THINK BRICK AUSTRALIA

Manual 19

# Industry Reference Guide

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**Cover:** Learning & Teaching Building Monash University - Clayton Campus by John Wardle Architects. Joint Winner - Horbury Hunt Commercial Award 2018.

The Learning and Teaching Building (LTB) for Monash University is a multi-faculty learning facility that serves a significant proportion of the student teaching load for the Clayton campus. The interior forms and materiality reflect a blurring of interior and exterior spaces, and between building and campus. Streets, courtyards, bridges, balconies and stairs are transformed into ravines, clearings, strands, perches, nests and amphitheatres that are choreographed to make an interior landscape. The forms of the brick towers within the interior serve to frame spaces. They are also reminiscent of other brick structures. They share their tapering and curvilinear character with the pottery kilns of Stoke-on-Trent in England, for example. This reference to an industrial landscape suggests the process of firing, which starts with malleable clay and is abstractly akin to the process of learning. The custom extruded brick elements are striking visual markers that extend the materiality of the ground plane upward. They draw the eye toward the sawtooth roof and skylights above, while accommodating a range of formal and informal learning spaces inside.

**Architect:** John Wardle Architects
**Manufacturer:** Krause Bricks
**Brick collection:** Bespoke
**Builder:** Multiplex
**Contractor:** Byrne Construction Systems
**Photography Credit:** Trevor Mein

THINK BRICK AUSTRALIA

PO Box 275 St. Leonards NSW 1590
Suite 7.01, Level 7, Pacific Highway St. Leonards NSW 2065, Australia
Telephone +612 8448 5500 **Technical hotline** 1300 667 617
ABN 300 0387 3309

**www.thinkbrick.com.au**

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# 1. Masonry Units

## 1.1 The role of Australian standards

Three Australian Standards supply the framework for defining and testing masonry units and their use in structures:

- AS 3700 Masonry Structures provides the basic rules for the design and construction of masonry structures.
- The masonry unit standard, AS/NZS 4455 Masonry Units, Pavers and Flags has three parts – Masonry Units, Pavers, Retaining Wall Units – that encompass all masonry units (fired clay, concrete, calcium silicate, autoclaved aerated concrete and dimension stone) and most segmental pavers. (It does not cover mud bricks and other similar unfired products.) In accordance with the general intent of AS 3700, there are no specific performance requirements apart from some basic product requirements such as strength, dimensional deviations and integrity.
- This standard is complemented by AS/NZS 4456 Masonry Units, Pavers and Flags – Methods of Test that describes the test methods for the determination of 16 properties of masonry units and pavers, as well as sampling procedures and the assessment of the mean and standard deviation of test results.

The standards covering the properties of building products such as bricks and blocks are written so as to describe the properties of the materials concerned. They provide test methods to determine the properties; however, they generally do not set limits of performance. It is the designer's responsibility to specify the performance level required of the units selected for a given project.

Not all the tests described in AS 4456 are required to be specified. AS 3700 or the project contract sets out the tests and properties required in each case.

## 1.2 What is a masonry unit?

Whereas earlier Australian standards specifically defined bricks in terms of their shape and maximum volume, no such definition exists in AS/NZS 4455. For inclusion in this standard, the only limitation is that face area of masonry unit must not exceed 0.1m$^2$ (about six times the face area of a traditional-size brick). However, the standard does define a number of masonry unit configurations:

a. **Solid unit –** a unit with less than 10 percent recesses and that is intended to be laid with full bed joints.

b. **Cored unit –** a unit intended to be laid with its cores vertical, with full bed joints.

c. **Hollow units –** a cored unit intended to be laid with its cores vertical and with face-shellbedded joints.

d. **Horizontally-cored unit –** a cored unit intended to be laid with its cores horizontal and with full bed joints

e. **Special purpose unit –** a unit intended for a special purpose that does not fall within the definitions of items (a to d) above.

Note that according to section 6.5.2 of AS 3700, the material thickness of cored units with 30 percent or less perforations is accepted as identical to solid units for the purpose of insulation for fire resistance.

## 1.3 Specifying essential qualities

Brick standards have not provided guidance on the classification of bricks according to appearance since 1984. However, when it comes to ordering, it is still common in the trade to describe bricks as first, second or common quality.

The previous standard set out a general principle regarding quality, namely that the basic standard should specify only the essential properties that should be common to all bricks. Other more stringent requirements that might be complied with – such as strength, greater precision, particular colour and textures – should be specified by the purchaser as required.

This principle was retained in AS/NZS 4455.1 and described in Appendix D, Purchasing Guidelines in which it recommends that "the colour, texture (including the acceptable extent of surface irregularities after handling during delivery) and regularity of size or shape requirements of masonry units be specified by the purchaser when ordering in terms of agreed sample, where possible, no fewer than three units representing the total range of acceptable variation."

A manufacturer's display panels should be indicative of the expected quality and appearance of a specific product.

## 1.4 Essential physical properties

### 1.4.1 Integrity

The integrity of units (put simply, their ability to remain whole) must be such that they can be handled and transported to the purchaser and be laid so as to fulfil their intended structural and protective functions.

For solid or cored bricks this requirement is deemed to be satisfied if the characteristic unconfined compressive strength is at least 2.5 and 3.0 MPa respectively. For hollow masonry units, this requirement is deemed to be satisfied if the average measurements of each part of five random-sampled units (measured at the same positions on each of the units) are not less than the values given in Table 2.2 of AS/NZS 4455.1.

### 1.4.2 Dimensions and tolerances

**General**

Section 2.1 of AS/NZS 4455.1 requires the suppliers of masonry units to make available the work size for all units and the face shell width for hollow units.

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. The relevant tolerances for each of these categories are shown here as Table 1.

The work size is the manufactured size from which dimensional deviations (or tolerances) are measured. For example, if a particular production type was consistently undersized, the work size should be declared accordingly, for example, 228 x 109 x 75 mm. The work size of a traditional clay brick is 230 x 110 x 76 mm and metric modular units are 290 x 90 x 90 mm. Some manufacturers may make other sizes.

**Table 1.** Dimentional deviations of masonry units

| Category | Work size dimensions, mm | | |
|---|---|---|---|
| | Under 150mm (for example, width & height) | 150 to 250mm (for example, length) | Over 250mm (for example, length of modular bricks or blocks) |
| DW0 | No requirement | | |
| DW1* | ± 50 | ±90 | ±100 |
| DW2* | ±40 | ±60 | ±70 |
| DW3 | By agreement between supplier and purchaser | | |
| DW4 ** | Standard deviation of not more than 2 mm and the difference between the mean and the work size of not more than 3 mm. | | |

* As determined by the cumulative method over 20 units

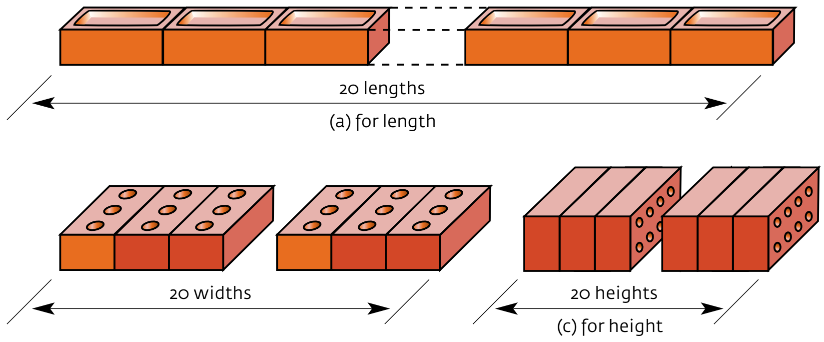
**As determined from the individual dimensions of 20 units (Method B of AS/NZ 4456.3)

### Determining dimensions by cumulative measurement

AS/NZS 4456.3 Determining Dimensions provides two methods for measuring the dimensions of masonry units. It is the manufacturer's right to nominate the method appropriate to their manufacturing process and quality assurance program.

Generally, the cumulative measurement method described in Method A of AS/NZS 4456.3 is the most appropriate for fired clay masonry. It is easy to apply, requiring the measurement of the overall length, width and height of 20 units placed side by side in a straight line (Figure 1).

**Figure 1.** Measuring cumulative dimensions




### Compliance

Unless by prior agreement to the contrary, all masonry units are expected to comply with category DW1, no tolerances apply (category DW0) where the intended surface character of the overall unit is irregular or rough, for example, tumbled or sandstock style bricks.

Where it is intended that only a face or faces of the unit are irregular; textured or rock face bricks, for example, the length and height of such units has to comply with category DW1. In this circumstance, there are no width tolerance requirements other than that the average width has to be at least 90 percent of the declared work size.

Supply of units to the closer tolerances such as in category DW2, DW3 and DW4 must be negotiated with the supplier. Some types of units may not be available to those tolerances.

Compliance with category DW4 is determined by measuring the individual dimensions corresponding to each of the three principal work sizes as described by Method B in AS/NZS 4456.3.

### 1.4.3 Strength

Section 2.1 of AS/NZS 4455.1 requires the suppliers of masonry units to make available the characteristic unconfined compressive strength for all units. This property, when coupled with the mortar strength (see Section 2.4), determines the ultimate compressive strength of the brickwork.

Note that the term 'characteristic compressive strength' is no longer in use. AS 3700 and AS/NZS 4455 requires designers to use the characteristic unconfined compressive strength (abbreviated to f'uc). For traditional size bricks, the (current) characteristic unconfined compressive strength is approximately 60 percent of the (superseded) compressive strength.

The test method requires that a correction factor (based on the aspect or height-to-thickness ratio) be applied to test results, allowing the reported result to be applied directly in design considerations without the need for further calculations. Some typical values of characteristic unconfined compressive strength are shown in Table 2.

**Table 2.** Typical characteristic unconfined compressive strengths (confined and unconfined) for Australian fired clay masonry

| Place and method of manufacture | Typical characteristic unconfined compressive strength ($f'_{uc}$) (MPa) | Range (MPa) |
|---|---|---|
| **New South Wales** | | |
| Extruded | 25 | 10–50 |
| Pressed | 15 | 10–35 |
| **Queensland** | | |
| Extruded | 15 | 10–25 |
| Pressed | 13 | 5–25 |
| **South Australia** | | |
| Extruded | 25 | 15–45 |
| Pressed | 20 | 15–25 |
| **Tasmania** | | |
| Extruded | 20 | 10–50 |
| **Victoria** | | |
| Extruded | 35 | 10–60 |
| Pressed | 25 | 15–40 |
| **Western Australia** | | |
| Extruded | 15 | 10–35 |

Note: The figures in this table are for general information only and should not be used for specific applications.

## 1.5 Other physical properties

### 1.5.1 Durability

Both the National Construction Code (NCC) Volume Two, Housing Provisions and Australian Standard AS 3700 Masonry Structures define the environments, in terms of varying severity, in which the appropriate brick, mortar, and fittings (such as wall ties and lintels) must be used.

The NCC defines the environment with three exposure classifications for brick. Hence bricks must be classified on the basis of their ability to withstand the effects of these environments.

**Exposure Grade (EXP):**

- Below the DPC in areas where walls are expected to be attacked by salts in the ground.
- On sea fronts where walls are exposed to attack from salt spray.
- In retaining walls.

**General Purpose (GP):**

- All areas except Exposure Grade

**Protected (PRO):**

- Suitable for use above damp proof course provided they are protected at the top of the wall by appropriate roofs, eaves, copings or toppings in internal walls or coated/rendered external walls.

Table 5.1 in AS 3700 defines the environment in terms of its location in relation to a surf coast and/or the application in which the brickwork is being installed.

Two of these environments are defined in more detail:

**Severe Marine Environment (where only EXP Grade bricks can be used):**

- Up to 1km from a surf coast.
- Up to 100m from an inlet or bay

**Marine Environment (where at least GP Grade bricks must be used):**

- Between 1km and 10 km from a surf coast.
- Between 100m and 1km from a non-surf coast.

