BUILDING in a SALINE ENVIRONMENT

LOCAL GOVERNMENT
SALINITY INITIATIVE

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Department of **Environment & Climate Change** NSW

Published by:
Department of Environment and Climate Change NSW
59–61 Goulburn Street
PO Box A290
Sydney South 1232

Building in a Saline Environment

ISBN - 978 07347 59702
DECC 2008/415
Second edition printed August 2008. First edition printed 2003 by the former Department of Infrastructure, Planning and Natural Resources

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Acknowledgements: NSW Department of Primary Industries
Sydney Metropolitan Catchment Management Authority

Contents

Introduction

Salts are a natural part of the Australian landscape. Concentrated salts and different types of salts once dissolved and mobilised in water, can have an impact on the durability of some building materials.

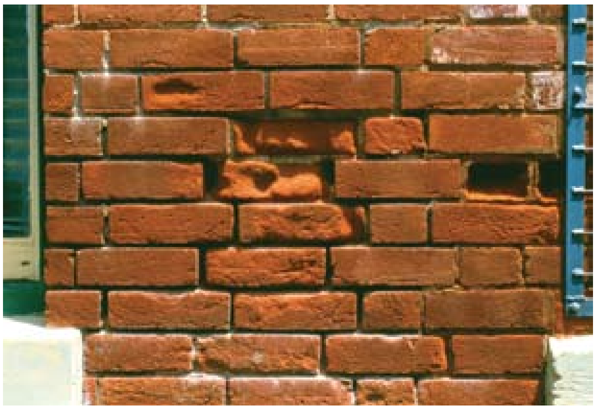
This booklet is part of the Local Government Salinity Initiative series and looks at:-

1. how salts enter building materials,
2. the effect of salt and water on some building materials,
3. information available for building in saline environments.

Other booklets in the Local Government Salinity Initiative series related to buildings include 'Repairing and Maintaining Salinity Affected Houses', 'Indicators of Urban Salinity', 'Site Investigations for Urban Salinity' and 'Land Use Planning and Urban Salinity'.

A verandah post showing signs of salt and water damage.

Render showing signs of salt and water.



Bricks showing signs of salt and water damage.

Paintwork blistering due to the accumulation of salts.

A sandstone church showing signs of salt and water damage.

Sources of Salt

Building products are made with various materials such as sand, aggregates and water that may contain salts. Alternatively the finished product may be stored in a location which allows the addition of salts carried by wind, rain or from the ground to enter the finished product.

Once the product is used in a building, sources of moisture, wind or rain can add more salts. Various coatings or treatments may also add to the type and quantity of salts present. For example magnesite was commonly used on the floors of apartment blocks during the 1960's and 70's to provide a fast level finish to the floor and for sound proofing. It has since been found that salts can leach out of the product and cause corrosion in the reinforcing within the concrete.

It is important to understand the source or sources of salts in order to determine the most effective course of action, if action is needed. For example layers of salty soil deep under ground are unlikely to be an issue if a water source is not bringing the salts to the surface and extensive cut and fill is avoided.

New bricks releasing salts.

New pavers laid on unwashed sand.

Sources of Water

The 'Building Code of Australia', has objectives and performance requirements to prevent undue dampness and moisture damage. Complying with these is very important for preventing salt movement and salt damage. Salts dissolve in water. They can therefore move with water into and around buildings. Houses impacted by urban salinity often have several water sources contributing to the salt attack.

Water sources include:

- **Rising damp**, where soil moisture is drawn up into the building material by capillary action. The ground moisture may be a result of one or several water sources near the building, on surrounding properties or further afield. For example, a leaking pipe may cause damp ground near the leak. A leaking pool may affect several houses, while numerous leaky structures and activities like the over watering of parks and gardens around a town may result in a high groundwater table that affects several sites, suburbs or the whole town.
- **Falling damp**, where leaking gutters, downpipes or roofs allow water to run down the outer face of the building or into the wall cavity. Movement of water is mostly downward due to gravity however water may soak into building materials as it runs down over the building or accumulates at the base of the building.
- **Condensation**, where water vapour in the air condenses on cooler wall surfaces. Examples can include hot moist air from clothes dryers, cooking, showers and unventilated combustion heaters.

A building with wet 'tide' mark (dark bricks) showing the height of the rising damp.

Courthouse showing symptoms of falling damp possibly from a blocked gutter.

A rusted down pipe allowing rainwater to mobilise salts in the soil.

Infiltration Rates

The three main factors driving the rate of water (and salt) entering a building are the

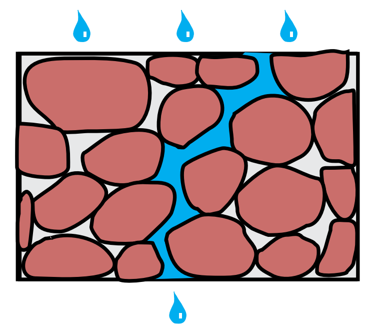
1. **Amount of available water**. This is influenced by the depth to the water table; the amount of water leaking from water, sewer and stormwater systems; the over watering of gardens; as well as the timing, distribution and intensity of rain.
2. **Rate of evaporation**. This is affected by such things as ventilation, temperature, relative humidity and the amount of building surface exposed to evaporative processes. Water is drawn towards the building surface where evaporation occurs.
3. **Permeability of the building material**. The size, distribution and continuity of the pores within a building material determines how easily water can enter and travel through a building material.

