Module 10: Masonry walls

Module Objectives

By the end of this session, participants will understand:

1. That there are three main types of walls used to building housing – masonry, monolithic and frame walls.
2. How masonry walls are built and what to watch out for when inspecting these walls.
3. How windows, doors and roof anchors are built into masonry walls.
4. Water penetration and exterior walls – making these walls watertight.
5. Common defects which the inspector may find when inspecting masonry wall structures.

Module at a glance:

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<td>Different types of walls</td>
<td>- About:</td>
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<td>- Collar jointed and cavity walls</td>
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Building a masonry wall

Good quality walls provide strength and stability, weather resistance, fire resistance, thermal insulation and sound insulation.

Masonry wall: Here the wall is built of individual blocks of materials such as brick, clay or concrete blocks, or stone, usually in horizontal courses bonded together with some form of mortar. Such walls can either be solid or have a cavity between two “skins” or “leaves”.

Masonry walls usually refers to the construction of walls built on top of concrete foundations using mortar (a mixture of cement, sand and water) and masonry units (conventional burned clay bricks or concrete bricks or blocks of various sizes).

Masonry units are laid on a mortar bed in horizontal “courses” which form vertical “leaves” or “skins”. The vertical ends of the masonry units are likewise bonded together with mortar. These vertical joints are known as the “perpends” or “perps”.

Perpend joints must be solidly filled with mortar as the work proceeds – perpend joints must be formed by buttering the end of the masonry unit – not by slushing with mortar after laying the unit. (NHBRC 3.3.5.4).

Load-bearing and non-load-bearing walls

**Load-bearing walls...**
These are walls which support loads from floors above and from the roof, in addition to their own weight.

**Non-load-bearing walls...** are walls which carry no floor or roof loads.
The home inspector should note that external walls are not always load-bearing. For example, the external end walls in a single story house, which has a simple gable roof. Here the weight of the roof is carried by the side walls which carry the weight of the load-bearing trusses.

On the other hand internal walls may be load bearing.

The question of load-bearing walls is an important issue for the property inspector to be aware of. Sometimes a client will want advice regarding the feasibility of a proposed alteration. And while an inspector’s advice should never be definitive (before going ahead with an alteration, the client should always be advised by the inspector to get professional help from an architect or an engineer), the inspector should at the least be able to advise whether an alteration is feasibl in terms of identifying load-bearing and non-load-bearing walls which may need to be broken out.

**Helpful tip....**

*Usually the inspector will need to enter the roof space to study the tops of the walls and determine which of the walls are carrying the roof structure.*

**Mortar thickness**

(NHBRC 3.3.5.9)

- Bed joint and perpend thickness – not less than 5mm or greater than 20mm. The thickness of the first bed joint above a supporting element (foundation, slab or lintel) should not be less than 5mm or more than 35mm.
- Walls can be single or double leaf walls (sometimes even triple skin or triple leaf).
- The pattern in which the masonry units are laid, is known as the “bond”.
- Non-load-bearing interior walls are generally single skin. Exterior walls (and other load-bearing walls are generally double skin. These walls may be solid walls - collar jointed together with masonry units laid at right angles to bond together the two skins – or cavity walls.
Brick bonds

The most common brick bond is "stretcher bond" (NHBR 3.3.2.3). This is the arrangement of masonry units of equal size, in such a manner that the "perpend" (vertical) joints in alternate courses are centred on the unit below, and are aligned vertically in each alternate course. This bond is suitable for the construct of double leaf and single leaf walls, and also cavity walls.

Stretcher Bond. "Perp" joints arrowed

"English bond" or "English garden bond" consists of stretcher bond, with alternating "header rows" at right angles to the wall face. This bond is often used for free-standing and retaining walls and is also suitable for solid double leaf walls and is sometimes referred to as "collar jointing".

