Design Manual 3

The Full Brick Manual

Acrobat Edition
For many years clay bricks have been central to our definition of housing. Today more and more Australians are re-discovering full brick construction.

The external walls of a full brick house are built with two leaves of clay brick masonry separated by a narrow cavity. This method of construction is also known as cavity brick, solid brick or double brick.

Single thickness brick walls may be used between rooms eliminating any requirement for steel or timber wall frames. Some or all of the inner walls of a full brick house may be left as face (or exposed) brick or finished with render, plasterboard, timber or paint.

Full brick houses are:
- Cooler in summer and warmer in winter.
- Quiet.
- Low maintenance.
- Affordable.

This manual sets out design and construction details for detached full brick housing and uses ample illustrations to show that building in full brick is as simple and economical as the familiar brick veneer.
INTRODUCTION ................................................................. 3
WHAT ARE THE ADVANTAGES OF FULL BRICK CONSTRUCTION? .............. 4
REGULATORY REQUIREMENTS ............................................. 4
MATERIALS ...................................................................... 5
  Bricks ................................................................. 5
  Mortar .............................................................. 5
  Accessories ......................................................... 5
  Damp-proof courses & flashings ................................. 5
  Vents ................................................................. 5
  Wall ties .............................................................. 5
  Flexible anchors or connectors .................................. 5
  Lintels ................................................................. 5
PLANNING ...................................................................... 6
  Passive solar design .................................................. 6
  Dimensioning drawings ............................................ 6
DESIGN & CONSTRUCTION ............................................... 7
  Footings & slabs ...................................................... 7
  Brick piers ........................................................... 9
  Termite control ....................................................... 9
  Fire resistance ......................................................... 9
  Brick walls .......................................................... 10
    Sub-floor clay brick masonry .................................. 10
    DPCs and cavity flashings ..................................... 10
    Walling above the DPC ........................................ 11
      • Bonding
      • Window and external door frames
      • Wall ties
    Walls subject to high winds ................................... 13
  Lintels ................................................................. 13
  Articulation joints .................................................. 14
  Control gaps ........................................................ 14
  Doors ................................................................... 16
    • Steel door frames
    • Timber door frames
    • Articulation joints at standard-height doors
    • External doors in cavity walls
  Brick cleaning ......................................................... 18
  Internal wall finishes ................................................. 19
    • Renders
    • Sheeting
    • Paints
  Skirtings .............................................................. 20
  Wall/ceiling junction ............................................... 20
  Services .................................................................. 21
    • Plumbing.......................................................... 21
    • Electrical ......................................................... 22
SCHEDULING TRADES ...................................................... 23
FIGURES

1. Full brick walling on slab ........................................... 3
2. Slab on ground for class A & S sites .............................. 7
3. Footing slab for class A & S sites ................................. 7
4. Slab on ground on class M & H sites ............................ 7
5. Strip footings with infill slab floors ............................... 8
6. Strip footings for class A & S sites ............................... 8
7. Strip footings on class M site ....................................... 8
8. Isolated brick pier with concrete footing ....................... 9
9. Isolated brick pier with brick footing ............................. 9
10. Cavity walls on strip footing with framed flooring & sub-floor vent .............................................. 10
11. Slab edge rebates for cavity walls ............................ 10
12. DPC and cavity flashings for full brick walls .................. 10
13. DPCs for full brick walls on strip footings ..................... 11
14. External doors showing lintel & flashing details & fixing of frames ............................................... 12
15. Lintel and flashing details and fixing of window frames .......... 12
16. Wall tie positioning and spacing ............................. 12
17. Reinforced hollow clay units in high wind areas ............... 13
18. Roof tie down for high wind areas ........................... 13
19. Tie down to clay brick masonry for tile or sheet roof in wind classification areas W28 and W33 ....................... 13
20. Typical articulation joint locations ............................ 15
21. Control and articulation joint detailing ......................... 15
22. Masonry flexible anchor in articulation joints and control gaps ............................................... 15
23. Internal doors showing switch wiring .......................... 16
24. Steel door frames in cavity walls ............................ 17
25. Typical wall/ceiling junction ............................... 20
26. Typical plumbing arrangements ................................... 21

TABLES

1. Lintels for 110 & 90 mm single-storey clay brick masonry (mm) .... 5
2. Optimum door width for standard-height doors .................. 16
3. Typical trades schedule for full brick house construction .......... 23
For many years Australia has had a love affair with clay brick. For most of us the ubiquitous brick veneer has defined the great Australian dream of home ownership. Today there is a new player in the market with full brick construction taking the high ground in quality residential construction.

