Brickwork and blockwork

Bricks and blocks are components of durable masonry construction in which uniformly shaped individual units are laid in courses with mortar as the bed and binding material. They consist of high mass materials with good compressive strength formed into units that can be lifted and handled by a single worker. Materials used can include brick, stone (e.g. marble, granite, travertine, limestone), manufactured stone, concrete, glass, stucco and tile.

Brickwork is usually left exposed for its aesthetic qualities and blockwork is usually rendered, but most bricks and blocks can be used as facing materials or given a render coating.

Four kinds of wall

There are four main ways to use bricks and blocks to make walls. Each method has its environmental and economic merits and it is important to understand the reasons for choosing any given method in building your home. It is quite feasible to use each method in the same home but generally more economical, logistically sound and environmentally effective to use just one or two.

- **Brick veneer** — A commonly used approach in which bricks form the external skin of a timber framed home
- **Reverse brick veneer** — Bricks form the internal skin of an insulated, framed home
- **Double brick** — Consists of two leaves of brickwork with a cavity
- **Solid brick** — A high thermal mass construction mostly used for internal walls

Brick veneer

Conventional brick veneer construction places the high mass of brickwork on the outside of the building, where it contributes little to the thermal performance of the building but takes advantage of the capacity bricks possess for long life and low maintenance. The leaf of bricks is tied to the loadbearing lightweight frame.

Reverse brick veneer

Reverse brick veneer, in which the brickwork or blockwork is the inside skin tied to an otherwise conventional lightweight stud-framed construction, takes advantage of the material's thermal mass properties. It can produce high performing buildings with lower than average energy demands for both heating and cooling.

Reverse brick veneer.

Double brick

In double brick, the two leaves of brick walls are separated by a cavity that reduces thermal transmission and prevents moisture being transferred directly from the outside wall face to the interior of the building. The internal leaf, or skin, may be plasterboard-lined concrete blockwork, with the external skin in facing brick. The leaves of double brick are joined with ties.

Solid brick

Solid brick or blockwork walls deliver good loadbearing capacity along with substantial thermal mass to provide a unique combination of structural, thermal and aesthetic benefits. Internal walls of solid brick or blockwork provide well-located thermal mass that can be either self-supporting or load bearing.

Insulation

Clay and concrete brickwork have low thermal resistance and therefore relatively poor insulation values. Combined with internal and external air films and a cavity, they achieve moderate thermal resistance.

The thermal resistance of brick and blockwork walls, including veneer or cavity construction, can be greatly enhanced by adding foil or bulk insulation. Wall insulation should be accompanied by appropriate detailing to avoid thermal transfers by bridging through window and door frames, by radiation through window openings or by convection through leakage. (see *Insulation*)

Sound insulation

Brick and blockwork walls provide excellent sound insulation.

Due to their mass, brick and blockwork walls provide excellent sound insulation, particularly for low frequency noise.

The Building Code of Australia (BCA) has specific requirements for sound attenuation in multi-unit dwellings which can be satisfied by providing two leaves of 110mm clay bricks with a cavity of 50mm between leaves and a 13mm cement render on each outside surface (see *Noise control*).

Clay and concrete brickwork

Clay brickwork is made from selected clays moulded or cut into shape and fired in ovens. The firing transforms the clay into a building component with high compressive strength and excellent weathering qualities, attributes that have been exploited for millennia. Clay brickwork is Australia's most widely used external wall cladding.

Clay bricks are affordable, readily available, mass-produced, thoroughly tested modular building components. Their most desirable acoustic and thermal properties derive from their relatively high mass. They require little or no maintenance and possess high durability and loadbearing capacity.

Concrete bricks are the same size and intended for the same uses as clay bricks. They share many of the same attributes of clay bricks but may require more control joints, may stain more easily and their colour may be subject to fading over time. They are more porous than clay bricks and must be sealed to prevent water penetration.

