PGH BRICKS™ TECHNICAL MANUAL

ACKNOWLEDGEMENT

THINK BRICK AUSTRALIA

Think Brick Australia represents Australia's clay brick and paver manufacturers. PGH™ work with Think Brick to inspire contemporary brick architecture and building design in all areas of the built environment: commercial, residential and landscape.

Think Brick undertake extensive research, provide technical resources and training to ensure clay brick is recognised as a pre-eminent building material by leading architects, developers, builders and property owners. As a valuable source of knowledge and expertise, PGH™ wish to acknowledge Think Brick Australia for their contribution to this technical manual.

To find out more about Think Brick, visit thinkbrick.com.au.

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1.1

BRICK PROPERTIES

1.100 INTRODUCTION

In construction, there is a hierarchy of minimum requirements for essential properties, designed to ensure that technical requirements do not provide barriers to new materials, techniques and designs. The National Construction Code (NCC) provides minimum performance requirements for all structures in Australia.

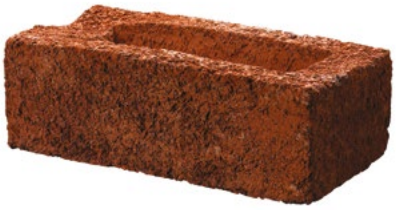
The Australian Standard AS 3700 *Masonry Structures* provides the basic rules for the design and construction of masonry structures to meet the requirements of the NCC.

All other standards covering the properties of building products such as bricks and blocks are written in such a way as to describe the properties of the materials concerned. They also provide test methods for the determination of those properties and set very low, or no, limits of performance. It is the designer's responsibility to specify the performance level required for the units selected for use in a given project.

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. If verification of the nominated values is required, it refers to AS/NZS 4456 which describes the test methods for the determination of 17 different properties of masonry units and segmental pavers, as well as sampling procedures and the assessment of the mean and standard deviation of test results. Not all the tests described in this standard are required to be specified, AS 3700 sets out the tests and properties required in each case.

1.101 BRICK RANGES

Dry Pressed



Sandstocks

Extruded
(Colour Through)

Extruded
(Surface Treated/Coated)

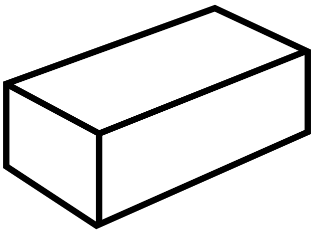
Extruded
(Semi Glazed)

Extruded
(Glazed)

Extruded Common

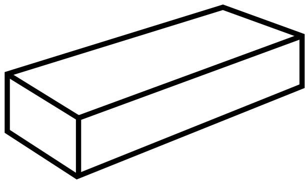
SECTION 1.1
BRICK PROPERTIES

1.102 BRICK DIMENSIONS AND RELATION TO MODULAR DESIGN



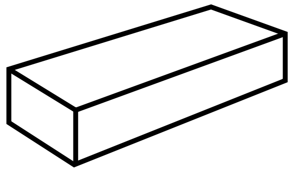
Standard
(230mm x 110mm x 76mm)

Used in all types of brick dwellings and structures. By far the most commonly used size. Can be cut and utilised across a variety of alternate bond patterns including flemish, half bond, stack bond etc.



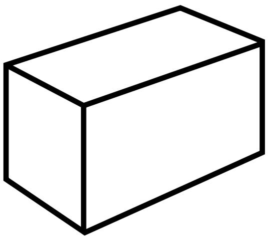
Split
(230mm x 110mm x 50mm)

Commonly used under window sills to assist in keeping the bond and gauge the same. Can also be cut from a standard brick, although production capabilities extend to purpose made split bricks. Occasionally used in an entire build rather than just as a feature wall.



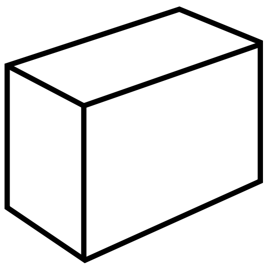
Linear
(290mm x 90mm x 50mm)

Used predominantly as a feature product, although occasionally used across the entire build. The longer, slim design adds a unique look and feel to the overall design of the structure.



One and a Half
(230mm x 110mm x 119mm)

Used predominantly as a differentiator in the market, one and a half sized bricks are less utilised than the other sizes on offer.



Double Height
(230mm x 110mm x 162mm)

Heavily used as both common and face brick, double height bricks offer an alternative to the standard brick sizings as well as adding speed and cost effectiveness to projects.

Modular Design
(using Australian standard sizes)

Advantages of Modular Layout:
Where possible, it is desirable to lay out the brickwork according to the module of the brick being used – both in length and height. Proper layout will minimise the cutting of bricks, thereby reducing costs. A good layout will also improve appearance by avoiding small cut pieces, mitres and uneven bonds. It also allows for uniformity in the mortar joints, avoiding unusually large or small joints.

1.103 BRICK DIMENSIONS

The work size of a brick unit is the manufactured size from which dimensional deviations (or tolerances) are measured in accordance with AS/NZS 4456.3 Determining Dimensions.

A traditional Australian clay brick has a work size of 230mm x 110mm x 76mm.

PGH™ also makes a range of alternate sizes which are outlined in '1.102 BRICK DIMENSIONS' and '1.201 SHAPES'.

Depending on their deviation from the declared work size and the method by which compliance to a specification is determined (see Figure 01 Measuring cumulative dimensions), masonry units are divided into five categories as outlined in Table 01 Dimensional deviations of masonry units.

Due to the natural variation in the raw materials used, masonry units individual sizes may vary after they are fired, however size variation between units averages out when blended properly during laying.

Figure 01 Measuring Cumulative Dimensions

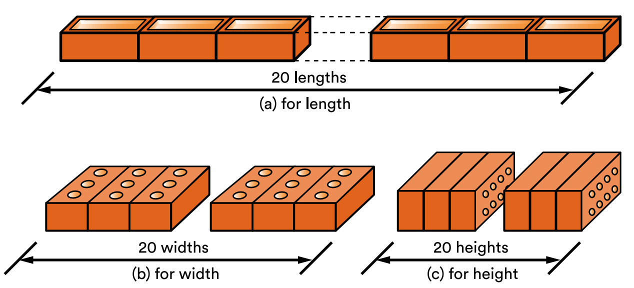


Table 01 Dimensional Deviations of Masonry Units

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 2mm and the difference between the mean and the work size of not more than 3mm.		

* 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)

1.104 WATER ABSORPTION

Cold Water Absorption (CWA)

The amount of water that a brick can absorb is measured by the water absorption test in accordance with AS/NZS 4456.14 Determining Water Absorption Properties.

There is no distinct relationship between water absorption and the water-tightness of walls, however, Cold Water Absorption can affect f'mt, efflorescence and water penetration. The results of water absorption tests are used by the brick manufacturer for quality assurance.

Initial Rate of Absorption (IRA)

The Initial Rate of Absorption (IRA) is the amount of water absorbed in one minute through the bed face of the brick, which is a function of the units porosity, according to AS/NZS 4456.17 Determining Initial Rate of Absorption (suction).

The bond between the masonry unit and mortar is largely influenced by the capacity of the brick to absorb water and the ability of the mortar to retain the water that is needed for the proper hydration of cement. If the brick sucks the water too quickly from the mortar, the next course may not be properly bedded. If the mortar retains too much water, the units tend to float on the mortar bed, making it difficult to lay plumb walls at a reasonable rate. In either case, there will be a poor bond. Therefore the water retentivity of the mortar needs to be matched to the IRA of the bricks to ensure that a strong bond is formed.

There is no requirement that must be met for IRA, however the optimum range is between 0.5 and 1.5kg/m²/min.

In cases where the brick has a very low IRA, proprietary admixtures (in compliance with AS 3700) often can be used with the mortar to combat the issues described above.

1.105 DURABILITY

Durability refers to the resistance of a masonry unit to weathering. The most common form of weathering is due to attack from soluble salts (commonly referred to as "Salt Attack") but can also include other environmental factors including chemicals in the soil. The way in which soluble salts attack porous materials (such as clay units, concrete, mortars and some natural stone) is depending on the environmental conditions and the nature of the product, to which soluble salts can be absorbed into the unit. The salt concentration in the solution gradually increases as the material dries. Crystallisation beginning when the volume of water remaining cannot dissolve all the salts present. Considerable pressure is applied to the walls of the pores during this crystallisation. When this occurs near the surface of the unit, the pressure applied on the pore walls may exceed the tensile strength of the material and fretting will take place.

The main conditions required for salt attack to occur are:

- Presence of salts
- Water ingress
- Drying/Evaporation of the water

Without these conditions, salt attack will not occur.

According to the National Construction Code (NCC) and Australian Standard AS3700 Masonry Structures, the environments in which bricks, mortar and fittings must be used are classified into three groups Exposure Grade, General Purpose and Protected. Bricks must be classified based on 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

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.

Two specific environments are defined in more detail:

Severe Marine Environment

- Only EXP Grade bricks can be used
- Up to 1km from a surf coast
- Up to 100m from an inlet or bay

Marine Environment

- At least GP Grade bricks must be used
- Between 1km and 10km from a surf coast
- Between 100m and 1km from a non-surf coast

Bricks are classified by the manufacturer/supplier in accordance with Table 02 Durability Categories.

Table 02 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 (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.

Figure 02 Effects of salt attack on the bricks and mortar

Figure 03 Effects of salt attack on the bricks and mortar

1.106 COMPRESSIVE STRENGTH

The ultimate compressive strength of brickwork (f'm) is a combination of the strength of the mortar, the characteristic unconfined compressive strength (f'uc), their bond as well as the aspect (height : thickness) ratio.

The test method AS/NZS 4456.4 *Determining Compressive Strength of Masonry Units*, involves subjecting a brick unit to increasing load by compressing it between two (2) metal platens in a compressive testing machine. The test method also requires a correction factor (based on the aspect or height-to-thickness ratio) be applied to test results, the application of the aspect ratio factor converts 'unconfined compressive strength' (in MPa) to 'characteristic unconfined compressive strength' (f'uc), therefore allowing the reported result to be applied directly in design considerations without the need for further calculations.

Characteristic Unconfined Compressive Strength (f'uc)

The characteristic unconfined compressive strength (f'uc) is used to find (f'm), which is used by Engineers in equations to determine the strength of a wall.

The standard is based on the 95% characteristic value at a 75% confidence level. This means that there is a 75% certainty that the strength of 95% of the units in the lot is higher than the characteristic strength determined from testing the sample.

Typical characteristic unconfined compressive strength values can be see in Table 03.

Table 03 Typical Characteristic Unconfined Compressive Strengths 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	12 – 48
Pressed	16	9 – 34
Queensland		
Extruded	16	9 – 23
Pressed	13	6 – 23
South Australia		
Extruded	28	13 – 46
Pressed	19	14 – 24
Tasmania		
Extruded	23	8 – 48
Victoria		
Extruded	34	10 – 49
Pressed	26	14 – 41
Western Australia		
Extruded	18	11 – 33

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

Figure 04 Compressive Strength Testing

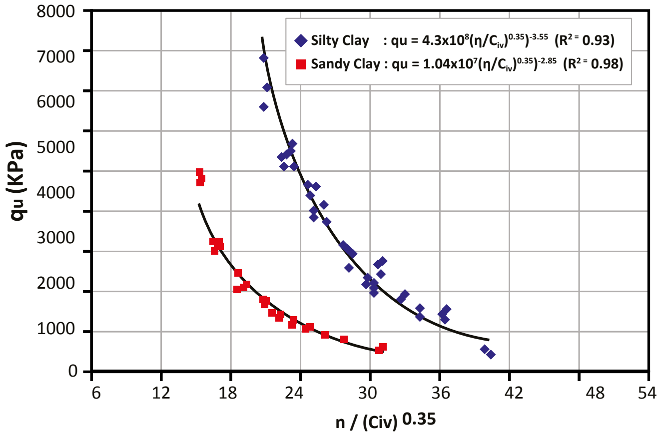
1.107 MOISTURE EXPANSION

Moisture expansion, or brick growth, is a property of all fired clay products (not just masonry) which are subject to reactions that cause them to expand in both horizontal and vertical directions. The amount of long-term permanent change in unit dimensions depends upon the material from which the units are made and how well that material was fired. The reactions begin from the time the masonry exits the kiln and cools, and continues at a reducing rate for the life of the unit.

Expansion over time is not uniform, it is in fact logarithmic, with the majority of the expansion occurring within the first six (6) months. Refer to Figure 05 *Typical expansion rate due to moisture in masonry units.*

For design purposes (size and spacing of expansion joints), the coefficient of expansion (e_m value) is used as a measure of the expected growth (mm/m) over 15 years, and is determined by the method of test given in AS/NZS 4456.11 Determining Coefficients of Expansion.

Figure 05 Typical Expansion Rate Due to Moisture in Masonry Units



Characteristic expansion can be classified as:
Low – up to 0.8mm/m
Med – 0.8 – 1.6mm/m
High greater than 1.6mm/m

However, it must be remembered that:
There is no pattern in characteristic expansions based on clay masonry unit colour or manufacturing methods.

Due to variations in the manufacturing process, the characteristic expansion can vary considerably between batches, even within a single masonry type.

For those reasons designers should obtain current expansion data from the manufacturer for the specific unit they propose to use. A summary of the most recent general data (collected until the mid 1980s and believed to be still relevant today) is given in Table 04. As this table shows, only a small proportion of clay masonry can be expected to have growth characteristics higher that the top end of the mid 65 percent range.

Moisture expansion must be considered when designing and constructing a clay masonry structure, in order to locate expansion and articulation joints which in turn reduce cracking in the masonry units and wall. Further details can be found in Think Brick - Manual 9, *Detailing Clay Masonry* and Manual 10, *Construction Guidelines for Clay Masonry.*

Control Joints

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

Control joints must be inserted to absorb expansion, both horizontally and vertically, to avoid damage to the masonry. The problem is well understood, and when the long-term expansion value (e_m) is known, suitable control joints can be designed. Guidelines for design and location of control joints can be found in Think Brick Manual 9 – *Detailing of Clay Masonry.*

Corners are particularly prone to damage as the growth occurs in orthogonal directions in the two intersecting walls. For this reason, a control joint should be located at or near a corner if long lengths of brickwork are involved.

Where articulation is required for other reasons, the articulation joints can also be designed as control joints.

Articulation Joints

Articulation joints are used in conjunction with a foundation to control the effects of ground movements. The joints articulate the masonry components of the building into separate elements, which undergo rigid body rotations as the footing deflects, without causing distress in the masonry. The more flexible the footing, or the more susceptible the surface finish is to cracking, the closer the required spacing of the joints will be. Articulation not only limits cracking of walls, but also avoids the potential jamming of windows and doors caused by foundation movement.

Table 04 Moisture Expansion of Australian Clay Masonry Units

Place and method of manufacture	Average (mm/m)	Range (mm/m)	Mid 65% (mm/m)
New South Wales			
Extruded	1.5	0.3 – 3.7	0.7 – 2.2
Pressed	0.8	0.1 – 2.6	0.4 – 1.1
Queensland			
Extruded	0.8	0.6 – 1.4	0.4 – 1.0
Pressed	1.0	0.3 – 2.5	0.6 – 1.4
South Australia			
Extruded	1.0	0.7– 1.6	0.8 – 1.0
Pressed	1.0	0.8 – 1.2	–
Tasmania			
Extruded	1.5	0.3 – 3.3	0.7 – 2.3
Victoria			
Extruded	1.0	0.3 – 2.6	0.6 – 1.2
Pressed	0.8	0.1 – 3.0	0.4 – 1.0
Western Australia			
Extruded	0.6	0.1 – 1.3	0.3 – 0.8

1.108 EFFLORESCENCE

Efflorescence is a soluble salt that deposits on the surface of masonry after evaporation of water. These deposits can either be loose crystalline salts or amorphous films. The majority of soluble salts that cause efflorescence come from sources outside the masonry unit such as ground water, sea spray, acidic atmospheric gases, mortar ingredients and other materials in contact with the units.

Generally, efflorescence does not damage the brickwork and can naturally disappear over time, or may be brushed off. Persistent efflorescence may be a sign of water entering the brickwork and if allowed to continue the salts carried to the surface of the brickwork may eventually attack the bricks.

AS/NZS 4456.6 Determining Potential to Effloresce classifies the potential of a masonry unit to effloresce as one of the following five categories as seen in Table 05 - Definitions of Efflorescence.

Table 05 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

Figure 06 Effects of Efflorescence

1.109 LIME PITTING

If the raw material used for brick-making contains particles of limestone (calcium carbonate) these can be converted to quicklime during firing in the kiln. If the fired unit is exposed to moisture, the quicklime converts to hydrated lime and in this process expands. If lime particles are sufficiently large and sufficiently near the surface they 'pop' off a piece of the brick, leaving a generally circular pit.

Table 06 Pitting due to lime, categories and definitions summarises the requirements of AS/NZS 4456.13 Determining pitting due to lime particles.

Improved production techniques have resulted in the number of cases of lime pitting drastically reducing.

Table 06 Pitting Due to Lime: Categories and Definitions

Category	Definition
Nil	No visible pits
Slight	Up to five pits, none over 8mm diameter
Moderate	No pit over 10mm diameter
Severe	Pits or pits over 10mm diameter

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

Figure 07 Lime Pitting

Figure 08 Lime Pitting

1.110 BASIX RATING/SOLAR ABSORPTANCE

Thermal properties are increasingly important for compliance with NCC energy efficiency performance requirements and other State prescribed schemes (such as NSW BASIX). Solar Absorptance is one (1) element of a buildings thermal performance that needs to be considered, the others include thermal capacitance (thermal mass) and thermal resistance (R value).

Solar Absorptance is a measure of how well a material absorbs heat from the sun (the remainder is reflected). Solar Absorptance is based on colour, rather than material used, and is reported as a number from 0 to 1. As the effect of absorptance by walls is not large (predominately roof colour related), it is usually shown as either 'light', 'medium', or 'dark'. Light materials have a lower Solar Absorptance and will reflect more heat, while dark materials have a higher Solar Absorptance and will absorb more. Unlike many other materials, clay masonry units absorb and release heat almost equally well.

The NCC sets out the classification of Solar Absorptance, with other State based schemes (such as NSW BASIX) adopting similar classifications (see table below). These classifications can be used in national energy efficiency schemes such as NatHERS.

Table 07 Solar Absorptance Classifications

	Light	Medium	Dark
NCC	<0.4	0.4 - 0.6	>0.6
NSW BASIX	<0.475	0.475 – 0.7	>0.7

BASIX (Building Sustainability Index) is a NSW planning initiative, incorporated as part of the development application (DA) process (under the Environmental Planning and Assessment Act) and applies to all residential dwelling types. BASIX is an assessment tool and aims to reduce water consumption, energy consumption and greenhouse gas emissions in homes across NSW.

The BASIX assessment measures the proposed development for sustainability against set BASIX targets. Once a design has complied with BASIX a BASIX certificate is generated and is attached to the development application for submission to Council (or certifying authority).

PGH Bricks™ & Solar Absorptance

PGH Bricks™ manufactures bricks with Solar Absorptance ratings varying from Light to Dark. Specific Solar Absorptance information for all bricks is available in product brochures or by request.

Thermal Mass

Thermal mass is the ability of a material to retain heat energy when subjected to a temperature differential and to slowly release it back into the environment as the conditions change. Structures with high thermal mass can reduce the transfer of heat by absorbing the heat energy flowing in from the outside. This process is slow and results in a delay called thermal lag. The ability to absorb large quantities of heat energy combined with the thermal lag effectively increases the thermal performance of a material. Heavy walling systems like brickwork coupled with concrete floors combine to produce relatively high thermal mass. From a sustainability perspective, high thermal mass is ideal as such buildings need less dependency for artificial heating and cooling, meaning less energy use and improved thermal comfort for building occupants.

