

# Basic Construction: An introduction to Walls

(Housing and Health Series - Booklet IV)

Richard Pixner and Jill Stewart



# Housing Construction: An Introduction to Walls

Housing and Health Series, Booklet 4

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Other booklets in series:

- 1) Course handbook for Private Rented Housing Sector: Effective Regulatory Strategy
- 2) Basic Terminology and Deficiencies: An Introduction
- 3) Basic Terminology and Deficiencies: A Workbook
- 4) Basic Construction: An introduction to Walls
- 5) Basic Construction: An introduction to Roofs
- 6) Basic Construction: An introduction to Floors
- 7) Houses in Multiple Occupation: An introduction

## Authors' biographical details

**Richard Pixner** is a member of the Royal Institution of Chartered Surveyors (RICS) and Chartered Institute of Environmental Health (CIEH). He has over 40 years' experience in local government, the majority of which have been spent addressing poor housing conditions in the private rented sector. He has been a surveyor for the English Housing Survey since 2002 and has taught at Middlesex University as a visiting lecturer.

**Jill Stewart** has worked in housing for over 30 years, as practitioner then academic and has published and presented widely. She has co-created and led courses in private sector housing regulation to help develop the environmental health and housing workforce. She is Associate Professor in Public Health at the University of Greenwich and is currently involved in a range of teaching and research projects around housing and health. She is co-Chair of the London Public Health Housing Network and is a Chartered Environmental Health Practitioner, Fellow of the Chartered Institute of Environmental Health and Member of the Chartered Institute of Housing.

## Introduction

This booklet is part of the ongoing Housing and Health Series intended to help plug a gap in resources available for those new to this area, or those who wish to refresh their knowledge and understanding. It should be read in conjunction with other booklets in this series, notably Basic Terminology and Deficiencies and its accompanying workbook.

This booklet focuses on construction and is authored by an expert in this subject both by qualification and many years' experience in front line practice. It seeks to focus necessary knowledge required by practitioners.

There are three booklets in this part of the Housing and Health Series covering Housing Construction of Walls, Roofs and Floors.

We hope that you find these booklets helpful.

## External Walls

### Functions

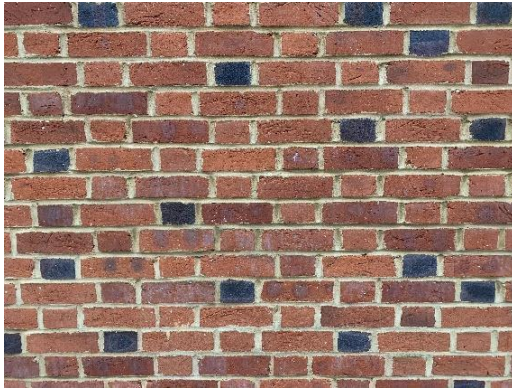
- Strength and stability. Loadbearing, for example, to provide support for live and dead loads
- An envelope to protect the interior from the weather and to limit heat gains and losses
- Privacy and security
- To resist the spread of fire over the walls and from one building to another having regard to the height, use and position of the building and to maintain stability for an acceptable period in the event of fire
- To act as a barrier to environmental noise
- Provide a suitable aesthetic appearance

### Types of external walls and their identification

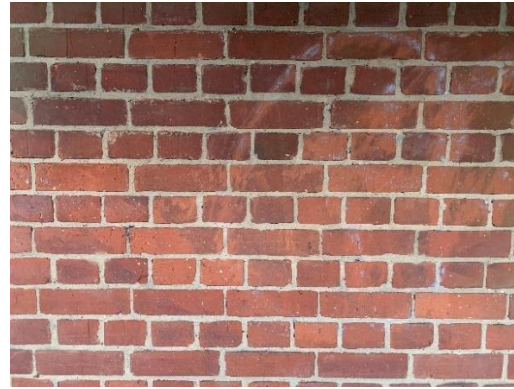
External walls in domestic buildings are generally either solid, cavity or involve some kind of framed construction (timber, concrete or steel). Identifying the different types can be tricky. The external appearance of a wall, its thickness and soundings (tapping the surfaces), can all help you identify it. Once established, your knowledge and experience of housing type as well as the age and form of construction associated with housing in a particular area are also important.

The regular appearance of header bricks in a wall can and more often does indicate solid brickwork. The outer leaf of a cavity wall, a half-brick thick with stretcher faces, will not contain headers.

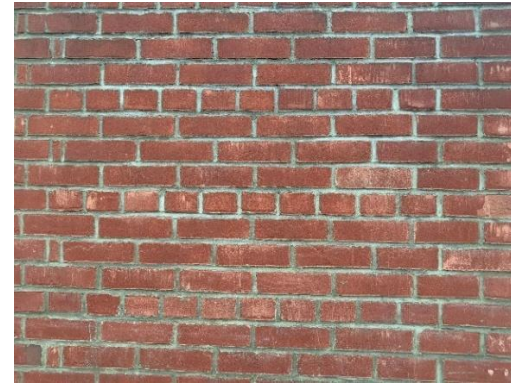
## Brickwork bonds



Solid wall with Flemish bond - alternate headers and stretchers in the same course.



