External Loadbearing Walls

Introduction

A wall has two basic functions:

- to support the loads of suspended floors and roof
- environmental protection

In order to satisfactorily fulfil these functions there are a number of requirements for an external loadbearing wall. These are:

- strength and stability
- weather protection
- good thermal insulation
- fire protection
- durability

Materials

The two most common materials used nowadays for walling in domestic construction are brickwork and blockwork. Stone or artificial stone (a mixture of stone dust and cement) may be used for new buildings but they are very expensive forms of construction and are unlikely to be found on new estates unless there are specific planning requirements.

Brickwork

The majority of bricks are made from clay which is usually prepared by grinding and mixing with water. This plastic compound is formed into the required brick shape and then dried and fired in a kiln. Different clays have different characteristics and, by using special manufacturing techniques, bricks of various colours and strengths can be produced.
Bricks can broadly be classified in three types:

- Common bricks
- Facing bricks
- Engineering bricks-

Bricks can also be classified by their resistance to frost attack and their soluble salt content, both of which affect their long term durability.

Some bricks (about 5% of the total in the UK) are made from concrete and some from sand and lime (calcium silicate bricks).

Blockwork

Blockwork has become very popular in the last 80 years or so because of its cost advantages over brickwork. They are made from cement and aggregate, and by varying the quantity of cement and the nature of the aggregate blocks with different strengths and levels of insulation can be formed. Since blocks first became popular in the late 1920s there have been several aggregates used in their manufacture such as crushed gravel, pulverised fuel ash, blast furnace clinker, gas coke breeze and pumice. Blocks can be broadly classified into two types; dense blocks (heavy weight blocks) and lightweight blocks.

Dense Blocks

These are made from cement, sand and crushed gravel and are suitable for work above and below ground level. Because of their high density they are good conductors of heat and are therefore unsuitable for modern cavity walls unless additional substantial insulation is provided. However, they provide good sound insulation and are therefore ideal for party walls and loadbearing partitions.

Lightweight Blocks

These incorporate a variety of lightweight aggregates and are generally used for the internal skins of cavity walls. Although slightly more expensive than ordinary dense blocks they have much better levels of insulation and are light and easy to handle. In modern construction aerated concrete blocks have become very popular. They are made from cement, lime, sand, pulverised fuel ash and aluminium powder. The blocks are very light but they can be porous and special precautions may be necessary when applying plaster or render.

Aerated blocks are easy to handle and provide good thermal insulation. They are very easy to cut and shape and will directly take the fixings of screws as well as nails. In modern cavity walls, with their emphasis on high levels of thermal insulation, aerated blocks are by far the most common method of forming the internal leaf. The blocks below left are dense blocks used in an internal loadbearing wall. The blocks on the right are aerated blocks, used normally in the internal leaf of cavity walls.

Mortar

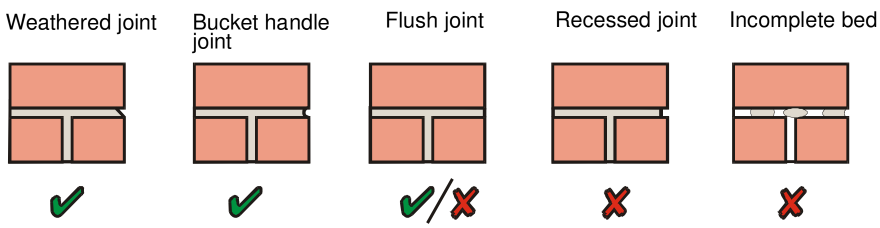
Mortar is the material which binds the bricks and blocks together. It helps to distribute the load through a wall and seals the brick or block joints against water ingress. Mortars should have:

- good workability
- sufficient resilience to accommodate long term thermal movement in the brickwork
- adequate bond strength
- good resistance to water penetration

Mortar is made from fine aggregate (usually sand) and a binding agent (nowadays usually cement). When mixed with water a chemical reaction, called hydration, occurs and the mortar sets. Early mortars were usually based on lime and sand but they were very slow to set and readily absorbed rain water (the mortar set through a process known as carbonation where the lime gradually hardened by absorbing carbon dioxide from the atmosphere). Modern mortars use cement as the main binding agent although lime is often introduced into the mix to give it a more plastic feel and to make it more 'workable'. Lime also improves the mortar's ability to cope with thermal and moisture movement. A strong (cement rich) mortar, say 1 part cement and 3 parts sand, is very brittle and cannot cope with long-term thermal and moisture movement.

