PART A

Chapter 1

Application

This chapter describes the typical applications of concrete masonry, ie brickwork and blockwork. It also describes the typical properties and features of concrete masonry buildings, including acoustics, thermal performance, structural performance and fire resistance.

Other concrete products such as segmental pavers and landscaping units are not dealt with in any detail, since information on their use may be obtained from other publications of the Concrete Masonry Association of Australia, or their web site: *www.cmaa.com.au*

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1.1 THE MANY FACES OF CONCRETE MASONRY

Concrete masonry is a generic term covering many building systems that incorporate bricks and blocks of many different shapes and sizes, colours and textures, strengths and other mechanical properties.

It includes:

- decorative face masonry such a coloured, polished, textured or split bricks and blocks;
- plain blocks used as the loadbearing leaf in cavity construction and non-loadbearing partitions;
- reinforced hollow blockwork in large building panels and retaining walls;
- mixed construction consisting of unreinforced and reinforced hollow blockwork.

Reinforced concrete masonry provides efficient resistance to wind loads and earthquake loads in large panels in low-rise commercial and industrial buildings such as:

- Factories
- Warehouses
- Shopping centres
- Auditoriums
- Schools and hospitals
- Housing in high-wind areas.

Unreinforced concrete masonry is widely used in high-rise and medium-rise commercial and residential buildings with loadbearing and non-loadbearing fire-rated walls, including:

- Home units
- Office buildings
- Hotels.

Decorative face masonry is often used in both prestigious residential buildings and project housing, such as:

- Single dwellings
- Duplexes
- Town houses
- Villa units
- Institutional buildings.

1.2 WHY MASONRY?

Large precast concrete panels, tilt-up walls and insitu concrete require formwork, constructed precisely to predetermined dimensions and reinforcement that is accurately placed. They are suitable for repetitive work or projects where a high level of supervision and control can be exercised over formwork construction and reinforcement positioning, but they are not suitable for projects involving lower levels of supervision or non-repetitive construction.

Metal and glass sheeting provide attractive and functional surfacing, but do not have the loadbearing properties necessary to support vertical gravity loads applied from above.

Similarly, metal and timber framed walls generally do not provide the requisite load bearing properties.

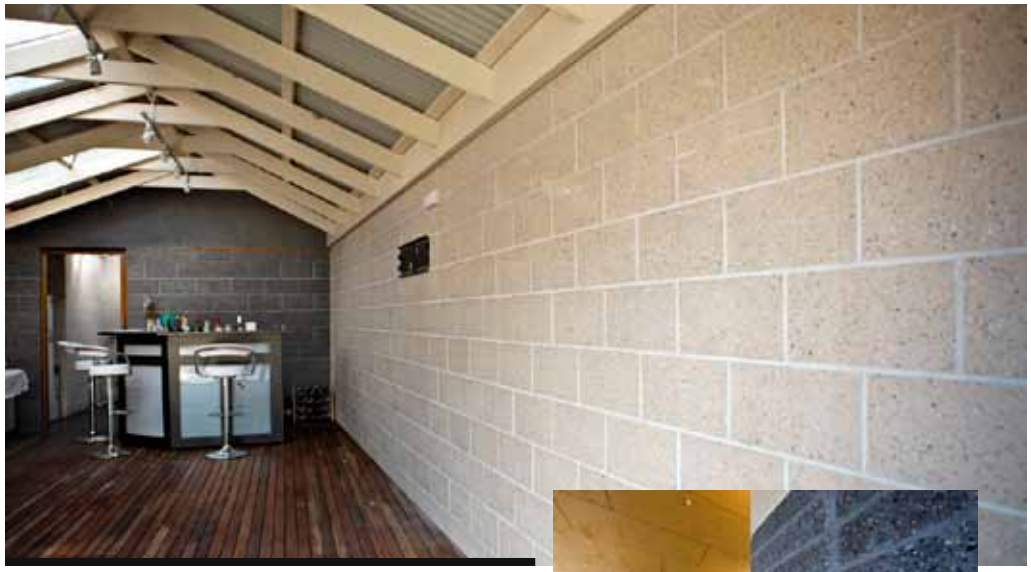
Masonry walls do not have these disadvantages. They can be laid to fit into an existing structure and can be laid around openings and other structural members. Whilst not sacrificing aesthetics, concrete masonry provides and efficient medium for supporting vertical loads, as well as effective resistance to horizontal loads.

