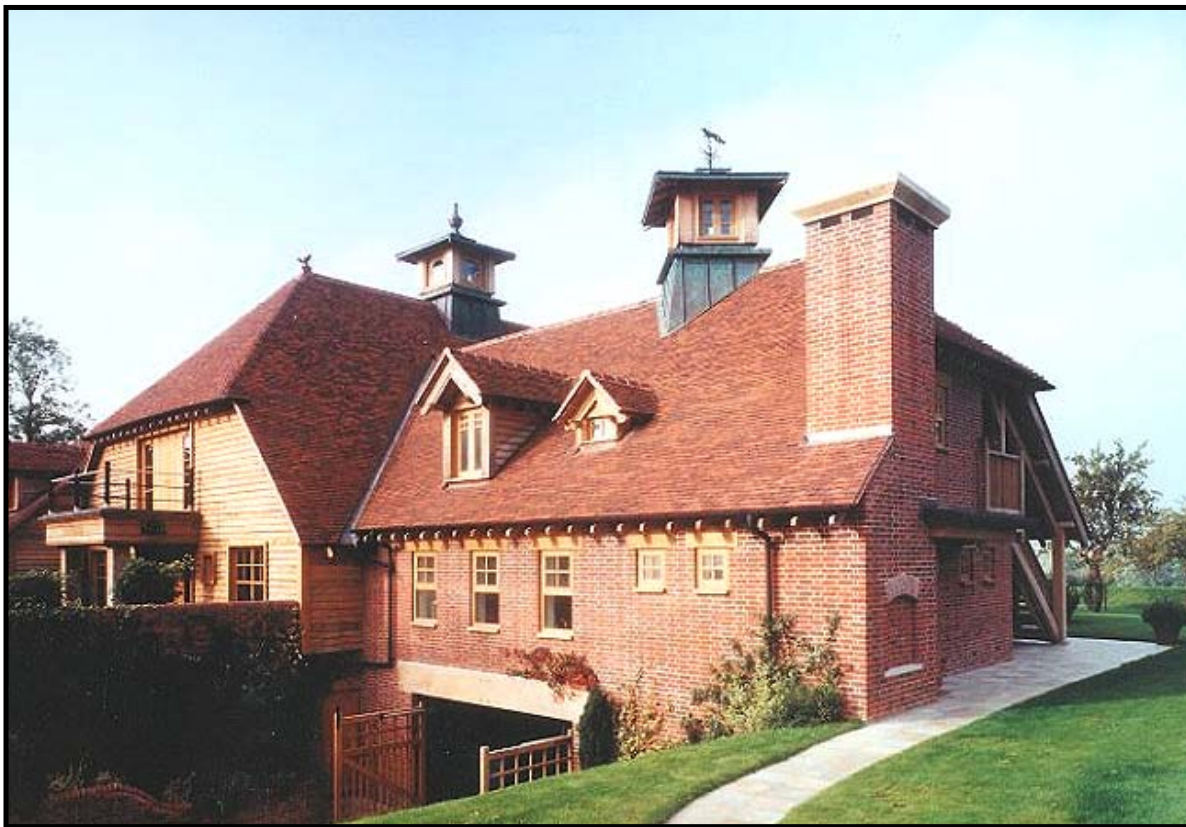




Clay Roof Tile Council

Vertical Tiling



Prepared by : The Technical Committee of the Clay Roof Tile Council, 2004



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INTRODUCTION TO CLAY TILES

With the increasing sophistication of the housing market, the external characteristics of a house can play as significant a role as the interior appearance in the purchasing decision. Eye pleasing, attractive features on the outside of the building add to its aesthetic appeal and make an immediate impression on the prospective buyers before they walk through the front door. And first impressions last. A clay roof undoubtedly distinguishes a house as a premium 'product' and, to the builder, offers the potential for 'added value' which will exceed the marginal increment to the overall cost of the construction that may be associated with the use of clay tiles.

Clay is a natural material, which in the form of clay tiles has played an integral role in the UK's built environment for over seven hundred years. Clay roof tiles are durable, natural, sustainable products that improve with age and weathering. Their appeal adds value to buildings and enhances the built environment.

Increasingly, concern for the environment is becoming a major influencing factor for the prospective homebuyers and builders. Whether or not they have any influence, buyers are concerned as much about preserving the landscape as they are about the materials used in building and demand natural, sustainable products. Clay tiles are considered by many planners and specifiers, as a sustainable product because of their durability, long term visual effect on the environment, and their properties as a renewable natural resource. These factors, along with the fact that they are being specified increasingly by planners and conservation officers to preserve the character of buildings and the architectural landscape, mean that clay continues to be one of the most desired roofing products. Recent evidence of the increase in the use of clay tiles is demonstrated by the fifty percent increase in the volume of clay tiles produced and sold per annum since 1995.

To support the renewed interest in traditional materials the CRTC members are making sure that a wide range of clay roof tiles are still available, producing more than 50 different colours. These colours range from deep reds, browns, warm oranges and plum coloured hues of heather to the muted blues of Staffordshire. Variations are obtained by controlling the kiln atmosphere to produce the rich heather shades.

Colours of the tile can also be enhanced through the firing process to create a brindle effect, which varies the colour between the outer edge and the centre of the tile. In addition, the firing process ensures that the colour of the tile is permanent and does not fade. A panoramic view of the rooftops of Britain reveals a patchwork of colours, with each region set apart by its own, distinct clay roof tile colour.

Whilst durability is a major factor that influences architects, specifiers, conservation officers and planners, the ageing benefits of clay tiles also feature very highly.

BRIEF HISTORY

It is believed that the first single lap clay roof tiles were formed from baked earth or clay around 2700 BC. The Romans were the first to make and use fired clay tiles in England but the practice died shortly after their occupation ceased. The craft was revived in the medieval period when a number of tile manufacturing centres were established in the East and Southeast of England.

In 1212 AD King John issued building by-laws for London that required combustible roof coverings to be replaced with clay tiles. At about the same time the Archbishop of Canterbury banned the use of thatch on buildings near the Cathedral. From this time clay tiles have never been out of production.

King Edward IV standardised the size of a plain tile in 1477 AD. The dimensions were 10½ inches by 6¼ inches by 5⁄8 ths of an inch thick. Standardisation allowed the tiles to be taxed at a consistent rate.

The introduction of the brick tax in 1784 led to the creation of mathematical tiles. Mathematical tiles are tiles that look like bricks and these were introduced to avoid the tax.

By 1835 both the plain tile tax and the brick tax had been repealed.

The British Standard for clay plain tiles was published in 1935 and with minor adjustments it remained in force until it was replaced by the European Standard in 1999.

DEFINITIONS

Plain tiles

Plain tiles, tile-and-a-half tiles, eaves / top tiles, and feature (decorative) tiles are illustrated in drawing 1.

Vertical

The term vertical applies to surfaces with a pitch equal to, and, greater than, 75° from the horizontal.

Fittings

Clay roof tile fittings are made of clay and are used in combination with tiles to complete the roof covering, e.g. hips, internal and external angles, monoridge and ridge.

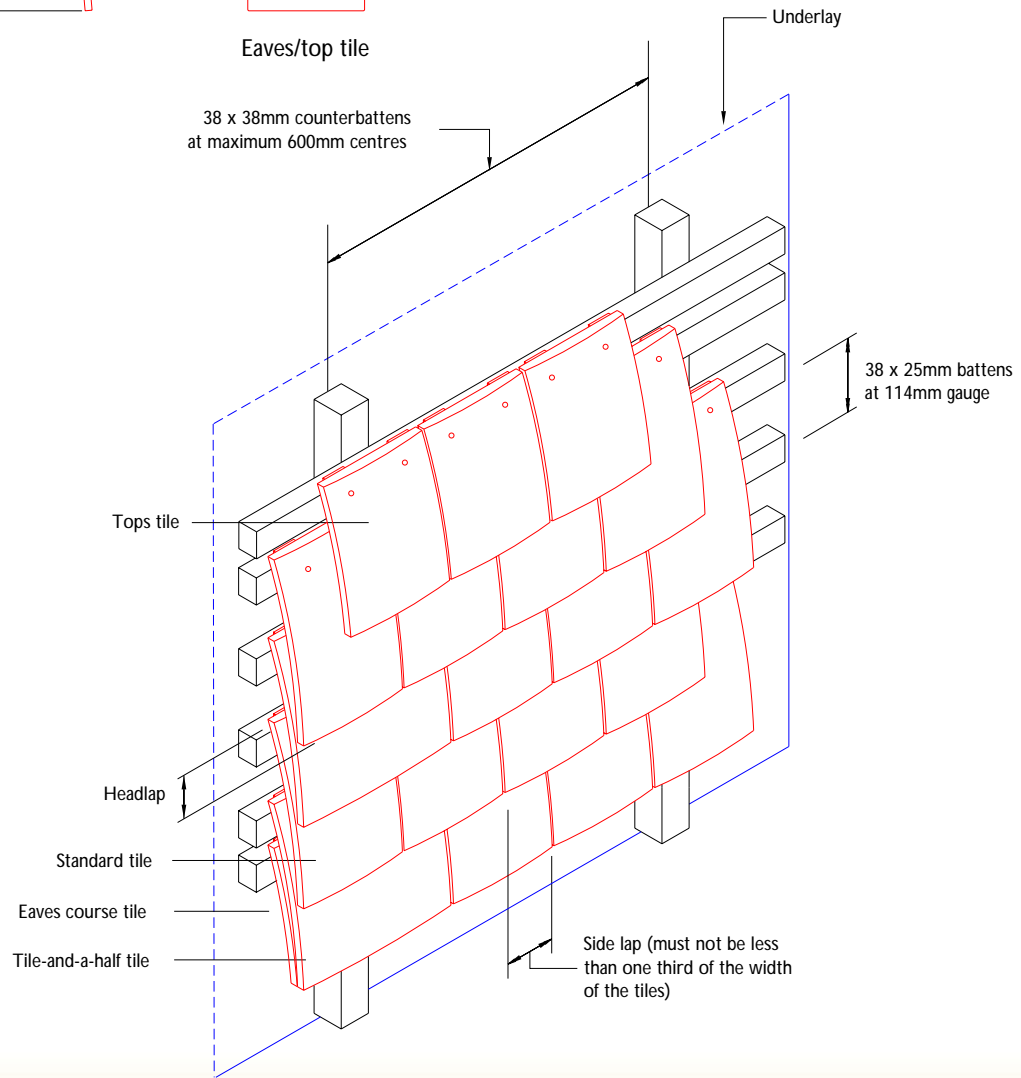
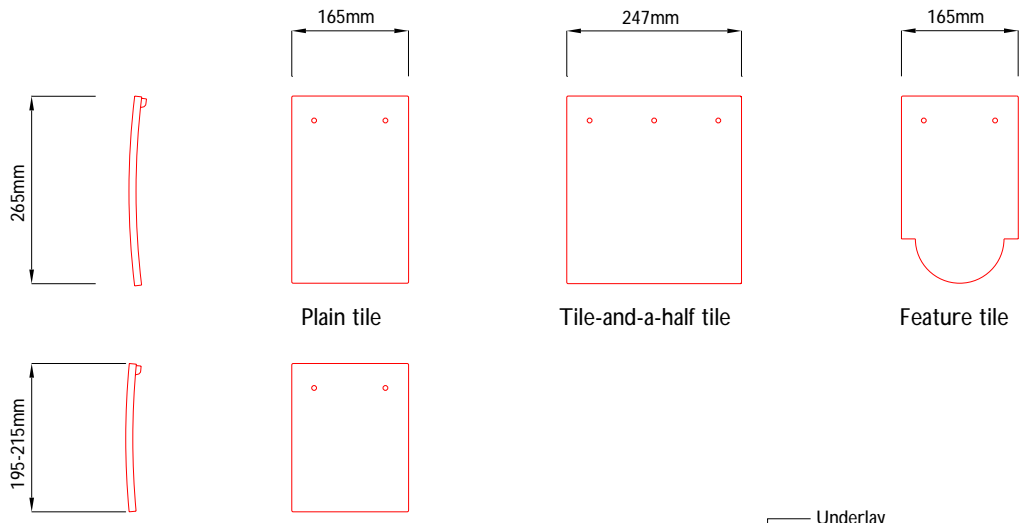
Accessories

Accessories may be made of clay or other materials and are used in combination with clay tiles to fulfil a functional requirement of the roof, e.g., ventilation tiles.

Common types of tiles and general terms

Drawing No 1 illustrates the common types of tiles and the general terms used in fixing them to a wall; ie gauge, headlap and sidelap.

(1) Vertical tiling - illustration of terms



DESIGN

Introduction

This chapter outlines the key issues that need to be considered during the design stage of a vertical tiling project. The design issues are listed under *Performance design specifications* and *Prescriptive design specifications*.

Performance design specifications:

Wind load

On the lee side of a building the wind can create a suction on the tiles and this vacuum effect is at its highest adjacent to the eaves. Because the wind force can be greater than the resistance provided by single nailing, twice nailing is specified in the Code of Practice for Slating and Tiling, BS 5534.

The methods for calculating the wind uplift load are given in BS 5534 and BS 6399 and an outline of the calculation method, and examples, are given in appendix B.

Where the minimum fixing specification of two smooth nails does not meet the calculated wind uplift resistance, alternative fixing methods must be used, e.g. improved nails (ring shank), screws, clips and proprietary fixings.

Control of Condensation

The method of assessment given in BS 5250 should be used and where the risk of condensation is identified a vapour control layer should be incorporated within the structure.

Rain and snow resistance

The lap arrangement for tiles has proven to be a good rain protection system. Please note that the European driving rain test for walls was designed for sealed systems and should not be used with tiled wall structures.

Tile durability

Plain tiles that meet the requirements of BS EN 1304 are satisfactory for vertical tiling. Experience has shown that the risk of freeze / thaw damage in vertical tiling is low, especially with a large eaves overhang, and tiles that do not meet the freeze / thaw requirements of BS EN 1304 may be acceptable for vertical tiling but the advice of the manufacturer should be sought on the suitability of the tiles for any particular application.

The development of a single European test method to establish durability has been approved and the development programme has been started. Five weathering sites have been established and these will be used to calibrate the proposed new test method. It is anticipated that there will be one test method and three, or, more, pass / fail criteria, which relate to the various exposure conditions in Europe.

Impact resistance

Traditionally, clay tiles have been used for vertical cladding and they have proved to be suitable for this application. Design consideration should be given to circumstances where impacts can be expected, e.g., sports activities, golf, tennis, etc., and guidelines on when they should only be used above 2 metres are given in the Building Regulations.

Thermal capacity

The product properties are specifically related to water permeability and aesthetics and it is the role of other products to provide the necessary thermal performance for the building. The thermal insulation contribution of clay tiles and batten cavity (0.17R) can be ignored.

Noise

The gaps between the tiles permit sound to be transmitted through the tile cladding and it is the role of other products in the wall construction to provide the sound insulation for the building.

Fire resistance

Vertical clay tiles meet the requirements of the Building Regulations Approved Document for walls within 1 metre of a notional boundary and greater than 15 metres above the ground.

It is anticipated that the proposed European external fire test will not apply to clay tiles because they are incombustible and have a reaction to fire rating better than class A2.

Where window openings occur close to the eaves the head of the window should not allow fire to spread into the batten cavity. The resistance to the spread of fire through the soffit into roof is a requirement for multiple occupancy buildings (Building Regulations, Section 9, Concealed Spaces and B4 External Fire Spread).

Moss, lichen and algae

Moss, lichen and algae occur in circumstances where vertical tiling dries slowly after rain, e.g., north facing walls, and, where the air is clean.

Insect and bird resistance

There is no requirement to resist the ingress of insects unless the design of the wall penetrates the underfelt which would allow access to the roof or wall structure.

The BS 5534 specifications are 4mm maximum opening for insects and 16mm opening for birds. Where there is a requirement to meet the 4mm recommendation this can be achieved with tiles where there is no cross camber or where the cross camber is less than 2mm. It may be necessary to select tiles without twist, or, where the twist is less than 4mm.

