## 1. BRICK PROPERTIES

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Brickworks Building Products is one of Australia’s largest and most diverse building material manufacturers. Under the Brickworks Building Products umbrella are some of Australia’s best known building materials brands including Austral Bricks, Bowral Bricks, Daniel Robertson and Nubrik. With manufacturing and sales facilities across Australia, Brickworks Building Products is uniquely placed to service the demands of the building industry.

The technical information in this manual is aimed to provide guidance on the properties of bricks and on the selection of bricks for specific applications. Brickworks Building Products manufactures all products to Australian Standard AS/NZS 4455 (Masonry units and segmental pavers), unless otherwise specified in the technical data sheet made available for each product. Australian Standard AS/NZS 4456 (Masonry units and segmental pavers - methods of test) outlines the test methods required for the determination of the brick properties discussed.

General information about bricklaying practices has also been provided to briefly explain some aspects of masonry construction.

The following sources are available for more detailed information:

Think Brick Australia
Australian Standards relevant to masonry
The Building Code of Australia

DISCLAIMER
All information contained in this publication was believed to be correct at the time of collation. Brickworks Building Products takes no responsibility for any errors or omissions. Users of this document are advised to make their own decision as to the suitability of this information for their situation.
1.1 Defining Masonry Units

According to AS/NZS 4455.1 Part 1, masonry units are defined in the following manner:

Table 1 – Graphical representation and physical guidelines for masonry unit descriptions

<table>
<thead>
<tr>
<th>Type of Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Solid unit</td>
<td>A unit that contains recesses no greater than 10% of its gross volume and is intended to be laid with full bed joints</td>
</tr>
<tr>
<td>b) Cored unit</td>
<td>A unit with cores, intended to be laid with its cores vertical and with full bed joints</td>
</tr>
<tr>
<td>c) Hollow unit</td>
<td>A unit with a void percentage higher than 70%, intended to be laid with its cores vertical and with face-shell-bedded joints and with face-shell-bedded joints</td>
</tr>
<tr>
<td>d) Horizontally cored unit</td>
<td>A unit with cores, intended to be laid with its cores horizontal and with full bed joints</td>
</tr>
<tr>
<td>e) Special purpose unit</td>
<td>A unit that does not fall within the parameters of the above</td>
</tr>
</tbody>
</table>

For further information, see section 1.4.12 of the standard.
1.2 Brick Dimensions

1.2.1 Dimensional Category

The dimensions of the brick are determined and classified through the cumulative measurement of 20 units in accordance with AS/NZS 4456.3. Then depending on their deviation from the declared work size and the method by which compliance to a specification is determined, masonry units are divided into five categories: DW0, DW1, DW2, DW3 and DW4, where DW stands for dimensional deviations for walling units. The relevant tolerances for each of these categories are shown in Table 1.

![Figure 1 – Measuring cumulative dimensions](image)

Table 2 – Dimensional deviations of masonry units, categories and definitions in accordance with AS/NZS 4456.3 (Sourced from Think Brick Australia Industry Reference Guide 5th Edition).

<table>
<thead>
<tr>
<th>Category</th>
<th>Work size dimensions (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Under 150mm (for example, width and height)</td>
</tr>
<tr>
<td>DW0</td>
<td>No requirement</td>
</tr>
<tr>
<td>DW1</td>
<td>± 50</td>
</tr>
<tr>
<td>DW2</td>
<td>± 40</td>
</tr>
<tr>
<td>DW3</td>
<td>By agreement between supplier and purchaser</td>
</tr>
<tr>
<td>DW4</td>
<td>Standard deviation of not more than 2mm and the difference between the mean and the work size of not more than 3mm</td>
</tr>
</tbody>
</table>

Note: DW4 can only be determined from the individual dimensions of 20 units (Method B of AS/NZS 4456.3)
1.3 Brick Strength

Characteristic unconfined compressive strength ($f'_{uc}$)

The $f'_{uc}$ values are determined using the test method detailed in AS/NZS 4456.4 and is expressed in MPa (Mega Pascal). The test method involves subjecting the masonry unit to increasing load by compressing it between two metal platens in a compression testing machine.

It is impractical to test every unit in a consignment, and usually a very small number of samples in relation to the large number of units it represents, are tested. For these reasons, the standard is based on the 95% characteristic value at a 75% confidence level. This means that there is a 75% certainty that the strength of 95% of the units in the lot is higher than the characteristic strength determined from testing the samples.

An aspect ratio (height-to-thickness ratio) factor is also incorporated to compensate for the frictional effects experienced between the unit and the platens which prevents the sideways spread of the unit as shown in figure 2. allows the results to be converted to an equivalent unconfined compressive strength value ($f'_{uc}$) independent of the dimensions of the unit. This strength value allows direct comparison of all masonry units, regardless of the size.

The characteristic unconfined compressive strength ($f'_{uc}$) values now supplied for a traditional sized brick are approximately 60% of the previously used characteristic confined compressive strength values. It is important to note that this difference is due to the altered approach used when determining the values and not a reduction in strength.

Refer to section 3 of Think Brick Australia Manual 2: The Properties of Clay Masonry Units for further information on compressive strength measurements.
1.4 Durability

Salt Attack

The durability of a brick is a measure of its resistance to attack by soluble salts. The test method used to determine the durability of bricks is given in AS/NZS 4456.10. The suitability of the units for use in a given environment determines their salt attack resistance category. The National Construction Code (NCC) defines the environment with three exposure classifications for brick:

1. Exposure Grade (EXP)
   Suitable for use in external walls exposed to aggressive environments, such as:
   - in areas where walls are subjected to salts in the soil, adjacent material or ground water,
   - in coastal areas where walls are exposed to attack from windborne salt spray, or
   - retaining walls that may be subjected to fertilisers and ground salts.
   In environments where exposure grade masonry is necessary, the minimum mortar classification required is M4 (refer to the section on mortar). In addition, exposure grade bricks may not be suitable for use in areas subject to cyclic freezing and thawing. For more information on the suitability of products contact Austral’s Technical Department.

2. General Purpose (GP)
   Suitable for use in an external wall under ordinary exposure conditions.

3. Protected (PRO)
   Suitable for use in internal and external walls only when above a sheet or membrane damp-proof course and protected by an adequate coping, eaves, roof or similar top covering. These units should not be directly exposed to saline environments.
   The ability of a unit to resist salt attack may be categorised either by past experience of the product demonstrating resistance to a saline or severe marine environment, or by testing in accordance with AS/NZS 4456.10.
   - Exposure Grade is survival of 40 cycles
   - General Purpose is survival of 15-40 cycles
   - Protected is less than 15 cycles of the immersion test in sodium chloride and/or sodium sulphate, as described in AS/NZS 4456.10.

Durability Required

The severity of the environmental conditions, such as the amount of moisture and the availability of soluble salts, determines the durability grade required. The NCC states that masonry units must be classified and used in the exposure conditions appropriate to their classification. Australian Standard AS 3700 provides details of these classifications. The durability requirements set out in AS 3700 are summarised in the following table:

Table 3 – Exposure Classifications

<table>
<thead>
<tr>
<th>Exposure Classification</th>
<th>Minimum Salt Attack Resistance Grade of Masonry Units</th>
<th>Minimum Mortar Classification</th>
<th>Minimum Durability Classification of Built-in Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe Marine Environment (EXP)</td>
<td>Exposure</td>
<td>M4</td>
<td>R4</td>
</tr>
<tr>
<td>Marine Environment (GP)</td>
<td>General Purpose</td>
<td>M3</td>
<td>R3</td>
</tr>
<tr>
<td>Below Damp Proof Course in Aggressive Soils (EXP)</td>
<td>Exposure</td>
<td>M4</td>
<td>R4</td>
</tr>
</tbody>
</table>

AS 3700 classifies a marine environment as:
- 1km to 10km from a surf coast, or
- 100m to 1km from a non-surf coast.

AS 3700 classifies a severe marine environment as:
- within 1km of a surf coast, or
- within 100m of a non-surf coast.

It is important to take into consideration the given environment during the design and construction of brickwork buildings, to minimise the potential for salt attack. The most suitable mortar joints for aggressive environments are ironed or weather struck joints. The mortar classifications given in the table and the types of mortar joints possible are discussed in more detail in the mortar section of this manual. It should also be noted that raked mortar joints should not be used in severe marine environments.

The minimum durability classification of built-in components is particularly relevant to the use of wall ties in masonry constructions. AS/NZS 2699.1 classifies the durability of masonry wall ties as:
- R3 - galvanised to a coating weight of at least 470g/m² on both sides, in accordance with AS/NZS 4680
- R4 - stainless steel grade AS 1449/316 or AS 1449/316L

Think Brick Australia Manual 2, Section 3, The Properties of Clay Masonry Units provides further information on the durability of bricks.
Fretting of Brickwork (Salt Attack)

Fretting of brickwork is linked to the durability of bricks and directly related to the exposure environment in which they are placed. The fretting (flaking or crumbling) of bricks can be prevented by the adequate maintenance of the wall structure. An extreme case of fretting is shown below.

Fretting is caused by the action of salt migration in the walling system. Water which has salt dissolved in it migrates through the brick to the brick surface. As the brick dries, the salt is left behind and forms a salt crystal. The salt crystals grow in the voids within the brick. As more salt is left behind by the evaporation of water, the salt crystal grows larger and larger. The strength of the growing salt crystal can be stronger than the elements that hold the brick together. If this occurs, the brick face begins to crumble and fall away. This is also the case for mortar joints.

For salt attack to occur the following three conditions are required:
• there must be presence of salts
• water ingress
• evaporation of salt water

The absence of any of these conditions will prevent salt attack. The fretting of bricks can be exacerbated at specific locations around a house, which undergo increased wetting and drying cycles. The brickwork will continue to deteriorate unless moisture movement through the masonry is prevented.

When treating fretting, “prevention is the best cure”. The source of the salt may be airborne salt from sea spray or salts that are naturally present in the soil, or introduced by fertilizers and salt-water swimming pools. The use of bore water may also provide the source of the salt.

The first step in treating fretting is to identify the source of the salt and where the salt might be coming from. The best method of preventing fretting is to prevent the salt from being absorbed into the wall. This may be a physical barrier such as plastic sheeting, digging the soil away from the wall or rearranging the sprinklers so that they do not spray directly onto the wall.

Once fretting has begun it will not stop until the salt source is identified and removed. It could then take another 12-24 months before the fretting process comes to a complete halt. Once the fretting process has stopped the brickwork can then be repaired. Any repairs made to the brickwork while the fretting action is still occurring will generally fail.

Fretting brickwork may be treated using breathable sealers that penetrate the brickwork and consolidate loose particles. However, depending on the degree of fretting it may be necessary to replace the affected brickwork.

Figure 3 – Effect of salt attack on brickwork
1.5 Expansion

**Brick Growth**

Bricks undergo long-term permanent expansion over time. This expansion continues for the life of the brick, but the majority of the growth occurs early in its life. Most bricks have a coefficient of expansion in the range of 0.5-1.5mm/m (millimetres per metre) over fifteen years. Designers can use the values of the coefficient of expansion to accommodate for the growth of bricks by the size and spacing of the control joints.

The coefficient of expansion, or e-factor value, of clay bricks is tested in accordance with AS/NZS 4456.11 and is an estimate of the amount of growth expected in the first fifteen years after the brick leaves the kiln. Typical values are given only as a guide as:

- there is no pattern in the coefficient of expansion based on brick colour or manufacturing methods, and
- the coefficient of expansion can vary considerably between batches even within a single brick type, due to variations in the manufacturing process and raw materials used.

**Control Gaps**

The provision of control gaps or articulation joints between parts of the structure during construction will accommodate movements within the structure over time. Numerous sources of movement exist and include:

- The change in size of building materials with temperature, loading conditions and moisture content
- The differential change in size of building materials (for example, cement products shrink over time, whilst clay bricks expand slowly over time)
- Foundation and footings movement
- Frame movement
- Frame shortening
- Temperature movement
- Internal horizontal and vertical movement

**Design of Control Gaps**

Typical control gaps should initially be about 20mm wide, clear of mortar dags or bridges, tied at appropriate intervals with flexible ties and sealed with a polyethylene rod or suitable compressible filler. The filler material should be positioned well back from the masonry surface to avoid the filler material becoming visible if the joint contracts.

**Common Problems**

The typical problems arising with expansion gaps include:

- Inadequate sealing
- Failure to ensure that the gaps are clean and that no hard materials such as mortar droppings are left before sealing
- The use of joint fillers that are too rigid, which have compressive strengths high enough to transfer forces across the joint.

However, these problems can be avoided by good workmanship during construction. Further information on expansion gaps is available in our Design Considerations section.
1.6 Efflorescence

Efflorescence is defined by salts left on the surface of units after evaporation of water. The surface deposits can be either loose crystalline salts or amorphous films which can be a result of small amounts of soluble salts. These salts are sulphates of calcium, magnesium, aluminium, sodium, and potassium.

Chlorides are almost non-existent, but in some instances carbonates of calcium, sodium and potassium may appear.

The method of testing for efflorescence given in AS/NZS 4456.6 classifies the unit as one of the categories in the table below.

Table 4 – Potential to efflorescence, categories and definitions in accordance with AS/NZS 4456.6.

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil</td>
<td>No observable efflorescence</td>
</tr>
<tr>
<td>Slight</td>
<td>No more than 10 percent of any surface of the specimen covered by a thin deposit of salt</td>
</tr>
<tr>
<td>Moderate</td>
<td>More than 10% of one surface but not more than 50% of the total specimen surface covered by a thin deposit of salt</td>
</tr>
<tr>
<td>Heavy</td>
<td>A deposit of salt covering more than 50 percent of the total brick surface</td>
</tr>
<tr>
<td>Severe</td>
<td>Any efflorescence that is accompanied by powdering and/or flaking of the surface of the specimen</td>
</tr>
</tbody>
</table>

Figure 4 – Brickwork effected by efflorescence
1.7 Lime Pitting

Lime pitting is an imperfection occurring in the surface of a brick due to the expansion of large lime particles just below the surface. The lime originates from the raw materials used in the manufacture of the bricks.

Lime pitting is observed when the lime particles are present just below or on the surface of the brick. The volume expansion of the lime particle, resulting from the presence of moisture, can cause it to pop out of the brick or break the brick surface, generating a defect. An example of a large lime pit is shown in the figure below:

![Lime pitting example](image)

Figure 5 – Lime pitting appearing on the face of the brick

Lime pitting is defined in AS/NZS 4456.0 and the degree of lime pitting can be determined in accordance with AS/NZS 4456.13. Lime pitting is classified by the number and size of lime pits on the face or ends of the brick, as described below.