The NCC acknowledges the contribution of the mass of a cavity brick wall to its thermal capacitance by including separate deemed-to-satisfy provisions for walls having at least 220kg of wall mass per square metre.

R-Value

The thermal resistance value or R-value of brick contributes to the thermal efficiency of a building or structure.

While insulation in external walls is essential, the R-value is a static parameter which alone does not predict the energy used in maintaining internal temperature in real-life dynamic temperature environments. Consequently, it also does not reflect the true superiority of clay masonry which is to its inherent thermal mass.

For further information, including results from a study conducted by the University of Newcastle into the Thermal Performance in Australian Housing, consult the industry association Think Brick.

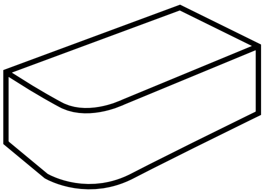
1.111 NATURAL COLOUR VARIATION

PGH bricks are made from natural clays, fired at extreme temperatures creating products of enduring colour and character. The natural variation in both clay and firing process means textures, composition, size and colour including the appearance of flashing, will vary from batch to batch. Often the character created by this variability is the very reason bricks are desirable.

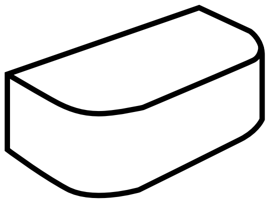
1.2

DESIGN & CONSTRUCTION

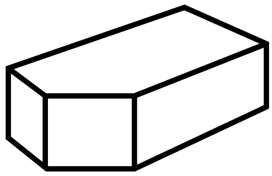
1.201 SPECIAL PURPOSE UNITS



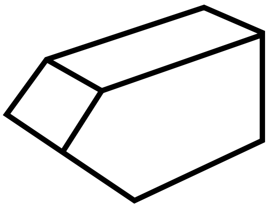
Single Bullnose



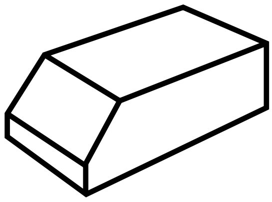
Double Bullnose



Single Cant



Single Squint



Plinth Header

Bricks are available in a range of dimensions. Decisions about size may depend on a range of factors, from the proportions of the house to the purpose of the bricks. Bricks are often used for decorative applications, such as feature walls, window sills and fire places. Different sizes and shapes can be combined to create visual interest and depth. Some of the more common shapes are shown above. Contact PGH™ to discuss your shapes requirements.

1.202 ROBUSTNESS LIMITS

AS 3700 requires masonry members and their connections to have an adequate degree of robustness, regardless of the level of load to which they are subjected. Robustness is a part of serviceability, ensuring adequate wall stability during construction.

Walls

The principle is that even if a wall is designed to satisfy all the prescribed loads, it should not be so slender as to fail under some unintended or accidental load and it should have adequate stiffness. If the wall is capable of withstanding a minimum level of lateral load of 0.5kPa, it is deemed to have the necessary robustness. The bending provisions in AS 3700 are used to determine if the wall satisfies the requirements for robustness and should be referenced as required.

It is also important to consider the effects of chasing and the presence of openings in walls when assessing robustness. The edge of an opening is usually considered to be an unrestrained edge of the wall.

Piers

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

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

$$\frac{H}{t_r} \leq C_v$$

Where -

H = Clear height of the member (in metres)

t = minimum thickness of the member

C_v = Robustness coefficient for vertical span. For piers unreinforced vertically - 13.5. For piers reinforced vertically or pre-stressed - 30.

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

The design rules can be expressed as limiting heights and lengths for a given wall thickness. These are shown as charts for various wall configurations in Figures 09 – 20.

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

1.202 ROBUSTNESS LIMITS

Figure 09 Robustness Limits: Laterally Supported Both Ends and Top Laterally Supported by a Concrete Slab

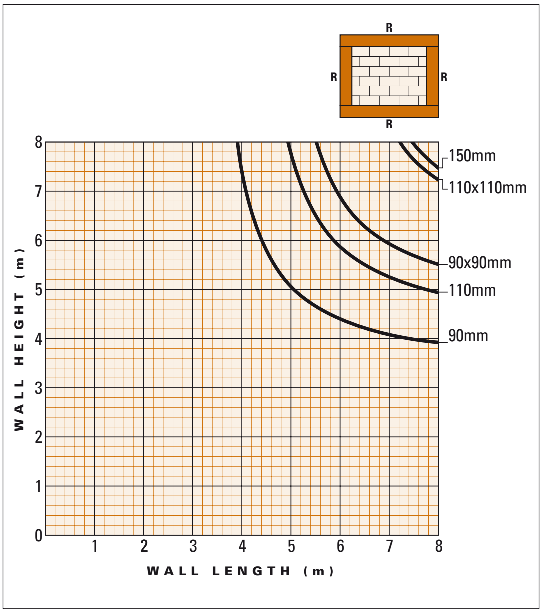


Figure 10 Robustness Limits: Laterally Supported Both Ends and Top Laterally Supported by Other than Concrete Slab

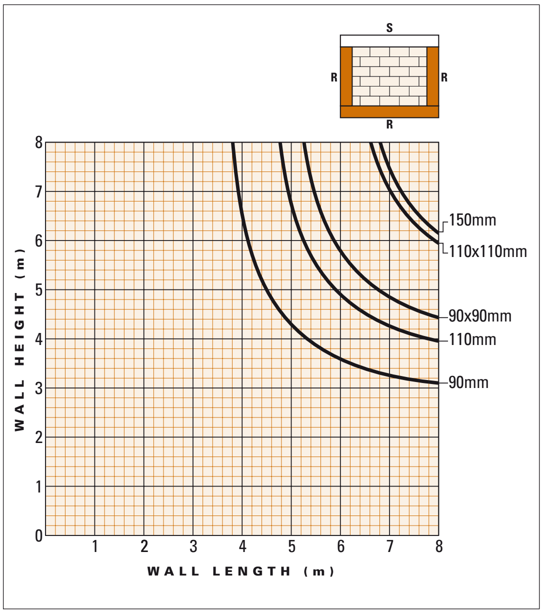


Figure 11 Robustness Limits: Laterally Supported Both Ends and Top Unsupported

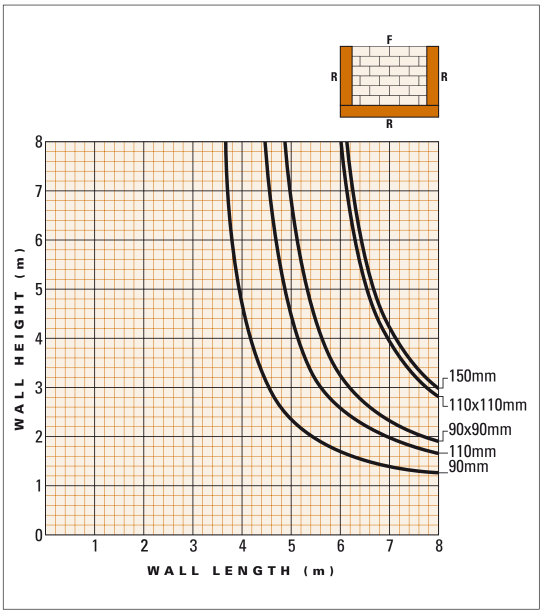
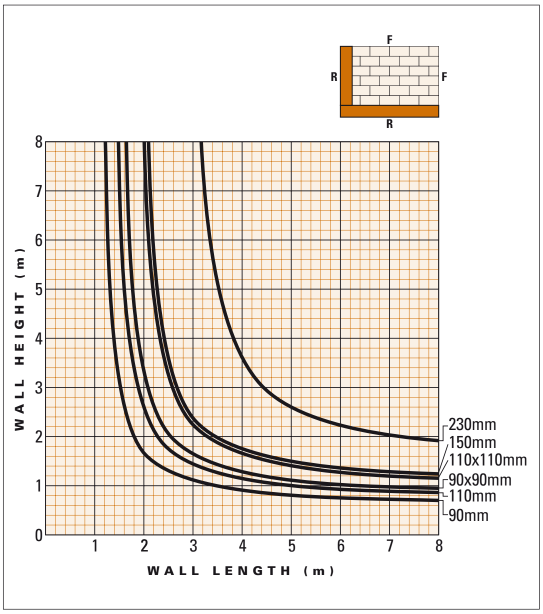


Figure 12 Robustness Limits: Laterally Supported One End and Top Unsupported



1.202 ROBUSTNESS LIMITS

Figure 13 Robustness Limits: Laterally Supported One End and Top Laterally Supported by Other than Concrete Slab

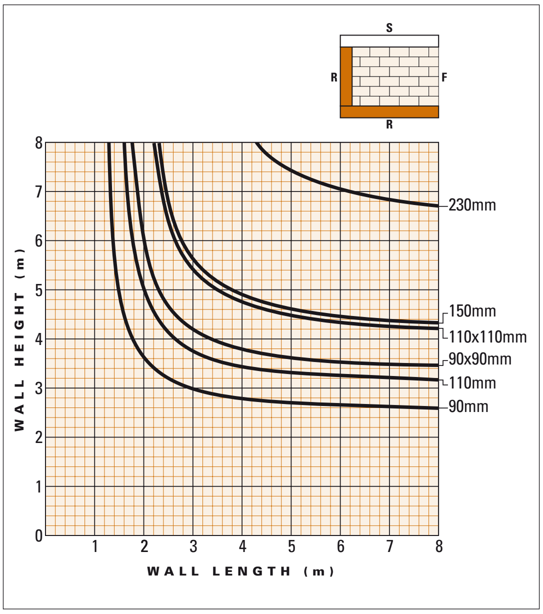
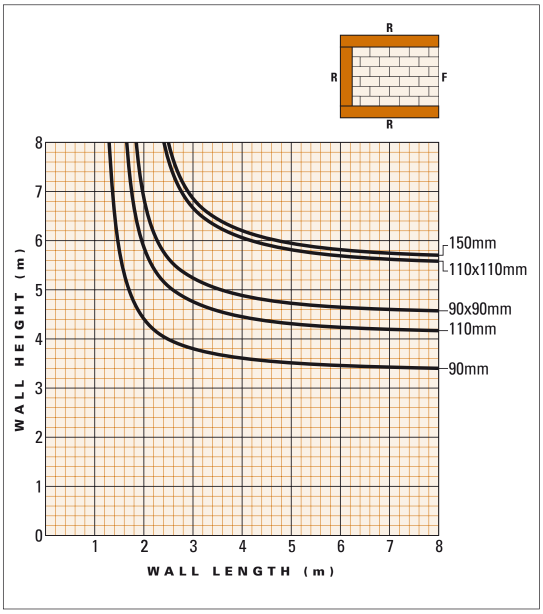


Figure 14 Robustness Limits: Laterally Supported One End and Top Laterally Supported by Concrete Slab



Limiting Dimensions for Robustness

Limitations for all charts:

- They apply to single-leaf walls without engaged piers, using solid or cored masonry units
- No superimposed compression is taken into account
- No joint raking is assumed
- f 'mt is assumed to be 0.2 MPa (AS 3700 default)
- f 'ut is assumed to be 0.8 MPa (AS 3700 default)
- Robustness should be checked separately.
- All supports are simple (without rotational restraint) unless otherwise indicated
- The dimensions of masonry units have been taken as 230L x 76H for 110mm units and 290L x 76H for 90mm units. This is conservative for other common sizes of solid or cored units in horizontal and two-way bending.

Figure 15 Limiting Dimensions for Robustness: One-way Vertical Bending

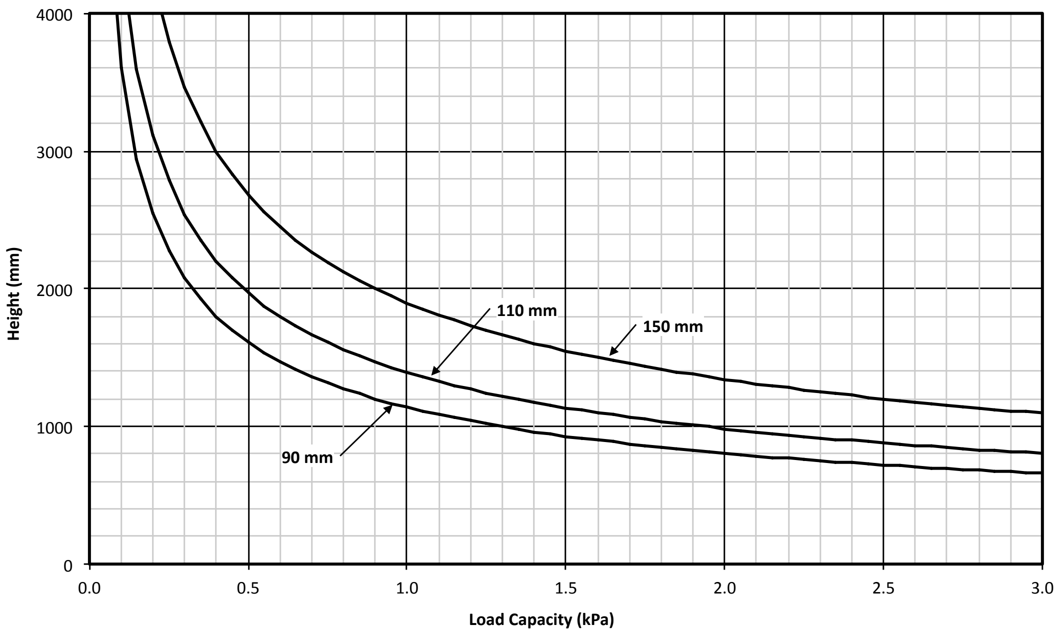


Figure 16 Limiting Dimensions for Robustness: One-way Horizontal Bending

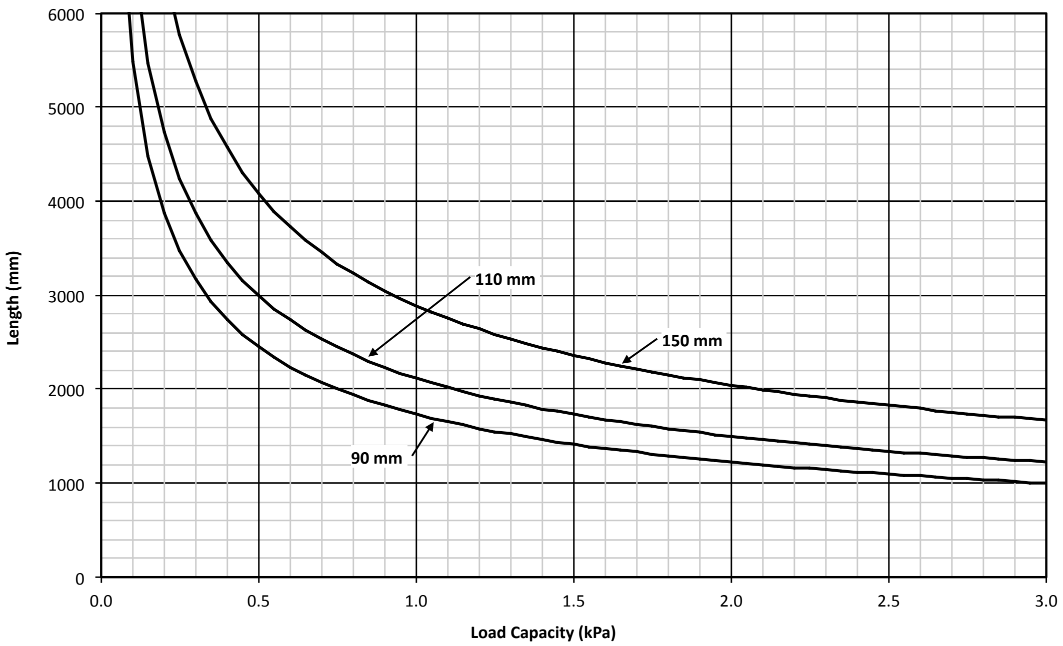


Figure 17 Limiting Dimensions for Robustness: 110mm without openings (no rotational restraint at the sides) – Both sides supported

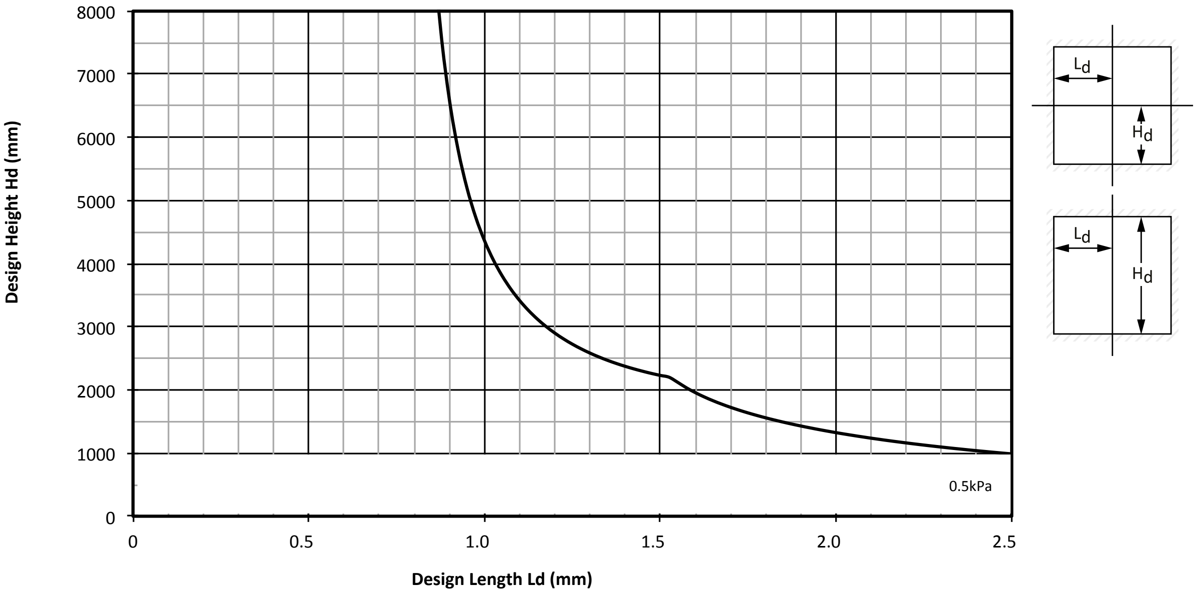


Figure 18 Limiting Dimensions for Robustness: 110mm without openings (no rotational restraint at the sides) – One side supported

