Cracking Report

CLIENT: CTS 42236

C/- Ace Body Corporate Management
(Brisbane South West & Ipswich)

PROPERTY: “Mayfair Estate”
35 Clarence Street, Calamvale QLD

OUR REFERENCE NUMBER: 24108

24 November, 2016
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Introduction

Property

Location: The property is located at 35 Clarence Street, Calamvale QLD
Description: Multiple two-storey residential apartment buildings

Report Request

A report was requested by the Body Corporate Manager, Mr John Adams of Ace Body Corporate Management (South West & Ipswich), for and on behalf of the Body Corporate.

Inspection Details

Date: 27 October, 2016
Purpose: To investigate and report on cracking to the driveway and building
Inspected By: Mr Terry O'Donoghue

Reviewed By: _____________________ Date: 24 / 11 / 2016

Mr Terry O'Donoghue
MTech (Civil), BE (Chem), Grad Dip FSE, Grad Dip BS, MIE (Aust), MAIBS, EC 42168, DB-M 38239
Preamble

The Body Corporate Manager has received advice that cracking has developed to Units 36 – 40 and in the driveway at the property.

Buildcheck has been engaged to determine the cause of cracking and advise on methods of rectification.

Property Description

The property comprises a two stage development of two-storey residential buildings approximately 5-6 years old as depicted in Figure 1 below.

A concrete driveway provides access to the various apartments.

A large treed reserve is located directly behind units to the west.
Summary

Building Cracking

Significant building cracking is occurring to Units 36 – 40 with buildings “opening” at masonry control joints and cracking to the front façade at garages.

Cracking is most likely caused by slippage in retaining walls directly behind the building and/or by inadequate footings combined with settlement. Construction drawings and soil tests would be required to assess the suitability of footings and retaining walls.

Irrespective of the cause, underpinning is required across the back of Units 36 – 40.

Driveway

Cracking has occurred to some sections of the driveway.

The driveway remains generally serviceable, however earlier than expected degradation and repair is required to approximately 250 sq.m, predominantly to pavement to the north which runs east west (refer Fig. 2, p.18).

Cracking is caused by incorrect placement of steel in the depth of the pavement and at corners abutting storm pits.

Various areas of pavement misalignment in height were pointed out, however I consider the heights satisfactory as the pavement has been graded to drains and to match footpath heights leading to unit entries.

Liability

As the building is 5-6 years old, Solicitors or QBCC could be consulted to assess builder liability.
1. **Building Movement**

1.1 **Condition – Units 36 - 40**

Front elevation of Units 36 – 40.

Typical construction is masonry ground floor with lightweight first floor.

Typical cracking at garage columns and in entry doors on front elevation.

Cracking opens at the top, with the bottom unaffected. The building frame appears to be moving laterally to the rear.

Typical control joint.

Cracking to Units 36 - 40 indicates the buildings are settling to the rear as control joints have opened at the top and not the bottom.
1. **Building Movement (Cont’d)**

1.1 **Condition – Units 36 – 40 (Cont’d)**

Top of control joints have opened 20mm.

![Photo 4](image1)

Further typical cracking at control joints – Units 36 – 40.

![Photo 5](image2)

Retaining walls approximately 2 metres deep are located directly behind Units 36 – 40.

![Photo 6](image3)
1. Building Movement (Cont’d)

1.2 Opinion

The cracks in the building at control joints are most likely caused by foundation settlement and/or movement in the retaining walls, which is the result of inadequate footing or fence design / construction or changes to soil moisture content.

1.2.1 Footings

The Australian Standard for Residential Slabs & Footings AS 2870 defines the requirements for footings, based on the soil properties and the type of construction. Generally a footing founded in Class M soil would be 800mm x 400mm. The depth of footing is critical and is determined by soil testing. As the retaining walls are very close to the building, we would expect the footing depth to be deeper than soil in the adjacent reserve.