<table>
<thead>
<tr>
<th>Table 5 – Lime Pitting Classifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil</td>
</tr>
<tr>
<td>Slight</td>
</tr>
<tr>
<td>Moderate</td>
</tr>
<tr>
<td>Severe</td>
</tr>
</tbody>
</table>
In the design of energy efficient buildings, it is important to be able to calculate the heat loss or gain of materials used to construct these buildings. To do so, the solar absorptances of all products were found in order to obtain a measure of the solar energy efficiency of each product.

Solar absorptance is an indication of the amount of solar energy or heat that passes into a material, compared to the amount that is reflected from the material. Solar absorptance relies on colour, no matter what material you use. Dark materials have a higher solar absorptance and will absorb more solar energy. Choosing lighter coloured bricks and roof tiles will reduce the amount of heat energy entering into your home, leading to lower energy bills and increased thermal comfort.

Austral Bricks has classified all wall colours as light, medium or dark on the basis of their solar absorptance and they are summarised in the table below. These classifications can be used in energy efficiency verification software, such as NatHERS.

Solar reflectance is the inverse of solar absorptance and is a measure of a material’s ability to bounce back solar energy, that is, to reflect light. A lighter colour will have higher heat reflection than a darker one, but it will not necessarily produce more glare or light reflection. It is possible to get a surface with low solar absorptance and low light reflection.

These categories are used by both the NCC and Building Sustainability Index (BASIX) with slightly different scales. These are summarized in the table below.

### Table 6 – Solar Absorptance Index for the BCA and BASIX scales.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Classification of Solar Absorptance Index (0 – 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Light</td>
</tr>
<tr>
<td>BCA</td>
<td>&lt;0.4</td>
</tr>
<tr>
<td>BASIX</td>
<td>&lt;0.475</td>
</tr>
</tbody>
</table>
1.9 Cold Water Absorption

The amount of water a masonry unit can absorb is measured by the cold water absorption test. This is calculated in accordance with AS/NZS 4456.14 whereby the unit is submerged in water for 24 hours and the subsequent amount of water that is absorbed is calculated as a percentage of the original weight of the unit.

**Initial rate of absorption**

The initial rate of absorption (IRA) is a function of the size and extent of the porosity of the bricks. The IRA is a measure of how quickly a brick will absorb water. The test method IRA is given in AS/NZS 4456.17 Determining Initial Rate of Absorption (suction).

**Determining initial rate of absorption (suction)**

The ability of bricks to absorb water affects the bond formed between brick and mortar. A tug-of-war occurs between the bricks ability to absorb water and the capacity of the mortar to retain water. If either the brick or the mortar wins, a poor bond will result. Therefore, the water retentivity of the mortar needs to be matched to the IRA of the bricks to ensure that a strong bond forms.

**High Suction Bricks**

If the brick wins the tug-of-war and the water is absorbed too quickly from the mortar, the cement will not undergo proper hydration. Therefore, if the bricks have high suction the mortar will stiffen in the bed joint before the next course can be properly bedded. To accommodate high suction bricks, a high water retention mortar is required. It may also be necessary to wet the bricks prior to laying, in order to reduce their suction. However, wetting the bricks may lead to efflorescence in the brickwork. Dry press bricks often have high suction. Dry press bricks can be lightly sprayed with a hose and left until the water has spread throughout the brick before laying.

**Low Suction Bricks**

If the mortar wins the tug-of-war and retains too much water, the bricks will tend to float on the mortar bed. Low suction bricks may, therefore, make it difficult to lay plumb walls at a reasonable rate. To accommodate for low suction bricks a leaner mortar is required. A lean mortar can usually be obtained by increasing the proportion of washed sand to unwashed sand used in the mix.

For further information on the absorption of water by bricks refer to section 3 of the Think Brick Australia Manual 2, *The Properties of Clay Masonry.*
1.10 Colour Variation

Our clay bricks and pavers are made from naturally occurring minerals that are kiln fired to lock in their colour and strength for life. The composition of the raw materials as well as the firing process may cause each manufacturing run to differ. The resulting colour and texture variation is inherent in the process and part of the appeal of our natural products.

The product images in our brochures and on our website give a general indication of colour for your preliminary selection. We recommend you also view current product samples and look at actual finished projects before making your final selection.

Please view our sample walls in our display centres. They are a general indication of the product with the normal amount of blend variation.
WORKING WITH BRICKS
2.1 Brick Bonds

A bond refers to the pattern in which bricks are laid. The most common bond used in construction is Stretcher Bond which provides the most effective bond strength for your brick wall and it complies with AS 3700. For other bonding patterns, structural integrity of the brickwork must be confirmed with a structural engineer.
2.2 Decorative Brick Patterns

Bricks are such a versatile material, they truly allow you to express your life and style in so many ways. Below are examples of brick patterns that can be used to differentiate your project. Structural integrity of the brickwork must be confirmed with a structural engineer for these brick patterns.
### 2.3 Blending

The composition of the raw materials as well as the firing process will result in colour variation not only within packs, but also from pack to pack. This variation is inherent in the process and part of the appeal of our natural products.

To ensure that colour variation from one pack to the next is dealt with correctly, we advise that the bricks are blended (mixed among themselves) during laying. The advised method to do this is to select units from down and across three to six open packs to ensure an even colour distribution across the surface.

![Figure 1 – Well blended](image1)

![Figure 2 – Poorly blended](image2)
Mortar joint style also plays a major part in determining the overall appearance of a building. The different styles possible are shown below.

Properly filled and tooled joints improve the durability, weatherproofness and sound performance of brickwork. Raked and ironed joints are used to achieve the ‘character’ look in a new home. Flush joints will increase the impact of the mortar colour when a contrasting colour is chosen. For bricks with a bevelled edge, it is recommended that a raked joint be used.

It should be noted that raked or recessed joints should not be used in severe marine environments and should be avoided in applications where durability is critical.

### Joint thickness and tolerances

The standard thickness for a mortar joint is 10 mm. However, joints must vary in thickness to allow for the natural size variation of clay bricks. AS 3700 allows a deviation from the specified thickness of bed joint of ±3 mm.

The minimum thickness of the perpends must not be less than 5 mm, while the allowable deviation from the specified thickness of a perpend is +/- 5 mm.
2.5 Mortar

Mortar colour

The mortar is no longer just a functional element. Today, the choice of mortar colour and style is just as important as the choice of brick. Mortar generally represents about 15% of the total visible area of brickwork and can dramatically change the look of a building. For example, mortar coloured to match the brick wall will give the impression of a large area of one colour. Whereas, contrasting mortar colour will highlight the shape of individual bricks.

Mortar can be coloured, usually by adding powdered or liquid pigments to the mortar as it is mixed by the bricklayer. All colours should be confirmed with the bricklayer before a decision is made. Mortar can also be tinted to match the brick colour, giving a very even wall colour. All colours should be confirmed with the bricklayer before a decision is made.

Examples of some mortar colours

Figure 3 – Off White*

Figure 4 – Grey*

Examples of same brick with different mortar colours

Figure 5 – Off White*

Figure 6 – Grey*

* Colours shown are an indication only. Mortar colours will vary depending on the type of cement, sand and pigments used.
Mortar Mixes

Mortar mixes are always specified as the proportion of cement to lime to sand. For example, a common mortar made from Portland cement has one part cement, to one part lime and 6 parts of sand is abbreviated C1:L1:S6 or 1:1:6 (the chief cementing agent will always be expressed as one).

The type of mortar mix is classified according to the Australian Standard AS 3700 as M1, M2, M3 or M4. The grade chosen by the masonry designer should match the requirements of the design.

AS 3700 lists the deemed-to-satisfy proportions for the various grades. A brief description of the various mixes is given in the table below.

For a more detailed description of the masonry mixes, grades and their applications refer to AS 3700 or to the Think Brick Manual 10; Construction Guidelines for Clay Masonry.

<table>
<thead>
<tr>
<th>Grade</th>
<th>C : L : S</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>M4</td>
<td>1:0.4</td>
<td>This cement mortar is very durable and is often specified to contain lime for added workability that may otherwise be very poor. In severe marine environments or below DPC in aggressive soils and saline water M4 mortar must be used with bricks of Exposure Grade.</td>
</tr>
<tr>
<td>M4</td>
<td>1:0.25:3</td>
<td>These are the strongest and least permeable composition mortars. In severe marine environments or below DPC in aggressive soils and saline water M4 mortar must be used with bricks of Exposure Grade. Because of its high durability this is the preferred mortar for producing fade-resistant pigmented mortar.</td>
</tr>
<tr>
<td>M3</td>
<td>1:1:6</td>
<td>This is the common general-purpose mortar found in most specifications and can be used in all areas except where an M4 mortar is required. It is usually specified when the properties of the brick to be used are unknown. This mortar suits the majority of building applications and brick types.</td>
</tr>
<tr>
<td>M2</td>
<td>1:2:9</td>
<td>This lime-rich composition mortar is most suitable for internal brickwork, brickwork above a damp-proof course and with General Purpose bricks when used in cottage construction in non-marine environments. This is a forgiving mortar with a good balance between strength, flexibility and permeability. It is not suitable for colouring with pigments as it is prone to apparent fading. This is the preferred mortar for fireplaces and barbecues.</td>
</tr>
<tr>
<td>M1</td>
<td>0:1:3</td>
<td>This is a straight lime mortar that sets slowly. It develops very little early strength. This mortar can only be used when repairing historic masonry originally built using lime mortar. In most cases a 1:3:12 mortar is preferable.</td>
</tr>
<tr>
<td>M1</td>
<td>1:3:12</td>
<td>This mortar has most of the flexibility of straight lime mortar and can be used for restoration and matching existing construction only.</td>
</tr>
</tbody>
</table>
Mixes for Different Mortar Colours

Table 2 shows the components required to give the best colour results in M3 mortar, compliant to AS 3700/4773.

Weathering and cleaning can adversely affect the colour of the mortar. Pigmented mortars must be strong enough to retain the pigment particles on the face of the joint. In weak mortars, the pigment particles may be rapidly eroded from the face of the joint by wind and rain.

Acid cleaning of brickwork may also degrade pigment colour, leading to faded, patchy and unattractive mortar joints. For durable pigmented mortar always finish the joint by tooling even when a raked joint is required.

<table>
<thead>
<tr>
<th>Mortar Ingredients</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Black</strong></td>
</tr>
<tr>
<td>6 parts white or yellow brick sand</td>
</tr>
<tr>
<td>1 part General Purpose cement</td>
</tr>
<tr>
<td>1 part lime</td>
</tr>
<tr>
<td>Black mortar oxide - volume according to directions on the packet</td>
</tr>
<tr>
<td><strong>Cream</strong></td>
</tr>
<tr>
<td>6 parts yellow brick sand</td>
</tr>
<tr>
<td>1 part off white cement</td>
</tr>
<tr>
<td>1 part lime</td>
</tr>
<tr>
<td><strong>Natural</strong></td>
</tr>
<tr>
<td>6 parts yellow brick sand</td>
</tr>
<tr>
<td>1 part General Purpose cement</td>
</tr>
<tr>
<td>1 part lime</td>
</tr>
<tr>
<td><strong>Off White</strong></td>
</tr>
<tr>
<td>6 parts white brick sand</td>
</tr>
<tr>
<td>1 part off white cement</td>
</tr>
<tr>
<td>1 part lime</td>
</tr>
<tr>
<td><strong>Red</strong></td>
</tr>
<tr>
<td>6 parts white or yellow brick sand</td>
</tr>
<tr>
<td>1 part off white cement</td>
</tr>
<tr>
<td>1 part lime</td>
</tr>
<tr>
<td>Red mortar oxide - volume according to directions on the packet</td>
</tr>
</tbody>
</table>

Other Mortar Components

**The Importance of Lime**

The addition of lime to mortar has the advantage of making the mortar workable in the wet state and may eliminate the need for plasticiser admixtures. Mortar containing lime will be less pervious, more durable and more ‘forgiving’ than a mortar without lime. There is no substitute for the benefits of lime.

**Admixtures**

The additives permitted by Australian standards (AS 3700) include:

- Plasticisers or workability agents, including air entraining agents complying with AS 1478
- Cellulose type chemical water thickeners
- Colouring pigments complying with BS EN 12878 (a British standard)
- Set-retarding chemical agents complying with AS 1478
- Bonding polymers

Other admixtures cannot be used unless they have demonstrated compliance with AS 3700.
2.6 Best Bricklaying Practices

Wall Ties
Wall ties are used to connect the leaves of a cavity wall or to connect a masonry wall to a timber frame or steel stud. The failure of wall ties may result in the masonry falling during an earthquake or in high winds.

It is essential that the wall ties are chosen for the design requirements, as specified in AS/NZS 2699. The durability requirements of AS 3700 (as previously discussed in the durability section) should also be met when selecting the wall ties. For example, the classification R4 needs to be met by the wall ties in severe marine environments. In addition, the installation of the wall ties is critical to the integrity of the system.

The wall ties should be:

• installed at the correct embedment distance and strength in the mortar,
• aligned correctly to prevent water transfer into the building, and
• placed at the required spacings.

Horizontal and vertical spacing of wall ties should not exceed 600mm, whilst features such as openings, control joints and wall edges generally require spacings of less than 300mm. The spacing of the wall ties relies on the individual design. AS 3700 should be referred to for more details on the design and installation of wall ties. A more detailed description of placement of wall ties is available in Think Brick Australia Manual 10, Construction Guidelines for Clay Masonry.

Damp-Proof Courses (DPC) & Flashings
AS 3700 requires that damp-proof courses and flashing be used to prevent the movement of moisture vertically in the masonry and from the exterior of the building to the interior. In addition, the moisture from a cavity should be shed to the outer course by the flashings.

It is important that the DPC should not be bridged, thereby allowing moisture to travel above the DPC level. The DPC should be exposed out of the face of the brickwork to prevent any moisture paths up the brickwork.

Care should also be taken during the application of a render coating, to prevent the formation of a bridge. The DPC should also be considered during exterior landscaping.

Weep Hole(s)
A weep hole acts as a drain hole through the brick wall. Weep holes are created during the construction of the brick wall. Weep holes are normally in the first or second brick course above ground level.

Weep holes are required at the head and sill flashing of windows over 1200mm wide and are commonly used for smaller windows also.

Prevention of Brickwork Stains
Good workmanship and correct storage of bricks during construction will ensure that a number of potential stains are avoided. In addition, the use of the correct cleaning methods will prevent further problems arising. It is also important that garden beds, paved, concrete or tiled areas should be below the level of the installed DPC and that they do not cover the weepholes in your brickwork.

