Applying Moisture-sensitive Floor Coverings and Adhesives to Concrete Slabs

Introduction

The *Help Desk* at the Cement and Concrete Association of New Zealand receives a number of calls each year asking about moisture in concrete slabs that are to be overlaid with moisture-sensitive flooring materials.

Moisture in concrete floors can adversely affect flooring materials and the adhesion of floor coverings such as sheet vinyl, tiles, timber strips and carpet. For this reason, floor-covering and adhesive manufacturers often stipulate the maximum moisture content or relative humidity that a concrete slab can have before the floor covering or adhesive can be applied. The drying time of the concrete floor should therefore be considered during the design, planning and execution of a project.

The purpose of this Information Bulletin is to provide guidance to designers, specifiers and contractors on this subject.

Moisture in Concrete

Water is added to concrete for two reasons:

(a) to hydrate the cementitious materials, and

(b) to make the concrete sufficiently workable so it can be satisfactorily mixed, placed, compacted and finished.

A *typical* concrete slab may have a cement content of around 250 kg/m^3 and a water:cementitious material ratio of 0.65. When this is the case, a cubic metre of concrete will contain approximately 160 kg of water. However about 40% of this water is chemically bound with the cement (as a result of hydration), which leaves around 95 kg of evaporable water in a cubic metre of concrete. (*Note*: this figure excludes any water added during curing or from other sources, such as water absorbed from the sub-grade, condensation, or from falling rain.) In other words, the minimum quantity of evaporable water in a 100 mm thick concrete floor slab is *typically* around 10 litres per square metre. This quantity increases proportionally with the depth of the floor slab. That is, the minimum quantity of evaporable water in a 150 mm concrete floor slab is *typically* around 15 litres per square metre.

Effects of Moisture on Floor Coverings and Adhesives

Moisture in concrete slabs can adversely affect the installation and performance of moisture-sensitive floor coverings and adhesives. This can lead to problems such as delamination, blistering, stains and mould, and the breakdown of flooring adhesives as water vapour tries to escape. Impervious floor coverings, therefore, must not be laid until the concrete is sufficiently *dry*. It is vital to ensure that the concrete slab is at or below the maximum specified moisture content or relative humidity before moisture-sensitive floor coverings or adhesives are applied.

Effects of Alkalis on Floor Coverings and Adhesives

Freshly-placed concrete has a high alkalinity (pH). However, this alkalinity gradually reduces as the concrete reacts with carbon dioxide from the atmosphere, in a process know as carbonation. Initially a thin layer of carbonated concrete is formed on the surface, but the depth increases with time as the concrete is exposed to carbon dioxide.

The presence of alkalis can be problematic as they can break down adhesives and also cause microbial growths that degrade the floor covering itself. It is therefore important that flooring is installed on a concrete surface only after it has carbonated sufficiently, and only after the concrete has dried sufficiently so that moisture does not carry alkalis to the surface.

A procedure for determining the alkalinity of the concrete is provided in Appendix B of AS/NZS 2455.1:2007. The instructions of the manufacturer/ supplier of the subfloor primers, adhesives, and floor coverings should provide information on the pH at which installation should proceed.

Flooring Suppliers' Specifications

Suppliers and manufacturers of flooring materials in New Zealand acknowledge the high risk that excess in-slab moisture poses for the satisfactory installation and ongoing performance of their products. At the time of publication, suppliers of flooring products require the following conditions for safe installation of their products:

1. Resilient flooring products (vinyl, linoleum, cork, rubber, etc) and all carpet must comply with Standards AS/NZ 2445:1 and AS/NZ 1884 (concrete slab moisture content less than 75% relative humidity, as measured by a hygrometer).

2. Timber (solid or engineered) overlay must comply with BRANZ Bulletin BU506 (concrete slab moisture content less than 70% relative humidity, as measured by a hygrometer).

Consult the flooring product manufacturer to ensure that the slab moisture content will not compromise the product's performance.

The New Zealand Building Code (NZBC) and New Zealand Standards

Clause *10.3.1 Concrete slab on ground – General* of *Acceptable Solution E2/AS1, External Moisture* of the *New Zealand Building Code* stipulates that every concrete floor slab on the ground shall have a damp-proof membrane (DPM) laid between the ground and the slab, or between the top of the slab and a concrete floor topping that is no less then 50 mm thick. The DPM material shall be bituminous sheet, polyethylene (polythene) sheet or rubber emulsion, as specified in NZS 3106 or 4229.

Acceptable Solution E2/AS1 also stipulates that concrete slabs shall be cast on a 75 to 600 mm thick granular base.

