Brick properties and bricklaying practices

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The technical information in this manual is aimed to provide guidance on the properties of bricks and on the selection of bricks for specific applications.

Austral Bricks Pty Ltd manufactures all products to Australian Standard AS/NZS 4455 (Masonry units and segmental pavers), unless otherwise specified in the technical data sheet made available for each product. Australian Standard AS/NZS

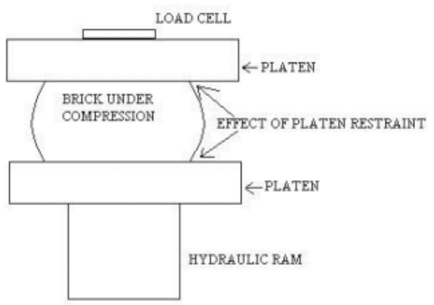
4456 (Masonry units and segmental pavers - methods of test) outlines the test methods required for the determination of the brick properties discussed. General information about bricklaying practices has also been provided to briefly explain some aspects of masonry construction.

BRICK PROPERTIES

Strength

Characteristic Unconfined Compressive Strength

Austral Bricks Pty Ltd makes available the characteristic unconfined compressive strength (f'uc) of their products as required by Australian Standard AS/NZS 4455. The f'uc values are determined using the test method detailed in AS/NZS 4456.4. The test method involves subjecting the masonry unit to increasing load by compressing it between two metal platens. The friction between the platens and the masonry unit acts to restrain the sideways spread of the unit, as shown in the diagram below.



COMPRESSIVE TESTING OF MASONRY UNITS

The effect of this restraint is more pronounced in shorter specimens than in taller specimens of the same width. The incorporation of an aspect ratio (height to thickness ratio) factor, allows the results to be converted to an equivalent unconfined compressive strength value (f'uc). That is, a correction factor, directly related to the dimensions of the unit, is used to compensate for the restraining effects of the platens during testing. The f'uc allows direct comparison of all masonry units, regardless of the size.

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

Refer to CBPI Manual 2: The Properties of Clay Masonry Units for further information on compressive strength measurements.

BRICK DURABILITY

Definition

All products manufactured by Austral Bricks Pty Ltd are classified by their durability. The durability of a brick is a measure of its resistance to attack by soluble salts.

The test method used to determine the durability of bricks is given in AS/NZS 4456.10. The suitability of the units for use in a given environment determines their salt attack resistance category.

Salt Attack Resistance Categories

1. Exposure Grade: Suitable for use in external walls exposed to aggressive environments, such as:

- in areas where walls are subjected to salts in the soil, adjacent material or ground water,
- in coastal areas where walls are exposed to attack from windborne salt spray, or
- retaining walls that may be subjected to fertilisers and ground salts.

   In environments where exposure grade masonry is necessary, the minimum mortar classification required is M4 (refer to the section on mortar within this page for further details). In addition, exposure grade bricks may not be suitable for use

   in areas subject to cyclic freezing and thawing. For more information on the suitability of products contact Austral's Technical Department.

2. General Purpose: Suitable for use in an external wall under ordinary exposure conditions.
3. Protected: Suitable for use in internal and external walls only when above a sheet or membrane damp-proof course and protected by an adequate coping, eaves, roof or similar top covering. These units should not be directly exposed to saline environments.

Durability Required

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

Exposure	Minimum Salt Attack Resistance Grade of Masonry Units	Minimum Mortar Classification	Minimum Durability Classification of Built-in Components
Marine Environment	General Purpose	M3	R3
Severe Marine Environment	Exposure	M4	R4
Below Damp Roof Course in Aggressive Soils	Exposure	M4	R4

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

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

It is important to take into consideration the given environment during the design and construction of brickwork buildings, to minimise the potential for salt attack. The most suitable mortar joints for aggressive environments are ironed or weather struck joints. The mortar classifications given in the table and the types of mortar joints possible are discussed in more detail

in the mortar section of this manual. It should also be noted that raked mortar joints should not be used in severe marine environments.