Undertaking a soil test and footing inspection will determine whether or not the footings were adequately designed.

1.2.2 Soil Moisture Content

Changes in sub-soil moisture content can cause alternate swelling and shrinkage of foundation soils, with resultant footing movement. Footings may rise, settle or rotate. In extreme cases, footings may sink into over wetted soils. With a large retaining wall to the rear, soil wash out could be occurring.

Sub-soil moisture changes can be caused by:

1. Unnatural drainage of the sub-soil
2. Trees seeking moisture for growth
1. Building Movement (Cont’d)

1.2 Opinion (Cont’d)

1.2.3 Unnatural Drainage

Unnatural drainage of the sub-soil can result from the interference of natural drainage patterns by nearby drains or sewers.

Blocked drains could cause soil to wash out beneath the rear retaining walls.

As downpipes are located on each building near the area of movement, we recommend undertaking CCTV testing of all stormwater and sewer pipes.

1.2.4 Tree Roots

The effect of trees on soil moisture content has been well documented in the attached C.S.I.R.O. publication. Considering the close proximity of the trees, it is possible that the trees have contributed to the soil drying without resultant retaining wall movement.

Typically trees should be located in accordance with the diagram below, which is an extract from The Guide to Residential Floors published by Cement Concrete & Aggregates Australia.

![Diagram](image)

**Figure 4.8 Suggested garden plan for a reactive site**

To negate the impact of reserve trees (if any), footings should be deeply founded.
1. **Building Movement (Cont’d)**

1.2 **Opinion (Cont’d)**

1.2.5 **Cracking Severity**

The pattern of the cracks at this property indicates that the footings are sliding to the rear or sinking.

The largest of the cracks in the building were measured to be between 15mm to 20mm, placing it in the “severe” category in accordance with Table C1 of AS 2870, “Residential Slabs & Footings.”

### TABLE C1
CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

<table>
<thead>
<tr>
<th>Description of typical damage and required repair</th>
<th>Approximate crack width limit (see Note 1)</th>
<th>Damage Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hairline cracks</td>
<td>&lt;0.1 mm</td>
<td>0 Negligible</td>
</tr>
<tr>
<td>Fine cracks that do not need repair</td>
<td>&lt;1 mm</td>
<td>1 Very slight</td>
</tr>
<tr>
<td>Cracks noticeable but easily filled. Doors and windows stick slightly</td>
<td>&lt;5 mm</td>
<td>2 Slight</td>
</tr>
<tr>
<td>Cracks can be repaired and possibly a small amount of wall will need to be replaced. Weather tightness often impaired.</td>
<td>5 mm to 15 mm (of a number of cracks 3 mm or more in group)</td>
<td>3 Moderate</td>
</tr>
<tr>
<td>Extensive repair work involving breaking out and replacing sections of walls, especially over doors and windows. Window frames and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted.</td>
<td>15 mm to 25 mm but also depends on number of cracks</td>
<td>4 Severe</td>
</tr>
</tbody>
</table>

Underpinning (piles) is required to stabilise movement.
1. Building Movement (Cont’d)

1.2 Opinion (Cont’d)

1.2.6 Conclusion

The rear of the building is settling, causing the building to open at control joints and “pull” the frame away from columns at the front of the building.

Settlement (in order of likelihood) could occur due to:

- Poorly designed footings – not deep enough.
- Poorly designed retaining walls – walls moving slightly.
- Soil wash out beneath retaining walls.
- Settlement due to soil drying.

Irrespective of the cause, due to the size of the movement, underpinning is required along with assessment of the stormwater and sewer to test for blockage or leakage.
1. **Building Movement (Cont’d)**

1.3 **Options**

There are several options available to rectify the settlement.

1.3.1 **Tree Removal or Isolation**

Isolation or removal of reserve trees will prevent the withdrawal of sub-soil moisture, however as a protected reserve this is not possible.