The use of clay and concrete brickwork is informed by extensive Australian research, manufacturing and construction experience.

Blockwork

Blockwork is construction with concrete or cement blocks that are larger than a standard clay or concrete brick. To make them lighter and easier to work with they have a hollow core that also improves their insulation capacity. They are available in a variety of densities to suit different applications. Their convenience and cost effectiveness have made them a popular alternative to clay bricks although they require an additional finish for reasons of aesthetics and water resistance. They are often used to build internal partition walls and retaining walls.

Autoclaved aerated concrete (AAC) is used to make a special kind of concrete blockwork much lighter than normal concrete and with significantly higher thermal resistance (see *Autoclaved aerated concrete*).

Performance summary

Appearance

Clay brickwork is available in a wide variety of natural colours and textures derived from fired clay used in combination with cement mortar joints of various colours and finishes. The colour of clay bricks is a direct consequence of the clay they are made from and the process of firing. Bricks remain stable and colour-fast and do not need to be rendered or painted. Clay brickwork is most commonly used uncoated to display the richness and texture of the material.

The colour of concrete bricks and blocks — light to medium grey — is a consequence of the cement used in their manufacture. Other colours from pigments added to the concrete mix are subject to changes from fading and weathering.

Structural capability

As already noted, fired clay bricks offer high compressive strength. Both clay and concrete brickwork walls can readily support relatively high loads such as suspended concrete slabs. Clay brickwork is commonly used in construction of up to four storeys and with suitable detailing can be used for loadbearing walls in much higher buildings.

Clay and concrete bricks are manufactured under close controls to the requirements of AS/NZS 4455:1997, Masonry units and segmental pavers; AS/NZS 4456:2003, Masonry units and segmental pavers and flags — methods of test; and AS 3700-2001, Masonry structures. These provide the means for determining the strength of clay brickwork walls when subjected to

horizontal loads resulting from wind, earthquake or fire. (see *Construction systems*)

Concrete blocks come in a variety of densities, and should be matched to the required application. High density blocks are generally made from cast concrete and aggregate, whereas lower density blocks may use fly ash or cinder.

The voids in hollow concrete blocks can accommodate reinforcement rods (a typical detail for retaining wall construction) or be filled with a variety of insulating materials to improve their thermal resistance.

Although traditional brickwork often included the use of partial or full arches, these forms are rarely used structurally in modern construction.

Thermal mass

Clay brickwork and concrete blockwork both have high thermal mass. If a building with internal masonry walls and concrete floors is subjected to a heating and cooling cycle that crosses the comfort zone, the walls and floors will maintain a relatively stable level of heat energy for an extended period. In summer they will remain relatively cool, and in winter the same building will remain relatively warm. (see *Thermal mass*)

