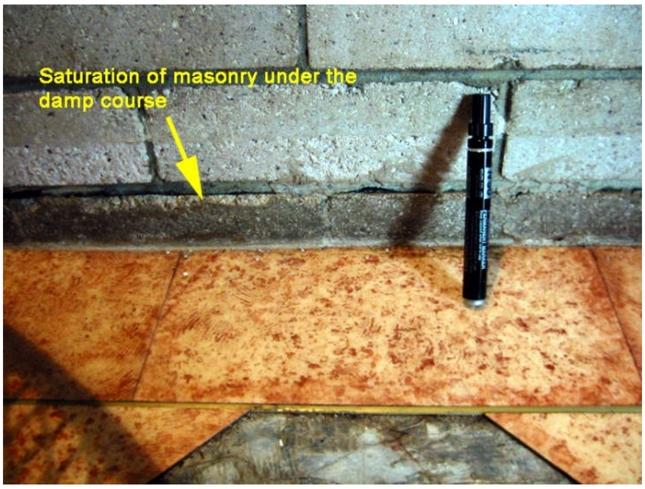


Figure 6

What was found inside the building? As can be seen the masonry below the damp course was saturated with moisture.

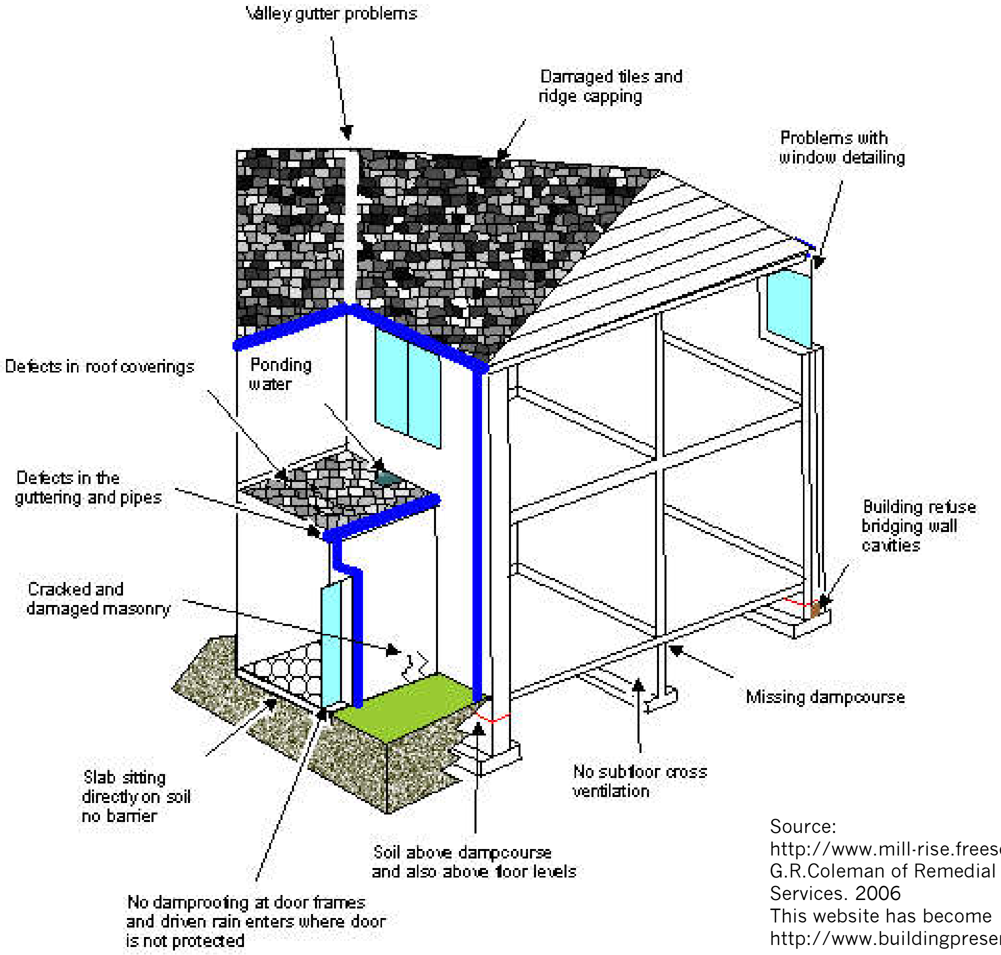
A vinyl installation was put in place without a membrane and suffered de-bonding due to rising damp.

