July 2020

RESISTING RAINWATER PENETRATION

Brick Development Association www.brick.org.uk

BRICK DEVELOPMENT ASSOCIATION

Contents

INTRODUCTION

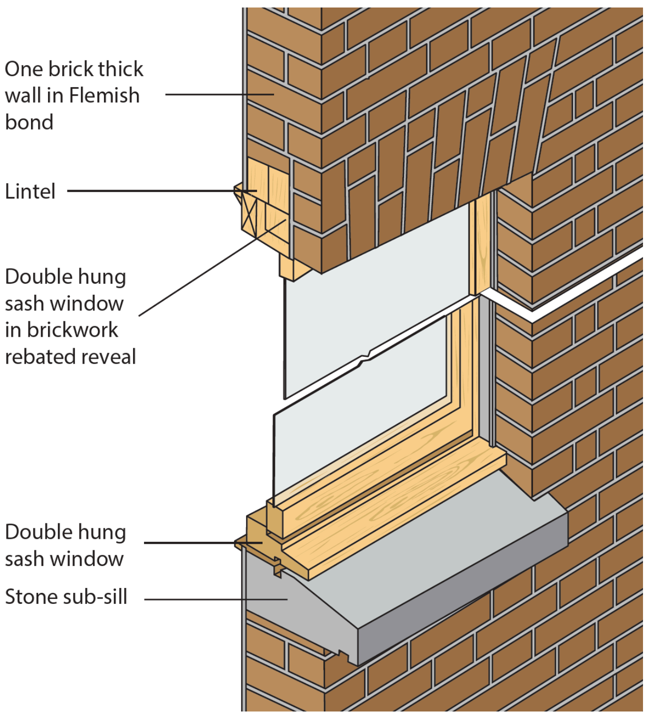
Brickwork has been a dependable form of construction for weather resistant walls for hundreds of years, but conventional bricks and mortars are not themselves waterproof.

Moisture may penetrate brickwork by diffusing through microscopic voids in the materials, or by percolating or flowing into and through hairline or more noticeable cracks in the fabric. The effectiveness of a brick wall in resisting penetration by wind-driven rain is in direct proportion to wall thickness. Historically, for buildings in locations where greater severity of exposure to wind-driven rain is experienced, thicker walls are used compared with those for buildings in more sheltered situations.

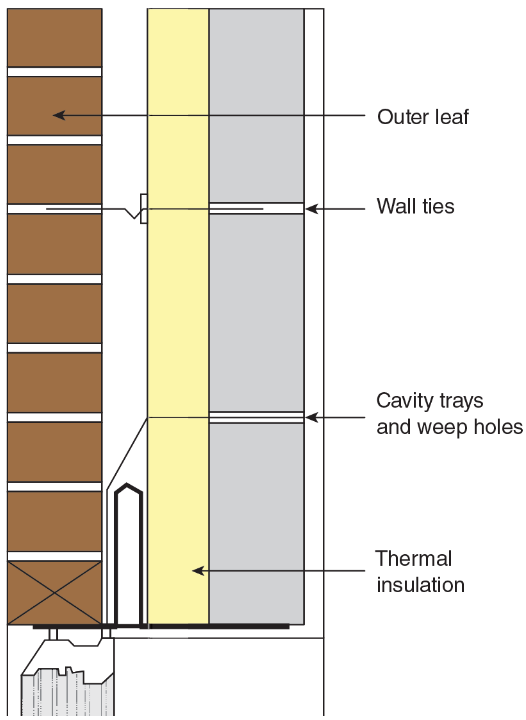
In the mid-nineteenth century there was a considerable increase in the construction of low-cost housing. Economy of material was sought, but thinner walls equated with reduced resistance to rain penetration. This shortcoming of solid walls led to experimentation with cavity wall construction by the use of particular bonding arrangements and also by the development of perforated bricks.

However, the most significant development was the introduction of double-leaf cavity walling. By the twentieth century this technique had become established and by the 1930's it was widely used in housing. The design of the cavity wall accepts that solid masonry subjected to wind-driven rain will not be absolutely waterproof but is capable of providing substantial resistance to penetration.

To divert the passage of any moisture that may pass through the external leaf of the wall the cavity is introduced to drain it down and out again to the exterior. This ensures that water will not penetrate to the internal leaf of the wall causing damp conditions within the building.



Traditional solid wall construction



Cavity wall construction

SCOPE

The resistance of masonry to wind-driven rain involves assessing performance relative to anticipated exposure, as opposed to achieving an absolute condition of being waterproof. This publication examines and comments on the relative significance of the various factors that need to be considered when assessing exposure and then specifying an appropriate wall construction for any particular application.

Solid brick wall construction is considered and also the protection offered by rendered finishes is acknowledged, but the publication concentrates on the detail design and specification of cavity walling with an outer-leaf of fair face brickwork. The affects of insulating materials within the cavity are also examined.

As damp proof courses and cavity trays are essential components in correctly detailed cavity wall design, guidance is included on their specification and installation.

With an understanding of the differences in severity of exposure and in the performance of construction details, a designer can exploit the great choice offered by brickwork to provide effective protection and attractive appearance.

Design details can have a large impact on exposure

Brickwork exposed to a marine environment

Brickwork in a shelted location

ASSESSING WIND DRIVEN RAIN

It is necessary to determine the severity of exposure that is experienced at the project location and then select and specify a construction to provide the appropriate resistance to the expected rain penetration.

Just because the performance of a specific form of wall construction has been satisfactory in a particular location, it must not be assumed that it will be equally suitable in other regions. Design and specification assuming worst case conditions may be considered to provide notional universal applications, but for the majority of buildings on the majority of sites the choice of construction would be unjustifiably restricted and lead to unwarranted expense. Sustainable design requires that the choice of construction is fit for purpose but not significantly more than is necessary.

When determining the likely exposure of a building, the most exposed part should be given particular attention as this will be the starting point for determining the choice of design and materials specification. Due regard should be paid to the importance of correct detailing and standards of workmanship.

The Building Research Establishment developed a method of assessing the quantity of rain falling on a vertical surface by using annual rainfall and average wind speeds recorded at various meteorological stations. This method demonstrated the wide variation of exposure to wind-driven rain experienced nationally. This work resulted in the publication of BS 8104 British Standard Code of practice for Assessing exposure of walls to wind-driven rain.