Prescriptive design specifications :

Head and sidelap

The headlap specification in BS 5534 is a minimum of 37.5mm and the maximum gauge of battens is 114mm. For visual continuity gauges of less than 88mm should be avoided.

The sidelap should be not less than one third the width of the tile, typically 55mm.

With Winchester cuts the side lap may be reduced to 38mm provided there is adequate overhang of the verge.

Aesthetics

Plain tiles can be obtained in a range of finishes and colours, e.g., they may be single or double cambered, smooth or sand finished, square or round edged. The photographs given throughout the text illustrate part of the range of colours and finishes that are available.

WALL STRUCTURE

Since it is possible to hang tiles on almost any wall construction it would not be possible to illustrate every combination of wall structure and tile fixing method. Nevertheless, the range of examples given in this guide should meet the needs of most new and replacement tile hung walls.

Types of wall construction

Drawings are provided for the following common wall structures :

- Lightweight concrete blocks (drawing number 2);
- Dense concrete blocks (drawing number 3);
- Stone (drawing number 3);
- Old and new common bricks (drawing number 4);
- Pre-cast concrete panels (drawing number 5);
- Timber stud and plywood sheathing (drawing number 7);
- Metal frame (drawing number 8);
- Rendered walls (drawing number 6);

Batten and counter batten security

The methods for securing battens and / or counter battens to the wall may be influenced by the age of the wall. Older walls usually require counter battens secured with a proprietary fixing system such as Rawlplug or Hilti type bolts.

Counter battens are recommended for wall types :

- Dense concrete blocks
- Pre-cast concrete panels
- Old bricks
- Old lightweight concrete blocks
- Stone

It is possible to secure battens directly to the following wall types :

- New common bricks
- New lightweight concrete blocks
- Timber stud and plywood sheathing
- Metal frames

Calculation method for determining the number and type of fixings for securing battens and counter-battens is described in Appendix B. The calculation includes consideration of tensile and sheer loads. Advice on fixing should be sought from the fixings manufacturer and the manufacturer of the material used to construct the wall.

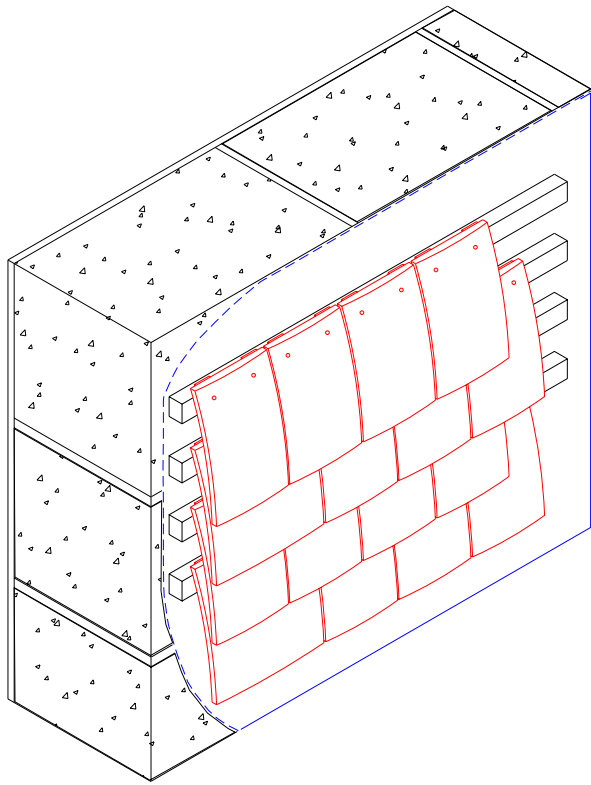
General considerations

The wall should be covered with a suitable underlay lapped 75mm horizontally and 150mm vertically. Ensure distance of fixing at edge is not less than 50mm from edge of tiles.

Tiling battens, minimum length 1200mm, should be fixed to the wall at maximum 114mm gauge or to counterbattens fixed at 450 to 600mm centres. The choice of fixings will depend upon the type of wall construction.

Lay plain tiles in staggered bond ensuring tails of tiles align and fix each tile to timber tile batten with two clout nails.

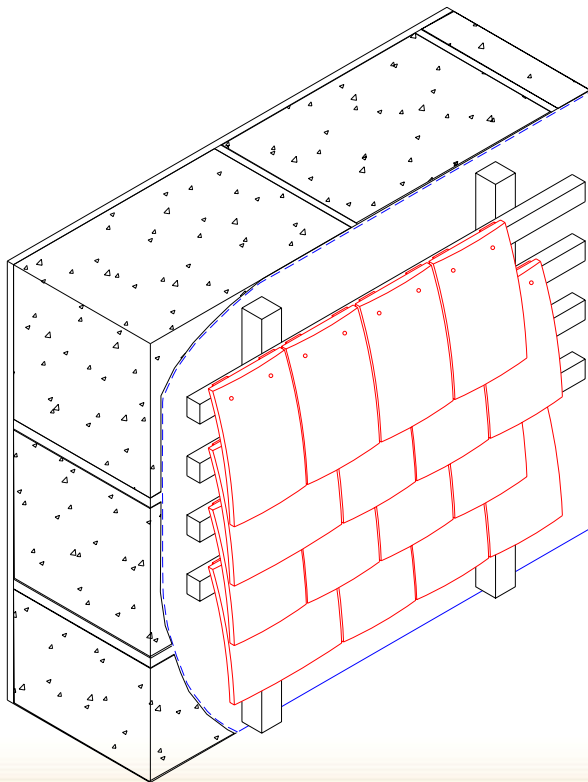




(2) Wall Construction

- new lightweight concrete blocks

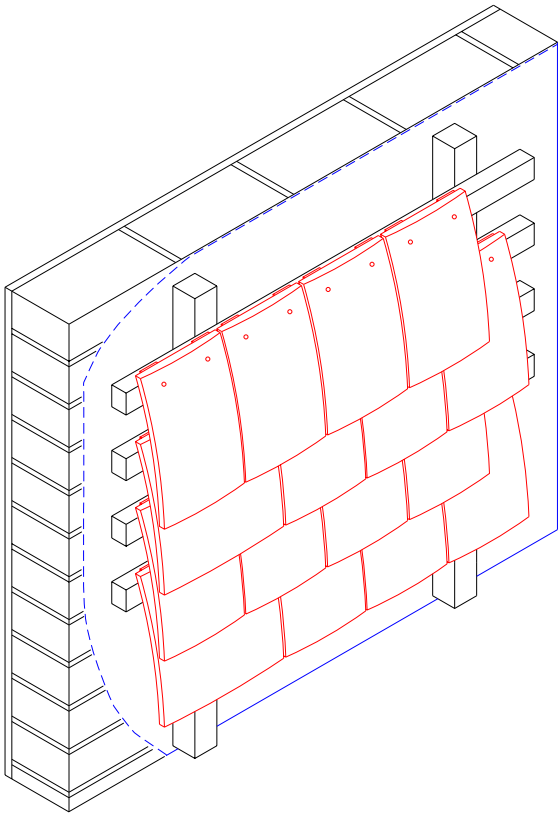
Fix tiling battens directly to blockwork using aluminium or mild steel cut nails (75 to 100mm long) driven in askew at 450mm centres into blockwork.



(3) Wall Construction

- dense concrete blocks
- old lightweight concrete blocks
- stone masonry

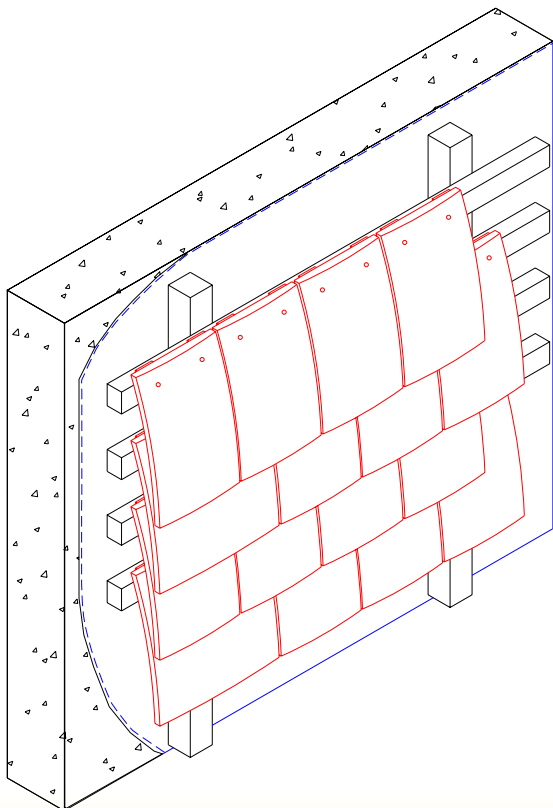
Fix timber counterbattens spaced at maximum 600mm centres to masonry using proprietary corrosion resistant fixings. Secure to timber pads set into bed joints or to drilled and plugged holes. Ensure that length and type of fixing has adequate withdrawal resistance in the material to which it is being nailed/screwed.



(4) Wall Construction

- old and new common brick

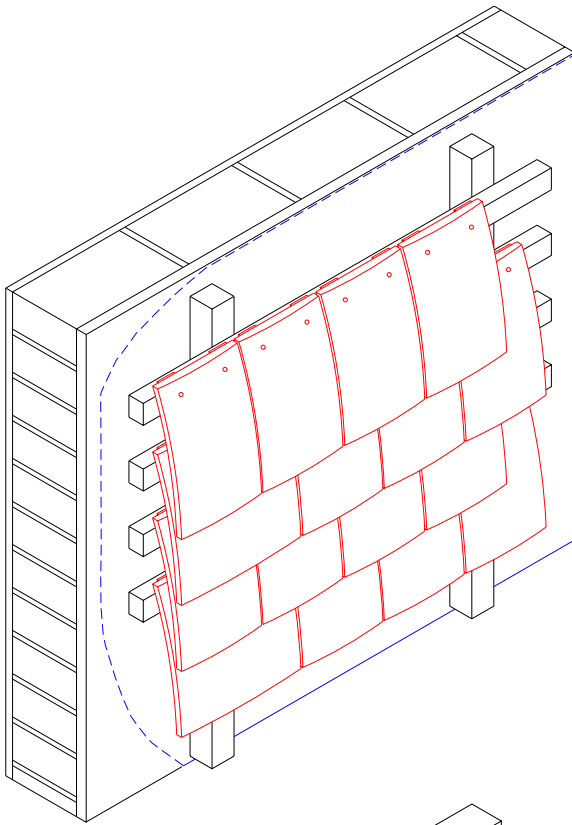
Fix timber counterbattens spaced at maximum 600mm centres to masonry using proprietary corrosion resistant fixings.
Secure to timber pads set into bed joints or to drilled and plugged holes.
Ensure that length and type of fixing has adequate withdrawal resistance in the material to which it is being nailed/screwed.
(It may be possible to fix tiling battens directly onto some types of new bricks)



(5) Wall Construction

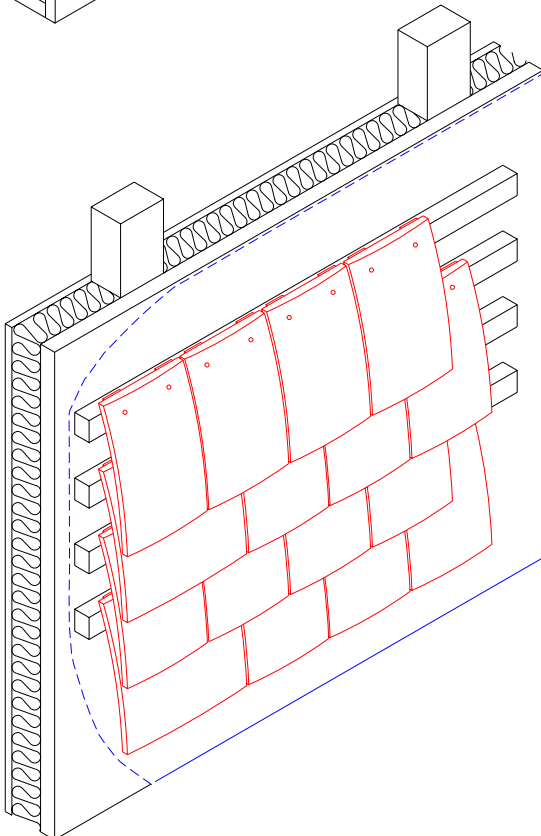
- pre-cast concrete panels

Fix timber counterbattens to concrete panel spaced at maximum 600mm centres using proprietary corrosion resistant fixings or nailed to timber pads set into concrete panel.
Ensure that length and type of fixing has adequate withdrawal resistance in the material to which it is being nailed/screwed.



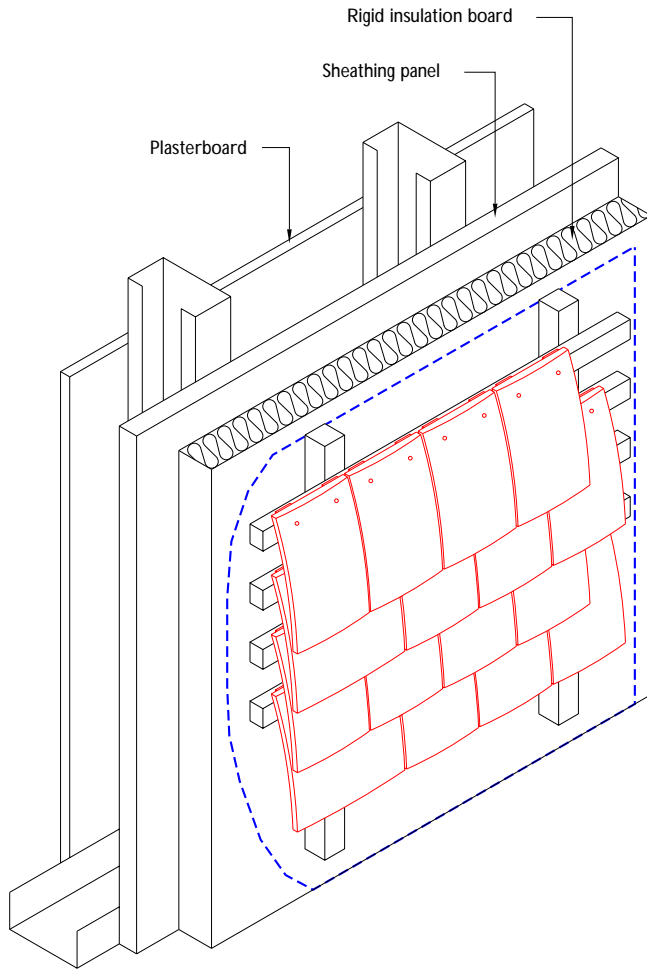
(6) Wall Construction
- rendered

Fix timber counterbattens to masonry spaced at maximum 600mm centres using proprietary corrosion resistant fixings. Secure to timber pads set into bed joints or to drilled and plugged holes. Ensure that length and type of fixing has adequate withdrawal resistance in the material to which it is being nailed/screwed - it should be assumed that the render has no significant withdrawal resistance.