Liquid plasticisers can be used in place of lime to improve the nature of a mortar. Plasticisers are usually air entraining agents; in other words air is introduced into the mix which breaks down the internal friction and produces more workable mortars. A mortar mix of 1 part cement to 6 parts sand, plus plasticiser is equivalent to a 1:1:6, cement, lime, sand mix.

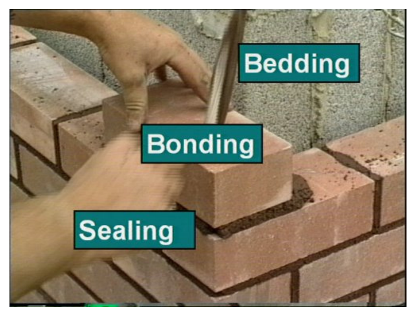
The face of the joint may be finished in a number of ways. These are largely dependent on the exposure of the building, the type of brick and the preference of the designer. Tooled joints offer the best weather protection because the tooling smoothes and compresses the joint.



Strong mortars may result in damp penetration. They are brittle, crack easily and cannot accommodate thermal/moisture movement.

Most brickwork, these days is jointed as work proceeds. Pointing is the term used to describe existing or new joints which have been raked out and filled with fresh, often coloured mortar. Pointing is relatively rare in new construction because coloured mortar mixes are now relatively cheap. In addition pointing requires great care. The pointing mortar mix must be slightly weaker than the jointing mortar. If it is stronger the outer face of the bricks, immediately above and below the pointing, will carry excess load. This can result in the edges of the bricks spalling.

Bricklayer finishing joints with a bucket handle – a quick and effective joint.

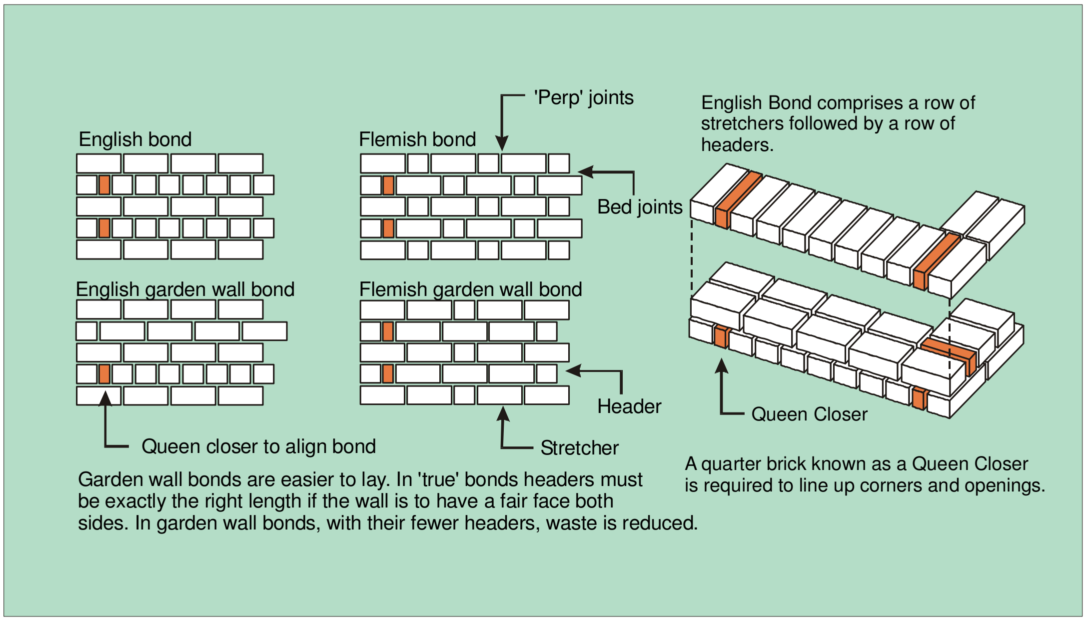


External walls before the 1920s

A wall must be at least 215mm or 1B thick in order to provide reasonable environmental protection and this was the standard form of construction for the majority of brick-built houses before the 1920s. The wall above is laid in stretcher bond but different bonding techniques were (and are) used for 1B walls. Two common bonds are English Bond and Flemish Bond. They both differ from stretcher bond (used in cavity walls) in that some of the bricks are laid at right angles to bind the two halves of the wall together. These bricks are known as headers and are illustrated in the diagram below.

This bond is known as Flemish bond. It's common in houses built before the 1920s. The headers bind the two halves of the wall together. These walls are normally 215mm (1 brick) thick.