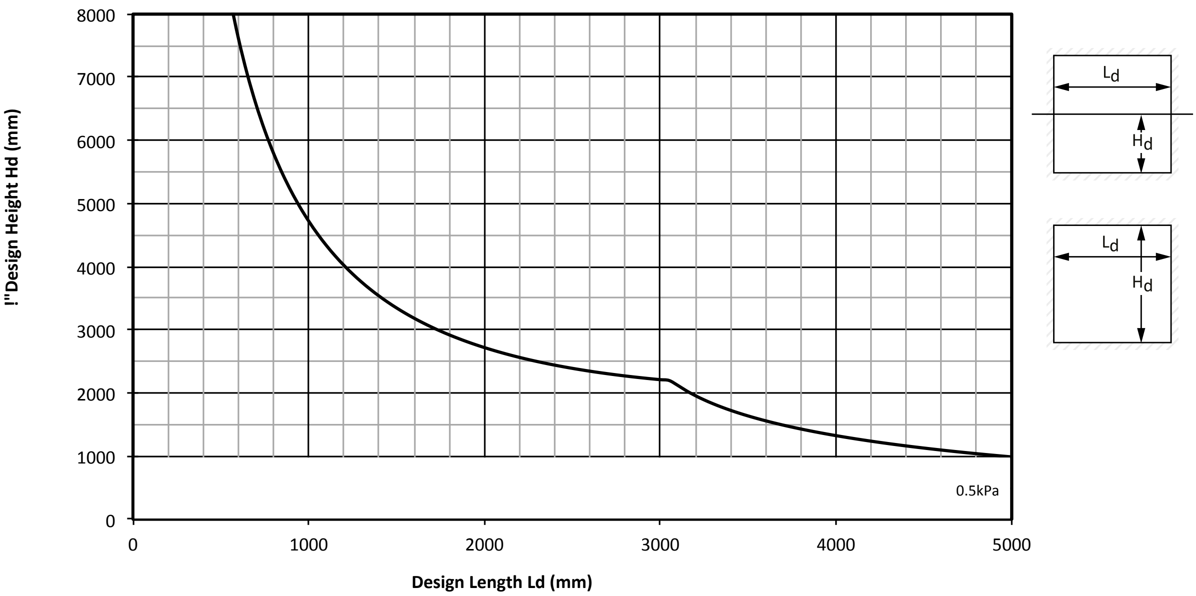


Figure 19 Limiting Dimensions for Robustness: 90mm without openings (no rotational restraint at the sides) – Both sides supported

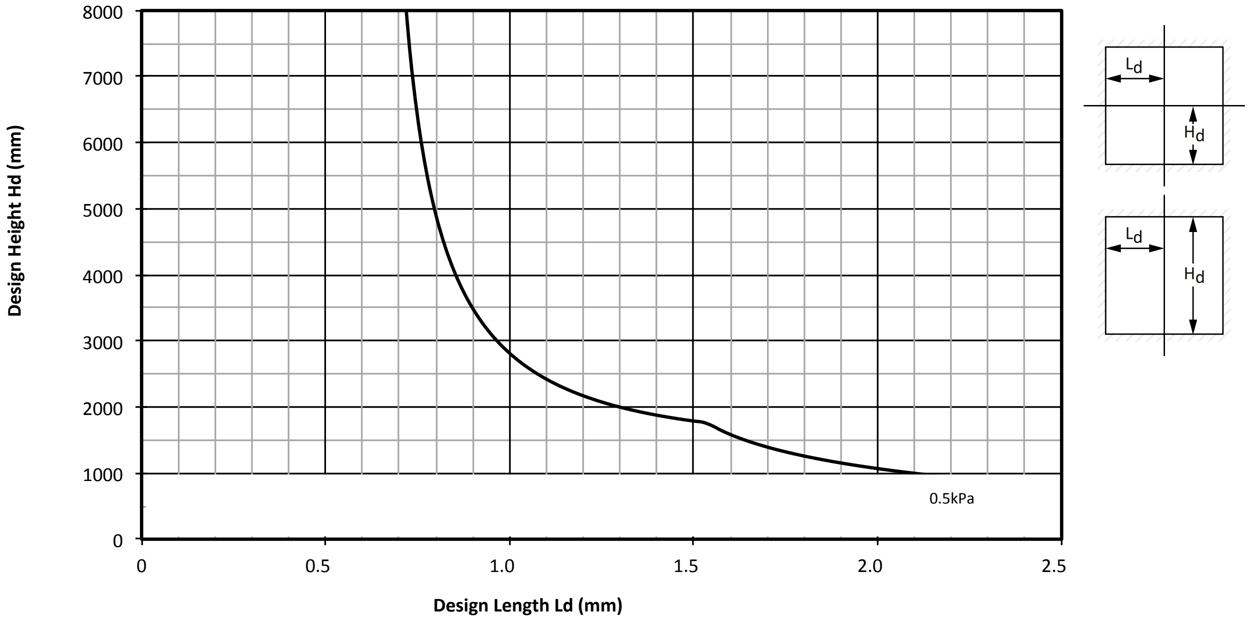
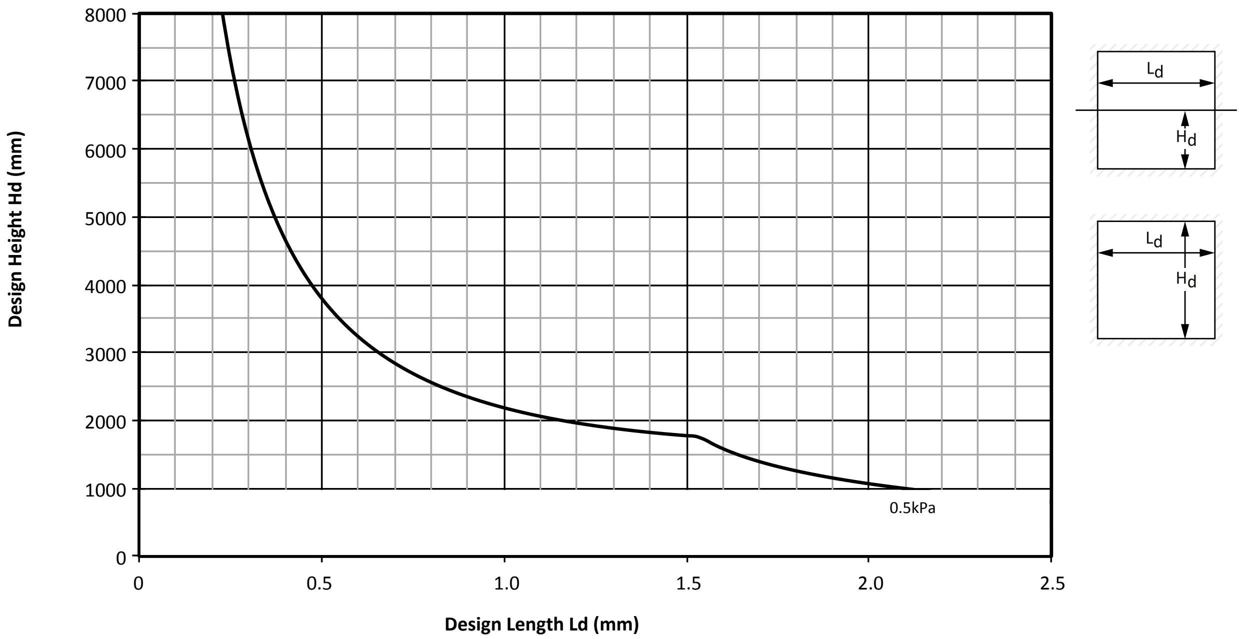


Figure 20 Limiting Dimensions for Robustness: 90mm without openings (no rotational restraint at the sides) – One side supported



1.203 MORTAR TYPES

Australian Standards contain performance statements for mortar, supported where possible by deemed-to-satisfy clauses. AS 3700 requires that mortar provide adequate workability, appropriate durability and the ability to impart to the masonry the required compressive and tensile strengths.

It is important to note that if Table 08 Mortar Mixes is followed, all of the requirements set out in AS 3700 for performance of mortar will be met.

The standards are based on the expectation that all masonry will have a characteristic flexural tensile strength of not less than 0.2MPa. This is to encourage the proper matching of mortar to the characteristics of the masonry units in each case. If this matching is not carried out, the appropriate level of strength might not be reached, even with high standards of workmanship.

Mortar determines the overall soundness of masonry. It bonds the units together in such a way that the applied loads can be resisted, while providing a construction method that makes possible the wide variety of shapes characteristic of masonry.

Mortar performs the following functions:

- Accommodates variations in unit size and shape – a nominal joint thickness of 10mm is usually adequate for this purpose.
- Provides adhesive bond strength sufficient to resist lateral loads and to provide overall robustness.
- Allows for even bedding of the units and sufficient strength to resist compressive loads.
- Provides a weather-tight and durable wall by sealing the joints between units.
- Provides aesthetic effects by various joint treatments, pigmentation, bonding patterns and so on.

The most important functional properties of mortar are its consistency, its durability and its ability to bond with the masonry units. All of these can be significantly affected by workmanship and site practices.

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 10.1 of AS 3700.

Mortar proportions are always expressed as the proportion of cement to lime to sand... and always in that order. Table 08 shows a range of mixes with the corresponding grade according to AS 3700, and comments on their applications.

Table 08 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 1:0:5:4-5	These are the strongest and least permable 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.

Mortar Quantities

Table 09 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 09 Estimated Quantities of Cement, Lime and Sand per 1000 bricks with 25 Percent Brick Perforation

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

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 20kg are ideal for this method.

Figure 21 Mortar Mixing (Cement Addition)

Figure 22 Mortar Mixing (Sand Addition)

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 mineral or inorganic pigment up to 10 percent by mass of the cement used (that is, 2kg pigment/20kg 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.

1.204 MORTAR JOINTS

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. Whilst flush joints can result in joint segregation from the brick, allowing water penetration to occur.

The NCC does not permit the use of raked joints in exposure environments.

Joint Thickness and Tolerances

The standard thickness for a mortar joint is 10mm. 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 allows a deviation from the specified thickness of bed joint of ±3mm.

The minimum thickness of the perpends must not be less than 5mm, 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.

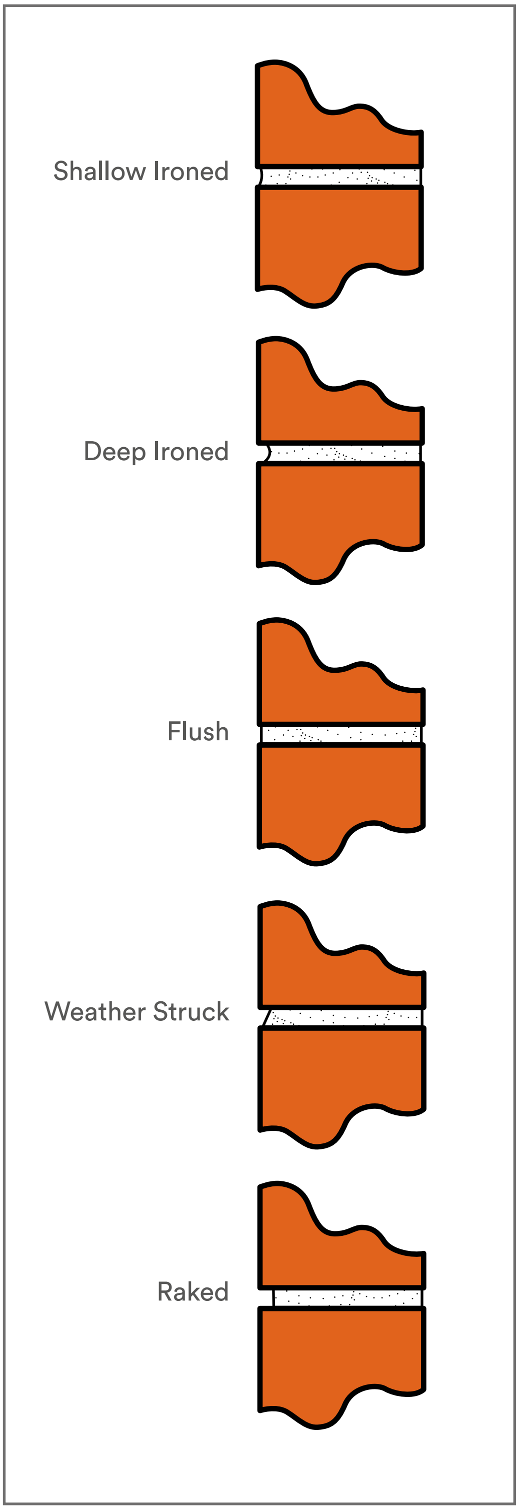


Figure 23 Common Mortar Joints

1.205 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

According to AS 3700, where flashings are incorporated in the masonry, weepholes of minimum 75mm height, by the width of the vertical mortar joint, shall be provided in the masonry course immediately above any flashing (including any damp proof course acting as flashing), at centres not exceeding 1200mm. However, it is common to see them placed at smaller intervals.

Weepholes are not required where head openings are less than 1200mm wide, or beneath window and door sills.

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 10mm rod or a square stick. Proprietary devices for weepholes are also available.

1.206 DAMP COURSES & FLASHING

Correct installation of damp-proof courses and flashings is one of the most important construction considerations for masonry. The standards require damp-proof courses and flashings to be provided for the following purposes:

- To prevent moisture from moving upward or downward through the masonry
- To prevent moisture passing from the exterior to the interior of a building, including passing across a cavity
- To shed moisture from a cavity to the outer face of a masonry wall.

While chemical parging of damp-proof courses has proven successful in some areas (for example Western Australia) the use of membrane damp-proof course materials is by far the most common. Recommended locations for flashings and damp-proof courses are given in Think Brick Australia Manual 9 – *Detailing of Clay Masonry.*

AS 3700 states that bituminous DPC materials without metal strips shall not be used where the superimposed masonry exceeds either two storeys, or 8m in height.

Sheet material used as a DPC shall be at least 20mm wider than the thickness of the masonry member in which it is placed.

Overflashings shall be designed such that they can be set to a depth of at least 15mm into the masonry.

Joints at the ends of DPC and flashing material should be lapped to a length at least as great as the thickness of the masonry leaf, to guard against moisture migrating along the lap and penetrating the wall. Care should be taken in storage and handling to avoid puncturing DPC and flashing materials, thereby allowing moisture to pass through.

The materials for damp-proof courses, copings, flashings and weatherings must comply with AS/NZS 2904 and must be corrosion resistant and compatible with all materials they will contact in service. The following are common materials used for this purpose:

- Aluminium
- Copper and copper alloys
- Lead
- Zinc
- Zinc-coated steel
- Bituminous-coated metal
- Bituminous materials without metal centres
- Polyethylene sheet

It is essential that the membrane DPC should be visible at the front surface of the wall after construction. This is best achieved by allowing the material to project while the masonry is under construction, followed by cutting it off flush or turning the edge down when construction is complete. The most common cause of dampness in masonry buildings is bridging of the DPC, either because of insufficient projection from the surface of the joint or by the application of a render coating after construction of the wall. Any external landscaping or rendering of the wall must not be allowed to bridge the DPC and form a path for moisture to pass above the DPC level.

Where the wall is to be rendered to below the DPC, the DPC should not be cut off until after the rendering is complete. The most common reason for render failing is saline ground water wicking up through the render, drying and depositing salt, which builds up between the render and the brick, eventually popping the render off.

1.207 GAUGING

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

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 10mm 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.

BRICK GAUGE

230MM			230MM		
NUMBER OF BRICKS	LENGTH (MM)	OPENING (MM)	NUMBER OF BRICKS	LENGTH (MM)	OPENING (MM)
1	230	250	26	6230	6250
1.5	350	370	26.5	6350	6370
2	470	490	27	6470	6490
2.5	590	610	27.5	6590	6610
3	710	730	28	6710	6730
3.5	830	850	28.5	6830	6850
4	950	970	29	6950	6970
4.5	1070	1090	29.5	7070	7090
5	1190	1210	30	7190	7210
5.5	1310	1330	30.5	7310	7330
6	1430	1450	31	7430	7450
6.5	1550	1570	31.5	7550	7570
7	1670	1690	32	7670	7690
7.5	1790	1810	32.5	7790	7810
8	1910	1930	33	7910	7930
8.5	2030	2050	33.5	8030	8050
9	2150	2170	34	8150	8170
9.5	2270	2290	34.5	8270	8290
10	2390	2410	35	8390	8410
10.5	2510	2530	35.5	8510	8530
11	2630	2650	36	8630	8650
11.5	2750	2770	36.5	8750	8770
12	2870	2890	37	8870	8890
12.5	2990	3010	37.5	8990	9010
13	3110	3130	38	9110	9130
13.5	3230	3250	38.5	9230	9250
14	3350	3370	39	9350	9370
14.5	3470	3490	39.5	9470	9490
15	3590	3610	40	9590	9610
15.5	3710	3730	40.5	9710	9730
16	3830	3850	41	9830	9850
16.5	3950	3970	41.5	9950	9970
17	4070	4090	42	10070	10090
17.5	4190	4210	42.5	10190	10210
18	4310	4330	43	10310	10330
18.5	4430	4450	43.5	10430	10450
19	4550	4570	44	10550	10570
19.5	4670	4690	44.5	10670	10690
20	4790	4810	45	10790	10810
20.5	4910	4930	45.5	10910	10930
21	5030	5050	46	11030	11050
21.5	5150	5170	46.5	11150	11170
22	5270	5290	47	11270	11290
22.5	5390	5410	47.5	11390	11410
23	5510	5530	48	11510	11530
23.5	5630	5650	48.5	11630	11650
24	5750	5770	49	11750	11770
24.5	5870	5890	49.5	11870	11890
25	5990	6010	50	11990	12010
25.5	6110	6130	100	23990	24010

BRICK GAUGE

236MM			236MM		
NUMBER OF BRICKS	LENGTH (MM)	OPENING (MM)	NUMBER OF BRICKS	LENGTH (MM)	OPENING (MM)
1	236	256	26	6386	6406
1.5	359	379	26.5	6509	6529
2	482	502	27	6632	6652
2.5	605	625	27.5	6755	6775
3	728	748	28	6878	6898
3.5	851	871	28.5	7001	7021
4	974	994	29	7124	7144
4.5	1097	1117	29.5	7247	7267
5	1220	1240	30	7370	7390
5.5	1343	1363	30.5	7493	7513
6	1466	1486	31	7616	7636
6.5	1589	1609	31.5	7739	7759
7	1712	1732	32	7862	7882
7.5	1835	1855	32.5	7985	8005
8	1958	1978	33	8108	8128
8.5	2081	2101	33.5	8231	8251
9	2204	2224	34	8354	8374
9.5	2327	2347	34.5	8477	8497
10	2450	2470	35	8600	8620
10.5	2573	2593	35.5	8723	8743
11	2696	2716	36	8846	8866
11.5	2819	2839	36.5	8969	8989
12	2942	2962	37	9092	9112
12.5	3065	3085	37.5	9215	9235
13	3188	3208	38	9338	9358
13.5	3311	3331	38.5	9461	9481
14	3434	3454	39	9584	9604
14.5	3557	3577	39.5	9707	9727
15	3680	3700	40	9830	9850
15.5	3803	3823	40.5	9953	9973
16	3926	3946	41	10076	10096
16.5	4049	4069	41.5	10199	10219
17	4172	4192	42	10322	10342
17.5	4295	4315	42.5	10445	10465
18	4418	4438	43	10568	10588
18.5	4541	4561	43.5	10691	10711
19	4664	4684	44	10814	10834
19.5	4787	4807	44.5	10937	10957
20	4910	4930	45	11060	11080
20.5	5033	5053	45.5	11183	11203
21	5156	5176	46	11306	11326
21.5	5279	5299	46.5	11429	11449
22	5402	5422	47	11552	11572
22.5	5525	5545	47.5	11675	11695
23	5648	5668	48	11798	11818
23.5	5771	5791	48.5	11921	11941
24	5894	5914	49	12044	12064
24.5	6017	6037	49.5	12167	12187
25	6140	6160	50	12290	12310
25.5	6263	6283	100	24590	24610