Figure 7

An example of a raised garden bed creating dampness in a wall, which then transferred through the masonry into the subfloor.

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. The figure below (Figure 8) modified after Coleman (2006) shows some sources of dampness.



Source:
http://www.mill-rise.freeserve.co.uk - by G.R.Coleman of Remedial Technical Services. 2006
This website has become
http://www.buildingpreservation.com/

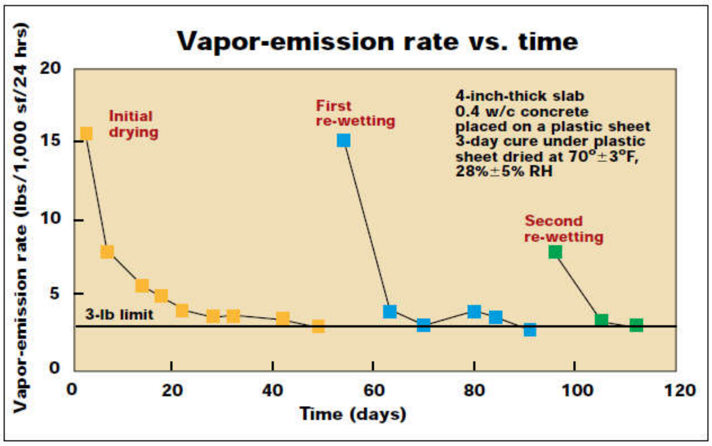
Usually the flooring has been installed during the summer of a dry spell. A week of heavy rain can result in an installation with moisture problems, which normally leads to the layer or contractor receiving the blame for something that is beyond their control.

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 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. In many ways, the US market is more advanced in site based research and knowledge with regards to vapour emissions, if not in the use of relative humidity measures as performed here.

The US system is based more around the concept of water vapour emission rates (described as WVER or MVER) which they express in lbs/1000ft^2/24hrs, when compared to Australia and New Zealand practice where the moisture levels are described in "% moisture contents" or % relative humidity. The US industry has the historic position (in flooring product datasheets for example) of requiring that slabs yield vapour at less than 3-5lbs/1000ft^2/24hrs which metricate to between 15 and 23gms/m^2/24hrs. The **site** test method basis for water vapour emission is ASTM F1869 which gives 'MVER' values.



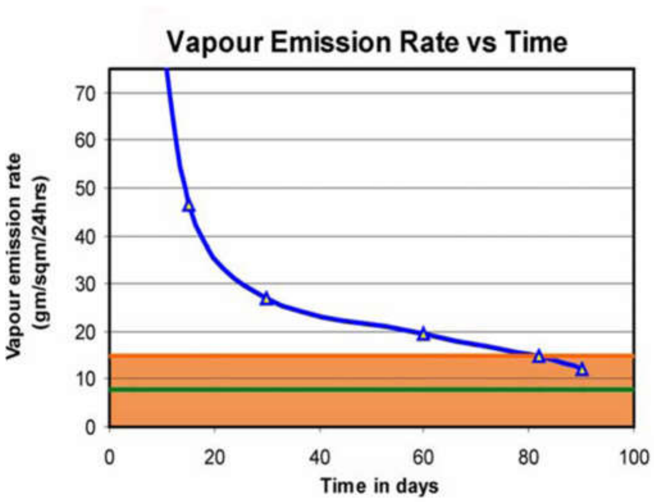


Figure 9

The accompanying graphs give an indication of the moisture vapour loss rate of fresh slabs based on US experience.