1.3 AESTHETICS, COLOUR AND TEXTURE

Plain face
Plain face units are available in a number of textures, each of which tends to reflect the type of mix employed. The coarsest face is obtained from a 'no-fines' mix. The texture becomes less coarse as the fines content and the moisture content in the mix is increased, giving a more workable concrete.

Honed face
To achieve a finely striated finish that appears similar to that produced by a diamond saw cut, dense concrete units can be honed by passing them through a machine that grinds approximately 2 mm from the surface. Both the face and an end can be honed to facilitate corners in the finished masonry.

Polished face
Further polishing after honing will produce a very smooth surface approaching that normally associated with terrazzo. The block undergoes several passes of the polishing disks, initially to remove scratches and striations, then to grind smooth and finally, to put a shine on the surface. Both the face and an end can be polished to facilitate corners in the finished masonry. Colour variations can also be achieved in polished and honed masonry.



Polished reconstructed granite blocks used for the external skin of a house

Flowing wall of shotblast and smoothface, sandstone-coloured concrete masonry

Split face

Split face units are amongst the most popular facing units supplied. They are produced as 'double-sized' elements. After curing, the elements are split by shearing to defined profiles.

The standard splitter induces a vertical split giving a block or brick with a tailored finish. If a more rugged character is sought the unit is split in a special machine using angled blades. Alternatively, the unit may be put through a hammer mill to remove the longitudinal arrises following splitting.

The size and colour of the coarse aggregate particles in the concrete mix have a considerable effect on the appearance of the finished face. Where the colour of the coarse aggregate contrasts with that of the matrix, the aggregate particles will 'read' quite clearly in the finished face. Normally, aggregate particles do no exceed 15 mm in size, and 10 mm maximum is preferred.

Split face units often come in the full range of sizes. 90 mm, 110 mm, 140 mm, 190 mm and 290 mm thick units are available from some manufacturers. Where it is required to form a return using split face units it may be necessary to form the return using quarter, half or three-quarter length units, or use a corner block available from some manufacturers.

Retaining wall blocks being split on a special splitter to give a profiled face

"Straight splitting" to concrete blocks

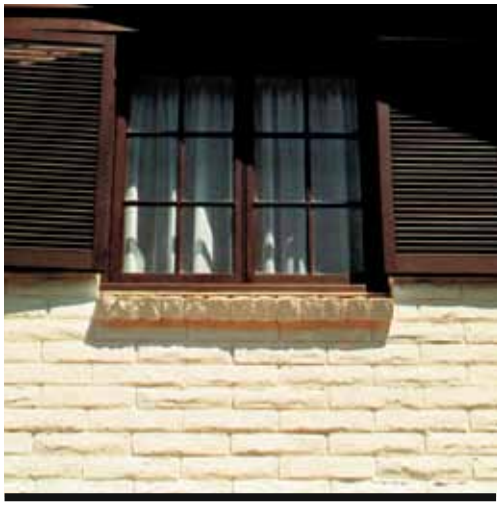
Split-face feature block wall in bedroom

"Angled splitting" to concrete blocks

Slump block and brick

Slump block and brick units, known as adobe units, have irregular dense faces. They are produced using a concrete mix having greater workability and higher moisture content than normal masonry mixes. The unit is extruded in the normal way but tends to 'slump' after manufacture – hence the name.

Although the height of the unit is constant, some variation in plan dimensions is inevitable. However, it is the variability which is the principal attraction of this type of unit and which gives the resulting wall its character. The maximum height of slump block is limited by the process. Normally, only 90-mm-high or standard brick-size units are available.



"Adobe" or "slump" bricks

Rumbled "Rustique" concrete bricks

Rumbled bricks and blocks

A rumbled surface is achieved by putting the units through a machine known as a 'rumbler'. This is a rotating tilted drum through which the units tumble under gravity. At the upper end a series of blades or protuberances cause the arrises to spall. In the lower end the spalls get rounded off through contact with the drum wall. The resulting unit has a much 'softer' appearance than the sharply defined faces of the original units. When blended colour units are rumbled, the resulting appearance is reminiscent of hand-made bricks. Since the extent of spalling is critical, only high strength solid or lightly cored masonry is suited to this process.

"Twin-blend" rumbled bricks showing comparison between raked and ruled joints

Colour

All masonry units can be produced in a rich variety of colours. The prime determinants of colour are:

- the colour of any metallic oxides used in the mix
- the colour of the cement
- the colour of the fine and coarse aggregates
- the curing system.