Since salts are mobilised by water, infiltration rates are very important in controlling salinity impacts. However, if salts have been accumulating for some time and the sources of water then controlled, salinity damage will continue to occur. This is because some salts will attract moisture from humid air. The hydration and recrystallisation of these salts will continue to exert physical pressure on the building. Also in some areas water tables take a long time to respond to changes in water management.

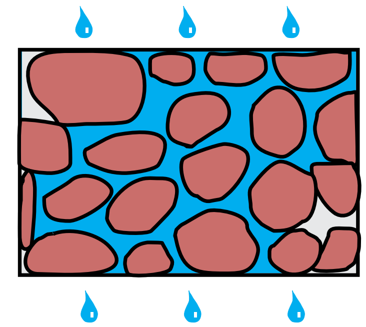
Bricks that have crumbled grain by grain as a result of salt hydration and crystallisation.

Porosity vs Permeability

A material may be porous but not permeable. That is, a material may have lots of pore spaces but at the same time not allow water to pass through it. If pores are isolated or closed, if they have a lining that can react with fluid to discourage movement, or are too small to be filled as the air they contain cannot escape, then the material is considered to have a low permeability.



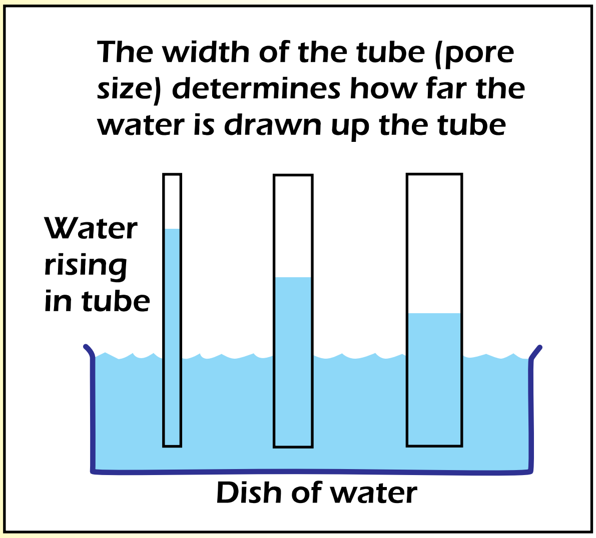
High porosity but low permeability



High porosity and high permeability

Pore size varies between materials but also within a material. In theory, a pore size of 0.001 mm can support a 1m high column of water. If salts are present in the water then the surface tension of the water is increased and there is increased 'pull' up the pore tube. This is partially offset by the increased weight of the water column due to the salts dissolved in the water.

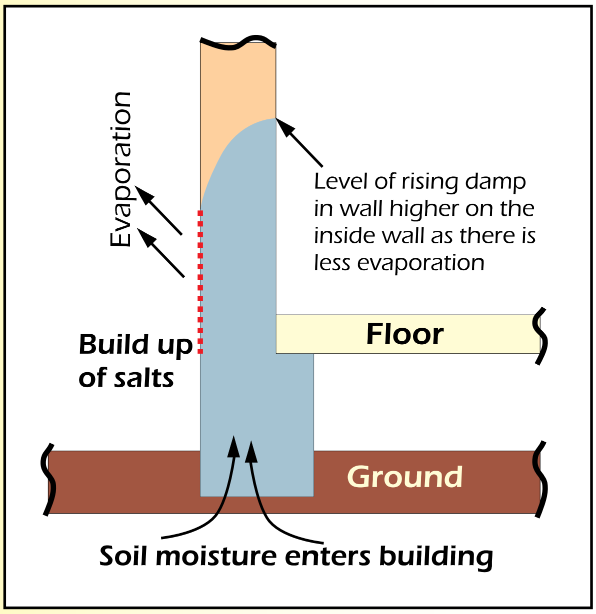
Pore diameters in mortar and brickwork are in the range of 0.1 *um* (0.0001 mm) to 10 *um* (0.01 mm) and can act as capillary tubes. Fine cracks in concrete and other products can also act as capillary tubes.



Exaggerated diagram of capillary rise in various size tubes.

A render with low permeability may reduce evaporation so more water is available to travel up the wall. In this photo, evaporation is occurring just above the top of the render, concentrating salts and resulting in the crumbling of the brickwork.

Moisture moves through material towards the surface where evaporation is occurring. The tide mark or height of the water on a wall is the point where the rate of evaporation equals the amount of water getting into and moving through the wall. Construction that maintains low permeability, allows increased ventilation and decreased contact between building materials and sources of water are therefore less prone to salt and water damage.