The minimum durability classification of built-in components is particularly relevant to the use of wall ties in masonry constructions. AS /NZS 2699.1 classifies the durability of masonry wall ties as:

- R3 - galvanised to a coating weight of at least 470g/m2 on both sides, in accordance with AS/NZS 4680

- R4 - stainless steel grade AS 1449/316 or AS 1449/316L

CBPI Manual 2, The Properties of Clay Masonry Units provides further information on the durability of bricks.

FRETTING OF BRICKWORK (SALT ATTACK)

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

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

For salt attack to occur the following three conditions are required:
- There must be salts present
- There must be water entering the wall
- The water must evaporate from the wall

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

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

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

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

Fretting brickwork may be treated using breathable sealers that penetrate the brickwork and consolidate loose particles. However, depending on the degree of fretting it may be necessary to render or replace the affected brickwork. For further information, contact Austral's Technical Department.

EXPANSION

Brick Growth

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

for the growth of bricks by the size and spacing of the control joints.

- The coefficient of expansion, or 'e' value, of clay bricks is tested in accordance with AS/NZS 4456.11 and is an estimate of the amount of growth expected in the first fifteen years after the brick leaves the kiln. Typical values are given only as a guide as:
- there is no pattern in the coefficient of expansion based on brick colour or manufacturing methods, and

the coefficient of expansion can vary considerably between batches even within a single brick type, due to variations in the manufacturing process and raw materials used.

For these reasons, Austral Bricks Pty Ltd regularly tests its products to determine the coefficient of expansion in accordance with AS/NZS 4456.11. Recent test data is available from our NATA accredited laboratory.

Expansion Gaps

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

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

Design of Control Gaps

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

Common Problems

The typical problems arising with expansion gaps include:

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

However, these problems can be avoided by good workmanship during construction. Further information on expansion gaps is available in CBPI Manual 10; Construction Guidelines for Clay Masonry.

INITIAL RATE OF ABSORPTION

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

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

High Suction Bricks

If the brick wins the tug-of-war and the water is absorbed too quickly from the mortar, the cement will not undergo proper hydration. Therefore, if the bricks have high suction the mortar will stiffen in the bed joint before the next course can be properly bedded. To accommodate high suction bricks, a high water retention mortar is required. It may also be necessary to shorten the bed joint or to wet the bricks prior to laying, in order to reduce their suction. However, wetting the bricks may lead to efflorescence in the brickwork (refer to Brick Manual 3 for an explanation of efflorescence). Dry press bricks often have high suction. Dry press bricks can be lightly sprayed with a hose and left until the water has spread throughout the brick before laying.

Low Suction Bricks

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

For further information on the absorption of water by bricks refer to the CBPI Manual 2, The Properties of Clay Masonry.

LIME PITTING

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

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

Lime pitting is defined in AS/NZS 4456 and the degree of lime pitting can be determined in accordance with AS/NZS 4456.13. Lime pitting is classified by the number and size of lime pits on the face or ends of the brick, as described below:

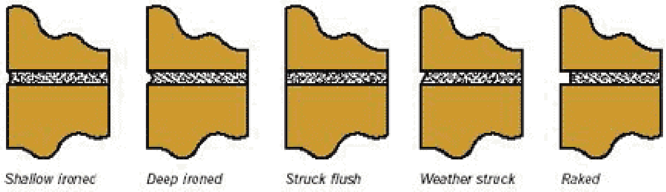
Nil	No Visible lime pits
Slight	Not more than 5 lime pits, none exceeding 8mm in diameter
Moderate	No pits exceeding 10mm diameter
Severe	Pit or pits in excess of 10mm diameter

BRICKLAYING

Mortar - Colour and Style

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

Mortar joint style also plays a major part in determining the overall appearance of a building. The different styles possible are shown below.



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

It should be noted that raked or recessed joints should not be used in severe marine environments and should be avoided in applications where durability is critical. Examples of the effect of the choice of mortar colour and style are given below:

(a) Two different mortar colours with the same blend

(b) The effect of mortar joint style on the same brick - flush joint and raked joint respectively

Wet sponging of the mortar joints is a common practice with smooth face bricks. Although this creates a smoother joint finish it smears a cement rich mortar film over the brick face, which often develops into staining.