Solid wall with English bond - common until the end of the 18<sup>th</sup> century when Flemish bond became predominant.



Solid wall with English Garden Wall bond. Found more rarely in house construction and more prevalent in free standing boundary walls.

It is wise to be cautious however. The use of snapped headers in the external leaf of older cavity walls, will give the appearance of Flemish bond usually associated with solid brick construction. Some early examples of cavity construction used specially made bricks rather than wall ties to join the two leaves together, also appearing as headers in the face of the brickwork.



Solid wall with a Rat Trap bond pattern. The bricks were laid on their sides, which was cost saving but left voids within the wall providing shelter to vermin. Not common but may be seen occasionally, especially in garden/boundary walls.

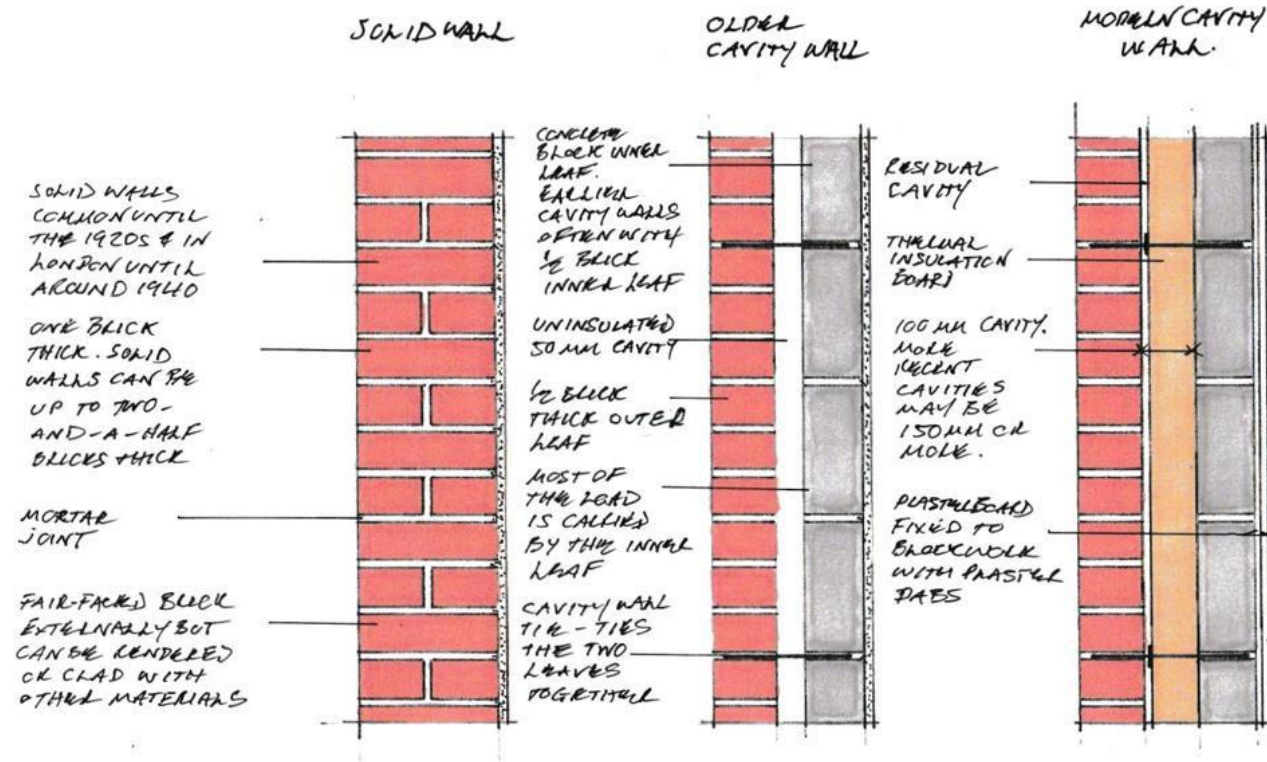


Stretcher bond which may indicate the outer skin of a cavity wall.



Beware, as sometimes not all is as it first seems! The use of brick slips or veneers can give the appearance of solid or cavity brickwork but are a form of wall cladding. This brick slip panel forms cladding to a framed building. Panels can match any bond pattern.