Exposure zones	Exposure to wind-driven rain (litres/m² per spell)
Very severe	100 or more
Severe	56.5 to less than 100
Moderate	33 to less than 56.5
Sheltered	Less than 33

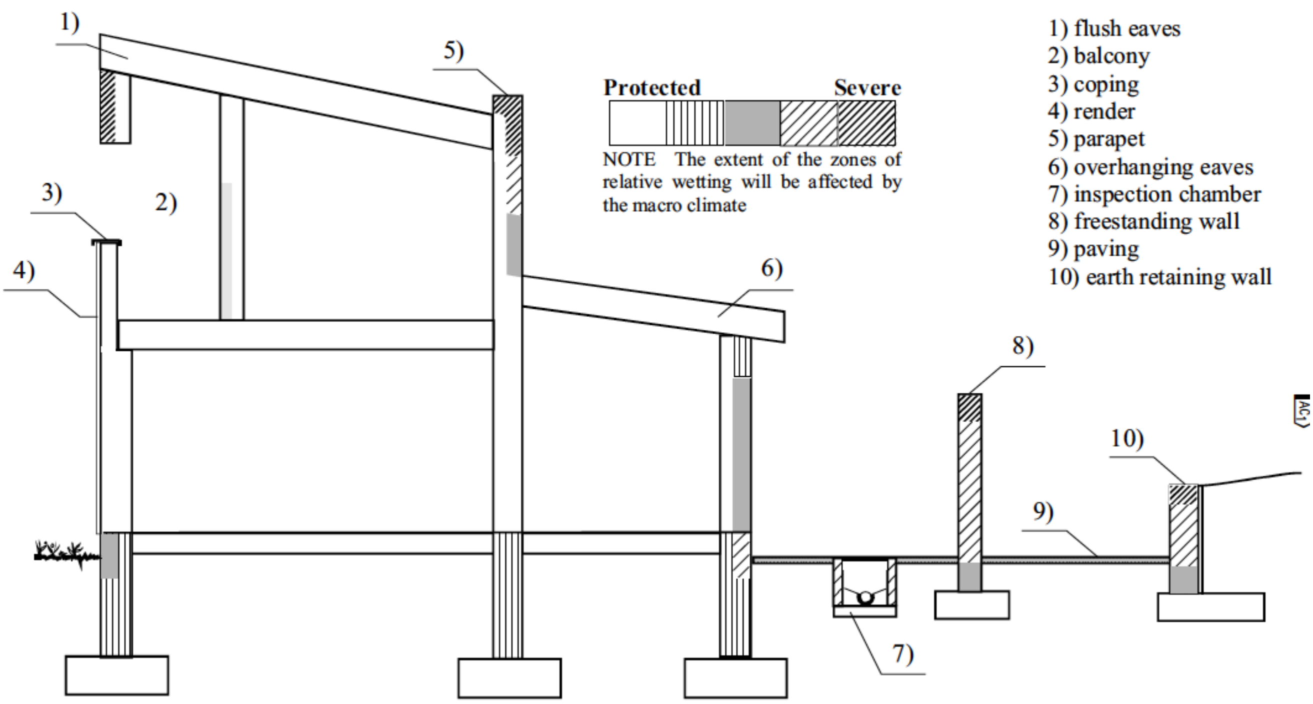
ASSESSING RELATIVE EXPOSURE

Rainfall varies considerably across the country but is largely unaffected by local features. Conversely, the general wind speed does not change much across the country, but it is affected significantly by local features such as the spacing and height of neighbouring trees and buildings and whether the ground is flat or rises steeply. BS 8104 permits corrections to be made for ground terrain, topography, local shelter, and the form of the building concerned. These factors can have a major effect on the calculations. The diagram below gives an indication of the relative exposure to wetting.

BS 8104 gives recommendations for two methods of assessing exposure of walls in buildings to wind-driven rain, namely the local spell index method and the local annual index method. The local spell index method should be used when assessing the resistance of a wall to rain penetration. The local annual index is intended for use when considering the average moisture content of exposed building material or when assessing durability, weathering and likely growth of mosses and lichens.

The table adjacent to the above map gives four exposure categories, defined in terms of wall spell indices, calculated using the local spell index method but they should not be regarded as precise. Where assessment produces an index near the borderline the designer should decide which is the most appropriate category for the particular case. These four categories should not be confused with the 7-category MX series specified in PD 6697. The MX series introduce the risk of freezing and are used to determine the required durability of the brick.

For specific requirements for brickwork in severely exposed conditions, see the BDA document *Severely Exposed Brickwork*.

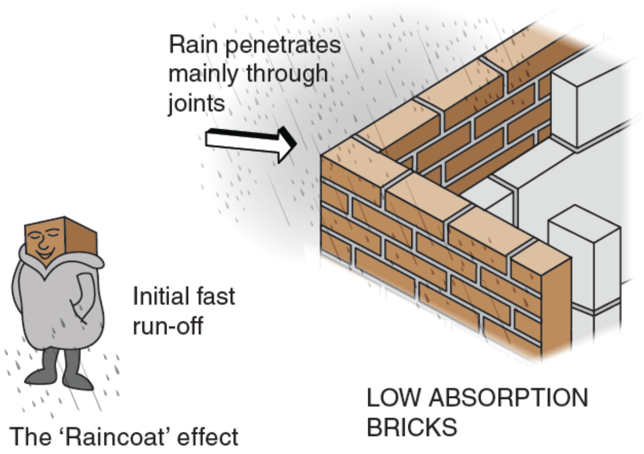


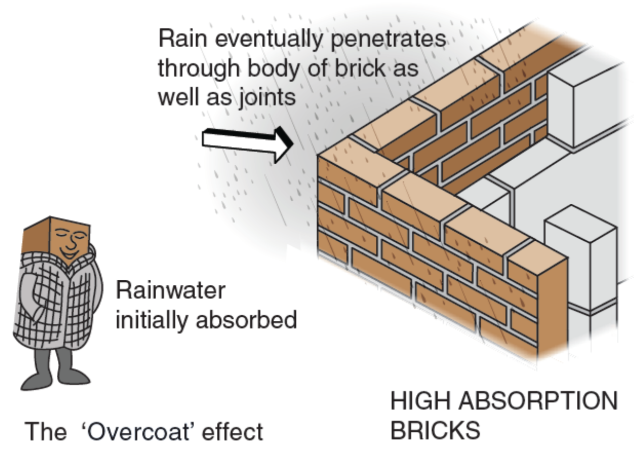
Relative expose to wetting diagram

DETAILED CONSIDERATIONS

The following factors affect the resistance of brickwork walls to wind-driven rain. The order of the listing does not indicate relative importance. Each factor must also be considered in relation to other functions of the wall such as strength, durability, sound and thermal insulation:

- type of brick
- mortar composition
- thickness of leaf
- presence of a cavity
- width of air space within any cavity
- mortar joint profile and finish
- presence, type and thickness of any cavity insulation
- architectural features and local practice
- presence of applied external surface finishes
- quality of workmanship to be achieved on site





Type of brick

Brick types vary considerably in their physical properties, but when specifying brickwork with regard to resistance to wind-driven rain no distinction is made between them. In a wall constructed of dense bricks, with low water absorption characteristics, only a relatively small quantity of water will be absorbed into the bricks. The greater proportion of any rainwater falling onto the wall will run down its face and may be blown into and through it via paths in the mortar joints.

In contrast, for bricks with high water absorption characteristics, such as many handmade and stock bricks, much of the water will be absorbed into the bricks. If the duration of the rainfall is short this behaviour may be considered beneficial because it limits the quantity of water reaching the mortar joints. However, when the surface of the bricks approaches saturation point water tends to run more readily down the surface and may penetrate via paths at the mortar joints.

In very severe and prolonged conditions, rainwater may be absorbed further into the bricks and eventually reach their inner surface, first as dampness and then as free water. Generally rain ceases long before complete saturation and water is evaporated from the wall.

These two modes of action are sometimes referred to as the raincoat and the overcoat effect. Solid walling can ultimately be penetrated by prolonged exposure to wind-driven rain regardless of the water absorption characteristics of the bricks.

DETAILED CONSIDERATIONS

Although water absorption varies greatly between different bricks, this property has only a relatively small influence on the resistance of the finished wall to wind-driven rain. No difference is detectable between the rain resistance of brickwork built of the various forms of brick unit – solid, frogged or perforated. Also there is no evidence that rainwater collect in perforations during rainy periods, subsequently causing efflorescence or frost attack.