What is full brick? The external walls of a full brick house are built with two leaves of clay brick masonry separated by a cavity. All or most of the internal dividing walls are built in single-leaf clay brick masonry. This is also known as cavity brick, solid brick or double brick construction. Figure 1 shows a typical section of full brick walling.

Full brick is much more than a revival of an ‘old’ form of construction. The internal walls of a full brick house may be displayed as face brick or given a conventional finish. Modern construction materials and techniques have also been adopted.

The purpose of this technical manual is to assist designers, builders, specifiers and others involved in housing construction and to demonstrate that building in full brick is as simple and economical as the familiar brick veneer.

“... building in full brick is as simple and economical as the familiar brick veneer.”
WHAT ARE THE ADVANTAGES OF FULL BRICK CONSTRUCTION?

• **Full brick houses are cooler in summer and warmer in winter.** The high mass of a full brick house absorbs the worst of the Australian summer and retains winter warmth. In conjunction with passive solar design principles, full brick construction ensures a comfortable, energy-efficient house.

• **Full brick houses are quiet.** The two leaves of dense clay bricks on the outside of a full brick house reduce noise entry. Single leaf internal clay brick masonry reduces noise transfer between rooms.

• **Full brick houses are low maintenance.** Bricks are extremely durable, immune to vermin and termite attack and do not require any finish to maintain their appearance or performance. Depending on the design, the full brick house may not require skirtings or architraves, reducing the amount of timber needing repainting.

• **Full brick houses are affordable.** As well as being more economical to run and maintain, the full brick house should cost little, if any, more to build than a conventional brick veneer. Full brick houses also command a premium when it comes time to sell.

REGULATORY REQUIREMENTS

All buildings are required to comply with the *Building Code of Australia* (BCA), which in turn requires clay brick masonry to comply with AS 3700-1988, *The SAA Masonry Code*.

At the time of writing this manual the Australian Building Control Board was preparing the *ABCB Housing Code* (a simplified version of the BCA, specific to house construction) and Standards Australia was preparing a code for masonry housing. As far as possible these preliminary documents have been considered in the preparation of this manual.
Wall ties
Wall ties are required to comply with AS 2699-1984, *Wall ties for masonry construction*, but a new Standard, AS/NZS 2699.1, *Connectors and accessories for masonry construction Part 1: Wall ties* is in preparation. Wall ties for full brick construction differ from those used in brick veneer but are readily available.

Flexible anchors or connectors
These are used to connect clay brick masonry across articulation joints or control gaps. Anchors or connectors are currently required to comply with AS 2975-1987, *Accessories for masonry construction*, but AS/NZS 2699.2, *Part 2, Anchors and accessories* is in preparation.

Lintels
Lintels are usually standard or proprietary steel sections. They may also be reinforced clay brick masonry, prefabricated or constructed on site. The following lintel span table is suitable for walls carrying a roof load provided there are not widely-spaced rafters or trusses located near the mid span of wide openings. If they occur, the given span should be reduced by 15 per cent. Engineering advice is needed for lintels in walls carrying floor loads or otherwise outside the limits of this table. Manufacturers also provide load/span tables for proprietary lintels.

<table>
<thead>
<tr>
<th>Span</th>
<th>Standard steel sections</th>
<th>Minimum end support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 1200</td>
<td>75 x 10 flat</td>
<td>100</td>
</tr>
<tr>
<td>1200 to 2100</td>
<td>100 x 100 x 6 angle</td>
<td>120</td>
</tr>
<tr>
<td>2100 to 3600</td>
<td>150 x 100 x 8 angle</td>
<td>150</td>
</tr>
</tbody>
</table>

Note: Unequal angle lintels should have their long leg vertical.