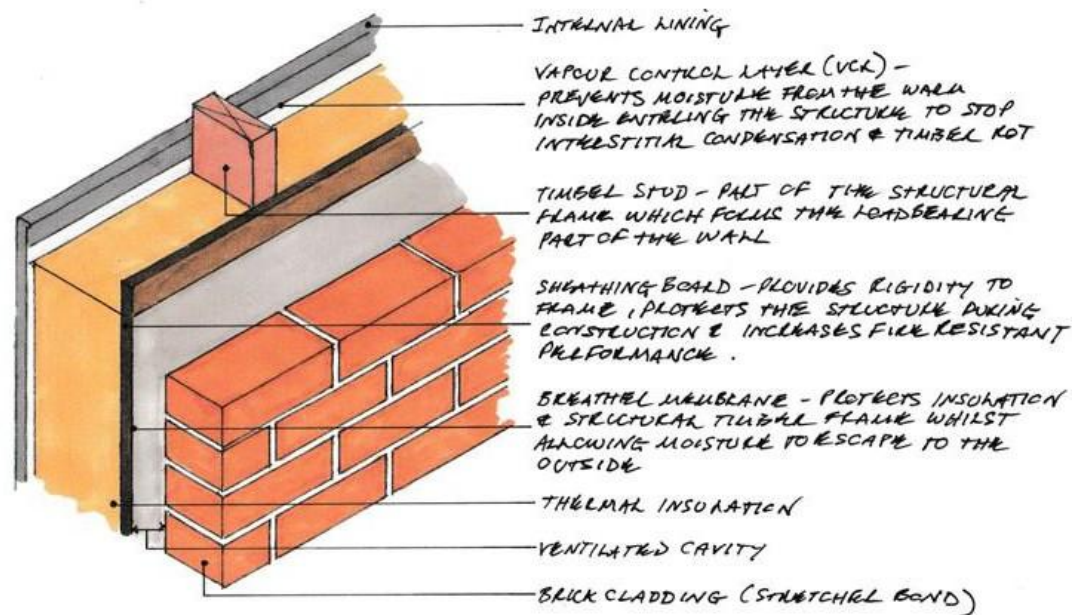
## Solid and cavity walls



Solid brick walls in domestic two-storey buildings, are typically 240mm-250mm thick including internal plaster (1 brick thick wall). In taller buildings, base brickwork can often be 355-365mm thick (1 1/2 bricks) or more, reducing in thickness with the height of the building.

Cavity walls with a 50mm cavity consisting of two leaves of brickwork are typically between 290mm to 300mm thick including plaster internally, although those from the 1950s with an internal leaf of blockwork are usually between 10mm-15mm narrower. The thickness of cavity walls to buildings in excess of 3 storeys, can be anything between 395mm and 415mm. Cavity walls of around 410mm can also be found and give the appearance of solid walls. These will have a 225mm outer leaf (one brick thick) and an inner leaf of 115mm separated by a 50mm cavity, although these are less common.

The external walls of modern timber framed domestic buildings will often look indistinguishable from a cavity wall, with an outer skin of fair-faced brickwork laid in a stretcher bond pattern.



TIMBER FRAMED WALL

The outer skin to a timber framed wall, may have weep holes to ventilate the frame at eaves level and/or at the base of the wall above or below the damp proof course (DPC), although cavity walls may also have weep holes above flashings, doors, windows and other features, to ventilate the cavity and to allow water to drain out of it. Original windows, where present, may be set flush with the frame, thus appearing to be recessed in the wall when viewed from the outside. Doors and windows have weather sealed gaps around them to allow for differential movement as the timber frame shrinks over time. A triangular timber frame of sheathing material fixed to the frame at gable ends, may be visible when inspected from the roof void. The gable ends of buildings with cavity wall construction tend to be built with brick or concrete blockwork. Any openings in the wall for metering, telecoms access points and vents may reveal the timber frame behind a brick outer skin.

The thickness of the walls in timber framed buildings tends to lie between 250mm-300mm depending on the precise form of construction and the type of external cladding used.



A timber framed house during construction. Here the cladding consists of concrete blockwork which will likely be rendered or some form of cladding applied.

Gangnail plate

Sheathing

Stud to timber frame

Blockwork cladding

Be mindful that the depth of plaster, external render or cladding, dry lining and the treatment of walls with retrofitted thermal insulation (applied internally or externally), will influence the thickness of the wall. External render will add from about 15mm-25mm to wall thickness. The application of thermal insulation can add a further 50mm-150mm, depending on the product and system used. Measurement of wall thickness should be carried out across a window reveal or door opening, or by comparing internal and external measurements at a suitable location. Avoid taking measurements across architectural details such as stonework, piers or at bay windows and ignore features such as window sills, window boards, architraves and mouldings.

A solid sound and feel from tapping an external wall from the inside, will tend to indicate the presence of masonry (solid or cavity) walls. A consistently hollow sound, may show framed construction, although it may also suggest plasterboard and other dry linings to a solid or cavity wall.