**Table 3.** Durability categories

| Grade | Requirement/description |
|---|---|
| Exposure | (a) Supplier's experience according to which it is possible to demonstrate that the product has a history of surviving in saline or severe marine environments<br>(b) Less than 0.4 g mass loss over 40 cycles when tested to AS/NZS 4456.10 |
| General Purpose | Supplier's experience according to which it is possible to demonstrate that the product has a history of surviving under environmental conditions similar to those at the proposed site. This definition includes marine environments. Products that fit into this grade are not expected to meet the loss criterion for Exposure Grade but will survive between 15 and 40 cycles when tested to AS/NZS 4456.10. |
| Protected | Usually units in this grade would suffer substantial and early failure in less than 15 cycles when tested to AS/NZS 4456.10. Normally the supplier would nominate products that fit this grade. |

Bricks are classified by the manufacturer/supplier in accordance with Table 3.

The ability of a unit to resist salt attack may be categorised either by a declaration of the supplier on the basis of experience with the units in question or by testing in accordance with AS/NZS 4456.10.

Section 2.5.2 of AS/NZS 4455.1 specifies testing procedures and the criteria of acceptance for clay masonry. The acceptance level for the Exposure Grade is survival of 40 cycles, General Purpose 15-40 cycles and Protected less than 15 cycles of the immersion test in sodium chloride or sodium sulphate, as described in AS/NZS 4456.10.

Units declared to be Exposure Grade are the most appropriate for use in saline environments.
General Purpose units should not be used in saline environments without adequate protection. Protected Grade units are suitable for use in external and internal walls when built above a damp-proof course and protected at the top by roofs, eaves, copings or coating. They are not suitable for use in saline environments.

### 1.5.2 Freeze/thaw

AS/NZS 4456 has no freeze/thaw test method and states that "Consumers should rely on manufacturer's recommendations or local experience."

### 1.5.3 Moisture expansion or '$e_m$' value

Brick growth, as it is often called, is a property of all fired clay materials that begins from the time the product comes out of the kiln and continues, at a reducing rate, for the life of the unit.

The $e_m$ value is an estimate of the amount of expansion expected over fifteen years after the brick leaves the kiln. This figure is used by designers to determine the size and space of control gaps. This value can vary from a very low 0.3 mm/m (millimetres per metre) to over 2.0 mm/m. However, most bricks have a characteristic expansion in the range 0.5 to 1.5 mm/m.

The rate of expansion is not uniform over time. For example, approximately one-quarter of the expansion will have taken place six months after the fired clay product has left the kiln, one-half after two years, and three-quarters after five years.

For design purposes, the $e_m$ value of the brick lot to be used in a construction must be determined by test. The method of test is given in AS/NZS 4456.11

### 1.5.4 Initial rate of absorption (IRA)

A method of test for IRA (commonly called suction) is given in AS/NZS 4455.17, but there is no requirement that must be met. IRA values range from less than 0.2 kg/m2 min to more than 2.5 kg/m2 min. The optimum range is 0.5 to 1.5.

The water retentivity of the mortar should be matched to the IRA for good bond strength and fast bricklaying.

**Table 4.** Definitions of efflorescence

| Category | Definition |
|---|---|
| Nil | No observable efflorescence |
| Slight | Not more than 10 percent of any surface of the specimen covered by a thin deposit of salt |
| Moderate | More than 10 percent of one surface but not more than 50 percent of the total specimen surface covered by a thin deposit of salt |
| Heavy | A deposit of salt covering more than 50 percent of the total brick surface |
| Severe | Any efflorescence that is accompanied by powdering and/or flaking of the surface of the specimen |

### 1.5.5 Efflorescence

The method of test for efflorescence given in AS/NZS 4456.6 requires the test results to be reported in accordance with Table 4.

AS/NZS 4455 requires the liability to efflorescence of bricks intended to be laid in brickwork that is to be exposed to view shall not exceed 'slight.' Note that this is a laboratory test carried out on a sample of bricks – it does not apply to laid brickwork.

### 1.5.6 Pitting due to lime particles

If the raw materials from which clay bricks are made contain lime particles, these will be turned to quicklime when the bricks are fired. Water contacting the lime particles on the surface of the fired brick will cause them to expand as the lime slakes and particles near the surface of the brick erupt leaving surface pits. Thanks to improved production techniques, lime pitting is rarely seen. Table 5 summarises the requirements of AS/NZS 4456.13

**Figure 2.** Typical efflorescence from ground salts

**Figure 3.** Example of lime pitting

**Table 5.** Pitting due to lime, categories and definitions (in accordance with AS/NZS 4456.13)

| Category | Definition |
|---|---|
| Nil | No visible pits |
| Slight | Up to five pits, none over 5 mm diameter |
| Moderate | No pit over 10 mm diameter |
| Severe | Pit or pits over 10 mm diameter |

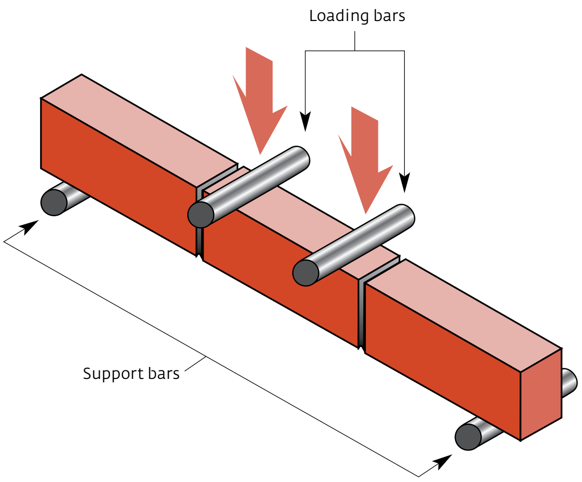
These definitions refer to pits in one face and both ends of a brick or the face of a paver.

### 1.5.7 Lateral modulus of rupture (LMOR)

This property measures the extreme fibre tensile stress at the face of a brick in bending. It is used to determine the horizontal bending capacity of brickwork. It is required for the design of brickwork panels subjected to lateral loads such as wind and earthquake loads.

AS 3700 permits the LMOR to be assumed as 0.8 MPa in the absence of test data. When specific tests are done, a more reliable LMOR figure can be used in design. A typical test result would give an LMOR figure in excess of 1.0 MPa.

**Figure 4.** Measuring lateral modulus of rupture



# 2. Mortar

## 2.1 Ingredients and proportions are vital

The most important functional properties of mortar are its consistency, durability and its ability to bond with the masonry units. In order to achieve these aims, it is important that the mortar ingredients and mix proportions should be exactly as specified.

## 2.2 Ingredients

### 2.2.1 Sand

Sand is the largest component of mortar and has a direct influence on all the properties of the mortar. AS 3700 Masonry Structures is the referenced Australian Standard relating to brickwork in the National Construction Code Volume 2 Housing Provisions. Sand shall be well graded and, when tested in accordance with AS 1141, shall contain no more than 10% of material passing 75 micron sieve.

Blended bricklaying sand should consist of no more than 10% fines (-75 microns), otherwise, it could lead to:

- Weak mortars
- High shrinkage
- Stickiness of the mortar
- Staining of the brickwork
- Cracks in the mortar

### 2.2.2 Lime – an essential ingredient

**Think Brick Australia strongly recommends the inclusion of lime in all mortar mixes.**

Bricklayers often avoid using lime because it is an additional material to mix. Lime mortars may also cause cuts and abrasions to sting.

Nevertheless, lime has the advantage of making mortar workable in the wet state and may eliminate the need for plasticiser admixtures. Furthermore, hardened mortar containing lime will be less pervious, more durable and more 'forgiving' than a mortar without lime. There is no substitute for the properties of lime including improved bond and workability (see below), and the ability to allow hairline cracks to self-heal.

Mortar workability is improved by adding lime at the mixing stage because it increases the amount of fine particles in the mortar mix. Moreover, workability will be greatly improved if the lime is slaked overnight (that is, by mixing lime and water to make a putty-like paste or by mixing the sand, lime and water one or more days before adding the cement.). Such an improvement eliminates the need to use plasticising additives in the mortar mix.

**Figure 5.** Shrinkage cracks in mortar joints

### 2.2.3 Cements

The majority of the strength of mortar comes from its cement content. Cement should be fresh and free-flowing. It must be stored under cover and off the ground to remain in good condition.

Until recently nearly all bagged cement for mortar was Portland cement. Now a significant portion of bagged cement is a blend of Portland cement and either fly ash, or finely ground blast furnace slag. Blended cements are sold under trade names such as 'Builders Cement' and 'Premium Cement'.

### 2.2.4 Go easy on admixtures!

Never use any mortar admixture in proportions greater than those specified by the manufacturer. The overdosing of plasticisers in particular, greatly reduces mortar strength and durability. Because of misuse and overuse, only certain additives are permitted by AS 3700:

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

Fire clay, sugar and detergent are not permitted to be used under the provisions of AS 3700.

## 2.3 Mortar mixes

The durability and strength of mortar are controlled by a classification system given in AS 3700, comprising grades M1, M2, M3 and M4. Typical mix proportions to achieve these grades are given in Table 11.1 of AS 3700:2018.

Mortar proportions are always expressed as the proportion of cement to lime to sand ... and always in that order. Table 6 shows a range of mixes with the corresponding grade according to AS 3700, and comments on their applications.

**Table 6.** Mortar mixes

| Grade | Composition | Application |
|---|---|---|
| M4 | 1:0:4 | 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. |
| M4 | 1:0.25:3<br><br>1:0.5:4.5 | 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. |
| M3 | 1:1:6 | 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. |
| M2 | 1:2:9 | 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. |
| M1 | 0:1:3 | 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. |
| M1 | 1:3:12 | This mortar has most of the flexibility of straight lime mortar and can be used for restoration and matching existing construction only. |

## 2.4 Mortar quantities

Table 7 gives an estimate of the amount of mortar used in laying 1000 bricks, including an allowance for 25 percent wastage.

This assumes the perforations are completely filled (the amount of loss will vary depending on size of the perforations) and typical site wastage. These estimates are the upper bound limit of the mortar volume required.

**Table 7.** Estimated quantities of cement, lime and sand per 1000 bricks with 25 percent brick perforation

<table>
<tr><th>AS 3700 code</th><th>Mortar composition (C:L:S)</th><th>No of 20 kg bags of cement</th><th>No of 20 kg bags of lime</th><th>Cubic metres of sand</th><th>Tonnes of damp sand</th></tr>
<tr><td rowspan="2">M4</td><td>1:0.5:4.5</td><td>17.3</td><td>3.2</td><td rowspan="6">0.55</td><td rowspan="6">1.04</td></tr>
<tr><td>1:0.25:3</td><td>25.9</td><td>2.4</td></tr>
<tr><td>M3</td><td>1:1:6</td><td>12.9</td><td>4.8</td></tr>
<tr><td>M2</td><td>1:2:9</td><td>8.6</td><td>6.4</td></tr>
<tr><td>M1</td><td>1:3:12</td><td>6.5</td><td>7.2</td></tr>
<tr><td>M1</td><td>0:1:3</td><td>–</td><td>9.7</td></tr>
</table>

## 2.5 Batching mortar

Mortar should be accurately batched to the required specification. This cannot be done with sufficient accuracy and repeatability using a shovel as a measuring device. Batching should always be carried out using buckets. If a separate bucket is provided for each part, the process is fast and batching errors are avoided.

An alternative method involves placing half a bag each of cement and lime in a three cubic metre concrete mixer and adding as much sand as will fit the mixer bowl. This produces a consistent 1:1:6 mortar mix. Bags of cement weighing 20 kg are ideal for this method.

**Figure 6.** Effects of bulking on shovels of cement (top) and sand (bottom)

## 2.6 Coloured mortars

Coloured mortars must be strong enough to retain the pigment (colouring) particles on the face of the joint. In weak mortars, wind and rain will rapidly erode these particles from the joint face. Cleaning brickwork using hydrochloric acid based solutions or masking of the mortar joint due to efflorescence may also degrade pigment colour, leading to faded, patchy and unattractive mortar joints.

Follow this guide for durable and fade-resistant pigmented mortars:

- Accurately batch 1 cement: 0.5 lime: 4.5 sand using a sand containing a minimum of clay (less than five percent).
- Use quality powdered metal oxide pigment up to 10 percent by mass of the cement used (that is, 2 kg pigment/20 kg cement bag). Exceeding 10 percent is uneconomic and begins to weaken the mortar. Five percent pigment addition usually achieves the desired result. The pigment, lime and cement should be well mixed with water before adding the other ingredients.
- Always finish the joint by tooling even when a raked joint is required.
- Clean the brickwork with water only as the job proceeds to avoid the necessity of cleaning with hydrochloric acid.