Building any form of structure over your weepholes can restrict the drainage of moisture that penetrates through your brickwork. Allowing moisture to enter the brickwork may result in efflorescence issues.
2.6.1 Guidelines for Laying Bowral Dry-Pressed Bricks

These guidelines are to provide a best practice guide to laying Bowral dry-pressed bricks, which, when followed will reduce common problems.

**Blending bricks**

Blend the bricks by stripping the pack vertically rather than horizontally, as well as between a minimum of 6 packs to create an even mottle.

**Do not soak bricks prior to laying.**

The brick pack can be lightly sprayed and allowed to dry initially to reduce the suction of the brick but saturating the brick will lead to staining problems.

**Adjust the mortar consistency to match the brick.**

The mortar for dry pressed bricks needs to be softer than for extruded bricks as the brick will absorb some of the moisture from the mortar quite quickly and reduce the time available for adjustment.

**Do not make the mix harder than necessary.**

If M3 mortar is required do not make M4 mortar. It is harder to clean later.

**Do not put clay into the mortar.**

This does not come off the walls and does not dissolve in hydrochloric acid. It makes cleaning very difficult. ‘Brickies Sand’ is a good mixture of clay and sand.

**Fill the perp joints.**

It makes a stronger wall and stops water penetration.

**Dry brush the wall at breaks during the day and before completing work at the end of the day.**

Reducing the excess mortar from the brick wall before it goes hard reduces the amount and duration of both acid and cleaning that needs to be done later.

**Do not sponge the walls.**

Using a sponge may smear mortar across the face of the brick which can react with the acid during the acid cleaning process and lead to problems.

**Storage**

Ensure bricks are stored appropriately (either on pallets or on plastic sheeting), to prevent bricks absorbing ground salts and excessive water, which may cause issues when laid.

**Copings, Sills, Weathering**

Stormwater should be shed so as to clear the masonry immediately below. Copings and sills should project at least 10 mm beyond the wall face at the underside of the sill or coping. Where downpipes have not been installed water from the guttering should be diverted away from the brickwork.

**Laying Recommendations**

1. **Do not soak bricks prior to laying.** The brick pack can be lightly sprayed and allowed to dry initially to reduce the suction of the brick but saturating the brick will lead to problems.

2. **Adjust the mortar consistency to match the brick.**

   The mortar for dry pressed bricks needs to be softer than for extruded bricks as the brick will absorb moisture from the mortar quite quickly and reduce the time available for adjustment.

3. **Do not make the mix harder than necessary.**

   If M3 mortar is required don’t make M4 mortar - it will only be more difficult to clean off later.

4. **Do not use clayey sand in the mortar.** This will be extremely difficult to clean off.

5. **Properly fill the prep joints.** It makes a stronger wall and reduces excessive water penetration.

6. **Cover the top of the wall when rain is expected and until eaves/roofing or coping is installed to prevent excessive water penetration.**

7. **Clean the job as you go to avoid the need for using hydrochloric acid later.** Take more care than normal to ensure no smears or dags of mortar are left to dry on the brickwork. If the use of hydrochloric acid is required to clean mortar from dirty brickwork a lot more work will then be required to remove the resulting vanadium stains.
2.6.2 Guidelines for Laying Designa Basalt Bricks

These guidelines are to provide a best practice guide to laying Designa Basalt bricks, which, when followed, will reduce common problems.

Compliance
Austral Bricks Designa Basalt is a natural stone product for use as an external cladding or as an internal walling material. Designa Basalt is manufactured to AS/NZS 4455.1. As such, Designa Basalt is a masonry material that complies with the performance requirements of the National Construction Code, NCC, Volume 2 Clause 3.3.1 unreinforced masonry when designed and constructed in accordance with AS 3700.

Designa Basalt meets the requirements of NCC Clause 3.3.4 weatherproofing of masonry when designed and constructed in accordance with AS 3700. This is based on the service history of masonry in cavity or veneer construction with a drained and vented cavity.

Laying Designa Basalt
Designa Basalt is to be constructed to AS 3700 and the following should be adhered to:

- Designa Basalt bricks shall be full bedded.
- Mortar shall comply with AS 3700 Table 11.1 and be of M4 classification.
- Mortar joints should be 10mm +/- 2mm.
- Masonry wall ties shall comply with AS 2699.1
- Face fixed ties are to be screw fixed. Side fixed ties can be screw or nail fixed.
- Damp courses, weep holes, lintels should be installed in the same way as standard brickwork.
- During installation, use clean water and brush to promptly remove any fresh mortar that splashes onto the brickwork.

Designa Basalt Mortar
Designa Basalt needs to be laid with a bonding polymer addition to the mortar. The acrylic additive is combined with water, in the ratio specified by the manufacturer, and added to the mortar mix. Lanko 752 Bondit is a suitable bonding polymer (Davco Construction Materials www.davco.com.au).

Cleaning
Being a natural stone, care should be taken to ensure a minimal amount of mortar gets on the face of the bricks, and all the mortar haze should be thoroughly removed during the initial installation process.

It is recommended that strong acids such as hydrochloric acid (HCl) are NOT used, as this could create an irreversible reaction in the stone.
2.6.3 Armaclay Building Guidelines

Only available in Western Australia

Construction and Application
• Armaclay is not suitable for external applications.
• Armaclay can be used for internal walls and for the inner leaves of external cavity walls in full brick construction above floor level.
• Armaclay is suitable for use in single-storey or the uppermost storey of multi-storey house construction within the geometric limits of AS4055: “Wind Loads for Housing”.
• All internal surfaces should be hard plastered or cement rendered.
• Armaclay meets the requirements of AS/NZS4455: “Masonry Units and Segmental Pavers”.
• All construction should comply generally with AS3700: “Masonry Structures”.

Wall Sizes
• The maximum height of internal walls is 2.7m. See National Construction Code.
• The lengths of external cavity walls please review Verticore – Building Standards

Joints
• All corners must have filled perpends; Gable walls and party walls must have filled perpends.
• Top and bottom courses must have filled perpends; Walls over windows and doors must have filled perpends.
• All perpend joints should be filled when sound and fire ratings are a consideration.
• The widths of any unfilled perpends must not be greater than 12mm but may be zero.

Wall Ties
All wall ties shall meet the requirements of AS2699.1: “Built-in Components for Masonry Construction - Wall ties” and conform in anchorage and embedment to the requirements of AS3700. Wall ties for cavity walls should be spaced as follows:
• For N1 wind category, light-duty ties at 450mm horizontally and 600mm vertically.
• For N2 wind category, light duty ties at 300mm horizontally and 600mm vertically or medium duty ties at 600mm horizontally and 600mm vertically.
• For N3 wind category, medium duty ties at 450mm horizontally and 600mm vertically.

Austral Bricks recommends intersections must be keyed with units engaged every second course. If ties are used as an alternative they must be medium duty wall ties every second course and the gaps must be filled with mortar.

Mortar
Mortar must comply with AS3700: and the following:
• M2 (1:2:9) or better for internal walls above the damp-proof course and fully enclosed within the building.
• For other locations, as required by AS3700: Table 5.1.
• Chasing should be kept to a minimum and where walls are chased on both sides, the chases must not be made in the same units.

Austral Bricks recommends that a Structural Engineer be consulted before construction of any building commences.
2.6.4 Verticore Building Standards
Only available in Western Australia

Construction and Application
• Verticore is suitable for use in single-storey or two-
storey house construction within the geometric limits
of AS4055: “Wind Loads for Housing”.
• Verticore can be used for internal walls, external walls
and for cavity walls in full brick construction.
• Verticore is suitable for use in areas where the design
wind category as stipulated in AS4055 is N1, N2 or
N3.

Joints
• All corners must have filled perpends; Gable walls
and party walls must have filled perpends.
• Top and bottom courses must have filled perpends;
Walls over windows and doors must have filled
perpends.
• All perpend joints should be filled when sound and
fire ratings are a consideration.
• The widths of any unfilled perpends must not be
greater than 12mm but may be zero.

Wall Sizes
• The maximum height of internal walls is 2.7m. See
National Construction Code.
• The lengths of external walls up to 2.7m high must not
be greater than the following shown in Table 8:

<table>
<thead>
<tr>
<th>Wind Category</th>
<th>Walls with four sides supported and no opening</th>
<th>Walls with four sides supported and an opening</th>
<th>Walls with a free end or control joint</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1</td>
<td>9.8m</td>
<td>4.3m</td>
<td>4.9m</td>
</tr>
<tr>
<td>N2</td>
<td>7.3m</td>
<td>3.1m</td>
<td>3.7m</td>
</tr>
<tr>
<td>N3</td>
<td>5.4m</td>
<td>1.7m</td>
<td>2.7m</td>
</tr>
</tbody>
</table>

Austral Bricks recommends intersections must be
keyed with units engaged every second course. If
ties are used as an alternative they must be medium
duty wall ties every second course and the gaps
must be filled with mortar.

Mortar
Mortar must comply with AS3700 and the following:
• M2 (1:2:9) or better for internal walls above the
damp-proof course and fully enclosed within the
building.
• M3 (1:1:6) or better for external walls, including
below the damp-proof course in non-aggressive
soils and in marine environments more than
100mm from a non-surf coast and more than 1km
from a surf coast.
• For other locations, as required by AS3700: Table
5.1.
• Chasing should be kept to a minimum where walls
are chased on both sides, the chases must not be
made in the same units.
Austral Bricks recommends that a Structural
Engineer be consulted before construction of any
building commences.
2.7 Brick Storage

The storage of bricks is very important, as it can directly affect the performance of the product.

Tips for good storage:

1. Place brick packs on plastic or timber when possible. Avoid placing brick packs directly on the ground where they can absorb dirty or saline ground water.

2. Don’t stack bricks in water puddles on concrete slabs. Concrete, especially fresh concrete, can leach calcium salts that may be absorbed by the bricks, and contribute to early age efflorescence of the bricks or brickwork.

3. Keep bricks dry by either covering them or leaving the plastic wrap they are delivered in on until they are to be used.

4. Attempt to keep bricks from becoming too hot as this may cause the mortar to dry too quickly.

5. Plan your brick delivery. Place the packs as close as possible to where the bricks are to be laid. Try to avoid too much handling of bricks on site – this increases efficiency and reduces the risk of damage to the bricks before being laid. Wherever possible group three or four packs to allow product to be blended down and across the packs simultaneously.

Figure 9 – Example of poor brick storage
BRICK CLEANING & MAINTENANCE
3.1 Brick Cleaning and Maintenance

Our clay bricks are made from naturally occurring minerals that are kiln fired to lock in their beauty and strength for life. Not only is brick the sturdiest building material, it is also the easiest and most economical to maintain. The following guidelines provide you with some essential information to ensure that your brickwork maintains its beautiful appearance well into the future.

3.1.1 Preventative Care is the First Step

Gardens add natural beauty to any home, however it is essential that garden beds, paved, concreted or tiled areas are below the level of the installed damp proof membrane and do not cover the weep holes in your brickwork. Building any form of structure over your weep holes can allow termites to infiltrate your barrier or restrict the drainage of moisture that penetrates your brickwork.

3.1.2 Cleaning Your Brickwork

**Brick Properties**

The appearance of a brick building can be permanently spoilt by bad cleaning techniques or by the use of the wrong cleaning agent. For this reason, it is important to ensure that the correct cleaning methods are utilised for the best results and to help reduce the associated problems with brick cleaning.

It is important to remember, that the services of a professional cleaner should be sought if a stain is too large or too difficult to remove.

**Safety Precautions**

Some chemicals used during cleaning are highly corrosive (some are classified as S6 poisons). The manufacturer’s instructions and safety precautions should always be followed when using acids and other proprietary cleaning chemicals. The few points below should be followed to avoid serious personal injury:

- Always wear protective clothing and protective equipment such as gloves, safety glasses, etc.
- Do NOT use high pressure cleaners to apply cleaning chemicals as it is dangerous to the operator and to those nearby.

**Step 1: Identify the type of stain**

Make sure you know the type of stain you are trying to remove to ensure you are using the most effective cleaning method.

**Step 2: Select the correct cleaning method**

Once you have identified the stain, you can use the cleaning methods described on the following page to remove it.

**Step 3: Follow the procedures**

Follow the written instructions as well as those shown on the labels of proprietary cleaners. Always clean a small test area first to ensure the cleaning method has worked to your satisfaction.

**Step 4: Safety precautions are essential**

Make sure you read safety precautions thoroughly, wear protective clothing and store any chemicals safely.

*Note:* Hydrochloric Acid is commonly used to clean mortar stains from brickwork when it is initially laid. It does not need to be used at any other time during the life of your brickwork. If used incorrectly it can cause unsightly staining that is extremely difficult to remove.

3.1.3 Removing Common Stains

**Adhesive tape**

*Remedy:* Wipe with petrol, lighter fluid or paint stripper.

**Blood**

*Remedy:* Wet the stain with water then cover it with an even layer of sodium peroxide powder. Sprinkle with water or cover with a water soaked bandage and leave for five minutes. Scrub vigorously with clean water and then neutralise using a five percent solution of acetic acid (vinegar) and rinse with water at end of treatment.

**Coffee stains**

*Remedy:* Apply a cloth that has been saturated in a solution of one part glycerin to four parts water. When the stain is drawn into the cloth, rinse with water.

**Egg**

*Remedy:* Wipe the stained area with acetone until the stain is removed.

**Ink and Biro**

Different inks require different treatments.

*Remedy:* Wipe with white spirits, acetone or apply an acetone poultice to help draw out the stain.
Marker pens
Remedy: Wipe off with acetone or a poultice of acetone and talc.

Oil, grease and animal fats
Remedy: Apply an engine degreaser emulsifier or a strong detergent, then rinse well.

Organic growths / fungus, mould and moss
Porous masonry provides a benign environment for organic growth when it is continuously moist, especially in light but shady conditions and when there are plenty of nutrients available. You will need to check downpipes, flashings etc for ways to stop continuous moist conditions. If brickwork dries, organic growth should not occur.

Remedy: Treat with diluted sodium hypochlorite bleach with a small amount of liquid detergent. Liquid chlorine, Exitmould and White King are suitable for this application. Clean with hot water and detergent. Repeat as necessary.

Soils
Remedy: Mix a strong detergent solution of one cup detergent to five litres hot water. Scrub and rinse well.

Paint and graffiti
These can be difficult stains to remove, particularly if they have aged. Therefore, it is best to treat them when fresh.

Wax Crayon
Remedy: Wax crayon can usually be removed with acetone. It should be applied with a rag or tissue on smooth surfaces or with a small brush on textured surfaces. If it tends to spread, try using a poultice and brush off when dry.