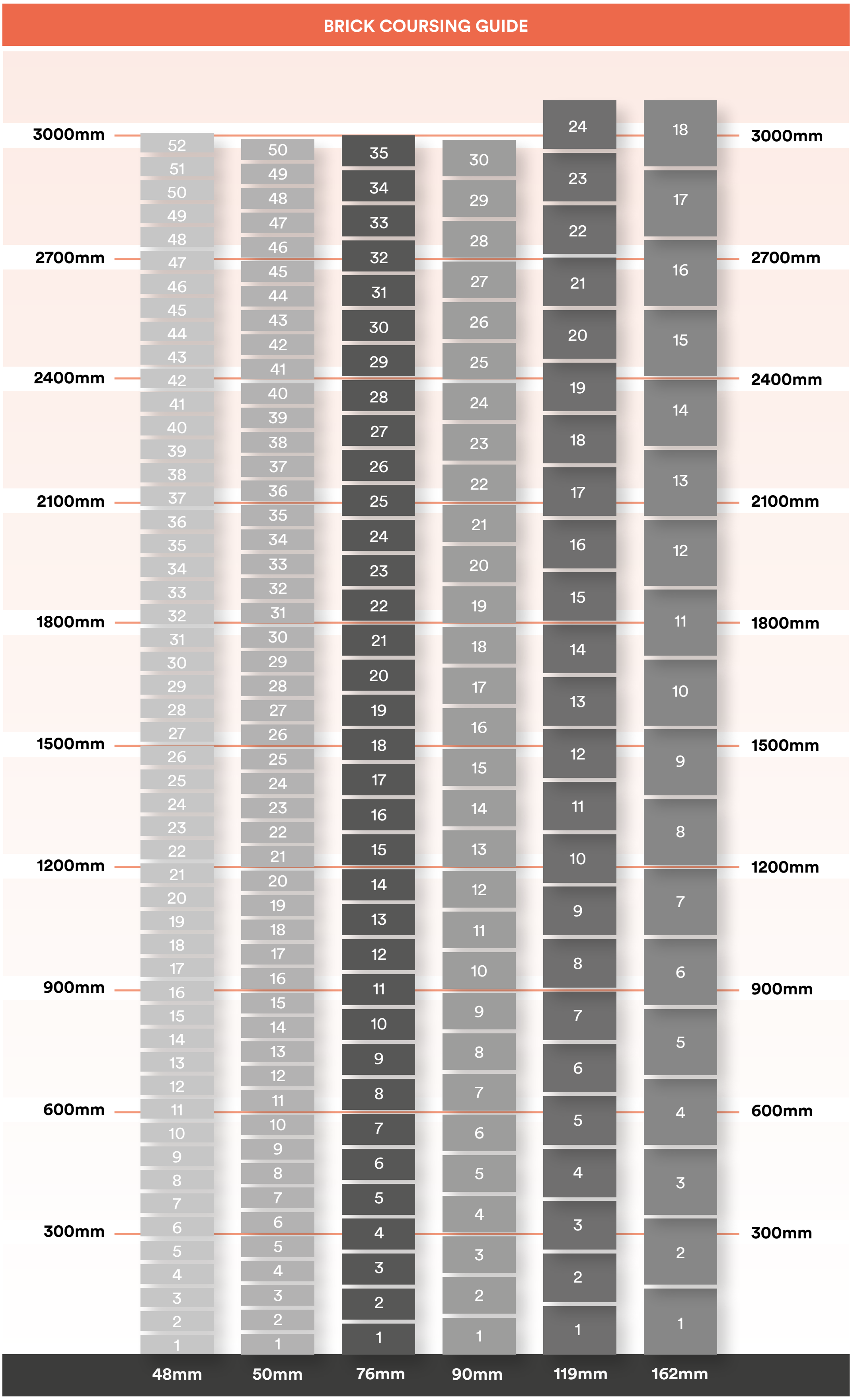
BRICK GAUGE

287MM			287MM		
NUMBER OF BRICKS	LENGTH (MM)	OPENING (MM)	NUMBER OF BRICKS	LENGTH (MM)	OPENING (MM)
1	287	307	26	7712	7732
1.5	435.5	455.5	26.5	7860.5	7880.5
2	584	604	27	8009	8029
2.5	732.5	752.5	27.5	8157.5	8177.5
3	881	901	28	8306	8326
3.5	1029.5	1049.5	28.5	8454.5	8474.5
4	1178	1198	29	8603	8623
4.5	1326.5	1346.5	29.5	8751.5	8771.5
5	1475	1495	30	8900	8920
5.5	1623.5	1643.5	30.5	9048.5	9068.5
6	1772	1792	31	9197	9217
6.5	1920.5	1940.5	31.5	9345.5	9365.5
7	2069	2089	32	9494	9514
7.5	2217.5	2237.5	32.5	9642.5	9662.5
8	2366	2386	33	9791	9811
8.5	2514.5	2534.5	33.5	9939.5	9959.5
9	2663	2683	34	10088	10108
9.5	2811.5	2831.5	34.5	10236.5	10256.5
10	2960	2980	35	10385	10405
10.5	3108.5	3128.5	35.5	10533.5	10553.5
11	3257	3277	36	10682	10702
11.5	3405.5	3425.5	36.5	10830.5	10850.5
12	3554	3574	37	10979	10999
12.5	3702.5	3722.5	37.5	11127.5	11147.5
13	3851	3871	38	11276	11296
13.5	3999.5	4019.5	38.5	11424.5	11444.5
14	4148	4168	39	11573	11593
14.5	4296.5	4316.5	39.5	11721.5	11741.5
15	4445	4465	40	11870	11890
15.5	4593.5	4613.5	40.5	12018.5	12038.5
16	4742	4762	41	12167	12187
16.5	4890.5	4910.5	41.5	12315.5	12335.5
17	5039	5059	42	12464	12484
17.5	5187.5	5207.5	42.5	12612.5	12632.5
18	5336	5356	43	12761	12781
18.5	5484.5	5504.5	43.5	12909.5	12929.5
19	5633	5653	44	13058	13078
19.5	5781.5	5801.5	44.5	13206.5	13226.5
20	5930	5950	45	13355	13375
20.5	6078.5	6098.5	45.5	13503.5	13523.5
21	6227	6247	46	13652	13672
21.5	6375.5	6395.5	46.5	13800.5	13820.5
22	6524	6544	47	13949	13969
22.5	6672.5	6692.5	47.5	14097.5	14117.5
23	6821	6841	48	14246	14266
23.5	6969.5	6989.5	48.5	14394.5	14414.5
24	7118	7138	49	14543	14563
24.5	7266.5	7286.5	49.5	14691.5	14711.5
25	7415	7435	50	14840	14860
25.5	7563.5	7583.5	100	29690	29710

BRICK GAUGE

290MM			290MM		
NUMBER OF BRICKS	LENGTH (MM)	OPENING (MM)	NUMBER OF BRICKS	LENGTH (MM)	OPENING (MM)
1	290	310	26	7790	7810
1.5	440	460	26.5	7940	7960
2	590	610	27	8090	8110
2.5	740	760	27.5	8240	8260
3	890	910	28	8390	8410
3.5	1040	1060	28.5	8540	8560
4	1190	1210	29	8690	8710
4.5	1340	1360	29.5	8840	8860
5	1490	1510	30	8990	9010
5.5	1640	1660	30.5	9140	9160
6	1790	1810	31	9290	9310
6.5	1940	1960	31.5	9440	9460
7	2090	2110	32	9590	9610
7.5	2240	2260	32.5	9740	9760
8	2390	2410	33	9890	9910
8.5	2540	2560	33.5	10040	10060
9	2690	2710	34	10190	10210
9.5	2840	2860	34.5	10340	10360
10	2990	3010	35	10490	10510
10.5	3140	3160	35.5	10640	10660
11	3290	3310	36	10790	10810
11.5	3440	3460	36.5	10940	10960
12	3590	3610	37	11090	11110
12.5	3740	3760	37.5	11240	11260
13	3890	3910	38	11390	11410
13.5	4040	4060	38.5	11540	11560
14	4190	4210	39	11690	11710
14.5	4340	4360	39.5	11840	11860
15	4490	4510	40	11990	12010
15.5	4640	4660	40.5	12140	12160
16	4790	4810	41	12290	12310
16.5	4940	4960	41.5	12440	12460
17	5090	5110	42	12590	12610
17.5	5240	5260	42.5	12740	12760
18	5390	5410	43	12890	12910
18.5	5540	5560	43.5	13040	13060
19	5690	5710	44	13190	13210
19.5	5840	5860	44.5	13340	13360
20	5990	6010	45	13490	13510
20.5	6140	6160	45.5	13640	13660
21	6290	6310	46	13790	13810
21.5	6440	6460	46.5	13940	13960
22	6590	6610	47	14090	14110
22.5	6740	6760	47.5	14240	14260
23	6890	6910	48	14390	14410
23.5	7040	7060	48.5	14540	14560
24	7190	7210	49	14690	14710
24.5	7340	7360	49.5	14840	14860
25	7490	7510	50	14990	15010
25.5	7640	7660	100	29990	30010

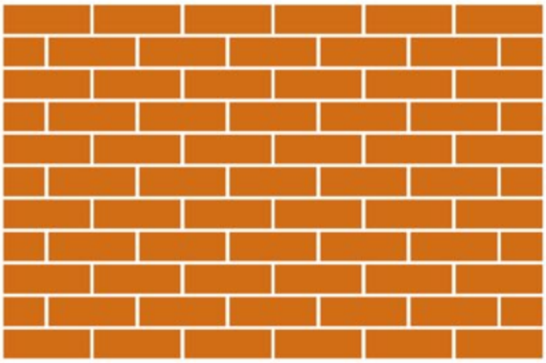
1.208 BRICK COURSING



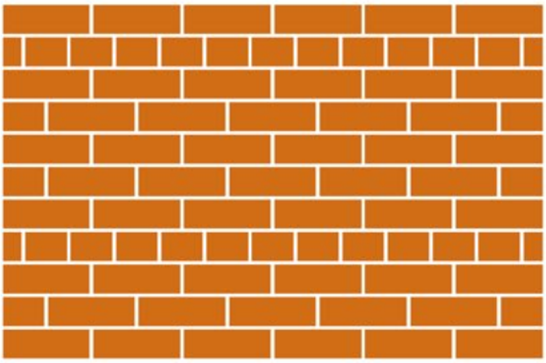
1.209 BRICK BONDS

Reference 1.210 Laying Practices for information on techniques required.

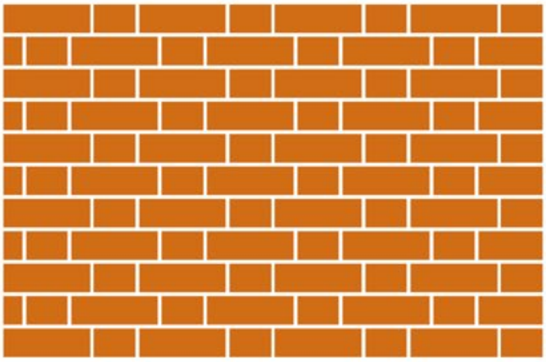
Stretcher Bond



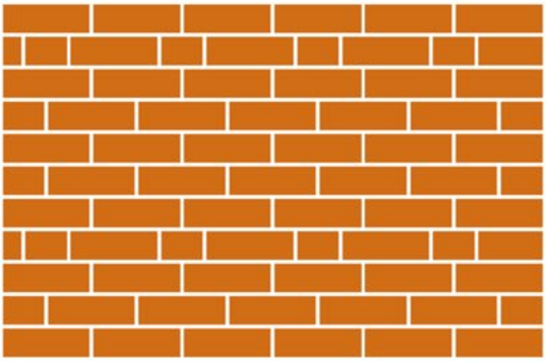
Common Bond (Full Headers every 6th Course)



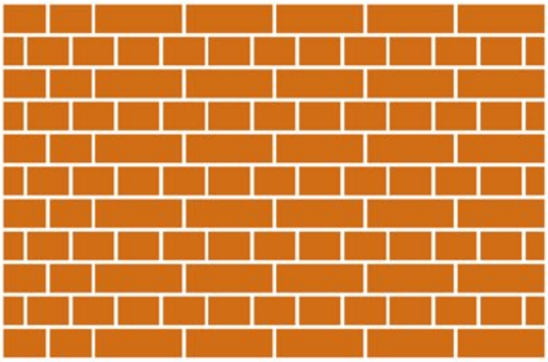
Flemish Bond



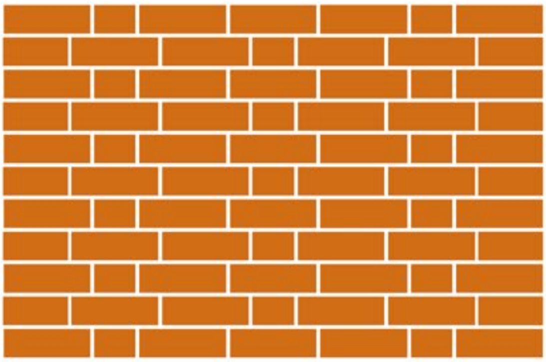
Common Bond (Flemish every 6th Course)



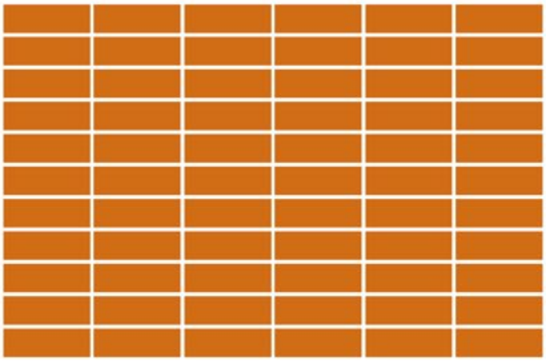
English Cross or Dutch Bond



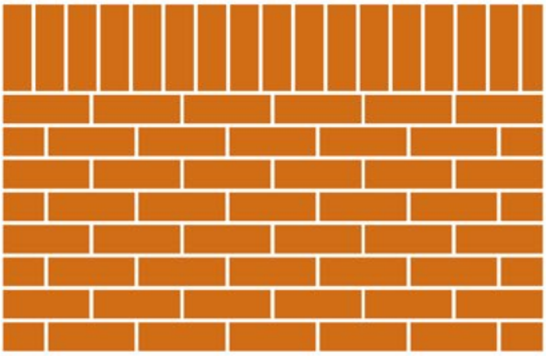
Garden Wall Bond



Stack Bond



Soldier Course (With Stretcher Bond)



1.210 LAYING PRACTICES

The following practices are recommended - refer to your engineer for further technical advice:

- Mortar, extruded from tapping the brick down to the string line, should be cut off with an upward stroke of the trowel. In this manner, a clean cut is made, without smearing the face of the brick.
- Joints should be tooled progressively as the bricks are laid, when the mortar is firm to thumb pressure. High suction bricks require joints to be tooled more frequently than low suction bricks. Tooling too late produces a 'burned' joint, where the surface may not be smooth and dense.
- After allowing the mortar to undergo initial set, within a day, dry brush mortar smears, to remove any dags, and then wet brush any remaining mortar stains. Mortar that is allowed to set on the masonry face may require high-pressure water jet cleaning or more costly, risky methods of cleaning.
- Cavities shall be free from mortar droppings or other materials that might bridge the cavity and allow transmission of moisture.
- Scaffolding should be kept at a minimum distance from masonry as specified by relevant standards.
- When bricklaying is interrupted by rain or rain is expected overnight, masonry should be protected by covering it. Saturated masonry may lead to excessive efflorescence or staining with some bricks.
- Face bricks are supplied with one face and one header suitable for exposing (i.e. to be seen after laying). Face bricks with unwanted marks, chips or cracks on a header should be laid with that header inside a mortared joint. Face bricks with unwanted marks, chips or cracks on the face should be set aside by the bricklayer (or labourer) for use as commons or when brick cuts are required.

1.211 BRICK BLENDING

As discussed in Section 1.111 Natural Colour Variation, clay bricks are made from natural materials. Variation in both the clay and firing process means textures, composition, size and colour can vary from batch to batch.

Poorly blended bricks may show unwanted patches, streaks and bands of colour in the finished masonry.

To avoid this:

- All bricks required for the project, or as many packs as will fit, should be delivered at one time and stored on site; and,
- Bricks should be drawn from at least four packs simultaneously, working down from the corners of each pack.

1.212 BRICK STORAGE

Bricks stored on site should be covered and kept off the ground. Bricks may absorb ground water containing salts or coloured minerals creating subsequent problems with staining. Bricks when laid saturated usually produce excessive efflorescence as the masonry dries. Saturated bricks may also adversely affect the mortar bond strength.

Moving bricks around the site may cause chipping and excessive movement of packs should be avoided.

1.3

FIRE & ACOUSTIC PROPERTIES

1.301 MASONRY DESIGN FOR FIRE RESISTANCE

Fire Resistance Levels (FRL)

A large proportion of the National Construction Code (NCC) deals with the design of buildings for fire safety. The NCC sets out the requirements, while the means for satisfying these requirements are detailed in the Australian Masonry Structures Standard AS 3700.

The NCC specifies that walls must be designed to achieve three Fire Resistance Levels (FRL's). These are defined as:

(i) Structural Adequacy

The ability of a wall to continue to perform its structural function for the fire resistance period.

(ii) Integrity

The ability of a wall to maintain its continuity and prevent the passage of flames and hot gases through cracks in the wall for the fire resistance period.

(iii) 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 temperature during the fire resistance period.

The resultant fire resistance level is expressed in minutes for each of these periods and always in the same order. For example, an FRL of 90/90/90 means a fire resistance period of 90 minutes each for structural adequacy, integrity and insulation.

The NCC/AS 3700 enables the fire resistant period (FRP) to be found by either the use of tabulated values, the use of test results, or a recognised method of calculation.

1.302 MASONRY DESIGN FOR STRUCTURAL ADEQUACY

Structural Adequacy is a minimum provision and may be overridden by design for robustness, wind, live or earthquake loads.

The Fire Resistance Period (FRP) for structural adequacy is specific to the wall type and its boundary support conditions. Examples of common wall types and sizes are given in Figures 24 – 43. These examples allow the designer to directly determine the FRP for structural adequacy for a given wall type with specific boundary conditions over a range of heights and lengths.

The examples are based on the limits for slenderness ratio given in AS 3700.