## External finishes

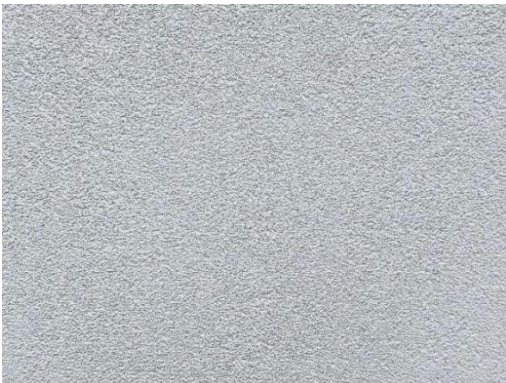
Externally, identify presence and type of exterior finishes or cladding. Here are some examples: -



Wet dash render (roughcast)



Dry dash



Tyrolean



sand and cement

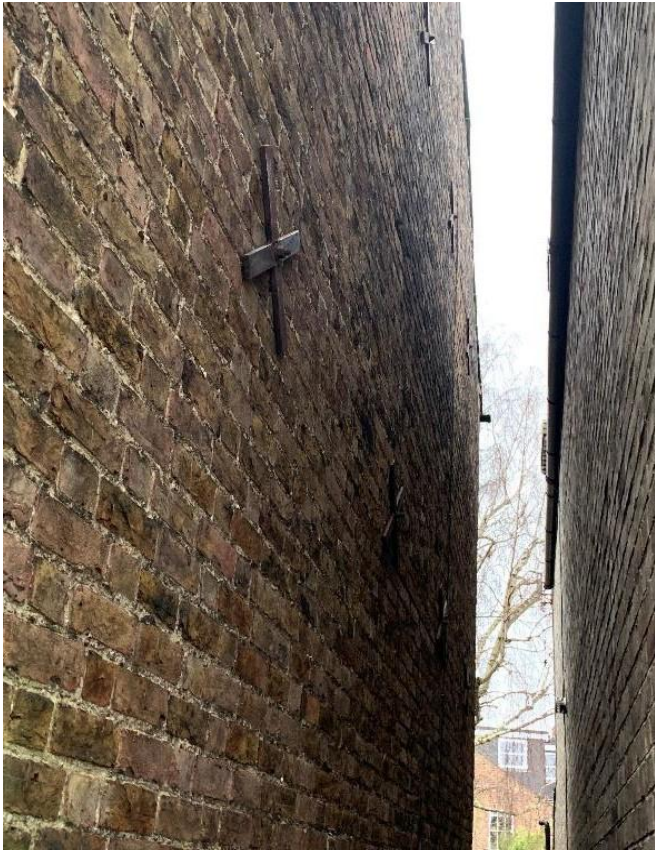


A natural Westmoreland slate hung feature between the floors of a two-storey bay window to this house built in and around 1910. The slates will be nailed to timber battens and often mask timber framing at first floor level. Note the scalloped lead apron beneath the sill to prevent rainwater ingress.



The flank wall of this end of terrace house is clad with painted timber weatherboarding

## Defects - externally



A solid wall (left) to an end of terrace house circa 1890. The wall has a pronounced bow. The presence of tie bars indicates that the wall may have lacked adequate restraint from the floor at first floor level and in this case, also from the roof.

Bowing, leaning or cracked walls can indicate foundation movement, subsidence, lack of or failure of restraint, inadequate wall thickness for its height or overloading. The failure of or inadequacy of wall ties in cavity walls can cause the outer skin to move away from the inner skin.

The pattern and location of cracking may give us clues as to its cause. Cracks can result from settlement, subsidence, heave, roof thrust, inadequate lateral restraint (tying in), the corrosion of some kinds of wall ties in cavity walls, sulphate attack, and thermal movements (look for presence and adequacy of movement joints). Cracks can appear where settlement of a building occurs at different rates due to variations in loading, ground conditions or foundations (differential settlement), for example, between bay windows and the main walls or between new extensions and older parts of a building. Similarly, insufficient bond or ties between extensions to existing walls can lead to cracking at junctions.



Crack diagnosis is a specialised business. There is a significant horizontal crack along the brickwork joint here which is repeated on the return wall. There is also displacement to the brickwork at the corner. Cracks often find their way to a door or window opening as these represent a weakness in the wall's structure. There may be sympathetic cracks on the inside of the wall. There is no indication of any previous attempt at repairs. Monitoring and further investigation will be required to determine the cause and progress (if any) of the movement. The crack is around 10mm wide and is considered to present moderate damage. Weathertightness may be compromised and remedial repairs will be necessary once the cause of movement has been identified.



One might suspect that the building here has subsided, but this is not the case. The outer leaf of the cavity wall has been built with calcium silicate bricks which are prone to thermal expansion and contraction. Thermal movements associated with these bricks are about 1.5 times greater than that of clay brickwork. A stronger mortar mix used for jointing, fails to accommodate this movement and cracks along the joints result. The cracks in this wall have been repaired but have negatively affected the aesthetics of the house.



The bitumen DPC acts as a slip plane to accommodate to an extent, differential thermal or other movements between the brickwork above and below it in a cavity wall. The brickwork above the DPC here is oversailing the lower courses. This might indicate a structural issue requiring remediation.



This flat gauged brick arch has dropped. A crack has developed above the arch where it is no longer adequately supporting the load of the wall. Any timber lintel behind the arch may be subject to decay as rainwater penetrates the cracks.