Acrylic Paint
Remedy: A commercial paint remover should be used.

Oil based paints or enamels
Remedy: Burn off and follow with scraping and wire brushing.

Fresh Aerosol Paint
Remedy: A commercial paint remover should be used.

Dried paint
Remedy: Flood the stained area for a few minutes with a paint remover eg. methylene dichloride. Scrub to loosen the paint film. Flush with water to wash away the loosened paint. Scrub with scouring powder until the stain is removed. Flush with water.

Note: Specialty propriety graffiti removal products are also available.

It is important to remember, that should a stain be too large or too difficult to remove, then the services of a professional cleaner should be sought.

Bitumen and Tar
Scrape off the excess material and scrub the surface with scouring powder and water. Chilling the surface with ice or solid carbon dioxide (dry ice) can assist removal. These stains usually need two treatments with a commercial emulsifying agent (or degreaser). First, mix the emulsifier with kerosene to remove the stain. Then clean the kerosene off, with emulsifier mixed only with water.

Soot and Smoke
Remedy: Minor stains can be removed with sugar soap. Mix 500g sugar soap with 2 litres of hot water and apply liberally with a brush. After stains disappear, scrub with a mixture of detergent and a household scouring powder containing sodium hypochlorite.

For stubborn stains treat the area with undiluted sodium hypochlorite for 10 minutes before scrubbing and hosing.

A poultice of sodium hypochlorite solution in an inert base (such as diatomaceous earth) could be used for severely affected areas. The poultice should be left for 1 to 2 days before scrubbing and removing.

Timber Stains
Remedy: Avoid leaving timber resting against the brickwork as the tannin may leach from the timber and cause staining. Wipe timber stains off with a solution of 120 grams oxalic acid per 4 litres of hot water. Neutralise the wall after this treatment.
3.2 Cleaning mortar stains with Hydrochloric Acid

Hydrochloric acid is only used to remove mortar stains from clay brickwork. Generally, hydrochloric acid should not be used to treat any other stains or at any other time during the life of your brickwork. If used incorrectly, it can cause unsightly staining that is more difficult to remove.

In particular, care should be taken to treat any vanadium stains prior to cleaning with hydrochloric acid. It is very important that protective clothing be worn and that the safety and chemical storage precautions necessary for working with hydrochloric acid are followed.

The following procedure is recommended when cleaning with hydrochloric acid:

1. All mortar dags should be removed using either a metal or wooden scraper. This should be done 24-36 hours after completion of the brickwork.

2. Protect all areas which may come in contact with the cleaning agent as recommended by the manufacturer of the proprietary cleaner. Special care should be taken with window frames, aluminium dampcourses and gutters.

3. Saturate the area of brickwork to be cleaned and all adjacent areas below with water.

4. Use the correct ratio of hydrochloric acid and water:
   - Light coloured bricks - 1 part hydrochloric acid to 20 parts water
   - Dark coloured bricks - 1 part hydrochloric acid to 10 parts water
   - Under no circumstances should more than 1 part hydrochloric acid to 10 parts water be used. It is better to scrub more vigorously than to use more acid.

5. When cleaning, try not to work in direct sunlight.

6. Always begin at the highest point and work down the wall.

7. Only clean small areas at a time, for example one square metre, so as to allow adequate time to wash off the cleaning solution, to ensure no staining occurs.

8. Allow solution to remain on wall for 3-6 minutes before scrubbing. Be sure not to scrub the joints.

9. Rinse thoroughly, making sure all cleaning solution has been removed.

Note: light coloured bricks should be rinsed with a neutralising solution, such as bicarbonate of soda or washing soda, instead of water.

Note: Bricks manufactured in Queensland, especially light-coloured bricks, may be more susceptible to acid burn, due to large amounts of iron oxide present in the raw materials. The following ratio could be substituted into Step 4 when acid cleaning these bricks: 1 part hydrochloric acid, 1 part phosphoric acid and 10 parts water. Contact Austral’s local technical department for further details.

Further details of the recommended cleaning procedure and the various techniques used are available in the Think Brick Australia Manual 3 Cleaning of Clay Masonry Guide 2014.

Cleaning Internal Brickwork

Extra care should be taken when using hydrochloric acid to clean mortar stains on internal masonry. Acid fumes produced during cleaning should be ventilated adequately. The likelihood that the acid fumes will persist into the period of occupation can be reduced by:

- Cleaning the internal masonry early in the construction period, thereby allowing the walls to be rinsed sufficiently
- Ensuring adequate ventilation apply a neutralising solution to the wall.
3.3 Hand Vs High Pressure

Hand Cleaning
Hand cleaning is appropriate for small jobs or for when the use of a high pressure water jet is likely to cause damage. Dry press bricks should be generally cleaned by hand. The following procedure should be followed:

1. Allow mortar to harden (clean 24-36 hours after completion of masonry work) and remove any large mortar particles with hand tools.
2. Protect adjacent materials as recommended by the manufacturer of the proprietary cleaner.
3. Saturate the wall with clean water. Never let the wall dry out during cleaning; work on small areas.
4. Test a small unseen section prior to full-scale cleaning.
5. Apply the acid solution (as described previously) to the wall using a brush or spray.
6. Allow solution to remain on wall for 3-6 minutes before scrubbing vigorously.
7. Rinse thoroughly as small areas are cleaned.

High Pressure Water Jet Cleaning
High pressure water jet cleaning can be used on clay masonry, but precautions must be taken so that the bricks and the mortar joints are not damaged by the process. The following procedure should be followed:

1. Allow mortar to harden (must be older than 3 days) and remove any large mortar clags with appropriate hand tools.
2. Protect adjacent materials as recommended by the manufacturer of the proprietary cleaner.
3. Saturate the wall with clean water. Never let the wall dry out during cleaning; work on small areas.
4. Test a small unseen section prior to full-scale cleaning.
5. Apply acid solution (as described previously) by hand.
Applying chemicals with high pressure cleaners is dangerous and is NOT recommended for safe and successful cleaning.
6. Wash the wall with high-pressure water after allowing the solution to remain on the wall for 3-6 minutes. When operating the equipment ensure to:
   • Keep pressure low - maximum 7000kPa (approximately 1000psi)
   • Use a wide fan spray nozzle (15°)
   • Operate the nozzle at generally 500mm from the wall or never closer than 300mm
   • Use ‘runs’ of approximately 1m in width and double clean to ensure the best clean
   • Keep the gun moving constantly or surface abrasion in one spot will result

Warning: If the mortar joints or the bricks are being damaged, either the pressure is too high or the water jet is too close to the wall.
It is strongly recommended that a test area should be used to check the impact of the high pressure cleaning on the bricks and mortar. High pressure cleaning is NOT recommended for dry press bricks and increased care should be taken with slurry coated bricks. Examples of the damage that can be caused by high pressure cleaning dry press bricks are shown below.

Figure 1 – Dry press brick damage due to high pressure cleaning
Figure 2 – Damage resulting from the use of a turbo head
3.4 Efflorescence

Efflorescence is a powdery deposit of salts which forms on the surface of bricks and mortar. It is usually white but efflorescence can be yellow, green or brown. A temporary efflorescence is particularly common on new brickwork as soluble salts are transported to the surface of the brickwork by water.

Efflorescence can occur from a variety of sources. New bricks contain minimal, if any, soluble salts, but mortar and concrete have relatively high soluble salt contents. Ground waters that are naturally salt-bearing can be drawn into base brickwork. A faulty or bridged damp-proof course will allow the salts to migrate up the wall. Render that has been applied over a damp-proof course can also allow salt to migrate up the face of the brickwork. Water allowed to enter uncovered cavity walls during construction is also likely to cause efflorescence, so brickwork must be protected from water entry during construction.

The amount of efflorescence that occurs is related to the amount of water in the bricks, and their drying time. The more water in the bricks, and the longer it is there, the more chance salts will have to dissolve and be brought to the surface as the bricks dry out.

Efflorescence on new brickwork may be unsightly, but it will not cause damage unless it persists for a long time. Persistent efflorescence should be taken as a warning that water is entering the wall through faulty copings, damp-proof courses or pipes. If allowed to continue unchecked, the salts carried to the face of the wall may eventually attack the bricks and cause deterioration.

**Remedy:** Laying dry bricks and providing good ventilation to speed up the drying process after the bricks have been laid can minimise efflorescence. Forced ventilation and heating of the premises may be necessary to ensure drying during cold winter months. The best removal method is simply to brush off the deposit with a stiff dry bristle brush after the wall has dried out.

Collect the removed salts with a dust pan or a vacuum cleaner to prevent the salts re-entering the brickwork. Alternatively, an absorbent cloth could be used to sponge down the surface. Use only a small amount of water and rinse the cloth in clean water regularly to remove the salts.

Wetting the wall by methods such as hosing usually dissolves efflorescence back into the brickwork, allowing it to reappear again when the wall dries out. Acid or alkaline treatments are not recommended as they do more harm than good because they add to the total salt content of the wall. The application of kerosene or oil does little or nothing to hide the efflorescent salts and prevents their subsequent removal by brushing and washing.

Figure 3 – Efflorescence on brickwork
3.5 Calcium Staining/Scum (Insoluble white deposits)

Insoluble white deposits appear almost as a milky film on the brickwork. The hard white deposits are insoluble in water and are invisible when wet. Do not confuse these deposits with efflorescence, which is soluble in water.

Most commonly this staining can arise from the products of the setting reaction of Portland cement, which are leached out of concrete elements such as sills, lintels, copings, cement render or from insufficiently-dense mortar. They combine with carbon dioxide from the atmosphere to form white deposits that are insoluble in water but soluble in dilute hydrochloric acid.

The combination of clay from the mortar with calcium and silica residues from the cement forms calcium silicate, which could also produce the insoluble white scum. Calcium silicate is highly insoluble in most acids and is white in colour. When wet these calcium deposits are invisible. Kaolin, a clay mineral present in most bricklaying sands, can also form a hard deposit. It is insoluble in most acids except hydrofluoric acid (which is a restricted product).

However, the main cause of these insoluble white deposits is bad cleaning practice; allowing mortar made with sand containing too much clay to remain too long on the surface of the bricks and then removing it with too much acid and/or too little water. Refer to the section on mortar stains within this page for details on the correct method of cleaning with acid.

When not enough water is used before and after the acid wash, the products of the reaction between the acid and the mortar can be absorbed into the face of the bricks instead of being washed off the wall.

Remedy: Apply full strength Noskum to stained bricks and allow the solution to stand for four to six minutes if the reaction is not immediate. Scrub vigorously and wash off with plenty of water whilst still scrubbing. There is no guarantee that this will resolve the problem in severe cases, as scum is extremely hard to remove.
3.6 Iron Stains

Dark patches (usually yellow to deep brown in colour) of iron oxide staining can occur on the face of the brick or in the mortar joints. Iron stains are more noticeable on light coloured bricks and in the mortar joints of dark coloured bricks.

Iron staining, also known as ‘Acid burn’ is caused by the use of an incorrect cleaning procedure when treating mortar stains with hydrochloric acid. The acid reacts with iron oxides in bricks or mortar to cause the stains. Common errors in the cleaning procedure include:

- Insufficient pre-wetting of the wall prior to applying hydrochloric acid
- The application of an acid solution that is too strong
- Insufficient rinsing of the brickwork following cleaning

Staining can also be caused by contact with rusting iron or steel such as lintels, nails and bolts, railings and packaging straps. Regular wetting from bore water used for irrigation and by welding splatter from welding near brickwork may also cause iron staining.

**Remedy:** Acid burn stains can be treated using a solution of phosphoric acid, in the ratio of one part acid to four parts water. The solution should be applied and allowed to stand. The stain will normally disappear in 30 minutes to 24 hours.

The treated area should be washed off and then neutralised. A solution of sodium bicarbonate should be applied to neutralise the area and should not be washed off. Proprietary neutralisers such as Neutril are also available.

An oxalic acid solution of 20-40 grams per litre of water is another solution that could be used in the place of phosphoric acid. However, the substitution of oxalic acid for phosphoric acid is not commonly performed. After the application of either solution, the area should be neutralised as described previously. Proprietary cleaners, such as Noskum, could also be used to treat iron stains.

Phosphoric acid will bleach any iron oxides used as colouring pigments. For this reason pigmented mortars will fade, so the entire wall will need to be treated to maintain a uniform appearance. Alternatively keep the solution off the mortar.
3.7 Vanadium Stains

Vanadium stains are evident by a yellow-green discolouration on the face of a brick resulting from the vanadium salts naturally present in most clay materials used to produce light coloured bricks.

Vanadium stains are not powdery crystalline deposits and cannot be simply brushed off. They are often mistaken for moss or algae, which usually grows in damp areas across the whole face of the bricks and mortar. By contrast vanadium stains (as shown below) appear on dry walls, normally as patches on the brick only. Vanadium is a metallic salt present in most light coloured clays throughout the world. It is present in very small quantities.

This process can occur whenever the bricks are subjected to excessive water from rain either before or (more often) during the bricklaying process. If vanadium stains are not removed prior to cleaning with hydrochloric acid (for the removal of mortar stains), they may turn a darker colour and be more difficult to remove.

These stains are neither harmful, nor permanent and do not indicate any defect in the product. They are a thin film on the surface of the brick or paver and will weather away with time. However, the removal of the stains can be hastened by chemical treatment.

Remedy: Hydrochloric acid should NOT be used, as it will aggravate the problem. There are a number of different methods for removing vanadium stains, including:

- **Method 1:** Spray or brush on sodium hypochlorite (found in household bleach or pool chlorine) onto the stain without wetting the area initially. Allow the solution to stand until the stain disappears and then rinse with water.

- **Method 2:** Apply a solution of oxalic acid (20-40 grams per litre of hot water) to bricks that have not been pre-wetted. Finally, neutralise the acid with a solution of 15 grams per litre of washing soda (or suitable neutraliser). Do not wash off the neutralising agent. Neutralising is very important, as further staining could result if this step is omitted.

- **Method 3:** A solution of potassium or sodium hydroxide (150 grams per litre of water) could also be applied to the stain. Wash off the solution and any white residue formed once the stain has disappeared.

Proprietary cleaners, such as Noskum, could also be used to remove the vanadium stains. Apply Noskum to the dry bricks.