Mortar composition

Mortars vary in water permeability relative to their cement content, high strength mortars being the least permeable. Such as designation (i) and (ii), 1: 0 to $^{1}/_{4}$: 3 and 1: 1/2 : 4 to $4^{1}/_{2}$ cement : lime: sand respectively. These high cement mortar designations are often used in conjunction with dense, low water absorption fired clay bricks. This combination is satisfactory but should not be regarded as waterproof.

This table lists various mixes for cement, lime and sand mortars, masonry cement and sand mortars, and mortars of cement and sand with the addition of air-entraining additives.

Mortar designation	Prescribed mortars (traditional proportion of materials by volume)[A]				Mortar class that may be assumed	Suitable for use in environmental condition
	Cement[B] : lime : sand with or without air entrainment	Cement[B] : sand with or without air entrainment	Masonry cement[C] : sand	Masonry cement[D] : sand		
(i)	1 : 0 to ¼ : 3	1 : 3	Not suitable	Not suitable	M12	Severe(S)
(ii)	1 : ½ : 4 to 4½	1 : 3 to 4	1 : 2½ to 3½	1 : 3	M6	Severe(S)
(iii)	1 : 1 : 5 to 6	1 : 5 to 6	1 : 4 to 5	1 : 3½ to 4	M4	Moderate(M)
(iv)	1 : 2 : 8 to 9	1 : 7 to 8	1 : 5½ to 6½	1 : 4½	M2	Passive(P)

[A] When the sand portion is given as, for example, 5 to 6, the lower figure should be used with sands containing a higher proportion of fines, whilst the higher figure should be used with sands containing a lower proportion of fines

[B] Cements in accordance with NA.1.3 (except masonry cements), or combinations in accordance with NA.1.4

[C] Masonry cement in accordance with NA.1.3 (inorganic filler other than lime)

[D] Masonry cement in accordance with NA.1.3 (lime)

For each designation the mix incorporating lime in their composition show an improvement in bond development and, as a consequence, a better resistance to rain penetration than those mortars based on air entrainment and/or mineral materials other than lime. However, although this advantage is detectable, it is not significant enough to justify limiting the application of any particular type of mix.

Thickness of leaf - solid walls

After wetting a masonry wall dries out again losing the moisture to the air by evaporation, which can be accelerated by wind. Although uncommon it is possible to have a solid wall that is resistant to water penetration.

The resistance to rain penetration of a solid wall is therefore dependent upon its thickness and this is reflected in traditional construction - thin walls are used in very sheltered locations and thick ones where exposure is greater.

DETAILED CONSIDERATIONS

Thickness of leaf - solid walls continued

This table shows the recommended minimum thicknesses for both rendered and unrendered solid walls for various categories of exposure.

Maximum recommended category of exposure for solid walls				
Thickness of brickwork (mm)	Unrendered (See note 1)	Rendered (See note 2)	Externally Insulated (See note 3)	Impervious cladding (See note 4)
90	Not recommended (see note 5)	Sheltered	Severe	Very severe
215	Not recommended (see note 6)	Moderate	Severe	Very severe
328	Sheltered	Severe	Severe	Very severe
440	Moderate	Severe	Severe	Very severe

NOTE 1: A notional cavity should be provided between the internal surface of the masonry and any internal lining.
NOTE 2: Rendering should comply with BS EN 13914-1.
NOTE 3: External insulation should have a technical approval for use on solid walls subject to severe exposure.
NOTE 4: Examples of typical impervious cladding systems are noted on page 12.
NOTE 5: Walls of half-brick thickness are widely used for domestic garages and garden stores, but they may be penetrated by persistent driving rain.
NOTE 6: Historically 215mm thick unrendered brick walls are commonly found performing satisfactorily in 2-storey houses in towns and cities. Such locations are generally very sheltered where local spell indices are of 20 l/m^2 or less.

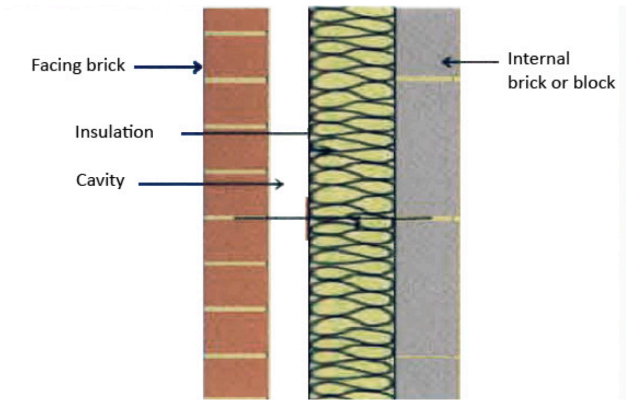
Cavity walls

The table above does not apply to cavity construction. In cavity walls it is accepted that some water will inevitably penetrate the outer leaf in prolonged periods of wind driven rain, but proper design and positioning of damp-proof courses, trays and insulation will minimise the risk of penetration. Where the cavity is unavoidably bridged, e.g. at window and door openings, correct detailing is essential.

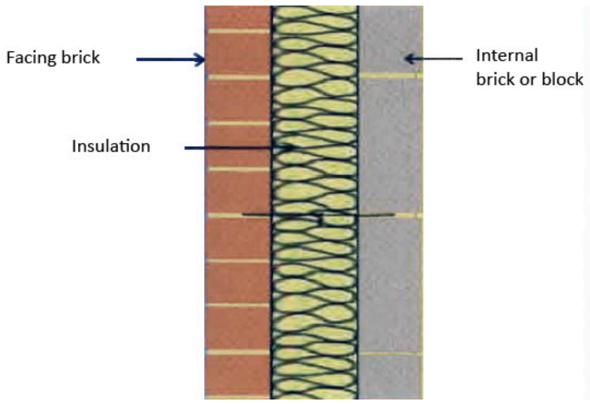
Cavity walls with a half-brick thick outer leaf (90mm minimum) can perform acceptably in all categories of exposure. No reliance should be placed on the inner leaf of a cavity wall to resist water penetration.

Width of air space within any cavity

In cavity walls the space between the two leaves of masonry is intended to prevent any water from passing from the outer leaf to the inner one. In most situations a cavity wall with a half-brick thick outer leaf (90mm minimum), a 50mm cavity and an inner leaf is satisfactory. In conditions of more severe exposure consideration should be given to the use of wider cavities.



Cavity wall construction



Full fill insulation construction

DETAILED CONSIDERATIONS

Cavity insulation

Thermal insulation materials are installed within the cavity of a cavity wall to increase the resistance to thermal transmittance. Incorrectly installed insulation can cause an increased risk of rain penetration.

Some insulation materials are built-in so that a free airspace is retained, i.e. a partial-fill system. In most cases the retained air space should be a minimum target width of 50mm.

Full fill mineral wool insulation

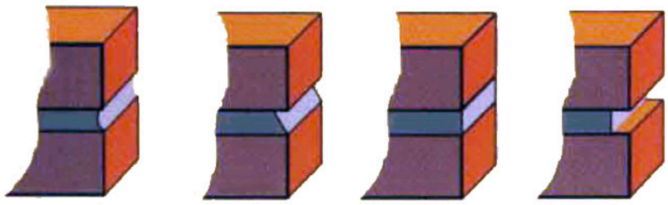
In a full fill system, the cavity space between the inner and outer masonry leaves is filled with insulation material either by building it in as construction proceeds or by injecting it into the cavity after the wall has been completed. The risk of rain penetration will be reduced if a wider cavity is used, but thermal insulation will be the main driver of insulation thickness. Full fill insulation should not be used in areas of severe exposure.