**Not recommended**

1.3.2 **Soil Testing**

Soil testing will determine the condition of founding soils and will identify any subsurface problems, (e.g. leaking pipes, excessive fill) which may be present and cannot be identified by visual inspection.

Soil test results are required prior to any underpinning works. Tests also include an examination of the foundations to assess the size compared with current requirements.

**Recommended**

1.3.3 **Soil Stabilisation**

Under some conditions, soil injection of proprietary products can both stabilise soils and lift the affected areas. Further discussion with specialist contractors may be useful to assess the applicability of these products.

This could be considered as a remedial option by trialling at one unit. Stabilisation is cheaper than pile underpinning, however it may not be applicable adjacent a retaining wall which might move under applied pressure.
1. Building Movement (Cont’d)

1.3 Options (Cont’d)

1.3.4 Underpinning

The wall should be underpinned if Option 1.3.3 is not viable. This involves pouring mass concrete under the footings, after excavating to a depth where the soil is unaffected by seasonal and tree affected moisture changes or inserting screw piles to 5-6 metres. The footings are then jacked back into their original position, after which patching can be done. Even with the installation of control joints between the firmly founded underpinned areas, and the other areas, some movement and cracking in other areas of the building can occur.

We note that access for machinery may be a problem unless fences are removed.

Underpinning or stabilisation required

1.3.5 Drainage Improvements

Repair / replacement of all defective drainage ensures the founding soils are not affected by excessive moisture.

The installation of PVC inspection openings at ground entry points of the stormwater drainage system can allow for regular flushing of pipework.

A survey of existing stormwater / sewer pipework will identify defective pipework and possible tree root infiltration to ensure founding soils are not affected by moisture variation.

Recommended
1. Building Movement (Cont’d)

1.4 Recommendations

We recommend the following action in order of priority:

- Undertake a soil test to assess the footings and the condition of the soil.
- Undertake CCTV testing of all storm and sewer. Repair defective pipes.
- Assess soil modification – Uretek.
- Alternatively underpin.
1. **Building Movement (Cont’d)**

1.5 **Costings**

Buildcheck can assist with preparing scopes, tendering and project management of the works. Expected costs are:

<table>
<thead>
<tr>
<th>Expected Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Soil test</td>
</tr>
<tr>
<td>2. CCTV testing scope and quotes</td>
</tr>
<tr>
<td>3. CCTV testing</td>
</tr>
<tr>
<td>4. Letter of Advice following testing</td>
</tr>
<tr>
<td>5. Scope of Works for underpinning</td>
</tr>
<tr>
<td>6. Engineering design for underpinning/Uretek</td>
</tr>
<tr>
<td>7. Estimated cost of underpinning works</td>
</tr>
<tr>
<td>8. Contracts</td>
</tr>
<tr>
<td>9. Project Management</td>
</tr>
</tbody>
</table>

Additional internal and grounds repair costs are likely.
2. Pavement Cracking

2.1 Condition

Pavement sections have a decorative colour etched in the concrete to replicate pavers.

Segments of pavement are separated by control joints with backing foam and sealant as required. In some instances sealant is missing.

Control joints have been installed approx. every 4-6 metres, slightly in excess of recommendations.

Typical 1-2mm cracking starting where pavement abuts the structure. This is generally caused by misplacement of re-entrant steel bars at building corners.

Typical cracking at storm pit due to poorly placed or absent re-entrant steel bars.

Surface is spalling and replacement is required.

Note control joints and saw cuts to pavement to control cracking, as required.
2. Pavement Cracking (Cont’d)

2.1 Condition (Cont’d)

Further examples of cracking and spalling requiring replacement.

![Photo 10](image1)

Further examples of cracking and spalling requiring replacement.

![Photo 11](image2)

Further examples of cracking and spalling requiring replacement.

![Photo 12](image3)
2. Pavement Cracking (Cont’d)

2.2 Opinion

It is our opinion that the concrete driveway cracking has been caused by:

- Incorrect placement of re-entrant steel bars at obstructions.
- Poor placement of steel mesh used to prevent cracking.
- Control joints placed too far apart.