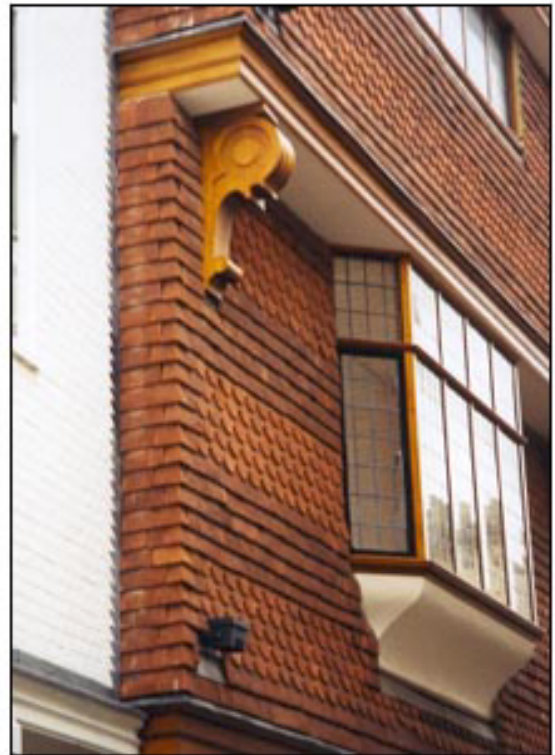
(7) Wall construction
- timber stud and plywood sheathing

Cover plywood sheathing with approved breathable membrane. Fix tiling battens to vertical studding using round wire, galvanised or improved nails of sufficient length required to resist predicted withdrawal loads.



(8) Wall construction
- metal frame

If required, cover sheathing panel with approved breathable membrane.
Secure tiling battens to metal frame using corrosion resistant self-tapping screws or proprietary fixings as recommended by manufacturer.
Fixings should be of sufficient length to resist predicted withdrawal loads.
(This illustration is re-produced with the kind permission of the Steel Construction Institute. For further information refer to the SCI publications 'Detailing and Practice' and 'Modular Construction').



TILING

Setting out

The means of securing the counter battens, or, battens to the wall structure should be decided before the tile battens are set out and nailed to the counter battens or the wall structure.

The setting out of battens needs to take into account the top and bottom of the wall and the openings through it, such as windows. The top of the wall and the bottom edge are called fixed points and the top and bottom of each opening are also defined as fixed points. The fixed points are used to calculate the batten gauge. For example, on a wall with one window, the bottom edge of the wall and the lower edge of the window will be used to calculate the batten gauge between these two points, and the bottom of the window and the top of the window are used to determine the batten gauge on this section of the wall, etc.

Starting at the bottom edge of the wall a full length tile is positioned to ensure that it just covers the wall structure below it but does not interfere the opening of any doors or windows. The position of the underside of the nibs are marked on the wall and the process repeated at various positions along the wall. Ideally, all the marks should be in the same horizontal plane. If they are not, one mark should be adopted as the common datum, or, a step in the tiling should be established to allow for at a feature such as an internal corner. Where a change of bottom row of tiles is planned the difference in level should be a module of the tile gauge, which can be any dimension between 114mm and 88mm. When the line of the top of the first batten is set, it should be nailed in position.

The top of the wall has the top course (eaves / top tiles) and is set out to allow the head of the top tile, including the nibs, to fit under the eaves, or, other feature. Once this batten is in place, the last full tile batten can be located to allow just enough space between the bottom of the top tile batten and the top of the last full tile batten, to permit the last full tile to slide between them. Provided the tile batten is no wider than 38mm the top tile should provide adequate cover for the last full tile course.

The first fixed point should be identified, which may be a windowsill. The top tile course (eaves / top tiles) is set out to allow the head of the top tile, including the nibs, to fit under the windowsill. With the batten in place, the last full tile batten can be located to allow just enough space between the bottom of the top tile batten and the top of the last full tile batten, to allow the last full tile to slide between them. Provided the tile batten is no wider than 38mm the top tile should provide adequate cover for the last full tile course. If the distance between the eaves course and the first fixed point is relatively short it may be difficult to set a gauge that reaches the windowsill and a decision to have a longer flashing may need to be made.

Between the top of the first and the last full tile courses of any fixed points, the intermediate battens will need to be set out to ensure that the gauge is as close to 114mm, but not less than 88mm. This is achieved by measuring the overall gauge distance and dividing it by 114mm.



The answer to the sum will be a whole number and a decimal point. Whatever the whole number is, increase it by one and divide that number into the gauge distance. The answer to this sum will provide the gauge that the intermediate battens should be set out at.

The next fixed point in the wall needs to be identified and set out depending upon whether it is a bottom edge or top edge, and the battens between them gauged out equally until the last full tile batten is reached.

All tile battens should be horizontal (level) and straight, with no sags.

Having set out and nailed all the battens the setting out of tiles on each batten should be considered. Each plain tile is 165mm wide and can have up to 3mm gap between them. The first course of tiles should be set out to equalise all the gaps between the tiles, start and finish at corner or abutments and hopefully line up with the sides of window openings. Having settled on an arrangement, the battens should be marked every third or fifth joint. To ensure that the joints are vertical drop plumb lines and mark the battens.

The eaves course of tiles are laid broken bond to the first course of tiles – this may require the use of an eaves tile and half. These can be made by cutting a full tile-and-a-half down to the same length as the eaves tile. The same may apply at the top tile course but is more critical as it is more visible.

At window reveals it may be necessary to finish with a cut tile-and-a-half on each course to maintain the vertical perpendicular joints. The tiles may need to be sorted to mix oversize and undersize tiles together to ensure that an averaging out allows the perpendicular joint lines to be kept vertical. If this becomes a problem it may be necessary to trim every fifth tile down to suit.

Tiles should always be sorted and mixed from at least three pallets to ensure that the variations in shade and colour from different parts of the kiln do not give a patchy effect. Also, tiles that are twisted may kick out in one position, but sit happily in another when tried.

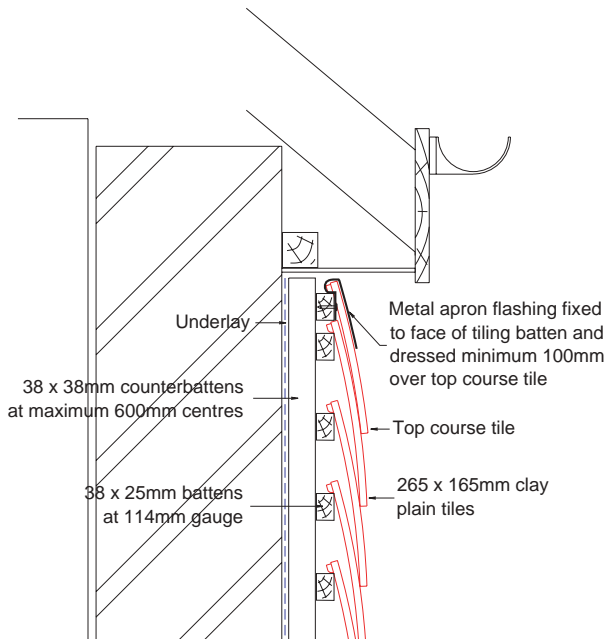
It can be seen that, like brick laying, vertical tiling needs more planning during the setting out phase than roof tiling and being more visible requires greater care in maintaining the vertical joint lines.

Because less rain and frost are likely to fall on vertical tiling the self cleaning action of the elements are a lot slower, therefore, marks on vertical tiling may need to be cleaned off rather than waiting for the natural weathering of the tiles.

Main tile design details

The following illustrations and text explain the common main tile design details that can occur on refurbishment and new work. The drawings include details at eaves, windows, abutments, internal and external corners. Tiling of gables is included and details of Winchester, Sussex and Soldier finishes are given.





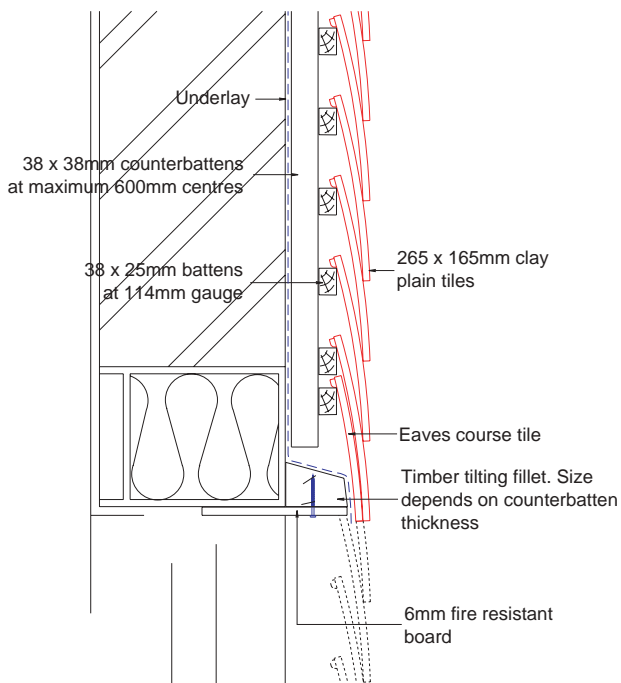
(9) Vertical tiling to eaves with soffit

Finish battens approximately 90mm below the soffit board to allow for the top tile batten to be installed. Install a lead cover flashing to lap over the top tile by a minimum of 100mm. If no top tile is used the lead flashing coverage should be extended to 150mm.

Nail the bottom edge of the lead flashing (minimum 200mm wide, Code 4) along the face of the top tile batten and dress it into the top tile nib space below the soffit board. Once the top tiles have been nailed the flashing can be carefully dressed onto the surface of the top tile.

When using a decorative flashing add the decorative section onto the coverage such that it does not compromise the lap relative to the vertical joint and the nail holes.

This arrangement is useful when fixing vertical tiling to the face of an existing building.



(10) Vertical tiling to window head: V1

Set the eaves course above the window to allow the window to be installed or removed after the vertical tiling has been installed.

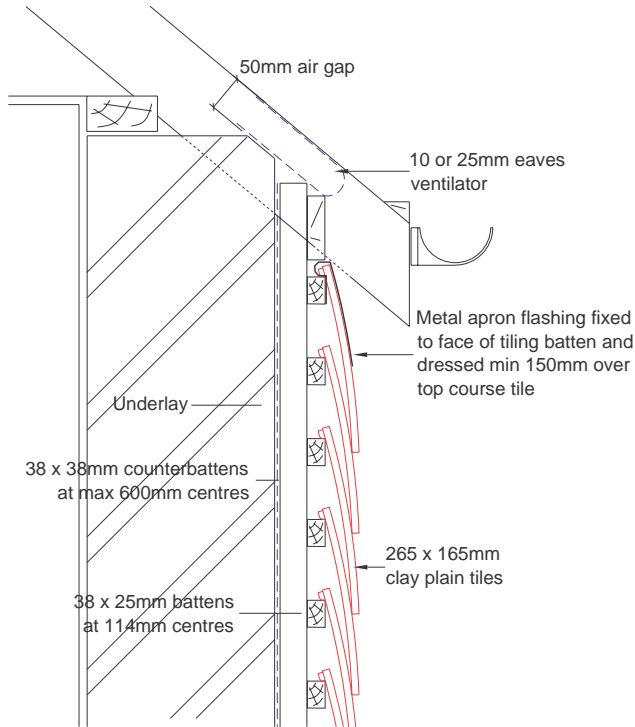
Set the gauge of the vertical tiling between the window sill and window head to eliminate the need for cutting the eaves course of tiles.

Fix a shaped timber tilting fillet to the face of the lintel (approximately 100 x 75mm) large enough to support the eaves course of tiles in the same plane as the rest of the vertical tiling.

Dress the underlay over the tilting fillet to a slight fall.

Terminate the counterbattens just below the eaves tile batten to allow the underlay to dress out over the tilting fillet.

Fix a minimum 6mm thick fire resistant board to the underside of the tilting fillet. Alternatively, cut plain tiles with their nibs removed could be used.



(11) Vertical tiling to eaves with open rafter

Finish under roof eaves with a continuous course of tops tiles.

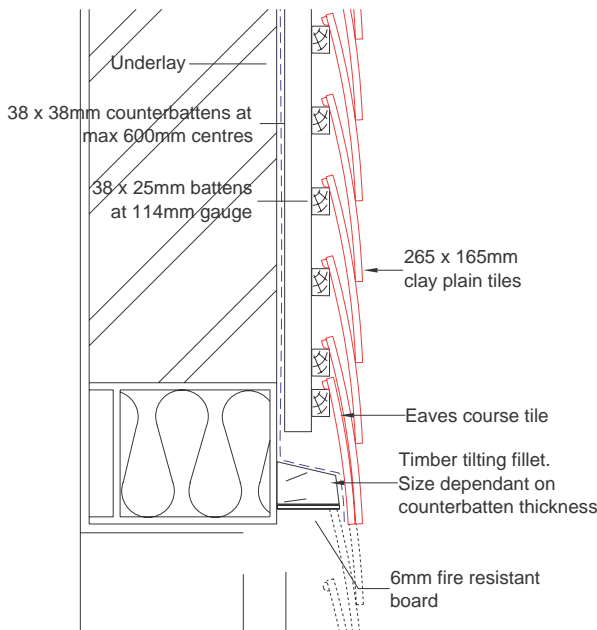
Fix a code 4 lead flashing to cover the top tiles as described in detail (9).

Where the roof is ventilated using a vent tray between the rafters, the air path to the grill must be maintained.

Set the counterbattens at maximum 600mm centres and extend as high as possible.

The spacing between the open rafters and above the top tiles needs to be in-filled. This can be achieved by 19 or 25mm timber boarding, fixed to vertical noggins nailed into the sides of the open rafters.

Note: Where there is no provision for eaves ventilation the timber boarding can be extended up to touch the underside of the roofing underlay. This detail will prevent birds from nesting between the rafters.



(12) Vertical tiling to window head: V2

Set the eaves course above the window to allow the window to be installed or removed after the vertical tiling has been installed.

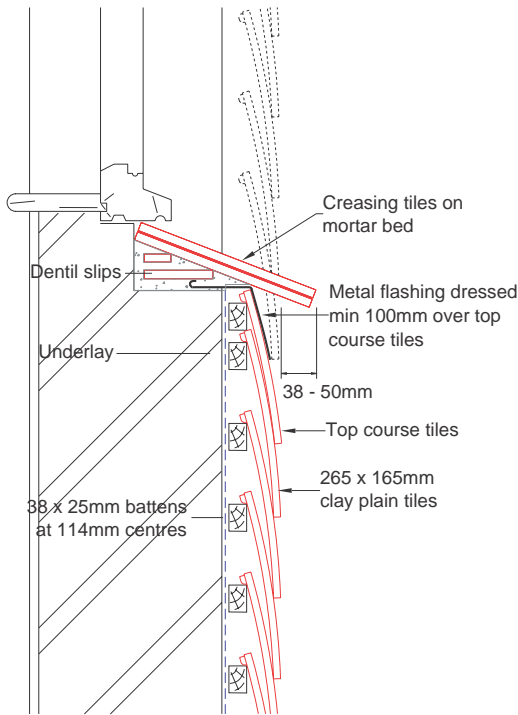
Set the gauge of the vertical tiling between the window sill and window head to eliminate the need for cutting the eaves course of tiles.

Fix a shaped timber tilting fillet to the face of the lintel (approximately 100 x 75mm) large enough to support the eaves course of tiles in the same plane as the rest of the vertical tiling.

Dress the underlay over the tilting fillet to a slight fall.

Terminate the counterbattens just below the eaves tile batten to allow the underlay to dress out over the tilting fillet.

Fix a minimum 6mm thick fire resistant board to the underside of the tilting fillet.



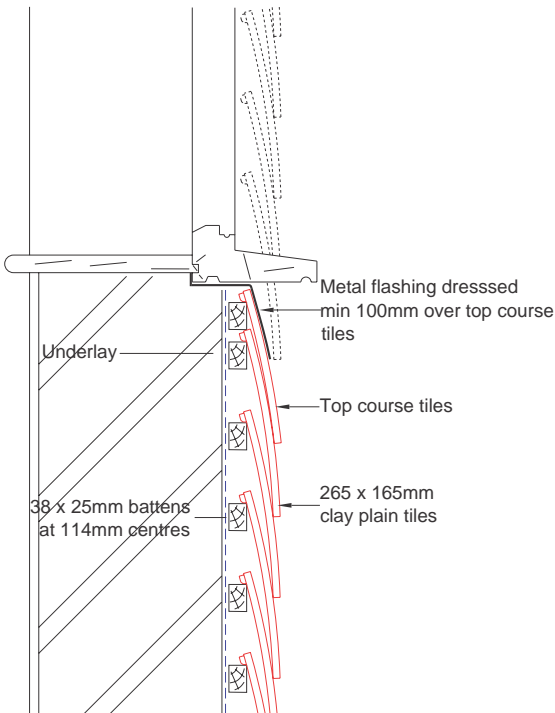
(13) Vertical tiling to tiled window sill

Ensure that there is a suitable fall on the top surface of the double course of creasing tiles to allow water to run away from the window frame. A cut out in the external wall may be required.