In this case the slab is 100mm thick and placed on Forticon plastic sheet barrier to replicate site conditions.

The upper figure Fig.,4 Suprenant & Malisch (1998a) shows the effect of re-wetting of concrete (i.e. no roof in place), whilst the lower one is a metricated version of Fig., 3 in Suprenant & Malisch (1998a).

The US flooring industry has a traditionally and nominally acceptable vapour transmission rate (MVER) at between 15gm/m^2/24hrs (3lbs/1000Ft^2/24hrs) and 23gm/m^2/24hrs (5lbs/1000Ft^2/24hrs).

The 3lbs/1000Ft^2/24hrs - 15gm/m^2/24hrs figure is shown by the limit of the shaded area in the graph at left. As can be seen it may take up the best part of 80 days (~3 months) to achieve a transmission rate that is satisfactory to lay resilient flooring.

The filled area defines the maximum MVER value allowable.

The lower green line is a laboratory test result achieved using Ardex WPM300 Moisture Barrier when tested to ASTM E96 for WVTR in 1999 (Note that the tests done at various times since vary from 1.4 to 6.4 gms). This reduces the MVER of the slab.

Whilst the flooring standard AS1884 was revised in 2012 and again in 2021, 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 2007 Cement Concrete and Aggregates Australia publication 'Moisture in concrete' gives a more complex picture.
The drying rate is not necessarily a linear relationship for slab thickness vs time and going from 100mm to 150mm doubled the drying time, and tripled it going from 100 to 200mm. Other work suggests that 200mm slabs can take up to 12 months to dry adequately from one side. This is halved for two sided drying.

When made, the concrete only requires 1/3 of the added water for the cement hydration reaction and the remainder is for workability so this water has to evaporate over time. It needs to be recognised that the cement-water ratio has a critical role in the drying rate. The usual recommended ratio is around 0.4 to 0.5, but can go over 0.7 when poorly controlled, and high ratios increase drying times not only because of more physical water, but also because the porosity of the concrete is changed as well due to the development and closure of capillaries. To compound matters, though aged high water ratio concretes are also more porous and hence more subject to rising damp problems. Recent types of high density concretes have been noted to dry more slowly than the figures quoted here due to closing of pores and trapping of moisture, so caution is urged on applicators to check moisture levels.

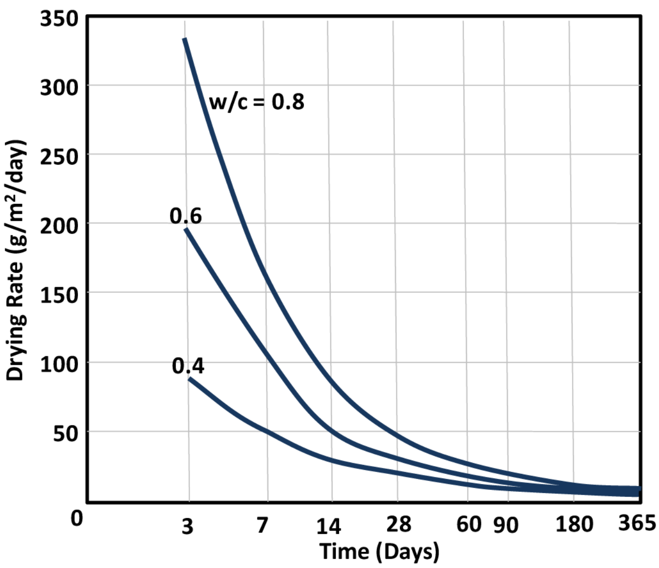
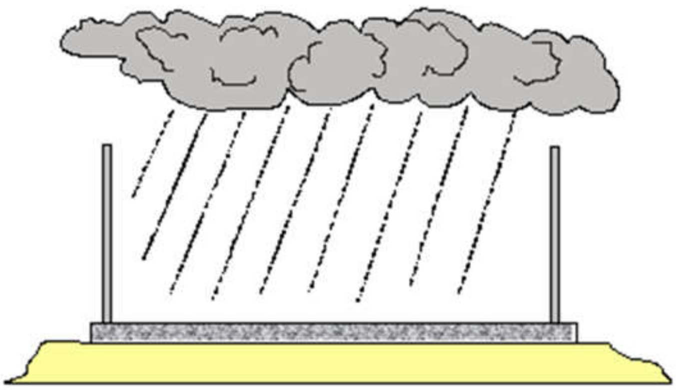