Wash off after the stain disappears and neutralise with a 15 grams per litre solution of washing soda (or suitable neutraliser).
3.8 Bowral Chillingham White
Cleaning Instructions

This product is very sensitive to vanadium staining, which is not permanent and will appear after exposure to hydrochloric acid or excessive water penetration (refer to pages 16 & 17 of the Think Brick Australia 'Cleaning of Clay Masonry' Manual). Vanadium salts are naturally occurring in many light coloured bricks and the resulting stains can be best managed as follows:

**Cleaning Instructions**

1. Yellow/green stains present on the bricks prior to laying can be treated successfully with sodium hypochlorite which is the active ingredient in household bleach and swimming pool chlorine (a trigger pack of exit mould is a convenient option). Once the stain has disappeared rinse the brick with clean water.

2. Any remaining stains may require a stronger treatment. Use either:

   a. A mix of 20 to 40 grams of oxalic acid per litre of water (preferably hot) applied to dry bricks, followed by a neutralising solution of 15 grams per litre of Sodium Bicarbonate once the stain has disappeared. The neutralising solution should not be rinsed off.

   OR

   b. Mix 150 grams of potassium or sodium hydroxide (caustic soda) per litre of water and apply to the stained bricks. Wash off with clean water once the stain has disappeared.

3. Some mild stains may reappear after more water (rain) on the masonry depending on the amount of salts originally in the brick and the amount already treated. Address these stains using step 1. Similar to typical white efflorescence, these stains will reduce and disappear in time.

* If hydrochloric acid is to be used, all existing vanadium stains must first be removed using steps 1 and/or 2. If this is not done the hydrochloric can cause mild yellow/green stains to become darker brown or black which will be much more difficult to remove. The wall should be pre-wet with clean water to minimize acid absorption into the body of the brick and the weakest possible solution of acid should be used. Once the bricks are surface dry, follow up with the neutralising solution as per 2(a) above. Any resulting vanadium stains then need to be treated using step 2.

**Test the chemicals removal efficiency and your application technique on a small discrete test area to determine the most suitable treatment to use, prior to use on the entire affected area.**
3.9 Bowral Bricks Cleaning Instructions

These recommendations are to provide a best practice guide to Bowral Blue dry-pressed bricks during the construction and cleaning processes, which, when followed, will reduce common problems.

Cleaning Instructions
The use of the correct cleaning methods will prevent further problems arising.

Clean As You Go
Cleaning as you go is the best method for ensuring good brickwork. Mortar smears are best cleaned when fresh.

Safety Precautions
The manufacturer’s instructions and safety precautions should always be followed when using acids and other proprietary cleaning chemicals.

Wet the Wall
The brickwork must be thoroughly wetted before any acid solution is applied and kept wet ahead of the acid application. Work a small area at a time and where possible avoid cleaning in direct sunlight.

The wall should be kept wet to prevent the acid from being absorbed by the brickwork which can cause staining.

Acid Concentration
Hydrochloric acid is used for cleaning mortar smear by dissolving the cement component of the mortar. The recommended maximum strength for Bowral Blue bricks is 1 part acid to 20 parts water.

Hydrochloric acid should not be used for any other cleaning of brickwork and may result in further staining if used inappropriately.

Acid Application
Apply the acid solution for up to 3 to 6 minutes to allow the chemical action to occur.

Hose Off
It is extremely important to thoroughly hose off the wall as the work proceeds. If the acid is left on the wall too long it can be absorbed into the brickwork and may cause staining.

High Pressure Cleaning
If high pressure cleaning is used, the following should be adhered to:
- Low pressure - max 7000kPa (approx 1000psi)
- Use a wide fan spray nozzle (> 15°)
- Distance of 500mm from the wall
- Use ‘runs’ of approximately 1m in width
- Keep the gun moving constantly
- Turbo head attachments should not be used

Warning: If the mortar joints or the bricks are being damaged, either the pressure is too high or the water jet is too close to the wall.
3.10 San Selmo Bricks Cleaning Instructions

These recommendations are to provide a best practice guide to San Selmo bricks during the construction and cleaning processes, which, when followed will reduce common problems.

**Cleaning Instructions**
The use of the correct cleaning methods will prevent further problems arising.

**Clean As You Go**
Cleaning as you go is the best method for ensuring good brickwork. Mortar smears are best cleaned when fresh.

**Safety Precautions**
The manufacturer’s instructions and safety precautions should always be followed when using acids and other proprietary cleaning chemicals.

**Wet the Wall**
The brickwork must be thoroughly wetted before any acid solution is applied and kept wet ahead of the acid application. Work a small area at a time and where possible avoid cleaning in direct sunlight.

The wall should be kept wet to prevent the acid from being absorbed by the brickwork which can cause staining.

**Acid Concentration**
Hydrochloric acid is used for cleaning mortar smear by dissolving the cement component of the mortar. The recommended maximum strength for San Selmo bricks is 1 part acid to 20 parts water.

Hydrochloric acid should not be used for any other cleaning of brickwork and may result in further staining if used inappropriately.

**Acid Application**
Apply the acid solution for up to 3 to 6 minutes to allow the chemical action to occur.

**Hose Off**
It is extremely important to thoroughly hose off the wall as the work proceeds. If the acid is left on the wall too long it can be absorbed into the brickwork and may cause staining.

Neutralise with 40g per litre bi-carb soda after cleaning.

**High Pressure Cleaning**
If high pressure cleaning is used, the following should be adhered to:
- Low pressure - max 7000kPa (approx 1000psi)
- Use a wide fan spray nozzle (> 15°)
- Distance of 500mm from the wall
- Keep the gun moving constantly
- Turbo head attachments should not be used

**Warning:** If the mortar joints or the bricks are being damaged, either the pressure is too high or the water jet is too close to the wall. Avoid stiff bristled brushes or metal brushes.
4.1 Fire Resistance

Fire resistance levels are specified in the National Construction Code (NCC). This system provides an accurate method of predicting the ability of a wall to maintain its strength in a fire and to resist the spread of the fire.

The fire resistance level (FRL) specifies the fire resistance periods (FRP) for structural adequacy, integrity and insulation. These components can be defined as:

- **Structural Adequacy** - The ability of a wall to continue to perform its structural function.
- **Integrity** - The ability of a wall to maintain its continuity and prevent the passage of flames and hot gases through cracks in the wall.
- **Insulation** - The ability of a wall to provide sufficient insulation, such that the side of the wall away from the fire does not exceed a predefined rise in temperature.

The fire resistance level is expressed in minutes and lists the three components in the same order as they are given above. For example, an FRL of 90/90/90 means a minimum fire resistance period of 90 minutes each for structural adequacy, integrity and insulation. FRPs can be determined from AS 3700 or by testing in accordance with AS 1530.4.

The fire resistance level of a wall depends not only on the thickness of the wall but also on its height, length and boundary conditions (i.e. how it is connected to other building elements). For this reason, it is impossible to give a FRL for a particular brick.

### 4.1.1 Structural Adequacy

The fire resistance period for structural adequacy is specific to the wall type and its boundary support conditions. The Think Brick Australia publication, Design Manual 5, Fire Resistance Levels for Clay Brick Walls provides charts for determining the structural adequacy of common wall types. The manual allows designers to assess the fire resistance level for a specific wall type and enables the FRP for structural adequacy to be directly read from a series of charts.

### 4.1.2 Integrity

The fire resistance level for integrity is the lesser of the values achieved for structural adequacy and insulation. That is, the required fire resistance for integrity is met if the level is met for structural adequacy and insulation.
4.1.3 Insulation

The fire resistance level for insulation is determined by the material thickness of the wall, as shown in the table below. The material thickness is a function of the type of masonry unit. Masonry units are classified as:

- **Solid or cored units**: If they have voids with a volume of less than 30%. This classification includes units with frogs. The material thickness for a solid or cored unit is the actual thickness of the units in the wall. For example, a 110mm solid or cored brick will give a 90 minutes fire resistance period for insulation, using the table above.

- **Hollow units**: If they have voids with a volume greater than 30%. The material thickness of a hollow unit is calculated as the net volume of the units divided by the area of the exposed unit. For example, the equivalent material thickness of a brick of dimensions 230mm x 119mm x 110mm containing 35% coring can be calculated as below:

<table>
<thead>
<tr>
<th>Material thickness (mm)</th>
<th>60</th>
<th>90</th>
<th>110</th>
<th>130</th>
<th>160</th>
<th>180</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire resistance period for insulation (mins)</td>
<td>30</td>
<td>60</td>
<td>90</td>
<td>120</td>
<td>180</td>
<td>240</td>
</tr>
</tbody>
</table>

**Solid or cored units**

If they have voids with a volume of less than 30%. This classification includes units with frogs. The material thickness for a solid or cored unit is the actual thickness of the units in the wall. For example, a 110mm solid or cored brick will give a 90 minutes fire resistance period for insulation, using the table above.

**Hollow units**

If they have voids with a volume greater than 30%. The material thickness of a hollow unit is calculated as the net volume of the units divided by the area of the exposed unit. For example, the equivalent material thickness of a brick of dimensions 230mm x 119mm x 110mm containing 35% coring can be calculated as below:

<table>
<thead>
<tr>
<th>Net volume = 230 x 119 x 110 x (100-35)%</th>
</tr>
</thead>
<tbody>
<tr>
<td>= 1956955mm³</td>
</tr>
<tr>
<td>Area of exposed vertical face of the unit</td>
</tr>
<tr>
<td>= 230 x 119 = 27370mm²</td>
</tr>
<tr>
<td>Equivalent material thickness = 1956955 / 27370</td>
</tr>
<tr>
<td>= 71.5mm</td>
</tr>
</tbody>
</table>

Therefore, the corresponding fire resistance period for insulation is 30 minutes (from the table above). In contrast, a solid or cored unit of the same size has the much higher value of 90 minutes. In addition, the type of wall impacts on the material thickness. For a single leaf wall the material thickness is based upon the type of unit used, as described previously. The material thickness for a cavity wall is equal to the sum of the material thicknesses of the separate leaves.

For example, the FRP for insulation for a cavity wall built with 90mm solid or cored bricks will be 240 minutes as the material thickness is 2 x 90mm = 180mm. Whereas, a single leaf of 90mm solid or cored bricks has a FRP of 60 minutes.

Note: the FRP is 240 minutes for materials with thicknesses over 180mm.

**Chasing and Recesses**

Chasing and recesses can affect the fire resistance periods for a wall. Refer to AS3700 or Think Brick Australia, Design Manual 5, Fire Resistant Levels for Clay Brick Walls for further details on when chasing and recesses must be considered.
4.2 Sound Rating

4.2.1 Acoustic Properties

Sound Transmission Measurements
The NCC requires that building elements have certain levels of insulation from airborne noise and impact sound. The weighted sound reduction index ($R_w$) describes the acoustic performance of a construction system. It is a single number quantity for the airborne sound insulation rating of building elements. As the acoustic performance of a material or construction improves, the higher the $R_w$ value will be.

$R_w$ ratings are determined by laboratory tests of a specimen of the construction system. The specimen is fixed within a frame to form the wall between two test chambers. A high noise level is generated in one room and the difference in sound level between the source room and the receiver room represents the transmission loss through the test specimen. The measurements are conducted over a range of sound frequencies. The $R_w$ rating is then determined by comparing the results with reference curves.

Correction factors ($C$ and $C_{tr}$) can be added to $R_w$ to take into account the characteristics of particular sound spectra and indicate the performance drop of the wall in the corresponding sound frequency range. The factor $C$ relates to mainly mid to high frequency noise, whilst $C_{tr}$ relates to lower to medium frequency noise. Some typical noises have been grouped by their corresponding correction factor in Table 3.

The weighted sound reduction index is quoted as $R_w(C,C_{tr})$. As an example, if a wall is measured as $R_w 54(-1,-4)$ the value of the index when the lower frequency correction factor ($C_{tr}$) is applied is:

$$R_w + C_{tr} = 54 + (-4) R_w + C_{tr} = 50.$$  

In practice, any small gaps and cracks which permit even minor air leakage will provide a means for sound transmission, leading to lower field performance. This degradation should be recognized and an appropriate allowance made when selecting a tested system to achieve a particular $R_w$ rating when installed.

The sound transmission class (STC) was the method that was used previously to measure acoustic performance. The requirements of the NCC have changed to comply with international regulations and $R_w$ is now used. The STC was based on different criteria and did not include any correction factors.

### Table 3 – Correction Factors

<table>
<thead>
<tr>
<th>Correction Factor</th>
<th>Type of Noise Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C$</td>
<td>Living activities (talking, music, radio, TV)</td>
</tr>
<tr>
<td></td>
<td>Railway traffic at high speeds</td>
</tr>
<tr>
<td></td>
<td>Highway road traffic (&gt;80km/h)</td>
</tr>
<tr>
<td></td>
<td>Jet aircraft at short distance</td>
</tr>
<tr>
<td></td>
<td>High and medium frequency factory noise</td>
</tr>
<tr>
<td>$C_{tr}$</td>
<td>Urban road traffic</td>
</tr>
<tr>
<td></td>
<td>Railway traffic at low speeds</td>
</tr>
<tr>
<td></td>
<td>Propeller driven aircraft</td>
</tr>
<tr>
<td></td>
<td>Jet aircraft at large distance</td>
</tr>
<tr>
<td></td>
<td>Low and medium frequency factory noise</td>
</tr>
</tbody>
</table>
4.2.2 Construction Details to Achieve Maximum Performance

For a wall to achieve its optimum acoustic performance, the construction must be solid without gaps through which air, and therefore sound, can pass. Masonry units must be laid with all joints filled solid including those between the masonry and any adjoining construction. Flanking transmission (through unfilled joints and gaps) is the major reason so many wall constructions fail to achieve their tested performance when in the field. Even a very small penetration will dramatically reduce the insulation performance of a wall. This is one reason why it is beneficial to finish masonry wall construction with render, or a cement-based paint. The render or paint acts as a sealant for the porous masonry and also fills any weaknesses in the mortar joints.

Another common sound path occurs at wall junctions such as at floor or ceiling level and also at the intersection with another wall. Larger voids should be solidly backfilled with mortar. However, where this is difficult to carry out successfully, an expanding foam sealant which is non-shrinking, durable and has a long life span, can be injected into the gap.

To maximize the acoustic performance of a masonry wall, it is important to avoid the following:

- gaps and cracks through which sound can pass
- gaps around service penetrations
- poorly sealed doorways
- back-to-back power outlets and cupboards
- chasing for services
4.3 National Construction Code (NCC) Requirements and Deemed to Satisfy Walls

4.3.1 NCC Requirements

The noise levels received from adjoining premises are dependant upon the level and type of noise generated and the acoustic performance of the construction between the two dwellings. The BCA requires that the $R_w$ and $R_w + C_w$ should be determined in accordance with AS/NZS 1276.1 using results from laboratory measurements.

