CRACKING IN BRICKWORK

This sheet constitutes a vital part of Archicentre's recommendations to you. Failure to observe the provisions of the warning sheet could lead to premature deterioration of the home.

If a crack appears overnight in your previously intact brick house, don't panic. It is not the first step in the total disintegration of the whole building.

Most cracks require cosmetic treatment only. The majority are not indications of grave structural damage. Remedies can be as simple as watering the garden a bit more or less, or just waiting for the season to change.

However it can be valuable, if only for peace of mind, to be able to recognise and evaluate the type of cracks. You will then have some logical basis for deciding which method of correction will be appropriate.

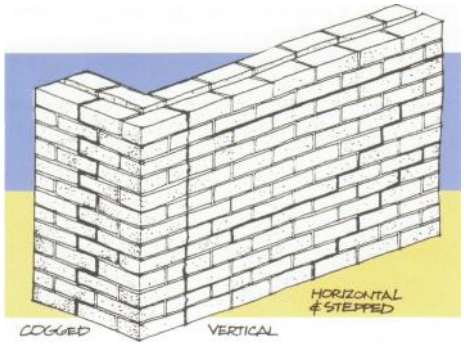
Unfortunately lack of knowledge can lead to the adoption of unnecessarily expensive treatments which may be suggested by firms or companies biased in favour of using their own patented and profitable 'cures'.

While cracking is most noticeable in solid brick or brick veneer buildings, timber and panel clad buildings are also affected by footing failure or differential foundation movement.

An independent assessment should be sought first from Archicentre's advisory service, a structural engineer, or a building consultant, prior to embarking on costly remedial action.

THE FORM IT TAKES

Cracking can be vertical, horizontal, cogged, stepped or a combination. The form it takes is sometimes a clear indication of the problem. For example, a diagonal crack starting at the corner of a door opening is sure to have been created by movement in the footings. It is also informative to watch what the crack does over various seasons.



FOOTINGS AND FOUNDATIONS

These terms are commonly confused. In this Technical Information Sheet, 'footings' refers to the structure below the floor level which rest on the soil. 'Foundations' are the soil (eg sand or clay) or rock material on which the footings rest.

What type of foundations is my house built on and can they move?

How much foundations move depends on the type of rock or soil and how that type is influenced by changes in moisture, temperature and imposed loads from the structure above.

The movement on the foundations is rarely uniform over the whole of the building site, or under the area of building and different movement under different parts of the footings creates stresses in the walls resulting in cracks.

Foundations are usually classified as either reactive or non-reactive to changes in their moisture content.

Reactive soils are typically clay soils, but also include the 'black soil' and 'black earth' found in Queensland, South Australia and Western New South Wales. All of these are plastic soils, shrinking and swelling rapidly as their moisture content decreases or increases.

Changes in the soil moisture content can cause deformation (a change in volume), particularly in modern houses with concrete slab floors. For example, reactive clays may swell and retain moisture when saturated, and shrink and collapse when water is removed from them by excessive evaporation during seasonal dry periods or periods of drought, or by the action of trees.

Non-reactive soils are such soils as rock, gravel, shale, phyllite or sand, whose volume does not increase or decrease with changes in the moisture content.

The Building or Engineers Department of your local Council, Shire or Building Authority should be able to provide information for you on the type of soil your house is built on. Your property may have had a geotechnical investigation as part of a building development permit submission. This information can be useful in determining the required remedial action, as cracking caused by drying out of normal reactive soils can often be simply remedied, whereas owners of houses built on very reactive soils or on filled land which has subsided permanently, may have to pursue more elaborate solutions such as underpinning.

Different types of soil move, but what causes them to move? What are the remedies?