Figure 10

The graph at left shows the effect of increasing the water-cement ratio on the moisture emission rates.

(Figure 2 from Building & Construction Research & Consultancy. TN024 Concrete and Moisture Sensitive Covering)..

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 (as shown in Figures 9 & 11).



Rain on exposed slab

Figure 11

When did the roof go on to the building?

When did the rain last fall on the slab?

For typical sand-cement or granolithic screeds used under tile finishes, they dry at a rate of around 1.0mm thickness per day.

AIR-CONDITIONING

Air conditioning appears to be playing a major part in moisture related blow-ups, 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.

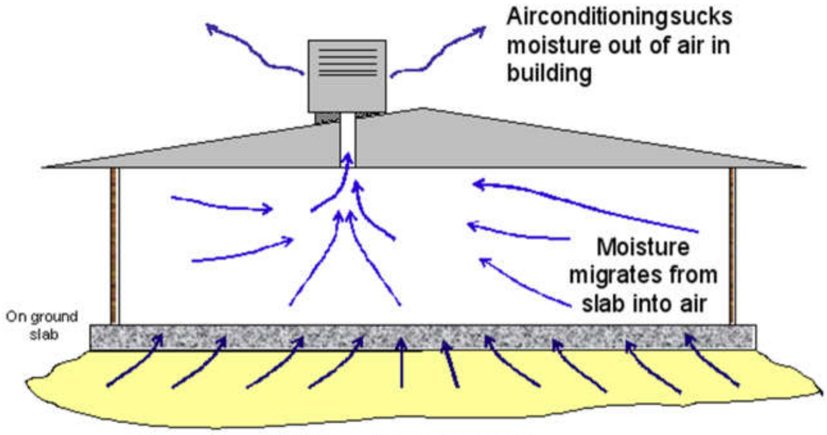


Figure 12

A schematic showing the effect of airconditioning on the suction of moisture into a building from external sources.

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.
What do the standards say on this matter? The resilient flooring standard makes the following suggestions (unchanged from 2012);

> ***AS1884-2021 Floor coverings—Resilient sheet and tiles—Installation practices***:
> ***"4.1.2 Air-conditioned areas***
> *Where air conditioning is installed, no underlay or floor covering shall be laid on the subfloor until the conditioning units have been in operation at expected operating temperature and humidity for at least seven days. During this period the temperature and humidity shall not be allowed to fall outside the limits of the instructions of the manufacturer of the floor covering. These conditions shall be maintained during laying and for 48 h thereafter.*
> *NOTE Without such temperature control at this stage, subsequent failure of the subfloor, underlay or underlayment and floor covering may occur. "*

The New Zealand version of this standard NZS1884-2013 leaves out the NOTE but is otherwise the same.
The textile standard says,

> ***AS/NZS 2455.1-2019 Textile floor coverings – Installation practice. Part 1: General***
> ***"2.3.2 a) Air-conditioned area***,
> *Airconditioning units should be in operation at normal operating temperature for at least seven days prior to the installation of the textile floor covering. The building owner or head contractor shall be responsible for ensuring that ambient room temperature and RH are within specified ranges".*

THE AUSTRALIAN AND NEW ZEALAND STANDARDS

We bring the reader's attention to the fact that AS 1884-2012 (then 2012) and NZS 1884-2013 are NOT the same, even though the NZS was based on the earlier 2012 AS document. Also the textile standard 2455 has now been split effectively in AS/NZS 2455-2007 and AS 2455-2019.