Australian cements may be grey, off-white or tan in colour, the depth of colour depending partly on the source rock. These, together with the more expensive imported white cements, give the masonry manufacturer a much wider range of colour opportunities from locally-available aggregates.

Because colours are a function of variable raw materials, curing techniques and atmospheric conditions prior to curing, some minor colour variation, particularly between pallets, is inevitable. It is, therefore, good practice to select units in random fashion from several pallets rather than to lay from a single pallet at a time. In this way any variation in colour tends to be scattered at random within the wall, and areas of localised contrast are avoided.

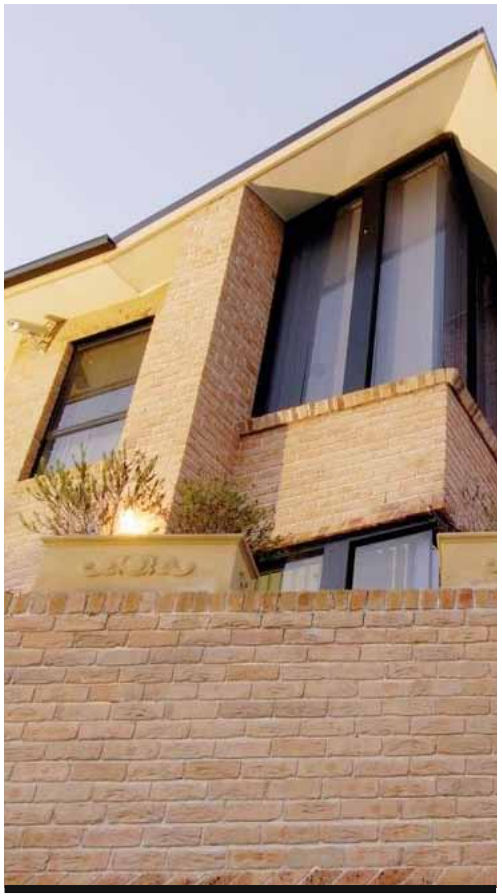
Where a mottled appearance is sought, units of different colours can be used in a random pattern in the wall. The degree of colour contrast will be a function of the colours selected, and can be as little or as much as the designer wishes.

Multi-blend

Multi-blend units exhibit a random distribution of colour in the face with no two units having identical faces. Walls constructed using these units have a very relaxed 'natural' look, akin to natural stone or clay brickwork.

Two basic methods of manufacture are employed. In the first, two discrete compatible mixes of different colours are partially blended together, prior to admission to the mould box. Under compaction, the two mixes form a cohesive blend with slight yet random merging occurring between the two colours. The resulting face exhibits the two extremes of colour of the two mixes plus a soft gradation of colour between. The distribution of colour is random, both within the mould box and in the individual units.

In the second process, a coloured cementitious slurry, compatible with the parent base grey or coloured concrete mix, is injected into the mould box immediately prior to the admission of the parent mix. Under compaction, partial intermixing occurs between the grout and the parent mix, giving a unit with a random 'flare' across each face and a soft colour transition between the two colours employed.



"Multi-blend" rumbled bricks in exterior application

Ribbed Block

Concrete masonry is one of the few loadbearing materials that can be manufactured having a heavily profiled face. Although the manufacturing process tends to dictate a face profile which 'reads' vertically in the wall it is also possible to develop profiles to 'read' horizontally. The form of ribbing that can be incorporated is almost limitless, from the provision of minor grooves in the face to the use of substantial protruding nibs. Design of the face is generally a function of the ability to negotiate a return whilst maintaining both bond, width of joints and – even more importantly – vertical continuity for the grooves or nibs. Ribbed block is normally made in full-height units (190 mm) to minimise the number of horizontal joints.

