TECHNICAL BULLETIN – TB040

SUBFLOOR PREPARATION – SOURCES OF MOISTURE AND DAMP SLAB PROBLEMS

24th October 2024

INTRODUCTION & SCOPE

Excessive moisture in new and old concrete substrates has been a problem for many years, causing concerns to the contractor, Installer, and client. These problems 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. Remember 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 concrete is a sound sub-slab moisture barrier, but is this in place, and if so, is it still sound?
This bulletin examines 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 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 formalized 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 years or possibly been punctured during the reinforcement installation and concrete placement, rendering it useless.
A typical example of a problem faced by Installers 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 (“blackjack”), was removed. It was replaced with 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. 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 “blackjack” 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.

While the number of installations involving these older tiles and bituminous adhesives has faded with time, the problem still exists with old slabs that are subject to dampness. While the newer adhesive materials can be more resistant to dampness, they have a performance limit that 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 moisture upwards from the slab. These problems are exacerbated in areas with a high water table, high humidity, or high rainfall wet seasons, such as 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 travels into the slab and upwards.

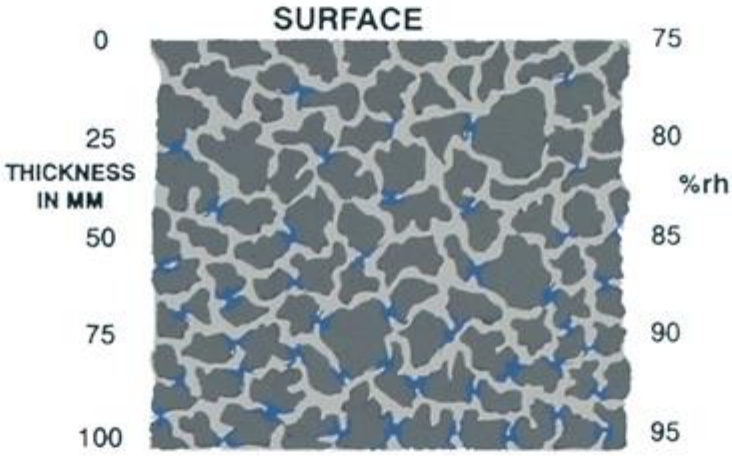


Figure 2

The adjacent floor was in a supermarket with vinyl tiles 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, in which moisture rose to evaporate through the tile joints, was revealed.

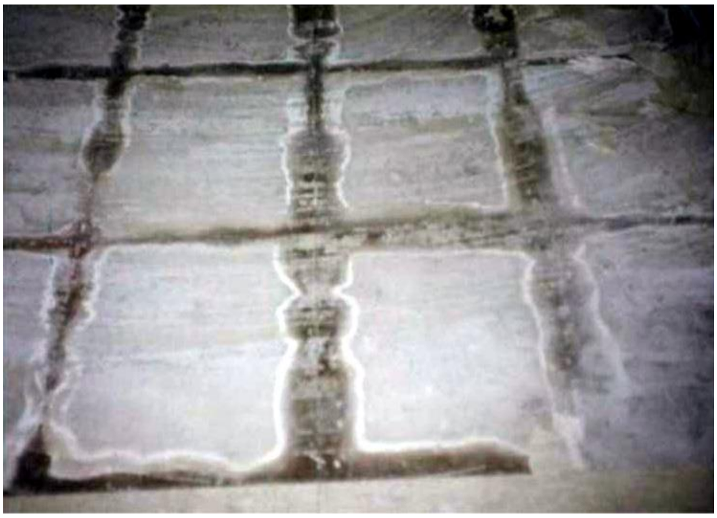
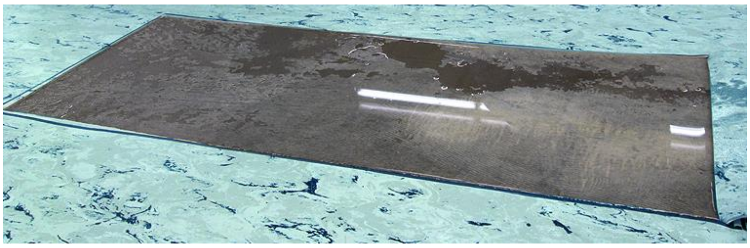


Figure 3

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



Below Grade Slabs

Slabs that 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, 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.