The section of wall above an opening must be supported. Brick and stone arches and lintels bear the load of the wall above the opening. Lintels may be timber, steel or reinforced concrete. The failure of arches or lintels can cause cracking and disturbance to brickwork above them. In the absence of an arch or lintel, the removal and replacement of windows previously supporting the wall above openings may lead to similar failures.

Diagonal crack in the wall above the arch

The arch has dropped



The window opening has deformed as the support below it has been lost

The brickwork has collapsed

Catastrophic failure of the concrete beam above a large structural opening in the wall below

An extreme example showing a fire damaged building. The concrete beam across the opening on the ground floor has failed. The damage caused to the unsupported wall above it is evident.



Timber beams were often used to carry the load of the wall above bay windows. If the beam was inadequate for the load or has become affected by dampness and decay or wood boring insect attack, it can fail to support the wall. Inadequacy of or defects to the flashing above the bay roof may be the cause of dampness affecting the beam.

The beam (not visible) supporting the wall above this bay window has deflected. There is a noticeable wave in the black patterned band course above the bay and the sills to the windows on the first floor are sloping toward one another. The pattern of brickwork in the panel between the first floor windows is also distorted. The issue may not be progressive. Thick mortar joints apparent to the top of the bay brickwork and the main wall on the right-hand side, may indicate repairs made necessary by possible movement in the bay historically. Again, this may not be ongoing.



staining to the brickwork to this solid wall indicates saturation by rainwater and could be causing penetrating dampness evident to internal finishes and decorations, leading to their eventual deterioration. This may be caused by inadequate edge detailing to the felt roof covering and/or discharge behind the gutter, as well as by a defect to the gutter itself (here it has deflected). The exposed parapet wall to the rear elevation has no capping and water cannot be shed sufficiently far enough away from the face of the wall.

Heavy saturation of brickwork caused by leaking rainwater gutters, or downpipes, blocked or leaking waste and soil pipes, can lead to penetrating dampness, often visible as staining and sometimes accompanied by green vegetative growth. In addition, the inadequate projection of sills, copings and roof tiling or slating, can result in the wall below these features becoming saturated. Penetrating dampness through the thickness of a wall will appear as dampness, staining or spoilage/deterioration to the internal wall lining/finish. This is more common in a solid wall than a cavity wall but can occur in the latter where cavity insulation or wall ties have been incorrectly installed, are contaminated with mortar droppings or the cavity is bridged by an obstruction or filling material to form a moisture pathway from the outer to the inner leaf of the wall.



soft red clay bricks are prone to frost damage, leading to their eventual disintegration.

Frost attack and spalling to brickwork as well as reducing a wall's strength and structural integrity, can also make the wall less resistant to the passage of moisture. The condition of mortar joints should also be assessed.



Efflorescence caused by the crystallisation of salts on the brick's surface. It is unsightly but often not damaging, although in some instances, this can suggest persistent damp conditions and in the worst cases, can result in spalling.

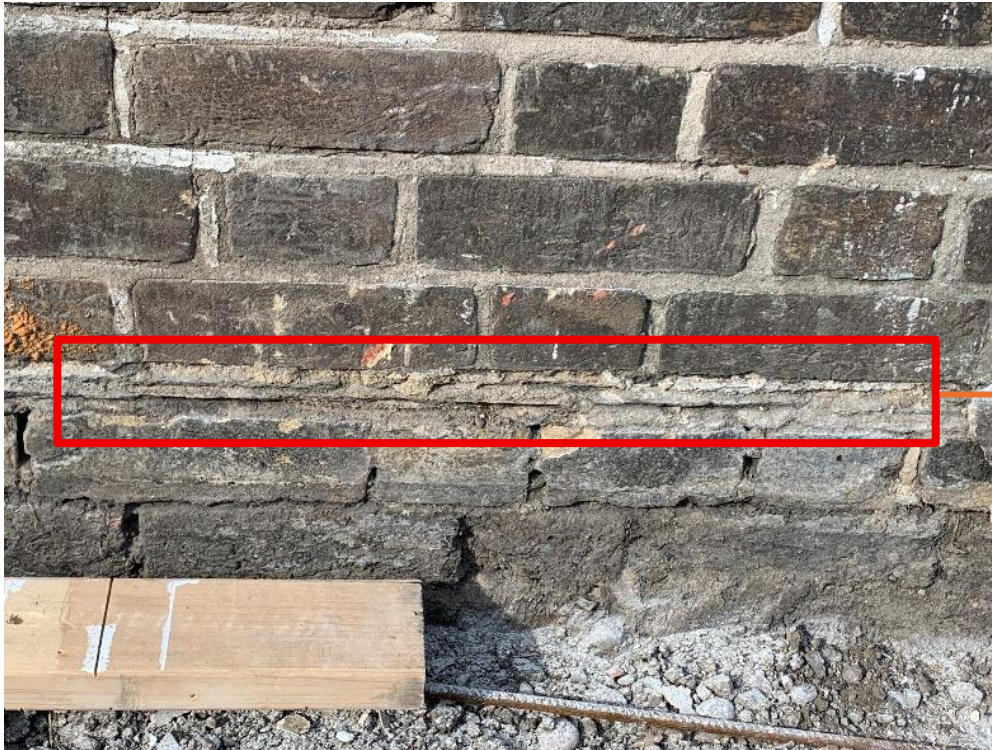
Deterioration of timber windowsills, inadequate detailing and sealing around window or other openings, can also lead to dampness penetration.