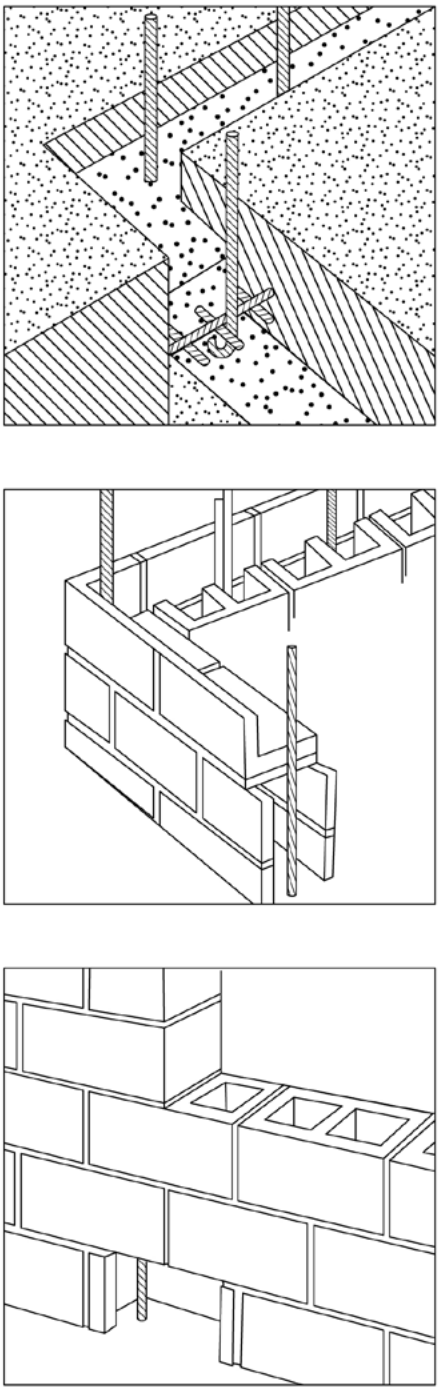
Toxicity and breathability

Clay bricks are inert and are not prone to giving off volatile materials. Clay brickwork and its constituents are non-toxic; however, when handling cement (used in the mortar) or cutting brickwork with a masonry saw, observe the manufacturer's safety procedures to minimise the risk of skin irritation and lung damage.

Similarly, concrete bricks and blocks are inert, do not give off volatile materials and are non-toxic once manufactured. The same provisions apply to safe handling of cement and cutting procedures.

Fire resistance

Clay bricks and concrete blockwork both have excellent fire resistance. The design for fire is covered by AS 3700-2001, Masonry structures. Clay and concrete brick and blockwork does not burn when exposed to bushfire and can help protect the more combustible items inside a house.



Source: Concrete Masonry Association of Australia

A typical reinforced 200mm single-leaf masonry system.

Thermal resistance (R) of cavity brickwork

Brick width/ cavity/brick width (mm)	Bulk density of bricks (kg/m³)	Thermal conductivity of bricks, k (W/m.K)	Thermal resistance, R (m²K/W)					
			External air-film	External leaf of brickwork	Cavity	Internal leaf of brickwork	Internal air-film	**Total thermal resistance**
90/50/90	1690	0.653	0.03	0.14	0.16	0.14	0.12	**0.59**
110/50/110	1950	0.547	0.03	0.14	0.16	0.14	0.12	**0.59**
	1690	0.653	0.03	0.17	0.16	0.17	0.12	**0.65**
	1430	0.778	0.03	0.20	0.16	0.20	0.12	**0.71**

Source: Adapted from AS 3700-2001, Masonry structures.

Design of clay brickwork for fire resistance

Fire resistance period (minutes)	Required material thickness for insulation (mm)	Maximum slenderness for structural adequacy (mm)
30	60	25.0
60	90	22.5
90	110	21.0
120	130	20.0
180	160	18.0
240	180	17.0

Source: Adapted from AS 3700-2001, Masonry structures.

Vermin resistance

Clay and concrete brickwork and blockwork consist of dense inorganic materials that do not harbour vermin. Termite resistance may be achieved in a variety of ways, including proprietary termite barriers developed for use with brickwork.

Durability and moisture resistance

Clay brickwork is extremely durable. The requirements for bricks, mortar, built-in components and reinforcement to achieve various levels of durability are tabulated in AS 3700-2001, Masonry structures.

Although not completely waterproof, clay brickwork is extremely durable.

Although not completely waterproof, clay brickwork walls resist the penetration of rainwater, including wind-driven rain. Some moisture may eventually soak through the mortar joints. For this reason external brickwork is generally constructed with a space separating it from the internal leaf in the form of brick veneer or cavity walling.

Clay bricks can be subject to fretting where the surface of the brick progressively spalls off. This is caused by water migrating in the wall and transporting salt to the brick surface where it forms crystals that grow in voids in the brick and break off from the brick surface as they expand. Appropriate use of damp courses and good detailing to avoid moisture penetration and build-up can eliminate most of the risk of fretting.