1.302 STRUCTURAL ADEQUACY FOR 60 MINUTES FRL

Figure 24 Structural Adequacy for 60 minutes FRL: Laterally Supported on all sides

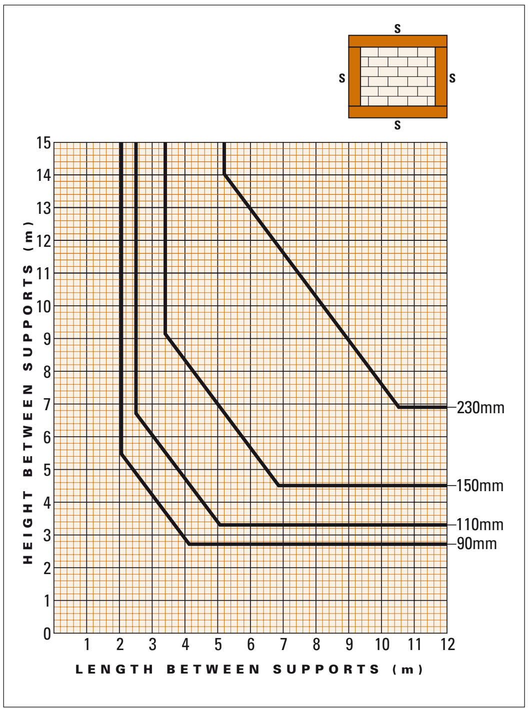


Figure 25 Structural Adequacy for 60 minutes FRL: Laterally Supported on three sides, one side unsupported

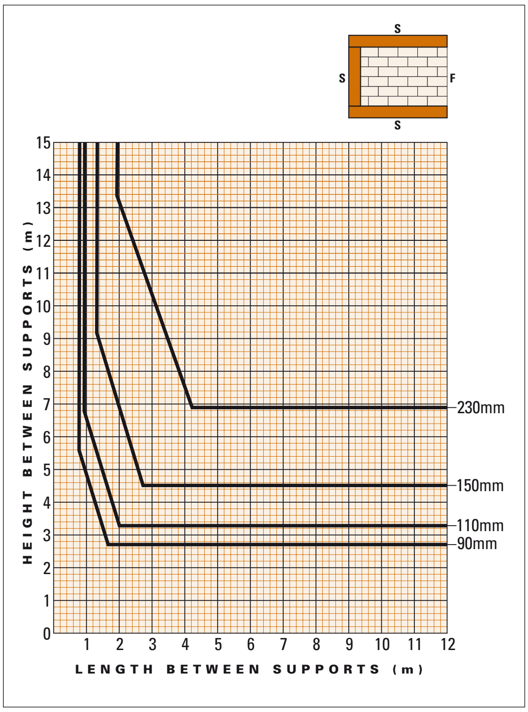


Figure 26 Structural Adequacy for 60 minutes FRL: Laterally Supported on three sides, top unsupported

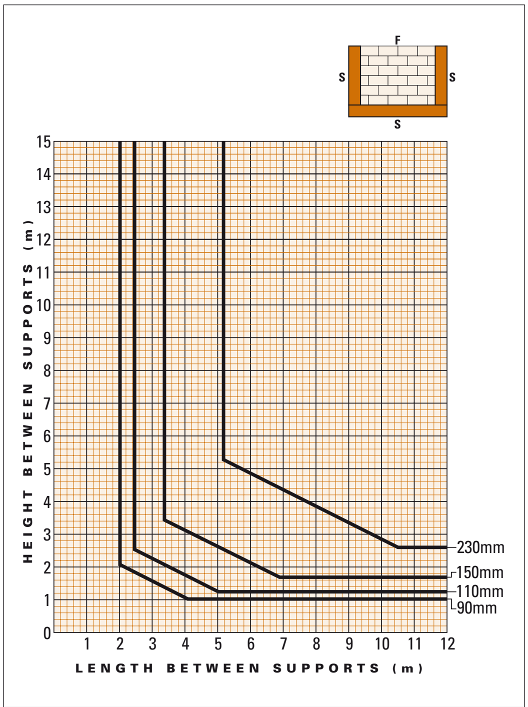
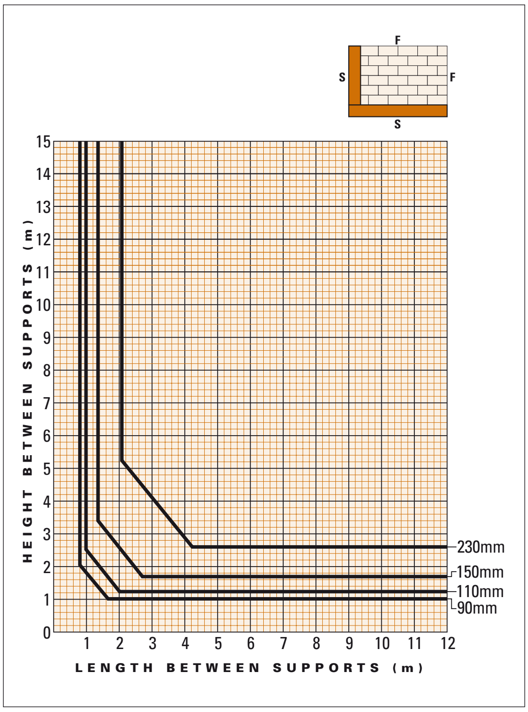


Figure 27 Structural Adequacy for 60 minutes FRL: Laterally Supported one end and bottom, one end and top unsupported



1.302 STRUCTURAL ADEQUACY FOR 90 MINUTES FRL

Figure 28 Structural Adequacy for 90 minutes FRL: Laterally Supported on all sides

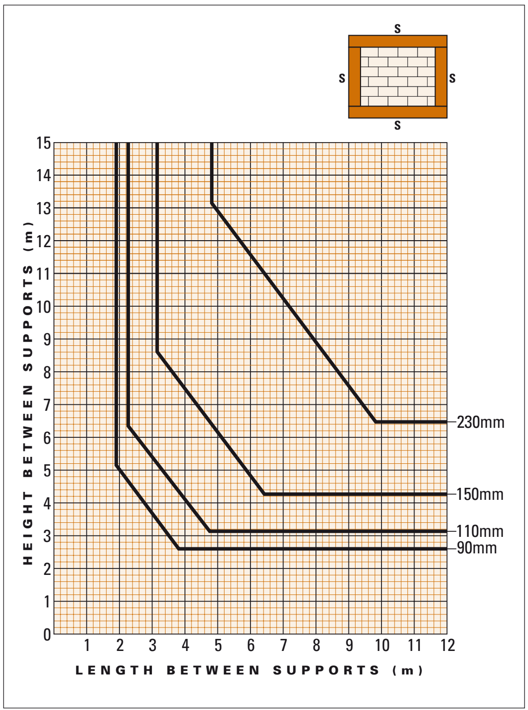


Figure 29 Structural Adequacy for 90 minutes FRL: Laterally Supported on three sides, one side unsupported

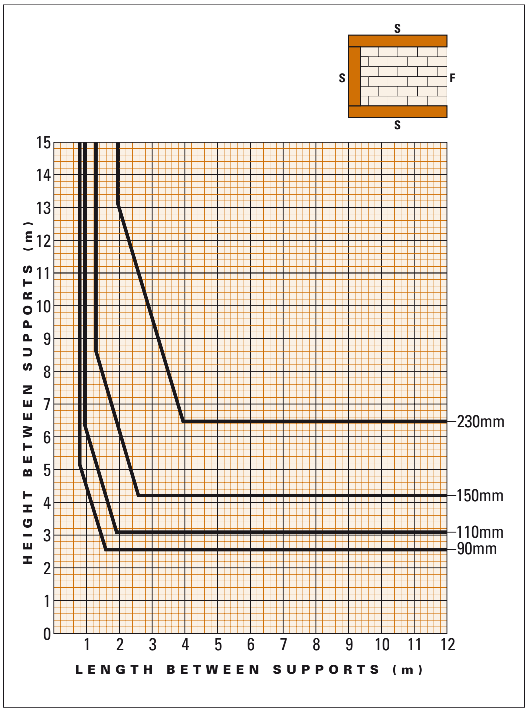


Figure 30 Structural Adequacy for 90 minutes FRL: Laterally Supported on three sides, top unsupported

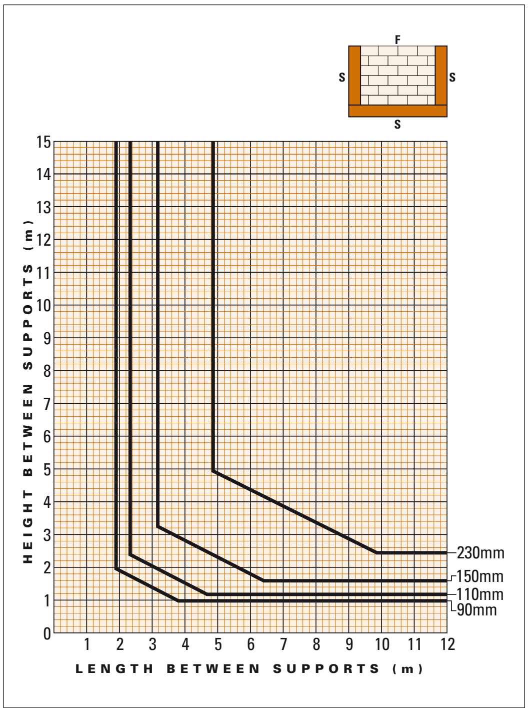
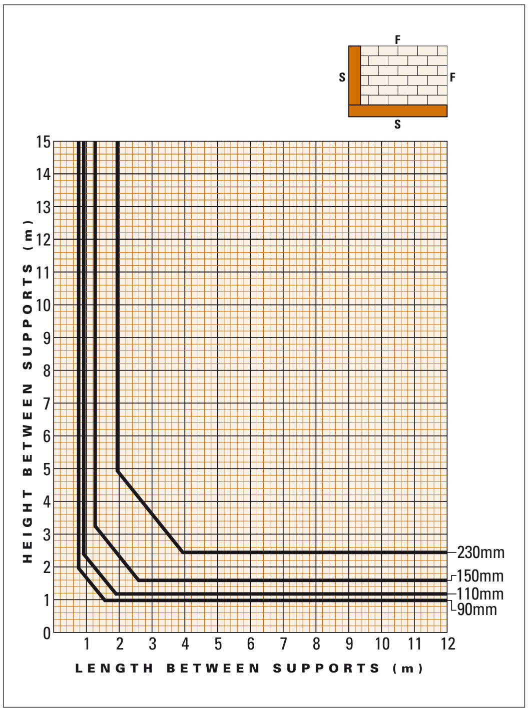


Figure 31 Structural Adequacy for 90 minutes FRL: Laterally Supported one end and bottom, one end and top unsupported



1.302 STRUCTURAL ADEQUACY FOR 120 MINUTES FRL

Figure 32 Structural Adequacy for 120 minutes FRL: Laterally Supported on all sides

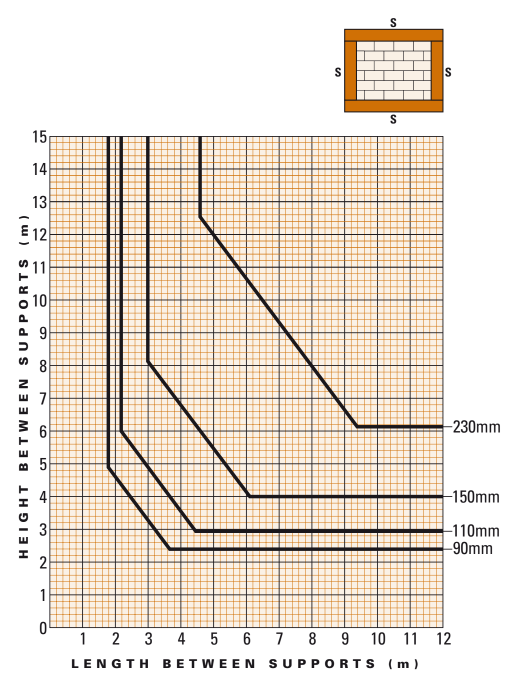


Figure 33 Structural Adequacy for 120 minutes FRL: Laterally Supported on three sides, one side unsupported

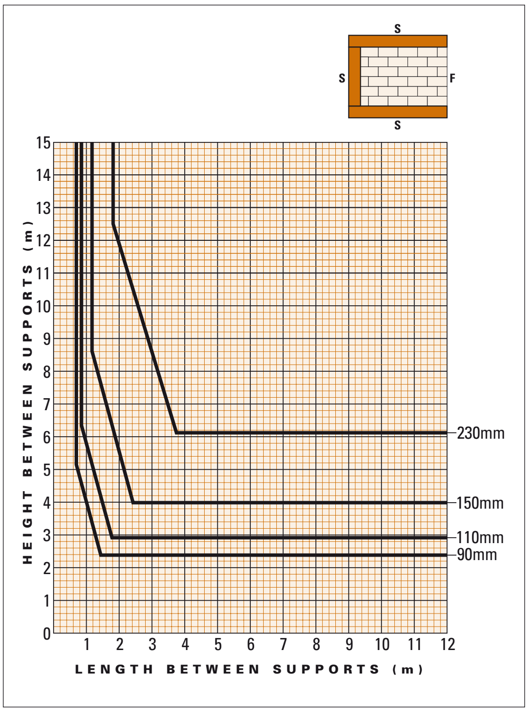


Figure 34 Structural Adequacy for 120 minutes FRL: Laterally Supported on three sides, top unsupported

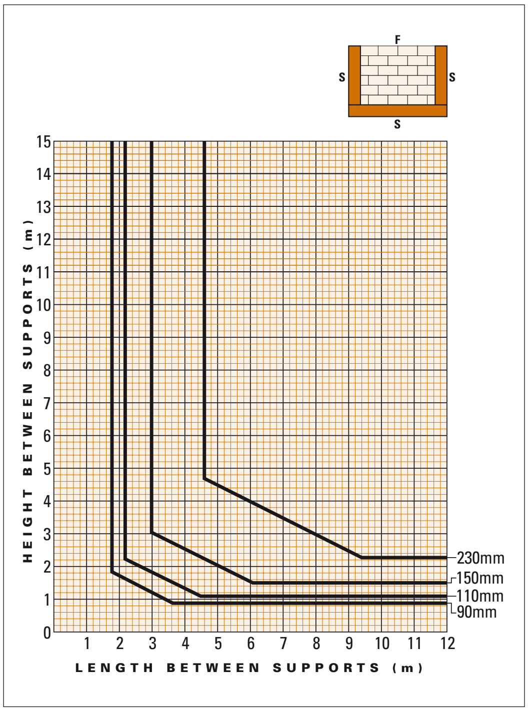
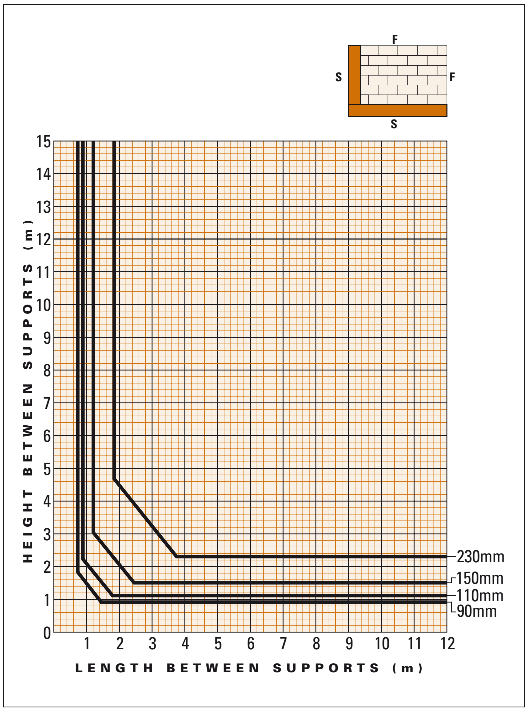


Figure 35 Structural Adequacy for 120 minutes FRL: Laterally Supported one end and bottom, one end and top unsupported



1.302 STRUCTURAL ADEQUACY FOR 180 MINUTES FRL

Figure 36 Structural Adequacy for 180 minutes FRL: Laterally Supported on all sides

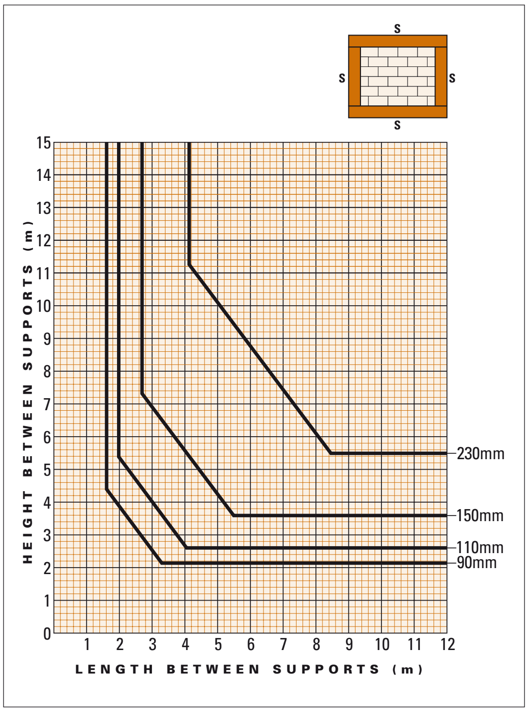


Figure 37 Structural Adequacy for 180 minutes FRL: Laterally Supported on three sides, one side unsupported

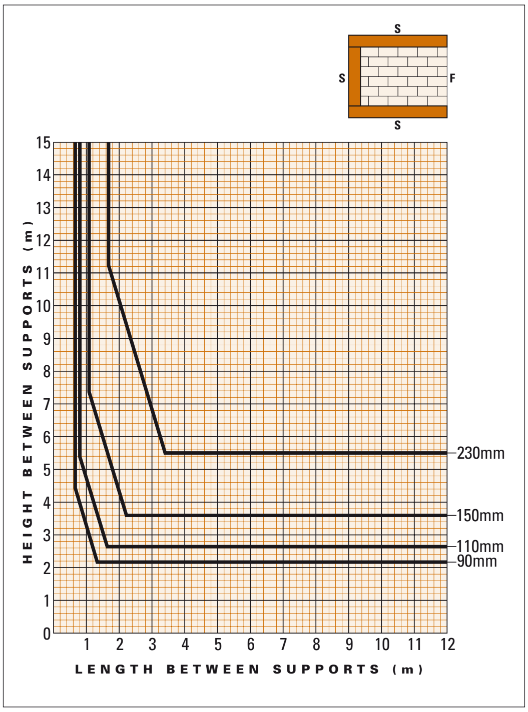


Figure 38 Structural Adequacy for 180 minutes FRL: Laterally Supported on three sides, top unsupported

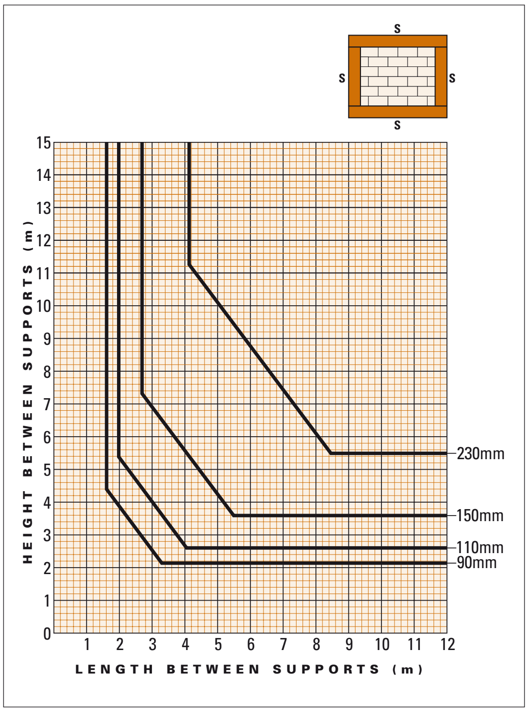
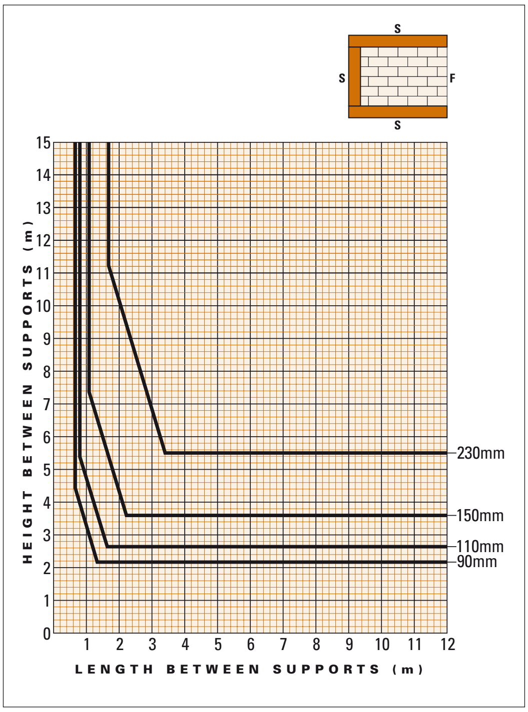


Figure 39 Structural Adequacy for 180 minutes FRL: Laterally Supported one end and bottom, one end and top unsupported



1.302 STRUCTURAL ADEQUACY FOR 240 MINUTES FRL

Figure 40 Structural Adequacy for 240 minutes FRL: Laterally Supported on all sides