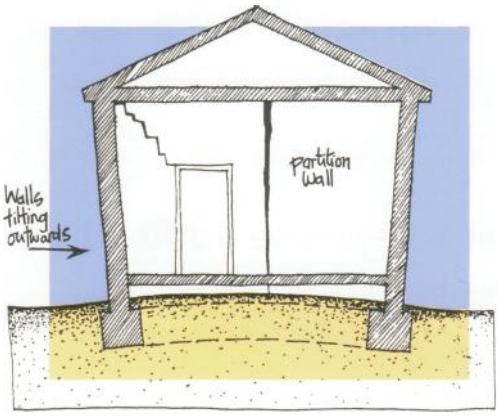
1. Moisture movement in reactive soils

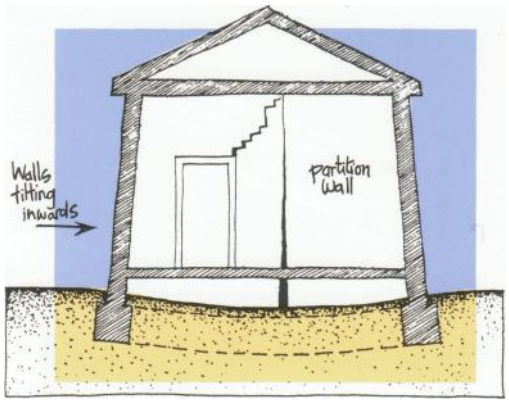
Experts suggest that changes in the water content of clay-type soils cause up to 90% of all cracking problems in houses. So what factors affect the water content in the soil?

(a) Migration of moisture

The movement of moisture beneath a building can produce the phenomenon known as long term dome and saucer effect.

The dome effect is a slow heaving of the soil caused by movement of moisture from the perimeter of the house to its centre, and the saucer effect is moisture moving in the opposite direction, from the centre towards the perimeter. Extended periods of severe drought are likely to result in perimeter drying and the doming effect, while rehydration once the drought has broken, or during periods of extreme and persistent wet, are likely to result in the reverse saucer effect. Unfortunately both actions may cause cracking.





The dome effect causes the walls to tilt outwards and the restraining influence of the roof produces horizontal cracks on the outside wall. These will be wider on the outside surface rather than the inner.

The long term saucer effect causes the external walls to tilt inwards and partition walls to sag. Cracking may be similar to that seen with the dome effect but the width of the cracks will be greater on the internal surface of the walls.

The most economical solution, and one which gives good results where damage is not too severe, is to improve the sub-floor ventilation so that the atmospheric conditions under the floor and those outside are not too different.

It is worthwhile understanding that while impermeable paths or paving around a home can mitigate seasonal drying and saturation, after the cessation of extended periods of either condition they can also slow down the soil's return to its 'normal' condition and reduce the benefits of supplementary perimeter

watering.

(b). Water extracted by trees and shrubs
The greatest damage occurs when trees are planted close to the building after construction.

Contrary to popular belief, it is rarely the growth or uplift of the tap roots of big trees which disturb the foundations. The damage is done by the plant roots extracting considerable quantities of moisture from the soil, which reduces the volume of the soil, causing footings to subside in that area and cracks in the masonry to appear.

This phenomenon is known as tree drying settlement. The way it works is the tree takes water from the soil by a system of fine hair-like roots. The moisture is then transported to the trunk of the tree via the main tap roots. The astonishing fact is that, depending on the type and age of the tree, this fine root system can extend over several hundred metres, and the amount of water transpired daily by a tree can be several hundred litres.

A more commonly accepted formula is that a tree's root system will extend for a horizontal distance equal to its height. In a line of trees, where competition for water exists, the horizontal root spread is one and half times the tree height.

Of course, if the water available in the soil is sufficient to meet the tree's transpiration rate, no damage will occur. But a dry season, even in a temperate zone, can alter this balance.

Extended drought periods can significantly increase any effect. It is important to note that during prolonged periods of drought, particularly when these coincide with water restrictions, the foundation material around buildings can be exposed to persistent drying and shrinkage which may further exacerbate the potential for cracking.