Concrete bricks are designed to perform in a similar way to clay bricks and have a surface finish that resists the penetration of rainwater. As with clay bricks, general detailing and construction should seek to eliminate moisture penetration, typically with cavity walling.

Concrete blocks are porous and need to be treated, coated or covered to prevent moisture wicking through the material.

Detailing for brick and blockwork needs to incorporate:

- damp-proof courses
- flashings
- weep holes.

Environmental impacts

The manufacture of bricks and blocks in either clay or concrete uses energy but the investment of embodied energy is repaid by the longevity of the material. Masonry homes have a long life and low maintenance requirements and are highly recyclable, adding to their potential as a sustainable form of construction.

Clay bricks can often be reclaimed for reuse when a building is demolished. After cleaning they can either be directly reused as bricks or crushed for making path and road surfaces. Because of their inert, inorganic nature, crushed clay bricks may also be used as part of the growing medium of extensive green roofs. (see *Green roofs and walls*)

The use of fly ash in some concrete block manufacture replaces the energy-intensive material of cement with a waste product from power stations.

Buildability, availability and cost

As a result of the long history of building with cavity brick, brick veneer and concrete blockwork in Australia, there is a huge body of knowledge and experience on standards and techniques for these construction systems.

Clay and concrete bricks are manufactured throughout Australia and are available at competitive prices. Even in remote areas, bricks and blocks can be supplied at moderate prices due to the wide availability of truck transport and back-loading opportunities. Consider transport energy costs for any long-distance movement of heavy material. (see *Embodied energy*)

> *Brick veneer — the construction system of choice for most domestic builders — is one of the most economical ways of building in Australia.*

The prevalence of brick veneer construction means that the availability of the materials and skills to build brick veneer is generally very good; it is the construction system of choice for most domestic builders and this contributes to it being one of the most economical ways of building in Australia. Lightweight framing is the main structural part of brick veneer construction. It is quick, uses no wet trades and allows roofs to be erected early in the building process. (see *Lightweight framing*)

Double brick or double masonry typically requires that the inside leaf (in an equivalent position to studwork in a lightweight frame structure) is structurally sound before roof framing can begin. Double brick construction thus takes longer than brick veneer.

Reverse brick and masonry veneer uses trades and techniques that are familiar to the domestic builders but arranged in a different configuration. The external, lightweight leaf requires waterproofing treatment and the building's openings require slightly different detailing. As a result, reverse veneer is generally more expensive than conventional brick veneer and there may be some differences in the building program that slightly extend construction time.

Solid brick and blockwork walls are mostly used for internal walls and generally the only buildability issues arise from their connection with other components of the building and impacts that may have on the construction program.

The walls of this house are a combination of double brick and reverse brick veneer.

Typical domestic construction

Typical details

Volumes 1 and 2 of the BCA provide the regulatory framework for the design and construction of masonry. AS 4773.1-2010, Masonry in small buildings — Design, sets out minimum requirements for the design of unreinforced and reinforced masonry for use in small buildings and specifies requirements for the design and specification of masonry with a leaf thickness of at least 90mm in buildings of Class 1 and Class 10a, as defined by the BCA.

Brick and blockwork industry bodies and many of the manufacturing companies publish design manuals and standard details.

Footings

For clay and concrete brickwork houses, concrete footings and concrete raft slabs should comply with AS 2870, Residential slabs and footings. This standard has been based largely on the behaviour of clay brickwork houses. Footings for brick veneer buildings are generally smaller than the corresponding footings for cavity brickwork.

For other brick and blockwork buildings, concrete footings and concrete slabs should be designed and constructed in accordance with AS 3600, Concrete structures.

Frames

For brick veneer and reverse brick veneer houses, frames provide the required strength and stability. Timber frames should comply with AS 1684, Residential timber framed construction, and steel frames should comply with AS 3623, Domestic metal framing. (see *Lightweight framing*)

In architecturally designed homes the use of frames in association with clay and concrete brick or block walls may help the designer to better exploit the qualities of bricks to achieve particular outcomes.