Source: Department of Environment and Natural Resources (1995), Rising Damp and Salt Attack, State Heritage Branch and City Of Adelaide.

The Reactions of Salts with Building Materials

Once water and salts are absorbed by building materials, chemical and physical damage can result. The extent of chemical attack will depend on the concentrations and particular types of salts present, as well as the composition of the building material.

Physical attack on the other hand requires a wetting and drying process. Salts form crystals as the moisture in which they are dissolved evaporates. A large crystal will exert physical pressure on the building material surrounding it. New moisture allows the crystal to dissolve, move and grow as more salts are supplied in the water.

Different salts form different sized crystals and even the same salt forms different sized crystals under different conditions. These crystals can expand with heat. The effect on the building material will depend on the location of the crystal within the building material as well as the physical properties and cohesive strength of the building material.

Wetting and drying cycles can also significantly increase the concentration of salts over the life span of the building. In a brick veneer building for example, evaporation is most likely to be highest on the outside wall of the northern side of the building. Higher levels of evaporation lead to a greater concentration of salts and more damage provided there is a supply of salt and water. The supply of water may be intermittent over the lifespan of the building or occur regularly over a portion of the house's history until the water source is repaired or redirected.

Bricks showing symptoms of salinity damage while the mortar in this case, is slightly more resistant to the physical forces exerted by the salts.

Brick work showing signs of salinity damage and accumulation of brick 'grains' at the base of the wall.

Concrete

Generally, chemicals in their dry state do not attack concrete. However, once mobilised in water, various chemical and physical interactions can occur.

Acids dissolve the alkaline components of concrete eg calcium hydroxide to form soluble salts. These can be leached from the concrete, increasing its porosity and decreasing its strength. Concretes containing blast furnace slag or fly ash have less calcium hydroxide than other non blended products and are therefore less susceptible to acid attack.

Sulphates react with the hydrated calcium aluminate component of cement. The products of these reactions have a larger volume than the original ingredients and exert a physical stress on the concrete. The rate of sulphate attack is affected by factors such as the solubility of the different sulphates. For example, calcium, magnesium and sodium sulphates have different solubilities. Also the process is exacerbated if magnesium and /or ammonium are present as they attack the silicates and calcium hydroxide components not just the calcium aluminates.

Concrete kerb and gutter affected by sulphates.

Sulphate resistant cement is often called marine grade and contains only small amounts of calcium aluminates. Note that calcium sulphate (gypsum) is often applied to saline soils to improve the soil properties for landscaping and soil erosion purposes. The level of gypsum applied should be taken into account when designing concrete structures.

Chlorides do not react chemically with concrete. However, wetting and drying cycles, changes in humidity and temperature, can result in the formation of salt crystals that exert a physical stress on concrete. Cement containing higher proportions of tricalcium aluminate may be less susceptible to chlorides. Chloride ions can react with the tricalcium aluminate in the cement to form an insoluble new product thus rendering part of the chlorides harmless.

Carbonates can decrease the alkalinity of the cement paste from around pH 12 to pH 9.5. This decreases the resistance of the reinforcing metal within some concrete structures, to corrosion.

Corrosion of reinforcement in concrete occurs in two phases, namely initiation and propagation. The initiation phase is where concrete alkalinity is reduced by carbonation or ionization. Carbonates may come from sources such as groundwater or carbon dioxide in the air. Ionization occurs where there is a higher concentration of reactive ions such as chlorides. Chlorides sources include: groundwater, the soil, the atmosphere, acid etching, admixtures, or the water, aggregate and sand, used to make the concrete. Once initiated, the propagation phase of the corrosion continues at a rate dependent on the amount of available oxygen, moisture, reactive ions and remaining alkalinity.

It is therefore important to know the salt types, salt levels and water sources on the building site at the time of construction and what is likely throughout the lifespan of the building. This knowledge allows the choice of suitable building materials and techniques to avoid potential physical and chemical salt damp attack.

Rust formation exerts physical pressure on the surrounding concrete and leads to weakening of the reinforcement steel.

Bricks Resistant to Salt and Water

The 'Building Code of Australia' (BCA) requires moisture control to prevent damage, dampness, deterioration, loss of amenity, unhealthy or dangerous conditions. Acceptable construction practices or deemed to satisfy provisions to achieve these objectives and performance requirements listed in the BCA include the classification of masonry units and their use in appropriate areas.