Insulation materials are provided in a form specifically intended for a particular installation method. Products for partial-fill applications should not be used for full-fill ones, and vice versa. Only products specifically manufactured for insulating masonry cavity walls should be used.

Mortar joint, profile and finish

Regardless of the type of brick or the mortar composition, it is essential to fill completely all bed joints and cross joints (sometimes referred to as "perps" or "perpends") to minimize the risk of rain penetration.

The brick to mortar interface is the positions most vulnerable to rain penetration. Microscopic voids exist at the interface which make it a likely location for capillary cracks due to imperfect adhesion between mortar and brick.



Good adhesion of the interface may be degraded further by cracking due to moisture and thermal movements subsequent to construction.

The tooling involved in finishing joints such as those with bucket handled and struck weathered profiles firms the mortar, reducing its permeability at the surface, and pushes it tight to the bricks, thereby improving its adhesion. Both characteristics improve the resistance to penetration by water. A recessed joint profile forms a ledge which impedes the run-off of water, thereby increasing the potential for water penetration.

Recessed joint profiles formed by raking out the mortar without subsequent tooling to firm its surface further increases the vulnerability of the wall to rain penetration. Recessed joints also reduce the width of the mortar joints so they should only be used in Sheltered exposure category locations, with F2 durability brick.

DETAILED CONSIDERATIONS

Architectural features and local practice

Architectural features have an important affect on the risk of rain penetration. The designer should consider whether the details will increase the tendency for the masonry to be wetted.

Examples of features that cause concentrated wetting are:

a) An area of glazing or impervious cladding can produce a large amount of surface water run-off and unless there is a gutter to collect it, or a projecting sill to throw it clear, excessive wetting and possible water penetration can occur in any masonry below.

b) Recessed details can cause local concentration of wetting. Corresponding intrusions into the cavity may increase the risk of water crossing the cavity. The introduction of a cavity tray immediately above the set-back may be considered.

The degree of wetting of masonry can be reduced by ensuring that rainwater is thrown clear of the walls by adequate overhangs and drips or by providing drainage to take water away from the masonry. Projecting features such as sills, copings, string courses, roof eaves and verges are effective in protecting walls.

It might be anticipated that water dripping from a projection would quickly be blown onto the wall a short distance below. However, air close to the wall forms an almost still boundary layer which flows parallel to the surface. Because of this, droplets falling from projections tend to fall vertically down to the ground.

Surface water concentration can also be affected by surface texture and by wind concentration at external and internal corners of buildings. The designer should always take account of local knowledge and traditional forms.

Traditional brick detailing to minimise saturation of solid brickwork .

Vegetation staining due to lack of drip detail from timber cladding

DETAILED CONSIDERATIONS

Applied external surface finishes

For both single-leaf and cavity walls, total resistance to rain penetration can be achieved only by the use of impervious cladding systems. Typically such systems are jointed panels of metal, plastics and timber or overlapping tiles.

Also rendering can enhance the rain resistance of brickwork walls. It can be applied to solid walls and to cavity walls. It is essential to select the right mortar mix, the thickness and to detail the wall correctly in order to minimise shrinkage cracking.

The combination of full-fill insulation and rendering inhibits the drying out of any moisture that may enter the outer leaf of masonry. The moisture content of the outer leaf may consequently rise increasing the risks of frost action on the masonry and sulfate attack of the mortars.

Clay bricks of durability designations F0 are not recommended for such walls in locations exposed to Severe or Very Severe categories of exposure to wind-driven rain. F1 or F2 clay bricks may be used. In all categories of exposure where S0 or S1 clay bricks are to be used behind rendering, the jointing and render undercoat mortars should be made with Sulfate Resisting Cement.

The use of masonry paint systems and other proprietary external finishes including colourless treatments, e.g. silicone-based water repellents may increase the resistance to rain penetration. However, they may also reduce the rate of evaporation of any water from the wall. The moisture content of the wall can increase if water gets behind the paint or surface treatment either by penetrating imperfections in it or entering from adjoining construction.

Render and brickwork cladding

Always check with the manufacturer before painting brickwork

DETAILED CONSIDERATIONS

Applied external surface finishes - continued

In some cases this has led to localised water penetration or saturation of the brickwork sufficient to cause frost damage to clay bricks of F0 and F1 durability designation in winter conditions.

Water repellent surface treatments are not generally recommended for clay brickwork. Traditionally brickwork that is correctly specified and constructed is durable, withstands weathering and resists the penetration of wind driven rain without the need of water repellent treatments. They should not be applied without the approval of the brick manufacturer.

Quality of workmanship to be achieved on site

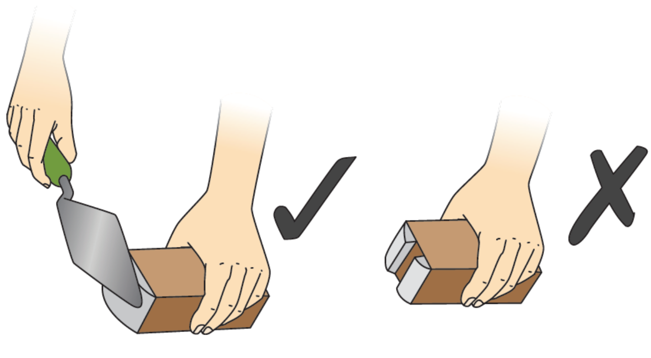
The quality of workmanship is the most important factor affecting resistance to rain penetration. All workmanship should be in accordance with BS 8000-3. Detailed guidance on workmanship is also given in the BDA document Good site practice and workmanship.

The importance of filling all mortar joints to ensure good resistance to rain penetration cannot be overstated. Cross-joints (perps) are often not filled properly because they are formed using a poor technique known as tipping and tailing. Small dabs of mortar are wiped on the leading and trailing edges of the end of each brick when laying which means cross-joints are not adequately filled.

Any anticipation that the joints will subsequently be filled by mortar flowing down into them from the next layer of bedding mortar is incorrect. Stretcher bonded walls have sixty cross-joints per square metre and so if they are poorly filled the shortcoming can be significant.

Anything that allows water to bridge the cavity between the two inner and outer leaf has the potential to increase water penetration. The most common scenario is incorrectly placed wall ties that slope towards the inner leaf. Mortar that is dropped into the cavity can also create a bridge for water to cross.

Insufficient mortar in cross joints



Tipping and tailing brickwork

Wall tie sloping towards inner leaf

DPCs AND CAVITY TRAYS

General

A damp-proof course (dpc) in a building is intended to provide a barrier to the passage of water from the exterior of the building to the interior, or from the ground to the structure, or from one part of the structure to another.

Where the dpc is intended to prevent the upward movement of water due to capillary action through masonry, materials continuity is important. Joints should be made in accordance with the instructions of the dpc manufacturer. Where no specific instructions are given, the dpc should be lapped a minimum 100 mm or the full width at corners. Penetration of dpc's and cavity trays by services and fixings should be avoided as far as possible.