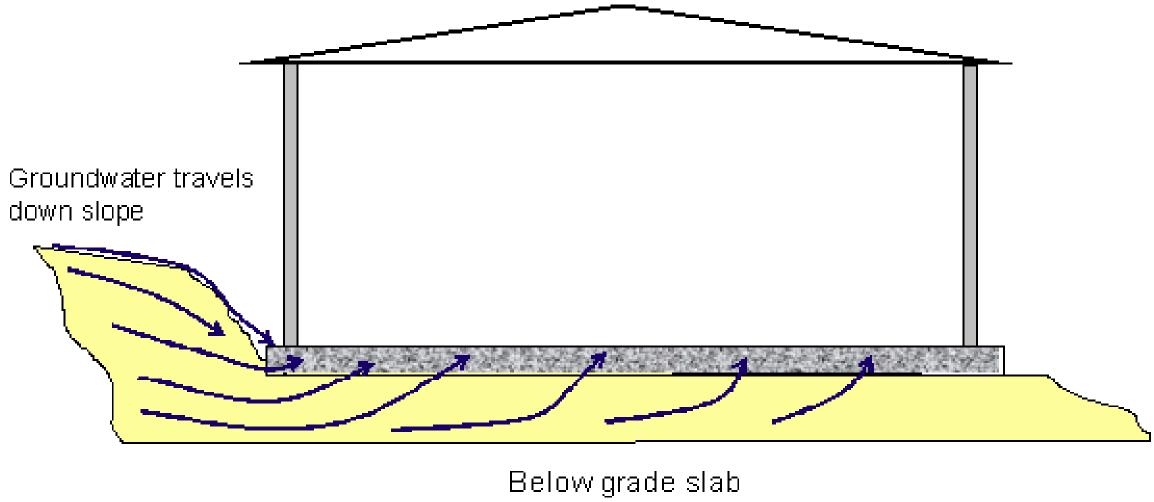


Figure 4. This schematic shows an example of a below-grade slab and how moisture can travel into the concrete. The picture below shows an example of a below-grade slab.

Figure 5

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

Water from surface runoff onto the slab and percolating groundwater through the base and edges have penetrated the slab and resulted in high moisture content in the concrete inside the building.