Finish battens below the window opening to allow the top course of tiles to fit under the window sill. Lay the creasing tiles broken bonded bedded on mortar (1:3 Cement:sand) using dentil slips as required. The creasing tiles should overhang the vertical tiling by 38 to 50mm.

Install the lead flashing (Code 4) into the mortar bed. Once the top tiles have been fixed the flashing can be carefully dressed onto the surface of the top tiles. When using a decorative flashing add the decorative section onto the coverage such that it does not compromise the lap relative to the vertical joint and the nail holes.

The flashing should cover the top tiles by a minimum 100mm. If tops tiles are not used then the flashing should be extended to 150mm. It should extend a minimum of 150mm beyond the jamb on either side.

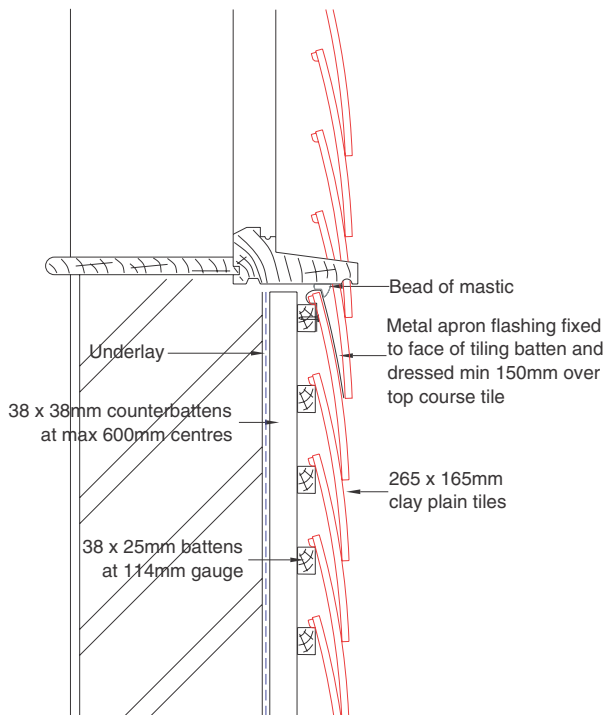


(14) Vertical tiling to timber window sill: V1

Finish battens below the window opening to allow the top course of tiles to fit under the window sill. Nail a lead flashing (minimum 200mm wide: Code 4) to the underside of the timber sill before it is installed. Once the tops tiles have been fixed the flashing can be carefully dressed onto the surface of the top tiles.

When using a decorative flashing add the decorative section onto the coverage such that it does not compromise the lap relative to the vertical joint and the nail holes.

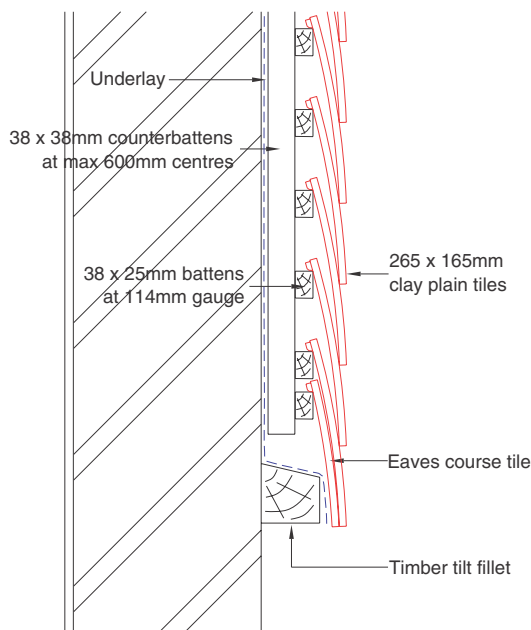
The flashing should cover the top tiles by a minimum 100mm. If tops tiles are not used then the flashing should be extended to 150mm. It should extend a minimum of 150mm beyond the jamb on either side.



(15) Vertical tiling to timber window sill: V2

Finish battens below the window opening to allow the top course of tiles to fit under the window sill. Nail the bottom edge of the lead flashing (minimum 200mm wide: Code 4) along the face of the top tile batten and dress it into the top tile nib space. Once the top tiles have been fixed the flashing can be carefully dressed onto the surface of the top tiles. When using a decorative flashing add the decorative section onto the coverage such that it does not compromise the lap relative to the vertical joint and the nail holes.

The flashing should cover the top tiles by a minimum 100mm. If top tiles are not used then the flashing should be extended to 150mm. It should extend a minimum of 150mm beyond the jamb on either side.



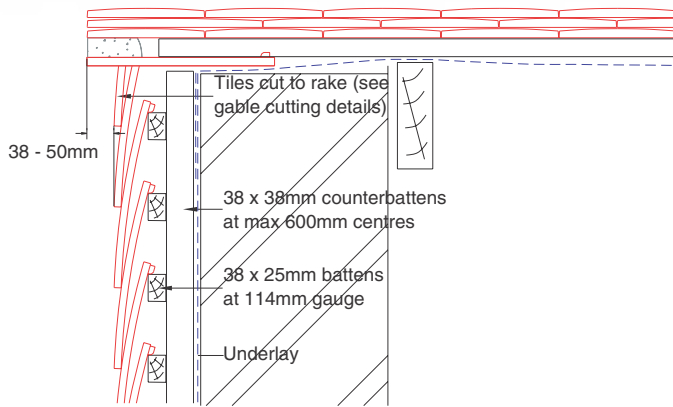
(16) Vertical tiling eaves

Fix a shaped timber tilting fillet to the face of the lintel (approximately 100 x 75mm) large enough to support the eaves course of tiles in the same plane as the rest of the vertical tiling.

Dress the underlay over the tilting fillet to a slight fall.

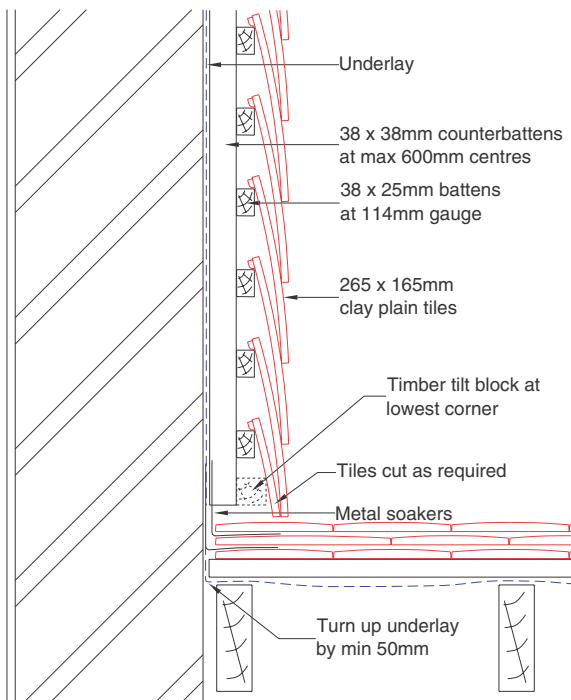
Terminate the counterbattens just below the eaves tile batten to allow the underlay to dress out over the tilting fillet.

Where there is a risk of fire entering the batten cavity fix a minimum 6mm thick fire resistant board to the underside of the tilting fillet.



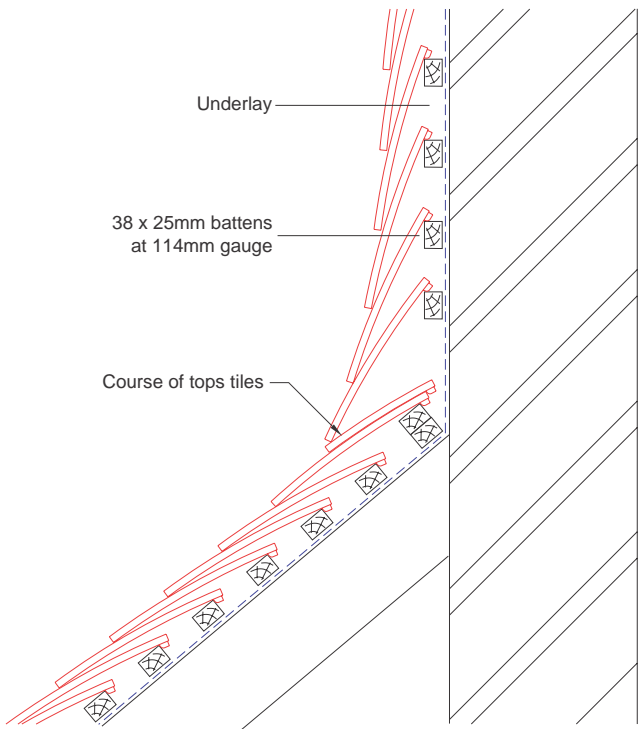
(17) Vertical tiling junction with verge

Extend underlay on main roof to overlap vertical underlay by a minimum 150mm.
 Ensure that verge undercloak extends a minimum 38 to 50mm beyond face of vertical tiling.
 Fix timber batten in line with rake of verge undercloak to provide fixing for cut vertical gable tiles.
 Cut tiles neatly to form detail at junction with verge undercloak.
 (See details 37 to 43 for gable verge treatments)



(18) Vertical tiling junction with side abutment

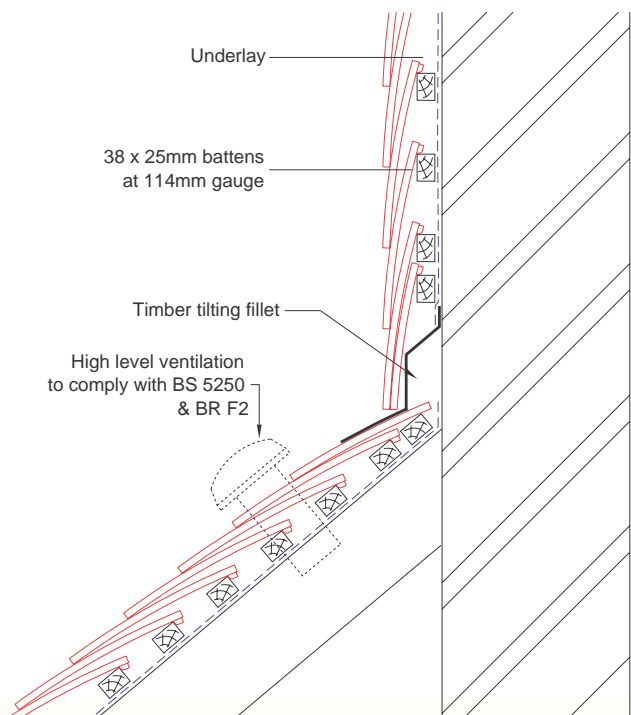
Extend underlay on main roof vertically up the wall by a minimum 50mm and overlap by vertical underlay.
 The vertical upstands of the Code 3 lead soakers inserted between each course of roof tiles should be secured behind the battens/counterbattens of the vertical tiling.
 Fix a timber tilt batten to the rake of the roof tiling to provide support for raking cut vertical eaves tiles.
 Cut tiles neatly and as close to the main roof tiling as possible.



(19) Swept tiling to top abutment

Extend underlay on main roof vertical up the wall by a minimum 50mm and overlap by vertical underlay. Fix a double thickness of tiling battens at the top of the main roof slope and lay a course of tops tiles 'piggy back' and broken bonded with the standard tiles in the course below.

The bottom course vertical tiling batten should be fixed in position so as to allow the tail of a standard plain tile to rest on the front of the tops tiles.

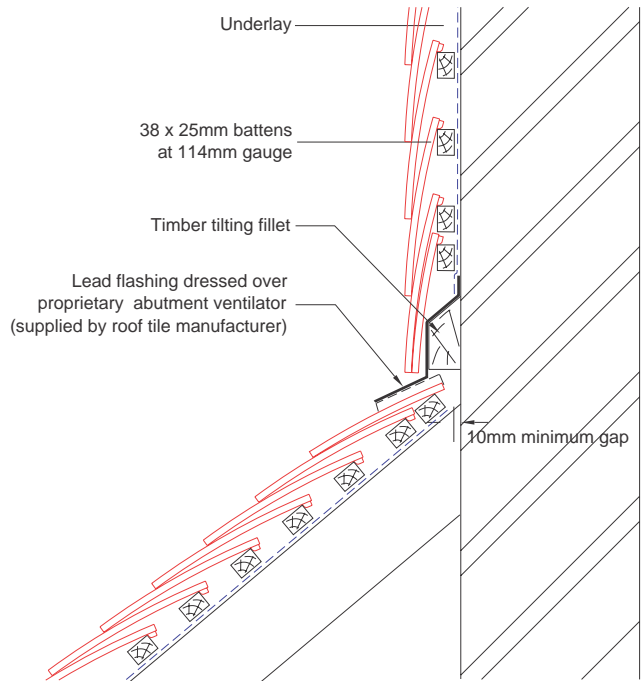


(20) Flashing to top abutment

Extend underlay on main roof vertical up the wall by a minimum 50mm and secure under timber tilting batten.

Dress a Code 4 lead cover flashing over the top course of roof tiles and the tilting batten, carrying up under the underlay and secure behind the bottom vertical tiling batten.

The eaves course of vertical tiling should be positioned closely to the top course of roof tiles.



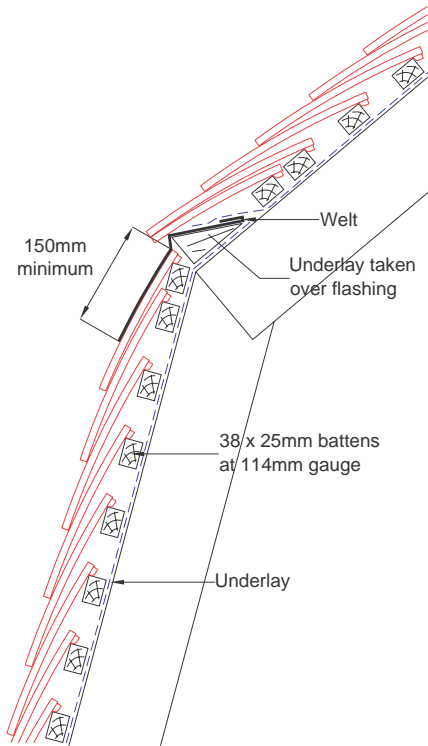
(21) Ventilated flashing to top abutment

Cut back the underlay on the main roof to provide a minimum 10mm gap at the junction with the vertical wall.

Dress a Code 4 lead cover flashing over the proprietary abutment ventilator and the timber tilting batten, carrying up under the underlay and secure behind the bottom vertical tiling batten.

Position the eaves course of vertical tiling closely to the top course of roof tiles and ensure that a minimum 5000 sq mm per metre run air path is maintained.





(22) Flashing to mansard roof

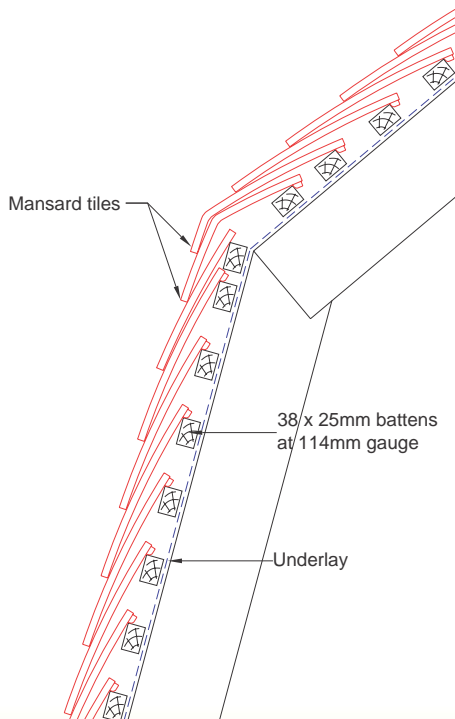
Fix continuous timber tilt batten at eaves to provide support for Code 4 lead cover flashing and eaves course of tiles.