MATERIALS FOR FULL BRICK CONSTRUCTION

- **Bricks**: identical to those used in brick veneer.
- **Mortar**: identical to that used in brick veneer.
- **DPCs and flashings**: identical to those used in brick veneer.
- **Wall ties**: full brick wall ties are readily available.
- **Flexible anchors or connectors**: identical to those used in brick veneer.
- **Lintels**: identical to those used in brick veneer, but needed also on the inner leaf.
- **Vents**: identical to those used in brick veneer.
PLANNING

PASSIVE SOLAR DESIGN

This term is widely used but little understood. The basis of passive solar design is heavyweight construction that has the ability to store heat and moderate internal temperatures.

A full brick house with internal (partition) brick walls provides this mass, particularly when combined with a concrete slab floor. Studies have shown that the temperature range in a full brick house is close to the preferred human comfort zone in both the coolest and hottest months. The other principles of good solar design, such as providing large areas of appropriately shaded north-facing glass, particularly apply.

This design technique works equally well in the temperate zones of Australia that includes Adelaide, Brisbane, Hobart, Melbourne, Perth and Sydney, and the cool temperate zones that take in Canberra, Snowy Mountains, NSW Central Tablelands and Victoria’s High Country. Some designers favour the use of a relatively light-weight and light-coloured brick in the outer leaf (for maximum insulation and heat reflection) and a dark, heavyweight brick in the inner leaf (for maximum sound and heat absorption and heat storage). This is feasible but not necessarily practical. However it does reinforce the point that different types and colours of brick can be used inside and out.

DIMENSIONING DRAWINGS

Plan the house so that dimensions are exact brick or brick-and-a-half lengths. Where interior walls are to be face brick, dimension wall lengths from corners to openings in brick unit sizes. This is critical because these walls will be regularly seen at close quarters. In the same way, vertical dimensions to window sills, heads and wall heights should be taken from the brick height gauge.

A further advantage of full brick construction is that all walls are constructed by the one trade thereby reducing the possibility of dimensional errors and set-out difficulties.

CHECK LIST

PLANNING THE FULL BRICK HOUSE

✓ The high mass of full brick houses is ideal for passive solar design.
✓ The passive solar benefits of full brick apply in most areas of Australia
✓ Different bricks can be selected for the internal and external clay brick masonry.
✓ Dimension in brick and brick-and-a-half lengths.
✓ Fewer trades equals fewer errors.
FOOTINGS & SLABS

Footings for brick walls must be designed in accordance with AS 2870-1996 Residential slabs and footings. Slabs for full brick are little more complicated than those for brick veneer. The principles for footing and slab design for full brick on sloping sites are identical to those for brick veneer.

Local experience on known stable sites (around Perth, for example) may permit thinner slabs and less reinforcing than shown here. In other places, a variation of the slab-on-ground known as a waffle-raft may be used.

In areas with very reactive, deep-seated soil movements (such as Adelaide) local experience indicates that stiffer slab footings than those shown here are required. In such cases AS 2870 gives guidance under the additional site classifications of M-D and H-D. It is also recommended that an experienced local engineer design the slab or check the proposed design when building on such sites.

Sizes and reinforcing for strip footings, slabs-on-ground and footing slabs for full brick construction are shown in figures 2 to 4 and 5 to 7.

Figure 2. Slab-on-ground for class A & S sites

Figure 3. Footing slab for class A & S sites

Figure 4. Slab-on-ground on class M & H sites
Figure 5. Strip footings with infill slab floors

Turn membrane up walls to form a bond break when slab is placed. Trim membrane after slab is finished.

Figure 6. Strip footings for class A & S sites

"Local experience on known stable sites may permit thinner slabs and less reinforcing"

Figure 7. Strip footings for articulated full brick construction on class M site

Ant capping is only required in termite-prone areas.
BRICK PIERS
Pier construction for full brick is similar to that in brick veneer and is illustrated in figures 8 and 9.