Where they have to pass through care should be taken to form the necessary hole neatly and carefully seal around the breach. Where water is subjected to hydrostatic pressure, or is moving in a downwards direction under the influence of gravity, any joints in the dpc should be made waterproof by lapping and sealing, following the dpc manufacturer's requirements.

Dpc's should generally extend through the full thickness of a wall or leaf, and to the external face where it should be clearly visible. A dpc should not be covered by pointing or rendering. To prevent penetration of water beneath the dpc, and to produce a good bond, dpc's should be laid on a smooth bed of fresh mortar. The use of coarse aggregates for the mortar should be avoided as they might damage the dpc.

Sometimes dpc's are installed to form a slip plane to accommodate differential sliding movements between adjacent parts of the building structure. In such a case the mortar bed should be trowelled smooth, allowed to set, and then cleaned off before the dpc is laid. Alternatively, a double layer of appropriate sheet dpc material with no mortar or adhesive between them may be specified.

Performance

To ensure adequate performance, dpc's and cavity trays should have the following material properties:

(a) an expected life at least equal to that of the building

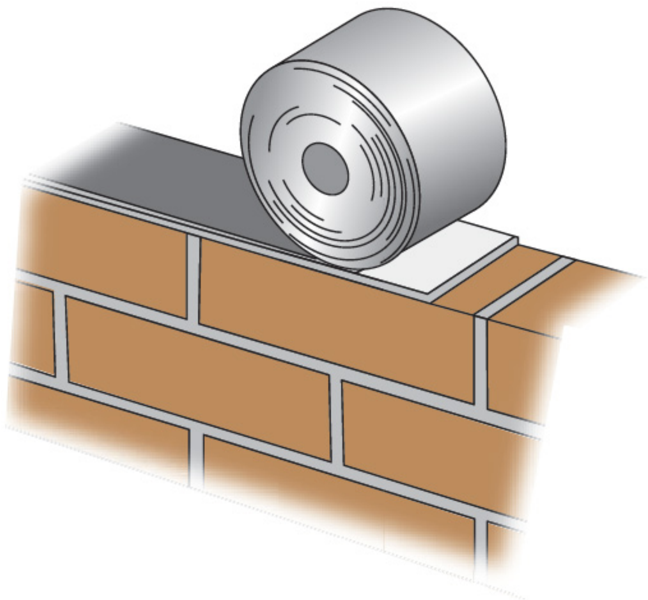
(b) resistance to compression without extrusion

(c) resistance to sliding where necessary

(d) adhesion to units and mortar where necessary

(e) resistance to accidental damage during installation and subsequent building operations

(f) workability at temperatures normally encountered during building operations, with particular regard to forming and sealing joints, fabricating junctions, steps and stop ends, and the ability to retain shape



DPCs AND CAVITY TRAYS

The table gives information on performance of individual materials currently used for dpc's.

Material	Resistant to extrusion under high load	Ease of jointing	Limitations or benefits in use
Rigid Materials			
CLAY DPC BRICKS Less than 7% water absorption by mass.	✓	✓	Suitable against rising moisture only. Good performance in resisting flexural stress.
SLATE complying with BS 743 and most granites	✓	✓	Suitable against rising moisture only.
Semi-Rigid Materials			
MASTIC ASPHALT complying with BS 6925	x	n/a	
Flexible Materials			
LEAD SHEET	x	✓	Requires protective coating against corrosion when set in mortar > 25mm.
COPPERSHEET complying with BS EN 1172, 2.28 grades	✓	✓	Requires protective coating to avoid staining masonry.
BITUMEN SHEET complying with BS 6398			
with Hessian base (class A)	x	✓	Difficult to handle in cold weather
with Fibre base (class B)	x	✓	Difficult to handle in cold weather.
with Hessian base and lead (class D)	x	✓	Difficult to handle in cold weather
with Fibre base and lead (class E)	x	✓	Difficult to handle in cold weather
LOW DENSITY POLYETHYLENE SHEET complying with BS 6515	✓	x	Poor bond performance. Not recommended for use in conditions of flexural stress.
BITUMEN POLYMER & PITCH POLYMER	✓	✓	Good bonding performance with mortar.

Junctions

Dpc and cavity tray details can be simple in straight plain walls, but at corners, junctions, returns, curves, changes in level, and around openings the need for continuity requires careful installation. During the detail design and specification careful consideration should be given to these positions. Many common details cannot be formed satisfactorily in-situ. In complex situations pre-formed cloaks should be specified, to restrict the site operation to simple jointing.

Continuity and support

Where practicable, dpc's and cavity trays should be formed in a continuous length of material to minimise the need for joints. Cavity trays should be supported at their joint positions to facilitate effective sealing. Continuous support is advantageous as it avoids sagging and deformation.

Resisting rising damp - Immediately above ground level

In every external wall, a dpc should be provided at least 150mm above the finished level of the external ground or paving. To prevent the transfer of moisture from external walls into solid floors, the damp-proof membrane in the floor, and the dpc in the wall, should overlap a minimum of 100 mm or be sealed. In cavity work the cavity should be filled to ground level with fine concrete, and weepholes should be left in the vertical cross joints of the outer leaf, at intervals not greater than 1m, immediately above the top of this fill. The purpose of the fill is to prevent the leaves of the cavity wall being displaced into the cavity by pressure from the ground during backfill operations or subsequent loading of the ground.

Resisting rising damp - Below ground level

Horizontal and vertical dpc's are required where the lowest floor of the building is below ground level. In this situation it may be necessary to consider tanking.

DPCs AND CAVITY TRAYS

Controlling downward movement of water

Cavity walls

The design and specification of a cavity wall should be based on the assumption that, in conditions of persistent driving rain, water will penetrate the outer leaf and run down its inner surface within the cavity. Where the cavity is bridged by lintels or services, dpc's in the form of cavity trays, with stop ends and weepholes, should be provided to divert water out.

Over openings

In cavity walls, cavity trays should be provided over all openings (including small openings for ducts, services, etc), unless they are well protected by a roof or balcony overhang. The cavity tray should step down or slope across the cavity not less than 150 mm towards the external leaf and terminate flush, or slightly projecting, the external mortar face.

The cavity tray over an opening should overlap the vertical dpc's at the jambs to ensure continuity of damp-proof measures.

Cavity tray over lintel

Pre formed arch tray

Arches

The curved form of an arch makes the use of a normal cavity tray impossible. A conventional cavity tray can be installed in the bed joint immediately above the crown of an arch and for a minor segmental arch in a relatively sheltered location this may be considered acceptable. The tray should extend beyond the width of the arch and be fitted with stop ends. To improve the construction short lengths of flexible sheet dpc material can be set around the curve of the arch in an overlapping arrangement.

A simpler and more reliable construction is to use a pre-formed arch tray. Depending on the detail design of the opening the tray may be installed at the intrados or the extrados, i.e. under or over the arch ring.

A pre-formed tray should incorporate stop ends and, because the arch form inevitably drains any penetrating water to its bearings, care should be taken to ensure effective weepholes are provided.