English bond. "Header" rows arrowed

The NHBRC (3.3.2. Figure CM3) refers to "collar joint" walls as two masonry leaves built close together with the gap between the leaves filled either with masonry, or concrete. Galvanised ties (in South Africa normally crimp wires) are used to tie the two leaves of the collar jointed wall together are installed in bed joints at a rate of at least 5/m².
Collar jointed wall with specialised ties

Reinforcement of masonry walls

Masonry walls are commonly reinforced with brick force – galvanised wire welded together in a ladder pattern (of various widths) – which is placed in the mortar bed, every fourth course, or as specified. Brick force in buildings within 1 km of the sea, must be either Class A galvanised wire, or stainless steel wire (tidal and splash zones) (NHBRC 3.3.3.7.).

Brick force comes in various standard widths – 77mm, 150mm and 230mm – and is laid by the bricklayer in the mortar bed every fourth course or as specified.

Cavity walls, weep holes and wall ties

(NBR KK8 and NHBRC 3.3.3.):

A wall consisting of two separate leaves built side by side, with a gap of at least 50mm and not more than 110mm and tied to each other with wall ties.
Typical detail for exterior cavity wall. It is good practice to support the floor slab on the inner leaf of the cavity wall.

Exterior cavity walls (commonly used in the Cape Condensation Area) to combat condensation/damp, by way of circulating air within the wall cavity, and by providing a gap to prevent moisture seeping through the walls from the exterior brick leaf (“skin”) to the interior leaf. The prescribed installation of weep holes immediately above the damp proof courses provides ventilation and drainage for the wall cavities.

**Weep holes** are formed in the outer leaf of a cavity wall, immediately above the DPC at maximum spacing of 1000mm. Weep holes are formed by leaving perpend joints open for a height of approximately 50mm or by providing openings approximately 30mm wide. (NHBRC)

Weep holes are designed to provide ventilation within the wall cavity and also allow drainage of condensed moisture. The practice of building the walls complete, plastering and then drilling weep holes is problematic, inasmuch as there is less chance that the cavities will be clear of rubble, and secondly it is difficult to align the bottom of these drilled weep holes with the top of the DPC.

**Wall ties** are galvanised wire reinforcing used to tie together double skin cavity walls. Wall ties come in a variety of shapes: The butterfly commonly has a downward pointing “drip” in the centre to prevent
the wall tie from bridging moisture across the wall cavity. Where there is a high risk of atmospheric corrosion, then Class A galvanised wire or stainless steel ties must be used (NHBRC 3.3.3.11.1.)

Wall ties in cavity walls must be placed uniformly (normally in a diamond pattern) with vertical centres not exceeding 450mm and horizontal centres not exceeding 600mm (NHBRC 3.3.7.3). Wall ties must be installed in any cavity wall in an evenly distributed pattern, at a rate of 2.5 ties/m² of the face area where the cavity is not more than 75 mm, and at a rate of 3 ties/m² of the face area, where the cavity is more than 75 mm in width.

It is important to position wall ties correctly and to ensure that when the wall cavities are flushed at the end of each day’s work, the ties remain clean and do not become coated with mortar. Dirty, mortar coated ties can provide a bridge for moisture to “wick” from the outer, to the inner leaf of the cavity wall.

**Foundation walls**

(NBR KK9)

The NBR state that the height of any foundation wall not acting as a retaining wall, must not be more than 1.5 m. If the difference in ground level including backfill between the two sides of a foundation wall exceeds 1m, then the NBR prescribe minimum thicknesses for the foundation walls:

Where a difference in ground level including backfill exists between the two sides of any foundation wall such difference shall be not more than 1.0m.
No foundation wall shall have a thickness less than the relevant value given in the table below:

<table>
<thead>
<tr>
<th>Type of foundation wall</th>
<th>Minimum thickness of wall, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Acting as a retaining wall</td>
</tr>
<tr>
<td></td>
<td>Difference in ground height, mm</td>
</tr>
<tr>
<td></td>
<td>Less than 500</td>
</tr>
<tr>
<td>Single leaf brick</td>
<td></td>
</tr>
<tr>
<td>External</td>
<td>140</td>
</tr>
<tr>
<td>Internal</td>
<td>190</td>
</tr>
<tr>
<td>Single leaf hollow block (cavities filled with concrete)</td>
<td>External</td>
</tr>
<tr>
<td>Internal</td>
<td>140</td>
</tr>
<tr>
<td>Cavity walls (cavity filled to 150 mm below damp-proof course level)</td>
<td>External</td>
</tr>
</tbody>
</table>
Balustrade walls

(NBR KK10)
Balustrade walls must be a minimum of 1m high and solid masonry balustrade walls must be tied or bonded to the surrounding masonry or concrete. The top four courses of brick balustrade walls must be tied with anchors, extending at least 150mm into the supporting columns or piers.