When pigmenting mortars with coloured oxides, a small addition of dark oxide enhances the colour of the primary pigment.
For example, add a little black oxide when mixing red pigmented mortar or a small amount of brown oxide when making yellow pigmented mortar.

# 3. Brickwork

## 3.1 Mortar joints

### 3.1.1 Purpose

The mortar joint serves several purposes in brickwork. Its primary function is to bond the bricks together, allowing the brickwork to act as a structural element to carry both vertical and lateral loads. The second function of joints is to accommodate the dimensional variations inherent in clay bricks.

Properly filled and tooled/ironed joints improve the durability, weather-proofness and sound performance of brickwork. For durability in a salt atmosphere (for example, near the coast) and good fire resistance (for example, in bushfire-prone areas or in fireplaces) a tooled, flush or near-flush joint is best. Raked or recessed joints should be avoided in these circumstances and when using bricks with significant dimensional variation.

Note: The NCC does not permit the use of raked joints in masonry veneer systems in saline environments or areas subject to heavy industrial airborne pollution.

**Figure 7.** Common mortar joints


### 3.1.2 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 Table 12.1. Tolerances in Masonry Construction allow 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 for non-structural facework is ± 5 mm average and the maximum difference in perpend thickness in any wall is 8 mm.

### 3.1.3 Gauging

Brickwork should be laid to a standard gauge. For standard/ traditional bricks and modular bricks (and all other bricks that are 76 mm high), the gauge is seven courses equals 600 mm of wall height. For modular bricks (and other 90 mm high bricks) the gauge is one course equals 100 mm.

Manufacturers who make bricks of other than normal manufacturing size (for example, sandstock or 'handmade' bricks) should determine the mean size of these units. The unit size tolerances apply to the stated size of the units. The purchaser should be advised of the recommended laying gauge based on a nominal 10 mm joint size.

Note that for units with a mean size significantly different from the standard size it may be necessary to:

- Use non-standard doors and windows, or
- Cut a considerable number of units as closers, or
- Adopt non-standard joint widths or gauges that are taken into account in plan and elevation drawings.

## 3.2 Bond strength

Characteristic bond strength (also known as flexural tensile strength) is an important property of brickwork. As its name implies, it is a measure of the strength of the bond between brick and mortar. This can be measured by constructing nine-brick high piers for testing as beams in bending, or single joints can be broken using the bond wrench apparatus (Figure 8), either on site or in a laboratory.

AS 3700 assumes all normal brickwork will have a characteristic bond strength of not less than 0.2 MPa (200 kPa). Brick industry sponsored research project into the actual bond strengths being achieved on building sites concluded that average bond strengths on site are relatively high, ranging from 0.2 to 0.8 MPa.

For engineering design, characteristic bond strength values derived from specific tests are used. Typically these would not be greater than 0.4 MPa for specified and supervised brickwork.

**Figure 8.** Bond wrench tester

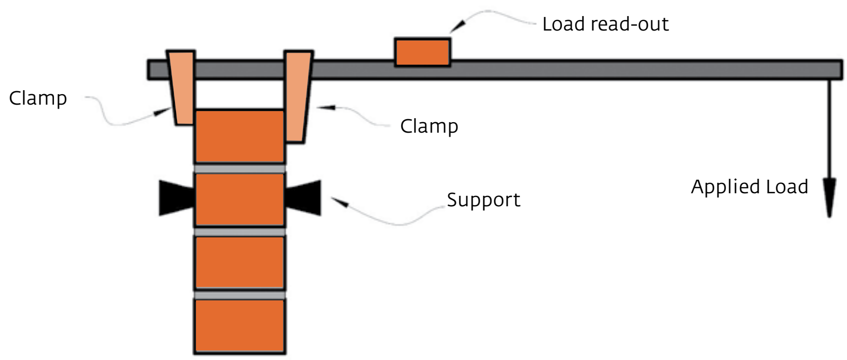



**Figure 9.** Bond wrench being used to test brickwork in a wall

## 3.3 Brickwork strength

The characteristic compressive strength of masonry is dependent on the properties of both the bricks and the mortar. This property is determined by testing four-brick high piers laid using the mortar intended for the construction.

In the absence of test information, the characteristic compressive strength of masonry can be determined from AS 3700, assuming the properties of the bricks and the mortar used in the brickwork are known.

This property varies from 4.3 MPa for clay bricks with a characteristic unconfined compressive strength of 15 MPa in a 1:2:9 mortar, to 9.5 MPa for bricks with an unconfined compressive strength of 40 MPa in a 1:0.5:4.5 mortar. Using special-order bricks with higher compressive strengths will produce even higher brickwork strengths.

## 3.4 Slenderness ratio & robustness requirements

Masonry members such as walls and columns that are subjected to compressive loads must be designed to satisfy the slenderness ratio requirements of AS 3700.

Masonry members not subjected to loads, for example, a partition wall in non-loadbearing construction, must satisfy the robustness requirements of AS 3700. These effectively limit the height and length of walls of a given thickness according to the support conditions.

## 3.5 Acoustic properties

### General

The acoustic provisions of the National Construction Code were amended in December 1999 to change the terminology from sound transmission class (STC) to weighted sound reduction index (Rw). This modification brought the Australian provisions into line with international regulations by referencing AS/NZS 1276.1, Acoustics - Rating of Sound Insulation in Buildings and of Building Elements - Airborne Sound Insulation.

The Rw rating system has two correction factors that are calculated for a wall whenever a laboratory test is carried out, for example, Rw (C; Ctr) = 52 (-1:-4).

These spectrum adaptation terms, C and Ctr have been introduced to take into account different spectra of noise sources:

- C for the following noise sources: talking, music, radio, TV, children playing, railway traffic at high speed, short distance jet aircraft and highway traffic greater than 80 km/h.
- Ctr for the following noise sources: urban road traffic, railway traffic at low speeds, home theatre systems, heavy bass music and long haul jet aircraft.

**NCC requirements for New South Wales, Victoria, South Australia, Tasmania and Western Australia**

**Class 1 buildings:**

Common walls are required to have an Rw + Ctr of not less than 50 (Figure 10). In addition, a wall separating a habitable room (living, dining, and kitchen) in one unit from a wet area (bathroom, toilet, and laundry) in another unit must be of discontinuous construction (Figure 11).

**Class 2 or 3 buildings:**

Walls separating sole occupancy units are required to have an Rw + Ctr of not less than 50 (Figure 10). In addition, a wall separating a habitable room in one unit from a wet area in another must also be of discontinuous construction (Figure 11). A wall separating a unit from a plant room, lift shaft, stairwell or public area it must have an Rw of not less than 50 and be of discontinuous construction.

**Class 9c buildings:**

Walls separating sole occupancy units or a sole occupancy unit from a kitchen, bathroom, laundry, plant or utilities room must have an Rw of not less than 45. A wall separating a sole occupancy unit from a kitchen or laundry must have satisfactory impact sound resistance. This 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 all cases, special attention must be paid to the junction of sound insulated walls with perimeter walls, floors and roofs. This is detailed in the NCC.

**Figure 10.** Habitable-habitable for Class 1, 2 and 3 buildings Rw + Ctr ≥ 50

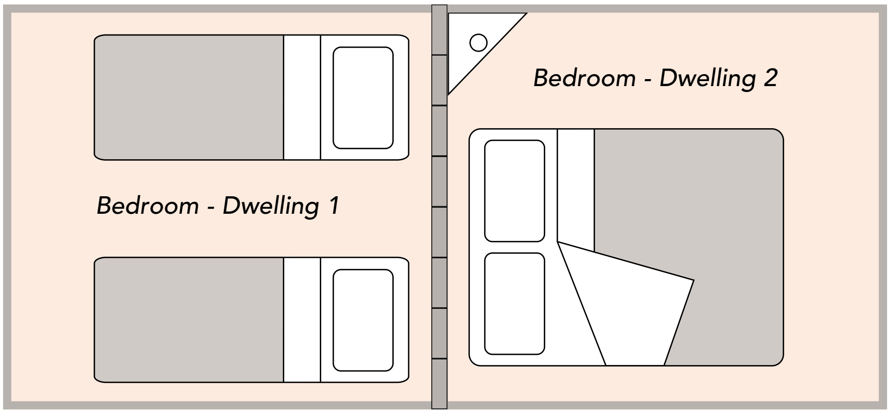
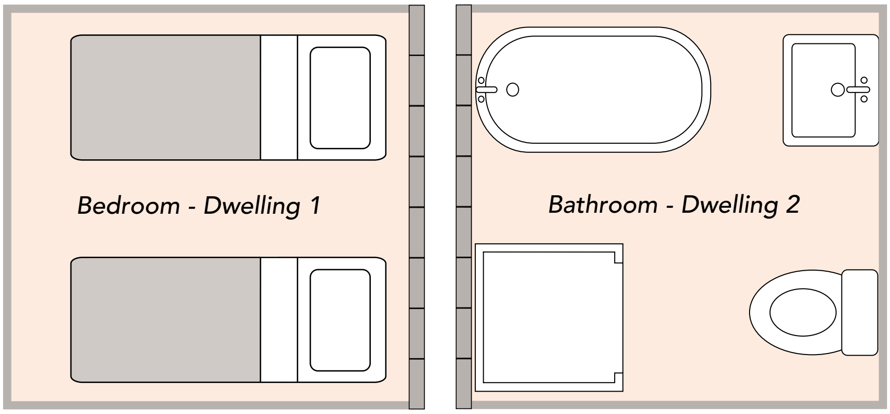



**Figure 11.** Habitable-wet for Class 1, 2 and 3 buildings Rw + Ctr ≥ 50 and discontinuous construction



## NCC requirements for Queensland and Northern Territory

### Class 1 buildings:

A wall separating two habitable rooms in adjoining units must have an Rw of not less than 45 (Figure 12). A wall separating a habitable room from a wet area requires an Rw of not less than 50 with satisfactory impact resistance (Figure 13). This 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.

### Class 2 or 3 buildings:

Walls separating adjoining sole occupancy units require an Rw of not less than 50. A wall separating a habitable room in one sole occupancy unit from a wet area in another requires an Rw of not less than 50 with satisfactory impact resistance (Figure 13). A wall separating a sole occupancy unit from a lift shaft, stairwell, plant room or public area must have an Rw of not less than 45.

**Figure 12.** Habitable-habitable areas in class 1, 2 and 3 require Rw ≥ 45

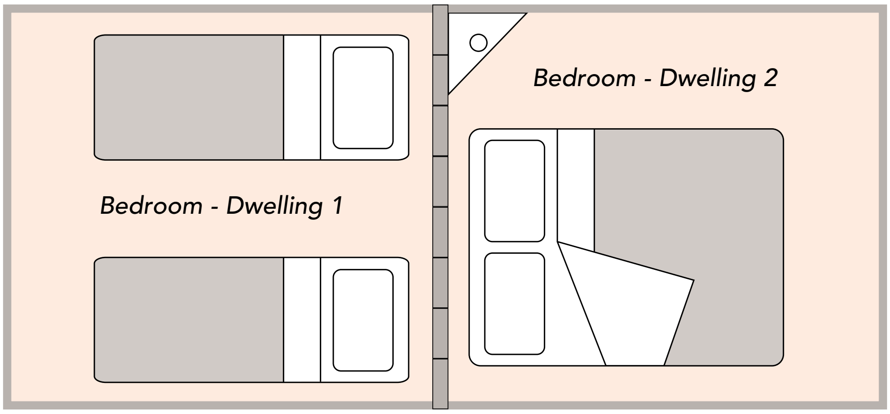
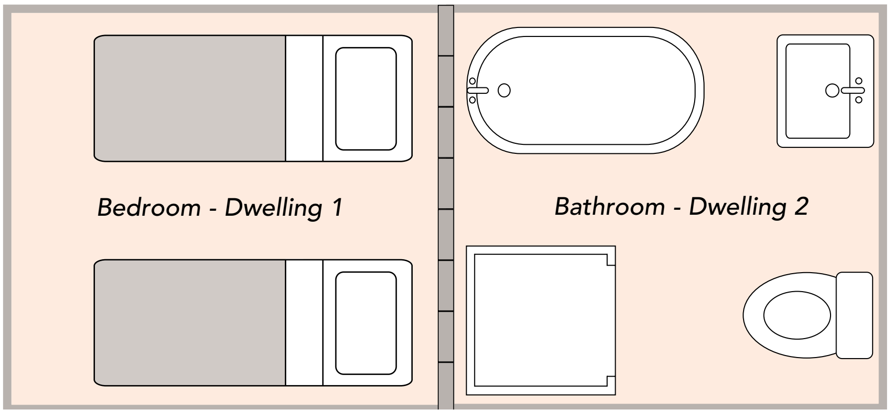



**Figure 13.** Class 2 and 3 buildings, habitable-wet areas in adjoining units require Rw ≥ 50 plus impact



**National Construction Code – deemed-to-satisfy clay brick wall systems**

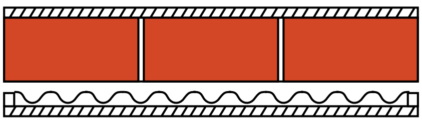
The NCC currently requires Rw 45 for walls between sole occupancy units with the extra requirement of Rw 50 plus a satisfactory level of impact insulation for walls between a bathroom, sanitary compartment, laundry or kitchen and a habitable room (other than a kitchen) in an adjoining unit.