TERMITE CONTROL
In termite risk areas the BCA requires attack to be controlled in accordance with AS 3660.1-1995 Protection of buildings from subterranean termites Part 1: New buildings. That standard requires any structural material vulnerable to termite attack to be protected. Therefore in a full brick house with a concrete floor and a timber framed roof, that frame must be protected, but no protection is needed for the walls or floors. Under AS 3660.1 termite protection for full brick is identical to that for brick veneer even though the material requiring protection is at least 2400 mm above the termite barrier. This suggests that full brick houses are over-protected by the standard and are therefore super-safe from termite attack.

FIRE RESISTANCE
Any external wall closer to a boundary than 900 mm is required to have an FRL of not less than 60/60/60 when tested from the outside. The material with that resistance must extend to the underside of a non-combustible roof. Full brick construction easily satisfies this requirement.
A garage needs a similar FRL 60/60/60 separation from the residence to which it is attached. This means that a full brick house with a garage separated from it by a single leaf of clay brick masonry satisfies the BCA requirements for fire resistance.
For more information on this topic refer to Design Manual 5, Fire Resistance Levels for Clay Brick Walls, published by the Clay Brick and Paver Institute.

CHECK LIST
- Footing and slab design for full brick is very similar to that for brick veneer.
- Brick piers are virtually identical for full brick and brick veneer.
- Termite control measures are identical for full brick and brick veneer.
- Full brick construction easily satisfies regulation fire resistance requirements.
BRICK WALLS

Sub-floor clay brick masonry

The construction of sub-floor clay brick masonry (figures 7, 8 and 10) is substantially similar to that in brick veneer. Masonry units used below the DPC shall be at least General Purpose class but must be Exposure class in a known aggressive environment. The provision of vents under suspended floors is shown in figure 10. It is also important to provide for good air circulation by leaving openings in internal base walls, large enough to also allow access to internal sub-floor spaces.

DPCs and cavity flashings

The various forms of DPCs and cavity flashings are illustrated in figures 11, 12 and 13. These membranes should project beyond the wall face during construction but may be cut off flush after the mortar has set.
Walling above the DPC

The bricklaying process for full brick varies little from that used in brick veneer. Flush mortar joints are usually preferred internally for aesthetic reasons and because they eliminate dust-collecting ledges and harsh shadow lines. Where render or sheeting finishes are to be applied, internal clay brick masonry is sometimes laid without filling the perpend joints. This is common practice in Western Australia.

To reduce efflorescence and staining it is good practice to cover the top of incomplete clay brick masonry during breaks in construction until the roof is in place.

Bonding of clay brick masonry above the DPC is the straightforward process of building everything in bond, including all intersecting walls. Building up to toothings does not provide adequate bond strength. Where it is not possible to build connecting walls in bond by raking back they must be tied with the equivalent of a light-duty tie in every second course.

Window and external door frames can be fixed after the masonry is constructed but are usually built in as bricklaying proceeds with ties and flashings as illustrated in figures 14 and 15. Temporary protection of frames against damage or scratching of finishes may be needed.

Wall ties must be included at the centres illustrated in figure 16 to provide stability to the outer leaf. Particular attention must be given to the building in of extra ties at unbonded cross-wall intersections and at discontinuities such as window jambs and articulation joints or control gaps.

“Flush mortar joints are usually preferred internally for aesthetic reasons”
Figure 14. External doors showing lintel and flashing details and fixing of frames

STEEL DOOR FRAME

ALUMINIUM-FRAME SLIDING DOOR

TIMBER DOOR FRAME

Figure 15. Lintel and flashing details and fixing of window frames

Figure 16. Cavity wall tie positioning and spacing

Medium-duty wall ties at 600 mm centres (maximum) in body of wall. Ties at 300 mm average (400 mm maximum) centres at top edge around openings, at control gaps and at lateral supports
Walls subject to high winds
In those areas with design wind speeds of 28 m/s and above it is necessary to provide anchorage for the roof. Details are provided in figures 17, 18 and 19.
Where the design wind speed is above 41 m/s it may be necessary to reinforce the clay brick masonry. This is commonly done with external walls made from hollow units. (See figure 17.)