A rotted external timber windowsill leading to dampness penetration. The other issue here is that the sill will be less effective at throwing rainwater away from the wall below it. With the brickwork consequently becoming saturated, further penetrating dampness can result.

This timber windowsill has rotted and is now susceptible to letting in rainwater which will be evident to the wall below the window internally, potentially causing spoilage to decorations and the failure of plaster finishes.

Look for the presence, location and condition of the damp proof course (DPC), as well as any bridging of the DPC by raised ground levels or cement renders. The DPC should be at least 150mm above the adjacent ground level.



A slate DPC in this solid wall in a house built in the late 19<sup>th</sup> century is visible. Slates are laid in two courses to 'break joint' (staggered) in order to maintain continuity as a barrier to rising dampness. Usually this is hidden behind a thick mortar joint, but here the mortar over the DPC has deteriorated to reveal it. The slates are not tolerant to substantial movement and can fracture leading to failure.

Look for the presence and location of weep holes in a cavity wall or in timber framed construction. The absence of weep holes can cause water or moisture to accumulate in the cavity leading to dampness penetration.

or to interstitial condensation within the cavity and the subsequent deterioration of components (e.g. rot to a timber frame, damage and loss of efficiency to thermal insulation) and even structural failure in severe cases.

Look for the presence and condition of external wall finishes - loose and/or cracked render and defects to tile hanging features or other cladding materials/systems and their components.



Fine shrinkage cracks in this render likely too rich in Portland cement. Rainwater has been drawn in and trapped behind it. Dissolved sulphates in the water have attacked the mortar joints in the brickwork, resulting in the more obvious horizontal cracks. The render is blowing because the trapped water has frozen, pushing it away from the wall. The render was likely applied to hide the spalling faces of the bricks in the wall behind. Sulphate attack is more prevalent to walls in exposed positions, including parapet and freestanding walls as well as to brick-built chimney stacks.

Internally look out for:



Cracking due to any number of causes, including roof thrust (top floor only), lintel failure/rotation, poor connections between walls, drying shrinkage to plaster (fine cracks), settlement and subsidence, as well as differential movement between timber frames and brick cladding (timber framed buildings only).

Timber 'backing' lintel affected with wet rot. The sagging lintel has lost its strength and load bearing capacity.

In older buildings behind a brick arch, timber lintels were used to carry the weight of the wall above it so that the wall was supported throughout its thickness. These are prone to decay as they are only a ½ brick away from the outside face of the wall and may fail without remedial works, which can involve replacement with a reinforced concrete or galvanised steel lintel.



The crack in the wall below the window opening internally may have resulted from the replacement of the windows in the storey below and a failure to provide adequate support to the wall above it. It may also indicate subsidence. Further investigation is necessary and the pattern of any cracking to the wall externally noted.



Rot in the timber skirting board in this room on the ground floor is the result of rising dampness in the wall behind. The same kind of damage may though have been caused by penetrating dampness or by a plumbing leak, especially one affecting a solid floor which can soak up the water like a sponge. It could also occur because of a failure of the DPM in a solid floor with which the skirting may be in contact.

Look for dampness due to plumbing and rainwater leaks, rainwater penetration, condensation and mould growth. Rising dampness, typically up to around 1-1.2m high, may be accompanied by a tide mark (ground floors only) and subsequent deterioration of plaster/internal finishes. Take note of any ventilation provisions. In basements, also look for signs of inadequate or absent tanking (waterproofing to prevent the ingress of adjacent groundwater), flooding, incorrect wall plaster and the presence of salts on wall surfaces as well as rot or wood boring insect attack to timber skirting boards, door and window architraves.

## Framed buildings

These buildings are supported by a structural loadbearing frame which can then be clad with a variety of different materials or cladding systems.

As well as tall blocks of flats, there have been many low rise non-traditional and 'system built' forms of house building, most of which have involved some degree of prefabrication before delivery to site. Following both world wars, there was tremendous shortage of housing as well as some kinds of materials. The manufacture of components in factories meant faster assembly on site to satisfy the urgent demand for housing, particularly in the social sector.

## Timber framed buildings

Timber frames have been used in house building for many centuries and can take many forms. The walls of modern timber framed buildings may, without detailed inspection, look like cavity construction. Many historic timber framed houses easily give away their form of construction from their appearance.



An oak framed timber building (not a house in this case but a barn). Their popularity in domestic construction waned after about 1700, particularly in urban areas until relatively recently (from the 1980s onward).



A London County Council system-built timber framed house, the Scano Type III, from 1925-1929. The timber frame is raised off a brick perimeter wall which stands just over 600mm above ground level. The outside of the frame was originally lined with bituminous felt and finished with a cladding of horizontal timber panels treated with creosote. The inside of the frame was lined with fibreboard. This variant features a jettied (projecting) first floor supported by timber posts which are visible in this photograph.