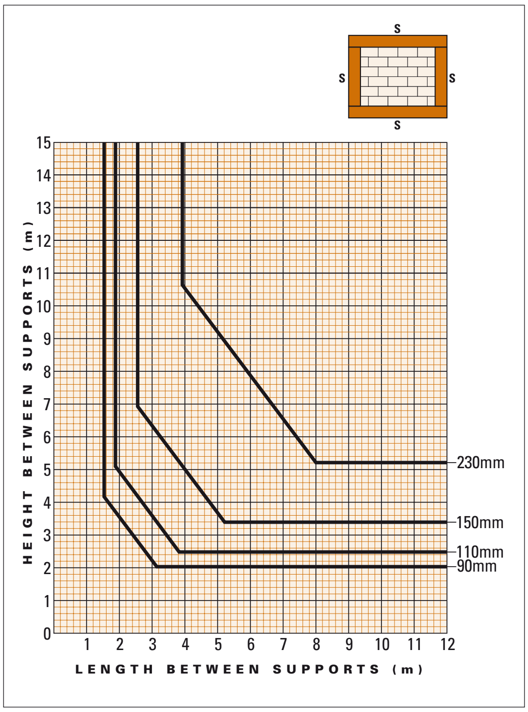


Figure 41 Structural Adequacy for 240 minutes FRL: Laterally Supported on three sides, one side unsupported

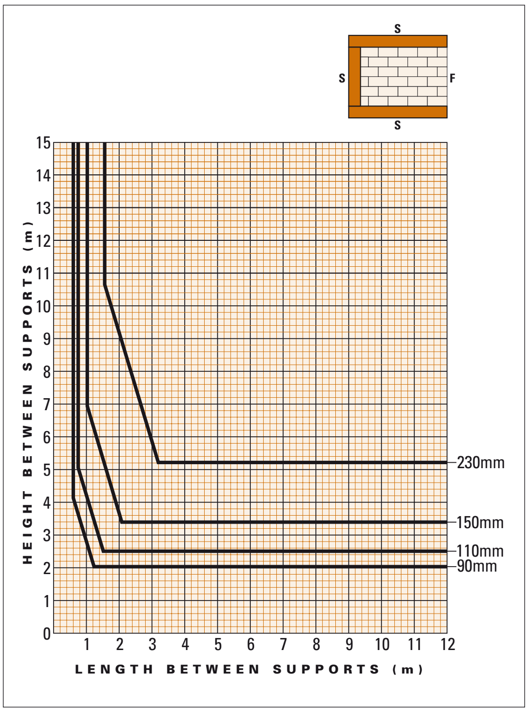


Figure 42 Structural Adequacy for 240 minutes FRL: Laterally Supported on three sides, top unsupported

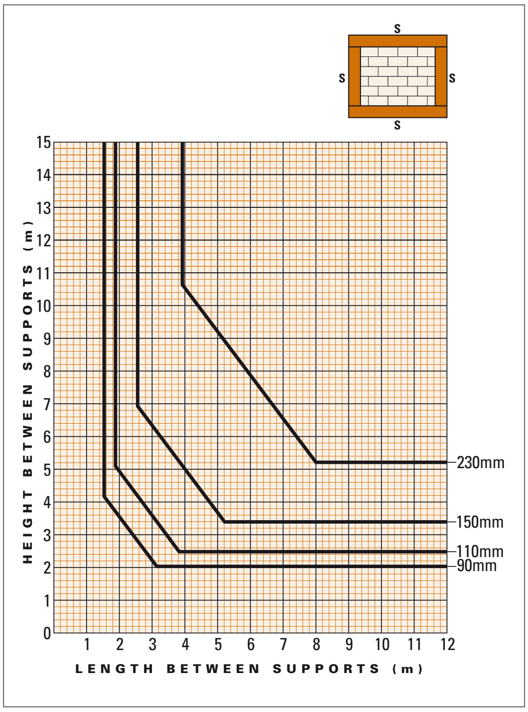
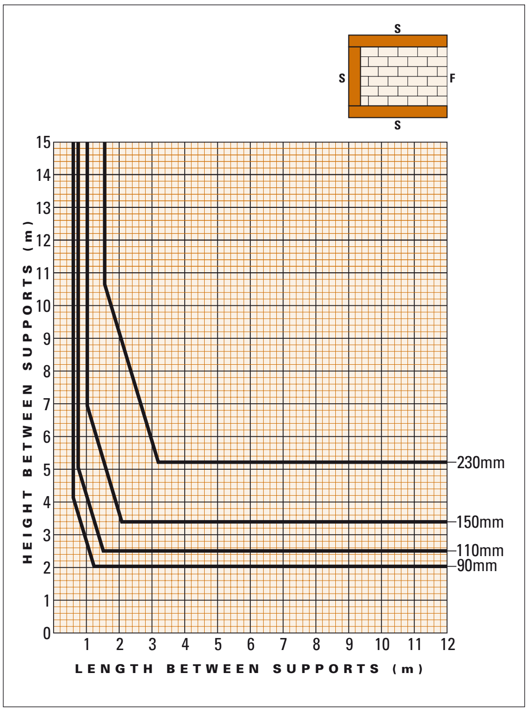


Figure 43 Structural Adequacy for 240 minutes FRL: Laterally Supported one end and bottom, one end and top unsupported



1.303 MASONRY DESIGN FOR INTEGRITY

Tabulated values for integrity resistance are not provided in AS 3700. A member is deemed to have the required fire resistance for integrity if that level is met for both structural adequacy and insulation. The fire resistance for integrity can be taken as the lesser of the values for structural adequacy and insulation.

1.304 MASONRY DESIGN FOR INSULATION

The fire resistance period (FRP) for insulation is a function of the material thickness of the wall.

Material Thickness

For a solid wall built from cored or solid units (including those with frogs), or from hollow units fully grouted, the material thickness is the overall thickness of the wall.

For these purposes, a cored unit is one with voids not greater than 30% of the total unit volume.

For a wall built from hollow units (with voids greater than 30%) the material thickness is the net volume of the unit divided by the area of the exposed vertical face of the unit.

For cavity walls, the material thickness is equal to the sum of the material thicknesses of the separate leaves.

For a rendered wall, any render up to 20mm thickness applied to the face of the wall not exposed to fire may be considered part of the material thickness. On a face exposed to fire, render is assume to be ineffective.

Insulation

Material thicknesses for insulation are tabulated in AS 3700, from which the following summary is applicable to clay masonry.

Table 10 Maximum Thickness of Clay Masonry for Insulation Resistance

Fire Resistance period for structural adequacy (mins)	30	60	90	120	180	240
Material thickness (mm)	60	90	110	130	160	180

1.305 EFFECT OF RECESSING AND CHASING ON FIRE RATED MASONRY

Recesses

Recesses made in walls for services may be ignored provided

(i) They penetrate less than half the wall thickness, and

(ii) Their total area (in both faces) within any 5m² of walling is not more than 10,000mm²

Otherwise, the wall thickness for fire resistance should be taken as the overall thickness less the depth of the recess.

Chases

For the purposes of determining structural adequacy, chases in vertically spanning walls may be ignored if:

(i) The chase is vertical, or

(ii) The chase is horizontal and its length is not greater than 4 times the wall thickness

Otherwise, the slenderness ratio of the wall is to be based on the overall thickness of the wall less the depth of the chase.

Chases in walls spanning both horizontally and vertically (panel action) can be ignored if:

(i) The chase is horizontal and its length is not greater than half the wall length, or

(ii) The chase is vertical and its length is not greater than half the wall height

Otherwise, the slenderness ratio of the wall is to be based on the thickness of the wall less the depth of the chase. Alternatively, where a vertical chase is greater than half the height of the wall, the chase may be regarded as an unsupported edge and the wall designed as two sub-panels.

For the purpose of determining integrity and insulation resistance the effect of chases in walls of solid, cored or grouted hollow units can be ignored if:

(i) The chase depth is less than 30mm

(ii) The section of chase is less than 1000mm², and

(iii) The total chased face area on both sides of the wall is less than 100,000mm² per 5m² of walling

Otherwise, determining the integrity and insulation FRP's based on the wall thickness less the chase depth. For ungrouted hollow masonry units, the integrity and insulation FRP's must always be determined based on the wall thickness less the chase depth.

1.306 BUILDING IN BUSHFIRE PRONE AREAS

During manufacture clay bricks are fired at temperatures as high as or higher than anything reached even at the heart of a large bushfire and are in the kiln for much longer than it takes for the front of a bushfire to pass a given point. It follows that the bricks themselves are incombustible.

It is accepted that bricks and the mortar are not combustible and that well-designed and constructed brick walls have an inherently high level of fire resistance. However, many other structural components (and furnishings) may burn and lead to the destruction of everything except the brick walls.

For bushfire-prone areas it is advisable not to rake back the mortar joints, but to use a flush, ironed or weatherstruck joint. These joint types are less affected by heat than raked joints and more easily re-pointed should extreme exposure to heat cause deterioration of the mortar surface.

For further information on this subject refer to Think Brick – *Building in Bushfire-Prone Areas.*

1.307 SOUND INSULATION

One objective of the National Construction Code (NCC) is to ensure that the occupants of multi-dwelling residential buildings, such as villas, townhouses, units and apartments, are not subjected to excessive noise transmitted from adjoining dwellings.

A number of amendments have been made to the code so that it complies with international practice and these changes will decrease the allowable level of sound transmitted between adjoining units in multi-dwelling residential buildings.

1.308 WEIGHTED SOUND REDUCTION INDEX (R_W)

Weighted sound reduction index (R_W) is a single figure used to indicate the sound insulation performance of a building element. The higher the number, the better the performance.

R_W ratings are determined by laboratory tests and cover all frequencies from 100Hz to 3.15kHz (inclusive). Measurement results are compared to reference curves to determine the result.

The weighted sound reduction index (R_W), when measured, included two correction factors, C for high frequency noise and C_{tr} for low frequency noise. C and C_{tr} are correction factors used to modify the measured sound insulation (R_W). They are referred to as a spectrum adaptation value and a negative number which is added to the R_W value to take into account mid- to high-frequency and low frequency noise respectfully.

The weighted sound reduction index is commonly denoted in the format R_W (C,C_{tr}). As an example, if a wall is measured as 56(-1,-5), the value of the index when the lower frequency correction factor (C_{tr}) is applied is:

$R_W + C_{tr} = 56 + (-5)$

$R_W + C_{tr} = 51$.

Table 11 R_W Correction Factors

Correction Factor	Type of Noise Source
C	Living activities (talking, music, radio, TV)
	Railway traffic at high speeds
	Highway road traffic (>80km/h)
	Jet aircraft at short distance
	High and medium frequency factory noise
C_{tr}	Urban road traffic
	Railway traffic at low speeds
	Propeller driven aircraft
	Jet aircraft at large distance
	Low and medium frequency factory noise

As most noise related issues involve the transmission of low frequency sound from audio equipment, the NCC's requirements for sound insulation generally include the C_{tr} term by setting a minimum R_W (airborne) + C_{tr} (impact) value – typically 50db.

For further information please consult Think Brick Manual 11 – *Design of Clay Masonry for Sound Insulation.*

1.309 IMPACT SOUND RESISTANCE

The NCC says there is no appropriate test for impact sound reduction in walls. However, in the case of Class 9c buildings the NCC allows impact sound reduction to be demonstrated by showing a wall performs no worse than a deemed-to-satisfy wall. To achieve impact sound resistance, the NCC requires walls consist of two leaves with at least a 20mm cavity between them and if ties are needed in masonry walls they must be of the resilient type. Except for the resilient ties in masonry walls there are to be no mechanical linkages between the walls, except at the periphery (i.e. through walls, floors and ceilings).

1.310 NCC DEEMED-TO-SATISFY WALLS

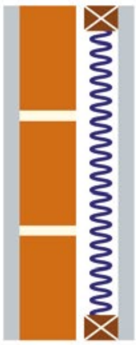
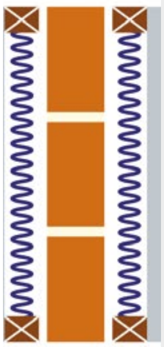
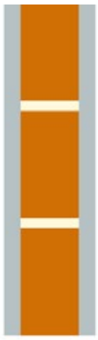
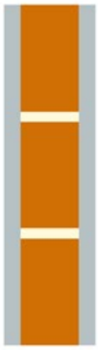
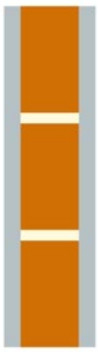
NCC Volume 1 Specification F5.2 gives deemed-to-satisfy walls for sound insulation for walls separating sole occupancy units.

NCC Volume 2 Table 3.8.6.1 Acceptable forms of construction, gives deemed-to-satisfy walls for sound insulation for walls separating two or more Class 1 Buildings. These walls are the same as those in Volume 1 except only walls achieving $R_W + C_{tr} \geq 50$ are allowed.

Deemed-to-satisfy clay brick walls are detailed in Figure 44 NCC Volume 1 Deemed-to-Satisfy Brick Walls.

1.310 NCC DEEMED-TO-SATISFY WALLS

Figure 44 NCC Volume 1 Deemed-to-Satisfy Brick Walls

CONSTRUCTION		RATING
Two leaves of 110mm clay brick masonry with: (a) A cavity not less than 50mm between leaves; and (b) 50mm thick glass wool insulation with a density of 11kg/m³ or 50mm thick polyester insulation with a density of 20kg/m3 in the cavity.		$R_W+C_{TR} \geq 50$
Two leaves of 110 mm clay brick masonry with: (a) A cavity not less than 50mm between leaves; and (b) 13mm cement render on each outside face.		$R_W+C_{TR} \geq 50$
Single leaf of 110 mm clay brick masonry with: (a) A row of 70mm x 35mm timber studs or 64mm steel studs at 600mm centres, spaced 20mm from the masonry wall; and (b) 50mm thick mineral insulation or glass wool insulation with a density of 11kg/m³ positioned between studs; and, (c) one layer of 13mm plasterboard fixed to outside face of studs and outside face of masonry.		$R_W+C_{TR} \geq 50$
Single leaf of 90mm clay brick masonry with: (a) A row of 70mm x 35mm timber studs or 64mm steels studs at 600mm centres, spaced 20mm from each face of the masonry wall; and, (b) 50mm thick mineral insulation or glass wool insulation with a density of 11kg/m³ positioned between studs in each row; and, (c) one layer of 13mm plasterboard fixed to studs on each outside face.		$R_W+C_{TR} \geq 50$
Single leaf of 150mm brick masonry with 13mm cement render on each face.		$R_W \geq 50$
Single leaf of 220mm brick masonry with 13mm cement render on each face.		$R_W \geq 50$
Single leaf of 110mm brick masonry with 13mm cement render on each face.		$R_W \geq 45$

1.311 SOLID VERSUS CAVITY WALLS

Acoustic performance with single leaf masonry follows the 'Mass Law'. The acoustic performance of these walls depends on their mass. More mass gives better performance, however, the relationship is logarithmic: If a 110 mm wall gives R_w = 45, a 230mm wall of the same brick may give R_w = 57.

Cavity walls behave differently because sound waves can resonate in cavities. The narrower the cavity becomes, the more resonance occurs. Insulation in the cavity helps absorb resonating sound and narrow cavities should have bond breaker board, to prevent mortar from providing a bridge for sound to travel between the leaves.

1.312 BRICK WALLS WITH PLASTERBOARD

Cornice cement daubs, used to fix plasterboard directly to brick walls, create a small cavity in which resonance occurs. Brick walls with daub fixed plasterboard on both sides stop **less noise** than the same walls, bare. Adding extra daubs (halving spacing) gives **lower performances**, presumably due to extra 'bridges' through the daubs.

Plasterboard on furring channel is marginally better than daub fixed. A bigger cavity between the wall and the plasterboard makes it harder for resonating energy to build up pressure on the board. When standard furring channel clips are used, this system transfers vibrations to the plasterboard via the channels and clips.

Polyester and glass wool in the cavity helps prevent resonance and further decreases the sound transmission. Denser grades of plasterboard and additional layers of plasterboard (fixed with grab screws and leaving no cavities) also decrease sound transmission.

1.313 NCC REQUIREMENTS FOR SOUND INSULATION

Where walls separate sole-occupancy units, their acoustic performance should ensure that sound from one dwelling does not result in ambient sound levels in the adjoining dwelling that exceed the values regarded as providing a satisfactory working, living or sleeping environment.

NCC determines the classification of a building or part of a building by the purpose for which it is designed, constructed or adapted to be used. The following classes are applied to sound insulation provisions.

Class 1 – one or more buildings which in association constitute:

Class 1a – a single dwelling being either a detached house or one of a group of two or more attached dwellings separated by a re-resisting wall.

Class 1b – a boarding house, guest house, hostel or the like for no more than 12 persons, with a total area of all floors not exceeding 300m² measured over the enclosing walls of the Class 1b; or no less than 4 single dwellings located on one allotment and used for short-term holiday accommodation which are not located above or below another dwelling or another Class of building other than a private garage.

Class 2 – a building containing two or more sole-occupancy units each being a separate dwelling.

Class 3 – a residential building, other than a building of Classes 1 or 2, which is a common place of long term or transient living for a number of unrelated persons (e.g. hostel, hotel, boarding house).

Class 9c – an aged care building.

For Class 1, the intent of the NCC sound provisions is to safeguard occupants from illness or loss of amenity as a result of undue sound being transmitted between adjoining dwellings.

(National Construction Code Series Volume Two Part 3.8.6)

For Class 2, 3 and 9c, the intent of the NCC sound provisions is to minimise noise transmitted:

- between adjoining sole-occupancy units; and
- from common spaces to sole-occupancy units; and
- from parts of different classification to sole-occupancy units.

(National Construction Code Series Volume One Part F5)

Methods of Compliance

The following are methods available for complying with the provisions of the NCC. Compliance with the NCC's performance requirements can only be achieved by:

a) complying with the *Deemed-to-Satisfy Provisions*

b) formulating an alternative solution to the *Deemed-to-Satisfy Provisions.*

Any alternative solution must be assessed to demonstrate that the performance requirements have been met. The assessment methods include:

i) **Documentary Evidence** – Testing by a registered testing authority, for example the National Building Technology Centre (NBTC), CSIRO or an authority registered by the National Association of Testing Authorities (NATA).

ii) **Verification** – Field measurement to demonstrate that the weighted standardised level difference with spectrum adaptation term, DnT,w + Ctr is not less than 45 when determined by AS/NZS 1276.1. (This does not apply in Qld, NT and WA.)

iii) **Comparison** with deemed-to-satisfy provisions.

iv) **Expert** judgement.

NCC DEEMED-TO-SATISFY WALL SYSTEMS (ACT, NSW, QLD, SA, TAS, VIC, WA)

1.313.1 Clay brick wall systems that achieve $R_W + C_{tr} \geq 50$

1.313.1.1 Single leaf of 110mm clay brick masonry with:

a) a row of 70mm × 35mm timber studs or 64mm steel studs at 600mm centres, spaced 20mm from the masonry wall; and

b) 50mm thick mineral insulation or glass wool insulation with density of 11kg/m³ positioned between studs; and

c) one layer of 13mm plasterboard fixed to outside face of studs and outside face of masonry.

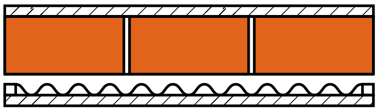


Figure 45 NCC Deemed-to-Satisfy Wall Systems (ACT, NSW, QLD, SA, TAS, VIC, WA): Single leaf brickwork, 110mm clay bricks

1.313.1.2 Single leaf 90mm clay brick masonry with:

a) a row of 7mm × 35mm timber studs or 64mm steel studs at 600mm centres, spaced 20mm from each face of the masonry wall; and

b) 50mm thick mineral insulation or glass wool insulation with density of 11kg/m³ positioned between studs in each row; and

c) one layer of 13mm plasterboard fixed to studs on each outside face.