Free-standing walls

(NBR KK11)
Free-standing walls (i.e. garden or boundary walls) can be built of solid masonry units in any acceptable fully-bonded pattern. Free-standing walls must not have a DPC – this is because a DPC will decrease the bonding of the free-standing wall to the foundation. Where moisture from ground water is likely to be a problem then high density bricks with low water absorption should be used up to 150 mm above ground level.

Important...
Any cavities in piers in a free-standing wall constructed of hollow units must be filled with concrete.
Where any wall consists of two or more sections of different thicknesses, the top section may not be wider than the lower section. Any piers used in the thickest section of such wall must extend, without reduction in size, to the top of the wall.

<table>
<thead>
<tr>
<th>Thickness of free-standing wall in mm</th>
<th>Maximum height in m of wall above finished ground</th>
<th>Size and spacing of piers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without piers (min. dimensions, projection x width)</td>
<td>With piers</td>
</tr>
<tr>
<td></td>
<td>Min. spacing (centre to centre), m</td>
<td>Max. spacing (centre to centre), m</td>
</tr>
<tr>
<td>90</td>
<td>0,8</td>
<td>1,2</td>
</tr>
<tr>
<td>110</td>
<td>1,0</td>
<td>1,4</td>
</tr>
<tr>
<td>140</td>
<td>1,3</td>
<td>1,6</td>
</tr>
<tr>
<td>190</td>
<td>1,5</td>
<td>2,0</td>
</tr>
<tr>
<td>230</td>
<td>1,8</td>
<td>2,3</td>
</tr>
<tr>
<td>290</td>
<td>2,2</td>
<td>2,6</td>
</tr>
</tbody>
</table>

**Retaining walls (masonry)**

(NBR KK12)

Masonry retaining walls, not being a basement or foundation wall of a building, which are designed to carry only pedestrian within a distance equal to the height of the fill retained by such wall, are subject to the following National Building Regulations:

- No fill behind such wall within a distance equal to the height of the wall
- Movement joints provided at distances not exceeding 10 m
- Subsoil drainage provided behind the retaining wall, together with sufficient weep holes in such wall to prevent the accumulation of water
- No horizontal DPC must be used in any such retaining wall
- Masonry retaining wall must be constructed of solid masonry units laid in any acceptable fully-bonded pattern
- Retaining walls must not exceed the limits for height, wall thickness and pier size contained in the table below and where piers are indicated, each length of wall must be supported at each end by a pier.
- All piers must project from the face of the wall which is not in contact with the fill
- All piers must be bonded into the wall and extend to the full height of the wall.

<table>
<thead>
<tr>
<th>Wall thickness, mm</th>
<th>Maximum height of fill to be retained, m</th>
<th>Piers</th>
<th>Dimensions (projection x width), mm</th>
<th>Maximum spacing (centre to centre), m</th>
</tr>
</thead>
<tbody>
<tr>
<td>190</td>
<td>0,8</td>
<td>No piers required</td>
<td>300 x 190 400 x 190</td>
<td>2,0 2,4</td>
</tr>
<tr>
<td></td>
<td>1,1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>230</td>
<td>0,9</td>
<td>No piers required</td>
<td>360 x 230 480 x 230</td>
<td>2,5 2,7</td>
</tr>
<tr>
<td></td>
<td>1,4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>290</td>
<td>1,1</td>
<td>No piers required</td>
<td>300 x 290</td>
<td>3,0</td>
</tr>
<tr>
<td></td>
<td>1,5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>390</td>
<td>1,4</td>
<td>No piers required</td>
<td></td>
<td></td>
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</tbody>
</table>
Other ways to build a wall

Information...
There are various other ways to construct a wall and many different materials can be used.