It is also important to remember that tree roots do not recognise a property's boundaries; trees on your neighbours' properties will seek out moisture from every possible direction, just as your trees' roots may trespass on your neighbours'. Successful remedial action may require the fostering of good neighbourly relations.

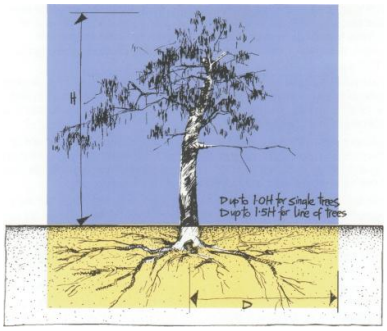
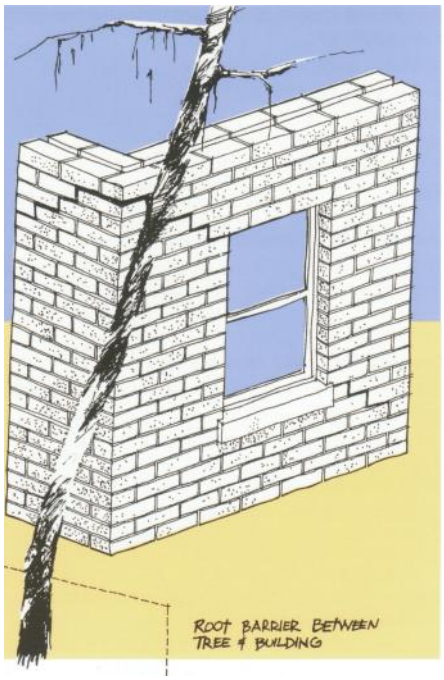


Diagram 3 on the next page shows the typical damage resulting from a large tree having been planted too close to the footings at a corner of a brick house – the tree has extracted the moisture from around and under the corner, resulting in subsidence. A tree root barrier would have restricted the spread of the roots and therefore the consequential water extraction form the soil under the footings.



Planting trees

When planning to plant trees, it is important to also consider the strength of the footings under the house. For example, an old brick house with stone footings on a clay foundation offers little resistance to drying settlement, whereas a well designed concrete slab may tolerate even a heavily planted garden. Knowing your building's footing type is important. As a rule of thumb, trees should be planted at a distance from the house equivalent to their mature height, although trees may be planted closer and culled as they grow as part of on-going garden maintenance.

Removing trees

Well established trees are an asset to most properties. It is important to understand their growth pattern, particularly when moving into a new home, this way through careful and informed tree management and watering routines, you may be able to avoid the need for outright removal.

It is also important to understand that by removing a large well established tree, you may also be significantly altering the ground conditions, as the moisture levels adjust and the ground settles over time around the void left by the now-removed tree and its decaying tree roots, which can in turn result in further cracking, or cracking in other parts of the property.

We recommend seeking expert advice before arranging for the removal of mature trees.

Appropriate tree selection

The following is a list of common trees and plants of which to be wary. The list is not meant to be totally comprehensive but can be taken as a general guide. Further information may be available from your local building authority or plant nursery.

(Note: Height of tree and spread of roots can vary dramatically from region to region depending on climate, soil type, rainfall, etc.

Common Name	Botanical Name	Mature Height (m)
African tulip tree	Spathodea campanulata	6-15
Athel tree	Tamaris aphylla	Up to 6
Bamboos	Phyllastachus species	variable
Black bean	Castanospermum australe	9-18
Black locust/ False acacia	Robinia pseudoacacia	9-15
Bougainvilleas	Bougainvillea species	variable
Brush box	Tristania conferta	10-40