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.

Ardex strongly recommends that contractors familiarise themselves with the provisions of the relevant Australian or New Zealand Standards.

AS 1884-2012 & 2021

The following excerpts are taken from AS1884-2012 and 2021 and AS/NZS2455.1-2007 and 2019 (together with the two excerpts already discussed above) and define two **'golden rules'** for installers in relation to moisture. We have retained the 2012 and 2007 versions for comparison of how the changes have affected the newer documents.
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.

> ***AS 1884-2012/2021 3.1.2 and NZS 1884-2013 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.*

AS 1884-2012 - 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.

The 'hood method' was withdrawn by ASTM in late 2014.

The full rationale given can be found at http://www.astm.org/Standards/F2420.htm, but in summary ASTM considered the method to be both unstable in terms of obtaining a constant reading in a workable number of days, but also non-reproducible across different testing devices and set ups.

A further comment on the older style of test of surface test in AS1884-1985 comes from the TN024 report mentioned in the caption for Fig., 10. It is a less than ringing endorsement,

6) The AS 1884 RH Box test is hopelessly flawed. The BS8203 RH box test at least gives a stabilised RH value. However even the BS8203 test is not recommended as a determinant of the floors long term moisture state as water may be locked deep in the concrete.
7) The only test for moisture that is considered suitable for final evaluation of concrete dryness is the ASTM F 2170 test.

As the reader might guess, this created a problem and as a consequence the committee responsible for AS1884 reconvened in 2019 to create the 2021 revision. The primary test method ASTM F2170 remained the same however, a different method was selected as the secondary.

B.2 Moisture vapour emission rate surface test (secondary test method)

Concrete subfloors shall be considered suitable for the installation of resilient floorcoverings when measurements taken in accordance with ASTM F1869 do not exceed 15 g/m^2/24hr (3.0lbs/1000 Square feet/ 24 hr). Three tests shall be performed for the first 100 m^2 and at least one additional test for each additional 100 m2 at recommended positions in accordance with ASTM F1869.

IMPORTANT NOTE

Under the new revisions in AS1884-2020, the permitted %RH when measured to ASTM F2170 has been raised to 80% from 75%. This was in line with the claims from adhesive suppliers that newer generation adhesives could tolerate a higher degree of moisture.

The pass/fail figure for the ASTM F1869 test was set at 15gms/m^2/24hrs which is the same as the US 3lbs/1000^2ft/24hrs measure.

NZS 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, (the allowance % RH for both is the same at 75%!). The use of a recommended process rather than a test is similar to the generic approach in the older version of AS1884-1985.

Using generic methods effectively sidesteps the specific issue of foreign standards being changed or revoked as encountered with ASTM F2420 in AS1884-2012, but not the underlying issue of whether or not surface measurements are valid.

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/NZS 2455-2007 and AS 2455-2019

The textile floor covering, %RH figures are different. Note that the older 2007 standard only used the surface hygrometer test, whereas the newer one used the surface test (i.e. ASTM F2420, BS8203-2017 or ISO DIN 18167 style) and in situ probe (i.e. ASTM F2170 type) tests. The method is not specified, only that the type of test can be used.

Also note the 2019 version is AS only.

> ***AS/NZS 2455-2007***
> ***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.*
>
> ***AS 2455-2019***
> ***B5 Default moisture content (RH%) and alkalinity (pH) values for concrete subfloors.***
> *If the products are being used with no manufacturers recommendations, measured moisture content (RH%) should not 75% using the invasive hygrometer test (insitu probe) and 70% using the surface mounted hygrometer test (sealed hood).*

% Relative Humidity vs % Moisture Content

It is important to recognise that the moisture figures are very different to the elder AS 1884-1985 with removal of the 5.5% moisture content measured with an electrical probe, and the deletion of the surface relative humidity test and 70% RH from the 1985 and 2012 versions. The in-slab test has been retrained but with a new value now at 80% RH, whilst the alternate surface test uses a water vapour emission figure. The latter has not been used in Australia, and is not directly equivalent to the %RH or %MC measures, but follows the resilient flooring manufacturer's general recommendations in the US.