Plain ribbed block to wall and balustrade of residential units

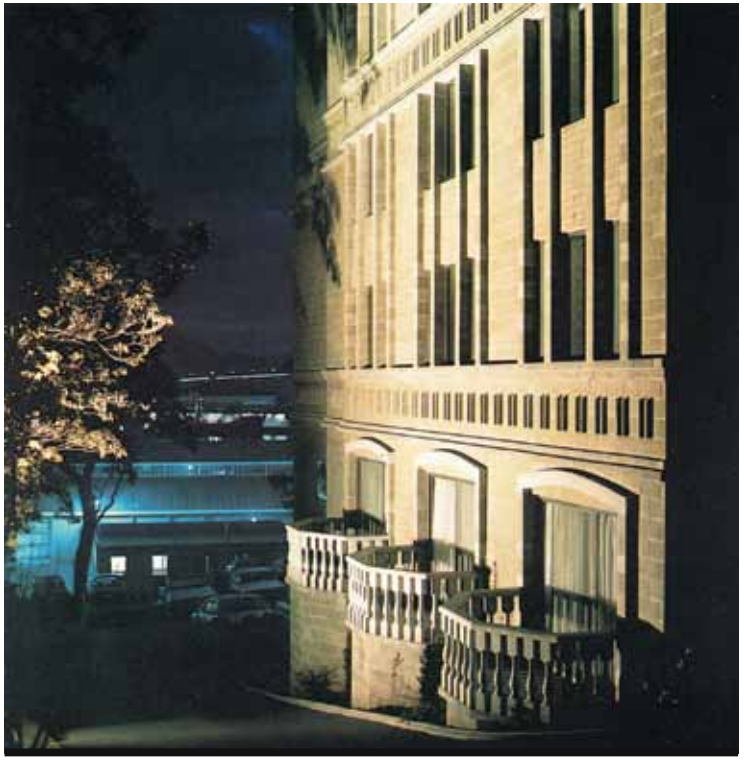
Plain ribbed blocks used to assist acoustics in an auditorium

Profiled walls
These may be constructed of standard units employed in unusual ways and have long intrigued imaginative designers.

Lintel units can be incorporated in a wall as a decorative element turned through 90° and laid with the "prongs" projecting.

Quoin blocks may be used as corbels in an otherwise plain wall to provide a series of bold, square projections.

Use of different blocks to produce a profiled banding effect



Projections producing a profiled effect as part of the design to blend a modern building into an area of 'period' buildings

Simple screen block wall

Screen Blocks
The range of screen blocks is considerable. It differs greatly between manufacturers and it is essential to determine local availability before detailing a screen-block wall.

Screen blocks can be manufactured in most colours, but are probably most effective in either white or soft brown colours. Contrasting elements in two colours can produce a delicate tracery or emphasise modelling to advantage.

They provide one of the cheapest and most effective forms of sun screening when erected in front of a window wall. Properly designed screen walls can also provide a most effective windblown-debris barrier in cyclone-prone areas.

White and grey screen blocks develop a delicate tracery for a carport screen wall

Custom Designed Concrete Masonry
Designers can elect to design their own concrete masonry elements and are limited only by the operational parameters of high-speed automatic production machinery.

The additional cost of developing custom-built masonry, as against the use of normal production units, comes about through:

- Design and construction of moulds and mould accessories
- Trial production runs
- Change of moulds and parts at the commencement and end of each production run.

Whilst these costs are significant, they are spread over the total number of units produced. Providing a sufficient number of units is required, the unit cost need not be unduly high. Naturally, the larger the run the lower the unit cost premium.

Dimensional limitations on the size and shape of units vary with the type of machine used and the size of machine pallet. It is desirable to keep to the preferred modular dimensions, remembering that actual overall dimensions are 10 mm smaller than the nominal dimensions given.

In the design of custom-built units it is essential to minimise the number of types of units required. Where special-sized units are required to fill up the mould area it is important to remember that each machine cycle will produce these units which then have to be incorporated in the wall in the proportion in which they are manufactured.

Division plates within the mould are usually about 10 mm thick. To allow units to be extruded, moulds and cores have to be tapered slightly so that the upper dimensions of solid parts of each unit, as moulded, are smaller than the lower dimensions.

Whilst the manufacturing process encourages the use of a profile which reads vertically in the wall, it is possible to extrude a solid unit which can be bedded at 90° to the direction of manufacture. For example, a rebate could be formed along one vertical face in manufacture which – when bedded in the wall in this way – would 'read' as a horizontal indent. Such units are restricted in 'length' by the maximum 'height' of unit that the machine can extrude. Alternatively, 'core pullers' can be used to form horizontal rebates in most modern machines.

The least expensive approach to custom designed masonry is in the production of special blends of colours. It is possible to develop a special colour combination for a building, one suited to the identity of the company occupying the building for example. In developing special requirements it is wise to appreciate that the light colours are often the easiest to control.