Bunya	Araucaria species	30-60
Camphor laurel	Cinnamonum camphora	6-15
Cedars	Cedrus species	variable
Claret ash	Fraxinus "Raywood"	9-15
Coral trees	Erythrina species	Up to 24
Cypress	Cupressus species	variable
Date palms	Phoenix species	variable
Desert ash	Fraxinus oxycarpa	9-15
Elms	Ulmus species	Up to 30
English ash	Fraxinus excelsior	Up to 20
Figs	Ficus species	Up to 30
Flame tree	Brachychiton acerifolium	6-30
Gum tree (most species)	Eucalyptus species	Up to 60
Hackberry	Celtis species	Up to 24
Hollies	Ilex species	Up to 12
Hoop pine	Araucaria species	30-60
Jacaranda	Jacaranda mimosaepholia	5-12
Kanuka box	Tristaniopsis laurina	5-15
Magnolias	Magnolia species	variable
Mango	Mangifera indica	10-18
Norfolk Island Pine	Araucaria species	30-60
Oaks	Quercus species	Up to 20
Pampas grass	Cortaderia selloana	2.5-3.5
Pepper tree	Schinus molle	6-15
Pines	Pinus species	Up to 30
Planes	Platanus species	15-36
Poinciana	Delonix regia	variable
Poplars	Populus species	Up to 30
Privets	Ligustrum species	Up to 8
Pyramid tree	Lagunaria patersonia	6-12
Rhus trees	Rhus species	variable
Sheoaks	Casuarina species	12-30
Smooth barked apple	Angophora costata	15-24
Southern silky oak	Grevillea robusta	15-30
Swamp cypress	Taxodium distichum	Up to 30
Tipuana	Tipuana tipu	10-20
Umbrella tree	Schefflera actinophylla	Up to 8
Willows	Salix Species	9-15

(c) Damage caused by solar radiation

While drying out of soil by trees is one of the most common reasons for cracking in brickwork, some clays are also very susceptible to drying out by direct solar radiation, ie, the sun on the ground.

The northern facing wall is the most likely to be affected and stepped diagonal cracking is the most common symptom, usually occurring at the north east and north west corner of the building.

Again underpinning should be considered only as a last resort and more simple remedies tried first.

Some remedies

Now the good news: if you take moisture out of clay soils, you can put it back.

Mulching of garden beds around the house will cut down loss of moisture by solar radiation and evaporation. Another measure is to provide an impermeable ground cover around the house together with a vertical impermeable barrier or border which should preferably be taken down to a depth where the moisture content of the soil is constant, approximately 300mm to 600mm.

In one case seen by Archicentre, a row of large trees within 3 metres of a house had, during a prolonged dry spell, caused substantial cracking and distortion of the wall nearest to them. The trees were removed and the area flooded with water. Within two months the clay soil had absorbed the water and heaved

some 35mm to the original position, closing nearly all the gaps completely.

So, if some cracks appear in your house for the first time during a dry season, the best thing is to water the soil close to the building and do nothing more. Wait until after the next wet season and see if they close up by themselves. Try and keep the soil near any large trees constantly moist and don't be tempted to fill the cracks with anything rigid, which will prevent them closing naturally, as more cracking could develop in response elsewhere.

If cracks are more serious, for example large enough to insert one or more fingers, the tree, shrub or root system responsible for the damage should be removed. Pruning is of short term value only. Local flooding of the area will accelerate the heave recovery of the foundations.

Alternatives to cutting down the trees are root barriers made from concrete or other impermeable materials, such as fibre cement sheet wrapped in plastic, inserted between the tree and the affected footing, to a depth greater than the surface root system of the appropriate tree.

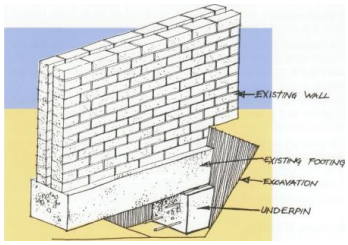
Another remedial system aimed at retaining the trees, is to drill holes into the soil with an auger approximately 1.5m deep and close to the wall which has subsided and cracked. Water is then poured into these holes and kept topped up to a constant level to introduce moisture back to the soil. Copper sulphate or other root suppressant chemicals are added to the water to repel the approach of the tree's roots.