However, with surface method being considered ineffective by ASTM, it raises the question of its validity in any other standards that refer to hood-hygrometer methods, such as AS/NZS 2455-2007 and AS 2455-2019, BS 8203-2017 and ISO DIN 18167.

Research showed that when the surface was covered over with impervious flooring, moisture rose from below to restore equilibrium rendering surface measurements less reliable. This is shown in Figure 13 below.

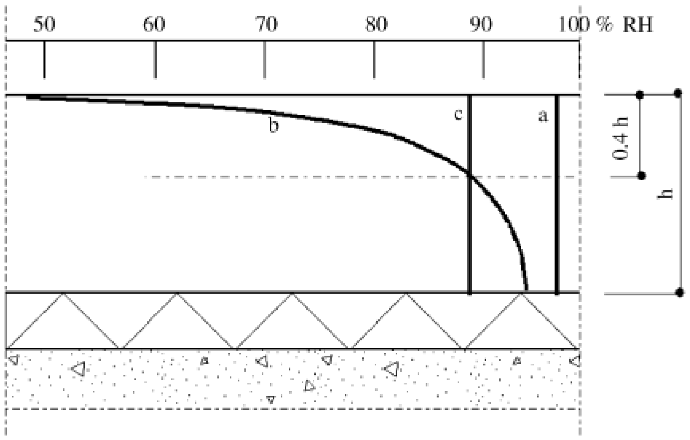


Figure 13

This schematic shows the relative humidity relationship between the drying of open concrete (b) and what occurs after the surface is closed by the floor covering (c).The other line (a) refers to the freshly laid material properties.

This is Figure 1 from Rentala & Leivo (2009)

Because of the way measurements were shown in AS 1884-1985, the local industry seemed to develop the perception that 5.5% MC and 70% RH were the same measurement. The current version of ISO DIN 18167 continues this and compounds it, by linking these two values to the 75% in-slab test. To our understanding there is 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 ≈≥85%+ RH, and 70% RH at the surface was equivalent to around 1.75% moisture content. The 2012 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 newest value of 80% RH at 0.4x slab depth will have a slightly higher %MC and surface %RH equivalent.

The problems of correlating the moisture contents to the humidity measures can be seen in the graph in Fig 14., below, but in effect the industry for a long time had been laying floor coverings over subfloors considered to be damp 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. It is also in part a reflection of the previous prevalence of VCT/VAT tiles which allowed more moisture to escape.

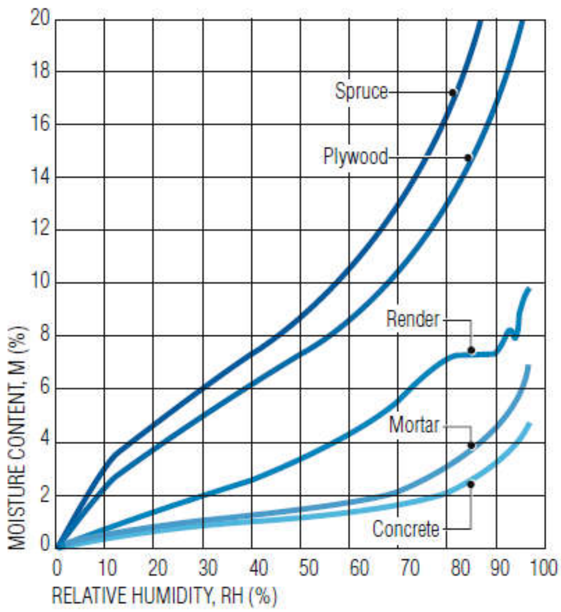


Figure 14

This graph shows the generalised relationship between relative humidity and moisture content.