The NCC classifications for acoustic performance are categorized based on the building type. Class 1 buildings include single dwellings that do not have another dwelling above or below it, such as a stand-alone house or a row of townhouses. Class 2 buildings include buildings that contain two or more sole-occupancy units, such as an apartment unit. Class 3 buildings include residential buildings that contain a number of unrelated persons, such as a guest house or the residential part of a school, hotel, etc. Aged care buildings are classified as Class 9c. The NCC should be referred to for more detail on these and other classifications.
4.3.2 Requirements for New South Wales, Victoria, South Australia, Tasmania and Western Australia

**Note:** These requirements came into effect from the 1st of May, 2004, except for Western Australia where they came into effect from the 1st of May, 2005.

Common walls separating Class 1 buildings are required to have an $R_w + C_{tr}$ of not less than 50. In addition, the construction must be discontinuous, if the wall separates a habitable room (living room, dining room, bedroom, study and the like) from a wet room (kitchen, bathroom, sanitary compartment or laundry). Discontinuous construction requires:

- A minimum 20mm cavity between two separate leaves
- If required, in masonry walls resilient wall ties such as those provided by Matrix Industries should be used, and
- No mechanical linkage if the leaves are not masonry.

Walls in Class 2 or 3 buildings that separate sole-occupancy units must have an $R_w$ of not less than 50. In addition, if the wall separates a habitable room in one sole-occupancy unit from a wet room in another sole-occupancy unit the construction must be discontinuous. The BCA also requires that walls in Class 2 or 3 buildings that separate a sole-occupancy unit from a plant room, lift shaft, public corridor, public lobby or the like must have an $R_w$ of not less than 50. If the wall separates the sole-occupancy unit from a plant room or a lift shaft, the construction must be discontinuous.

In Class 9c buildings, walls separating sole-occupancy units must have an $R_w$ of not less than 45. Walls separating a sole-occupancy unit in a Class 9c building from a kitchen, bathroom (not including an associated ensuite), laundry, plant room or utilities room must have an $R_w$ of not less than 45. In addition, walls separating a sole-occupancy unit from a laundry or a kitchen must have satisfactory impact sound resistance.

A summary of the BCA’s requirements is given below.

**Note:** Impact sound insulation is determined by laboratory testing. A ‘tapping machine’ is set to operate on a horizontal steel plate which rests against the test specimen. The sound transmission through the wall is then measured and normalized using a reference equivalent absorption area. Adequate impact sound insulation is achieved if the performance of the test specimen is equivalent to, or better than, the performance of deemed-to-satisfy construction under the same test conditions.

In addition, the BCA requires that soil and waste pipes in a Class 1, 2 or 3 building must have a minimum $R_w$ of 40 if adjacent to a habitable room (but not the kitchen). Or, a minimum $R_w$ of 25 if the pipes are adjacent to a kitchen, bathroom, laundry or the like.

---

<table>
<thead>
<tr>
<th>Building Class</th>
<th>Construction</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>Habitable - Habitable</td>
<td>$R_w + C_{tr} \geq 50$</td>
</tr>
<tr>
<td>Class 1</td>
<td>Habitable - Wet</td>
<td>$R_w + C_{tr} \geq 50$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>With discontinuous construction</td>
</tr>
<tr>
<td>Class 2 or 3</td>
<td>Habitable - Habitable</td>
<td>$R_w + C_{tr} \geq 50$</td>
</tr>
<tr>
<td>Class 2 or 3</td>
<td>Habitable - Wet</td>
<td>$R_w + C_{tr} \geq 50$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>With discontinuous construction</td>
</tr>
<tr>
<td>Class 2 or 3</td>
<td>Sole-Occupancy - Public Area</td>
<td>$R_w \geq 50$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>With discontinuous construction (if lift shaft or plant room)</td>
</tr>
<tr>
<td>Class 9c</td>
<td>Sole Occupancy Unity - Sole Occupancy Unit</td>
<td>$R_w \geq 45$</td>
</tr>
<tr>
<td>Class 9c</td>
<td>Sole Occupancy - Wet</td>
<td>$R_w \geq 45$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>With satisfactory impact resistance (refer to note) if laundry or kitchen.</td>
</tr>
</tbody>
</table>
4.3.3 Requirements for Queensland and the Northern Territory

Common walls separating Class 1 buildings in the Northern Territory or Queensland are required to have an $R_w$ of not less than 45 if the rooms separated are habitable. Whilst, a separating wall between a habitable room and a wet room is required to have an $R_w$ of not less than 50, with satisfactory impact resistance.

Walls in Class 2 or 3 buildings in the Northern Territory or in Queensland, that separate sole-occupancy units must have an $R_w$ of not less than 45. If the wall separates a habitable room in one sole-occupancy unit from a wet room in another sole-occupancy unit the construction must have an $R_w$ of not less than 50, with satisfactory impact resistance. The BCA also requires that walls in Class 2 or 3 buildings that separate a sole-occupancy unit from a plant room, lift shaft, stairway, public corridor, public lobby or the like must have an $R_w$ of not less than 45.

Walls separating sole-occupancy units in Class 9c buildings in the Northern Territory or Queensland, must have an $R_w$ of not less than 45. Walls separating a sole-occupancy unit in a Class 9c building from a kitchen, bathroom (not including an associated ensuite), laundry, plant room or utilities room must have an $R_w$ of not less than 45. In addition, walls separating a sole-occupancy unit from a laundry or kitchen must have satisfactory impact sound resistance.

A summary of the requirements for the Northern Territory and Queensland is given below.

**Note:** Impact sound insulation is determined by laboratory testing. A 'tapping machine' is set to operate on a horizontal steel plate which rests against the test specimen. The sound transmission through the wall is then measured and normalized using a reference equivalent absorption area. Adequate impact sound insulation is achieved if the performance of the test specimen is equivalent to, or better than, the performance of a cavity brick construction of two leaves of 90mm bricks under the same test conditions.

In addition, the BCA requires that soil and waste pipes in a Class 1, 2 or 3 building must have a minimum $R_w$ of 45 if adjacent to a habitable room (other than the kitchen). Or, a minimum $R_w$ of 30 if the pipes are adjacent to a kitchen, bathroom, laundry or the like.

<table>
<thead>
<tr>
<th>Building Class</th>
<th>Construction</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1, 2 or 3</td>
<td>Habitable - Habitable</td>
<td>$R_w \geq 45$</td>
</tr>
<tr>
<td>Class 1, 2 or 3</td>
<td></td>
<td>$R_w \geq 50$ With satisfactory impact resistance (refer to note)</td>
</tr>
<tr>
<td>Class 2 or 3</td>
<td></td>
<td>$R_w \geq 45$</td>
</tr>
<tr>
<td>Class 9c</td>
<td></td>
<td>$R_w \geq 45$ With satisfactory impact resistance (refer to note) if laundry or kitchen.</td>
</tr>
</tbody>
</table>
4.3.4 Achieving the Required Acoustic Performance

The performance requirement of the NCC can be satisfied by:

- Building a deemed-to-satisfy wall as specified in the NCC
- Demonstrating compliance by laboratory testing of an exact construction, or
- Demonstrating compliance by performing field testing

The $R_w$ figures presented in the following examples of deemed to satisfy walls are the lowest bound results. Further details of these walls can be found in the NCC. Walls built of specific clay bricks may have better performance, as indicated by the manufacturer from individual tests.

It is important to recognize that bricks from different manufacturers and manufactured in different plants give different results. To allow for these differences Austral Bricks test each state’s products separately.

As such, the results provided by Austral Bricks are specific only to the state in which they were tested and are not transferable to products manufactured outside that state or to another company’s products.

Direct fixing of plasterboard to single skin masonry walls reduces the acoustic performance of the walls. Plasterboard needs to be fixed on resilient mounted furring channels or on a separated stud wall on one side of the wall, to avoid deterioration of the $R_w$ rating.

Rendering one or both sides of a wall increases the $R_w$ rating primarily because the render seals the fine pores in the brickwork and eliminates partially filled mortar joints. In addition, a layer of 13mm render increases the mass of the wall thereby increasing the acoustic performance.

The application of a layer of 13mm render to one side of the wall is predicted to give an increase of 1 in the overall $R_w$ rating of the construction. In a CSIRO technical study, the tested performance was much better than this prediction, which indicates that factors other than just the mass of the structure play a part in the effect of applying a surface finish to a wall.

Once one side of a wall has been rendered, little acoustic benefit will be gained by rendering the other side. This is largely due to the fact that the relative increase in the mass is small compared to the overall mass of the structure and also because the initial benefit of sealing the pores of the brickwork has already been largely achieved by the first layer of render.

For highly porous masonry wall constructions, sealing one side with an application of a cement-based paint will also result in a noticeable increase in acoustic performance.
4.4 Sound Rating of NSW Common Bricks

**BCA Deemed to Satisfy Walls**

110mm
- Cavity wall.
- 50mm cavity.
- 13mm cement render both sides.
- Wall thickness: 296mm.
- Discontinuous construction.

$R_w + C_{tr} \geq 50$

**R\_w + C\_tr \geq 50 Test Results**

90mm - Maxi
- Solid wall.
- 10mm mortar core between two leaves.
- 12mm cement render both sides.
- Wall thickness: 214mm.

$R_w 56 (-1:-5)$
ATF Report 1609

90mm - Maxi
- Single skin bricks.
- 13mm plasterboard screw fixed to 64mm Rondo Steel Stud built 15mm from wall with 64mm track top and bottom with insulation both sides.
- Wall thickness: 274mm.
- Discontinuous construction.

$R_w 65 (-7:-14)$
ATF Report 1131

110mm - Standard
- Solid wall.
- 10mm mortar core between two leaves.
- 10mm plasterboard directly fixed both sides.
- Wall thickness: 250mm.

$R_w 54 (-2:-4)$
ATF Report 1612

110mm - Standard
- Solid wall.
- 10mm mortar core between two leaves.
- 10mm plasterboard directly fixed both sides.
- Wall thickness: 230mm.

$R_w 59 (-1:-5)$
ATF Report 1610
**110mm - Standard**
- Solid wall.
- 10mm mortar core between two leaves.
- 13mm cement render both sides.
- Wall thickness: 256mm.

*R_w 61 (-1;-5)*
ATF Report 1615

**110mm - Standard**
- Single skin bricks.
- 13mm plasterboard direct fixed one side.
- 13mm plasterboard screw fixed to 64mm Rando Steel Stud built 15mm from wall with 64mm track top and bottom with insulation on other side.
- Wall thickness: 215mm.
- Discontinuous construction.

*R_w 62 (-3;-9)*
ATF Report 1125

**110mm - Standard**
- Single skin bricks.
- 13mm plasterboard screw fixed to 64mm Rando Steel Stud built 15mm from wall with 64mm track top and bottom with 9kg/m² polyester insulation both sides.
- Wall thickness: 294mm.
- Discontinuous construction.

*R_w 70 (-5;-13)*
ATF Report 1123

**110mm - Dry Press**
- Cavity wall.
- 50mm cavity.
- Wall thickness: 270mm.
- Discontinuous construction.

*R_w 53 (-1;-3)*
ATF Report 1174

**110mm - Dry Press**
- Cavity wall.
- 40mm cavity.
- 10mm plasterboard direct fixed both sides.
- Wall thickness: 280mm.
- Discontinuous construction.

*R_w 54 (-1;-4)*
ATF Report 1463A

**110mm - Dry Press**
- Cavity wall.
- 50mm cavity.
- 13mm cement render both sides.
- Wall thickness: 296mm.
- Discontinuous construction.

*R_w 55 (-1;-4)*
ATF Report 1175

**150mm - TW**
- Single skin bricks.
- 12mm cement render both sides.
- Wall thickness: 174mm.

*R_w 55 (-1;-5)*
ATF Report 1596

**150mm - TW**
- Single skin bricks.
- 13mm sound resistant plasterboard direct fixed one side.
- 13mm sound resistant plasterboard screw fixed to resilient mounted furring channels with 9kg/m² polyester insulation on other side.
- Wall thickness: 217mm.

*R_w 60 (-2;-8)*
ATF Report 1595
110mm - Boxer LW

- Single skin bricks.
- 13mm fire-rated plasterboard direct fixed one side.
- 13mm fire-rated plasterboard screw fixed to 64mm steel stud built 20mm from wall with 64mm track top and bottom with Autex ASB5 insulation other side.
- Discontinuous construction.
- Wall thickness: 220mm.

\( R_w \geq 50 \) Test Results

90mm - Maxi

- Solid wall.
- 10mm mortar core between two leaves.
- Wall thickness: 190mm.

\( R_w \ 50 \ (-1;-5) \)
ATF Report 1607

90mm - Maxi

- Single skin bricks.
- 13mm plasterboard direct fixed one side.
- 13mm plasterboard screw fixed to 64mm Rondo Steel Stud built 15mm from wall with 64mm track top and bottom with 9kg/m³ polyester insulation on other side.
- Wall thickness: 195mm.
- Discontinuous construction.

\( R_w \ 57 \ (-2;-8) \)
ATF Report 1132

90mm - Maxi

- Cavity Wall
- 50mm cavity with no wall ties.
- 13mm render both sides
- Discontinuous construction.
- Wall thickness: 296mm.

\( R_w \ 58 \ (-1;-6) \)
Opinion PKA-A068

110mm - Boxer LW

- Single skin bricks.
- 13mm sound resistant plasterboard direct fixed both sides.

\( R_w \ 60 \ (-3;0) \)
Opinion PKA-A068

110mm - Boxer LW

- Cavity Wall
- 50mm cavity with no wall ties.
- 16mm fire-rated plasterboard direct fixed both sides.
- Discontinuous construction.
- Wall thickness: 302mm.

\( R_w \ 60 \ (-3;0) \)
Opinion PKA-A068

110mm - Standard

- Single skin bricks.
- 13mm plasterboard direct fixed one side.
- 13mm plasterboard screw fixed to resilient mounted furring channels with 9kg/m³ polyester insulation on other side.
- Wall thickness: 177mm.

\( R_w \ 53 \ (-4;-10) \)
ATF Report 951
110mm - Dry Press
• Single skin bricks.
• 12mm cement render both sides.
• Wall thickness: 134mm.

$R_w$ 52 (-1;-5)
ATF Report 1125

110mm - Dry Press
• Single skin bricks.
• 13mm plasterboard direct fixed one side.
• 13mm plasterboard screw fixed to resilient mounted furring channels with 9kg/m³ polyester insulation on other side.
• Wall thickness: 177mm.

$R_w$ 56 (-3;-9)
ATF Report 1391

150mm - TW
• Single skin bricks.
• Wall thickness: 150mm.