In conjunction with this, holes are drilled into the soil on the side of the tree away from the house. These holes are then filled with water and nutrients which will attract tree roots in their general direction.

This system does require maintenance in keeping the holes filled with water (although this could be accomplished with an automatic irrigation system) and replenishing supplies of repellent chemicals and nutrients.

Finally, we come to the remedy known as underpinning, an expensive operation and only to be undertaken if all else fails. Underpinning can mean two things, depending on where the failure has occurred: first, the removal of soil below an existing footing and its replacement with (usually) concrete, and the second, if the footing sub-wall (the section of wall below floor level) is badly damaged, is the removal of the lower defective part of the wall and its replacement with new masonry.

Although underpinning is not a complicated operation, it is slow and awkward and must be done properly to be effective. The new footing system must be designed properly to start with, if future problems are to be avoided. It would be wise to ask to see the Engineer's drawings of any proposal.



It would also be wise to obtain several quotations from firms specialising in underpinning. Ask to see successfully completed jobs and make sure a guarantee will be forthcoming. It is essential that a building permit from a building surveyor be obtained for any underpinning work.

2. Uneven settlement of foundations

Where a particularly heavy load is placed on the foundation such as a large column, movement may occur as moisture is squeezed out of the soil or the soil readjusts itself. This consolidation will stop when the soil has finally compacted enough to support the load.

Cracks which may result from movement during compaction can be measured to see if and when the movement has ceased.

Then a decision can be made as to whether the cracks may simply be patched up or if the size of the existing footing needs to be increased to support the load i.e. underpinnning.

3. Sliding surface layers

Overloading can also cause shear failure in the soil. The soil can slip in a downward, sidewards and

upward movement allowing the footings to settle as a result.

A typical example may be caused by an excavation on an adjacent site to a greater depth than the footing, thus robbing it of lateral support and causing it to tilt towards the hole.

Flooding or diversion of natural drainage channels beneath the footing can produce shear failure as some soils, especially clay, lose cohesion when too much water is added to them.

The cracks occurring will more often be vertical than diagonal.

The movement can not only cause damage to service pipes and drains, but damaged pipes and drains may exacerbate the situation, resulting in greater building and service network damage. The in-ground service pipes should be carefully checked for damage. This check should also cover existing drains, down pipes and gutters. Rectifying the source of the failure is important before rectifying building cracks.

4. Building on variable foundations

Finding part-rock, part-shale, or part-clay on a flat site is possible but more probable on a sloping site where part of the slope has been cut into and the material cut out has been used as fill to extend the horizontal surface for the house.

The fill can compress more readily than in-situ material and uneven settlement can 'bend' the house at the point where the two materials meet. The resulting cracks will be vertical, wider at the top than at the bottom.

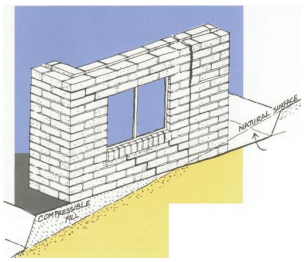
The remedy may have to be underpinning or some comparable method to spread the load more evenly.

Houses built on fill only will be subject to settlement which will frequently be uneven. If the fill is loose, but not uniformly so over the site, the cracking may be extensive and unpredictable.

Loose but uniform fill can produce either stepped or vertical cracks.

Pier and beam footings can be used to underpin the building or, if the fill is reasonably compact, widening existing strip footings may be sufficient.

Either solution requires design by an engineer and implementation by a reputable underpinning contractor.

