Clay brick

Clay brickwork is made from selected clays that are moulded or cut into shape and fired in ovens. The firing process transforms the clay into a building component with high compressive strength and excellent weathering qualities, attributes that have been exploited for millennia to build structures ranging from single-storey huts to enormous viaducts. Clay brickwork is Australia's most widey used external cladding and loadbearing wall medium and continues to enjoy rapid growth in its use.

The use of clay brickwork is informed by extensive Australian research, manufacturing and construction experience evident in the extent and variety of clay brickwork housing across the Australian suburbs.

Clay bricks are readily available, mass-produced in modern efficient factories, environmentally friendly and thoroughly tested. Their most desirable acoustic and thermal properties derive from their relatively high mass. Clay bricks are affordable, require little or no maintenance, have an attractive appearance and possess high durability and load bearing capacity.

PERFORMANCE SUMMARY

Appearance

Clay brickwork is available in a great variety of natural colours and textures derived from fired clay used in combination with cement mortar joints of various colours and finishes. The 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.

Structural capability

The high compressive strength of fired clay bricks has been exploited for millennia to build structures ranging from single-storey huts to massive public buildings and enormous bridges and viaducts.

Clay brickwork walls can support relatively high loads such as suspended concrete slabs. Clay brickwork is commonly used in four-storey construction and with suitable detailing can be used for loadbearing walls in much higher buildings.

AS 3700 also provides the means of determining the strength of clay brickwork walls when subjected to horizontal loads resulting from wind, earthquake or fire. Clay bricks are manufactured under close controls to the requirements of AS/NZS 4455 Masonry units and segmental pavers.. [See: Construction Systems Overview]

Thermal mass

Clay brickwork has high thermal mass. If a building with internal clay brickwork walls and concrete floors is subjected to a heating and cooling cycle that crosses the comfort zone, the brickwork and concrete will maintain a 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. This phenomenon is recognised in the BCA (Building Code of Australia) Volume 2, which permits, in some climate zones, an exemption from adding wall insulation in cavity brickwork buildings.

Research recently undertaken at the University of Newcastle found that only a small proportion of the heat on a typical cavity brick or brick veneer wall enters the building directly through the wall in temperate conditions. The rest is either reflected or absorbed. [See: Thermal Mass]

Insulation

Clay brickwork, combined with internal and external air films and a cavity, has moderate thermal resistance, R. Typical values are shown below.

The thermal resistance of clay brick veneer or cavity walls can be enhanced by adding either 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 Overview]

Sound insulation

Due to their mass, clay bricks provide excellent sound insulation, particularly for low frequency noise.

The Building Code of Australia has specific requirements for sound attenuation for multi-unit dwellings which can be satisfied by two leaves of 110 mm clay brick masonry with cavity of 50 mm between leaves and 13 mm cement render on each outside surface. [See: Noise Control]

Vermin resistance

Clay brickwork consists 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 clay brickwork.

Durability and moisture resistance

Clay brickwork is extremely durable. AS 3700 Masonry structures Tables 5.1 and 12.2 provide the prescriptive requirements for bricks, mortar, built-in components and reinforcement to achieve various levels of durability.

Clay brickwork walls resist the penetration of rainwater, including wind-driven rain, although they are not completely waterproof. Some moisture may eventually soak through the mortar joints. For this reason external clay brickwork is generally constructed as either cavity walling (two leaves of brickwork separated by ties) or brick veneer (one leaf of brickwork separated from, but tied to a structural frame). Detailing incorporates damp-proof courses, flashings and weep holes.

Fire resistance

Clay bricks are an excellent medium for achieving fire resistance, with their design for fire covered by Australian Standard, AS 3700.

Clay brickwork does not burn when exposed to bushfire and can help protect the more combustible items inside a house.

DESIGN OF CLAY BRICKWORK FOR FIRE 1

Fire resistance period, minutes	Required material thickness for insulation[2] Mm	Maximum slenderness for structural adequacy [3]
30	60	25.0
60	90	22.5
90	110	21.0
120	130	20.0
180	160	18.0
240	180	17.0

Notes
1. Based on AS 3700 Clauses 6.3.2, 6.4,2 and 6.5.3.
2. For bricks with less than 30% core volume, the material thickness equals the external thickness of the unit plus (if both faces are rendered) the thickness of render on one face.
3. The slenderness of a wall is determined in accordance with AS 3700 Clause 6.3.2.2 taking into account its thickness, length, height and support conditions.
4. The integrity requirements are deemed to be met if both the insulation and structural adequacy requirements are met.