$R_w$ 50 (-1;-5)
ATF Report 1594

150mm - TW
• Single skin bricks.
• 13mm plasterboard direct fixed one side.
• 13mm plasterboard screw fixed to resilient mounted furring channels with 9kg/m³ polyester insulation on other side.
• Wall thickness: 217mm.

$R_w$ 56 (-2;-9)
ATF Report 1117

110mm - Boxer LW
• Single skin bricks.
• 10mm plasterboard direct fixed one side.
• 10mm plasterboard screw fixed to 64mm steel stud built 20mm from wall with 64mm track top and bottom with 9kg/m³ polyester insulation other side
• Discontinuous construction.
• Wall thickness: 214mm.

$R_w$ 56 (-2;-8)
ATF Report 1899
4.5 WA Utility Bricks

Test Results

90-50-90 cavity brick wall with resilient ties
- 13mm render with 2mm plaster set both sides
- Double 90mm Verticore brick (300 x 90 x 162h) with 37% core at 5.56 kg/brick
- 50mm cavity with Matrix resilient ties at 600mm centres

Results: \( R_w \) (-2; -4)  
\( R_w + C_n \), 55

90-70-90 cavity brick wall with resilient ties
- 13mm render with 2mm plaster set both sides
- Double 90mm Verticore brick (300 x 90 x 60h)
- 70mm cavity with Matrix resilient ties at 600mm centres

Results: \( R_w \) (-2; -6)  
\( R_w + C_n \), 55

90-50-90 insulated cavity brick wall with no ties
- 10mm render with 2mm plaster set both sides
- Double 90mm Verticore brick (300 x 90 x 162h) with 37% core at 5.56 Kg/brick
- 50mm cavity with 50mm Bradford Glass Wool Partition Batts (11 Kg/m³)

Results: \( R_w \) (-2; -6)  
\( R_w + C_n \), 55

90-70-90 cavity brick wall with no ties
- Double 90mm Verticore brick (300 x 90 x 60h)
- 70mm cavity with no ties
- Struck joints

Results: \( R_w \) 54 (-2; -4)  
\( R_w + C_n \), 50
90-70-90 rendered cavity brick wall with resilient ties

- 13mm render with 2mm plaster set both sides
- Double 90mm Verticore brick (300 x 90 x 162h) with 41% core at 5.0 Kg/brick
- 70mm cavity with Matrix resilient ties at 600mm centres

Results: $R_w$ (-1, -5)  
$R_w + C_n$ 55

90-70-90 cavity brick wall with no ties

- 13mm render with 2mm plaster set both sides
- Double 90mm Verticore brick density (305 x 90 x 60h)
- 70mm cavity with no ties

Results: $R_w$ 61 (-2, -6)  
$R_w + C_n$ 55

All tested to AS1191
DESIGN
CONSIDERATIONS
5.1 Design for Durability

5.1.1 General

For a structure to remain serviceable, it must be durable throughout its life, assuming a reasonable level of building maintenance is carried out. The main causes of durability failure are corrosion of embedded steel items and the effects of crystalline salts in the masonry. These salts can be absorbed from either the ground, or from materials such as the sand used in the mortar mix.

To ensure adequate serviceability, AS 3700 requires a structure to have the necessary durability to withstand the expected wear and deterioration throughout the intended life – typically 50 years, without the need for excessive maintenance. For any building element, the required durability depends on the exposure environment, the location within the building and the importance of the structure.

AS 3700 gives extensive deemed-to-satisfy solutions for each of the wall components and for a range of environmental conditions. In order to satisfy the requirements, each component must be graded in accordance with its respective durability. Durability requirements are stipulated for each combination of environment and location.

The exposure environments referred to in Table 5.1 of AS 3700 are as follows:

<table>
<thead>
<tr>
<th>Exposure Environment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe marine</td>
<td>Up to 100 metres from a non-surf coast and up to 1 km from a surf coast. The coast is defined as the mean high-water mark.</td>
</tr>
<tr>
<td>Marine</td>
<td>Between 100 metres and 1 km from a non-surf coast and between 1 kilometre and 10 kilometres from a surf coast. As before, the coast is defined as the mean high-water mark.</td>
</tr>
<tr>
<td>Industrial</td>
<td>Within 1 km of major industrial complexes producing significant acidic pollution.</td>
</tr>
<tr>
<td>Moderate</td>
<td>Areas within 50 km of the coast and more than 1 km from a non-surf coast, or 10 km from a surf coast. These are considered to be subject to light industrial pollution and/or very light marine influence.</td>
</tr>
<tr>
<td>Mild</td>
<td>Typically inland, more than 50 km from the coast and away from industrial areas. This environment has been subdivided as follows:</td>
</tr>
<tr>
<td></td>
<td>• Mild-tropical – within the tropical climatic zone (for example, Katherine and Mt Isa).</td>
</tr>
<tr>
<td></td>
<td>• Mild-temperate – within the temperate climatic zone (for example, Dubbo and Mildura).</td>
</tr>
<tr>
<td></td>
<td>• Mild-arid – within the arid climatic zone (for example, Alice Springs and Kalgoorlie).</td>
</tr>
</tbody>
</table>
5.1.2 Masonry units

When masonry units absorb moisture containing dissolved salts, damage can result when this moisture dries out. This damage can affect either the mortar joints (if the mortar is soft) or to the units, and sometimes to both.

The mechanism operating is that the dissolved salts crystallise just below the surface as the moisture evaporates and the growth of the crystals causes physical stresses leading to particles being dislodged from the surface; this is referred to as salt attack.

A standard salt cycling test is given in AS/NZS 4456.10 to measure the resistance of masonry units to salt attack. The available grades, in order of increasing resistance, are Protected, General Purpose and Exposure.

<table>
<thead>
<tr>
<th>Table 2 – Durability Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Protected Grade Bricks</strong> are usually used for internal walls above a damp-proof course.</td>
</tr>
<tr>
<td><strong>General Purpose Grade Bricks</strong> are suitable for use in external walls in mild exposure environments and normal (non-wet area) interior walls.</td>
</tr>
<tr>
<td><strong>Exposure Grade Bricks</strong> are suitable for saline environments and should always be used below the damp-proof course and in other locations of severe exposure.</td>
</tr>
</tbody>
</table>

Figure 1 – Salt attack damage to masonry unit

Figure 2 – Salt attack damage to mortar
5.1.3 Mortar

The resistance of mortar joints to degradation during the life of a building is related to surface hardness, which is strongly related to cement content. Low hardness will lead to progressive erosion of the surface of the joints by physical damage, wind action, insect attack and the effects of salt crystallisation.

Mortar is classified in AS 3700 as grades M1, M2, M3 or M4. These grades are used for durability requirements as well as for strength properties. Mortar of type M1 can only be used for restoration work to match existing construction and therefore has no corresponding durability provisions. Refer to Mortar section 2.5 in this manual for more details.

5.1.4 Ties, Connectors and Lintels

Wall ties are readily available for a range of exposure environments in galvanised steel, stainless steel and polymer. Designers and specifiers should consider carefully the consequences of failure during the design life of the building and choose the materials accordingly. The cost to replace these items should they fail is far more expensive than their original cost and therefore should not be considered in any cost saving scenarios.

Wall ties and other built-in components such as connectors for control joints, connectors for attachment of masonry to building frames, and lintels, are required to have a rating for durability (called a durability class). The durability ratings required by AS 3700 are R0, R1, R2, R3, R4 and R5. Table 5.1 in AS 3700 sets out the required durability rating for each exposure environment and location using the symbols R0 to R5.

Durability class R5 is intended for critical applications in special situations such as tidal and splash zones or areas of heavy chemical pollution. No test criteria or deemed to-satisfy solutions are given for the R5 rating.

Wall ties manufactured from non-metallic materials such as polymers are also available and can be used provided they have been shown to satisfy the exposure conditions set out in AS/NZS 2699.1 corresponding to the requirements of AS 3700.

AS/NZ 2699.1 requires all ties to be marked on the packaging and on individual ties with the durability rating. For the packaging, this must consist of a reference to AS/NZS 2699.1 and a rating (R0 to R5). For individual ties, they should be stamped with 0 to 4, indicating the corresponding rating R0 to R4, or colour coded as follows:

Table 3 – Tie Durability Rating

<table>
<thead>
<tr>
<th>Rating</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>R0 and R1</td>
<td>green</td>
</tr>
<tr>
<td>R2</td>
<td>yellow</td>
</tr>
<tr>
<td>R3</td>
<td>red</td>
</tr>
<tr>
<td>R4</td>
<td>white or blue</td>
</tr>
</tbody>
</table>

5.1.5 Reinforcement

Reinforcing bars can be provided with a corrosion resistant coating to achieve the required durability rating, but will usually rely on a minimum grout cover to ensure an acceptable level of resistance. Refer to Table 5.1 in AS 3700 for full details.

Reinforcement embedded in mortar joints must have corrosion protection to achieve a durability rating of R0 to R5, as for ties and accessories, plus a minimum cover of 15mm of mortar to the outside of the masonry. The requirement for separate protection to provide the durability rating is in recognition of the fact that mortar does not give the same degree of protection to the steel as does the cement-rich grout. Clause 5.9 of AS 3700 provides guidance on reinforcement in mortar joints and unbonded tendons.

For further information on Durability, please refer to Section 7 of the Think Brick Australia manual 7, Design of Clay Masonry for Servicability.
5.2 Robustness of Brickwork

5.2.1 Design Principles

AS 3700 requires masonry members and their connections to have an adequate degree of robustness, regardless of the level of load to which they are subjected to.

Walls
The principle is that even if a wall is designed to satisfy all the prescribed loads, it should not be so slender as to fail under some unintended or accidental load and it should have adequate stiffness. If the wall is capable of withstanding a minimum level of lateral load of 0.5 kPa, it is deemed to have the necessary robustness.

Consideration must be given to the effects of chasing and door or window openings in a wall when assessing robustness. The edge of an opening is usually considered to be an unrestrained edge of the wall.

Piers
Unreinforced isolated piers are more vulnerable than walls and the limiting slenderness ration for an isolated pier is therefore approximately half the value of a similar wall. A pier usually has both length and width less than one-fifth of the height.

Robustness of isolated piers is controlled by an equation, which gives a limit on height for one-way spanning members as follows:

\[ H \leq \frac{C_v \cdot t_r}{t_r} \]

Where

- \(H\) = Clear height of the member (in metres)
- \(t_r\) = minimum thickness of the member
- \(C_v\) = Robustness coefficient for vertical span. For piers unreinforced vertically – 13.5. For piers reinforced vertically or pre-stressed - 30.

The stiffening action of engaged piers is only taken into account for walls in pure vertically spanning walls. Even then, the piers must be quite substantial before they are effective. Note that an engaged pier has insufficient strength and stiffness to provide lateral support to the wall. Both leaves of a cavity wall are considered to act together for the purposes of robustness, unlike for compressive strength design.

The charts for walls with side support (leading to two way bending) show a smooth curve, unlike the cases with only top and bottom support, and this recognises the importance and effect of having at least one vertical support to stabilise the wall.
5.2.2 Limiting dimensions for robustness

The following charts show limiting heights and lengths for single leaf and cavity walls constructed with clay masonry units of common sizes. Support conditions and the applicable slenderness coefficients are indicated by an icon on each chart.

Where the icon shows hatching along an edge, the corresponding edge of the wall is laterally supported.

The chart for walls supported only at the top and bottom (chart 5) show the transition to limiting heights for isolated piers when the length falls below five times the thickness at the left-hand side.

For further information on Robustness, please refer to section 8 of the Think Brick Australia manual 7, Design of Clay Masonry for Servicability.

Chart 1 – Wall is laterally supported from both ends and the top
Chart 2 – Wall is laterally supported from both ends only

Chart 3 – Wall is laterally supported from one end and the top
Chart 4 – Wall is laterally supported from one end only

Chart 5 – Wall is laterally supported from the top only
5.3 Design to Avoid Cracking

5.3.1 General

To avoid cracking in masonry work, the use of both effective tying and support in addition to correct masonry detailing must occur. Assuming the quality of the masonry is adequate, cracking can be avoided by the provision of various forms of control joints and adequate detailing. The positioning of the joints will depend upon the movements for which they are inserted, and in many cases can compensate for several types of movements.

5.3.2 Locations of articulation joints

Articulation joints are used in conjunction with a foundation to control the effects of ground movements. The joints articulate the masonry components of the building into separate elements, which undergo movement as the footing deflects, without causing distress in the masonry. The more flexible the footing, or the more vulnerable the surface finish is to cracking, the closer the required spacing of the joints will be. Articulation not only aids in minimising wall cracks, but all helps reduce the likelihood of windows or doors jamming due to foundation movements.

Placement of articulation joints is based on the conditions and also the proposed joint width. Joints should also be included at positions where potential concentrations or variations in the wall stresses might occur, for example at changes in wall height and thickness, at window and door openings, and at the intersection of dissimilar materials.

Articulation joints might also be required for internal walls. With good planning, the joints can be incorporated at full height openings such as doorways.

Where joints are unavoidable, for example in long unbroken lengths of wall, they should be of the same form as joints in the external walls.

Figure 3 – Effect of foundation movement on articulated walls (doming foundation)

Figure 4 – Effect of foundation movement on articulated walls (dishing foundation)
Articulation joints might also be required for internal walls. With good planning, the joints can be incorporated at full height openings such as doorways. Where joints are unavoidable, for example in long unbroken lengths of wall, they should be of the same form as joints in the external walls.

Table 4 – Recommended maximum spacing of 10mm wide articulation joints in walls up to 2.7m high.

<table>
<thead>
<tr>
<th>Site Class</th>
<th>Masonry Wall Construction</th>
<th>Joint Spacing (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A and S</td>
<td>Any</td>
<td>Not Required</td>
</tr>
<tr>
<td>M, M-D</td>
<td>Face finish or sheeted</td>
<td>6.5</td>
</tr>
<tr>
<td>H1, H1-D</td>
<td>Rendered and/or paint finish</td>
<td>6.0</td>
</tr>
<tr>
<td>H2, H2-D</td>
<td>Face finish or sheeted</td>
<td>6.0</td>
</tr>
<tr>
<td>E</td>
<td>Rendered and/or paint finish</td>
<td>5.5</td>
</tr>
<tr>
<td>All</td>
<td>Engineering Assessment Required</td>
<td>5.5</td>
</tr>
</tbody>
</table>

Site classes are as follows (refer AS 2870)

A = Most sand and rock sites
S = Most silt and some clay sites
M = Moderately reactive clay sites
D = Dense reactive clay sites
H1 = Highly reactive clay sites with high ground movement due to moisture changes
H2 = Highly reactive clay sites with very high ground movement due to moisture changes
E = Extremely reactive clay sites

For E class sites, a footing design prepared by an engineer is required together with a complementary articulation joint spacing.