(This is Figure 1 from Moisture in Concrete and Moisture-sensitive Finishes and Coatings. Cement Concrete & Aggregates Australia 2007)

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 surface methods are the older style and non-intrusive. For ASTM F1869 the equipment is relatively cheap though does require a small balance and some mathematical understanding. It was placed as the secondary method for users where holes in the slab are not possible.

The situation with the surface humidity test and remarks over this method and its validity, is no longer clear even if it has been accepted in the industry at least since the 1980s. Testing by ASTM in 2014 made the method appear empirically very questionable.

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 by some parties (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, ARDEX 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

Sub-slab vapour barriers

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. However material sourced from the US can be anywhere from 6-20mils (thousandths of an inch) which are equivalent to 0.15 to 0.50mm, and these have their own separate ratings for permeability.

The requirement for these sheets under the National Construction Code of Australia references AS2870. The equivalent American Standard is ASTM E1745. The former standard does not have a permeability specification for these sheets in the undamaged state (but recommends $2x10^{-3}$gm/N.s or 350 Perms after being subjected to a falling gravel test), whilst the ASTM sets the permeability of fresh sheet at 0.1 Perm ($5.7x10^{-9}$gm/N.s) when measured by ASTM E96 (this value is a very low level of permeability and was lowered from the original 0.3P when the 2009 version was published).

Examination of the effects of a sub-slab barrier by Suprenant & Malisch (1998b) showed that where a plastic sheet was in place, the rate of moisture transmission was reduced by between 44 and 54 gms/m^2/24hrs (9-11lbs/1000^2Ft/24hrs) compared to concrete without a barrier (note that when this testing was done, the older version of ASTM E1745 then in force allowed the higher permeability of 0.3 Perm). This finding was not the main purpose of test, it was actually to show the negative effect on the barrier performance of holes punched through it.

Craig (2004) quotes data to show that the drying rate of concrete slabs is dramatically decreased when there is no sub-slab barrier and the base of the concrete is exposed to 'ground' dampness. This shows how essential a correctly installed plastic barrier is in reducing hydrostatic and ground water infiltration, and also moisture being sucked into the system by moisture imbalances created by airconditioning and other air drying processes.

Topically applied surface moisture barriers

In the AS 1884-2020 revision, a normative requirement was introduced that when a slab failed the moisture content test, a moisture barrier with a prescribed WVTR is applied. The standard sets the maximum rate as ***10gms/m^2/24hrs*** when tested to ASTM E96. As we have already noted, ARDEX WPM300 falls under this value, and we are aware that ARDEX competitors have equivalent systems, so this measure applies across the industry.

In the US market, the standard ASTM F3010 requires a permeability of 0.1 Perms (the same as plastic sheeting for sub-slab barriers) for *100% solids two part moisture barriers* (i.e. epoxy resins such as ARDEX EG800F, ARDEX MC or the base resin for ARDEX EG15). According to this standards scope, it does not apply to water borne systems such as ARDEX WPM300, which has a nominal value of ~0.6P, but the comparison is interesting. It implies that in the most critical situations, the 100% solids ARDEX EG800F is the superior solution. This stricter standard arose because of the conditions in the US related to moisture problems found with their constructions methods and also the ground dampness conditions (remember that many parts of the US are subject to snow and ground dampness for more than half the year). In effect they have a situation where there are potentially two barriers in place with extremely low permeability. When compared with the less stringent requirements and more benign environment in Oceania, it seems clear that either the ambient and site conditions in the US must be quite different to create an environment where a stricter set of standard requirements are required, or the legal situation is more problematic and safer is well, safer.

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.

Green Slab Seal

We need to look at the concrete itself, for example when it is fresh (‘green’), the sub-slab barrier has aged, or the situation where the slab is not on grade but above it. Where time allows, the simplest method of dealing with new concrete is to let it dry naturally to an acceptable moisture content level as defined above.

Alternatively where time does not allow waiting, and it is known that **construction water** is the source of the moisture, ARDEX offers a solution to seal the concrete surface in the form of a single coat of ARDEX WPM300 Hydrepoxy applied at 3m^2/litre. However, the recommended moisture content should be less than 90% relative humidity (at 0.4x depth) <u>and</u> reducing. This is a green slab seal and a single coat does not provide a full barrier protection required for *constant damp*.