THERMAL RESISTANCE, R, OF CAVITY BRICKWORK

Description of cavity brick wall				
Brick width / cavity / brick width (mm)	90 /50/90	110/50/110		
Description of bricks				
Bulk density of bricks (kg/m^3)	1690	1950	1690	1430
Thermal conductivity of bricks, k (W/m.K)	0.653	0.547	0.653	0.778
Thermal resistance, R (m2K/W)				
External air-film	0.03	0.03	0.03	0.03
External leaf of brickwork	0.14	0.14	0.17	0.20
Cavity	0.16	0.16	0.16	0.16
Internal leaf of brickwork	0.14	0.14	0.17	0.20
Internal air-film	0.12	0.12	0.12	0.12
Total thermal resistance of wall, R (m2K/W)	0.59	0.59	0.65	0.71

Toxicity & breathability

Clay bricks are naturally inert and are not prone to off-gassing of 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, manufacturer's safety procedures must be observed to eliminate risk of skin irritation and lung damage. [See: Indoor Air Quality]

Sustainability (environmental impacts)

Clay brick manufacture uses energy but the investment of embodied energy is repaid by the longevity of the material. Clay brick homes have a long life and low maintenance costs making them a potentially sustainable form of construction.

To ascertain the energy efficiency of a small sized project home typical of Sydney's climate, a Life Cycle Analysis was carried out by BHP Research in collaboration with The Centre for Sustainable Technology at The University of Newcastle. The study considered a housing life of 60 years. It looked at all stages of production of building materials, transportation to the site, and construction including fit-out and appliances. It included the energy costs of cooking, lighting, heating and cooling, repairs and maintenance and building decommissioning (including credits for recycled building materials).

A range of construction materials and methods were considered for both their resource energy and greenhouse gas emissions. The house was a single storey project home of relatively simple design.

Option1
Brick veneer/timber frame/concrete slab

Option2
Brick veneer/steel frame/concrete slab

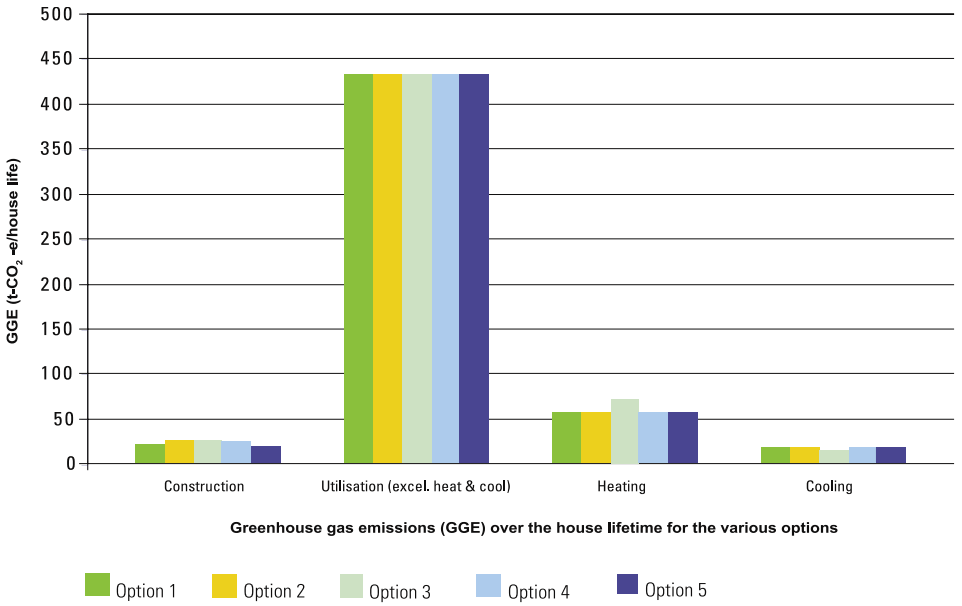
Option3
Double brick/concrete slab

Option4
Timber clad/steel frame/concrete slab

Option5
Timber clad/timber frame/concrete slab

The results are summarised in the following chart.