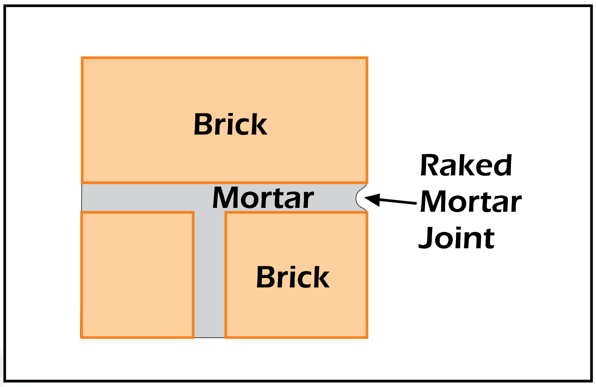
The BCA lists exposure class bricks as "Suitable for use in all classifications including severe local conditions such as:

a. below the damp-proof course in areas where walls are expected to be attacked by salts in the groundwater or brickwork itself (salt attack or salt damp)......"

The method for classifying bricks is further described in Australian Standard 3700 Masonry Units which in turn refers to a salt resistance test which is described in detail in Australian Standard 4456.1 Masonry Units and Segmental Pavers - Method of Determining Resistance to Salt Attack. The test involves soaking five bricks in a salt solution, drying the bricks then repeating the process 39 times. The weight of the bricks before and after this process is compared to measure how much of each brick has crumbled away due to salt attack.

Exposure class bricks are those that lose less than 0.4g of weight after 40 wetting and drying cycles or where a supplier can demonstrate that the product has a history of surviving in saline environments.

The BCA also gives the ratio of cement, lime and sand suitable for mortars used with exposure class bricks and prohibits the use of raked mortar joints with exposure class bricks.



Ideally the designer, builder, brick manufacturer, brick purchaser and building certifier should all be aware of the issue of salt attack and brick classification.

Within a style of bricks some are usually exposure grade and others general purpose, with no price differential. Therefore it is possible, at no extra cost, to use exposure grade bricks as a precaution against unknown, present or future salt attack.

Choosing a brick product with a lower initial salt content is not mentioned in the BCA. However there is an Australian Standard for testing the salt content of bricks, AS4456.6 Masonry Units and Segmental Pavers - Methods of Test - Determining Potential to Effloresce. This means choosing products with minimal existing salt content could be an easy to implement added precaution for building sites with existing high salt levels.

AUSTRAL
Build a better home

TEST REPORT ON FIRED CLAY PRODUCTS DETERMINING RESISTANCE TO SALT ATTACK TO AS/NZS 4456.10

Client: Dept of Land & Water Conservation
Sample Number: 410
Date of Sampling: 18/7/01
Location of Sampling: Plant #2
Sampled to: AS4456.1
Product: Heritage Castlereagh
File Number: 002
Date of Test: 14/8/01
Deviation to Standard Method: None
Report Number: 200205

Salt Solution Used (tick appropriate box): 10% Sodium Chloride, ✓ 6.2% Sodium Sulphate

Description of Sample:

Specimen Number	Total Mass Loss
1	0.10
2	0.08
3	0.06
4	0.06
5	0.06

Cycle at which testing ceased: 40

Salt Attack Resistance Category: Exposure Grade

Approved Signatory: (P.S. Morey)
Date:

This data or test certificate is supplied in good faith to show that this batch and this batch only exceeds our published performance data. Only our published performance data should be used in any engineering calculations.

Austral accepts no responsibility for use of data not published.

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The Austral Brick Company Pty. Ltd.
Wallgrove Road, Horsley Park, NSW 2164, P.O. Box 6550 Wetherill Park, NSW 1851

Concrete Resistant to Salt and Water

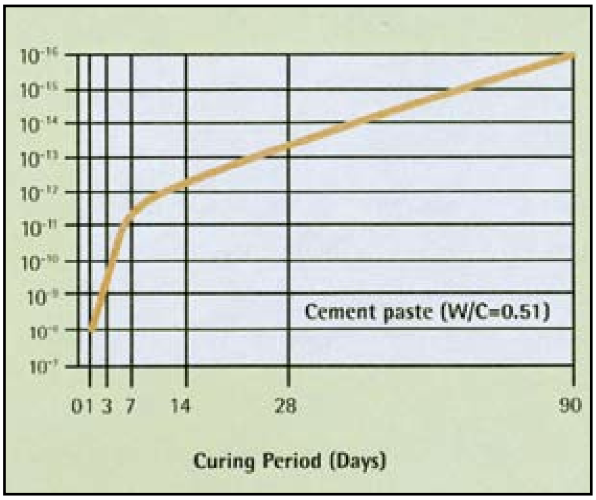
Concrete is a mixture of coarse and fine aggregate, cement and possibly other additives such as fly ash, slag or chemical admixtures added to enhance properties of the concrete for specific purposes.

Concrete forms by the chemical reaction of hydration, where water reacts chemically with the cement to form new compounds. The hydrated cement paste forms ribbon-like crystals that interlock and bind together the sand and gravel to form concrete.

Larger quantities of concrete are delivered to the building site while smaller amounts and cement based mortars and renders are often mixed on site.

The strength and permeability of the final concrete relies on several factors including the product ingredients and proportions, as well as the handling of the product when it is delivered and hydration is occurring.