Ensure that a clear ventilation path is maintained from eaves to ridge where insulation is positioned between the rafters.

Lap roof underlay over the lead welt and secure mansard underlay under tilt batten.

Dress cover flashing over the top course mansard tiles by minimum 150mm and extending 150-200mm up the tilt batten.

Clip the bottom edge of the flashing in exposed locations.

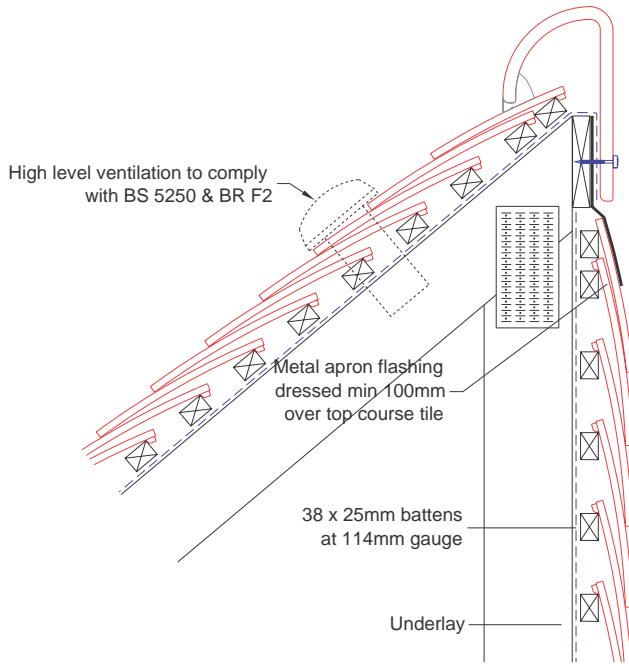


(23) Mansard roof with mansard tiles

Ensure that a clear ventilation path is maintained from eaves to ridge where insulation is positioned between the rafters.

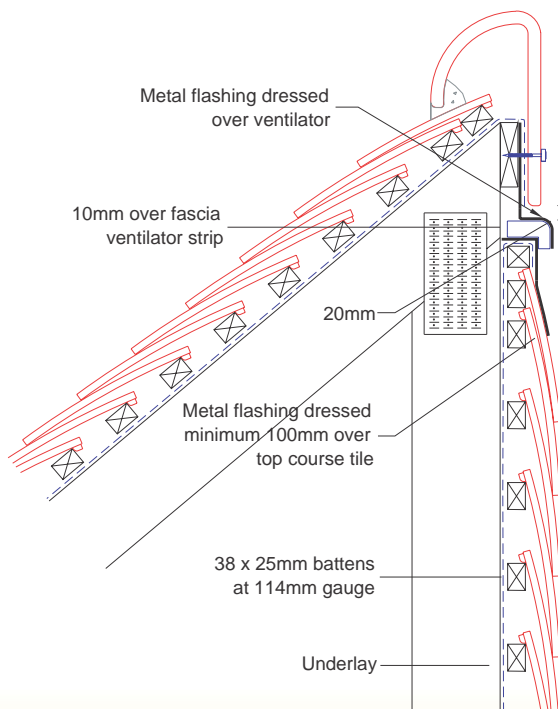
Lap the roof underlay over the mansard underlay by minimum 150mm.

Establish the correct number of courses of mansard tiles to maintain minimum headlap of 65mm.



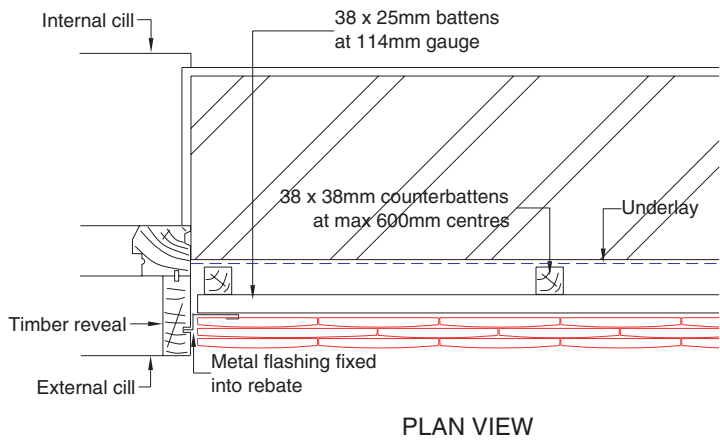
(24) Vertical tiling junction with monopitch roof: V1

Provide continuous timber fascia located directly above top course vertical tiles.
 Fix Code 4 lead cover flashing to fascia and cover with mono ridge tile.
 Dress lead cover flashing over the top course tiles by minimum 100mm.
 Install vent tiles spaced to provide the equivalent of 5000 sq mm per metre high level ventilation to the main roof space.



(25) Vertical tiling junction with monopitch roof: V2

Provide continuous timber fascia located directly above top course vertical tiles.
 Fix Code 4 lead cover flashing to fascia and cover with mono ridge tile.
 Install strip ventilator to provide 10,000 sq mm per metre high level ventilation to the main roof space.
 Dress lead cover flashing over ventilator.
 Dress lead cover flashing over the top course tiles by minimum 100mm.

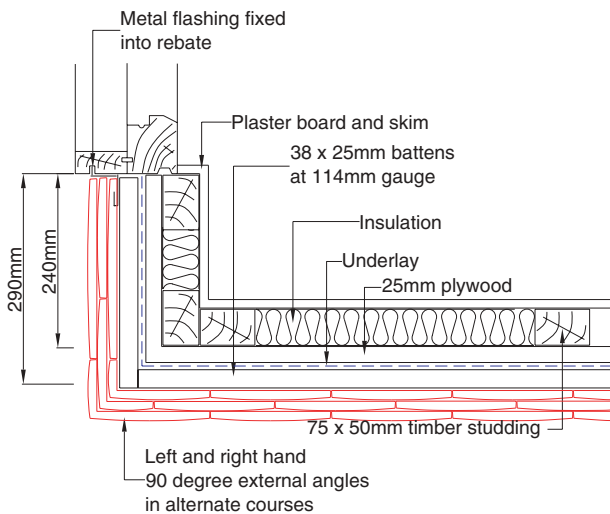


(26) Vertical tiling junction with timber frame side

Cover the ends of the vertical tiling with a timber reveal. The size of the reveal will depend upon the exact position of the window frame relative to the face of the wall.

Fix a vertical lead flashing approximately 200mm wide, turned into a rebate just behind the face of the tiles and terminated with a welt. Finish tiling against the reveal with a full tile and a tile and half in alternate courses.

The first counterbatten should be fixed approximately 20mm in from the end of the batten to prevent the end nail fixing from splitting the tile batten.



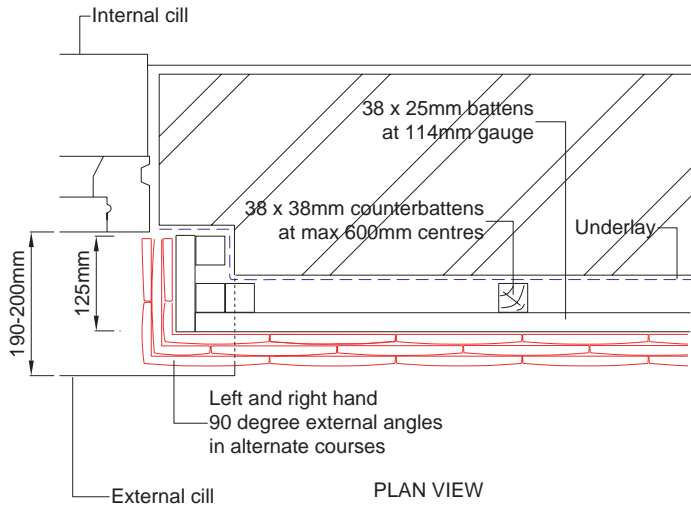
(27) Vertical tiling to dormer side

To avoid tile cutting the distance from the face of the tile batten on the side of the dormer to the window frame should ideally be 290mm. Reducing this distance in increments of 82.5mm will minimise tile cutting to a half tile module.

Handed external angle tiles are fixed in alternate courses up the external corner. Cutting of these should be avoided.

Fix a vertical lead flashing, approximately 200mm wide, turned into a rebate just behind the face of the tiles and terminated with a welt.

Note: If counterbattens are used, these need only be minimum 6mm deep when fixed to timber framing.



(28) Vertical tiling to inset frame: V1

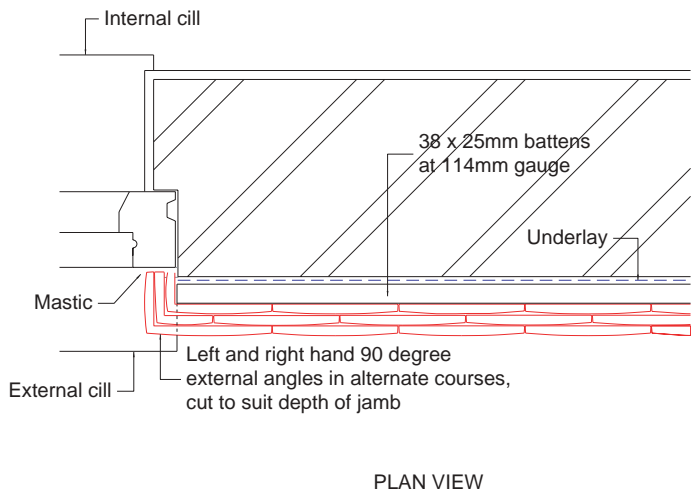
To avoid tile cutting the distance from the face of the tile batten to the window frame should ideally be 125mm, or in increments of 82.5mm to minimise tile cutting to a half tile module.

Handed external angle tiles are fixed in alternate courses up the external corner. Cutting of these should be avoided.

Fix a vertical lead flashing, approximately 200mm wide, turned into a rebate just behind the face of the tiles and terminated with a welt.

The first counterbatten should be positioned approximately 20mm in from the end of the tile batten to prevent the end nail fixing from splitting the tile batten.

(This detail requires a very wide sill and works better with a creasing tile sill detail)



(29) Vertical tiling to inset frame: V2

The window position should be set to eliminate or minimise tile cutting.

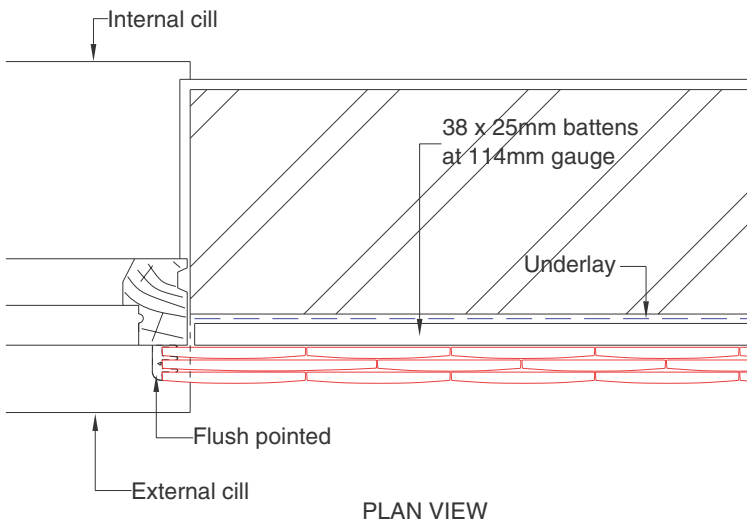
Tiling should finish with handed external angle tiles cut every alternate course to fit the frame.

The cut angle tile will require an additional fixing to maintain security.

The joint between the tiles and the window frame should be bedded in mastic.

The first counterbatten should be positioned approximately 20mm in from the end of the tiling battens to prevent the end nail fixing from splitting the tile batten.

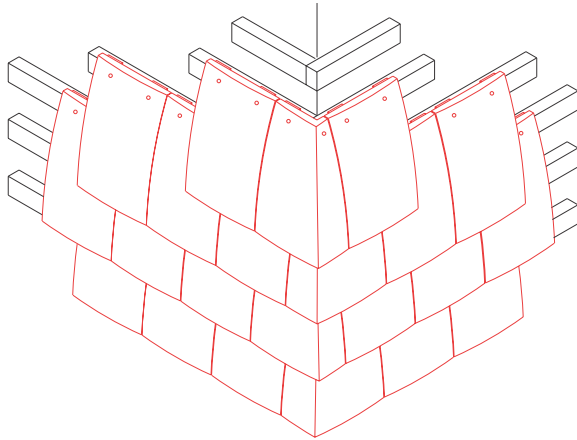
(This detail works best where counterbattens are not used)



(30) Vertical tiling to frame with pointed verge finish

Where the window frame is set back from the wall line, and is installed from the inside of the building, the tiling traditionally has been finished flush with the window opening and the window opening reveals rendered to cover the ends of the vertical tiles. The distance from the face of the windows to the face of the tiling battens is not critical. The tile battens should be cut approximately 50mm short of the end of the tiling to ensure that the mortar does not come in contact with the timber batten end. (This detail works best where there is a short sill to the window that starts below the eaves line of the vertical tiling, such as French windows)





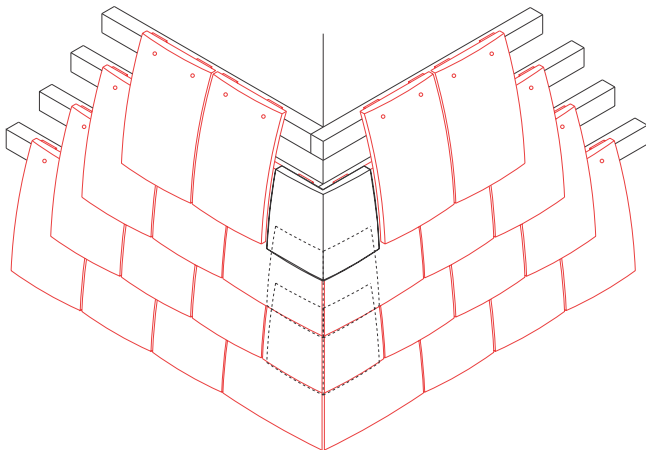
(31) External angle with angle tiles

The first counterbatten should be fixed approximately 20mm in front of the end of the batten to prevent the end nail from splitting the tile batten. The cut ends of the tile battens should be alternated to coincide with the short leg of the external angle tile.

Handed external angle tiles are laid alternately up an external corner.

Each external angle tile should be twice nailed.

Avoid cutting the external angle tiles to make them fit.

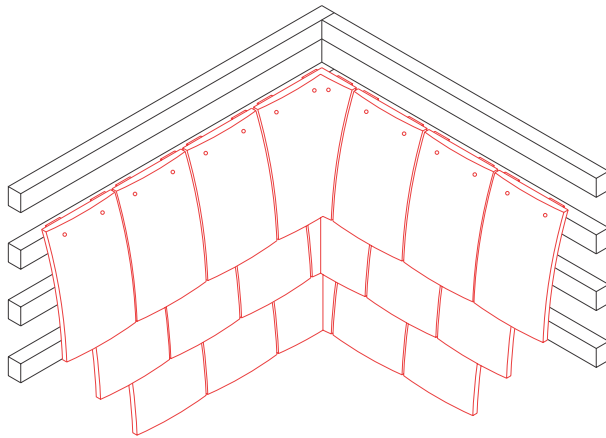


(32) External angle with metal soakers

The first counterbatten should be fixed approximately 20mm in front of the end of the batten to prevent the end nail from splitting the tile batten.