It should be noted that it is the NCC provisions – rather than an assumption that a sound level achieved in a laboratory can be repeated in the field – that must be constructed.

**Figure 14 (A-D). Clay brick wall systems which achieve Rw + Ctr not less than 50**

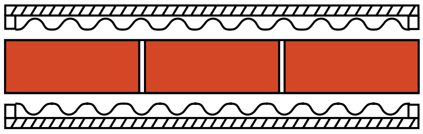
Note: These systems require that all mortar joints are filled.

**A.Single leaf 110mm clay brick masonry with:**



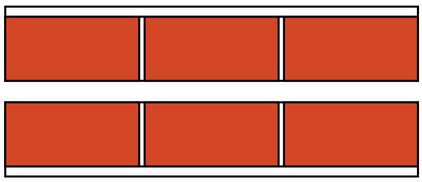
- One layer of 13mm plasterboard direct fix to one face; and
- 64mm metal or 70mm timber studs spaced 20mm from masonry wall; and
- 50mm of 11kg/m3 density insulation; and
- One layer of 13mm plasterboard fixed to the studs on the other face.

**B. Single leaf 90mm clay brick masonry with:**



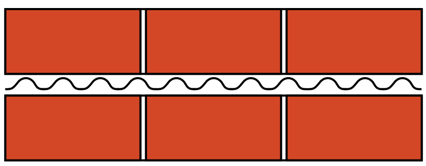
- 64mm metal or 70mm timber studs spaced 20mm from the face; and
- 50mm of 11kg/m3 density insulation on each face; and
- 13mm plasterboard fixed to the studs on each face.

**C. Two leaves of 110mm clay brick masonry with:**



- A cavity of 50mm between the leaves of clay brick masonry; and
- Each face rendered 13mm thick.

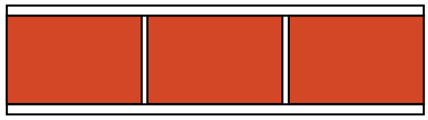
**D. Two leaves of 110mm clay brick masonry with:**



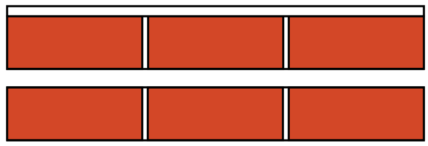
- A cavity of 50mm between the leaves of clay brick masonry; and
- 50mm of 11kg/m3 density insulation in the cavity.

**Figure 15 (A-B). Clay brick wall system which achieves Rw not less than 50**

**A. Single leaf of 150mm brick masonry with each face rendered 13mm thick**



**B. Two leaves of 90mm brick masonry with:**



- A cavity of 40mm between the leaves, and
- Each face rendered 13mm thick.

## 3.6 Thermal properties

The term which describes the ease with which heat moves through a wall is thermal transmission, known simply as the U value. The opposite of the U value is the R value, which measures thermal resistance, that is, the resistance given by a wall to the transmission of heat.

A U value of less than 1.3 is appropriate for temperate Australia and insulation in full brick construction is an unwarranted cost. In most areas of Australia, cavity brick walls built on a slab are exempt from the requirement for all new houses to have wall insulation. This exemption recognises the inherent thermal properties of full brick construction.

Table 8 sets out typical thermal values for a range of wall configurations. And as Table 9 shows, the R value varies considerably with the weight of an individual brick.

It should be noted that thermal resistance is not the best way to measure the thermal benefits provided by clay bricks. Research by the University of Newcastle has shown that thermal mass (the principal property provided by clay bricks to improve thermal performance) is critical to improving energy efficiency and that there are limitations in relying solely on R values.

R value is limited because used without thermal mass it does not delay heat entering a building. This results in peak indoor temperatures matching peak outdoor temperatures.

**Table 8.** Typical thermal values

| Wall Type | R value ($m^2.K/W$) $\Delta T$ = 18°C |
|---|---|
| **Single skin**<br>110 mm dry-pressed (single skin) | 0.12 |
| **Cavity wall (dry pressed)**<br>110 mm dry-pressed unit + 50 mm air cavity + 110 mm dry-pressed unit | 0.37 |
| **Cavity wall (internal horizontal core)**<br>110 mm extruded units + 50 mm air cavity + 90 mm horizontally cored unit + 12 mm render | 0.49 |
| **Cavity wall (extruded)**<br>110 mm extruded units + 50 mm air cavity + 110 mm extruded units | 0.43 |
| **Cavity wall (extruded, plasterboard)**<br>110 mm extruded units + 50 mm air cavity + 110 mm extruded units with 10 mm plasterboard glued at 600 mm centres | 0.55 |
| **Cavity wall (extruded, internal render)**<br>110 mm extruded units + 50 mm air cavity + 110 mm extruded units with 10 mm render | 0.44 |
| **Reverse brick veneer**<br>GranoSkin® finish on 7 mm blueboard + 90 mm pine studs at 600 mm centres with R1.5 glass wool insulation in frame cavity + 100 mm extruded units | 1.57 |
| **Lightweight wall**<br>2-3 mm GranoSkin® + 7 mm blueboard on 90 x 35 mm pine studs at 600 mm centres + R1.5 fibreglass batts in frame cavity + 10 mm plasterboard lining | 1.51 |
| **Insulated cavity wall (rendered)**<br>110 mm extruded units + 50 mm air cavity + 30 mm extruded polystyrene sheets glued to 110 mm extruded units with 10 mm render | 1.30 |
| **Brick veneer**<br>110 mm extruded units + 50 mm air cavity reflective foil insulation + 70 mm pine studs + 10 mm plasterboard | 0.83 |
| **Insulated brick veneer**<br>110 mm east coast extruded units + 50 mm air cavity with 90 mm pine studs at 600 mm centres with low glare wall wrap + R1.5 glass wool insulation in frame cavity and 10 mm plasterboard | 1.58 |

R value is limited because used without thermal mass it does not delay heat entering a building. This results in peak indoor temperatures matching peak outdoor temperatures.

Furthermore, while insulation (in theory) keeps heat out during the summer, in practice, heat still enters a building (for example via windows) which is trapped by the insulation, increasing the indoor temperature. Internal thermal mass improves thermal performance and energy efficiency by absorbing heat during the day and gradually re-releasing at night when temperatures drop. This is very beneficial in most parts of Australia because there is a large variation between day time and night time temperatures.

To overcome the limitations of R value, the University of Newcastle recommends using a combination of insulation (thermal resistance) and thermal mass.

For more information on the thermal properties of clay bricks refer to Energy Efficiency and the Environment; the Case for Clay Bricks on the Think Brick Australia website.

**Table 9.** Brick mass and R values

| Brick Mass (kg) | 2.5 | 2.75 | 3.0 | 3.25 | 3.5 | 3.75 | 4.0 | 4.25 |
|---|---|---|---|---|---|---|---|---|
| R value $m^2$ K/W | 0.22 | 0.20 | 0.18 | 0.17 | 0.16 | 0.14 | 0.13 | 0.12 |

## 3.7 Fire resistance levels

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

The fire resistance level of a wall depends not only on the thickness of the wall but also on its height, length and how the top, bottom and ends of the wall are connected to the other building elements. For this reason, it is impossible to give an FRL for a particular brick – it will always depend on the details of the wall built with a particular brick.

There are three components to a fire resistance level:

- **Structural adequacy:** The ability of a wall to continue to perform its structural function.
- **Integrity:** The ability of a wall to prevent the passage of flames and hot gases.
- **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 pre-defined rise in temperature.

A typical fire resistance level for a wall would have an FRL of 90/90/90 that is 90 minutes each for each of the three FRL components (and always in the same order, as above).

## 3.8 Construction details

### 3.8.1 Moisture penetration in single-leaf walling

On its own single-leaf masonry is not inherently waterproof. In masonry design and construction, damp-proof detailing using membranes, flashings and a good standard of workmanship are important elements.

Cavity wall construction prevents water reaching the internal leaf of brickwork. The external leaf can become saturated and permit water to reach the cavity. Free water in the cavity drains to the cavity flashing and out through the weep holes.

For single-leaf external walls to perform satisfactorily, it is essential that all joints are properly filled with mortar, are well tooled/ironed, and a generally high standard of workmanship is maintained.

Single leaf walling must be sealed using two or three coats of acrylic paint on the outside to prevent water penetration.

Clear non film-forming sealants that have proved successful are AV Syntec Damit, Thompson's Water Seal and Ramset Rain-away. They can be applied by brush, roller, airless spray gun or a knapsack type sprayer. The sealant manufacturer's instructions must be followed.

Regardless of the sealant or method of application, it is essential that all mortar joints be completely filled.

### 3.8.2 Weepholes

A weephole is simply a drain hole through a wall. To be more specific, the functions of a weephole are:

- Drain moisture that penetrates the outer leaf of brickwork or the sill
- Give a low level of cavity ventilation
- Discharge ground water through retaining walls

Weepholes are required at the head and sill flashings of windows over 1200 mm wide. However, it is common to see weepholes above and below small windows, or at windows protected by eaves where the amount of moisture does not justify their placement.

The simplest and most common weephole is the open perpend. However its large size – a brick height plus the lower mortar bed joint – creates an attractive nest for spiders and can be visually unsatisfactory, especially with light-coloured mortar. There should be no mortar on the flashing at the base of the weephole. Smaller more closely spaced weepholes may also be used.

The bricklayer forms small weepholes at the time of laying the bed mortar, using a 10 mm rod or a square stick. They should be spaced every two or three bricks and are particularly recommended for wind-exposed brickwork. Proprietary devices for use as weepholes are also available.

### 3.8.3 Control gaps

Control gaps (also called expansion gaps or joints) are essential in long runs of brickwork. All clay bricks expand, albeit at a minute rate, over many years. It is a simple matter to calculate the minimum gap spacing based on the expansion data available from the brick manufacturer. Where articulation joints have been included in the wall, this would in most circumstances negate the need for control gaps.

The gap should initially be about 20 to 25 mm wide, clear of mortar dags or bridges, tied at the appropriate intervals and sealed with a polyethylene tube or a suitable compressible filler to allow 10mm closure. Usually, a gunned sealant completes the gap. Where possible, control gaps should be placed behind downpipes, at door and window openings or re-entrant corners.

### 3.8.4 Weathering details

There is no doubt that clay brickwork weathers well. Brickwork that is well designed, specified and built is inherently durable and its surface can readily shed dirt and hide the weathering that occurs on all buildings. The fact that brickwork is made up of small modules enables the designer to easily create details to virtually allow the brickwork to self-clean. A drip course made by projecting a course about 10 mm will reduce or eliminate streaking. The 'bib effect' under windows (particularly on lower floors) can be eliminated by projecting sills about 10 mm. Parapets and freestanding walls should be capped to prevent moisture entering the brickwork.

### 3.9 What can be done about fretting brickwork?

The cause of fretting – crumbling or flaking of the brick – is salt crystals forming just below the brick surface when saline moisture is evaporated.