## Concrete framed buildings

Concrete framed residential construction is commonplace in the UK, particularly for high, medium and lower rise purpose-built blocks of flats.



In the process of construction, this block of flats shows off its concrete structural frame.



One of 32 concrete framed tower blocks of varying styles on the same London estate designed in 1946. The estate was not completed until 1962.

## Steel framed buildings

The use of steel framed construction in the UK began in the latter 19<sup>th</sup> century, when it was mainly confined to commercial building projects and some taller mansion blocks in London. The need for housing after both world wars prompted the use of steel and other framed construction in low rise housing. Although still rare, light gauge steel frames are occasionally used in modern house building, either in its own right or as extensions to existing houses or to provide additional floors to blocks of flats.



A steel framed house, the Atholl 1926 (1926-1928). As built, external walls are clad with painted flat steel sheets bolted to upright steel framed members (stanchions). Internal linings are fixed to timber battens.



A British Iron and Steel Federation (BISF) house with a steel frame and clad on the first floor with steel profiled sheeting and a cement render on metal lathing to the ground floor. Timber battens on the inside of the frame provide a fixing point for plasterboard linings.

## Freestanding & retaining walls

Boundary walls serve to enclose outside spaces. Retaining walls retain ground material on one side to prevent it from collapsing or slipping or by protecting it from erosion. Retaining walls must resist lateral pressure from the soil but also ground water and foundations from other proximate structures.



A [buttress](#) supporting a tall boundary wall.



A low half brick boundary wall with brick and half end terminal and intermediate piers.

### Defects to look out for include:

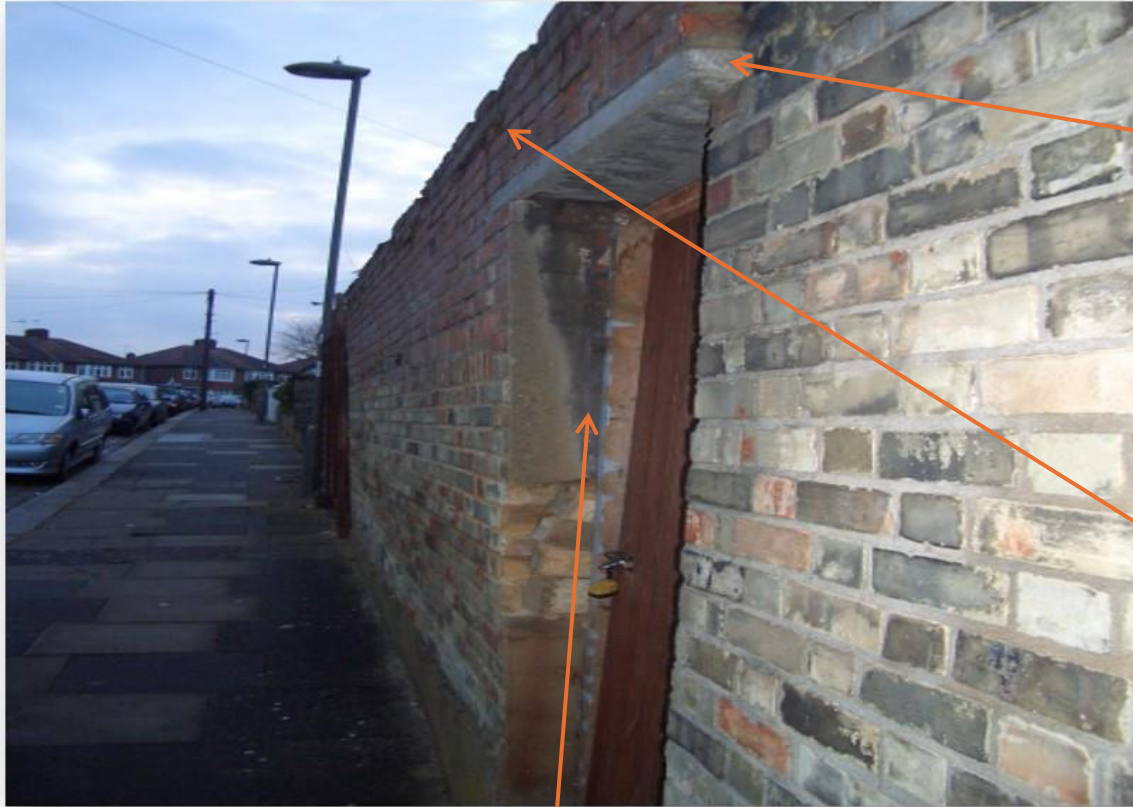
- Inadequate ratio of thickness to height (slenderness ratio) causing instability or inadequate supporting structures such as piers or buttresses
- Leaning, bulging and fractured walls
- Lack of expansion joints
- Frost damage to brickwork or copings and absence of a DPC
- Impact damage
- Inadequate drainage outlets to retaining walls (to relieve ground water pressure)



A crack in a long boundary wall without expansions joints caused by thermal movements.