Details of bonding techniques for solid walls are shown in the diagram below. Note that both English and Flemish bond require small bricks known as Queen closers to complete the bond at quoins (corners). Garden wall bonds are quicker and cheaper to lay – despite their name they can be found in house walls – especially at the rear of properties where they are less obvious.



Openings in solid brick walls

Where openings occur for doors or windows support is required at the top or head of the opening. A window frame is not designed to carry any wall loading. The load which has to be carried is, in fact, quite modest due to the bonding of the brickwork. The loads can be supported in a number of ways. Two common methods are shown below. The flat gauged arch is more likely to be found in better quality housing. The segmental arch (right) is more common in the cheap speculative inner city housing of the late Victorian period. Both would often have timber beams or lintels behind the facework to help support the loads.

Early damp proof courses

The wall below ground level is likely to be permanently damp and to prevent moisture rising up the wall it is necessary to provide a DPC just above external ground level. These became popular round the turn of the century (ie 1900) when materials such as tar and sand, or hessian soaked in tar were common. On more prestigious buildings lead and copper were often used. It was also common to find buildings with two or three courses of engineering bricks or layers of slate providing a barrier to rising damp. The DPC should be positioned well clear of the ground and should ideally be a flexible material to allow for slight differential movement. Slate DPCs often failed due to cracking as the building settled slightly during its life.

Environmental problems with solid walls

Thick brick walls, say over 450mm (2B) thick are usually free from environmental problems but they are unusual on two-or three-storey construction where 1B walls are the norm. 1B walls can suffer from three main areas of failure:

- Damp penetration
- High heat loss
- Condensation

Damp penetration

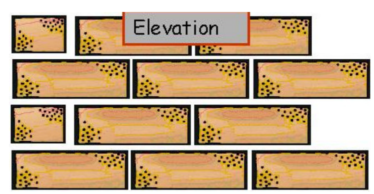
A well-built 1B wall should exclude rain unless it is in the most exposed of situations. Although some rain will be absorbed its thickness and density should prevent damp from reaching the inside face. When the rain stops the water will evaporate and the wall will become dry again. However, over the years the general deterioration of poor quality brickwork and old lime mortar can result in damp penetrating the inside face and effective solutions can be costly.

Heat loss

A 1B wall is not a good insulator against heat loss as the relatively dense nature of the bricks means that heat is easily transferred through the wall. Current Building Regulations do not permit the use of such walls unless expensive plastering techniques are used to improve their thermal efficiency. The ability of a structure to transfer heat is measured by its 'U' value. The lower the 'U' value, the better the thermal insulation of the structure; the maximum permitted under existing regulations is 0.35 (it can be slightly higher if other building elements such as the roof have improved insulation). Modern cavity walls can easily achieve this figure of 0.35 but a 1B solid wall has a 'U' value of somewhere between 2.0 and 2.5 depending on the nature and density of the bricks and plaster.

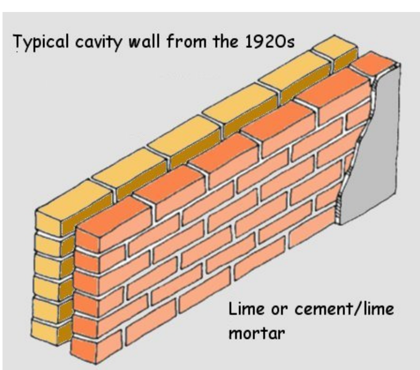
The cavity wall

The introduction of the cavity wall in the 1920s helped overcome the three problems described above. An early cavity wall basically comprises two 100mm skins or leaves of brickwork, laid in stretcher bond (see Elevation – right) separated by a gap of 50-70mm.



The cavity has two functions:

- it prevents water from reaching the internal skin.
- it improves the thermal efficiency of the wall as the air in the cavity is a good insulator.

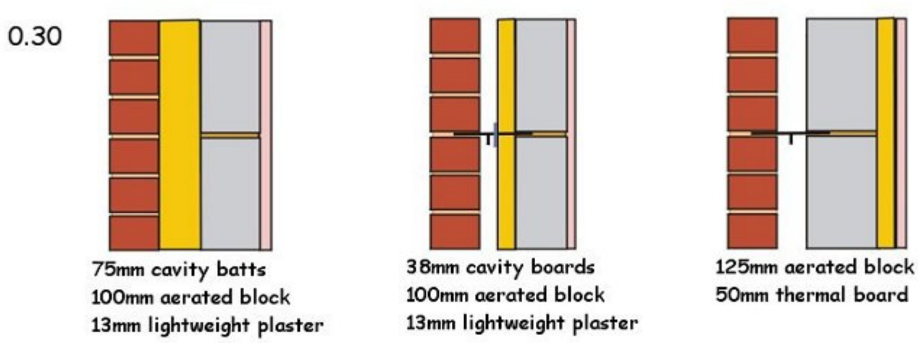


Two 100mm skins of brickwork each acting independently are not very strong or stable and it is a requirement of the Building Regulations that the two leaves of the wall are tied together at regular intervals. This is done by the use of wall ties which were originally made from galvanised steel (steel coated with zinc) but nowadays can also be made from plastic and stainless steel. Some of the very early ties were also made from iron; these are not acceptable in modern construction.