It is important to identify the possible source of salt. Airborne salt from sea spray or major industrial sites is obvious. Less obvious but increasingly more frequent is saline ground water caused by naturally-occurring ground salts, nearby salt water swimming pool filter overflows, rainwater runoff from concrete driveways, balconies or retaining walls, or garden fertiliser that may have been applied years before.

If saline ground water is being absorbed into brickwork, it is because there is something wrong with the damp-proof course (DPC). It could be too high, broken or left out. It will be necessary to put in another DPC.

When the bricks suffering salt attack are low in the wall (as is often the case), the best mode of repair is to insert a DPC close to ground level while rebuilding the base brickwork.

Another method is to dig away the soil in contact with the bricks at both sides of the wall down to the concrete footing. Wash the dirt off and paint the subsurface brickwork with bitumen paint (available at most hardware stores). While the paint is still tacky, stick on some plastic DPC material. Now backfill and compact the trench with soil to the top edge of the paint. The DPC should be visible above the ground.

If this method of adding a DPC is not possible, insert a membrane DPC or get a rising damp specialist to inject a chemical DPC in the lowest mortar bed joint. Badly fretted bricks should be replaced with matching bricks. Take care to match mortar colour.

**Figure 16.** Salt attack damage to clay masonry units

## 3.10 Storage of bricks on site

Storage of bricks can have an adverse impact on brick strength, durability and performance. Below are five tips for storing bricks on site.

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

2. Don't stack bricks in water puddles on concrete slabs. Concrete, especially fresh concrete, is saline and the bricks will absorb this saline moisture that will contribute to early age efflorescence of the bricks or brickwork.

3. Keep bricks dry. If they are delivered in plastic wrap, leave it on until they are ready to lay. Otherwise, cover the bricks to keep them dry.

4. In warm, sunny conditions it is advisable to shade the bricks so they are not too hot when laid. Hot bricks cause mortar to dry too quickly.

5. Plan where bricks are to be placed on delivery. Make allowance to 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 together to allow the product to blend down and across the packs simultaneously.

# 4. Cleaning Brickwork

## 4.1 Some precautions and a recommendation

This section provides an outline and overview on cleaning brickwork. Think Brick Australia recommends reading this section in conjunction with Think Brick Australia's Cleaning of Clay Masonry (2017).

Exercise great care when using chemical cleaning agents such as acids, strong alkalis and volatile solvents. Personal protective equipment and protective clothing is essential when cleaning interior brickwork and good ventilation is necessary.

When cleaning brickwork it is often advisable to conduct a test of the method and cleaning agents on a small inconspicuous area before proceeding with the whole job.

Difficult or large cleaning jobs are usually best carried out by experienced contract cleaners who are skilled and efficient. They use a variety of chemicals that can be dangerous in the hands of inexperienced users. It is usual for contract cleaners to use high pressure equipment to flush away the cleaning residue.

## 4.2 Cleaning mortar smears

### 4.2.1 Clean as you go – the best way

The best way to reduce the problems and cost associated with brick cleaning is to use well-trained and experienced bricklayers who have a good quality record.

However, new brickwork inevitably requires some cleaning of mortar smears. The easiest, quickest and cheapest method is to clean as the job proceeds using only clean water. This should be done as soon as practicable after the mortar has set. A scrubbing brush, clean running water and a sponge will produce the best results. Water absorbed into the brickwork during cleaning usually does not cause efflorescence problems. Cleaning should not wait until the end of the job. Removing hardened mortar requires a hydrochloric acid based cleaner.

Think Brick Australia recommends having the bricklayer quote on laying and cleaning the brickwork. Problems invariably arise from lay-only quotes that do not include cleaning.

### 4.2.2 Acid cleaning basics

Acids are dangerous. They burn skin tissue so it is essential to wear protective clothing, including gloves and goggles. Dilute acids by adding acid to water not the other way around. Protect adjacent building materials from acid contact. Use plastic tools, brushes and buckets.

Follow the safety instructions on the acid bottle, wear the required safety gear, work on a small section at a time, and ventilate the area (especially when working inside). Using acid concentrations higher than recommended may lead to staining, such as 'acid burn', of the brickwork.

When acid cleaning internal brickwork it is necessary to use an acid neutraliser immediately after washing off the acid solution to reduce the risk of rusting metal fittings. A readily available neutraliser is bicarbonate of soda mixed in a five percent solution with water.

### 4.2.3 Acid cleaning brickwork

**By hand**

- Pre-wet brickwork is not subject to vanadium staining with clean water to reduce the suction of the bricks and minimise acid absorption. (For brickwork subject to acid staining, substitute a neutraliser – 10 grams of washing soda or 50 grams of bicarbonate of soda per litre of water – for plain water.)\
- Dissolve mortar smears by scrubbing the brickwork with a solution of hydrochloric acid consisting of acid and water or use a proprietary acid cleaner such as Noskum. (The proportion of acid to water should be determined by the hardness and quality of the mortar. It is recommended that acid: water ratios not exceed 1:10.) Allow the solution to remain on the wall for sufficient time for the reaction to take place. This could take up to 3 to 6 minutes. Ensure the brickwork does not dry out prior to rinsing off the acid, particularly on hot or sunny days.
- Scrub the brickwork with a stiff nylon bristle brush or scouring pad until the mortar smears are removed. It is best to work vertical strips the full height of the brickwork, starting at the base of the wall and scrubbing up to the top.
- Rinse the cleaning residue from the brickwork using plenty of clean water, working down from the top of the brickwork. (For brickwork subject to acid staining, substitute a neutraliser – 10 grams of washing soda or 50 grams of bicarbonate of soda per litre of water – for plain water.)

**Using high pressure water**

Cleaning brickwork with high pressure water can be effective but failure may occur if the operator:

- Increases the acid content
- Moves the nozzle too close to the wall
- Increases the water pressure
- Reduces the spray angle
- Uses a turbo head nozzle

Any of these may cause damage requiring costly repairs. The last four points, in particular, can lead to erosion or 'blowout' of the mortar joints and may even erode the brick face, particularly of dry-pressed bricks.

If high-pressure water cleaning is to be used, specify a minimum nozzle angle of 15 degrees, maximum pressure of 7000 to 8000 kPa (1000 to 1200 psi) and a preferred operating distance of 500 mm and never less than 300 mm. Supervision is essential.

Some mortar dags will resist even a high-pressure spray and should be removed with a scraper prior to cleaning.

**Figure 17.** Damage to brickwork

**A.** Damage to mortar joints

**B.** Damage to brick face by turbo head

**C.** Pitting of brick face

**D.** Damage to mortar joints

#### 4.2.4 Acid cleaning brickwork subject to vanadium staining

Some of the raw materials from which clay bricks are made contain vanadium salts. Vanadium is harmless but highly visible in light-coloured bricks. If the brickwork is laid very wet, these salts will appear on the surface as a yellow/green efflorescence.

Vanadium salts may turn black if hydrochloric acid is applied. If vanadium is present on the surface it must be treated before further cleaning. Vanadium salts are more soluble in acids than water and if after cleaning the surface is left in an acidic condition, the stains will reappear when the brickwork dries out.

Vanadium salts that crystallise in an alkaline environment are colourless and therefore not a problem. It is important when acid cleaning bricks prone to vanadium staining to neutralise any remaining acid so that the stains will not reappear after cleaning.

Follow the guide in the next section but substitute a neutraliser (10 grams of washing soda or 50 grams of bicarbonate of soda per litre of water) for plain water in the pre-wet and final rinse.

### 4.3 Cleaning brickwork stains

#### 4.3.1 General

Note that hydrochloric acid is mostly used for removing mortar-based stains and smears. It is ineffective for cleaning organic or soil stains.

Trial first, work safely and use poultices for difficult stains.

This section relates to suggested remedial action for the treatment of staining of brickwork due to external influences and does not indicate any product fault. All methods are suggested only and must be trialled for effectiveness. Note the safety procedures discussed previously.

Some stains, especially when dissolved by solvents, will be absorbed into the face of the brickwork and made more difficult to remove. Poulticing involves the mixing to a paste of the cleaning compound and a fine filler such as whiting, kaolin, diatomaceous earth or talc. The paste is then applied to the area to be cleaned. As the cleaning compound does its work and the paste dries, the cleaning residue is drawn out of the brickwork into the paste.

#### 4.3.2 Efflorescence

Most building materials contain soluble salts that can migrate to the surface of the brickwork. When the water evaporates the salts crystallise to form efflorescence, a fine powder, usually white. Efflorescence is generally not harmful and will weather away with time.

The key to avoiding efflorescence is to lay dry bricks. Wet bricks hold enough water to cause efflorescence. Water allowed to enter uncovered cavity walls during construction is likely to cause efflorescence. Brickwork must be protected from water entry during construction.

Unfortunately, some dated specifications still require bricks to be wetted prior to laying. Only bricks having very high water suction (initial rate of absorption or IRA) need pre-wetting to reduce their suction, and then only in hot and windy weather with a light water spray to dampen the surface.

**Figure 18.** Efflorescence

The best way to remove efflorescence is to brush it off when the brickwork is dry. Wetting usually dissolves the efflorescence allowing the salt to be sucked back into the brickwork only to reappear when the brickwork dries. On external brickwork natural weathering soon removes most efflorescence. Dry brushing speeds the process.

Efflorescence on internal face brickwork is best removed on a hot, dry day after the brickwork has thoroughly dried out. Firstly, brush off any loose material then sponge the surface with a damp (wrung out) synthetic chamois or high suction sponge. Use very little water and the brickwork should dry off almost as soon as the sponge is taken away. Rinse the sponge frequently in fresh water.

### 4.3.3 Insoluble white deposits

These are hard white deposits, insoluble in water and invisible when wet. They appear as almost a milky film on the brickwork and are not to be confused with efflorescence, which is water soluble.

Most commonly, these stains arise from products of the setting reactions of Portland cement and bricklaying sand containing clay. The combination of clay from the mortar with calcium and silica residues from the cement form calcium silicate which produces the insoluble white deposit.

Calcium silicate is white and highly insoluble in most acids. Kaolin, a clay mineral present in most bricklaying sands, can also form a hard deposit. It is insoluble in most acids except hydrofluoric acid.

The problem is most likely to occur from incorrect hydrochloric acid cleaning. When too much acid and too little water are used, the products of the reaction between the acid and the mortar are absorbed into the brick faces instead of being washed clear of the wall.

Staining can occur in any of the following ways:

- When newly-laid masonry is unprotected and saturated by rain, lime is put into solution from either Portland cement or hydrated lime in the mortar. Frequently, new masonry is marred by bands of this white calcium carbonate stain confined to three or four courses, the result of rain saturating freshly-laid work.

**Figure 19.** Calcium staining

- By interaction with concrete elements and cement rendering when lime is leached from these elements by water.

- By the wet sponging of mortar joints. While this creates a smoother joint finish, it also smears a cement-rich mortar film over the brick face, which often develops into staining. When this joint finish is used, follow the hydrochloric acid cleaning immediately with a treatment of Noskum or an equivalent product to reduce the potential staining.

Insoluble white stains are removed by the application of Noskum or equivalent at full strength to the stained bricks. In some cases, the reaction is immediate and should be followed by vigorous scrubbing. In other instances, the cleaning solution should be allowed to stand for four to six minutes prior to scrubbing.

A small test area should be used to determine the appropriate treatment technique. More than one chemical application may be required. The wall should be rinsed off thoroughly after each treatment.

**Note: When proprietary cleaning products such as Noskum or equivalent are used, the manufacturer's instructions and safety precautions must be strictly adhered to.**

### 4.3.4 Iron oxide or acid burn

Iron oxide stains frequently result from the use of hydrochloric acid on clay masonry. This is a yellow to brown rust-like stain that can also affect mortar. The so-called acid burn is iron oxide staining caused by a reaction between hydrochloric acid and iron oxides in the clay brick.

Removal techniques for acid burn:

#### Phosphoric acid

1. The application strength and duration will vary. As a guide, use a mixture of 1 part phosphoric acid to 6 parts water.

2. Apply by brush or spray to the dry wall and allow to stand until the stain disappears, usually within 30 minutes but it can be up to 24 hours.

3. More than one application may be required.

Mortar containing an iron oxide colouring pigment will be lightened by this treatment.

To maintain a uniform appearance, treat an entire wall or keep the phosphoric acid clear of the mortar.