Custom-designed colours are an inexpensive approach

1.4 STRUCTURAL VERSATILITY

The versatility of concrete masonry as a structural building element is outstanding. It may be designed and constructed as unreinforced masonry, as reinforced masonry (with either close-spaced reinforcement or wide-spaced reinforcement) or as mixed construction consisting of a combination of reinforced and unreinforced elements.

In particular, high winds of northern Australia and earthquake loadings throughout the whole of the country make reinforced masonry a very attractive design option, with the requisite strength and stiffness properties to resist lateral loads.

Part B of this Manual provides detail on the background, design requirements, design charts and tables and worked examples covering the main applications of concrete masonry in resisting vertical and horizontal loads arising from gravity, wind and earthquake. **Part C** of this Manual provides specification and detailing for structural concrete masonry.

1.5 FIRE RESISTANCE

A major requirement of many walls in buildings is to prevent the spread of fire. Various concrete masonry wall systems/units are well suited to this application:

- Masonry systems which are deemed-to-comply with the NCC (National Construction Code) – BCA (Building Code of Australia) requirements provide an economical solution for most walls.
- Tested, purpose-designed unreinforced masonry units with light weight aggregate and/or basalt aggregate can be used to provide enhanced structural adequacy for larger wall panels or improved insulation and integrity.
- Where very-large walls are involved, reinforced masonry will provide effective solutions. Bond beams can be used to support 190-mm hollow blockwork in lengths up to 6.8 m. Vertical reinforcement (in partially-reinforced masonry systems) can span up to 8.0 m high.

Irrespective of the material used, designers must be careful to spell out the structural adequacy requirements, when specifying fire-resistant wall systems.

Part B of this Manual provides the background, design requirements, design charts and tables and worked examples for the design of concrete masonry to resist fire loads.

1.6 ACOUSTIC PERFORMANCE

Noise can be one of the most intrusive and annoying phenomena in modern buildings. Noise travels from its source through the air, through open windows or doors, through walls and into living or office spaces. It may be controlled by isolating the noise at its source (eg by enclosing it within walls that will absorb and dissipate it), or by preventing the noise from reaching the living or office spaces (eg by erecting sound-resistant walls in its path).

Concrete masonry is particularly suited to these applications:

- It may be used for sound barriers adjacent to busy roads and similar sources of noise.
- Concrete masonry loadbearing walls and non-loadbearing partitions in buildings, used in conjunction with paint and render or plasterboard, can provide the sound attenuation required by the National Construction Code (NCC) – Building Code of Australia (BCA).

Part B of this Manual explains the nature of sound, lists NCC–BCA requirements and provides design charts/tables and a worked example for the provision of concrete masonry capable of isolating sound.

1.7 THERMAL BEHAVIOUR

The energy efficiency of building envelopes has become a major focus of government initiatives in Australia, with the introduction of National Construction Code (NCC) – Building Code of Australia (BCA) Volume One, Part J and Volume Two, Part 3.12.

Calculated values of insulation to be added to various wall types, including brick veneer and cavity brick walls, are also included.

A masonry wall is made up of a number of components, each of which has a different ability to insulate against heat flow. Lightweight concrete masonry is a better insulator than dense weight concrete masonry while metal cavity ties are poor insulators. Thermal bridging is the phenomenon whereby heat flows through concrete webs, cavity ties or other bridges to enter or leave the building. In determining the thermal insulation of hollow concrete blocks, allowance must be made for the thermal bridging which can occur through the concrete webs and metal ties.

The main options to increase the thermal resistance of the walls are:

- Masonry veneer or cavity masonry with foil insulation
- Masonry veneer or cavity masonry with batts or other bulk insulation
- Masonry veneer or cavity masonry with pumped or poured insulation
- Single-leaf masonry with solid insulation within the cores
- Single-leaf masonry with pumped or poured insulation within the cores
- Single-leaf masonry with batts or other bulk insulation on the internal surface.

The regulations concentrate on insulation, ie the ability to prevent heat from passing through a wall. However, concrete masonry is also able to remain cool while the ambient temperature is high and to remain warm when the ambient temperature is low. This property is known as thermal mass or thermal inertia.

The concrete blockwork walls of a building will remain cool during the heat of the day, but at night, when the air temperature drops, the concrete masonry will keep the building at a comfortable temperature by releasing the heat.

Part B of this Manual provides the background, design requirements, design charts and tables and a worked example for the design of concrete masonry to provide enhanced thermal performance. **Part C** of this Manual provides specification and detailing for thermal performance.