The modern cavity wall

Modern cavity walls have not changed in principle but they do have much improved thermal insulation. They are tied together in just the same way as their earlier counterparts. Nowadays there are a variety of ties on the market, all of which are formed to prevent water from passing across them and reaching the inner leaf (modern ties are mostly stainless steel). It is important that the tie is correctly positioned to ensure that any water in contact with the tie does not reach the inside skin. The frequency and position of the ties is set out in the Building Regulations but generally they occur 900mm apart on each sixth course of bricks with extra ties required round window and door openings.

In modern construction cavity walls incorporate insulation to improve their thermal efficiency and to lower their ‘U’ values (to about 0.30W/m^{2}K or even less). The insulation can be in various positions (see lower graphic) and it can be omitted completely if very thick aerated blocks are used for the internal leaf. Two materials for insulation are shown below. The one on the left is rather like a foil backed bubble wrap. The one on the right shows insulation boards held against the internal leaf of blockwork. A plastic washer on the tie needs to be fitted to hold the insulation in place.



Structural stability

In domestic construction the stability of an external wall is assisted by the 'bonding in' of internal partitions and flank walls. Additional stability is provided by the floor joists and roof timbers. These items and typical examples are all considered in more detail in the appropriate revision guides.

Sound insulation

To reduce the problems of sound interference from adjoining properties the Regulations set minimum standards for party walls. Airborne sound (from voices, radios etc) is reduced by mass and in practice this can be achieved by using dense blocks or bricks in either a 215mm solid wall or a 250mm cavity wall. Materials such as standard aerated concrete blocks are not always suitable because of their low density.

Fire protection

The Regulations demand that the external walls of a two-storey house provide 0.5 hours fire resistance and any party wall 1 hour. In other words, in a fire the external wall will maintain its structural stability for 30 minutes thus enabling the occupants of the house to escape. This level of fire protection is easily achieved using materials such as clay bricks and concrete blocks.

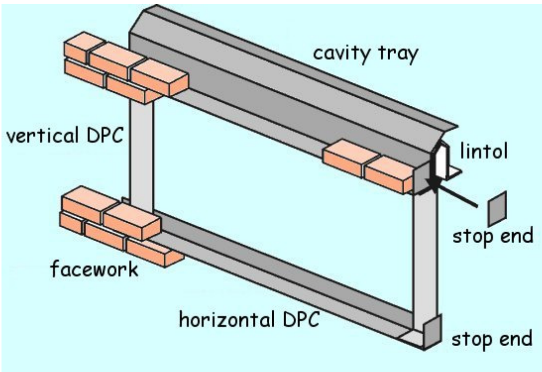
Modern damp proof courses

Modern damp proof courses are made from flexible materials and if correctly laid should prevent any damp from rising into the superstructure. It is also important to ensure that there is a good joint between the DPC in the wall and the DPM which protects the floor. This is covered in more detail in the next chapter. Modern materials include bitumen felt, lead cored bitumen felt and dense polythene. It is essential to ensure that the DPC does not cross the cavity as this will provide a path to the inside skin for any water running down the cavity.

Openings In Modern Walls

There are a variety of ways in which openings can be made in external walls to accommodate windows and doors. However, any design must safely support the loads from above and prevent lateral damp penetration.

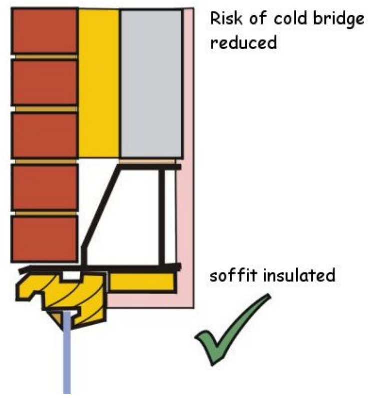
The diagram below shows a typical detail suitable for a modern wall. The DPCs, if correctly positioned, prevent the internal blockwork from coming into contact with the external brickwork.