Design requirements in the CCAA guide, to provide adequate performance and prevent concrete cracking include:

1. Drainage

   Appropriate drainage and falls are required to ensure there is no ponding exceeding 10mm on the surface, 15 minutes after the cessation of rain.

   It is apparent that a suitable drainage system has been installed beneath the drive with correct falls.

2. Concrete Strength

   Residential driveways require Normal class concrete strength or N20 Mpa.

   While we did not have concrete testing equipment on site, the appearance and condition of the concrete would indicate that the concrete strength is at least 20mpa.

   If required, testing can be carried out.
2. Pavement Cracking (Cont’d)

2.2 Opinion (Cont’d)

3. Concrete Thickness

The required concrete thickness is 75mm for pedestrian paths, 100 mm for cars up to 3 tonne and 150mm for vehicles between 3 & 10 tonne.

Measurements show the pavement to be at least 100mm thick.

4. Reinforcement

Steel reinforcement or mesh is installed in a pavement to prevent cracking during curing. It does not affect the strength or thickness of the pavement. SL 62 is required to be placed in 100 mm thick pavements where joints are installed in excess of 3m.

In this case, the panel joints vary from 3 to 6 metres which would account for some cracking.

Reinforcement must be installed approximately 30mm beneath the top surface of the concrete to be effective in controlling cracks which naturally form as concrete cures. Cracking due to this cause is generally minor and concrete remains serviceable.

Steel is also required to be placed wherever the slab abuts a structure, ie. storm pit or column. Most cracking observed is due to a lack of or poorly placed, re-entrant steel bars.

As cracking generally occurs in the first 1-5 years, further cracking from shrinkage is not likely. However, areas noted as needing replacement will degrade through vehicle usage.
2. Pavement Cracking (Cont’d)

2.3 Recommendations

We recommend the following action:

- Replace broad segments of concrete (repairing sub-base as required), as shown below in Figure 2.

Figure 2
2. Pavement Cracking (Cont’d)

2.4 Costings

Buildcheck can assist with preparing scopes, tendering and project management of the works.

Expected costs are:

<table>
<thead>
<tr>
<th>Expected Cost</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$2,200</td>
<td>1. Pavement Design</td>
</tr>
<tr>
<td>$1,100</td>
<td>2. Soil Test</td>
</tr>
<tr>
<td>$1,700</td>
<td>3. Scope, Tender, Review and Report</td>
</tr>
<tr>
<td></td>
<td>For Concrete Replacement</td>
</tr>
<tr>
<td>$1,100</td>
<td>4. Contract Preparation</td>
</tr>
<tr>
<td></td>
<td>Based on 6% of the Contact Works</td>
</tr>
</tbody>
</table>

Likely project costs are $30,000.
APPENDIX A

C.S.I.R.O. Publication

“Mayfair Estate”
35 Clarence Street, Calamvale QLD
Foundation Maintenance and Footing Performance: A Homeowner’s Guide

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types
The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870-2011, the Residential Slab and footing Code.

Causes of Movement
Settlement due to construction
There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil’s lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion
All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation
This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume, particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil
All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure
This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.

In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

<table>
<thead>
<tr>
<th>Class</th>
<th>Foundation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Most sand and rock sites with little or no ground movement from moisture changes</td>
</tr>
<tr>
<td>S</td>
<td>Slightly reactive clay sites, which may experience only slight ground movement from moisture changes</td>
</tr>
<tr>
<td>M</td>
<td>Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes</td>
</tr>
<tr>
<td>H1</td>
<td>Highly reactive clay sites, which may experience high ground movement from moisture changes</td>
</tr>
<tr>
<td>H2</td>
<td>Highly reactive clay sites, which may experience very high ground movement from moisture changes</td>
</tr>
<tr>
<td>E</td>
<td>Extremely reactive sites, which may experience extreme ground movement from moisture changes</td>
</tr>
</tbody>
</table>