A Code 3 lead soaker is required on each course of tiles. The soaker is cut and folded from sheet minimum 200mm wide and 200mm long. The bottom edge of the soaker is flush with the bottom edge of the tile course above and the top is folded over the head of the tile.

Use tiles and tile and half tiles cut to a mitre in alternate courses to maintain the bond. Twice nail all tiles.



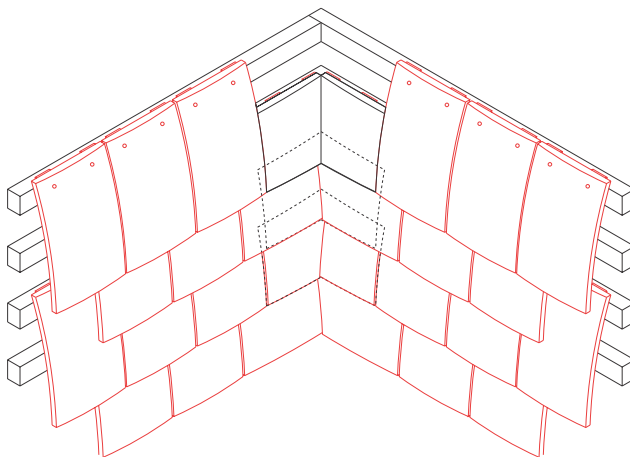
(33) Internal angle with angle tiles

The first counterbatten should be fixed approximately 20mm in front of the end of the batten to prevent the end nail from splitting the tile batten. The cut ends of the tile battens should be alternated to coincide with the short leg of the external angle tile.

Handed internal angle tiles are laid alternately up an internal corner.

Each internal angle tile should be twice nailed.

Avoid cutting the internal angle tiles to make them fit.



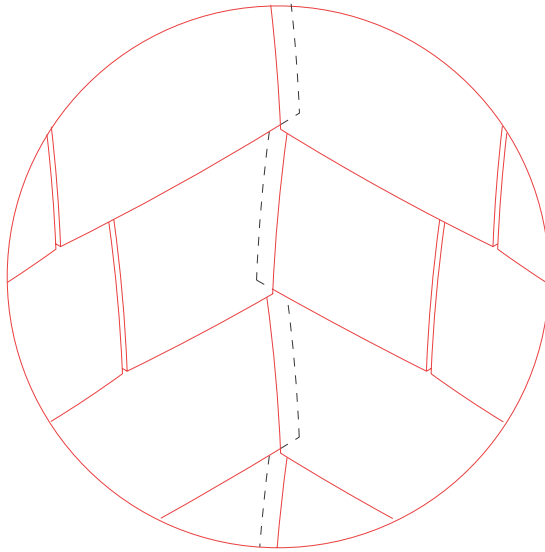
(34) Internal angle with metal soakers

The first counterbatten should be fixed approximately 20mm in front of the end of the batten to prevent the end nail from splitting the tile batten.

A Code 3 lead soaker is required on each course of tiles. The soaker is cut and folded from sheet minimum 200mm wide and 200mm long. The bottom edge of the soaker is flush with the bottom edge of the tile course above and the top is folded over the head of the tile.

Use tiles and tile and half tiles cut to a mitre in alternate courses to maintain the bond. Twice nail all tiles.

(35) Enlarged view of cutting to internal corner

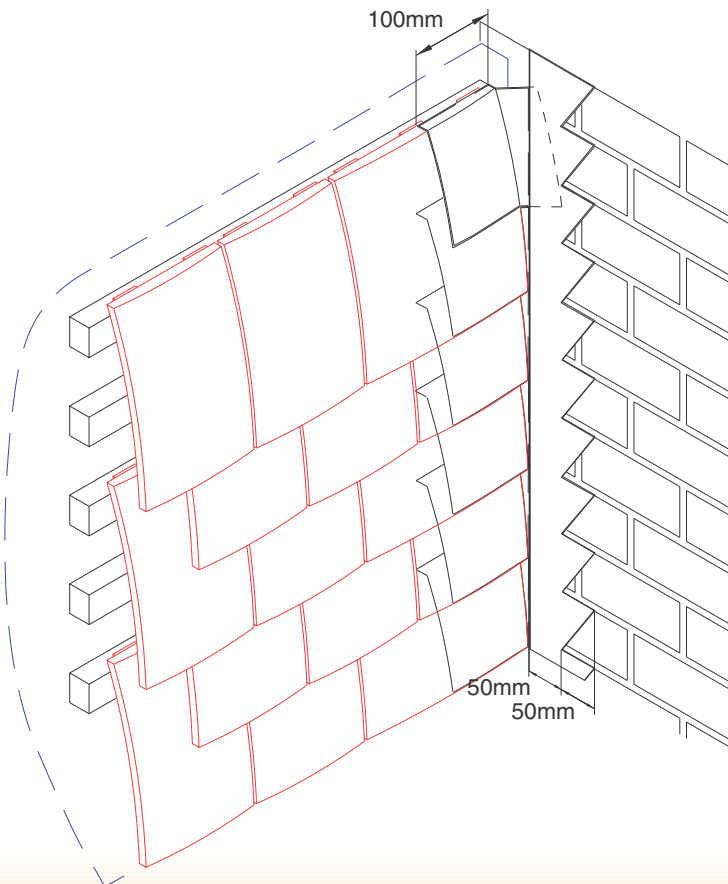


Finish battens approximately 10mm short of abutment wall to allow underlay to turn around the internal corner by 50mm.

Fix the first counterbatten approximately 20mm in from the end of the batten to prevent the end nail fixing from splitting the tile batten.

Turn a cut, folded and welted strip of Code 4 lead 1.5m long and approximately 250mm wide into the joints in the brick or block-work.

Dress the lead over each batten to hold it in place and not interfere with the tile nibs.



(36) Flashing to side abutment with soakers

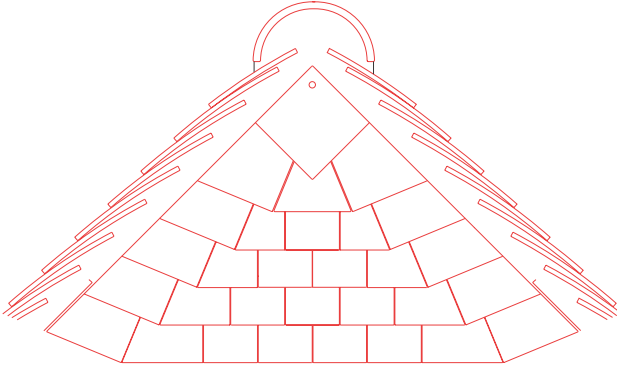
Finish battens approximately 10mm short of abutment wall to allow underlay to turn around the internal corner by 50mm.

Fix the first counterbatten approximately 20mm in from the end of the batten to prevent the end nail fixing from splitting the tile batten.

Fix a soaker, cut and folded from Code 3 lead sheet, minimum 200mm wide and 200mm long, to each course of tiles.

The bottom of the soaker should be flush with the bottom edge of the tile in the course above and the top should be folded over the head of the tile to prevent it dropping out.

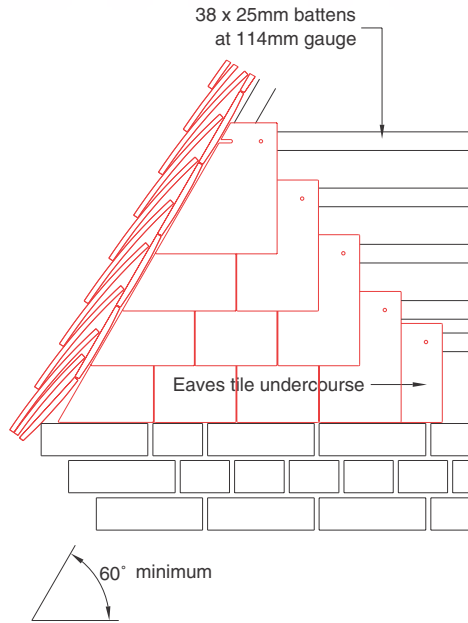
Turn a cut and folded strip of Code 4 lead 1.5m long and approximately 100mm wide into the joints in the brick or block-work, covering the exposed ends of the soakers by approximately 50mm.



(37) Setting out for vertical tiling to gable ends

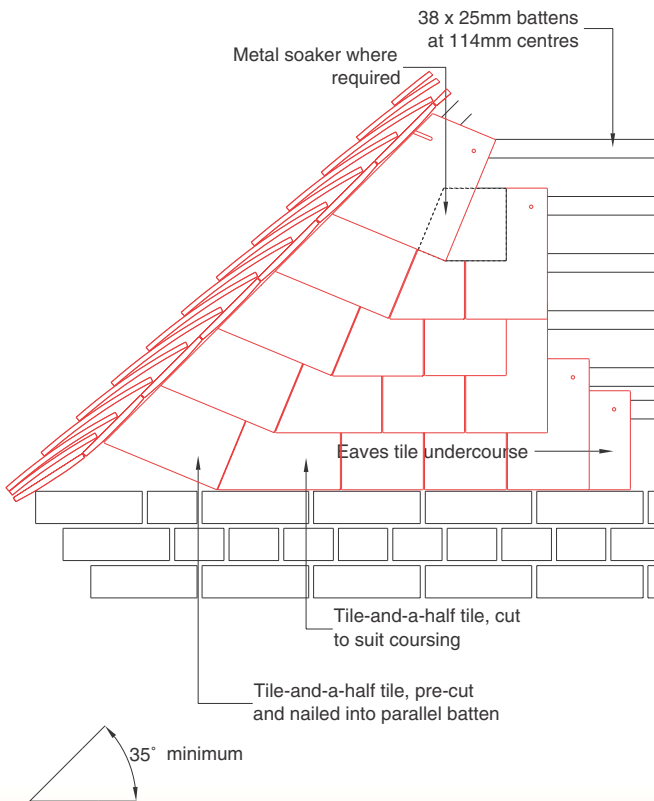
Mark out the gable end wall so that tiling is fixed to exact half bond and commenced so as to avoid a joint above a joint when finishing at the apex. The finish at the apex is best achieved using a shaped piece of tile which is both mechanically fixed and spot bedded.





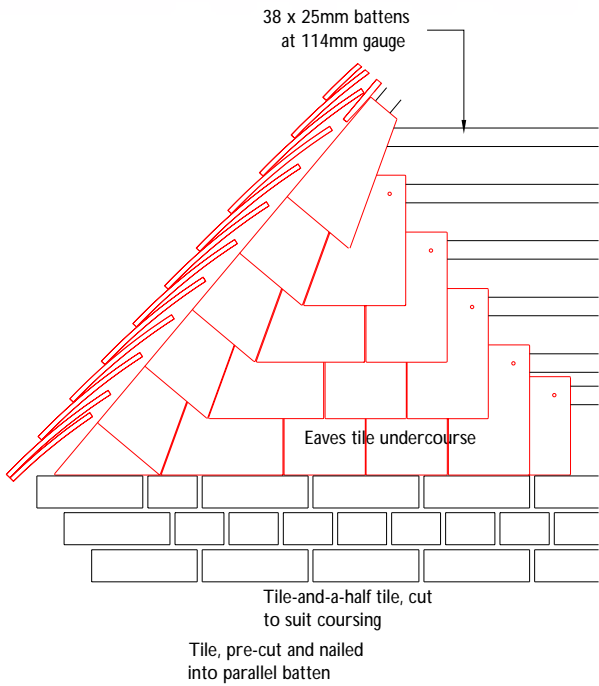
(38) Vertical tiling junction with roof verge

Use tile-and-a-half tiles in each course of tiling, neatly cut to fit close to the undercloak/soffit. Where possible, a second nail hole should be drilled or a slot formed with a cutting disk as shown on the drawing.



(39) Vertical tiling junction with roof verge - Winchester cutting: V1

Form the end under-eaves tile from a tile-and-a-half tile to provide extra width. Use tile-and-a-half tiles in each course of tiling. All cut tiles abutting the undercloak/soffit should be of identical shape and size to give uniformity. (See table for correct angle of cut) The second cut tile in each course will vary in size and tile-and-a-half tiles should be used as necessary to avoid narrow cuts. Use lead soakers, minimum 200 x 200mm, where side laps are less than 55mm. (An alternative method is to have the cut edge of the first tile-and-a-half tile adjacent to the next tile; ie so that the vertical tiling meets the undercloak/soffit at 90 degrees)

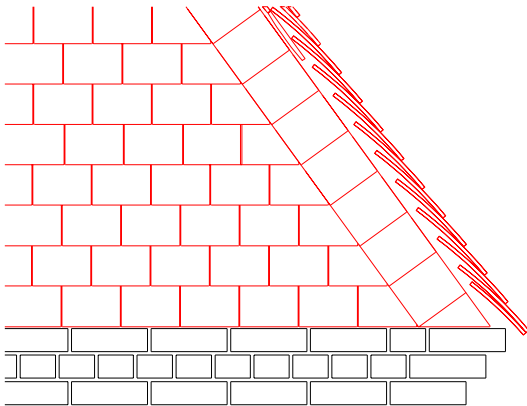


(40) Vertical tiling junction with roof verge - Winchester cutting: V2

Form the end under-eaves tile from a tile-and-a-half tile to provide extra width.
 All cut tiles abutting the undercloak/soffit should be of identical shape and size to give uniformity.
 (See table for correct angle of cut)
 The second cut tile in each course will vary in size and tile-and-a-half tiles should be used as necessary to avoid narrow cuts.
 Use lead soakers, minimum 200 x 200mm, where side laps are less than 55mm.

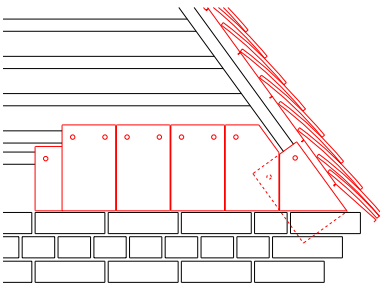
TABLE OF ANGLES OF CUT

ROOF PITCH	ANGLE OF CUT
35°	62°
37.5°	64°
40°	65°
42.5°	66°
45°	67°
47.5°	69°
50°	70°
52.5°	71°
55°	72°

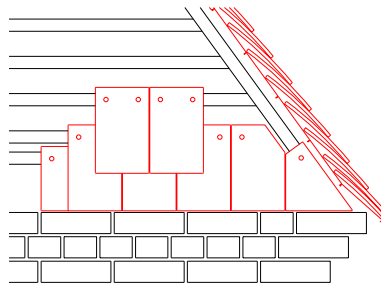


(41) Vertical tiling junction with roof verge - Sussex cutting

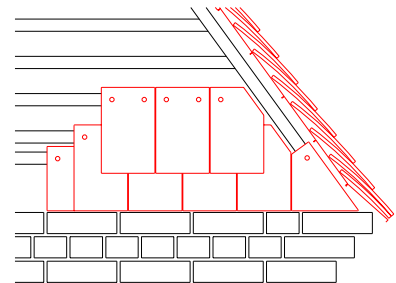
Fix an additional batten onto the face of the vertical tiling battens and parallel to the verge to allow fixing of cut tiles.
 Form raking cuts using tile-and-a-half tiles as necessary.
 Fix the edge tile close to the undercloak/soffit, securing by spot bedding and double nailing into the raking batten.