Clauses *1.5.3 Adhesives* and *2.4 Conditions of Floor Coverings and Subfloor* of AS/NZS 2455.1 specify, the following (among other things) for textile floor coverings:

Clause 1.5.3 Adhesives

- The choice of adhesive shall be made by consultation between the contractor and the manufacturers/ suppliers of the selected underlay, floor covering, and adhesive.

- Only adhesives suitable for use in buildings with relative humidity of 75% or more shall be used in such atmospheric conditions, and shall be used in accordance with the instructions of the manufacturers of the floor-covering and adhesive.

- Curing compounds, release agents and surface treatments on the subfloor should be removed prior to the application of trowel-applied levelling compounds or the installation of flooring.

Clause 2.4 Conditions of Floor Coverings and Subfloor

- Before installation, the floor-covering shall be at the same temperature and relative humidity as the area where it is to be laid.

- The preferred ambient temperature at installation shall be between 10 and 35°C, but reference shall be made to the manufacturer's recommendations.

- The floor-covering shall be installed only where the relative humidity of the area does not exceed 75% or fall below 30%.

- Heating units shall not be used to dry the concrete subfloor before the concrete has been cured for one month after placing. The concrete shall be allowed to dry out slowly to minimise cracking.

- All sub-floor surfaces shall be dry, smooth, plane, sound and clean. Dryness shall be considered satisfactory when the relative humidity, determined by the hygrometer test, does not exceed 75%.

Measuring Moisture in a Concrete Slab

Appendix B (Informative) of AS/NZS 2455.1:2007 *Textile floor coverings – Installation practice – General* sets out some general information and methods for determining the dryness of concrete subfloors.

The Appendix discusses the variables that can significantly affect the reliability of testing systems, and stresses that all moisture tests should be carried out in accordance with the instrument manufacturer's instructions. All testing instruments should be calibrated regularly in accordance with the manufacturer's instructions. Procedures for the hygrometer test and the capacitance test are described in Appendix B of AS/NZS 2455.1.

Hygrometer Test

The hygrometer test is used to estimate the egress of moisture by measuring a small amount of contained air at the surface of, or within a drilled hole in, a concrete slab. The surface test uses a humidity measuring device inside a vapour-proof box to measure the relative humidity of the contained air in a 16-hour period. The vapour-proof box is sealed to the concrete slab with a non-water based putty. The in-slab test uses a vented plastic insert (sealed at the surface) and uses a testing procedure similar to the surface method.

According to Standards AS/NZ 2455:1, AS/NZ 1884 and BRANZ, the hygrometer method is the most reliable method of assessing the degree of dryness of a concrete slab. However, the surface test will produce a lower reading than the in-slab test so is less indicative of slab moisture.

Capacitance Test

The capacitance test is used to estimate the moisture content of concrete through the emission and reception of low frequency energy waves, typically by placing an energy transmitter/receiver on the surface to be tested. The approximate saturation of the substrate to a nominal depth of up to 10mm is calculated using predetermined calibrations.

Although the capacitance test provides fast and immediate measurements of concrete, the test is less precise than the hygrometer test. The capacitance test is best suited to an initial testing regime to indicate the possibility of excess moisture.

Calcium Chloride Test

The calcium chloride test involves placing an open dish containing a specified mass of calcium chloride under a plastic dome that is sealed to the concrete slab. The moisture vapour emission rate (MVER) is determined by calculating the percentage increase in the mass of crystals due to moisture vapour absorption after 60 to 72 hours.

The standard test method is set out in ASTM F 1869-04. Appendix B of AS/NZS 2455.1:2007 states that this test is not recommended as insufficient experience has been gained of its use.

Polythene Sheet Test

This test is a qualitative field test rather than a standard test and is therefore of limited use. It involves tightly taping a large (say 450 x 450 mm) polythene sheet to the concrete slab for at least 16 hours. The slab is still too wet to apply moisture-sensitive floor-coverings if condensation forms under the polythene sheet. However, the test can provide false negative results, and therefore the absence of moisture under the polythene does not always mean that the slab is acceptably dry. For this reason, the dryness should be determined by the standard (hygrometer) method.

Electrical Resistance Test

The use of electrical resistance testing, where current is passed between to probes inserted into the concrete slab, is not a suitable method for assessing moisture content. Significant variables in the makeup of concrete mean the test results are highly unreliable.