Monolithic wall: Here the wall is built of a material placed in forms during the construction. The traditional earth wall and the modern concrete wall are examples. Earth walls are inexpensive and can be durable if placed on a good foundation and protected from rain by a rendering or wide roof overhangs. Examples of such walls can be found in traditional housing in the rural areas of South Africa.

Frame walls: These walls are used in timber house construction or in houses clad with fibre cement panels (“Nutec”, manufactured by Everite is the trade name in South Africa). Here the wall is constructed on a frame supported by vertical members (called “studs”) and the frame is clad with either timber or Nutec boards on the exterior and normally with dry walling (rhino board) on the interior.

Frame wall construction in very common in overseas countries such as the USA, Canada, Australia and New Zealand, and is slowly becoming a more widespread building method in South Africa. (Frame construction can be studied in the SAHITA Module 17 of this course.

Insulating material (both thermal and acoustic) can be installed within the cavity of masonry cavity walls or frame walls. In South Africa the use of such insulation is common with frame walls, but unusual with masonry cavity walls.
Water penetration of walls

(NBH KK14)

**Important...**

*Any external wall of any building must either pass a rain penetration test in terms of the NBR prescribed tests (see NBR KK17.2m), or satisfy the following minimum criteria:*

- A single leaf externally plastered block wall must be not less than 140 mm thick;
- A single leaf brick wall must not be less than 190 mm thick;
- Must be a masonry cavity wall
- Precast concrete walls of not less than 40mm thick may be used to form part of a garage or garden store, provided that any joints in this wall are sealed.

Notwithstanding the above requirements, the NBR allows that: “any local authority may, in areas of prolonged heavy wind-driven rain, require that any masonry external wall shall be a cavity wall, or a double leaf wall with the inner face, of the outer leaf, bagged and painted with two coats of approved sealer.”

If brickwork is to be left un-plastered then it is essential that only bricks suitable for this application are used. All face bricks manufactured under controlled conditions will have satisfactory rain penetration properties. These bricks are fired to a temperature where the permeability and durability of the product render them suitable for all normal exposure conditions.

The use of stock bricks in un-plastered application is asking for trouble, because these bricks will not perform adequately in terms of either durability or rain penetration resistance.

Manufacturers will supply face bricks (FBX, FBS or FBA bricks) which meet the durability requirements for un-plastered or bag-washed applications. These bricks should be used in place of stock bricks for these exposed conditions.
Quality of the mortar

The permeability of mortar plays an important role in rain penetration resistance and the use of poorly graded sand, or sand with high clay content, should be avoided. The presence of more than 10% of clay in mortar sand will cause excessive shrinkage of the mortar, with resultant joint cracks of up to 1mm wide.

Sands which comply with the grading requirements of SABS 1090 will give mortars with excellent rain resistance qualities. Such sands are readily available in most areas of South Africa.

Shrinkage cracking is not confined only to strong mortar mixes, but can also take place in mortars as weak as 1:6 or 1:7.

Builders often use mortar sands containing excessive clay because of the resultant plasticity of the mortar (making it easier to build with). However the poor rain penetration resistance of such mortars does not justify their use in order to improve plasticity of the mortar. If plasticity improvers are needed, then lime should be added to the mortar mix.

Workability is considerably improved by the addition of lime to the mortar mix, with additional benefits in joint quality, bricklayer productivity, and the appearance of the finished wall. Water retention is also improved, with resultant reduction of separation cracks. The free lime in the cured mortar is also slightly soluble and will migrate to areas of rain penetration, where it will crystallize and seal up leaks.