Modern cavity wall construction

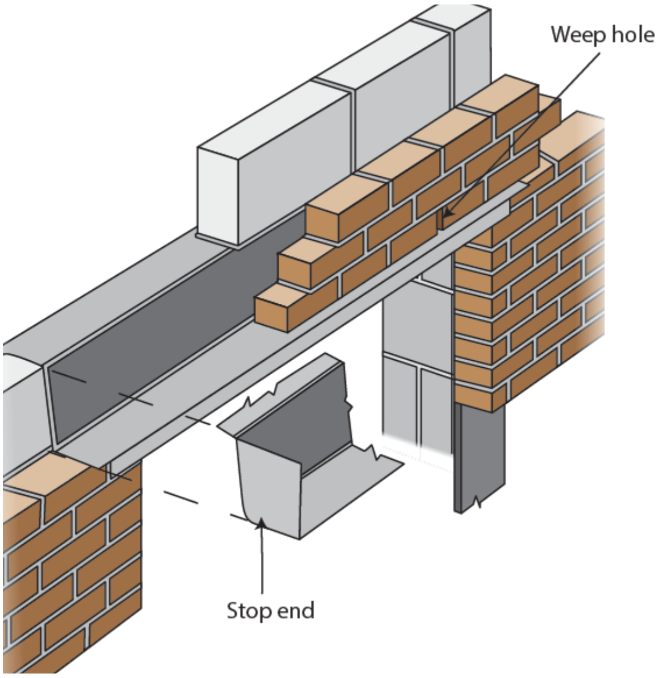
DPCs AND CAVITY TRAYS

Stop ends

Where trays are discontinuous, and in a position that is not well protected by a roof or balcony overhang, stop ends should be fitted at or near the ends of the tray, generally corresponding to cross joints in the brickwork. They should be bonded to the tray to give a waterproof seal. Stop ends prevent the possibility of water in the cavity running down onto the tray and being thrown off its ends into the cavity. At the jamb of an opening such a concentrated flow of water could run behind the vertical dpc in that part of the walling, and lead to dampness of the internal face of the wall.

Steel lintels are available which are shaped and finished to act as a cavity tray without the addition of sheet dpc material. These lintels also require stop ends to be fitted .

Stainless steel weep vent



Pre formed stop end

Weepholes

Weepholes are required in the outer leaf immediately above any cavity tray so that water collected on the tray can be diverted out to the exterior of the building. They should be formed in vertical cross joints at intervals not greater than 450mm. There should be not less than two weepholes over each opening.

It is possible to form weepholes by leaving a nominal 10mm wide cross joint without mortar. The height of the weephole is generally determined by the height of the brick but it is not critical. It should be large enough to avoid any tendency to become blocked by debris. Weepholes formed between soldier bricks may be full height, but need only be about 40 mm.

In tall buildings subjected to harsh exposure there has been experience of rain penetration due to high winds blowing into cavity walls through weepholes and moving water up beyond the upstand of dpc trays. Proprietary devices are available to assist the formation of weepholes that allow water to drain from the cavity but restrict the ingress of wind and/or rain.

Weep holes are available that can colour match the mortar if the design intent is that they should not be obvious.

DPCs AND CAVITY TRAYS

Requirements for damp proof courses and cavity trays for specific parts of buildings

At jambs of openings

Where a cavity wall is closed at the jambs of openings by masonry, a vertical dpc should be inserted to prevent moisture passing from the outer leaf to the inner parts of the wall.

The vertical dpc should extend into the cavity at least 25mm beyond the width of the closer and any cavity tray above should extend beyond it.

Proprietary closers are available which combine the functions of closing the cavity at the jamb, preventing moisture transfer, stabilizing the masonry leaves, reducing cold bridging and providing fixing for window or door frames. If these are used follow manufacturer's instructions for installation and linking with associated dpc's at the head and sill.

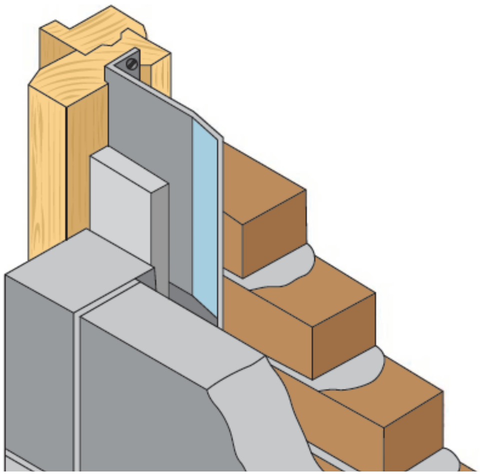
A frame in an opening should be located and fixed in such a manner that transmission of water past the vertical dpc is avoided. Where the frame is to be built in, the dpc should be secured to the frame first.

If the frame is to be fixed later, the dpc should be left projecting within the opening. Vertical dpc's at openings should be positioned to overlap any horizontal dpc at the sill of the opening and be overlapped by any cavity tray at the head.

Sills

All pervious or jointed sills, or sub-sills, should be provided with a dpc for the full length and width of the sill bed. The dpc should be overlapped by the vertical dpc's at the jambs of the openings.

Where the sill is in contact with the inner leaf, the dpc should be turned up at the back and ends for the full depth of the sill.



Vertical cavity tray

Window sealing collar

Proprietary cavity closer

DPCs AND CAVITY TRAYS

Requirements for additional cavity trays with framed structures

Masonry supported by a structural frame requires particular attention for the detailing of trays and dpc's, to ensure their continuity. A cavity tray with a minimum upstand of 150 mm should be provided to prevent moisture penetration into the structure. The cavity tray should be continuous around any column, or other structural member, that obstructs the cavity. Where complex shapes are needed, prefabricated cloaks should be considered to minimise difficulties of construction.

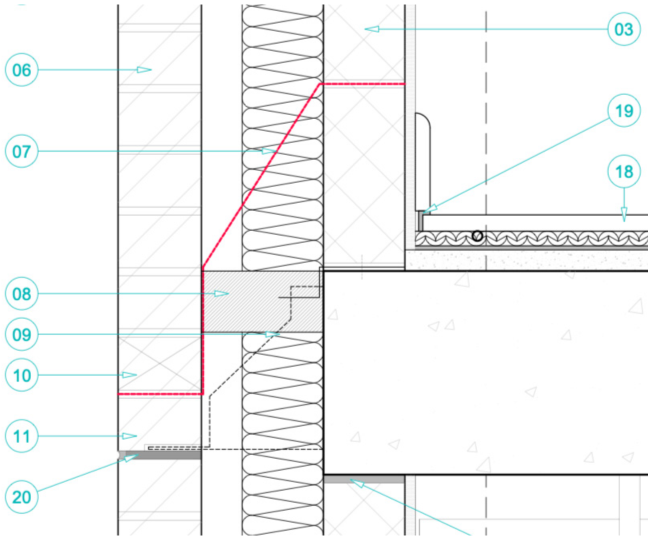
In buildings over 12 m high, cavity trays are required to subdivide the cavity, to avoid surcharge by water that may penetrate the outer leaf of masonry. They should be installed at a maximum of 12 m above ground level and at a maximum spacing of 7 m thereafter. Where fire barriers fully fill the cavity, a tray is required immediately above the barrier.

For framed buildings the trays required to subdivide the cavity are generally in the same position as the support angle. Weepholes should be provided at intervals not greater than 1m.