Drying Rates – Rules of Thumb

Many variables control the drying rates of concrete slabs, including initial moisture content, porosity, temperature, relative humidity, and air velocity. Drying does not progress at constant rates; the first water evaporates relatively quickly, while the last water comes out more slowly. BRANZ has published the following *rule of thumb* guidelines for the drying time of concrete slabs to reach the appropriate relative humidity in well-ventilated buildings:

Concrete thickness (mm)	Drying time (months)
75	3
100	4
150	9
200	16

Another oft-quoted *rule of thumb* is to allow one month drying time for every 25 mm depth of concrete. It is important to note that this general rule is applied from date of close-in (weather tight), not from date of placement. However, as pointed out previously, the last water to come out — that is, water from the deeper sections of the slab — actually comes out more slowly than the water nearer the surface.

It is important to note that drying times vary considerably with factors such as weather conditions, air temperature, humidity and air movement. Also, floor coverings can sometimes be laid successfully in less time than indicated above.

Avoiding Delays to Floor Covering Operations

Drainage

Protection against water ingress can be provided by ensuring that proper drainage away from the slab is considered during the design stage of a project and is provided during the construction phase.

Capillary Break

A granular base under a concrete slab on grade will act as a capillary break so that moisture rising from the underlying soil cannot be absorbed by the concrete slab. NZBC E2/AS1 stipulates such a granular base layer - see *The New Zealand Building Code (NZBC) and New Zealand Standards*, above.

Damp-proof Membrane (DPM)

A DPM under the concrete slab is designed to prevent moisture entering the slab from beneath. The NZBC requires interior concrete floors on the ground to have a DPM — see *The New Zealand Building Code (NZBC)* and *New Zealand Standards*, above.

Concrete Mix Design

The concrete mix should have as low a water-cementitious material (w:cm) ratio as practical in order to minimise the quantity of evaporable water. For example, reducing the w:cm from 0.65 to 0.50 will lower the quantity of evaporable water by around 35% (i.e. from 95 to 65 kg/m^3 for a concrete mix with a cementitious material content of 250 kg/m^3 and a w:cm ratio of 0.65). Water-reducing admixtures can be used to maintain adequate workability. Moreover, concrete with a low w:cm ratio that includes a supplementary cementitious material, such as fly ash, will have a reduced permeability to vapour transmission.

Rain and Other Sources of Water

All practical measures should be taken to protect the concrete slab from rain and other sources of moisture prior to installing the floor coverings.

Curing

Moist curing will increase the time it takes a concrete slab to dry. Moreover, the use of curing compounds should be avoided – refer clause 1.5.3 (e) of AS/ NZS 2455.1:2007. Curing the concrete under an impermeable sheet, in accordance with Clause 7.8.2(e) *Curing and protection/ unformed surfaces* of NZS 3109:1997, is recommended.

Forced Slab Drying

While the use of dehumidifiers and driers can appear to accelerate the drying process, the net effect on the moisture content of the slab is negligible unless the process is maintained for a considerable period, generally several weeks. Caution should be exercised when testing a forced-dried slab to ensure that sufficient time is given for the moisture content to achieve relative equilibrium between the bottom, centre and top of the slab. AS/NZ 2455:1 requires all air conditioning to be turned off for seven days prior to testing.

Applied Moisture Barriers

Where time constraints require, the excess moisture emission of a concrete slab may be reduced through the application of a topical epoxy or co-polymer moisture vapour barrier. This type of vapour barrier relies on the integrity and adhesion of the coating to the sub-floor. The performance of these coatings is highly dependent on the correct application, including the correct volume of product per square metre and close attention to the maximum moisture content of the slab. The manufacturer's specifications should be carefully followed. Caution is needed when treating cracks, cuts and/or joints in the slab, to ensure the performance of the coating is maintained. Topical epoxy or co-polymer moisture vapour barriers are typically applied immediately prior to installing floor coverings. Correct performance of the applied coating should be assessed through the use of a surface-mounted hygrometer after the coating has been applied.

Slab Thickness

According to ACI Committee (see *Source 4*) slab thickness affects the time needed to reach a given relative humidity within the slab; a thicker slab requires more time. See also *Drying Rates – Rules of Thumb*, below. However, slab thickness has no effect on the time required to reach a given moisture vapour emission rate.

Conclusions

Moisture in concrete slabs can cause problems to moisture-sensitive floor coverings and adhesives. The drying time of a concrete floor to be overlaid should therefore be considered carefully during the design, planning and execution of a building project to avoid problems.

To avoid problems, it is important to understand the following: the sources of moisture in a concrete slab; the proper design of slabs, with careful attention to detail; the Building Code and Specification requirements; and the measurement and testing methods. This knowledge can guide the design, planning and scheduling of building projects so that problems will be rare.

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