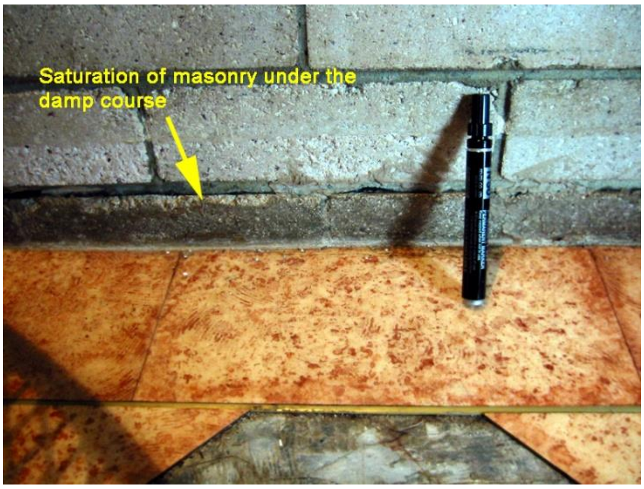


Figure 6

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

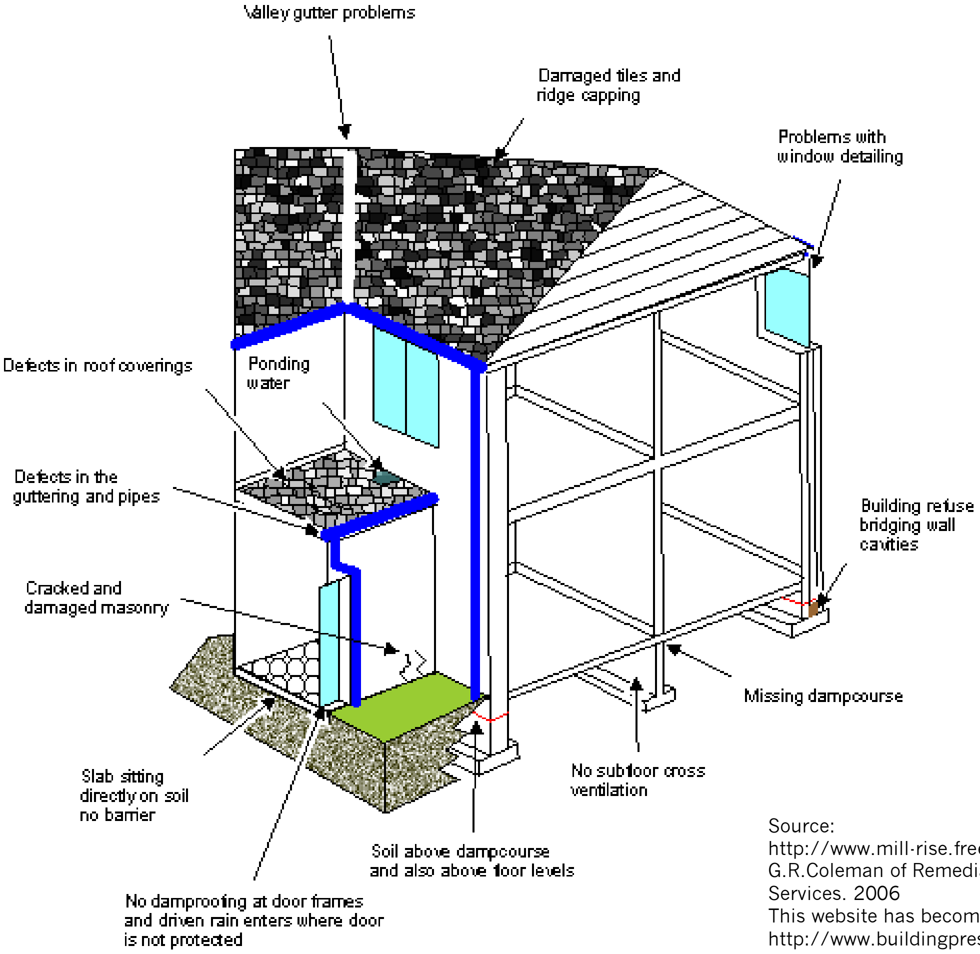
A vinyl installation was put in place without a membrane and suffered de-bonding due to rising damp.

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 travels throughout the construction, leading to difficulty in identifying 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 is installed during the summer or a dry spell. A week of heavy rain can result in an installation with moisture problems, usually leading to the contractor being blamed for something beyond their control.

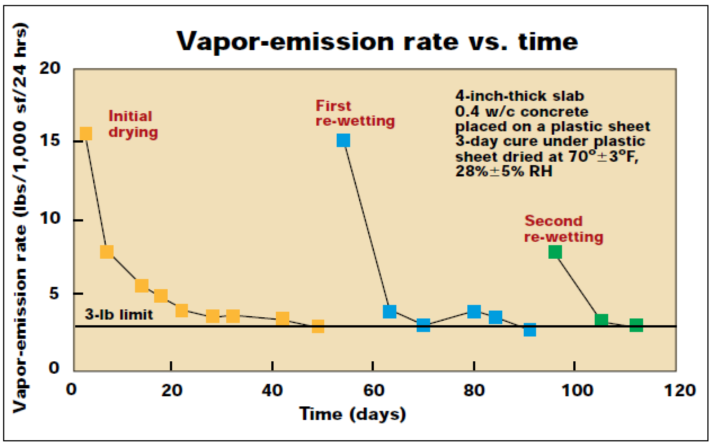
NEW CONCRETE

New concrete is a real problem for the Installer 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 sufficiently to meet the requirements of the Australian Standards. One is the speed at which modern buildings can be erected (often in a lock-up state with windows in place far earlier than before). This does not allow sufficient ventilation and air movement over the concrete. Evidence can often be seen by condensation forming on the windows due to the 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 concerning vapour emissions.

The US system is based more around the concept of water vapour emission rates (described as WVER or MVER) which they express in lbs/1000ft²/24hrs, 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/1000ft²/24hrs, which metricates to between 15 and 23gms/m²/24hrs. The **site** test method basis for water vapour emission is ASTM F1869, which gives 'MVER' values.