Greenhouse gas emissions over life cycle of a house



The study concluded that of the five housing options studied, utilisation energy had the greatest environmental impact over the lifecycle of the house, accounting for over 90% of energy consumption and greenhouse gas emissions for all options. Researchers reported that the materials of construction had only a very small impact on the overall resource energy and greenhouse gas emissions.
[See: Material Use Introduction]

Buildability, availability and cost

As a result of the long history of cavity brick and brick veneer construction in Australia, there is a huge body of knowledge and experience on construction standards and techniques.

Clay bricks are manufactured throughout Australia and are available at competitive prices throughout the whole of Australia. Even in remote areas, clay bricks can be supplied at moderate prices due to the wide availability of truck transport and back-loading opportunities.

TYPICAL DOMESTIC CONSTRUCTION

Construction process

First, concrete footings or a concrete raft slab are constructed.

For brick veneer, the timber or steel frame is then constructed. (For cavity brickwork, this step is not necessary.)

One or more courses of brickwork are laid up to the level of the damp-proof course. If appropriate, a termite barrier is installed.

The remainder of the brickwork is then constructed, inserting cavity or veneer ties, windows and doors, flashings and weep holes (to divert moisture out of the walls) and roof anchorages (to prevent the roof structure from separating in high wind).

Typical details

AS 3700 Masonry structures and the BCA Volumes 1 and 2 provide the regulatory framework for the design and construction of clay brickwork. The CBPI (Clay Brick & Paver Institute) and many of the brick manufacturing companies publish design manuals and standard details.

Footings

For clay 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 clay brickwork buildings, concrete footings and concrete slabs should be designed and constructed in accordance with AS 3600 Concrete structures.

Frames

Cavity brickwork houses do not require frames, the stability being provided by the combined thickness of the two leaves and cavity and the incorporation of cross walls and returns.

For 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.

In architecturally designed homes the use of frames and clay brick walls may more freely exploit the qualities of bricks to achieve particular design 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. The CBPI (Clay Brick & Paver Institute) provides comprehensive manuals with charts and tables for the design of loadbearing clay brickwork walls.

Joints & connections

Where practicable, brickwork should be constructed in stretcher bond, with fully bonded returns. Cross walls may be fixed using brick ties spaced in accordance with AS 3700. Provision of articulation joints at strategic locations will prevent cracking resulting from movement of supporting structures.

In most environments General Purpose Grade bricks and M3 mortar are appropriate, although there are some circumstances (e.g. interior environments above dpc etc.) where Protected Grade bricks and M2 mortar may be used. If brickwork is subjected to particularly harsh environmental conditions, Exposure Grade bricks with M4 mortar may be required. (See AS 3700 Tables 5.1 and 12.2 for options.)

Fixings

Major anchorages (such as roof tie-down anchorages) should be built into brickwork during construction. For high wind uplift, anchorages should pass down the brickwork cavity and be tied into supporting concrete slabs or footings. Windows and doors may be built into brickwork 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. If set into brick rather than mortar, higher anchorage strength can be achieved.

Openings

Most commercially available doors and windows are manufactured to be compatible with clay brickwork, either in veneer or cavity construction. CAD and hard copy details that provide information on the required sizes of openings and fixing information are available from window manufacturers and on the internet.

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.

Although clay brickwork is often used for internal feature walls, internal brickwork loadbearing walls, firewalls and acoustic partitions may be painted, rendered or sheeted with plasterboard.

ADDITIONAL KEY REFERENCES	
AS 3700 *Masonry structures*, Standards Australia	
AS/NZS 4455 *Masonry units and segmental pavers*, Standards Australia	
AS 2870 *Residential slabs and footings – Construction*, Standards Australia	
AS 1684 *Residential timber framed construction*, Standards Australia	
AS 3623 *Domestic metal framing*, Standards Australia	
Sugo, H. (2003), *Thermal Performance of a Cavity Brick Building Module - A Preliminary Report*, University of Newcastle	
Clay Brick & Paver Institute publications ww.claybrick.com.au	
M1	Clay Paving Design and Construction
M2	The Properties of Clay Masonry Units
M3	The Full Brick Manual
M4	Design of Clay Masonry for Wind & Earthquake
M5	Fire Resistance Levels for Clay Brick Walls
M6	Design of Clay Masonry for Compression
M7	Design of Clay Masonry for Serviceability
M9	Detailing of Clay Masonry Walls
M10	Construction Guidelines for Clay Masonry
T01	Removing Stains from Clay Pavements
T04	Durability of Brickwork
T05	Open Fireplace Design and Construction
Specifications and CAD drawings for clay brickwork www.electronicblueprint.com.au	