A builder generally orders a particular type, strength and quantity of concrete. This determines the water to cement ratio, size, type and amount of aggregate, sand and cement in the mix. The builder then places the concrete within the formwork and around the metal reinforcing, vibrating out trapped air, and protecting the concrete from processes that will cause excessive evaporation. Without good handling procedures, the final product will not achieve the correct strength. Adding extra water, over vibration, too little vibration, and poor curing methods, all result in a weaker more permeable concrete.



Protecting concrete from excessive water loss during the first seven days after placement has a dramatic impact on the permeability of the final product.

In order to improve the durability of concrete in moist saline environments consider:

- using a quality assurance certified cement manufacturer, concrete batcher and supplier
- the water to cement ratio – do not add extra water on site
- curing procedures and duration
- choice of concrete eg sulphate resistant or higher strength, to suit the site conditions
- vibration to remove entrapped air and ensure good placement in and around the reinforcing and formwork
- increasing the amount of concrete cover over steel reinforcement
- minimising cracks in the final structure
- minimising ponding of water on or next to concrete

All other factors being equal, increasing concrete strength will decrease its permeability. As there is no standard test for permeability in cement, strength is often used as an 'indicator' of permeability. However, this is an oversimplification and should not be used as the only specification or design criteria for ensuring concrete structures are durable in salinity hazard landscapes.

Preventing Salt and Water Moving into the Building

The 'Building Code of Australia '(BCA) deemed to satisfy provisions to meet the moisture control requirements, also includes installation of a damp proof course below floor level. In the past, damp proof courses have been made of various materials including coal tar, slate, coated metals, and mortars containing chimney soot. Today, it is common for the damp proof course to be polyethylene sheeting laid in a horizontal mortar joint of the brick work.

Acceptable building practice in the BCA states that the damp proof course (DPC) should be 150mm above the finished ground level or 100mm if the ground is sandy and well drained. This can be further reduced to 50mm if the area is finished with paving or concreting that slopes away from the building and is covered by a verandah.

This installation of a polyethylene damp proof course is unlikely to comply with the deemed to satisfy provisions regarding height above finished ground level.

A DPC if installed correctly as a continuous barrier around the house should stop the upward movement of rising damp.

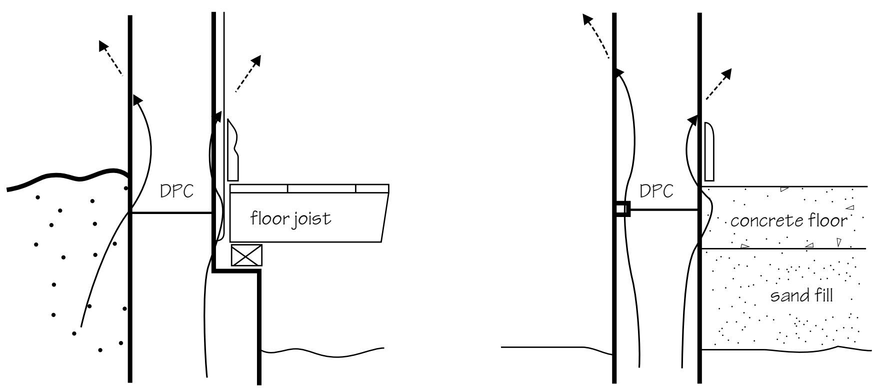
However a DPC may fail for a number of reasons:

- breakdown due to chemical attack
- cracking or penetration during installation
- breakage by differential settling of the building
- incorrect installation
- bridging by pointing or rendering
- bridging by the installation of garden beds and paving
- bridging by mortar droppings collecting in the wall cavity
- bridging by renovations or additions, eg incorrect replacement of a timber floor with sand and a concrete slab.

Once the DPC is bridged or broken, water and salts are able to move upwards through capillary action. This significantly increases the difficulty and cost of repairing salinity damage to buildings. Correctly installing and maintaining a durable DPC is therefore an important technique in controlling salt damage to buildings.

The South Australian Salt Damp Research Committee, in their Second Report (1978), stated, " Protection against salt damp is dependent upon each link in a continuous chain – competent design and specifications, painstaking construction, skilled supervision, good housekeeping and maintenance by the owner/occupier". It is logical that this theory holds true today.

Bridging the DPC: some examples



1
Raised garden bed provides a moisture path above DPC

2
Plaster brought down over DPC creates bridge

In this case the DPC should have been installed below all floor timbers

3
Pointing or repointing over the DPC

A render over the DPC would similarly create a bridge

4
Concrete floor laid across (or above) the DPC without a separating moisture barrier

External paths can also create bridges

Source :Department of Environment and Natural Resources (1995), Rising Damp and Salt Attack, State Heritage Branch and City of Adelaide.

Damp-proof course bypassed by rendering.

Damage limited to the area below the damp proof course.