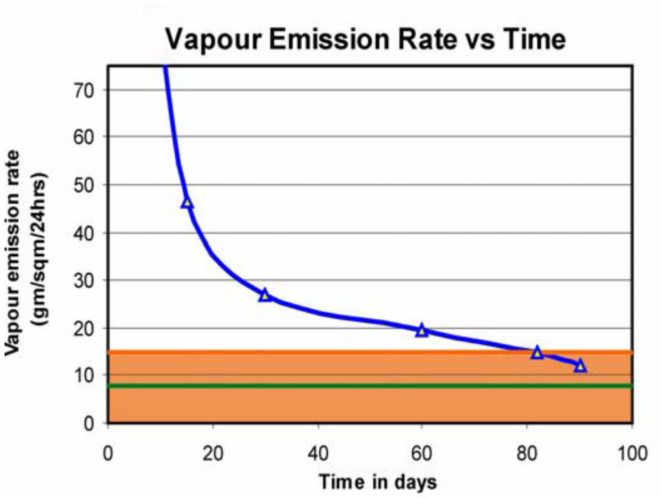


Figure 9

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

In this case, the slab is 100mm thick and placed on a 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) between 15gm/m²/24hrs (3lbs/1000Ft²/24hrs) and 23gm/m²/24hrs (5lbs/1000Ft²/24hrs).

The 3lbs/1000Ft²/24hrs—15gm/m²/24hrs figure is shown by the limit of the shaded area in the graph at left. As can be seen, it may take the best part of 80 days (~3 months) to achieve a transmission rate satisfactory for laying 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 vary from 1.4 to 6.4 gms). This reduces the MVER of the slab.

While 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 moisture content in equilibrium with the surrounding air. If*

ventilation is poor, the humidity is high, or the temperature is low, drying will naturally take longer. Conversely, 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 when the slab was last wetted by rain or dew. Even scrubbing of the surface before the flooring Installer commences work should be avoided if possible.

The basic measure is the required drying time is approximately 1 day per millimetre of concrete thickness from each exposed face to reach equilibrium with the surrounding air. While much of this useful information is generally true, recent research shows 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 linear for slab thickness vs. time. Going from 100mm to 150mm doubled the drying time and tripled it 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 mixed and cured, concrete requires only 1/3 of the added water for the cement hydration reaction, with the remainder for workability, so this water has to evaporate over time. It needs to be recognized that the cement-water ratio has a critical role in the drying rate. The recommended ratio is around 0.4 to 0.5 but can go over 0.7 when poorly controlled. High ratios increase drying times not only because of more physical water but also because the porosity of the concrete is changed due to the development and closure of capillaries. High water ratio concretes are more porous and subject to rising damp problems. Recent types of high-density concrete dry more slowly than the figures quoted here due to the closing of pores and trapping of moisture, so caution is urged on applicators to check moisture levels.

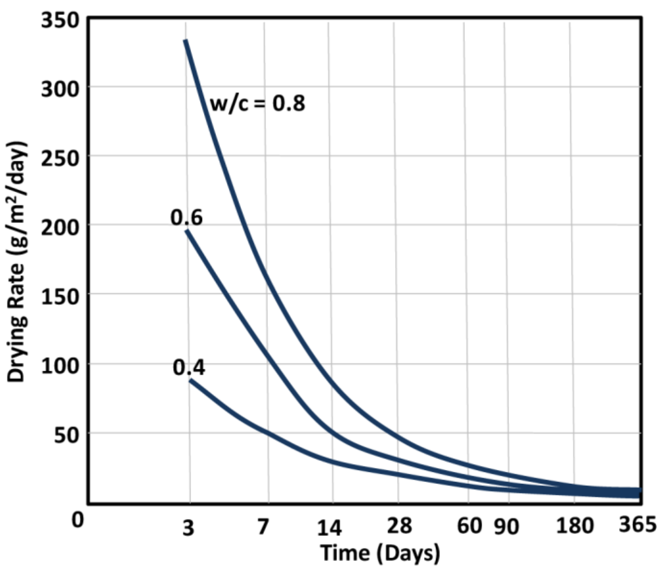
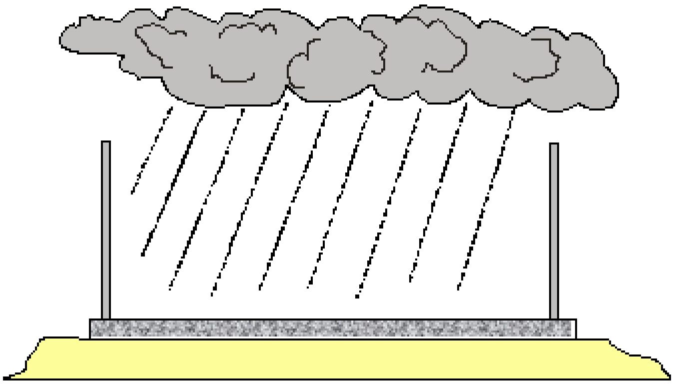


Figure 10

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)..