Loadbearing walls

Critical to the function of any building is the ability of the walls to support suspended floors in addition to the roof and walls in the storeys above. In most cases, the inclusion of concrete floor slabs dictates the use of loadbearing masonry. Industry bodies provide comprehensive manuals with charts and tables for the design of loadbearing masonry walls.

Fixings

Major anchorages (such as roof tie-down anchorages) should be built into brick or blockwork during construction. For high wind uplift, anchorages should pass down the cavity and be tied into supporting concrete slabs or footings. Windows and doors may be built into walls by setting the attached ties in the mortar joints.

Minor anchorages (such as hanging light loads from walls) may employ any of the wide range of commercially available proprietary mechanical or chemical anchors. These are set in holes drilled using a hammer drill of the appropriate size. Higher anchorage strength can be achieved if set into the bricks or blocks rather than the mortar.

Openings

Most commercially available doors and windows are manufactured to be compatible with standard brick sizes, in either veneer or cavity construction. Information on the required sizes of openings and fixing information is available on the internet and from window manufacturers.

The loadbearing masonry walls of this Rockhampton house are constructed of hollow blocks made from waste fly ash, externally rendered.

Finishes

External face clay brickwork capitalises on the broad variety of colours, textures and finishes of Australian bricks, mixed and matched with coloured or plain mortars in struck, ironed, pointed or raked joints. Clay brickwork is often used for internal feature walls — a particularly appropriate approach for reverse brick veneer construction.

Concrete bricks are available in a wide range of colours. Although concrete blocks can be used as facing material they are usually rendered to improve both aesthetics and their resistance to water penetration.

Internal brick and blockwork loadbearing walls, firewalls and acoustic partitions are usually painted, rendered or sheeted with plasterboard.

Timbercrete

Timbercrete is a relatively new addition to the domestic construction palette. It is a lightweight composite masonry material invented in Australia, and is available in the form of bricks, blocks, panels and pavers. Made from excess sawmill waste from plantation timbers mixed with sand and binders such as Portland cement and a non-toxic deflocculating additive, it is cured using sun and wind and has a lower embodied energy than traditional fired bricks.

Two-and-a-half times lighter than concrete or clay, it has a higher insulation value than brick, concrete or earth masonry, with moderate thermal mass and a high fire resistance. Timbercrete is manufactured in a range of blocks and bricks varying in thickness from 90mm up to 300mm. A 200mm block has an R rating of 1.02.

The material can be painted and internal faces do not need to be lined. It is available in a wide range of colours, textures, sizes or shapes that can be specified by the purchaser. It is not as brittle as clay or concrete and does not shatter. It can be used as a single skin building system and can be nailed or screwed like timber.

Timbercrete is a lightweight composite masonry material available in bricks, blocks, panels and pavers.

Stone masonry

The cutting of stone into building blocks is an ancient tradition and the basis of some of the world's oldest buildings but it is rarely part of modern construction. When stone masonry is used in modern Australian housing it is almost invariably as a kind of veneer.

Photo: Paul Downton

This stone wall provides thermal mass and a strong visual feature for a passive solar home in the Adelaide Hills.

Appearance

In modern Australian housing, stone masonry is typically used for feature walls, fireplaces, garden walls and landscaping. Its appearance can range from regular smooth-faced ashlar blocks to highly textured, knobbly, random rubble. The natural colour of stone ranges from the near-white of marble and limestone through the light yellows and reds of sandstone to the darker hues of granite.

Manufactured stone, which is essentially moulded and coloured concrete, has become increasingly popular, particularly for stone veneer applications.

Structural capability

Masonry is rarely used in a loadbearing capacity as part of a building's structure. There is no Australian Standard for stonework.