With the amount of mortar colours, brick colours and joints available, the combinations are almost limitless, which means that owners can proudly stamp their style and individuality onto their home. To make the choices easier, Austral BricksTM has display walls at each selection centre to help show the effects of using different colours and styles of mortar.

Batching Mortar

Unless the proportions of sand, lime and cement that go into a mortar mix are measured with care, it is impossible to be sure if the correct mix has been achieved. In order to ensure that the correct proportion of materials has been used it is suggested that batching be carried out using buckets. A shovel should not be used as the measure during batching, as a shovel is able to hold more sand than cement (as shown in the images below).


(a) Cement (b) Sand

Mortar Mixes

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

The type of mortar mix is classified according to the Australian Standard AS 3700 as M1, M2, M3 or M4. The grade chosen by the masonry designer should match the requirements of the design. AS 3700 lists the deemed-to-satisfy proportions for the various grades. A brief description of the various mixes is given in the table below.

Grade	Mix	Properties	Applications
M4	1:0:4	Durable, low workability (which can be improved with the addition of lime or a water thickener)	Used in reinforced brickwork. (Must be used with Exposure Grade bricks in severe marine environments.)
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M4	1:0:4	Durable, low workability (which can be improved with the addition of lime or a water thickener)	Used in reinforced brickwork. (Must be used with Exposure Grade bricks in severe marine environments.)
M2	1:2:9	Quite forgiving and with a good balance between strength, flexibility and permeability. Prone to fading, so not suitable for colouring with pigments	Suitable for internal brickwork, brickwork above a damp-proof course, fireplaces and barbeques.
M1	1:3:12	Weakest of standard composition mortars. Combination of flexibility due to lime and early strength due to cement.	Should only be used for restoration work to match existing construction, e.g. for heritage masonry.
M1	1:3:12	Weakest of standard composition mortars. Combination of flexibility due to lime and early strength due to cement.	Should only be used for restoration work to match existing construction, e.g. for heritage masonry.

The compositions listed are based on the use of GP Portland Cement and GB cement. The use of other types of cement (such as masonry cement) will require different proportions, as the various types are not equivalent. For a more detailed description of the masonry mixes, grades and their applications refer to AS 3700 or to the CBPI Manual 10; Construction Guidelines for Clay Masonry.

Mixes for Different Mortar Colours

The table below shows the components required to give the best colour results.

Colour	Sand	Oxide	Cement
Red	Yellow	Red	Grey
Brown	Yellow	Brown	Grey
White	White Bush	–	White
Off White	White Bush	–	Off White
Black	Yellow	Black	Grey
Natural	Yellow	–	Grey
Cream	Yellow	–	Off White
Yellow	Yellow	Yellow	Off White

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

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

Other Mortar Components

The Importance of Lime

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

Admixtures

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

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

Other admixtures cannot be used unless they have demonstrated compliance with AS 3700.

BRICKLAYING PRACTICES

Wall Ties

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

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

The wall ties should be:

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

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

Damp-Proof Courses (DPC)

Australian Standard AS 3700 requires that damp-proof courses and flashing be used to prevent the movement of moisture vertically in the masonry and from the exterior of the building to the interior. In addition, the moisture from a cavity should

be shed to the outer course by the damp-proof course. A good description of damp-proof courses is available in CBPI Manual 10, Construction Guidelines for Clay Masonry.

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

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

Weepholes
A weephole acts as a drain hole through the brick wall. Weepholes are created during the construction of the brick wall. Weepholes are normally in the first or second brick course above ground level.

Weepholes are required at the head and sill flashing of windows over 1200mm wide and are commonly used for smaller windows also. CBPI Manual 10, Construction Guidelines for Clay Masonry provides descriptions of the different types of weepholes possible.

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

Building any form of structure over your weepholes can restrict the drainage of moisture that penetrates your brickwork. Allowing moisture to enter the brickwork may result in efflorescence, as is discussed in Brick Manual 3.