When the client is asked when the slab was poured, the answer is “months ago.” One would think this would 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 onto 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 role 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 can be up to three months or more after the flooring has been installed.

Most installation procedures are done at a fairly stable ambient temperature, which does not initially lead to 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 the 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 dampness but provide a latent source of moisture that 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 moisture from the air. This can result in an unbalanced situation with relatively dry air above a source of moisture, and any excess moisture is drawn upwards, causing problems.

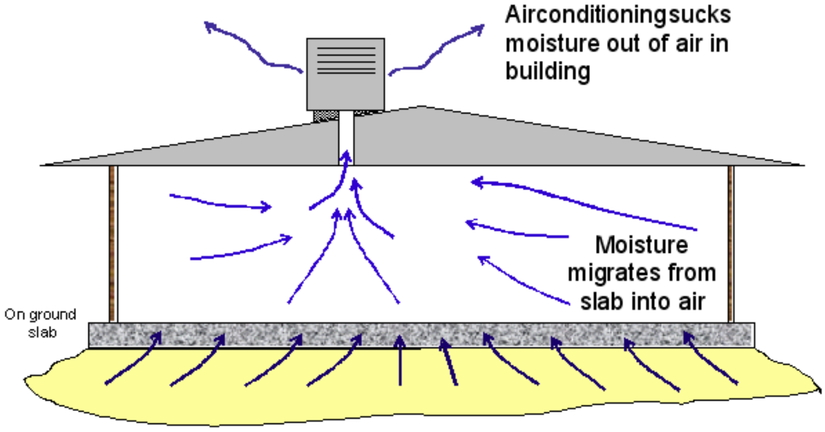


Figure 12

A schematic shows the effect of air conditioning on the moisture suction into a building from external sources.

A similar effect can result from slow combustion stoves, which tend to dry out the air and encourage water vapor formation. When the environment cools down, liquid water 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 the 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 floor covering manufacturer. These conditions shall be maintained during laying and for 48 h thereafter.*
> *NOTE: Without such temperature control at this stage, the 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

It should be noted 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 effectively split into AS/NZS 2455-2007 and AS 2455-2019.

Therefore, you need to refer to the relevant standard 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 setups.

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 AS1884-2021, 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^{2}ft/24hrs measure.

NZS 1884-2013

The New Zealand version of the standard does not specify 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%!). Using 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 the type of test can be used.

Also, note that the 2019 version is only available in AS format.

> ***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 recognize that the moisture figures are very different from the elder AS 1884-1985, with removing the 5.5% moisture content measured with an electrical probe and deleting the surface relative humidity test and 70% RH from the 1985 and 2012 versions. The in-slab test has been retained but with a new value now at 80% RH, while 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 it follows the resilient flooring manufacturer’s general recommendations in the US.

However, ASTM's decision to consider the surface method ineffective raises the question of its validity in 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 with impervious flooring, moisture rose from below to restore equilibrium, rendering surface measurements less reliable. This is shown in Figure 13 below.

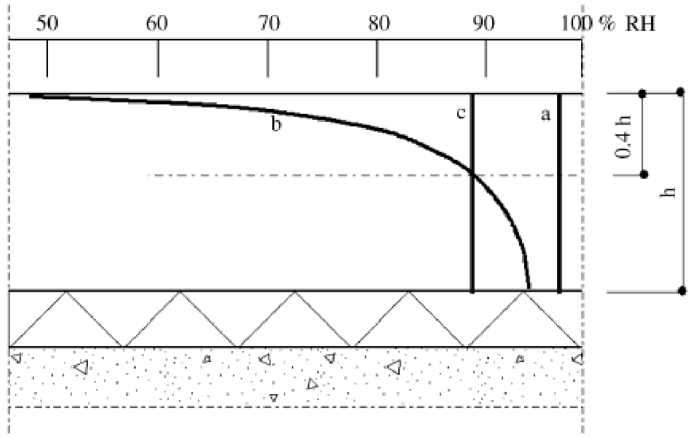


Figure 13

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 measurements. 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, more detailed research 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 0.4 x 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 0.4 x 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 about 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.