Damp Proof Membranes

It is common practice at present, to construct houses with concrete floors essentially laying at ground level. For moisture control in these houses the 'deemed to satisfy provisions' in the BCA for New South Wales (NSW) and South Australia (SA) include installation of a high impact resistant 0.2mm polyethylene damp proof membrane as a continuous layer under the slab and wrapped around the footings to ground level.

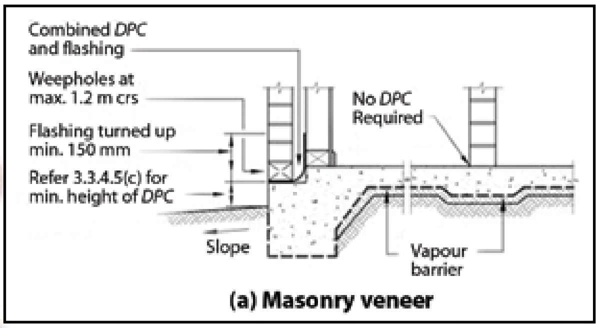
This provision was introduced in May 2004 in NSW as a state variation to the Building Code of Australia to "better protect houses against the effects of urban salinity".

Damp proof membranes are more resistant to puncture than the low impact resistant vapour proof membranes. Membranes are laid on the excavated and prepared site prior to placement of reinforcing, concrete formwork and concrete. Builders therefore have to walk on the membrane. A high impact resistant membrane is less likely to be pierced by stones caught in the tread of the builder's boots or protruding from the ground below the plastic.

Prior to the 2004 NSW BCA amendment, builders in all states except SA, were required to use high impact resistant damp proof membranes only in areas prone to rising damp and salt attack. This meant builders had to be aware of the provision of when a low impact resistant vapour barrier was not acceptable as well as be aware of local rising damp and salt attack issues. Policing by building certifiers was also difficult as both types of membranes are available in orange and black, the membranes are laid with the printed branding face down, and the membrane is covered by concrete early in the construction process. These difficulties are minimised with the NSW and SA requirement for the standard use of high impact damp proof membranes on all house sites.

There is only a small price differential between the low impact and high impact membranes while repair of salt attack is expensive.

The potential for salt attack during the lifespan of a house is high and widespread. Australia is one of the most saline continents in the world and all urban house sites have some water sources that may mobilise these salts. Cost effective precautions to salt attack are therefore justified.



Part of Figure 3.3.4.1, Volume 2 of the BCA. Note Damp proof barrier not vapour barrier required in NSW and SA. This barrier underlays the slab, wraps the footings and is finished at ground level. The slope away from the building is a drop of 50mm over the first 1m.

Some NSW councils (eg Wagga Wagga, Camden, Junee and Fairfield) recommend or require via local building policies, the use of a 50mm layer of sand under the high impact damp proof membrane. This is an added precaution against puncture but also improves drainage and minimises capillary rise of moisture from the soil. Many builders also use sand to prepare a site for the laying of the concrete slab, offsetting the cost[1] by shorter site preparation times and less concrete wastage.

Prior to slab on ground construction being so popular, floors rested on bearers and joists, supported by piers. This type of construction has less building material in contact with possible salt and water sources in the soil. It more readily allows ventilation, evaporation and the concentration of salts to occur in the soil rather than building materials. The building is also less likely to impact on natural salt and water processes. The 'deemed to satisfy provisions' in the BCA require the space between the ground and suspended floor to be a minimum clearance of 400mm in houses that require termite management. Ease of access for termite inspection also allows a visual inspection for salinity damage to piers.

Damage to brick piers discovered during a building inspection.

Maintaining Good Drainage on a Building Site

The movement of water and mobilisation of salts at various scales needs to be considered with respect to house construction and drainage on the building site. On a catchment scale, water may be entering a groundwater system kilometres away from where the water returns to the surface. Along the way this water may have picked up salt from the rocks and soils it has passed through. In this situation on-site action as well as work further up the catchment such as increasing perennial vegetation, where the water is getting into the groundwater system, could be more cost effective.

On an urban subdivision scale, decisions such as whether to use septic tanks, irrigate large areas, infiltrate stormwater, supply piped potable water, how much native vegetation is retained, all impact on the salt and water movement. A salt and water balance at the planning stage can estimate the impact of these changes within the subdivision and surrounding area. If the environmental, social and economic costs are too high, alternative decisions may be made about the nature and type of development, or a management plan put in place to deal with any adverse impacts. In western Sydney, salinity management plans submitted by developers of large new estates often include drainage and additional building/ construction requirements to address the salt and water issues of the region.

This property is located where high groundwater levels are a result of the catchment shape and land uses. Installation of extra air vents and more efficient vents is unlikely to prevent salt damage. Moisture barriers and salt resistant materials may be a more effective choice.

[1] In 2007, approximately $350 for a 200m^2 house.

In this town during wetter periods, the water table is close to the surface and evaporates, leaving behind an accumulation of salts. During periods of below average rainfall and water use restrictions the water table is several metres below ground. Building design and construction should take into account these longer term changes.