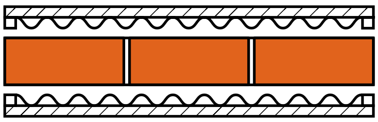


Figure 46 NCC Deemed-to-Satisfy Wall Systems (ACT, NSW, QLD, SA, TAS, VIC, WA): Single leaf brickwork, 90mm clay bricks

1.313.1.3 Two leaves of 110mm clay brick masonry with:

a) cavity not less than 50mm between leaves; and

b) 13mm cement render on each outside face.

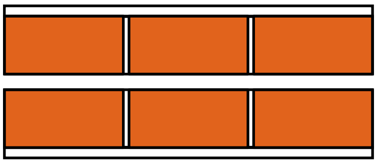


Figure 47 NCC Deemed-to-Satisfy Wall Systems (ACT, NSW, QLD, SA, TAS, VIC, WA): Rendered cavity brickwork, 110mm clay bricks

1.313.1.4 Two leaves of 110mm clay brick masonry with:

a) cavity not less than 50mm between leaves; and

b) 50 mm thick glass wool insulation with a density of 11kg/m³ or 50 mm thick polyester insulation with a density of 20kg/m³ in the cavity.

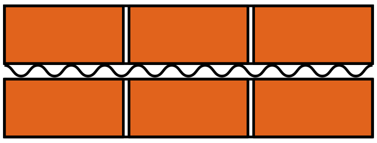


Figure 48 NCC Deemed-to-Satisfy Wall Systems (ACT, NSW, QLD, SA, TAS, VIC, WA): Insulated cavity brickwork, 110mm clay bricks

1.313.2 Clay brick wall system that achieves $R_W \geq 50$ (only for class 2, 3 and 9c buildings)

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

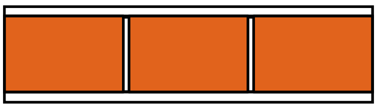


Figure 49 NCC Deemed-to-Satisfy Wall Systems (ACT, NSW, QLD, SA, TAS, VIC, WA): Rendered single leaf brickwork, 150mm clay bricks

1.313.3 Clay brick wall systems that achieve $R_W + C_{tr} \geq 50$ (only for class 2, 3 and 9c buildings)

Single leaf of 220mm clay brick masonry with each face rendered 13mm thick.

Figure 50 NCC Deemed-to-Satisfy Wall Systems (ACT, NSW, QLD, SA, TAS, VIC, WA): Rendered single leaf brickwork, 220mm clay bricks

1.313.4 Clay brick wall system that achieves $R_W \geq 45$ (only for class 2, 3 and 9c buildings)

110mm thick brick masonry with 13mm cement render on each face.

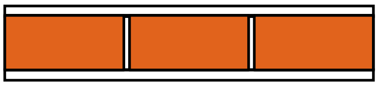


Figure 51 NCC Deemed-to-Satisfy Wall Systems (ACT, NSW, QLD, SA, TAS, VIC, WA): Rendered single leaf brickwork, 110mm clay bricks

NCC DEEMED-TO-SATISFY WALL SYSTEMS FOR NT

1.313.5 Clay brick wall system that achieves $R_W \geq 50$ and impact

1.313.5.1 Two leaves of 90mm clay brick masonry with:

a) All joint solid filled with mortar

b) Minimum cavity of 40mm

c) Leaves connected with ties in accordance with AS 3700and AS 4773.1

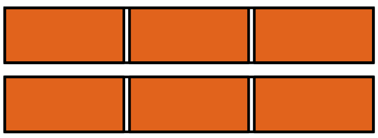


Figure 52 NCC Deemed-to-Satisfy Wall Systems for NT: Cavity brickwork, 90mm clay bricks

1.313.5.2 Single leaf of 80mm thick brick masonry with:

a) Both faces rendered 13mm thick

b) 50 × 12 mm thick timber battens at less than 610mm centres fixed to each face but not recessed into the render

c) 12mm thick softboard nailed to the battens

d) 6mm thick medium density hardboard fixed to the softboard using adhesive.

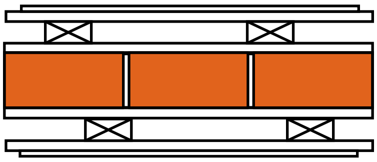


Figure 53 NCC Deemed-to-Satisfy Wall Systems for NT: Single leaf brickwork, 80mm clay bricks

1.313.6 Clay brick wall system that achieves $R_W \geq 45$

1.313.6.1 Single leaf of 110mm clay brick masonry with:

Mass per unit area ≥290 kg/m³.

Figure 54 NCC Deemed-to-Satisfy Wall Systems for NT: Single leaf brickwork, 110mm clay bricks

1.313.6.2 Single leaf of 90mm thick pressed brick with:

a) 13mm thick render on one side

b) Mass per unit area of unrendered wall ≥215kg/m³.

Figure 55 NCC Deemed-to-Satisfy Wall Systems for NT: Rendered single leaf brickwork, 80mm clay bricks

1.314 POINTS TO CONSIDER WHEN DESIGNING WALLS FOR ACOUSTIC PERFORMANCE

The NCC specifies minimum levels for sound isolation but experience shows that achieving the minimum standards is not always sufficient to satisfy occupants. In view of this it is recommended that architects, developers, builders, etc., consider a higher level of sound insulation, commensurate with the expectations of the end user. End user expectations are frequently related to the cost of occupying the unit.

Wall design is a balance between acoustical performance, thickness, weight and cost. Frequently it is not possible to optimise one factor without seriously compromising the others.

Acoustic Performance on Site

The Rw ratings on walling systems are obtained from tests carried out in accredited laboratories, under controlled conditions. When identical partitions in buildings are tested in-situ, it is often found that the actual result obtained, called the Weighted Standardised Level Difference (Dnt,w), is lower than the laboratory Rw. This reduction in performance can be due to rooms being too small, varying size of the element being tested, flanking paths (noise passing through other parts of the building) or background noise. The allowance in the NCC for a difference of 5 between the laboratory test and the field test is not to allow for poor construction practice. To repeat the performance in the field, attention to detail in the design and construction of the partition and its adjoining floor/ceiling and associated structure is of prime importance. Even the most basic elements, if ignored, can seriously downgrade the sound insulation performance.

The most common field faults include bricklayers not completely filling all mortar joints, poor sealing between walls and other building elements, electrical power outlets being placed back to back, chasing masonry and concrete walls, leaving gaps in insulation, screwing into insulation and winding it around the screw when attaching sheet materials, not staggering joints in sheet materials and poor sealing of penetrations.

PGH Bricks & Pavers™ cannot guarantee that field performance ratings will match laboratory performance. However, with careful attention during construction of the wall, correct installation to specification and proper caulking/sealing, the assembly should produce a field performance close to and comparable with tested values. The following items can also affect the acoustic performance on site.

Perimeter Acoustical Sealing

As the Rw of a wall increases, the control of flanking paths becomes more critical. Consequently, the perimeter sealing requirements for a low sound rating wall, such as Rw = 45, are much less than for a high sound rating wall, such as Rw = 60.

Note: it is neither necessary, nor is it cost effective, to provide very high perimeter acoustic sealing for a low Rw wall.

Effective sealants have the following properties:

- Good flexibility, (elastic set);
- Low hardness;
- Excellent adhesion, usually to concrete, timber, plaster and galvanised steel;
- Minimal shrinkage (less than 5%);
- Moderate density (greater than 800kg/m^3); and are,
- Fire rated where required (All walls required by the NCC to be sound rated also have fire ratings).

All of the above properties must be maintained over the useful life of the building, that is, greater than 20 years.

Note: Use of expanding foam sealants is not acceptable.

Refer to the manufacturer to ensure the particular type or grade of sealant is suitable for the purpose.

Doors

Hollow, cored and even solid doors generally provide unsatisfactory sound insulation. Doors can provide direct air leaks between rooms lowering the overall Rw of the wall in which they are inserted. Where sound insulation is important, specialised heavyweight doors or, preferably, two doors separated by an absorbent lined airspace or lobby should be used.

Lightweight Panels Above Doors

Panels are often incorporated for aesthetic reasons, however, they should not be used unless they have an Rw equal to or better than the wall's requirement.

Air Paths through Gaps, Cracks or Holes

Seal all gaps, cracks or openings, however small, with an acoustic sealant. Holes readily conduct airborne sounds and can considerably reduce the Rw of a wall.

Appliances

Noise producing fixtures or appliances such as water closets, cisterns, water storage tanks, sluices, dishwashers, washing machines and pumps should be isolated from the structure with resilient mountings and flexible service leads and connections.

Electrical Outlets and Service Pipes

Penetrations of all sorts should be avoided but if unavoidable, seal around them effectively. If possible introduce a discontinuity in pipe work between fittings, such as a flexible connection within or on the line of a partition.

Use acoustically rated boxes for all general power outlets, light switches, telephone connections, television outlets, etc. Seal the sides of electrical boxes and the perimeter of all penetrations with acoustic sealant. Offset all power outlets on either side of a wall by at least 100mm.

1.4

BRICKLAYING & CLEANING

1.401 MINIMISE CLEANING

Consideration should be given during design and construction to the following matters to avoid or minimise clay masonry cleaning problems.

Bricklaying

Mortar extruded from masonry joints during laying should be cut off with a trowel. In this way a clean cut can be made with little smearing of the unit face.

On completion of laying and joint tooling, mortar smears on the work face should be removed by dry brushing.

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 that often develops into staining.

Cleaning Cavities

Cavities can be cleaned by hosing at the end of a day's work. Temporarily leave bricks out at the wall base to enable mortar to be hosed clear of the cavity.

Take care to ensure that mortar does not set on masonry below the base of the cavity. This is best done by thoroughly hosing the masonry below.

Concrete Droppings

Masonry supporting reinforced concrete slabs and beams is frequently disfigured by droppings and spattering from the concrete pour. If these deposits are allowed to set it is sometimes impossible to rectify the damage. Protection is best achieved by covering the walls with plastic sheeting. Where this is not done, any deposits on the wall must be thoroughly hosed off before they set.

Copings, sills, weathering

Stormwater should be shed so as to clear the masonry immediately below. Copings and sills should project at least 10mm beyond the wall face at the underside of the sill or coping. Sills should be angled to properly shed water.

Where downpipes have not been installed water from the guttering should be diverted away from the brickwork.

In-built Elements

In-built elements should slope away from masonry. The soffit of major elements such as balconies should be provided with a drip mould. It is desirable for all roofs to be provided with sufficient overhang to protect the wall below.

Mortar Additives

Some mortar additives if used incorrectly may create problems during the brick cleaning process, examples being:

- Air-entraining agents used to improve the workability of mortar. Overuse creates a highly porous mortar that is easily eroded during cleaning.
- Water modifying agents used to retard the absorption of water from the mortar into the brick are extremely difficult to remove from the brick if left on for more than one to two weeks.
- Excessive clay content in mortar (around 15%) is detrimental to the mortar as excessive shrinkage will occur, creating cracks within the mortar and at the mortar/brick interface.

Paint Overspray and Splashing

Extreme care is needed to avoid paint and timber stains being splashed onto masonry. Dried paint is extremely difficult to remove, therefore prevention is the best cure.

Rain interruption

When rain interrupts bricklaying – or is expected overnight – protect the top of the newly laid wall with plastic sheeting.

See also 1.502 Calcium Stains.

Retaining Walls

The rear face of retaining walls should be waterproofed by such methods as cement rendering, use of a plastic sheet or applying a bituminous coating. This will prevent the migration of soluble salts through the wall. Proper drainage should also be provided behind the wall.

Scaffolding

Scaffolding planks should be laid at least 150mm clear of the wall, allowing mortar droppings to fall clear instead of building up on the plank and disfiguring the wall. At the end of each day's work – or when rain interrupts work – the plank nearest the wall should be propped on edge to prevent mortar which may have collected on it being splattered onto the wall.

1.402 A CLEAN START

The cleaner the bricklayer leaves the wall the easier the cleaning task will be. The majority of mortar residues and smears should be cleaned before they set. However, in most cases some additional cleaning will be required to completely remove the mortar residue.

1.403 ACIDS – THE BASICS

Safety Requirements

All acids and proprietary cleaners are dangerous. Users are required by law to:

- Obtain a copy of the manufacturer's Safety Data Sheet (SDS) for every chemical used in the conduct of their work and to only use the product in accordance with the instructions in the Safety Data Sheet (SDS).

In particular you are reminded that hydrochloric acid is classified as a corrosive S6 poison. All steps should be taken to comply with the requirements for its use in the Safety Data Sheet (SDS).

To avoid personal injury users should always:

- Wear all necessary safety equipment detailed in the Safety Data Sheet (SDS) including but not limited to goggles or face mask, gloves, and protective clothing as advised.
- Pour acids into water – this avoids splashes of highly concentrated acid onto the operator.

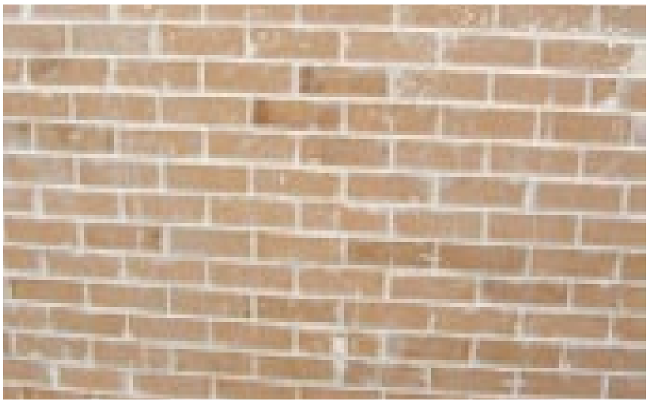


Figure 56 Typical wall after bricklaying

- If an acid or proprietary cleaner is splashed onto the skin, it should be immediately washed thoroughly with clean water or a solution of bicarbonate of soda and water that will neutralise the acid. Medical attention should be sought with respect to any injury arising from the use of chemicals. Chemical spills are required to be treated in accordance with the advice contained in the Safety Data Sheet (SDS).

Acid Concentrations and Cautions

The traditional masonry cleaning chemical is hydrochloric acid, (also known as muriatic acid or spirits of salts). Its main function is to put portland cement into solution, that is, dissolve the cement in the mortar mix. It has few other uses and in many stain situations SHOULD NOT BE USED.

The recommended maximum strength for light coloured clay bricks is 1 part acid to 20 parts water, and the recommended maximum strength for all other clay bricks is 1 part acid to 10 parts water.

Note: This point must be strictly adhered to particularly for bricks manufactured in Queensland. Their raw materials naturally contain large amounts of iron oxide, sometimes just below the surface. The use of acid solutions stronger than 1 part acid to 20 parts water can dissolve these particles and create iron oxide staining. Removal of these stains is treated in Section 1.501.

Proprietary masonry cleaning solutions are available. The manufacturer's recommendations must be adhered to strictly.

1.404 CLEANING – THE BASICS

Cleaning techniques may involve high-pressure water jet equipment or hand methods. Both are detailed later in this section. Whatever technique is used, the following requirements must be observed to ensure that additional staining problems are avoided:

Saturate the Wall

The brickwork must be thoroughly wetted by hosing before any acid solution is applied and kept wet ahead of the acid application. The area to be cleaned must be saturated as well as all brickwork areas below. The hose should be trained upon the wall until the brick suction is exhausted.

If the wall appears to be drying on the surface, reapply water until ready to apply the cleaning solution.

Failure to completely saturate the wall is a major cause of cleaning stains. Cleaning solutions containing dissolved mortar particles will be drawn into a dry masonry wall, causing further staining. Furthermore saturating the wall keeps the acid solution on the face of the masonry where the mortar smears are present.

Recommended acid strengths are based on application to a saturated wall and it is a myth to consider that pre-wetting 'weakens' the acid.

Note: This point must be strictly adhered to for bricks manufactured in Queensland. Failure to saturate the wall allows acid solutions to react with the iron oxide and create iron oxide staining. Removal of iron oxide stains is treated in Section 3.

Acid Application

Apply the acid solution and leave to stand on the wall to allow the chemical action to take place, this could take up to 3 to 6 minutes, however for bricks manufactured in Queensland and Western Australia a lesser time is advised or secondary staining can occur.

Hose Off

If the acid is left on the wall too long it can be absorbed into the brickwork and may cause staining.

It is extremely important to thoroughly hose off the wall as the work proceeds. The acid solution and debris cleaned off the wall must not be allowed to dry on the wall. Weather conditions, location of the masonry, and the suction of the bricks will affect the timing of the hosing off. Generally two to six square metres should be treated at a time.

1.405 PROCEDURE FOR HAND CLEANING

Hand cleaning is appropriate for small jobs, or where the use of high pressure water jet equipment may cause further problems.

1. Wait for mortar to harden. It is possible to start cleaning 24 to 36 hours after completion of masonry work, depending on the type of brick and the weather (drying) conditions.
2. Remove large mortar particles with hand tools before applying water or cleaning solutions. This 'pre-cleaning' is an important part in cleaning new masonry. Don't expect acid and/or water alone to remove large particles of hardened mortar.
3. Mask and otherwise protect adjacent materials such as metal, glass and wood, as recommended by product manufacturers.
4. Care should be taken to identify and remove any vanadium staining on the brickwork prior to applying the solution of hydrochloric acid, as it may turn the vanadium black and make it more difficult to remove. For further information regarding removal of vanadium stains refer to Section 1.503.
5. Thoroughly wet the face of the wall with clean water. All areas to be cleaned must be saturated as well as masonry areas below.
6. Use a brush or spray to apply the acid solution to the saturated wall. Start cleaning at the top of the wall. Cover a small area.
7. 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. Then scrub vigorously with a scrubbing brush. Scrub bricks not joints.
8. Rinse thoroughly as small areas are being cleaned. To slow evaporation, work ahead of sunshine. These ideal conditions allow walls to dry soon after being washed, permitting the operator to observe if all stains are being removed before moving too far ahead.

1.406 HIGH PRESSURE WATER JET CLEANING

High pressure water jet cleaning can be used on clay masonry but the following simple precautions must be taken so that the bricks and the mortar joints are not damaged by the process.

Caution: Turbo or rotary head attachments damage brickwork and are not recommended.

Caution: Test clean a sample area to determine the effectiveness of the cleaning compound and the technique, and to check the wall for possible damage caused by the system.

Allow mortar to harden. Cleaning with high water pressure should not start before mortar is at least three days old.

1. Remove large mortar particles with hand tools before applying water or cleaning solutions. This 'pre-cleaning' is an important part in cleaning new masonry. Don't expect acid and/or water alone to remove large particles of hardened mortar.
2. Mask and otherwise protect adjacent materials such as metal, glass and wood, as recommended by product manufacturers.
3. Care should be taken to identify and remove any vanadium staining on the brickwork prior to applying the solution of hydrochloric acid as it may turn the vanadium black and make it more difficult to remove.
4. Thoroughly wet the face of the wall with clean water. All areas to be cleaned must be saturated as well as masonry areas below.
5. When the suction of brick is exhausted, apply the appropriate cleaning solution, starting at the top of the wall working in small areas. The solution can be applied to the wall with a masonry cleaning brush or soft broom.
6. Allow the cleaning solution to remain on the wall to allow the chemical reaction to take place, this could take up to 3 to 6 minutes, however for bricks manufactured in Queensland and Western Australia a lesser time is advised or secondary staining can occur.
7. Wash the wall with high pressure water from top to bottom so all dissolved mortar particles will be completely flushed from wall surfaces.