Protection should be provided to powder coated fixtures, painted surfaces and concrete coloured with oxides, such as paths and roof tiles, to prevent discolouration by the phosphoric acid solution.

#### Oxalic acid

1. Use solution strength of 20 to 40 grams per litre of water.

2. The method of application is the same as for the phosphoric acid treatment.

3. More than one application may be required.

4. Neutralise the oxalic acid by applying a solution of 15 grams of sodium bicarbonate per litre of water. Do not wash off.

**Note: Poulticing techniques may be needed for extreme cases. Furthermore, proprietary chemicals such as RidRust or Renex can be used.**

**Figure 21.** Manganese stains

**Figure 20.** Iron oxide stains

### 4.3.5 Manganese stains

A dark brown to violet stain may occur on clay bricks containing manganese minerals. The stain occurs along the edges of the bricks, or in the centre of the face of lighter-fired products. It can also appear around mortar droppings on bricks due to the alkalinity of the mortar.

Removal techniques for manganese stains:

#### Phosphoric acid

1. Mix 1 part phosphoric acid to 6 parts water.

2. Apply with brush or spray to dry wall.

3. Avoid splashing any adjoining metal surfaces.

4. Reaction can take up to 24 hours, and more than one application may be required.

**Acetic acid**

1. Mix 1 part acetic acid (80% stronger) with 1 part hydrogen peroxide (30 to 35% concentration) with 6 parts water.

2. Apply with brush or spray to dry wall.

3. Avoid splashing any adjoining metal surfaces.

4. Reaction should be almost immediate; however, more than one application may be required.

### 4.3.6 Organic growths – fungus, mould, lichen 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.

Organic growth can be killed by treating with dilute sodium hypochlorite bleach with a small amount of liquid detergent. Exit mould and White King are suitable for this application. Repeat as necessary.

Check downpipes, flashings etc. for ways to stop continuous moist conditions. If brickwork dries, organic growths should not occur.

### 4.3.7 Soils

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

### 4.3.8 Soot and smoke stain

A scouring cleanser such as Ajax or equivalent can be used to remove stubborn stains by scrubbing. Wash off with detergent and water.

**OR** Sodium bicarbonate can be used to great effect to remove smoke stain.

**OR** Trisodium phosphate can be used to remove smoke stain from clay bricks.

**OR** Noskum works well on most smoke stains.

**OR** Bleach using calcium hypochlorite or sodium hypochlorite solution in a poultice.

**AND**

always finish with a thorough wash down with clean water.

### 4.3.9 Timber stains

Wipe off with a solution of oxalic acid at 20 to 40 grams per litre. Follow with a misting of sodium hypochlorite bleach. Exit mould, available from supermarkets, is suitable.

### 4.3.10 Vanadium stains

There are a number of methods for removing vanadium stains including cleaning with solutions of oxalic acid, sodium hypochlorite, sodium hydroxide or proprietary chemicals such as Vango or Noskum.

Cleaning should commence as soon as possible after the stains first appear. When acid cleaners are used (including proprietary cleaners containing acid) the acid must be neutralised and the wall washed down with fresh water.

Vanadium stains should not be cleaned with hydrochloric acid (spirits of salts) as this will aggravate the problem.

**Figure 22.** Vanadium stains

# 5. Clay Pavers

## 5.1 Paver standard

AS/NZS 4455 Masonry Units and Pavers is the standard that applies to units for segmental pavements, including clay pavers. In general, Section 2.1 of this standard requires that "The suppliers of pavers shall make available the work size and the characteristic breaking load (P'b)." There are only a small number of specific performance requirements.

## 5.2 Essential physical properties

### 5.2.1 Dimensions

**Two measurement methods**
AS/NZS4456.3 sets out two alternative methods for measuring the dimensions of masonry units and units for segmental pavements and it allows the manufacturer to select which of the two methods is appropriate to their manufacturing process.

Generally, the cumulative method adopted by the industry of measuring the overall dimensions of 20 units (Method A, as shown for bricks in Figure 1) is preferred over individual measurement of 20 units (Method B) which is more practical for larger sized units. The tolerances are set out in Tables 10 (Method A) and 11 (Method B).

**Table 10.** Dimensional deviation of clay pavers measured by Method A (cumulative over 20 units)

| Category | Work size dimensions (mm) | | |
|---|---|---|---|
| | Under 150 | 150 to 250 | over 250 |
| DP0 | No requirement | | |
| DPA1 | ±50 | ±60 | ±75 |
| DPA2 | ±40 | ±50 | ±60 |
| DPA3 | By agreement between supplier and purchaser | | |

**Table 11.** Dimensional deviation of clay pavers (determined by individually measuring 20 units)

| Category | Work size dimensions (mm) | | | |
|---|---|---|---|---|
| | Plan | | Height | |
| | Standard deviation | Mean | Standard deviation | Mean |
| DP | No requirement | | | |
| DPB1 | 2.0 | ± 3.0 | 3.0 | ± 2.5 |
| DPB2 | 2.0 | ±2.5 | 3.0 | ± 2.0 |
| DPB3 | By agreement between supplier and purchaser | | | |

**Dimensional deviations**

Manufacturers shall make available the work size of the pavers and supply them with deviations not greater than category DPA1 or DPB1 unless otherwise declared by the supplier or agreed between the supplier and purchaser.

**Consistency between deliveries**

For categories DPA1, DPA2, the dimensions of units taken from all deliveries of units of the one type and the subject of a single order shall not differ by more than 40 mm over 20 units.

### 5.2.2 Strength

**Breaking load**

The integrity of pavers (their ability to remain whole) must allow them to be handled and transported to the purchaser and be laid so as to fulfil their intended functions. For clay pavers, this requirement is deemed to be satisfied if the characteristic breaking load is at least 2 kN. Although the standard does not state it, the minimum breaking load for pavers intended to carry light vehicles should be 3 kN, rising to 5 kN for general vehicles.

The test method for this property is given in AS/NZS 4456.5 and the method for demonstrating compliance is given in Appendix A of AS/NZS 4455.

The compressive strength of pavers is not considered to be relevant for their intended use.

### 5.2.3 Slip/skid resistance

The slip/skid resistance of pavers is measured using the British Pendulum Skid Resistance Tester, and the results are quoted as BPN numbers.

The test method for this property is described in AS/NZS 4586, Slip Resistance Classification of New Pedestrian Surface Materials. In this standard, different pedestrian surface materials are classified according to their likely contribution to slipping on the basis of test results obtained by the nominated test methods.

The relevant test method for the classification of clay pavers is described in Appendix A, the wet pendulum test method. AS/NZS 4586 nominates the TRRL rubber slider as the appropriate test rubber slider for clay pavers.

However when using the TRRL rubber slider, if the mean BPN number was found to be less than 40, according to Table 2 of AS/NZS 4586, in order to facilitate classification of the product, the test would have to be repeated with the alternative

**Table 12.** Classification of pedestrian surface materials according to the wet pendulum test

| Class | Pendulum* mean BPN | | Contribution of the floor suface to the risk of slipping when wet |
|---|---|---|---|
| | Four S rubber | TRRL rubber | |
| V | >54 | >44 | Very low |
| W | 44–54 | 40–44 | Low |
| X | 35–44 | – | Moderate |
| Y | 25–34 | – | High |
| Z | <25 | – | Very high |

* While either of these test methods may be used, the test report should specify which method was used.

NOTE: It is expected that these surfaces will be more slip resistant when dry.

## 5.3 Pavers – which ones and what for?

- The qualities of the pavers must match the application.
- Exposure Grade pavers should be specified in severe marine environments or around saltwater swimming pools.
- Pavers for pedestrian traffic and commercial vehicles should have a minimum characteristic breaking load of 5 kN.
- Minimum paver thickness depends upon the application, as summarised in Table 13.

The mean pendulum test result values shown in Table 13 are industry recommendations which exceed the requirements of Class V (the top scale) in AS/NZS 4586 for a Very Low contribution to the risk of slipping when wet. This provides a safety margin which compensates for possible lowering of BPN values after use.

Some house bricks, are satisfactory for use as pavers. However, most manufacturers have a range of purpose-made pavers that are specially designed and formulated for that task. Pavers are often harder than house bricks and their dimensions make them easier to lay in a greater variety of patterns. Therefore pavers should be preferred, but house bricks can be used in certain circumstances.

For the recommended usage of clay pavers refer to Table 13.

**Table 13.** Recommended specifications for clay pavers

| Application | Minimum thickness (mm) | Minimum characteristic breaking load (kN) | Dimensional deviation | Slip resistance classification | Mean abrasion index (cm³) |
|---|---|---|---|---|---|
| Residential pavements | | | | | |
| Pedestrian Traffic only | 40 | 2 | DP0 | W | No requirement |
| Driveway, light vehicles only | 40 | 3 | DPA1 | | |
| Driveway, including commercial vehicles | 60 | 5 | DPA1 | | |
| Public area pavements | | | | | |
| Pedestrian traffic only (see notes 1 to 3) | 40 | 2 | DPA1 | W | Low volume:7 |
| Pedestrian traffic and light vehicles (axle loads <3.0t) | 50 | 3 | DPA2 | | Med volume:5.5 |
| Pedestrian traffic and commercial vehicles (axle loads >3.0t) | 60 | 5 | DPA2 | | High volume:3.5 |
| Roads | | | | | |
| General vehicle traffic on minor or local roads (see note 4) | 60 | 6 | DPA2 | W | No requirement |

**Notes to Table 13:**

1. Typical low volume pedestrian areas include paths in public gardens, schools or campus pavements, hard landscape areas, and common areas of residential buildings.

2. Typical medium volume pedestrian areas include suburban shopping area pavements, and pedestrian areas around institutional buildings, sporting or recreational venues.

3. Typical high volume pedestrian areas include inner city and major suburban pedestrian malls and paths, pavements with high volume pedestrian traffic (over 30,000 passes per day) that includes about one-third with high-heel shoes.

4. Minor local roads, excluding collector roads, carrying up to 1000 vehicles per day.

5. Pavers not reaching these requirements may be used when supported by local manufacturer's experience and performance data.

6. Other test methods may be used when they have been used extensively and shown to relate to performance data.

7. Exposure Grade units are required for use in severe marine environments and around saltwater swimming pools.

# 6. Pavement design & construction

### 6.1 Flexible v rigid pavements – what's the difference?

From paths to parking lots, clay pavers offer low maintenance, exemplary performance and an appearance that cannot be approached by other paving materials.

There are two basic methods of constructing a clay segmental pavement:

- **Rigid pavements** rely on a rigid underlying layer, such as a reinforced concrete slab, to distribute superimposed loads to the subgrade (ground).
- **Flexible pavements** don't use a rigid layer; the pavers are bedded in a thin layer of highly compacted sand over a much thicker layer of compacted crushed rock.

The decision as to whether a flexible or rigid pavement is used depends on specific site conditions and a comparative cost analysis of the two systems. This decision must be made on an individual project basis and, therefore, no recommendations are made here as to which type of pavement system to utilise.

However, the flexible system has been successfully used in a wide variety of applications for many years, including paths, patios, driveways and pedestrian areas. In some locations, flexible pavements have provided effective service in heavy vehicle applications (however the paver manufacturer's advice and local knowledge should be obtained on this point).

For these reasons, most of the information in this section is related to flexible pavement design. Figures 23 and 24 illustrate cross-sections of typical flexible and rigid pavements.