Lintels
It is common practice to leave a gap in the mortar of about 10 mm at both ends of a steel lintel to allow it to expand without cracking the clay brick masonry. Reinforced clay brick masonry lintels can be used.
Articulation joints
Articulation joints are vertical gaps in brick walls, or between clay brick masonry and windows or doors, that allow for minor footing movements without causing distress or significant wall cracking. Articulation joints provide the flexibility needed when building on reactive clay soils. Articulation is not required for clay brick masonry on stable sites. The basic design and construction of articulation joints in the outer leaf of a full brick house is similar to that in a brick veneer. The principles are illustrated in figure 20. Where it is not possible to provide ties to the other leaf on either side of an articulation joint, it is necessary to provide a structural connection across the joint. This is made with masonry flexible anchors (MFAs) mortared into bed joints of clay brick masonry. See figure 21. Where MFAs are used in walls over 3 m high or exposed to high winds, they must be built into the clay brick masonry at half-height then at every seventh course (600 mm) above. See figure 22. Articulation joints can usually be placed so that they function also as control gaps.

Control gaps
Control gaps are also called expansion gaps or joints and their purpose is to control differential and thermal movement of materials. They are essential in long runs of clay brick masonry. The design and construction of control gaps in the external leaf of a full brick house is identical to that in a brick veneer. Except at re-entrant angles in long walls, control gaps are not usually required in internal clay brick masonry. Where an internal gap is required it can usually be located at a full-height opening such as a door or window.

“Control gaps are not usually required in internal clay brick masonry”
Alternative window lintel of timber or sheeted frame sufficient to carry top plate and roof loads. This acts as an articulation joint between the lintel and clay brick masonry.

Lintel carrying clay brick masonry with offset articulation joints at ends of lintel

Articulation joint at full-height doors or windows. Note there is no articulation joint in clay brick masonry below small window.

Full-height door opening acts as articulation joint

Articulation joint at (or within 600 mm of) internal corners

Articulation joint at standard-height door

Alternative positions for articulation joint 1-1/2 H from external corners

Figure 20. Typical articulation joint locations

"Articulation is not required for clay brick masonry on stable sites"

Figure 21. Control and articulation joint detailing

Figure 22. Masonry flexible anchor in articulation joints and control gaps

Doors
Full height doors have many advantages in full brick construction:
• They are simple, neat and economical to build.
• They act as articulation joints.
• They allow for simple reticulation of electrical switch cabling.

The door itself can be full height or alternatively of normal height and have a fixed panel of matching thickness over it or the frame can be made with a transom and fixed glass above the door leaf.

With full height doors there is no need to match opening widths to brick sizes, but if they are to be of normal height with brickwork above it is important that both heights and widths be compatible with brick sizes.

Standard door height is 2040 mm so 24 courses of traditional bricks or 21 courses of modular bricks give the required door opening height while allowing for the frame thickness.

Door widths that match brick openings are given in table 2 and the concepts are illustrated in figure 23.

“With full height doors there is no need to match opening widths to brick sizes ...”

Table 2. Optimum door width for standard-height doors

<table>
<thead>
<tr>
<th>Brick length (mm)</th>
<th>Frame type</th>
<th>Door width (mm)</th>
<th>Brick width opening (mm)</th>
<th>Brick width opening (bricks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard (230)</td>
<td>Steel</td>
<td>720</td>
<td>730</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Steel</td>
<td>820</td>
<td>850</td>
<td>3/2</td>
</tr>
<tr>
<td></td>
<td>Timber</td>
<td>770</td>
<td>850</td>
<td>3/2</td>
</tr>
<tr>
<td></td>
<td>Timber</td>
<td>870</td>
<td>970</td>
<td>4</td>
</tr>
<tr>
<td>Modular (290)</td>
<td>Steel</td>
<td>770</td>
<td>810</td>
<td>2 1/2</td>
</tr>
<tr>
<td></td>
<td>Steel</td>
<td>870</td>
<td>910</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Timber</td>
<td>720</td>
<td>810</td>
<td>2 1/2</td>
</tr>
<tr>
<td></td>
<td>Timber</td>
<td>820</td>
<td>910</td>
<td>2</td>
</tr>
</tbody>
</table>