External wall becoming an internal wall

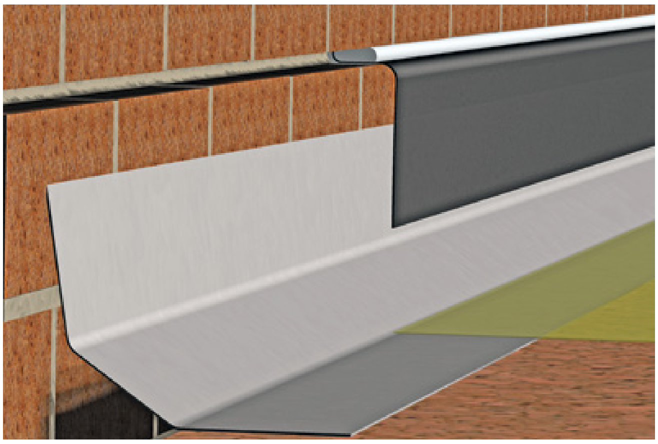
If an external wall becomes an internal wall at lower level, as in the case of a roof abutting a wall (e.g. in a stepped terrace of houses, or a porch, garage or conservatory annex) a cavity tray should be installed to drain the cavity above the level of the lower roof.

A horizontal abutment requires a level cavity tray with stop ends and weepholes. When a pitched roof abuts such a wall, a cavity tray stepped to correspond with the slope will be required. Alternatively, a system of overlapping preformed trays may be installed to collect and discharge water from the cavity. In either case stop ends and weepholes are essential. Proprietary systems exist for these applications.



Cavity tray above a full width cavity closer

Stepped cavity tray for pitched roof



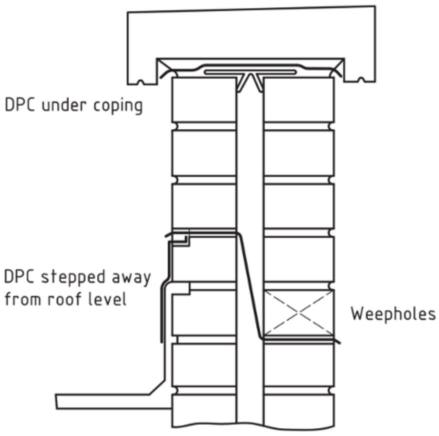
Flat roof flashing tied in to cavity tray

DPCs AND CAVITY TRAYS

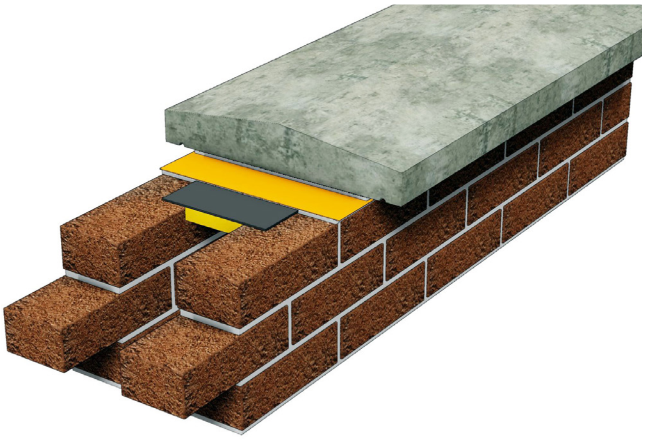
Parapets

In a parapet wall a cavity tray should be installed to step at least 150 mm within the cavity. The tray should step down to the outer leaf (away from the roof). It is safer to direct water towards the outer face, away from the roof. Concern that this may cause staining on the face of the wall below is exaggerated. If sloped inwards (towards the roof) experience shows that there is a danger of rainwater being driven below the tray and track along its underside and so gain access to the inner leaf of the wall, the underside of the roof covering and the interior of the building.

It should be noted that dpc's and cavity trays can impair the structural integrity of the parapet and the wall beneath and also the coping above. Dpc materials with good bonding performance should be specified.



Parapet cavity tray and DPC under coping



Proprietry closer with DPC

Copings and cappings

A coping is a construction that protects the top of a wall and sheds rainwater clear of the brickwork below, generally by having a weathered top surface and a throated overhang. A capping is a, generally flush, construction on the top of a wall and it does not shed rainwater clear of the wall surfaces below.

Severely exposed parapet walls, chimney terminals, free standing walls and retaining walls should be provided with copings. The drip edge of a throating should be positioned a minimum of 40mm from the face of the wall it is intended to protect. Flush cappings can be used in areas that are not severely exposed, providing that the durability specification is appropriate for the capping and walling below.

Where the capping or coping is jointed, a continuous sheet dpc should be provided in the bedding mortar joint. To increase the stability of the detail for light weight copings, the dpc can be placed in a bedding two or three courses below the topmost one. All materials above the dpc must be frost resistant. Flexible dpc's require support over the cavity to avoid sagging and deformation and to facilitate effective sealing of lapped joints.

Resistance to water penetration should not prejudice provision for masonry movement. Movement control joints in the masonry should be carried through any coping or capping and sealant applied as in the corresponding joint in the wall below.

Consideration should be given to copings and cappings being displaced by lateral loads, and to the possibility of vandalism. L shaped copings and clip-over copings may be more satisfactory in some situations. Where necessary, copings should be suitably fixed down and may be doweled together. Copings and cappings to the sloping tops of gable end walls require particular attention to the practicality of construction.

DPCs AND CAVITY TRAYS

Chimneys

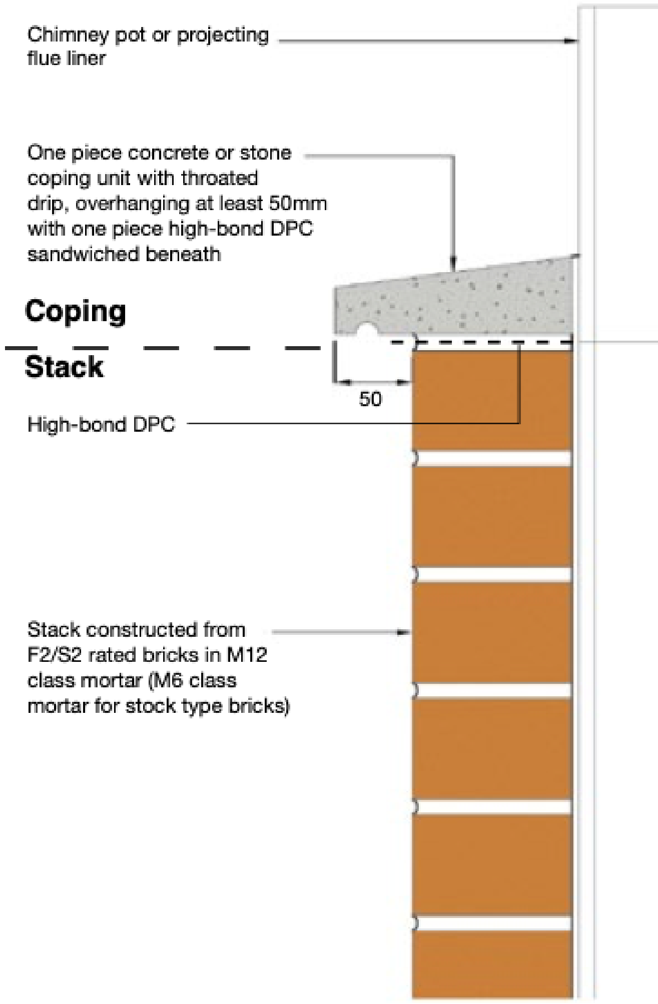
Chimneys may be built in solid or cavity wall construction. Where a chimney stack is incorporated in an outer cavity wall, preferably the outer leaf and cavity should be continuous around the chimney stack for the full height of the outer wall and then completely surround the chimney stack where is projects above the roof.