**Figure 23.** Section through a typical flexible clay pavement and edge restraint

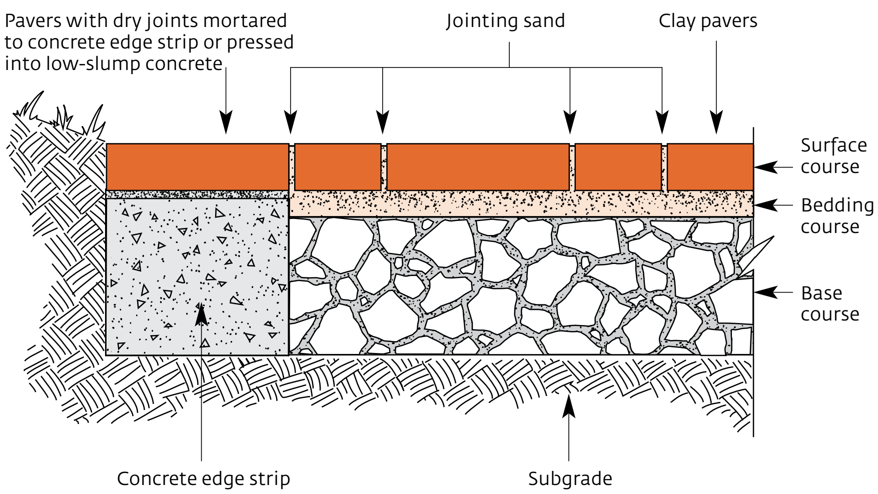
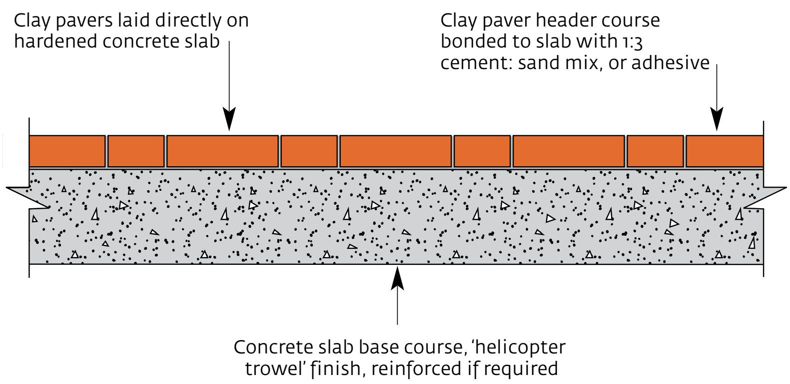



**Figure 24.** Section through a typical rigid clay pavement



## 6.2 Drainage

The drainage of pavements is a subject that is too complicated to cover adequately here. However, there are three important considerations:

- Surface runoff, that is, the water that falls directly onto the pavement and flows off the surface.
- Subsurface flow, that is, water from beyond the pavement and flowing under it.
- Infiltration water, that is, water entering the bedding sand. This must not be allowed to pond.

The principle of drainage is simple: surface water must be directed somewhere. For this reason, the pavement must slope slightly. Ideally, this runoff should be directed away from buildings, but if this cannot be done a channel and grate should intercept the water before it reaches the building. The subsurface may also need to be drained.

The next consideration is where the water that flows off the pavement goes to. Sometimes it may flow onto grass (for example a lawn edge on one or more sides of a patio), but this is rarely the case. More often it must be directed through a channel into stormwater drains.

Failure to provide proper drainage will almost inevitably lead to ponding and the subsidence of the pavement. In some circumstances, it may be necessary to seek professional advice to ensure a pavement will be properly drained.

## 6.3 Base course

The base course is a structural layer, and its thickness will vary according to the type of traffic it will carry. Because the purpose of the base course is to spread the load over a larger area of the subgrade, it is important that its thickness be consistent across the pavement.

For pedestrian and patio areas not subject to vehicle wheel loads the subgrade may be strong enough to carry the loads without any base course. If the subgrade is poorly drained or soft when wet, then 50 mm of compacted road base should be used.

For pavements carrying domestic vehicles a minimum of 100 mm of compacted crushed rock or road base should be used. A single pass by a heavy vehicle such as a delivery truck may cause significant damage to a pavement that was only designed for use by a relatively light vehicle such as a family car.

If the pavement is laid on controlled fill, use 100 mm of fine crushed rock as a base course. If the pavement is laid on uncontrolled fill, then remove the fill and replace it in compacted layers followed by a 100 mm base course. Alternatively, a reinforced concrete base may be needed on uncontrolled fill. A typical specification for a base course material is a well-graded crushed rock, minus 40 mm with a PI (plasticity index) of less than 5.

## 6.4 Bedding sand

The bedding course should be neither less than 20 mm thick (after compaction) nor more than 50 mm. A thickness of 30 mm is the usual average. It is important that the bedding course be the same thickness across the pavement. The bedding sand should comply with the grading limits shown in Table 14.

**Table 14.** Bedding sand grading limits

| AS sieve (mm) | Percent passing |
|---|---|
| 9.52 | 100 |
| 4.75 | 90-100 |
| 2.36 | 75-100 |
| 1.18 | 55-90 |
| 0.60 | 35-59 |
| 0.30 | 8-30 |
| 0.15 | 0-10 |
| 0.075 | 0-5 |

Typically, washed concrete sand will satisfy the requirement for well-graded coarse sand free of excessive amounts of silt and clay (that is, not more than five percent passing the 0.075 mm sieve).

The bedding sand should act as a capillary break to prevent ground water from moving up into the pavers. Dolomite (crushed limestone) and other crushed rock with a high proportion of fine material is unsatisfactory as a bedding layer.

Many landscape contractors in NSW, Queensland and Victoria use 'crusher dust' or 'cracker dust' as a bedding layer. This is strongly advised against as it can lead to these problems:

- Failure to achieve interlock because fines do not rise in the underside of the paver joints during final compaction.
- Absorption of impurities causes staining on surface of paver.

## 6.5 Laying patterns

Because of their rectangular shape, clay pavers can be laid in a wide range of attractive patterns (or bonds). A range of popular patterns is illustrated in Figure 25.

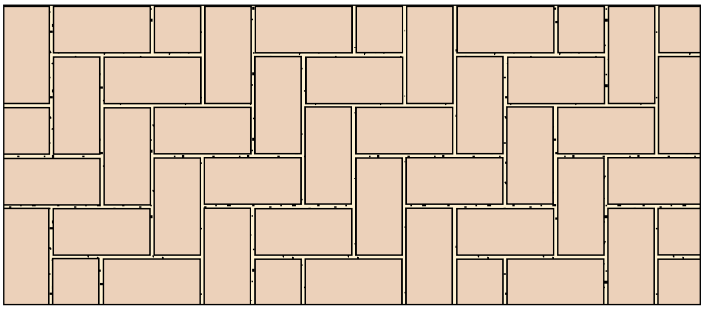
**Herringbone** is the strongest pattern and the only one recommended for vehicle pavements, including driveways and roadways. Both 45 and 90 degree herringbone allow the pavement to change direction, for example, around a corner. Some cutting of part-pavers is needed in both patterns, more so with 45 degree herringbone where the entire perimeter must be cut.

**Basketweave** is easy to lay, provided the pavers are the right ratio of length to width. Little cutting is required, except at infills or possibly on boundaries.

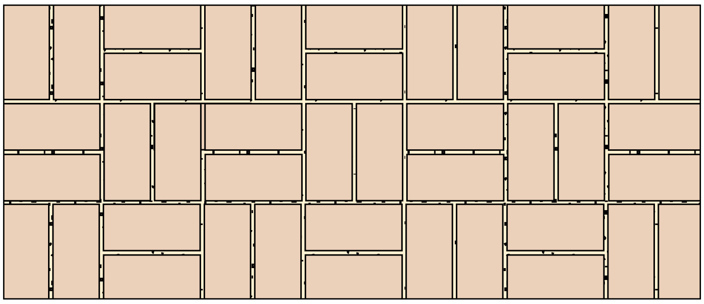
**Stretcher** is also an easy pattern to lay, requiring little or no cutting. It is very suitable for paths as it can curve or wind without cutting. Generally, a path in stretcher will be laid with the long side of the paver parallel to the edge of the path. Although herringbone patterns are preferred for vehicle pavements, transverse stretcher patterns (in which the traffic flows in the direction of the short side of the paver) have been used successfully.

**Tracery** is a very attractive pattern that is easy to lay, but requires some cutting.

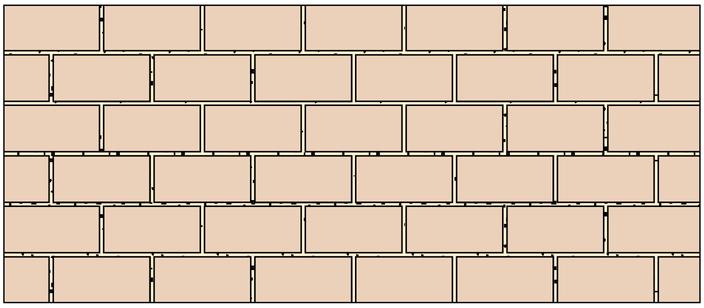
**Figure 25.** Four popular paving patterns



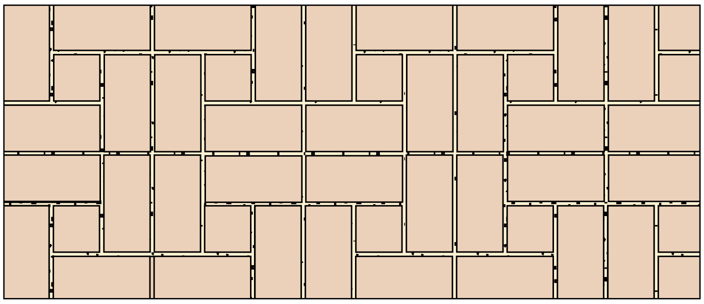
**Herringbone**



**Basketweave**



**Stretcher**



**Tracery**

## 6.6 Joint widths

Clay paving should be laid to a gauge determined by measuring the average paver size over 20 units and allowing 2.5 mm for each joint width. The often-quoted gap width is between 2 and 3 mm. It is important to give a range because it acknowledges that there is an inevitable variation in the size of fired clay pavers. Paving with gap widths over 5 mm should be taken up and relaid. Equally, gaps under 1mm should not be permitted.

Laying to gauge will ensure:

- No point contacts between pavers and therefore no edge chipping.
- No pattern distortion.
- Straight lines.
- The largest of the pavers will fit in the space provided.
- Control gaps will not be needed.
- Adequate joint filling to ensure interlock.

## 6.7 Jointing sand

The jointing sand should comply with the grading limits shown in Table 15.

**Table 15.** Jointing sand grading limits

| AS Sieve (mm) | Percent passing |
|---|---|
| 2.36 | 100 |
| 1.18 | 75 to 95 |
| 0.60 | 50 to 80 |
| 0.30 | 20 to 45 |
| 0.15 | 5 to 15 |
| 0.075 | 0 to 5 |

Joint filling sand should contain some clay to assist in reducing water permeability during the early stages of traffic use prior to the accumulation of detritus (particles of disintegrated matter that act to bind the jointing sand together after a period of time).

Jointing sand should not contain any material that will stain the pavers. Fine foundry sand with poor grading is not recommended as it will be easily eroded from the joints.

## 6.8 Bound joints

Pavements subject to in-plane loads such as driveways on a slope (up to 20 percent, over this figure specialist advice is needed) and pavements subject to vehicles braking, turning or accelerating, may require bound joints to reduce shunting. Bound joints may also be required to resist water or wind erosion on steeply sloping sites or perhaps around swimming pools. Joint binding also reduces the problem of weed growth between pavers and controls ants making nests under pavers. There are four methods for binding joints:

- Add a liquid copolymer such as Sanstik to the jointing sand.
- Use bagged jointing sand with a binding agent in it. Use slurry-filled or cemented joints.
- Mix dry sand and cement and sweep into the joints. This technique may cause excessive staining and the joint surface may form a crust that may subsequently break up.

## 6.9 Subgrade

The considerations with regard to the subgrade for a rigid pavement are the same as those for a flexible pavement. In every case, the pavement designer and/or the contractor must consider all measures necessary to determine the site conditions that will impact on the long term performance of the pavement including, but not limited to:

- Loadbearing capacity of the subgrade
- Subgrade drainage
- Removal and replacement of unsuitable material.

## 6.10 Base course

The base course for a rigid pavement is a concrete slab having the following properties:

- Strength to be consistent with expected traffic loading and subgrade strength but, in general terms, should always exceed an ultimate strength of 20 MPa.
- Thickness to satisfy predicted loadings.
- Reinforced, if required due to predicted loading.
- Finished to a smooth surface by floating with a 'helicopter trowel'.
- Allowed to harden overnight before pavers are laid.

## 6.11 Paver laying

Pavers should be selected as to their suitability for the intended application by reference to Section 3.0. Pavers can be laid once the concrete slab base course had hardened sufficiently to resist deformation, usually overnight.

The perimeter pavers are laid first, generally as a header course around the job. They are bonded to the hardened slab either by a strong cements and mix (1:3 or 1:31/2) or by an adhesive.