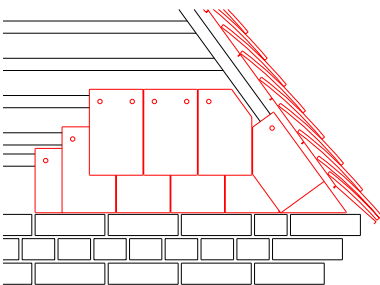
Step 1



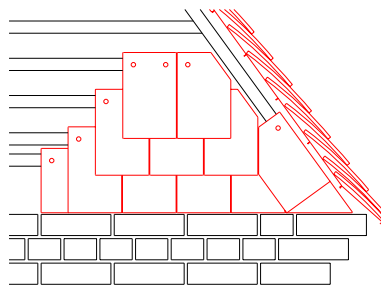
Step 2



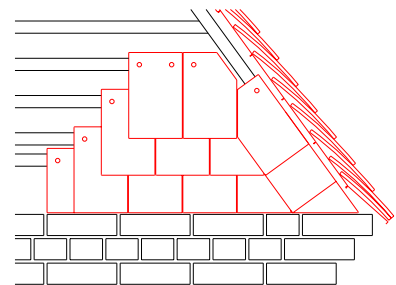
Step 3



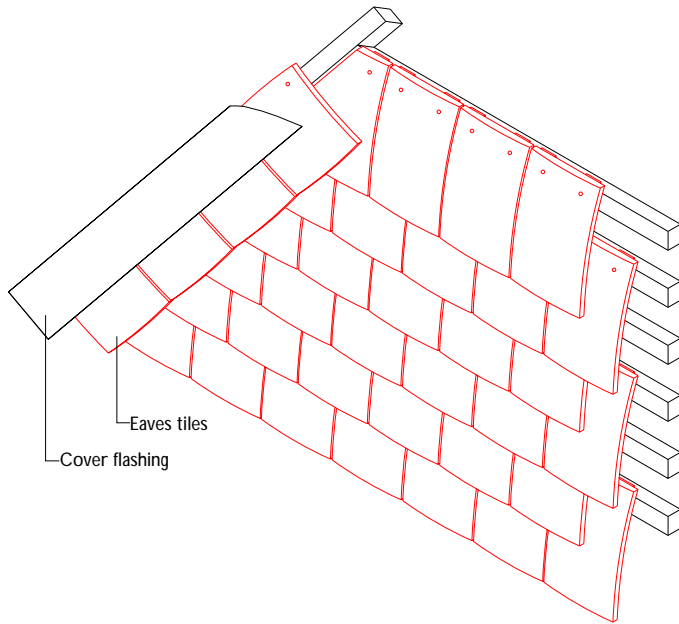
Step 4



Step 5



Step 6

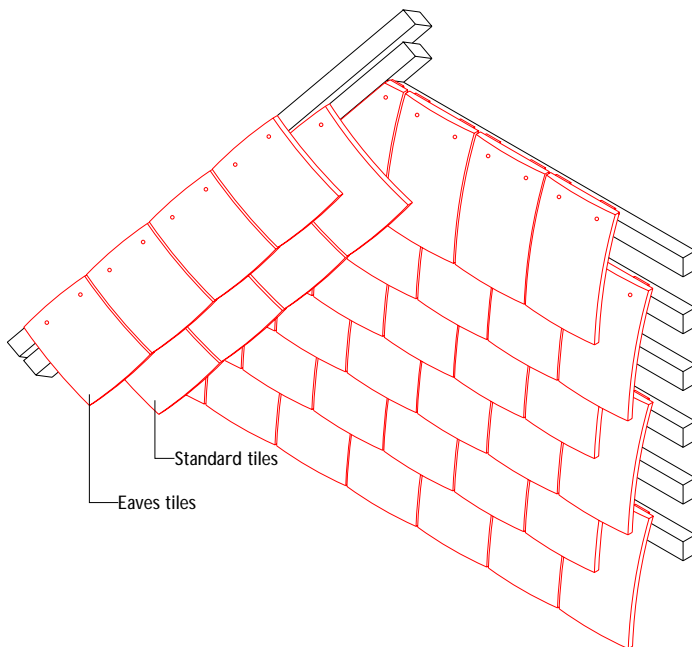


(42) Soldier course

Vertical tiling beneath verges less than 35° roof pitch can be weathered by nailing a soldier course of eaves tiles to a raking batten fixed close to the undercloak/soffit. The raking batten should be positioned to allow the tiles to hang properly on their nibs.

Spot bedding is recommended to prevent wind damage.

A cover flashing can be used to provide extra weathering over the soldier course tiles' nailholes and to the apex.



(43) Double soldier course

Vertical tiling beneath verges less than 35° roof pitch can be weathered by nailing a double soldier course of tiles/eaves tiles to raking battens fixed close to the undercloak/soffit. The raking battens should be positioned to allow the tiles to hang properly on their nibs.

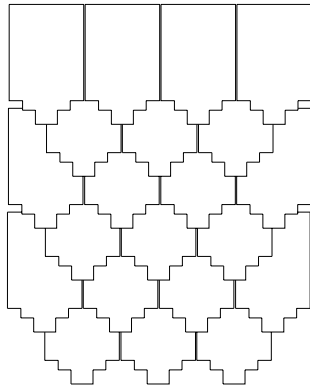
Spot bedding is recommended to prevent wind damage.

A cover flashing can be used to cover the soldier course tiles' nailholes and to the apex.

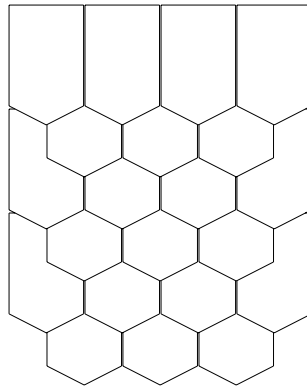
Decorative tiling design details

The following drawings illustrate some of the range of decorative finishes that are available. The drawings only deal with the physical shape of the tiles and do not reflect the wide range of colours that are available.

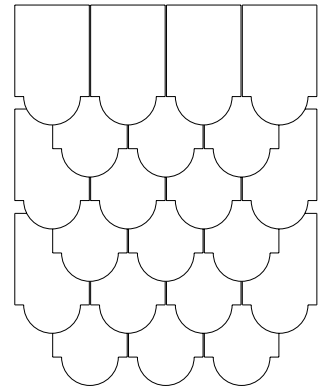
(44) Vertical tiling patterns



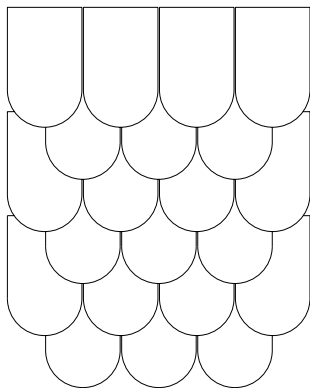
Step



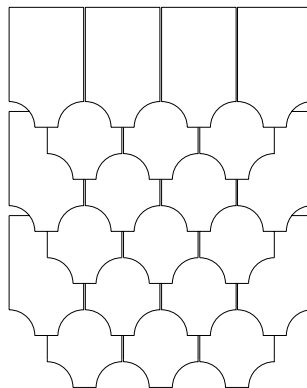
Pointed (also called Arrowhead)



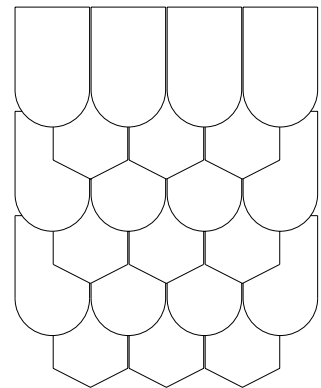
Club



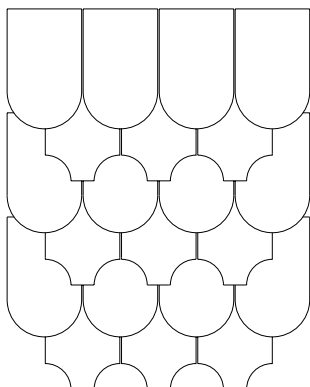
Bullnose (also called Beavertail or spade)



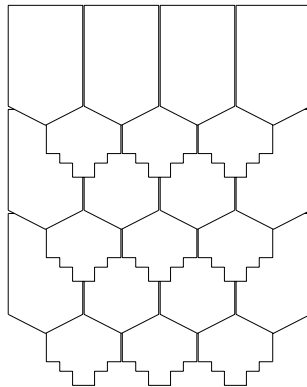
Fishtail



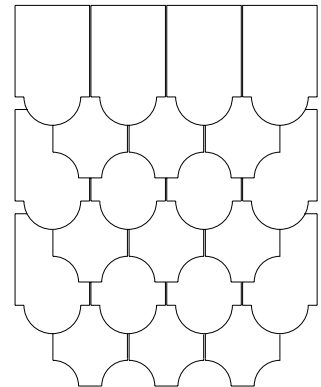
Pointed & Bullnose



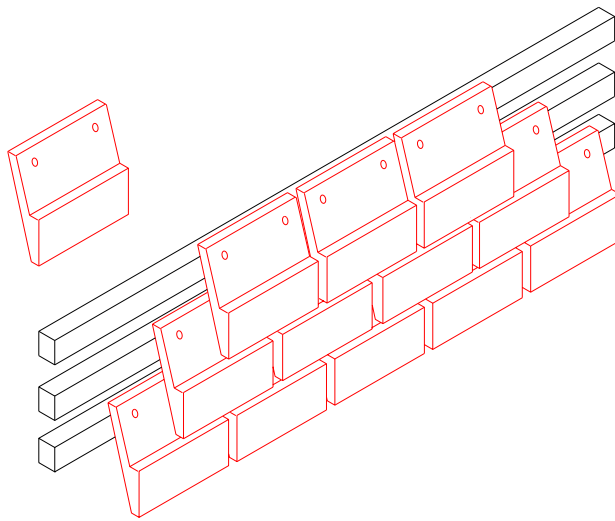
Bullnose & Fishtail



Pointed & Step



Club & Fishtail

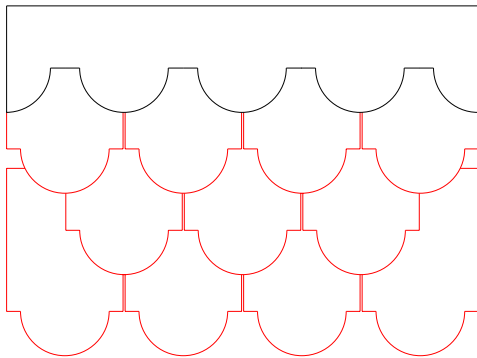


(45) Mathematical tiling

Fix 38 x 25mm tiling battens to specified gauge for the design of the product and secure to groundwork with recommended fixings.

Lay tiles in broken bond fashion and twice nail each tile.

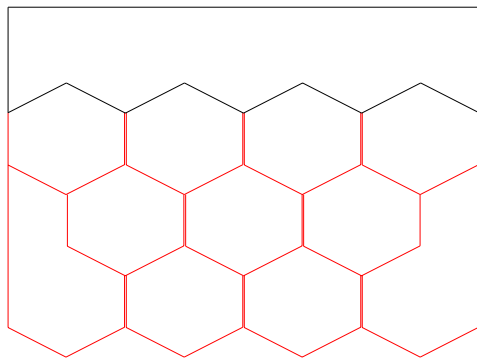
Joints may be left dry or can be bedded and pointed in accordance with manufacturers' instructions.



(46) Decorative flashings

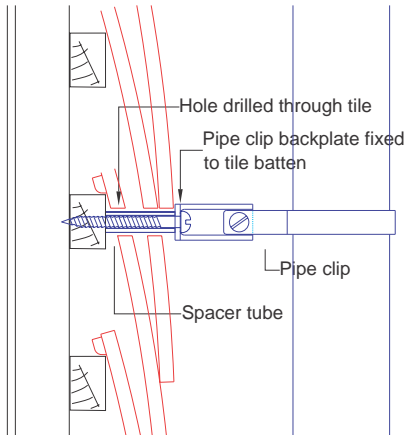
Where a top course tile is used the minimum coverage of the flashing is 100mm. If no top tile is used coverage should be extended to 150mm.

The decorative section of flashing should be added onto the coverage such that it does not compromise the lap relative to the vertical joint and the nail holes.



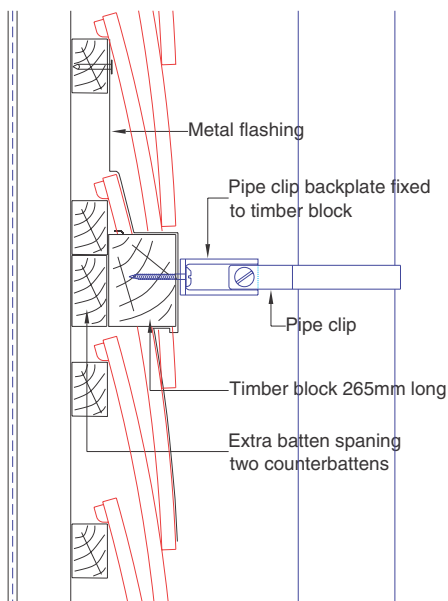
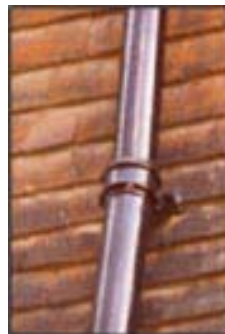
Pipe fixing details

There are a limited number of accessories that can be fixed through vertical tiling but the examples given in the attached drawings illustrate the possible fixing methods.



(47) Pipe fixing through vertical tiling: V1

Drill hole through tile to suit tube diameter (for example 15mm copper tube).
 Insert spacer tube through tile and fix pipe clip back plate to tile batten with suitable screw.
 Secure rainwater pipe clip to bracket.



(48) Pipe fixing through vertical tiling: V2

Provide suitable 265mm wide timber block fixed on top of an extra tiling batten spanning at least two counterbattens or supports prior to tiling.
 Form Code 4 lead flashing to fixing block through hole cut in tiling.
 Fix pipe clip back plate to timber block with suitable screw.
 Secure rainwater pipe clip to bracket.

REPAIR AND MAINTENANCE

When correctly installed in accordance with the manufacturer's recommendations the finished wall should give trouble-free performance for the guaranteed life of the product without the need for extensive maintenance or repair.

Basic precautions

A periodic visual inspection of the wall should be undertaken to check that tiles have not been damaged and that moss and lichen growths that could affect the flow of water off the wall are removed. Any openings or ventilation grills should be checked and cleared if blocked. Gutters should be cleared of debris and leaves.

Access to wall

Care should be taken to avoid access to the wall by window cleaners, aerial installers, etc. without adequate access equipment.

If ladders are used for temporary access to windows or roof, the ladders should not rest against the tiles without a suitable packing material to protect the tiles against breakage.

Mobile access platforms are suitable where the repair work is not extensive. All mobile tower platforms should be constructed to the requirements of BS 7171 : 1989 (power operated) or BS 1139 : Part 3 : 1994 and BS 1139 : Part 5 : 1990 (mobile working towers).

Scaffolds should be used where the repair work is extensive. All independently tied scaffold should conform to BS 5973 : 1993.

Repair and replacement of broken tiles

To successfully repair damaged vertical tiling, the tiles directly above the damaged tiles should be stripped out from the top down in a vee. The damaged tiles can then be removed and replaced. When fixing replacement tiles the fixings should go into fresh timber, or, larger diameter nails, or, screws, can be used.

Major Repairs

Where the condition of the roof of a historic building is poor enough to warrant stripping and re-tiling, it is acknowledged that English Heritage and local authority conservation officers like to see sound tiles salvaged and re-used on the same roof, with any deficiencies made up with new tiles which match the existing. Members of CRTC are in the unique position of being able to assist in the provision of new tiles to match historic patterns and thereby ensure the success of such projects. When recovering, it is advisable to photograph the roof prior to stripping, to ensure that the existing details are properly followed.



Stripping should be carried out carefully to ensure that any sound existing tiles remain undamaged so that they can be sorted according to type, size and thickness and stored for re-use. When assessing existing tiles for reuse, their likely further life should be carefully considered.

Retiling should be carried out using sound tiles salvaged from the roof, with any deficiencies made up with suitable replacement tiles, matching the existing ones in type, size, thickness, colour, and texture. The selection of existing tiles for reuse should be carried out with great care to ensure that they will have a significant life in relation to the new material. If the direct equivalent of the original tiles are not readily available from stock, member companies of CRTC can supply to order specially made tiles for such projects.