Thermal mass and insulation

Even the lightest stone, such as Mount Gambier limestone, has substantial thermal mass and its use should be considered carefully to gain maximum performance benefits in your home's passive design. Its thermal lag properties may be useful in mild climates but should not be confused with insulation. (see *Thermal mass*)

There is little thermal insulation value in most stone masonry, particularly when used as a veneer, but it can provide good sound insulation. (see *Noise control*)

Fire and vermin resistance

Stone is vermin-proof and generally has a very high fire resistance. However, if used in loadbearing situations, it can crack and crumble in very hot fires, depending on thickness and type.

Durability and moisture resistance

Stone masonry is extremely durable — it has provided some of history's most enduring monuments — but its moisture resistance varies enormously. Generally, the harder the stone the greater its moisture resistance, but any flaws, porosity or cracking that allow moisture penetration will compromise its overall resistance to weathering, particularly in frost-prone regions.

Toxicity and environmental impacts

Stone is essentially inert and non-toxic. Its main environmental impacts relate to quarrying. Modern Australian quarrying techniques include site remediation but stone sourced from overseas may be from quarries that do not have such advanced environmental management. The other potentially major impact of using stone is in its transportation — you should try to use stone sourced from local, quarries whenever possible. Large amounts of granite used in conjunction with well-sealed construction may require appropriate ventilation to eliminate the build-up of radon, but this is rarely a concern in Australia.

Buildability, availability and cost

Traditional stonework requires a high level of specialist skill but although moves to introduce Australia's first accredited course in stone masonry didn't begin until early 2012, stone masons can be found in all parts of Australia, often with qualifications and training from other countries. Heritage restoration and maintenance is a major part of modern Australian masonry work.

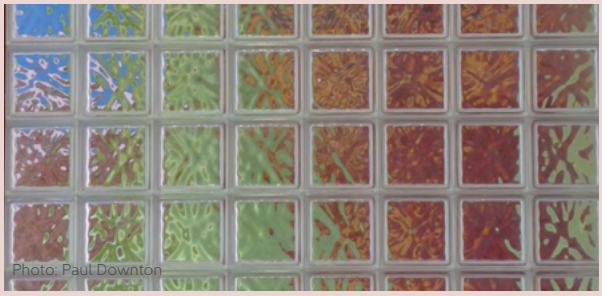
Stone masonry is widely available. A surprising amount of stone is imported into Australia, including specialist marbles from Italy and cheap slate from India. Check the provenance of stone intended for use in your home if you have any concerns about transport energy or the labour conditions in its point of origin.

The cost of stone masonry varies widely, generally according to the quality of the stone and the labour involved. You may consider stone building as a self-builder, but first seek extensive advice from qualified masons and builders.

Glass blocks

Also known as glass bricks, glass blocks share some of the properties of both blockwork and glazing. They are made in modular units that can be built into walls and they transmit light. Made from two halves of heat-proof glass pressed together, the modern, industrially produced hollow glass block dates from the early decades of the 20th century. Glass blocks can be set directly in mortar as part of a brick or blockwork wall, and although a wall or panel of glass blocks is essentially self-supporting, they are generally set in a frame, usually steel or aluminium (and sometimes UPVC), and fixed with silicone to help accommodate differential movement relative to the containing wall.

Glass blocks have higher thermal insulation values than double glazing and are approximately equivalent to double brick walls. In a recent innovation to improve thermal efficiency, a sheet of floating glass is set between the two halves of the block to create two chambers that are filled with argon gas, reducing thermal transmission by 50%. Glass blocks are recyclable at the end of their lives.



Glass block wall to lobby area of Christie Walk apartment building, Adelaide.

References and additional reading

Australian Stone Advisory Association www.asaa.com.au; www.traditionalstone.com.au; www.stonemasonartist.com.au; www.homeimprovementpages.com.au

Cement, Concrete and Aggregates Australia. www.concrete.net.au

Think Brick Australia. www.thinkbrick.com.au

Timbercrete. 2012. Timbercrete, an introduction. www.timbercrete.com.au

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