Once the perimeter pavers have been installed, the main body of the pavement can be laid in the chosen pattern. For rigid pavements that will be used for vehicular traffic it is strongly recommended that a 45 or 90 degree herringbone pattern is used.

The gaps that are essential between pavers in a flexible pavement are not necessary in a rigid pavement. They can be used if this is an aesthetic requirement, but gaps are not essential to the performance of a rigid pavement.

It must be noted that with this system, there is no allowance for the variation in the depth or height of the pavers as they are being laid on a hardened concrete base. Therefore any variation in height of the units will show up in the finished pavement. Pavers that have a bevelled or rounded arris can disguise this variation.

## 6.12 Expansion joints

Expansion must be considered when laying a rigid pavement. The gaps between pavers in a flexible pavement allow for thermal and long-term moisture expansion of clay pavers to be taken up. In a rigid pavement this does not occur. Therefore expansion joints are required in rigid pavements. The paver manufacturer should be consulted for advice on the location of such expansion joints.

## 6.13 Joint filling

Once all the full and cut pavers have been laid, it is time to fill the joints. The jointing mix is 1:3 cement: fine sand mixed with sufficient water to turn it into a fluid slurry. The mixture must be sufficiently fine so that the slurry mix can flow around any gaps in the paver and fill any voids underneath them. Finally, once the slurry filling of the joints is complete, the surface of the pavers should be hosed down using a high-pressure, fine mist spray to remove the excess slurry.

Vehicular traffic should be prevented from traversing the pavement for at least four days.

## 6.14 Edge restraints

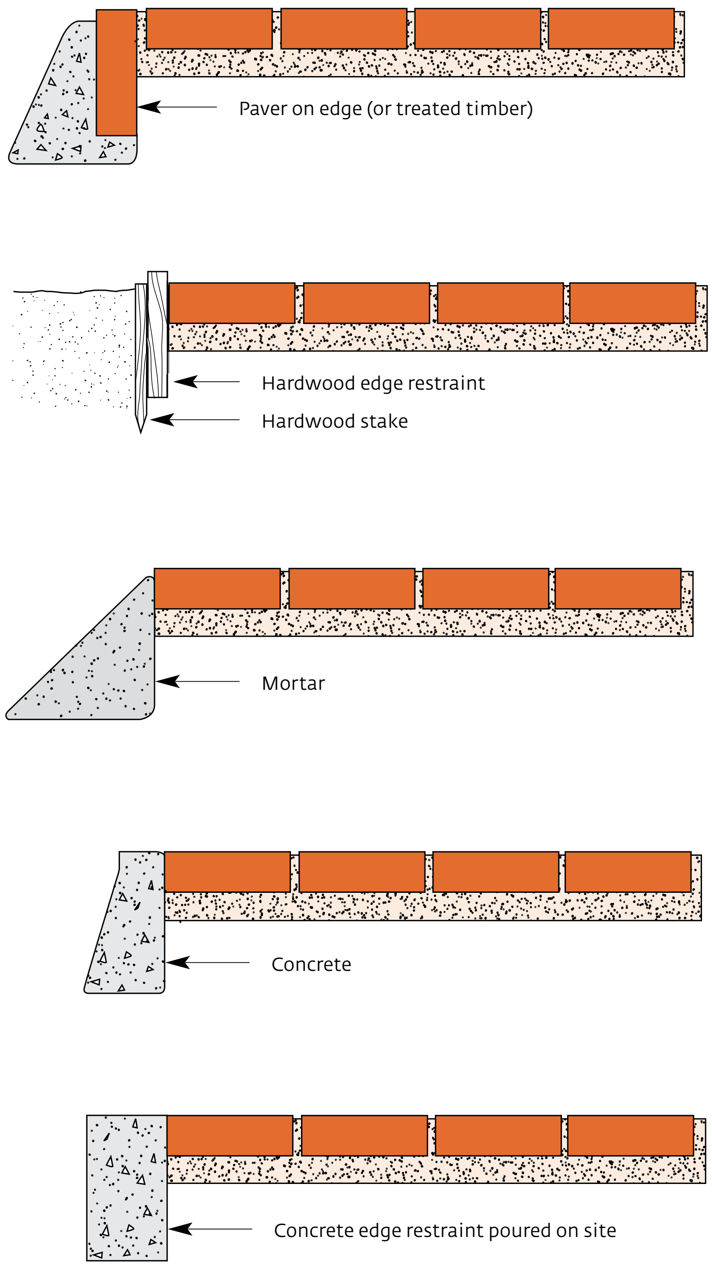
Edge restraints are necessary around the perimeter of clay paving to provide proper support to the edge pavers and to prevent lateral spreading of the pavers and the consequent loss of interlock.

Existing buildings, kerb and channel, or other structures may serve as an effective edge restraint where they are present. Care should be taken not to bridge damp-proof courses.

Edge restraints can consist of concrete haunching, soldier courses of pavers, timber or metal strip edging or a header course of pavers laid in mortar.

Some typical edge restraints are shown in Figure 26. The concrete edge beam at the bottom of the page is not commonly used in domestic pavements.

**Figure 26.** Typical edge restraints



# 7. Cleaning stains from pavers

## 7.1 Take care and trial first

Pavement cleaning is rarely as extensive as brick cleaning and usually does not require the use of strong acids. However, it is still essential to take great care when using chemicals such as acids, strong alkalis and volatile solvents. Protective clothing may be required, and good ventilation is necessary.

When cleaning paving, it is often advisable to conduct a test of the method and cleaning agents on a small inconspicuous area before proceeding with the whole job. It may be desirable to limit the access of children and pets to the paved area during cleaning.

## 7.2 Removing common stains

### 7.2.1 Chewing gum

In large areas, wire brushes free from rust should remove the majority of chewing gum. This may require several attempts. Careful application of high-pressure water jets can also be successful. For smaller areas freeze each piece of chewing gum with a carbon dioxide aerosol or dry ice. The chewing gum can then be chipped off with a scraper or chisel.

### 7.2.2 Dirt and grime

Frequent sweeping and hosing will usually ensure a clean pavement. If this is not enough, washing with detergent or a proprietary cleaner may be required.

### 7.2.3 Efflorescence

This is a powdery deposit of salts (usually white or yellow) often found on the surface of clay pavers after rain. The source of this stain is usually the surrounding materials, for example, the soil under the pavement, or from cement (if the soil was stabilised) or both.

Efflorescence is usually harmless and can be removed by dry brushing and removing the residue by wiping with a damp mop or cloth. Never hose the efflorescence from the surface as this will dissolve the salt to be reabsorbed by the paver.

It may also be necessary to properly drain the bedding sand to ensure the problem does not recur.

### 7.2.4 Food stains and tyre marks

Scrub with a neat commercial detergent and rinse well. Using Noskum or Amway LOC has also been successful. Note that some tyre marks are caused by bitumen transferred to the pavement by vehicle tyres. Treat these as discussed in the section on cleaning bitumen stains (Section 7.2.7).

### 7.2.5 Fresh mortar stains

The simplest way to remove wet mortar stains is to lightly cover the pavement before the mortar sets hard, with clean, but slightly damp, washed sand. Sweep the sand towards the edges of the pavement. If necessary, repeat this until the surface is almost clean. The most important point to remember is that the sand MUST be free of clay.

Follow this up with a further sweep with dry washed sand. Any sticky wet mortar residues that escaped the wet sanding will be removed. Once again, the sand must be free of clay.

A final clean up using a large foam pad (or even an old foam pillow attached to a broom head) will remove most remaining cement paste. Clean the foam frequently in clean water.

One or two days after the pavement has dried, some mortar residues may still be visible as a faint white film. Normally this will weather away. The appearance of efflorescence is almost certain, but do not panic, just follow the instructions above.

### 7.2.6 Hardened mortar stains

Experiment on a small section of the pavement with hydrochloric acid or a proprietary cleaner such as Noskum. Use decreasing proportions of water mixed with hydrochloric acid, starting with one part acid to eight parts of water.

Once you have determined the appropriate proportion of hydrochloric acid (or proprietary cleaner) to water, proceed as follows:

1. Slightly wet the pavement with a fine spray of water.

2. Using a stiff brush, apply the acid over approximately one square metre. Vigorously scrub the areas stained with mortar. When scrubbing is not sufficient, loosen thick mortar patches with a hard implement such as a steel scraper. Work on the mortar stain until it is dissolved.

3. Give the area a good hose-down. A high-pressure water spray unit is useful for this job.

4. Repeat 1 to 3 until the whole pavement has been cleaned.

A final rinsing of the pavement with a high-pressure water jet is often beneficial. However, there are some pavers that could be damaged by the overuse of high-pressure water jets. Care must also be taken not to remove sand from the paver joints.

### 7.2.7 Oil, bitumen and tar

These stains usually need two treatments with a commercial emulsifying agent. First, mix the emulsifier with kerosene to remove the stain. Then clean the kerosene off with the emulsifier mixed only with water.

When dealing with petroleum asphalt and bituminous emulsion, scrape off the excess material and scrub the surface with scouring powder and water. Chilling the surface with ice or solid carbon dioxide can assist removal.

Cutback bitumen stains will penetrate deep into the pavement, making effective treatment nearly impossible. However, a poultice of benzene, toluene or 15 percent trisodium phosphate will reduce the intensity of the stain. Scrub the surface with scouring powder and water. Alternatively, replace the affected pavers.

For petrol or lubricating oil stains, mop up free oil immediately with an absorbent material, such as paper towels. Wiping should be avoided as it spreads the stain and tends to force oil into the pavement. Hardened oil must be scraped off.

The area affected should then be covered with a dry absorbent material such as diatomaceous earth, fine white clay, kaolin or whiting and the procedure repeated until there is no further improvement. Subsequently use detergent to clean up, and rinse well with clean water.

### 7.2.8 Organic growths

Fungi, moulds, moss, lichens and particularly algae can disfigure a clay pavement and make it dangerously slippery. The usual causes are dampness, the availability of nutrients and a shady, but light, location. This frequently occurs on a southerly aspect, especially in winter. Potted plants usually mean extra nutrients as fertilisers leach from the pots during watering.

Common household bleaches such as White King and Exit mould will kill the growth. Simply spray the surface and brush off the residue.

To prevent the problem from occurring (or recurring) treat the surface with a solution of 15 grams of copper sulphate per litre of water. This is best carried out in late summer when the pavers are dry. The copper sulphate will remain in the pavers after the water has dried out and inhibit any growths. A repeat treatment may be necessary. Copper sulphate is available from fertiliser suppliers or from your pharmacist.

# 8. Appendix: Technical standards, codes and references

**Standards and codes**

National Construction Code

AS/NZS 1276.1:1999, Acoustics - Rating of Sound Insulation in Buildings and of Building Elements Airborne Sound Insulation

AS 3700–2018, Masonry Structures

AS 4455.1:2008,and AS4455.2:2010 Masonry Units and Segmental Pavers

AS/NZS 4456:2008, Masonry Units and Segmental Pavers, Methods of Test

AS/NZS 4586:2013, Slip Resistance Classification of New Pedestrian Surface Materials

**Think Brick Australia technical references**

These are available in Acrobat (PDF) format for free download from www.thinkbrick.com.au.

Brick and Paver Dictionary

Brickwork in Landscape

Building in Bushfire-Prone Areas

Cleaning Clay Masonry (also available in print)

Design of Free-Standing Clay Brick Walls

Energy Efficiency and the Environment: The Case for Clay Bricks

Manual 1, Clay Paving Design and Construction

Manual 2, Properties of Clay Masonry Units

Manual 3, The Full Brick Manual

Manual 4, Design of Clay Masonry for Wind and Earthquake

Manual 5, Fire Resistance Levels for Clay Brick Walls

Manual 6, Design of Clay Masonry for Compression

Manual 7, Design of Clay Masonry for Serviceability

Manual 9, Detailing of Clay Masonry Walls

Manual 10, Construction Guidelines for Clay Masonry

# Notes

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PO Box 275, St Leonards NSW 1590 Australia
Suite 7.01, Level 7, 154 Pacific Highway, St Leonards NSW 2065 Australia
Telephone +61 2 8448 5500
**Technical hotline** 1300 667 617
ABN 30003873309

**www.thinkbrick.com.au**

THINK BRICK AUSTRALIA