On an individual house lot scale, a number of construction and maintenance decisions affect the potential for water movement and the related salinity damage. These include:

- whether to cut or fill the site
- whether the ground is reshaped to slope away from the building
- how the site is landscaped
- how the landscaping is watered
- how much of the site is hard surfaces vs pervious surfaces
- whether a path is provided around the perimeter of the house and sloping away from the building
- what stormwater drainage is provided
- whether pools, taps, and downpipes are regularly checked for leaks

A builder does not have control over many of these factors so needs to design and construct for the most likely scenario and the salinity risk of the area.

Over-irrigation can lead to rises in the water table.

Building Codes

The 'Building Code of Australia' is a performance based code that sets out the objectives and outcomes required for different classes of buildings. Acceptable building solutions (also called "deemed to satisfy provisions") are listed to show how to achieve these requirements. However, a builder may choose other construction materials and practices provided it can be demonstrated that all the required outcomes of the BCA are met.

The Damp and Weatherproofing provisions require the following:

- F2.2.2 A building is to be constructed to provide resistance to moisture from the outside and moisture rising from the ground.
- P2.2.3 a) Moisture from the ground must be prevented from causing—

  (i) unhealthy or dangerous conditions, or loss of amenity for occupants; and

  (ii) undue dampness or deterioration of building elements.

  And NSW adds

  (b) Barriers installed beneath slab on ground construction for the purposes of (a) must have a high resistance to damage during construction

The Australian Building Code Board has been reviewing the issue of urban salinity/ salt attack for a number of years. One of the outcomes of this process may be to improve the clarity of these performance requirements by including a reference to salt as well as water. Another may be modification of the deemed to satisfy provisions.

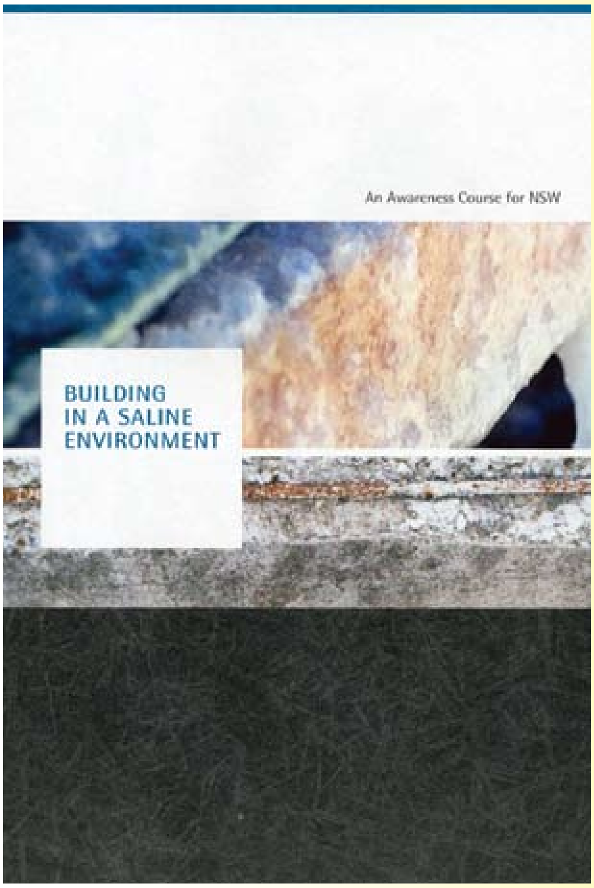
In NSW, the Building Code of Australia becomes legislation through the Environmental Planning and Assessment Act. The Building Systems Unit within the Department of Planning, consults with the NSW construction industry and stakeholders via the Building Regulation Advisory Council to consider national proposals in terms of their suitability for NSW. The State variation to the BCA implemented in 2004 and still current today, relating to use of high impact damp proof membranes under house slabs was introduced as an interim measure while national debate regarding salt attack continues.

In NSW, local government may also introduce building policies above and beyond the BCA although they cannot water down or make any BCA provisions not apply. Several councils have or are currently reviewing the necessity of this option for building in saline environments. The existing NSW local government policies generally require:

- 50mm of sand under the building slab
- 32MPa concrete
- seven days curing time for concrete
- and reinforce the NSW BCA requirement of a high impact resistant damp proof membrane

References to urban salinity are also being made in Council Engineering Guidelines and one council is considering the introduction of a higher minimum construction standard for domestic pools. Leakage from pools not only wastes water but adds to the salinity potential of the area.

The NSW Office of Fair Trading requires all builders and tradesperson who undertake work in the home building industry (for jobs over $1000 including labour and materials) to be licensed. License holders must regularly update their knowledge by undertaking continuing professional development. Sydney Metropolitan Catchment Management Authority, the Department of Environment and Climate Change, and TAFE NSW have developed a four hour course for builders, building inspectors and certifiers to increase their awareness and understanding of urban salinity and its management. The course is called 'Building in a Saline Environment – An Awareness Course for NSW.'