NOTE: **Construction water** is the water left over in fresh concrete that is not used for the hydration of the cement in the concrete. It has to evaporate out over time.

Alternatively application of ARDEX WPM368 at 3m^2/litre will provide a green slab moisture barrier that is single part and does not require sand blinding or use of a primer.

Constant moisture

In all other situations in Australian and New Zealand conditions including new slabs and old damp slabs, the most effective and proven system uses ARDEX WPM300 Hydrepoxy. The system is based on a special two pack water based epoxy system which is simply rolled on in two separate coats, allowed to cure, then primed and a levelling compound is applied as a normal floor preparation. The water vapour transmission has been tested at to ASTM E96 on *varying substrates* with different test conditions and found to be between 1.4 and 6.4gms/24 hours /m² (@25°C@50% RH) and 7.9gms/24 hours /m² (@32°C@100% vapour pressure); the latter figure is close to *half the maximum* value nominally recommended by the American Floor Covering Institute for resilient flooring to be laid and lies under the new AS1884-2021 requirement.

ARDEX Moisture Barrier/WPM300 can be used internally or externally and can be installed over damp surfaces and fresh concrete only 24 hours old as a curing compound, but when used as a moisture barrier it is preferred that 4-7 days are allowed to elapse as a minimum to reduce the risk from initial shrinkage in the concrete. Cracks that develop in the barrier render it inoperative.

Refer to Ardex Technical Bulletins TB006 or TB192 for the full barrier system or TB172 for a moisture suppression system for green slabs.

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.

AS1884-2021. Floor coverings - Resilient sheet and tiles - Installation practices.

AS/NZS2455-2007. Textile floor coverings - Installation practice – General.

AS2455-2019. Textile floor coverings - Installation practice – Part 1 General

ASTM E96/E96M. Standard Test Methods for Water Vapor Transmission of Materials.

ASTM E1745 Standard Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs.

ASTM F1869. Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.

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

ASTM F2420. Standard Test Method for Determining Relative Humidity on the Surface of Concrete Floor Slabs Using Relative Humidity Probe Measurement and Insulated Hood.

ASTM F3010. Standard Practice for Two-Component Resin Based Membrane-Forming Moisture Mitigation Systems for Use Under Resilient Floor Coverings.

BS8203-2017. Installation of resilient floor coverings – Code of practice.

ISO/DIS 18167-2019. Textile floor coverings — Installation practices — General

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

Coleman G. (2006) http://www.mill-rise.freeserve.co.uk - by G.R.Coleman of Remedial Technical Services.

Craig P. (2004) Vapor barriers: Nuisance or Necessity? Publication #C04C032 Hanley Wood. LLC.

Rentala J. & Leivo V. (2009) Drying of insitu cast concrete ground slabs and covering critiera. Building and Environment 44, pp331-337.

Suprenant B.A & Malisch W.R. (1998a) Are your slabs dry enough for floor coverings? Publication #C980671, The Aberdeen Group.

- (1998b) Don't puncture the vapor retarder; Even small holes increase water-vapor emissions. Publication #C981071, The Aberdeen Group.

REASON FOR REVISION - ISSUER

Major revision due to changes to AS1884-2021 and AS2455-2019.

DOCUMENT REVIEW REQUIRED

36 months from issue

Technical Services 1800 224 070. email: technicalservices@ardexaustralia.com
Australia http://www.ardexaustralia.com
NSW-HO 61 2 9851 9199. **Customer Service and Sales** 1300 788 780 **Sales Fax** 1300 780 102
New Zealand Christ Church 64 3373 6900, Auckland 9636 0005, Wellington 4568 5949
Technical Inquiries NZ 0800 2 ARDEX New Zealand http://www.ardex.co.nz
Web: Corporate: http://www.ardex.com