Figure 23. Internal doors showing switch wiring
Steel door frames have been popular in commercial buildings and home units and are increasingly used in houses. They are readily available with hinges fitted and can be prepainted to match powder-coated aluminium window frames. Steel frames form a guide for bricklayers to build to and they increase the sense of a strong, solid building. They do not require architraves, saving finishing time and cost. Basic steel frame sizes allow building into 110 mm or 90 mm thick clay brick masonry with head heights to match 24 courses of standard bricks or 21 courses of modular bricks. Full-height steel frames are also available to order.

Timber door frames are best with full-height, floor-to-ceiling doors. When full-height timber frames are used it is best to finish the ceiling flush through the door opening without a frame at the top of the door. This way the timber door jambs are simply two straight lengths fixed to the clay brick masonry. The architraves covering the gap between frame and bricks are four straight pieces from floor to ceiling, eliminating mitre cuts in frames or architraves.

Timber frames for standard 2040 mm high doors are widely available and require a flat steel arch bar to support the clay brick masonry above.

Articulation joints at standard-height doors When there is a potential for footing movement, stresses in the wall are concentrated at door heads and may cause cracking at corners. An articulation joint above selected internal doors will help to solve this problem. The articulation joint should run from the door head to the ceiling and be a half-brick length away from the side of the door frame. This gives a seat for the arch bar or clay brick masonry spanning the opening. See figure 23.

External doors in cavity walls Steel door frames in a cavity wall are illustrated in figure 24.

“Steel door frames ... do not require architraves, saving finishing time and cost”

CHECK LIST

ARTICULATION JOINTS, CONTROL GAPS, INTERNAL DOORS

- Articulation joints will usually be required on reactive sites.
- Articulation joints can also act as control gaps.
- Control gaps may be required in long runs of external clay brick masonry but rarely in internal clay masonry
- Full height door openings have many advantages.
- Standard door sizes suit brick dimensions.
- Door openings can act as articulation joints.
- Steel door frames are inexpensive and solid.
- Timber door frames are best if full height.
Brick cleaning
The cleaning of external clay brick masonry in a full brick house is identical to that of a brick veneer. Internal face clay brick masonry may be acid cleaned. Neutralise after acid cleaning and provide adequate ventilation to ensure thorough drying otherwise acid vapour may corrode unprotected metallic and other susceptible objects. Follow local health and safety regulations. Prewetting the clay brick masonry is recommended but do not saturate the bricks — a light spray just ahead of the work in progress should be sufficient.

If internal walls are to be painted, mortar dags should be removed and the walls hosed down with plain water and allowed to dry prior to painting. The advice of the paint supplier should be sought if walls have been washed with a chemical rather than water.

“Neutralise (internal face clay brick masonry) after acid cleaning and provide adequate ventilation”
Internal wall finishes

Clay brick external walls do not require any finish to preserve their function or appearance. In full brick construction all or some of the internal walls may be displayed as face brick. Clay bricks are naturally durable and attractive and do not require the initial and ongoing cost of additional treatment. Face brick is also economical as skirtings (and in many instances architraves) are not required, reducing the amount of timber to be purchased, fitted, finished and maintained.

Where other than internal face brick is desired a number of finishes are available: renders, board sheeting and paints. These can be applied to full or dado height to selected areas (for example specific walls or rooms) during construction or at a later stage, for instance during renovations.

Where render, sheeting or wallpaper is used, service conduits or pipes may be chased into walls. (Some states permit electrical cable to be buried in the render.)