The head

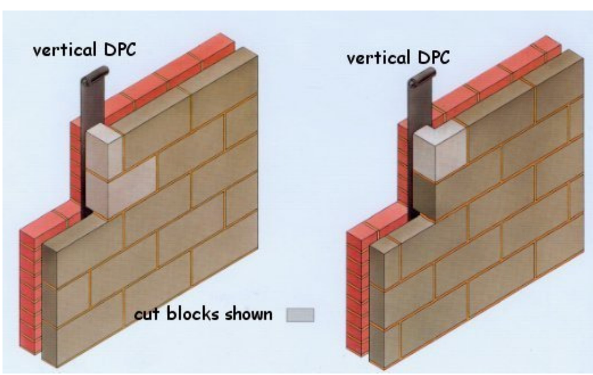
The top or head of the opening must be capable of carrying the loads of the wall above. In old buildings with solid walls it is common to find arches combined with stone or timber lintels (lintols). These are not used in modern construction where lintels made from steel and concrete are the norm. In modern highly insulated walls there is a risk of cold bridging where cavities are closed around openings. In the graphic below there is a risk that the box-shaped metal lintel just behind the top of the window frame will be quite cold. There is a risk of condensation forming here. To prevent it a strip of insulation can be fixed to its soffit. There are a variety of lintels on the market, the one on the left is a slightly different pattern; it contains a strip of insulation inside the lintel to maintain insulation levels.

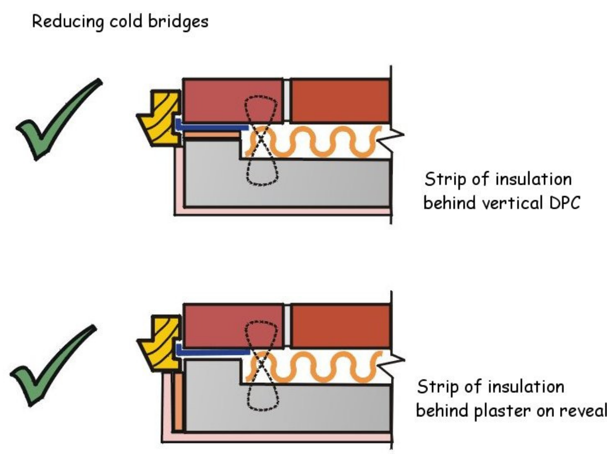
Two patterns of steel lintel – both these forms of construction will avoid cold bridging.



The jambs

At the sides or 'jambs' of the opening it is important to provide a good fixing for the window or door frame and to prevent damp penetration of the internal skin. The former is achieved by closing the cavity as shown in the diagram and the latter by using some form of vertical DPC. The blocks can be cut at the return as or special reveal blocks can be used.



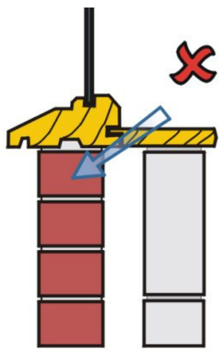


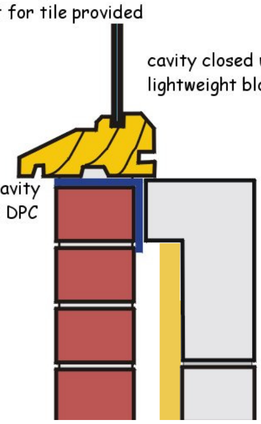
Again there is the risk of cold bridging just behind the window frame. To prevent it there are a number of options. Two are shown above (right).

The sill

In many cavity walls the cavity is not closed at the sill where window boards are provided. However, if the sill is to be tiled, eg in a kitchen or bathroom then the sill can be closed in the same way as the jambs. This provides support for the tiling. In this situation a DPC is required to prevent lateral damp penetration.

Cold bridge at sill





Conclusion

This short revision paper can only be regarded as a very elementary introduction to old and modern walls. In practice you will come across a wide range of alternative forms of construction, particularly with regard to window openings. If you appreciate the principles, changes in practice will be easier to understand and evaluate.

Questions – All the answers are in the above text.

1. Why should strong mortars be avoided?
2. Why are some jointing methods better than others?
3. Explain the difference between Flemish and English bond.
4. What is a garden wall bond?
5. How were loads over windows supported in solid walls?
6. Describe an early cavity wall.
7. Where in modern houses are dense blocks used?
8. How can cavity walls be insulated?
9. What is a cold bridge?
10. How can cavities be closed at the jambs and how is damp penetration avoided?