IMPORTANT

- **The maximum pressure at the pump should be kept low, around 7000 to 8000kPa (1000 to 1200 psi), to prevent damage to either the masonry units or the mortar.**
- **The concentration of power with which the water jet strikes the wall is a function of the flow in the hose, the pressure, the type of nozzle and the distance from the nozzle to the wall.**
- **A straight or zero degree water jet should never be used. A spray angle of 15 degrees, called a fan jet, will allow the operator to concentrate the pressure on the bricks and not on the joints. The jet should generally be 500mm from the wall and never closer than 300mm for localised patches.**
- **Pressure cleaning should be carried out in 'runs' from the top of the wall down, to rinse down debris during cleaning.**
- **The width of a run is usually 1 to 1.2 metres, and should only be as wide as the operator can clean while keeping full control of the pressure gun. The gun must be kept moving: surface abrasion will occur if it pauses in one spot.**
- **Turbo head water jets are not recommended as there is a high potential for damaging the bricks and/or mortar by the concentrated force of the water.**

Any lumps or smears remaining after initial treatment will require another scrape, followed by wetting, acid treatment and pressure cleaning. The patience of double cleaning on difficult stains will be rewarded with a first class finish. It also eliminates the risk of eroding bricks or joints, the main objections to the water-blast cleaning method.

When all cleaning is finished, go back and rinse loose sand and dirt from the eaves, walls and windows. Once the walls begin to dry, check to see if any further cleaning is required.

Caution: If the mortar joints or the bricks are being damaged, either the pressure is too high or the water jet is too close to the wall.

Caution: Before cleaning dry pressed bricks the manufacturers advice should be obtained as the use of high pressure water cleaning is not recommended.

Figure 57 Damage caused by incorrect high pressure water jet cleaning

Figure 58 Damage caused by incorrect high pressure water jet cleaning

Figure 59 Damage caused by incorrect high pressure water jet cleaning

1.407 CLEANING INTERNAL BRICKWORK

Using hydrochloric acid to clean mortar deposits on internal masonry requires special care. The work should be done before the building is enclosed to ensure maximum ventilation and exhaustion of acid fumes.

Frequently this procedure is not followed and the masonry is cleaned at the completion of the building, making it impractical to use large quantities of water. The result can be acid fumes flowing from the masonry for some time after occupation, attacking metal door furniture, light fittings, steel furniture, exposed metal grid ceilings and other metal components.

In addition to early cleaning, the following procedures are recommended when cleaning internal brickwork:

- Use a proprietary cleaner containing an acid inhibitor that reduces fumes from hydrochloric acid; OR
- After washing down, apply a neutralising wash consisting of 65 grams of Sodium Bicarbonate per litre of water.

Leave this on the wall. If acid fumes are suspected to be coming from the wall, test using litmus paper. Moisten a strip and apply it to the wall. If the blue paper turns red, acid is present and a neutralising wash should be applied.

Quite often stains occur on brickwork from the failure to follow correct cleaning procedures when removing mortar residue. Stains are aesthetic blemishes and do not affect the structural adequacy of the brickwork and are generally easily removed.

The correct identification of stains on brickwork is a first step in the removal process.

Testing on one or more small areas is the safest way to determine the correct chemical solution and technique to remove a particular stain. This must take place well ahead of final cleaning as it will usually not be possible to assess the effectiveness of the test clean until the masonry dries.

The cleaner the bricklayer leaves the wall the easier the cleaning task will be. The majority of mortar residues and smears should be cleaned before they set. However, in most cases some additional cleaning will be required to completely remove the mortar residue.

1.5

STAIN REMOVAL

1.501 ACID BURN (IRON OXIDE STAINS)

This is a yellow, orange to brown rust-like stain. It is most obvious on cream bricks but can similarly occur on darker coloured bricks. Iron oxide stains frequently result from the incorrect use of hydrochloric acid on clay masonry.

This stain is commonly called 'acid-burn' because the reaction between hydrochloric acid and iron oxides in the brick and/or mortar sand causes the formation of iron oxide or rust on the face of the brick and can also leach into the mortar joint.

The most common causes of incorrect hydrochloric acid cleaning leading to iron oxide staining are:

- Failing to thoroughly pre-wet the wall and keep it wet ahead of the cleaning operation.
- Failing to thoroughly hose down each four to six square metres of the cleaned area.
- Using a hydrochloric acid solution stronger than 1 part acid to 20 parts water on light coloured bricks, or stronger than 1 part acid to 10 parts water on other bricks.
- Too often the acid solution is not given sufficient time to act properly, usually resulting in the operator increasing the acid strength.

Pre-wetting and frequent washing off is designed to prevent undue penetration of the acid into the brick and mortar where further reactions and staining often occur.

Window sills and corners require particular attention with pre-wetting as the water readily runs off instead of being absorbed.

Removal Technique 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 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 a 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.

Figure 60 Acid Burn

1.502 CALCIUM STAINS

Calcium stains appear as almost a milky film on the brickwork. These hard white deposits are invisible when wet but insoluble in water, unlike 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 that produces the insoluble white scum. Calcium silicate is 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.

Staining can occur in any of the following ways:

- 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.
- When newly laid masonry is unprotected and saturated by rain, lime is put into solution either from the cement or hydrated lime in the mortar.
- By the interaction of lime leached by water from concrete elements or cement rendering.
- By the wet sponging of mortar joints that smears a cement-rich mortar film over the brick face.

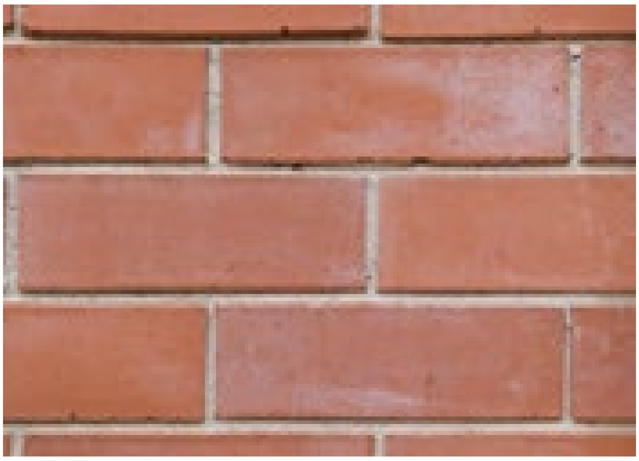


Figure 61 Calcium Stain

Figure 62 Calcium Stain

Removal Techniques for Calcium Stains

The application of some proprietary cleaners at full strength will usually remove these stains. In some cases, the reaction is immediate and should be followed by vigorous scrubbing. In others, the cleaning solution should be allowed to stand for some 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 thoroughly after each treatment.

Note: The manufacturer's instructions and safety precautions must be followed when a proprietary cleaning product is used.

1.503 VANADIUM STAINS

Light-coloured clays often contain vanadium salt that are generally colourless, but under certain conditions may appear as a yellow, green or reddish-brown discolouration of the brick.

It is essential that any vanadium salts evident prior to the removal of mortar residue be removed, as the hydrochloric acid may turn the salt black and become difficult to remove.

Vanadium stains are often generated by the use of too strong a concentration of hydrochloric acid during the initial cleaning process, or from excessive water penetration.

Vanadium stains are neither permanent nor harmful and do not indicate a defect in the brick. Vanadium stains in exposed areas generally wash off in time but their removal can be hastened by chemical treatment.

After the initial removal of vanadium stains, more water on the masonry – even that used in the cleaning process – may induce further effloriescing of the salts to the surface, depending on the amount within the brick.

Removal Techniques for Vanadium Stains

A number of chemical treatments are available to remove vanadium stains. It is best to test the efficiency of these chemicals on a test area to determine the most suitable treatment to use.

Sodium Hypochlorite

This is the active ingredient in household bleach and swimming pool chlorine. It is an inexpensive treatment for mild cases of vanadium staining. Simply spray or brush sodium hypochlorite onto the stain without pre-wetting, allow it to stand until the stain disappears, and then rinse.

Oxalic Acid

This is probably the best known chemical for removal of vanadium stains. However if used it must be followed by a neutralising wash. This action is commonly omitted and further staining of a serious nature can result. The correct procedure is:

1. Mix 20 to 40 grams oxalic acid per litre of water (preferably hot).
2. Apply to the stained bricks without pre-wetting.
3. Neutralise the oxalic acid by applying a solution of 15 grams of Sodium Bicarbonate per litre of water. Do not wash off.

Potassium Hydroxide or Sodium Hydroxide (Caustic Soda)

Mix 150 grams potassium or sodium hydroxide per litre of water and apply to the stained bricks. Leave on the wall until the stain disappears, then wash off. A white residue may appear after this treatment and this should also be hosed off. Extra care should be taken when using highly corrosive solutions such as these.

Proprietary Cleaners

These are general purpose cleaners that rapidly remove the stain. The manufacturer's instructions and safety precautions must be followed when using a proprietary cleaning product.

Figure 63 Vanadium as a green stain on light coloured bricks

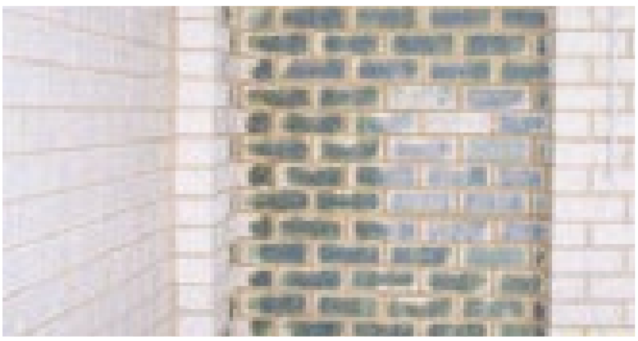


Figure 64 Vanadium stain not removed prior to hydrochloric acid application

1.504 EFFLORESCENCE

Efflorescence is not a stain, it is a powdery and sometimes 'fluffy' deposit that forms on the surfaces of porous building materials such as masonry units, mortar and concrete. The temporary appearance of efflorescence is common on new masonry.

The formation of efflorescence requires three conditions:

- The presence of soluble salts.
- Excessive amounts of water entering the masonry.
- The evaporation of water as the masonry dries out, depositing salts on the surface.

The soluble salts that appear as efflorescence can enter the wall from various sources:

- Mortar components, particularly cement.
- Soil or fill in contact with the wall.
- Sea spray in coastal areas.
- Masonry units, however this is not a common source.

Any situation that allows excessive amounts of water to enter the wall is likely to promote efflorescence. The most common causes are:

- Poor copings and flashings.
- The failure to protect new brickwork when rain interrupts bricklaying.
- Poor storage of masonry units on site. Before units are placed in the wall they can absorb ground salts and excessive water in the stockpiled masonry, and can mobilise latent salts if they are present in the masonry.

Persistent efflorescence may be a warning that water is entering the wall through faulty copings, flashings or pipes.

Removal Techniques for Efflorescence

Most efflorescence will naturally disappear over time, however its removal can be accelerated by brushing with a stiff dry brush. The use of a dust pan or vacuum cleaner to collect the salts after brushing is recommended as this will prevent salts from re-entering the brickwork or any porous paving materials below. After brushing and cleaning up, an absorbent cloth (wrung out until damp only) can be used to pick up any residue.

Frequent rinsing of the cloth in fresh water is advisable. Rinsing brickwork with water will only cause the salt to be reabsorbed into the bricks and reappear when dry.

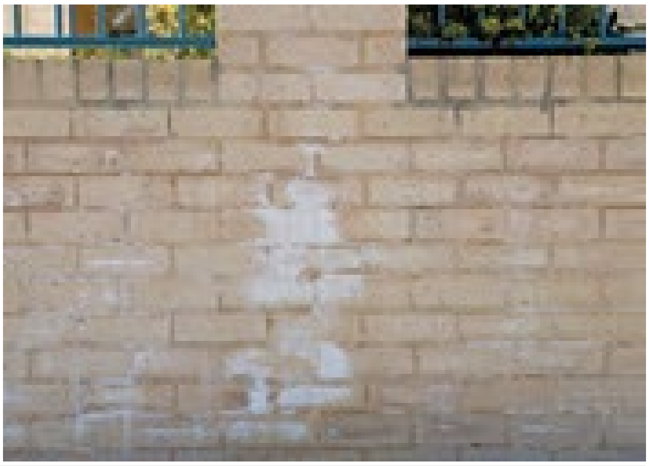


Figure 65 Efflorescence as seen on brick faces

Figure 66 Efflorescence from ground salts

1.505 GRAFFITI AND PAINT

Removal Techniques for Graffiti and Paint

For cleaning fresh aerosol paint, use a commercial paint remover in accordance with the manufacturer's instructions.

Oil-based Paints or Enamels

Burn off and follow with scraping and wire brushing ensuring not to damage the brickwork.

Dried Paint

1. Flood the stained area for a few minutes with a paint remover.
2. Scrub to loosen the paint film.
3. Flush with water to wash away the loosened paint.
4. Scrub with scouring powder until the stain is removed.

Poultice Method

If these methods do not remove all traces of the paint, it will probably be necessary to apply a poultice:

1. Mix a strong solution of sodium hydroxide (caustic soda) in an inert base such as diatomaceous earth.
2. Apply to a depth of about 5mm, and leave on the wall for at least 24 hours before hosing off.

1.506 IRON WELD AND SPLATTER

Where unprotected steel is built into masonry, unsightly rust stains may result on both bricks and joints. Similar stains will occur if welding is carried out too close to masonry.

Removal techniques for iron and welding spatter.

Phosphoric Acid

1. The application strength and duration will vary. As a general 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 can be up to 24 hours.
3. More than one application may be required.

Oxalic Acid

1. Use a 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.

Proprietary cleaners that are general purpose cleaners can rapidly remove the stain. The manufacturer's instructions and safety precautions must be followed when using a proprietary cleaning product.

1.507 OIL, BITUMEN AND TAR STAINS

These stains generally arise from the actions of other trades or due to a lack of care in protecting materials in the structure.

Removal Techniques for Oil, Bitumen and Tar Stains

1. Treatment with a commercial emulsifying agent (degreasing solution).
2. Mix an emulsifier with kerosene to move the stain. Clean the kerosene off with the emulsifier only mixed with water. Hardened oil must first be scraped off or free oil mopped up immediately with an absorbent, such as paper towels.

Wiping should be avoided as it spreads the stain and tends to force the oil into the masonry.

The area affected should then be covered with a dry absorbent material such as diatomaceous earth, hydrated lime, or whiting and the procedure repeated until there is no further improvement.

(The selection of the absorbent material will be a function of the colour of the unit and the acceptability or otherwise of materials being trapped within interstices in the surface.)

3. Steam cleaning with a hot 10 percent sodium hydroxide solution may also be used but there is a risk of bleaching.
4. A further method is to apply a poultice of naphtha or trichloroethylene to the stained area.

1.508 ORGANIC GROWTHS

These are common where masonry is in contact with damp soil, such as flower boxes, retaining walls and in sunless spots. Some control of organic growth can be achieved by the use of water repellents or clear sealers. Flower boxes and the rear of brick retaining walls should be cement rendered with waterproof mortar or covered with heavy duty plastic sheeting to prevent water seepage into the wall.

It is also advisable to render the top of these walls or provide a brick coping, ensuring that a good cross fall is provided to shed water rapidly.

Removal Techniques for Organic Growths

As much growth as possible should be removed by vigorous brushing with a bristle brush. For heavy growth, scraping and wire brushing may be necessary.

After this dry cleaning, apply a proprietary weed killer or liquid chlorine that should be left on the surface for several days. Brush off and clean with hot water and detergent.

1.509 SMOKE STAINS

These stains vary from minor conditions around domestic open fireplaces to major problems of cleaning of face masonry in fire-damaged buildings.

The following chemical treatments may be supplemented by high-pressure water jet cleaning to scour the many small crevices on the masonry surface.

Removal Techniques for Smoke Stains

Minor Stains

Minor stains can be removed readily with sugar soap that is a highly alkaline mixture. Mix about 500 grams into 2 litres of hot water and apply liberally by brush. After the stains disappear scrub with a mixture of detergent and a household scouring powder containing sodium hypochlorite.

Smoke-damaged Buildings

The problems in fire-damaged buildings are usually complex, with widespread smoke stains and localised severe staining where highly-combustible materials have burnt. An initial treatment with sugar soap will remove some of the deposits. This can be followed by an application of sodium hypochlorite. The full strength chemical should be left on the wall for about 10 minutes before scrubbing and hosing.

Note: The manufacturer's instructions and safety precautions must be followed when using any chemicals or proprietary cleaners.

Severely-affected Areas

These may require a poultice treatment:

1. Use an inert filler material such as diatomaceous earth, mixed with sodium hypochlorite (bleach) to form a thick paste.
2. Apply to the stained areas by trowel or steel float to a depth of 5mm.
3. Leave on the wall 24 to 48 hours before removal by hosing and scrubbing.

1.510 SOIL AND GRIME

Base courses of masonry are frequently disfigured with splashing from adjacent soil. These deposits should be removed as soon as possible.

These stains arise from long-term airborne deposition. Grime is worst in industrial areas with heavy pollution problems. Special cases can arise, for example from bird fouling or proximity to railway lines.

Horizontal surfaces such as ledges, sills and raked masonry joints are the worst affected areas.

Removal Techniques for Soil and Grime

Scrubbing with a fibre or soft bronze bristle brush and a liquid detergent is usually effective. Steel wire brushes should not be used, to avoid rust staining from broken bristles.

Large jobs are usually carried out by specialist cleaners using high-pressure water and dry or wet sandblasting. Test cleaning should be carried out before the final cleaning technique is adopted.

1.511 TIMBER STAINS

These usually arise from water spreading tannin or resin stains on the wall, particularly from hardwoods. The stains are usually brown or grey and are present on both bricks and mortar.

Removal Techniques for Timber Stains

Normally timber stains will be removed by scrubbing with a solution of 20 - 40 grams oxalic acid per litre of hot water. Neutralise the wall after this treatment.

Where the stain is not removed by this solution, two other treatments can be used. One is to apply a bleaching solution containing sodium hypochlorite and allow it to dry on the wall. The other treatment is the same as that recommended for the removal of acid burn given in this section.

Note: The manufacturer's instructions and safety precautions must be followed when using any chemicals or proprietary cleaning products.

1.512 MANGANESE STAINS

A dark-blue brown discolouration may occur on bricks that have been coloured grey or brown by the addition of manganese during manufacture. The stain occurs most characteristically along the edges of the brick and is generally caused by excessive water penetration. In severe cases it may show as a stain across the face of the brick.

The problem with manganese staining is not so much the removal of the stain, as preventing its return in a short period by:

- Minimising water penetration into brickwork by ensuring all mortar joints are filled.
- Using ironed joints as they form a better weather-shield than other types.
- Ensuring copings at the top of the wall are effective.
- Covering all brickwork under construction during periods of wet weather.
- Insertion of effective damp proof membranes as brickwork progresses.

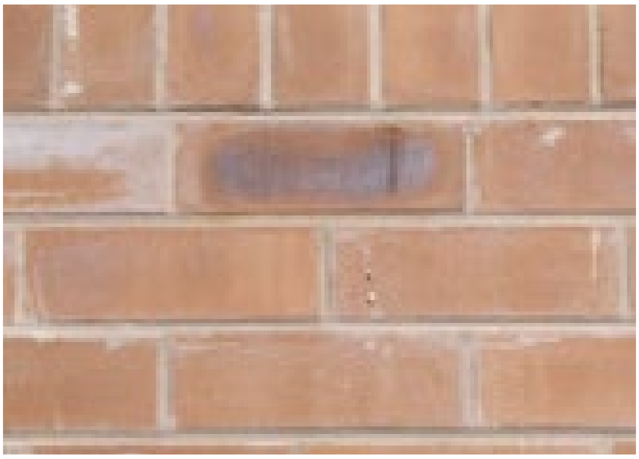


Figure 67 Signs of manganese staining

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.

1.6

FACE BRICK RANGE

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1.7

COMMONS RANGE

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1.8

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