This is a summary covering simple cases for more information; refer to AS 3700, AS 4773.1 and CCAA TN 61.
5.3.3 Detailing of articulation joints

Articulation joints must be capable of expanding or contracting inline with the walls. The joint is usually packed with a compressible filler to provide a backing for the flexible sealant compound applied to the surface of the joint.

Alternatively, a circular polyethylene backer-rod can be used as backing for the sealant. It is extremely important that the joint be free of mortar droppings or other obstructions that will impede the closing of the joint.

Flexible masonry anchors should be installed between the masonry panels on either side of the joint. These anchors are capable of transmitting shear forces across the joint from loads normal to the wall, but still allow the joint to open or close.

In many cases, articulation joints will also serve as expansion or contraction joints. In clay masonry walls, brick growth will occur over time and tend to close the joint. The initial joint size must allow for this effect and would usually be larger than the common 10 mm joint width. A width of 20 mm would be a typical for this situation, but should be determined by considering the need for control joints.

The use of full height openings for doors and windows is an effective means of articulation. Full height windows, or windows with infill panels below the sill, eliminate the need to form an articulation joint in the masonry. Openings for external doors should also be the full height of the wall if possible. Full height door openings provide an excellent location for articulation joints, which can be covered by the architraves.

5.3.4 Control joints

Control joints are required in clay masonry to relieve the effects of long-term expansion of the units. The detailing of these joints is similar to that for articulation joints.

Brick growth or expansion is irreversible and takes place in both the horizontal and vertical direction. Control joints must therefore be inserted to absorb this expansion and avoid damage to the masonry. Corners are particularly prone to damage as the growth occurs in orthogonal directions in the two intersecting walls. For this reason, a control joint should be located at or near a corner if long lengths of brickwork are involved.

For further information on how to avoid cracking in your masonry work, please refer to section 4-6 of the Think Brick Australia Manual 7, Detailing of Clay Masonry for Servicability.
5.4 Design Considerations of Designa Basalt

Designa Basalt can be used as an external cladding material in a brick veneer or a cavity wall. Wall ties are used to secure the Designa Basalt to either the building frame or to another layer of masonry. Typical details are shown below.

In general, wall ties must have 50mm embedment and 15mm cover to external surface of mortar. To achieve this with a 40 to 50mm cavity the maximum raking permitted is 5mm.

When face fixed ties are used, they are to be screw fixed. Alternatively, side fixed ties can be screw or nail fixed.

In a stretcher bonded brick veneer wall or a cavity wall, wall ties must be installed at maximum 600mm centres both horizontally and vertically. In a stack bonded brick veneer wall or a cavity wall, wall ties must be installed at maximum 450mm centres horizontally.

Cavity Brick

![Typical Eave Detail](image1)

**Figure 6 – Typical Eave Detail**

- **SELECTED TILE ROOF**
- **SELECTED GUTTER AND FASCIA**
- **BOXED EAVES**
- **470x70x76 FACE DESIGNA BASALT BRICKWORK**
- **EAVES TRIMMER**
- **RAFTER**
- **CEILING JOIST**
- **EXTERNAL**
- **INTERNAL**

Brick Veneer

![Typical Eave Detail](image2)

**Figure 8 – Typical Eave Detail**

- **SELECTED TILE ROOF**
- **SELECTED GUTTER AND FASCIA**
- **BOXED EAVES**
- **470x70x76 FACE DESIGNA BASALT BRICKWORK**
- **EAVES TRIMMER**
- **RAFTER**
- **CEILING JOIST**
- **EXTERNAL**
- **INTERNAL**

**Figure 7 – Typical Footing Connection**

- **GROUND LINE CONCRETE**
- **FLASHING / DPC**
- **470x70x76 FACE DESIGNA BASALT BRICKWORK**
- **FLAMING / DPC**
- **EXTERNAL**
- **INTERNAL**

**Figure 9 – Typical Footing Connection**

- **GROUND LINE CONCRETE**
- **FLASHING / DPC**
- **470x70x76 FACE DESIGNA BASALT BRICKWORK**
- **FLAMING / DPC**
- **EXTERNAL**
- **INTERNAL**
Wall Tie Requirements

In a stretcher bonded brick veneer wall or cavity wall, when wall ties are placed at a vertical spacing of 600mm centres, the grade of wall ties in each wind class is dictated by their horizontal spacing as shown below.

Table 5 – Wall Tie Spacing - 600mm vertical centres

<table>
<thead>
<tr>
<th>Wind class</th>
<th>General area</th>
<th>Within 1200mm of corners</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>300</td>
<td>450</td>
</tr>
<tr>
<td>N1</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>N2</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>N3</td>
<td>M</td>
<td>H</td>
</tr>
<tr>
<td>N4/C1</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>N5/C2</td>
<td>H</td>
<td>-</td>
</tr>
<tr>
<td>N6/C3</td>
<td>H</td>
<td>-</td>
</tr>
<tr>
<td>C4</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: “L” = light duty, “M” = medium duty, “H” = heavy duty, “-” = no ties suitable.
Refer to Table 3.5 of AS 3700 for mean tie strength for each duty rating.

Figure 10 – Example showing bed course location for wall ties placed at a vertical spacing of 600mm centres and a horizontal spacing of 450mm centres

76mm Designa Basalt

162mm Designa Basalt

Wall ties should be placed every 7th course for the 76mm Designa Basalt

Wall ties should be placed every 3rd course for the 162mm Designa Basalt
In a stretcher bonded brick veneer wall or cavity wall, when wall ties are placed at a vertical spacing of 450mm centres, the grade of wall ties in each wind class region is dictated by their horizontal spacing as shown below.

Table 6 – Wall Tie Spacing - 450mm vertical centres

<table>
<thead>
<tr>
<th>Wind class</th>
<th>General area</th>
<th>Within 1200mm of corners</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>300</td>
<td>450</td>
</tr>
<tr>
<td>N1</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>N2</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>N3</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>N4/C1</td>
<td>M</td>
<td>H</td>
</tr>
<tr>
<td>N5/C2</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>N6/C3</td>
<td>H</td>
<td>-</td>
</tr>
<tr>
<td>C4</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: “L” = light duty; “M” = medium duty; “H” = heavy duty; “-” = no ties suitable.
Refer to Table 3.5 of AS 3700 for mean tie strength for each duty rating.

Figure 11 – Example showing bed course location for wall ties placed at a vertical spacing of 450mm centres and a horizontal spacing of 600mm centres.

76mm Designa Basalt

Wall ties should be placed every 5th course for the 76mm Designa Basalt

162mm Designa Basalt

Wall ties should be placed every 2nd course for the 162mm Designa Basalt
For stack bond, horizontal spacing of wall ties must be limited to one tie every 450 mm. The grade of wall ties in each wind class region is dictated by their vertical spacing as shown below:

Table 7 – Wall Tie Spacing - 450mm vertical centres and 450mm horizontal centres

<table>
<thead>
<tr>
<th>Wind Class</th>
<th>General area</th>
<th>Within 1200mm of corners</th>
<th>General area</th>
<th>Within 1200mm of corners</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1</td>
<td>M</td>
<td>M</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>N2</td>
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<td>N3</td>
<td>H</td>
<td>H</td>
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<td>H</td>
</tr>
<tr>
<td>N4/C1</td>
<td>H</td>
<td>-</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>N5/C2</td>
<td>-</td>
<td>-</td>
<td>H</td>
<td>-</td>
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<td>N6/C3</td>
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<td>-</td>
</tr>
<tr>
<td>C4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: "L" = light duty, "M" = medium duty, "H" = heavy duty, "-" = no ties suitable.
Refer to Table 3.5 of AS 3700 for mean tie strength for each duty rating.

Figure 12 – Example showing bed course location for wall ties placed at a vertical spacing of 450mm centres and a maximum horizontal spacing of 450mm centres

Wall ties should be placed every 5th course for the 76mm Designa Basalt

Wall ties should be placed every 2nd course for the 162mm Designa Basalt
**Internal non-loadbearing wall**
Designa Basalt at 70mm thick cannot be used as a single leaf internal wall. Internal non-loadbearing walls need to satisfy the 0.5kPa lateral load requirements as set out in AS 3700. To satisfy this requirement, Designa Basalt must be constructed as a solid wall combined with a 90mm brick. Typical details are shown below.

**Figure 13 – Typical Internal Wall Suspended Slab Detail**

**Figure 14 – Typical Internal Wall Detail**
**Internal Wall Design**
When Designa Basalt is laid as a solid wall combined with regular 90mm bricks in a stretcher bond manner, the dimensions of the wall are dictated by the amount of support the wall has.

Consult graph 1-5 for the dimensions of the walls. For stack bond, only graph 1 “Laterally supported top only” applies.

**Chart 6** – Wall is laterally supported from the top only

![Chart 6](image)

**Chart 7** – Wall is laterally supported from both ends and the top

![Chart 7](image)
Chart 8 – Wall is laterally supported from both ends only

Laterally supported both sides, top free

Chart 9 – Wall is laterally supported from one end and the top

Laterally supported one end and top
Chart 10 – Wall is laterally supported from one end only
5.5 Armabeam Clay Brick Lintels
(Available in Western Australia only)

The strength of a fired clay product ensures compatibility with rendered surfaces and reduces the possibility of cracking. Perfect for construction in the coastal areas of Western Australia.

ARMABEAM clay brick lintels are ideal for both domestic and commercial applications, and are intended for use in single-storey constructions or in the uppermost storey of multi-storey constructions.

ARMABEAM is a composite construction of cored clay brick, concrete and galvanised deformed reinforcing bar.

The application of ARMABEAM is subject to loading requirements. (Subject to your engineer’s or builder’s specification).

* Minimum overhang 150mm. Recommended 230mm.

Please note: Beware of non-galvanised lintels! Builders using non-galvanised lintels run the risk of non-compliance with building codes and the possibility of litigation.

Table 8 – Standard lintel sizes

<table>
<thead>
<tr>
<th>No. of clay bricks in lintel</th>
<th>Overall lintel length (m)</th>
<th>Weight (kg)</th>
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</thead>
<tbody>
<tr>
<td>3</td>
<td>0.935</td>
<td>28</td>
</tr>
<tr>
<td>3.4</td>
<td>1.080</td>
<td>32</td>
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<tr>
<td>3.5</td>
<td>1.110</td>
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<td>3.7</td>
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</tr>
<tr>
<td>4</td>
<td>1.250</td>
<td>37</td>
</tr>
<tr>
<td>5</td>
<td>1.565</td>
<td>46</td>
</tr>
<tr>
<td>6</td>
<td>1.880</td>
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<td>7</td>
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<td>9</td>
<td>2.825</td>
<td>84</td>
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<tr>
<td>10</td>
<td>3.140</td>
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</table>
The following values do not allow for any brick wastage. It is recommended that you allow approximately 5% extra to cover this.

Table 9 – Brick estimator

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<th>Brick Dimensions</th>
<th>Number of Bricks</th>
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<td>48.5</td>
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<tr>
<td>230 x 110 x 119</td>
<td>32.3</td>
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<tr>
<td>230 x 110 x 162</td>
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<tr>
<td>290 x 90 x 76</td>
<td>38.8</td>
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</tr>
<tr>
<td>290 x 90 x 119</td>
<td>25.8</td>
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<tr>
<td>290 x 90 x 162</td>
<td>19.4</td>
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<tr>
<td>305 x 90 x 76</td>
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<tr>
<td>305 x 90 x 162</td>
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## 5.7 Brick Coursing Heights

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<th>119mm</th>
<th>162mm</th>
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</table>

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## 5.8 Brick Gauge

### 5.8.1 230mm Long Bricks

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<th>Length (mm)</th>
<th>Opening (mm)</th>
<th>No. of Bricks</th>
<th>Length (mm)</th>
<th>Opening (mm)</th>
<th>No. of Bricks</th>
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### 5.8.2 290mm Long Bricks

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### Design Considerations

The table above provides the dimensions for 290mm long bricks, detailing the number of bricks, length, and opening in millimeters. These specifications are crucial for architectural planning and construction, ensuring that the bricks fit accurately within the intended structures. The table is comprehensive, covering a range from 1 to 50 no. of bricks, with corresponding length and opening values to facilitate precise measurements and planning. This information is vital for architects and builders to ensure structural integrity and aesthetic appeal of the final construction. The care taken in detailing these dimensions reflects the precision required in brickwork, highlighting the importance of accurate measurement and planning in the building process.
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Manufacturing Size: 305 x 90 x 162mm
Vertical Gauge: 7 courses to 1200
(Bricks per m² in wall = 18.5 approx)
### 5.8.5 Face Block

**Format Size** 300 x 100 x 172  
**Manufacturing Size** 290 x 90 x 162  
**Vertical Gauge** 7 courses to 1200  

(Bricks per m² in wall = 19.5 approx)

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5.8.6 Peninsula Brick

Format Size: 300 x 100 x 172mm
Manufacturing Size: 290 x 90 x 162mm
Vertical Gauge: 7 courses to 1200

(Bricks per m² in wall = 19.5 approx)

HALF BOND COURSING

Peninsula

Corner Pier to Opening
- Is a brick run starting with a 240mm cut
- The 240mm cut is considered as one brick in the ‘No. Bricks’ column.
- 1/2 brick represents 140mm cut brick

Note: Cnr pier to opening refers to a 240mm cut being used on every course on every corner and the use of 140mm cuts for openings to maintain 1/2 bond.

Overall Opening
Is the same calculation as cnr pier, but it includes 100mm which is including a 90mm header return and 10mm mortar joint.

Modular 76
If building with Modular 76 bricks, use height dimensions from Standard brick chart. For length dimensions, use Armaclay/Verticore brick chart. (Bricks per m² in wall = 37 approx)
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*Brickworks*

Brickworks Building Products is one of Australia's largest and most diverse building material manufacturers. Under the Brickworks Building Products umbrella are some of Australia's best known building materials brands. Our products include bricks, pavers, masonry blocks, retaining wall systems, precast concrete panels, concrete and terracotta roof tiles, timber products, terracotta façades and specialised building systems.

With a broad product portfolio and manufacturing and sales facilities across Australia, Brickworks Building Products is uniquely placed to service the demands of the building industry.

With over 1200 staff across Australia and New Zealand, we pride ourselves on our commitment to product, service excellence and our leadership position.