Damp proof courses in walls

(NBR KK15)
Any wall or sleeper pier of a building must be provided with a damp proof course (DPC) to satisfactorily protect the wall against rising damp and the interior of the building, against ingress of moisture from abutting ground.
A DPC must be installed in masonry walls in the following positions:

- At the level of the top of a concrete floor slab resting on the ground;
- Where applicable, below any ground floor timber beam or joist;
- In any timber framed wall, a damp-proof course shall be installed between the bottom plate of the wall and any foundation wall or concrete floor slab;
- In the case of any solid masonry wall or timber framed wall, any damp-proof course shall extend over the full thickness of such wall;
- In the case of any masonry cavity wall, each leaf of the cavity wall must be provided with its own damp-proof course which must extend over the full thickness of such leaf, if the cavity extends at least 150 mm below the DPC;
- Where necessary, weep holes to prevent build-up of water in the cavity must be provided in the external leaf of every cavity wall, spaced not more than 1 m apart, in the masonry unit course immediately below the DPC.
- No horizontal DPC is allowed that is less than 150 mm above the level of the adjacent finished ground. This means that care must be taken to ensure that the finished ground level is at least 150 mm below the DPC. Very often home inspectors find the finished ground level at, or above, weep hole height. This obviously compromises the purpose of the DPC in combating damp.
- Joints in the DPC must be overlapped by at least 150 mm and at junctions and corners by a distance equal to the full thickness of the wall or the leaf, as the case may be.
- Where any part of any wall, of a room is situated so that the ground is in contact with the wall, then this wall must be protected by a vertical waterproof membrane, or by a drained cavity which must extend below the level of the floor of the room. Drainage shall be provided at the base of such a wall to prevent water accumulating there.
Door frames & window frames

Building in

Metal door and window frames are secured to the masonry by building in the metal lugs forming part of the door or window.

With timber frames NHBRC (Part 3.3.13.1) recommends creating cramps (lugs) by securing 30mm hoop iron straps to the sides (styles) of the frames, by means of at least two brass screws. These cramps are to be installed 300mm from the top and bottom of the frame, with intermediate centres not exceeding 900mm. These hoop iron cramps are required to extend approximately 250mm into the masonry and should be built in as the work proceeds.

External sills

External sills must project at least 15mm beyond the finished plaster (or wall face) (NHBRC 3.3.16.1). Fibre cement sills must be of single length between reveals. If fibre cement sills are plastered into the reveals, the ends of the sill should be encased in plastic to allow for minor expansion and contraction (NHBRC 3.3.16.3).

Remember...

*If the walls are cavity walls, remember that there needs to be DPC and weep holes above doors and windows.*

The NHBRC requires horizontal damp proof courses above all window openings in cavity wall construction, unless the roof overhangs by 750mm or more and the distance between the top of the window frame and the wall plate is less than 700mm. (NHBRC 3.3.10.2). As with all horizontal DPC, the DPC must be sandwiched between mortar (NHBRC 3.3.10.3).

The NHBRC (3.3.10.6) also requires a DPC under window sills in accordance with the sketch below. See NHBRC Manual (Figures CM18 & CM 19 pp. 54, 55) for additional detail on sill construction for cavity walls and single leaf and collar jointed walls.
Interestingly, the NHBRC does not require vertical DPC along the edges of windows and doors in cavity wall construction. The reason for this is not known. However, it is sound building practice to provide vertical DPC on each side of the frame. Normally this DPC is built into the brickwork when the cavity is closed in the reveal. Some window manufacturers provide vertical DPC pre-installed on the window frames.

**True or False...**

All joints between the frame and the reveal should be tightly sealed with a flexible sealant. **Answer: true**
Roof anchoring

(NBR KK13 & NHBRC 3.3.17)
In order to securely tie the roof structure to the walls of the house, roof anchors are used for masonry and concrete walls. See SAHITA Module 14 Roof Structure Part 1 for more information on roof anchoring.

Common defects in masonry walls

The most common wall defects likely to be encountered by a home inspector are cracks and damp damage. For a full discussion on this see the SAHITA Module on Inspecting the Foundations and Walls – Module 7.

Before you take the online test, please......
Make sure that you are thoroughly familiar with the material in this module before completing the online test. The more familiar you make yourself with the information presented in this Module the better you will be as a professional home inspector. Review thoroughly all areas of this module before and during the open book online test.