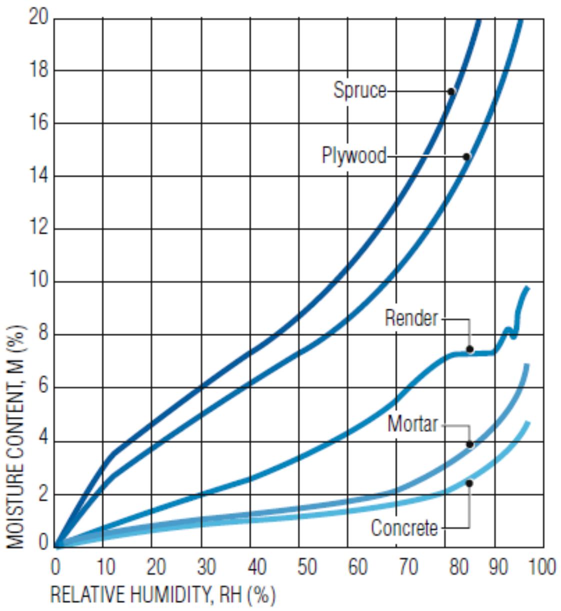


Figure 14

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

(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 probes placed into holes drilled in the slab to a depth of 0.4 x the slab thickness. The method measures residual moisture and avoids problems where surface drying could lead to a low moisture figure being measured.

The surface methods are the older style and are non-intrusive. For ASTM F1869, the equipment is relatively cheap, though it 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 on this method and its validity are no longer clear, even though it has been accepted in the industry at least since the 1980s. Testing by ASTM in 2014 made the method appear empirically questionable.

The continued use in the NZS1884 of electronic-type methods (capacitance) or the potential use of hygroscopic materials to directly measure the moisture gives other options around this problem. However, as that standard notes, these methods require experience to be used effectively, and in the case of hygroscopic chemicals, the answers provided need to be correlated with the US usage of moisture emission rather than humidity. Also, some parties have questioned the use of calcium chloride 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 the substrate for moisture (amongst other things).

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

If you conduct your own reading and the results are borderline, ARDEX recommends having another test done with calibrated equipment from a professional company to prevent future demarcation problems.

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 on the ground need a below-slab moisture/vapor 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), 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). At the same time, 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 test's main purpose; it was actually to show the negative effect on the barrier performance if holes were punched through it.

Craig (2004) quotes data to show 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 to reduce hydrostatic and groundwater infiltration. Also, moisture is being sucked into the system by moisture imbalances created by air conditioning and other air-drying processes.

Topically applied surface moisture barriers

In the AS 1884-2021 revision, a normative requirement was introduced that a moisture barrier with a prescribed WVTR was applied when a slab failed the moisture content test. 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 or the base resin and hardener for ARDEX EG15). This standard scope does not apply to waterborne systems such as ARDEX WPM300, which has a nominal value of ~0.6P, but the comparison is interesting. This implies that in the most critical situations, 100% solids ARDEX EG800F is the superior solution. This stricter standard arose due to the conditions in the US, which were related to moisture problems. It was found to be related to their construction methods and 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 with extremely low permeability. It appears (compared with Oceania) that ambient and site conditions in the US are different, creating an environment where a stricter set of standards are required or the legal situation is more problematic.

Silicate treatments

The use of reactive silica-based materials is interesting. These materials are 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 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’), when the sub-slab barrier has aged, or when 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) and reducing. This is a green slab seal, and a single coat does not provide the full barrier protection required for *constant dampness*.

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 3m2/litre will provide a green slab moisture barrier that is single-part and does not require sand blinding or the use of a primer.

Constant moisture

In all other situations in Australian and New Zealand conditions, including new 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 rolled on in two separate coats, allowed to cure, then primed, and a leveling 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.

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IMPORTANT

This Technical Bulletin provides guideline information only and is not intended to be interpreted as a general specification for the application/installation of the products described. Since each project potentially differs in exposure/condition, specific recommendations may vary from the information contained herein. For recommendations for specific applications/installations, contact your nearest ARDEX Australia Office.

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