An expansion joint in a tall boundary wall. This is filled with a flexible filler and pointed with a mastic sealant. They should be provided every 6m to accommodate thermal movement.



The degree of movement in the wall can be seen here as the lintel above the side door opening has broken away from its bearing above the near part of the wall, which has remained true to the vertical. Without remedial work, the wall may eventually collapse posing a significant danger to those using the public footpath

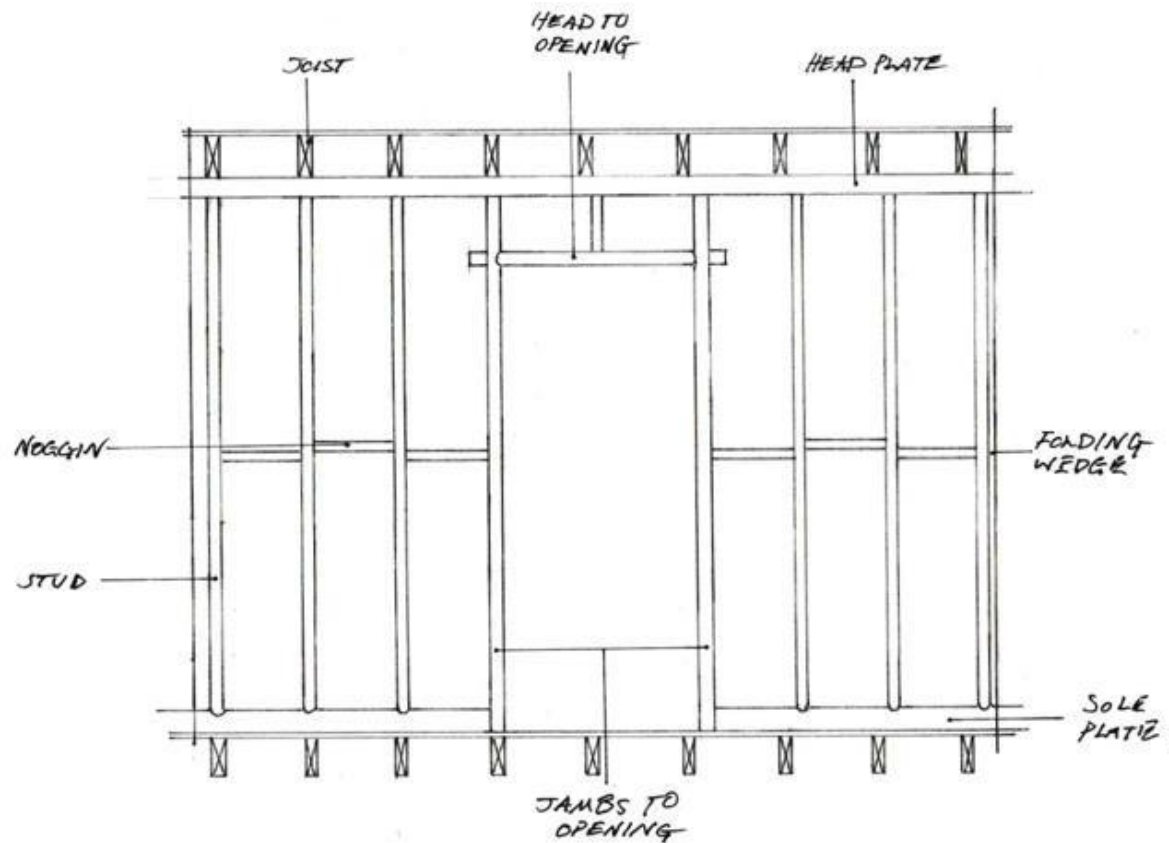
The brick-on-edge copings protecting the top of the wall are spalling and some of them are loose.

This brick boundary wall is around 2m high and significantly out of plumb, leaning toward the pavement.

## Partitions

### Function

To divide the building into different rooms and circulations spaces. These may be loadbearing or non-loadbearing. They can also function to give lateral restraint to structural walls and prevent the spread of fire and smoke from one area to another (compartmentation), as well as the passage of sound.



### Identifying Construction

Partitions may be formed from bricks, concrete/clay/other blocks or timber studwork with plasterboard or lath and plaster finishes. Light gauge steel framed partitions are becoming increasingly common place in residential buildings. Again, soundings will help identify the type of partition. Hollow sounding partitions are more likely to be of some form of framed construction. Loadbearing partitions will be required to transfer loads imposed by purlin roofs or floors for larger houses with greater spans.

## Defects

Defects to look out for are bowing or other deformation (inadequate support or accidental loading), door openings out of square or doors binding on the frame indicating movement, inadequate fixings/bonding to external walls, dampness, inadequate thickness, design or construction, poor sound insulation or resistance to fire. Inadequate fixings to plasterboard linings and the failure of or mechanical damage to lath and plaster.



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