Notes
1. Where controlled fill has been used, the site may be classified A to E according to the type of fill used.
2. Filled sites. Class F is used for sites which include soft fills, such as clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soil subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise.
3. Where deep-seated moisture changes exist on sites at depths of 3 m or greater, further classification is needed for Classes M to E (M-D, H1-D, H2-D and E-D).
Tree root growth
Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:
• Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
• Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement
The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:
• Differing compaction of foundation soil prior to construction.
• Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may cause local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun’s heat is greatest.

Effects of Uneven Soil Movement on Structures
Erosion and saturation
Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by the removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:
• Step cracking in the mortar beds in the body of the wall or above below openings such as doors or windows.
• Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with a minor cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun’s effect is strongest. This has the effect of lowering the external footings. The doming isaccentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots
In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself
Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures
Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely stabilised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swelling/shrinkage effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.
The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

**Effects on framed structures**

Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the deforming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation causes a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

**Effects on brick veneer structures**

Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

**Water Service and Drainage**

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interrera strata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem. Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil.

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.

- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

**Seriousness of Cracking**

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870-2011. AS 2870-2011 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

**Prevention/Cure**

**Plumbing**

Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

**Ground drainage**

In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grained drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

**Protection of the building perimeter**

It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems. For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving should

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**CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS**

<table>
<thead>
<tr>
<th>Description of typical damage and required repair</th>
<th>Approximate crack width limit (see Note 3)</th>
<th>Damage category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hairline cracks</td>
<td>&lt;0.1 mm</td>
<td>0</td>
</tr>
<tr>
<td>Fine cracks which do not need repair</td>
<td>&lt;1 mm</td>
<td>1</td>
</tr>
<tr>
<td>Cracks noticeable but easily filled. Doors and windows stick slightly.</td>
<td>&lt;5 mm</td>
<td>2</td>
</tr>
<tr>
<td>Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weather tightness often impaired.</td>
<td>5–15 mm (or a number of cracks 3 mm or more in one group)</td>
<td>3</td>
</tr>
<tr>
<td>Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted.</td>
<td>15–25 mm but also depends on number of cracks</td>
<td>4</td>
</tr>
</tbody>
</table>
extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove caps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation
In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

**Warning:** Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

**The garden**
The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

**Existing trees**
Where a tree is causing a problem of soil drying or there is the existence of threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

**Information on trees, plants and shrubs**
State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

**Excavation**
Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

**Remediation**
Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and footings is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

**This BTF was prepared by John Lever FAIB, MIAMA, Partner, Construction Diagnosis.**

*The information in this and other issues in the series was derived from various sources and was believed to be correct when published. The information is advisory. It is provided in good faith and not claimed to be an exhaustive treatment of the relevant subject. Further professional advice needs to be obtained before taking any action based on the information provided.*
APPENDIX B

Conditions of Engagement

“Mayfair Estate”
35 Clarence Street, Calamvale QLD
CONDITIONS OF ENGAGEMENT

1. This report is provided solely for the use of the client named on the face of this report, and no responsibility to other persons is accepted.

2. This report describes the condition of the property at the time of inspection, detailing visible defects within the scope of the client brief.

3. This report does not include:
   (a) defects in inaccessible parts of the property
   (b) defects not apparent on visual inspection
   (c) defects apparent only in different weather or environmental conditions

4. No special investigation of insect attack (e.g. borer, termite etc.) or soil contamination has been made, and any reference to this has been based on a casual visual inspection.

5. Unless otherwise specified:
   (a) no soil, etc. has been excavated
   (b) no plants or trees have been removed
   (c) no fixtures, fittings, cladding or lining materials have been removed
   (d) no items of furniture or chattels have been moved
   (e) no inquiries to Councils or other Authorities or persons have been made

for the purposes of inspecting the property and providing this report.