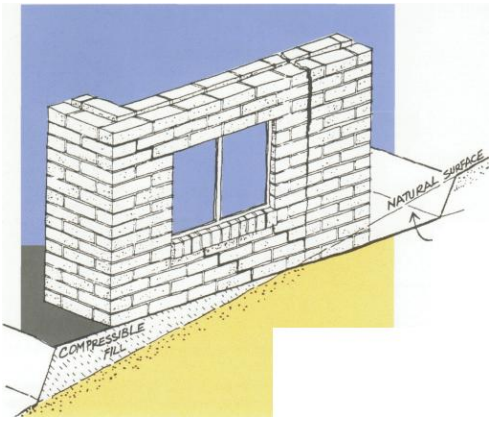


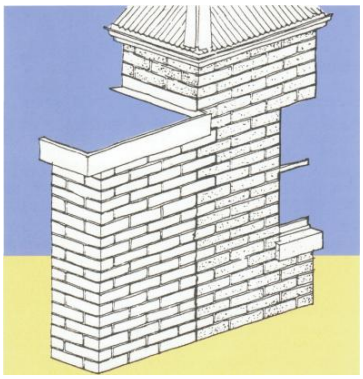
5. Additions to buildings

Building an addition onto a house can impose a load intensity on the soil different to that which was there prior to the building works and so cause differential settlement. Even if the loading intensities are similar, the difference in time between when the two settlements occurred can be enough to create cracks.

This may typically result in vertical or cogged cracking occurring near where the new work keys into the old. Cracking between old and new sections can also occur as the new framing timbers naturally shrink and settle during their first few years in service. It is therefore often difficult to conclusively identify the cause of some types of cracking.

Monitoring and measuring the crack to assess when the new settlement is complete and then patching the crack is probably the best method. Again underpinning the new work should only be contemplated in an extreme case.





6. Excessive vibration

Damage caused by vibration from earth tremors, heavy traffic or pile driving is fairly rare, however if the vibration is great enough to actually cause the foundation to move, cracking can occur. In this case a rock foundation is not the best as it can easily transmit vibrations to the building.

The cracks show up irregularly and if the source of the vibration can't be removed, a possible remedy is the installation of anti-vibration mats beneath the footings – this is difficult to fit retrospectively but is something to consider if building near a known source of constant vibration. If the source of the vibration is some machine operated within the building, these mats could be placed between the machine and the floor.

7. Other causes of cracking

All the above information relates to cracking associated with movement of the foundations caused in the most part by drying out of the soil, or the changes due to imposed building load.

Statistics compiled by Archicentre show that cracking from other causes is relatively rare, but can occur when various elements of the building itself move, for example; movement of steel frames with brick infill panels or the shrinking of concrete elements. Cracking can also be due to the expansion or shrinkage of the clay brickwork itself.

A word of warning at this point about organisations which offer cure-alls for cracking: Archicentre has found that some of these firms exaggerate the dangers involved with some small cracks and recommend expensive patent treatments or unnecessary underpinning where the cracks might simply respond to a bit of water added to the soil.

Remember that a company offering a particular treatment will probably be biased in favour of using it regardless.

A non-involved, independent, experienced professional such as a structural engineer or architect should be consulted first. They won't be inclined to overlook the more humble remedies, while recommending further professional investigation where appropriate.

SOME GENERAL MAINTENANCE TIPS

- Don't plant trees or allow them to exist closer to the house than their expected mature height, unless their roots are discouraged or contained in some way, as in the systems described.
- Keep the garden and lawns around the house evenly damp throughout the drier months. Don't neglect one side of the house just because nothing much grows in the area.
- Regularly check existing drains, down-pipes, guttering and service piping to ensure no leakages occur over the life of the building.
- If you think your house needs underpinning or other building work carried out, make sure you first have an independent assessment undertaken by an architect or engineer. Archicentre can help you here with an inspection and recommendation. Underpinning works will require engineering computations and design and an associated geotechnical (soil) test report. You should then obtain at least three quotations based on a professionally documented scope of works and specification, and make sure you have a firm written contract with the company and appropriate permits if required.

If you would like to talk to an Archicentre building, design or inspection expert about a particular matter please call Archicentre on **1300 134 513** or go to **www.archicentre.com.au.**