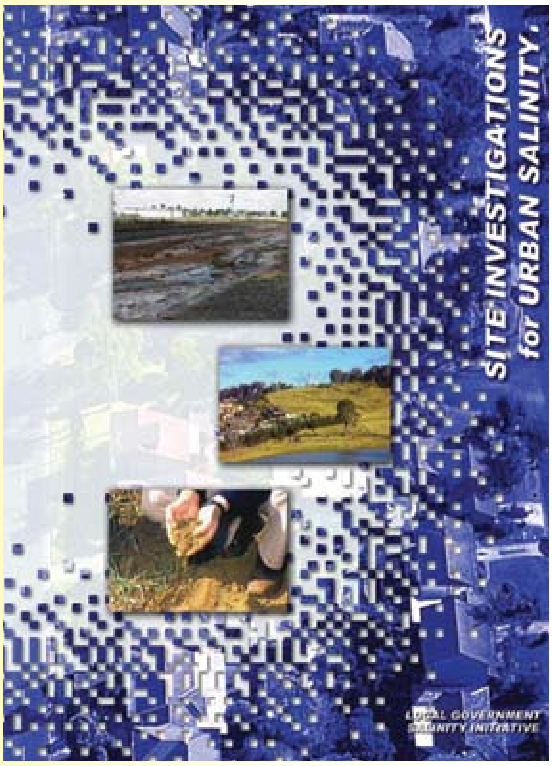


Trainer's manual, trainer's video, powerpoint presentation and participants notebook available from the Department of Environment and Climate Change.

Australian Standards

Australian Standards are created by groups of interested stakeholders donating their time and expertise to follow a prescribed process and format to create a reference document. The BCA deemed to satisfy provisions refers to over 100 Standards thus these standards become part of the legislative framework of the building industry. Several provide requirements for construction in saline soils.

'AS 2159 Piling Design and Installation (1995)' provides table (6.1) Exposure Classification for Concrete Piles. Soil conditions are listed as non-aggressive, mild, moderate, severe or very severe, based on test results for pH, chlorides, sulphates and soil resistivity, for permeable soils which are below the groundwater table and for low permeability soils or all soils above the groundwater table. Various notes of caution are attached to the table such as the impact of magnesium or ammonium ions, in the presence of sulphates, increases the aggressiveness of the soil on concrete. This standard also recommends site specific design of concrete for sulphate attack noting that dense, well compacted, low permeable concrete of the correct type is more important than a high characteristic strength. Extracts from this standard are provided in the Local Government Salinity Initiative booklet: 'Site Investigations for Urban Salinity'.



'AS 2870 Residential Slabs and Footings (1996)' requires:

- a design life of 50 years (clause 1.4.2)
- drainage to be designed and constructed to avoid the ponding of water against or near footings. A graded fall of 50mm minimum away from the footing over a distance of 1m is required even on the ground uphill from the slab on cut and fill sites (clause 5.2.1)
- 40mm cover to reinforcement
- concrete to be vibrated and cured for at least three days in known salt damp areas (clause 6.4.8)
- careful detailing of DPC in high salt damp areas (clause 5.3.4)
- damp proof membranes to be extended under the edge beam to ground level (clause 5.3.3.3)

It also provides an advisory note to use damp proof membranes in South Australia and areas prone to rising damp and salt attack (clause 5.3.2).

A new version of this Standard will be released in 2008. Within the durability section, the draft includes specific references to saline soils. These are based on the Cement, Concretes and Aggregates Australia 2005 publication 'Guide to Residential Slabs and Footings in Saline Environments'. Soil electrical conductivity measurements are used to determine the concrete strength, cover to reinforcing and curing requirements. Guidance is not given on how to take representative samples, how to manage different types of salts, or management of changes in salt levels over time.

This series of photos taken approximately seven years apart shows how salt levels and salinity indicators can change with time.

'AS 3600 Concrete Structures (2001)' also includes a detailed section on durability considerations. Concrete strength, cover over reinforcing and curing times are specified for several environmental classifications. The description of mild environments includes those where the concrete is in non aggressive soils or protected by a damp proof membrane. "Aggressive soils include permeable soils with a pH < 4.0, or with ground water containing more than 1 gram per litre of sulphate ions. Salt-rich soils in arid areas should be considered as exposure classification C." This Standard is also under review and one of the issues to be addressed is saline soils in order to provide more guidance to designers.

Some of the construction and product standards have provisions allowing modification based on experience with the product. It is therefore important that members of the design and construction industry become more aware of urban salinity processes, impacts and the long term fluctuating nature of the issue.

Traditionally salinity has been addressed by natural resource managers and primary producers. Information on the dynamic nature of salinity and widespread potential for occurrence, or the impact of urban land use is therefore not always widely available to the building or construction industry. While natural resource managers may not be aware of trends in the construction industry towards more salinity sensitive building materials and practices, or the difficulties in fully investigating deteriorating structures 5, 10, or 15 years post construction.