Renders include:
- Float and set
- Exposed aggregate render
- Stucco/rustic
- Bagging
- Lime wash

These are applied to the completed clay brick masonry by separate trades (except bagging that is usually done by the bricklayer). Render finishes are generally more expensive and, except for exposed aggregate renders and lime wash, also require painting. Bagging mortar may be coloured to eliminate painting. These finishes require more building time as they must dry thoroughly prior to any final paint application. Render finishes usually eliminate the brick outline, the exceptions being lime wash and, in some cases, bagging.

Sheeting requires fixing by trades-persons. There are four basic sheeting methods:
- Plasterboard is fixed by proprietary adhesives directly to the clay brick masonry. Alternatively it can be fixed onto plasterboard packing pieces, battens or furring channels. Plasterboard requires painting.
- Fibre-cement board must be fixed to battens and also requires painting.
- Timber, either sheeting or board, can be fixed to battens to full or dado height and can be painted or stained.
- Wallpaper may be hung on backing paper glued directly to the clay brick masonry providing flush mortar joints have been used.

Paints Brick walls can be painted with any one of the many paints available for masonry walls. These include standard acrylic or oil-based paints or thick (filler) paints designed to smooth uneven surfaces. Almost all paints require a sealer coat.
- Standard paints are suitable for clay brick masonry laid to face standard.
- Standard paints may also be used on non-face clay brick masonry with filled, flush mortar joints. ‘Sponged’ or ‘rubbed’ joints are also suitable.
- Thicker paints are more suitable for clay brick masonry that has not been laid to face standard.
- The paint manufacturer’s instructions must be followed.
**Skirtings**
Skirtings are not required on face brick walls or walls that have been bagged or lime washed. Otherwise secure skirtings with wall plugs.

**Wall/ceiling junction**
A typical wall/ceiling junction using a standard cornice junction is shown in figure 25.

---

**CHECK LIST**

**BRICK CLEANING AND INTERNAL FINISHES**

- ✓ Neutralise after acid cleaning internal clay brick masonry and provide good ventilation
- ✓ No special finish is required for external clay brick walls.
- ✓ Some or all internal full brick walls may be displayed as face or finished.
- ✓ Finishes include render, sheeting, paint or wallpaper.

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Figure 25.
Typical wall/ceiling junction
Services

Plumbing

Designing and installing plumbing in a full brick house requires more consideration than in a framed structure and minor changes in procedure. Here are some guidelines:

- Position baths, sinks, basins and showers on external walls so that pipe runs to the outside are short and can, where practicable, be run directly through the wall.
- Reduce chasing by hiding pipes behind or under sinks, baths, vanities and basins.
- Choose baths, basins and sinks that allow taps to be mounted on the fitting rather than on the wall.
- Provide maintenance access to junctions, traps and connection points.
- Where chasing is necessary use a twin-blade masonry saw and render or tile the area. Avoid inhaling dust containing silica.

Some typical plumbing options are illustrated in figure 26.
**Electrical**

As with plumbing, electrical wiring requires more consideration in a full brick design. With a little planning it is possible to wire a full brick house without chasing. Practices vary from state to state but here are some guidelines:

- Position as many GPOs as possible on external walls.
- Where possible position GPOs in adjacent rooms back-to-back.
- Use full-height door frames to route cables from the ceiling space to the switch location. (See figures 23 and 24.)
- Use architrave-mounted switches where possible. Alternatively use surface-mounted switches located within 150 mm of the door frame. (See figures 23 and 24.)
- Route cable (through surface-mounted conduit if required by regulations) in cupboards and wardrobes.
- Have the bricklayer place flat plastic conduit in the bed joints from door openings to the GPO or switch location.
- Flat conduit can also be used in a rendered wall although some states still permit the cable to be buried in the render thickness.
- Conduit can sometimes be routed through the cavities in bricks or blocks.

Some of the electrical installation must be carried out during bricklaying and the electrician may also need to coordinate some aspects with the bricklayer.
The scheduling of trades for full brick construction will be different from that for brick veneer. A typical schedule is shown in table 3.

### Table 3.
Typical trades schedule for full brick house construction

<table>
<thead>
<tr>
<th>Week</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
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<th>11</th>
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Note: This schedule is indicative only. Shading shows the period during which the activity is carried out.