HEALTH AND SAFETY

The recommendations in the HSE guidance note HSG 33⁶: 'Health and Safety in Roofwork' and the National Federation of Roofing Contractor's safe wind speed recommendations should be followed.

A safety method statement should be prepared that includes :

- the working positions at the vertical face;
- access routes;
- how falls are to be prevented;
- how the danger from falling materials to those at work and to the public is to be controlled;
- how risks to health will be controlled;
- how other risks identified at the planning stages are to be controlled;
- what equipment will be required;
- what competence and training will be needed;
- who will supervise the job 'on-site';
- how changes will be made to the work without prejudicing safe working;
- who will monitor that the safe system of work is operating properly.

The most relevant legislation for construction health and safety is:

- The Health and Safety at Work etc. Act, 1974;
- The Management of Health and Safety at Work Regulations, 1992;
- The Construction (Health, Safety and Welfare) Regulations 1996;
- The Construction (Design and Management) Regulations 1994;
- The Construction (Head Protection) Regulations, 1989;
- The Construction (Lifting Operations) Regulations 1961.

Tile cutting

When cutting tiles precautions should be taken not to inhale the dust. Wet cutting is preferred but if dry cutting is undertaken an appropriate mask should be worn. The mask suppliers' recommendations should be followed.

⁶ See References & Bibliography

Appendix A

MATERIAL SPECIFICATIONS

Tiles and fittings

Plain clay tiles and fittings should comply with BS EN 1304. It should be noted that hand made tiles and second hand tiles, which may not comply with the dimensional requirements of BS EN 1304, may be used for vertical tiling.

Accessories

Accessories, e.g., ventilation tiles, proprietary soakers, outlets, edge trims, proprietary flashings etc., may have third party approval for the design and performance.

Lead

Where lead is exposed to weathering it should be code 4 BS 1178 as a minimum and where it is protected it may be code 3. Surfaces of all exposed lead should be treated with patination oil to prevent lead oxide staining of the tiles.

Mortar

Where mortar is used as a filler a mix of 1 part cement to 4 parts sand would be satisfactory, but, where the mortar is used to fix tiles, a mix of 1 part cement to 3 parts sand should be used. Most sands conforming to BS 1200 are suitable. However, a test method for measuring the tensile bond strength of the mortar is given in BS 5534.

Adhesives

Where adhesives are used the adhesive manufacturer's recommendations for the material with clay tiles should be followed.

Underlays

Underlays installed on or above boarding or plywood sheathing should be permeable to water vapour to prevent the formation of condensation between the underlay and the wood support. A minimum permeability of 0.36 g / m² per 24 hours when tested in accordance with BS 4016 at 25 °C and relative humidity 75 %. Bituminous underlays should be reinforced.

Underlays installed on or above brick or blockwork should conform to types 1F or 5U as specified in BS 747, or, that specified for boarding and plywood given above.

Battens and counter battens

Timber species

The timber species should comply with type A or type B as specified in BS 5534 and should be treated where the Building Regulations and bye-laws require protection against the House Longhorn beetle. Suitable treatments are given in BS 5268 : part 5.

NOTE : Where there is a risk that timber moisture content will be greater than 22%, treatments that react with metal fixings should be avoided, e.g., copper chrome arsenate which reacts with aluminium.

Batten and counter batten sizes

Up to 600mm support centres the :

Counter batten sizes should be 38mm by 38mm minimum;
Batten sizes should be 38 (+3 / -3) mm by 25 (+ 3 /-0) mm.

Notes : In timber frame structures the counter batten sizes can be reduced.

Where counter battens are used on timber frame constructions the counterbattens need only be minimum 6mm deep. They must be placed directly above and secured into the timber framing.

Where batten bounce is a problem on brick structures counter battens used at 450mm centres may prevent the problem.

Fasteners

Nails for tiles and fittings

Clout head nails complying with BS 1202 part 1 (stainless steel), part 2 (copper), part 3 (aluminium) may be used.

Aluminium clout head nails of 3.35mm diameter may be used and they should be a minimum of 38mm long. Stainless steel or copper clout head nails of 2.65mm diameter may also be used.

Improved nails (annular, ring shank and drive screws) or screws may be used where the wind load calculation indicates that smooth shank nails will not meet the requirement. Nail 'pull-out' resistance figures can be found in BS 5268.

Steel, or, galvanised nails should not be used for nailing tiles.

Nails and fasteners for securing battens to counter battens

Round wire nails complying with BS 1202 part 1, part 7 or hot dipped galvanised or stainless steel should be used. The nails are usually 2.65mm, or, 3.55mm in diameter and 65mm long, however, they may be longer to meet the requirements for wind loading.

For exposed conditions improved nails, screws or helical fixings may be required.

Nails and fasteners for securing battens and counter battens to the wall

Cut clasp nails (BS 1202 part 1) may be used with aerated concrete blocks and the length should be the thickness of the timber to be fixed plus the recommended penetration, typically, 50mm to 75mm. Wall anchors should be used for dense concrete blocks, brick work and precast concrete panels and the length and diameter of the anchor should be in accordance with the fixing manufacturers recommendations.

Flashing and junctions

Where required, metal flashing and junctions should be fixed with copper or stainless steel nails. The size of the nails should be in accordance with the recommendations given in the Lead Sheet Manual⁵, volume 1. Aluminium nails must not be used to fix lead flashing.

Flashing in exposed locations may need to be clipped and this should be in accordance with Lead Sheet Manual⁵ recommendations.

Recommendations for copper and stainless steel to be added (contact to the copper and zinc development associations to be made).

⁵ See References & Bibliography



Appendix B

WIND UPLIFT CALCULATIONS

Introduction

BS 5534: Part 1: 2003: The British Standard Code of practice for Slating and tiling, recommends that, where plain tiles are used for vertical tiling, all tiles should be twice nailed, using nails not less than 2.65mm in diameter and of a length which gives at least 15mm penetration into the tile batten.

However, it must be stressed that there will be situations where fixing the tiles at this minimum requirement may not be enough to prevent tiles being dislodged in high winds.

The following calculations can therefore be used to establish whether a higher level of fixing is required.

These calculations must not be used to justify using a lower level of fixing than that which is recommended in BS 5534.

The following sections, A and B, show how the predicated wind uplift force for a particular project and its location can be determined.

The calculations in Section C provide the resistance to this wind force of the tiles, battens, counterbattens and their fixings.

Section D gives an example of these calculations.

A To Determine Wind Uplift Force - A summary of calculations according to requirements of BS 6399

1. Basic equation

It is assumed the force that the wind could exert directly on the windward side of the building will act as a vacuum force on the lee side of the building and it is this vacuum that causes the tiles to lift off the roof. It is assumed that the uplift force is equal to the force applied to the windward side of the building and conventionally this is given a negative sign.

Force = Pressure x Area

Force (F_t) = dynamic pressure of wind (q_s) x pressure coefficient ($C_{pe} - C_{pi}$) x area (A_t)

The dynamic pressure of the wind is proportional to the wind speed and the pressure coefficient converts the wind speed to a pressure. The coefficients have been derived from wind tunnel testing where wind speed and pressure generated were measured.

C_{p_e} is the external pressure coefficient
 C_{p_i} is the internal pressure coefficient

Therefore,

$$F_t = q_s (C_{p_e} - C_{p_i}) A_t$$

Where,

$$q_s = 0.613 V_e^2$$

and,

0.613 is an experimentally determined constant and V_e is the effective wind velocity

and, $V_e = V_b \cdot S_a \cdot S_b \cdot S_d \cdot S_s \cdot S_p$

Therefore,

$$F_t = 0.613 [V_b \cdot S_a \cdot S_b \cdot S_d \cdot S_s \cdot S_p]^2 (C_{p_e} - C_{p_i}) A_t$$

where,

V_b is the site wind speed which is obtained from the 50 year return wind speed map of the UK (given in BS 6399 and BS 5534).

S_a is a factor that takes the altitude into consideration and,

where the topography is not significant, $S_a = 1 + \Delta_s$, and

where the topography is significant, $S_a = 1 + \Delta_s$, or, $1 + 0.001 \Delta_T + 1.2 S$,
(the greater value is taken).

Δ_s is the site altitude

Δ_T is the base altitude of the topographical feature

s the slope

S is a factor that allows for the position of the building on the slope

Significant topography, the calculation methods for Δ_T , and S are described in BS 6399.

S_b is a factor that takes into consideration the effective height of the building, whether the building is in a town or country environment and the distance from the sea or large open expanse of water. The method of establishing the effective height and the related values of S_b are given in BS 6399.

S_d is a wind direction factor and usually given the value 1 which allows for wind from all directions. A lower figure can be entered if there is a single or predominant wind direction.

S_s is a wind season factor which is usually set at the value 1 which allows for wind at all times of the year. A lower figure can be used if there is a significant variation in the wind loads in the different seasons.

S_p is a probability factor which is assumed to be 1 if the expected wind return rate is once in fifty years. Other figures can be used if different return periods are anticipated.

C_{p_e} is the external pressure coefficient and values can be obtained from BS 6399.

C_{p_i} is the internal pressure coefficient and the values can be obtained from BS 6399.

A_t is the exposed area of the tile and is usually calculated from the product of the batten gauge (G_a) the cover width (B) of the tiles.

B Modifications to calculation method introduced by BS 5534

1. The $C_{p_e} - C_{p_i}$ is replaced by C_{p_t} which can be used for most common applications and when the values of C_{p_t} were calculated from BS 6399 they were modified to ensure that the values obtained were consistent with the values obtained from the previous CP3 standard.
2. A factor D was introduced to allow for the air permeability of the tiles.
3. An S factor was introduced to allow for the shielding effect of the underfelt, when used.
4. The modified equation is :

$$F_t = 0.613 [V_b \cdot S_a \cdot S_b \cdot S_d \cdot S_s \cdot S_p]^2 \cdot C_{p_t} \cdot (B \cdot G_a) \cdot D \cdot S$$

C Calculation of resistance to uplift

There are three matters to be addressed when considering the resistance of vertical tiling to wind forces and, in addition, the shear load created by the weight of the wall cladding on the batten and counterbatten fixings also needs to be considered.

The three wind uplift resistances are:

- the resistance of the tile fixings;
- the resistance of the batten fixings; and,
- the resistance of the counterbatten fixings.

In addition:

- the resistance to shear of the counterbatten fixings

It is a requirement of BS 5534 that all vertically hung plain tiles are twice nailed and the following example describes a method of calculating if the nail resistance will be greater than the wind uplift force. Where the wind uplift force is greater than the nail resistance consideration should be given to using improved nails or screws or proprietary fixings.

The fixing of the batten to the counterbatten requires fixing at 115mm gauge and this requires a large number of fixings and the following example illustrates that this resistance can be significantly greater than the uplift force. Equally the shear force on the fixings is also likely to be within their safe working load. Should the calculations indicate that the resistance of the nails is insufficient then improved nails or screws or proprietary fixings can be considered.

The counterbatten fixings have to resist the withdrawal force imposed by the wind load and the shear load imposed by the weight of the wall cladding. It is important to select the fixing and the fixing pattern to ensure that adequate resistance is achieved. The example calculation illustrates how the type and number of fixings can be selected.

D Example resistance calculation

Plain tiles (Town Site)

Assume :

Tiled wall, Newcastle area, town position and no buildings within 45 m, 2 kilometres from the sea, 30 m above sea level, no significant topographical features and 7.5 m to ridge.

Wind uplift

$$F_t = 0.613 [V_b \cdot S_a \cdot S_b \cdot S_d \cdot S_s \cdot S_p]^2 \cdot C_{pt} \cdot (B \cdot G_a) \cdot D \cdot S$$

V_b	24 m / s	BS 6399 figure 6	
S_a	1.03	$1 + 0.0001 \cdot \Delta_s$	where Δ_s is height of site above sea level
S_b	1.615	BS 6399 table 4	$H_e = 7.5$ m; 2 km from sea; town position; no significant topographical features
S_d	1	BS 6399 2.2.2.3	
S_s	1	BS 6399 2.2.2.4	
S_p	1	BS 6399 2.2.2.5	
C_{pt}	-0.1	BS 6399	lee of building (by convention negative)
B	0.165 m		width of tile in metres
G_a	0.1 m		gauge in metres
D	2.70	BS 5534 table 9	air permeability factor
S	1	BS 5534 table 10	underfelt / wall shielding factor

When the values given above are substituted in the basic equation the following values is obtained:

$$F_t = - 4.35 \text{ N}$$

Tile resistance

Assume:

Each tile is held with two 2.65mm diameter nails in a type A batten. Each nail has a resistance of 1.5 N per mm of penetration (BS 5268 part 2). The nails have 17mm of penetration

Therefore,

$$\text{Nail resistance} = 17 \times 1.5 \times 3 \times 2 = 153 \text{ N} \quad (\text{the factor 3 is recommended by BS 5534 1994 clause 3.6.3.4.2 (b)})$$

Comparison

$$\text{Uplift moment} = - 4.35 \times 0.13 = 0.57 \text{ Nm} \quad (0.13 \text{ m is distance from centre of tile to batten})$$

$$\text{Nail resistance moment} = 153 \times 0.015 = 2.295 \text{ Nm} \quad (0.015 \text{ m is distance from nail hole to batten})$$

This comparison indicates that the nail resistance in this example is significantly greater than the wind uplift.

Batten resistance

Assume:

Each tile has a $F_t = - 4.35 \text{ N}$ and there are 53 tiles per m^2 .

Therefore,

$$\text{Wind uplift per } \text{m}^2 = 53 \times - 4.35 = 230.55 \text{ N}$$

Assume:

Battens are fixed to counterbattens that have been fixed at 600mm and that 3.35mm diameter x 65mm long nails have been used with a penetration of 40mm.

If a withdrawal resistance of 1.5 N per mm of penetration is assumed (the value for 2.65mm diameter nails) the resistance will be understated.

There will be 1.67 counterbattens per metre of wall.

A batten gauge of 115mm gives 8.7 fixings per metre.

Therefore,

$$\text{Fixings per } \text{m}^2 = 1.67 \times 8.7 = 14.5$$

$$\text{Nail resistance} = 14.5 \times 40 \times 1.5 \times 3 = 2610 \text{ N}$$

Comparison

In this example the batten nail resistance is significantly greater than the wind uplift.

Counterbatten resistance

Wind uplift resistance

Assume:

Wind uplift will be the same as the battens (230.55 N per m²)

If one fixing per metre length is used then with counterbattens at 600mm intervals there are 1.67 fixings per m².

The safe working load in tension for a 4mm screw with a Rawlplug plastic plug in a 7 N lightweight block is 16kg.

Therefore,

Wind uplift = 230.55 N per m²

Pullout resistance = $1.67 \times 16 \times 9.81 = 262.12$ N per m²

Comparison

This illustration demonstrates that the resistance is greater than the wind uplift, although, a better margin of safety will be obtained with 5mm screws which have a safe working load in tension of 35kg.

Shear resistance

Assume:

The shear load on the counterbatten fixings is the weight of the tiles and the battens and batten nails.

The load per tile is 1.1kg and there are 53 tiles per m².

The shear load of common fixings are considerably in excess of the tension resistance and tension values would normally be considered safe, nevertheless, the fixing manufacturer should be consulted to confirm the relationship between the tension and shear resistance for their fixings. In this example the tension value will be used. The safe working load in tension for a 4mm screw with a Rawlplug plastic plug in a 7 N lightweight block is 16kg.

Therefore,

The shear load per $m^2 = 1.1 \times 53 = 58.3\text{kg}$

With 1.67 counterbattens per m^2 the shear load per metre of counterbatten = 34.9kg

Fixing 4.0mm screws with Rawlplug plastic plugs at 400mm (2.5 screws per metre) will give a resistance = $16 \times 2.5 = 40\text{kg}$ per metre length of counterbatten.

Comparison

In this example the shear resistance of the fixings is greater than the shear load of the tiles.

Appendix C

References and bibliography

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