If the chimney is set in an internal partition or party wall and the roof is steeply pitched, a reasonable height of chimney will be exposed in the roof void and any dampness in the masonry can dry out in a ventilated roof space. However, with a low-pitched roof, when a chimney is located at the eaves, or the roof space accommodates habitable rooms, particular care in the design and construction of the roof/ chimney intersection will be necessary to prevent moisture penetrating into the masonry below.

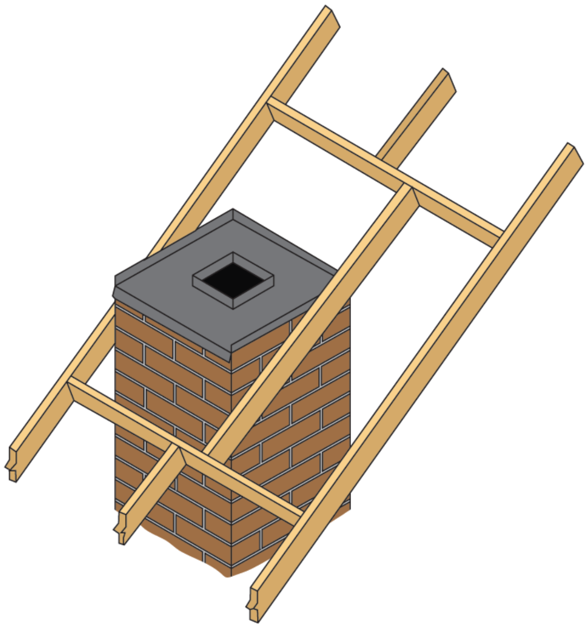
Dpc trays should be provided to prevent the downward passage of water. Horizontal trays should extend through the thickness of the chimney wall and into the flue liner, with an upturn at the inner face of the flue. Externally it should be linked with any flashing at the intersection of the chimney with the roof.

It should be noted that a sheet dpc at the point of intersection with the roof can reduce the structural integrity of the masonry, and the stability of the chimney stack and its resistance to lateral wind loading needs to be considered. Chimney stacks built in cavity work may be provided with a dpc tray of a material stiff enough to form a cavity tray without being built into the inner leaf and this provides structural continuity.

A horizontal dpc should always be provided below any coping or capping at the top of the stack unless it is a jointless, water resistant material, eg. a one-piece dense terracotta, slate or reconstructed stone unit, or a sheet metal assembly in one-piece or with waterproof joints.



Throated coping for chimney stack



Cavity tray turned up at flue

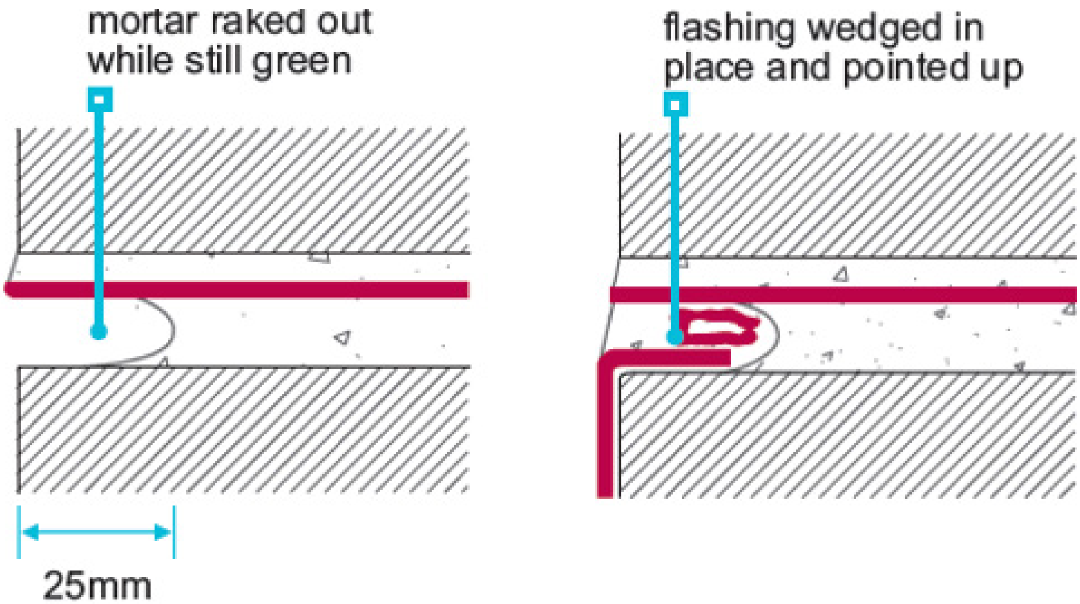
DPCs AND CAVITY TRAYS

Flashings and weatherings

The material to be used should be sufficiently malleable to permit dressing into shape, but sufficiently stiff to maintain its shape and to resist lifting by the wind. Metal flashings other than lead should, preferably, be pre-formed.

Flashings should be bedded into the work a minimum of 25 mm, and be provided with welted, or otherwise sealed, joints, or adequate overlaps.

The designer should consider how flashings are to be fixed and at what stage in the construction programme to provide secure fixing and avoid damage to dpc's. The materials should be selected with due regard to the likelihood of corrosion and given protective treatment as necessary. To avoid staining of masonry from the runoff of rainwater, consideration should be given to the need for surface treatment of some metals.



Mortar under cavity tray should be raked out to allow for flashing

Conclusions

Most external walls are expected to prevent rain penetrating to the interior of buildings. In masonry cavity walls it is accepted that some water will pass through the outer leaf in prolonged periods of wind -driven rain, but the design of the wall is intended to deal with this inevitable eventuality. The risk of further penetration through the wall and into the building is minimized by the proper design and installation of the wall's associated damp-proof systems.

The incidence of wind and rain experienced in the United Kingdom can be very testing, but walls with facing brickwork can efficiently meet the challenge. With care and attention to design and workmanship, straightforward and well-established construction methods can provide walls that are resistant to rain penetration and also attractive, durable and economical.

REFERENCES AND FURTHER READING

EN 771-1, Specification for masonry units Part 1: Clay masonry units

BS EN 845-1, Specification for ancillary components for masonry – Part 1: Ties, tension straps, hangers and brackets

BS EN 845-2, Specification for ancillary components for masonry – Part 2: Lintels

BS EN 845-3, Specification for ancillary components for masonry – Part 3: Bed joint reinforcement of steel meshwork

BS EN 998-2, Specification for mortar for masonry – Part 2: Masonry mortar

BS EN 1990, Eurocode – Basis of structural design

BS EN 1996-1-1, Eurocode 6 – Design of masonry structures – Part 1-1: General rules for reinforced and unreinforced masonry structures

BS EN 1996-1-2, Eurocode 6. Design of masonry structures. General rules. Structural fire design

BS EN 1996-2, Eurocode 6 – Design of masonry structures – Part 2: Design considerations, selection of materials and execution of masonry

BS EN 1996-3, Eurocode 6. Design of masonry structures. Simplified calculation methods for unreinforced masonry structures

PD 6697, Recommendations for the design of masonry structures to BS EN 1996-1-1 and BS EN 1996-2

BS 8000-3, Workmanship on building sites – Part 3: Code of practice for masonry

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