Construction Notes - No 11 Mortar bedded hip

CONCRETE TILE MANUFACTURERS ASSOCIATION

In a series of articles on interlocking concrete roof tiles, experts from the **Concrete Tile Manufacturers Association** have pooled their knowledge. This Construction Note discusses mortar bedded hips.

Hip

A hip occurs where two roof slopes of any pitch meet, forming a junction from which water runs away from. Usually the two roof slopes will intersect at either side of 90 degrees on plan, but other plan angles are also quite common, for example, a hexagonal shaped roof.

Four hips meeting at an apex would form a pyramid. Unlike a ridge, a hip will never be horizontal. Generally a hip will start at an eaves level and finish at a ridge level, but may start and finish at any junction in the roof construction where two roof slopes meet. If the rafter pitch on either side of the hip is different, the hip line will vary on plan and may cause water to run into the hip, rather than away from it. Water running into a hip should be avoided at all cost.

A hip formed in a roof with a traditional open loft below it will not require the hip line to be ventilated. However when the insulation is installed between the rafters, where a rafter space meets the hip it should be ventilated to comply with the high level ventilation requirements of British Standard 5250 Code of practice for the control of condensation in buildings, and Building Regulation Approved Document F2.

A hip may be formed with or without mortar bedding to comply with BS 5534 Code of practice for slating and tiling, and BS 8000 part 6 Workmanship on building sites part 6 Code of practice for slating and tiling of roofing and cladding. Where mortar bedding is not used, a proprietary system will be required to prevent wind driven rain and large insects from gaining access to the roof; this will be dealt with in a later article. In all instances some, if not all, of the ridge assembly will need to be mechanically fixed to the roof structure to ensure that the ridge is not displaced during hurricane force winds, which can occur anywhere in the UK, at least once in any fifty year period.

Hip Tiles

The junction of the tiles between the two roof slopes needs to be covered with a purpose made hip tile **(A)** which is similar in shape to a ridge tile but flatter due to the flatter dihedral angle between the two slopes. The dihedral angle between the two slopes will vary with rafter pitch, this is important if angle hip tiles are used as the dihedral angle of the angle hip tile needs to be the same or slightly smaller than that of the hip it self. The width of a hip tile is approximately 230mm, enough to bridge the gap between the tiles and lap onto the cut tiles on each slope by a minimum of 75mm. The length of the hip tile is normally approximately 450mm. The design of hip tiles may be third round, segmental or angular.

The Roof structure

The roof structure, which will normally be timber pre-formed trussed rafters **(B)**, should have individual truss rafters meeting at a hip rafter. With a cut timber roof there should always be a hip rafter, to support the top of the jack rafters. The hip rafter should be at the same height as the adjacent rafters to ensure that packing of the battens is not required to prevent the battens kicking up or down at the hip. Ideally the pitch on either slope should be the same. If the pitches are not the same the whole hip will sit over towards the steeper slope. A hip iron, which is galvanised steel 25mm wide x 6mm thick should be screw fixed to the bottom of the hip rafter, oversailing the fascia board by approximately 80mm to support the first hip tile and prevent it slipping off the roof slope.

Underlay/Battens/Tiles

The underlay **(C)** should be laid to finish on the first slope to a raking cut at the hip line. On the second slope the underlay should extend beyond the hip line and lap onto the underlay of the first slope by a minimum of 150mm. The ends of all tile battens should finish on and be nailed to the hip rafter, such that they do not slope up or down at the end, otherwise the end cut tiles will not sit correctly. The tiles cut to the rake of the hip should be as close to the centre of the hip line as possible to ensure that a 75mm lap with the hip tiles. With high profile tiles this may require an undercut at steeper rafter pitches. Small cuts can be avoided on some tile profiles by using a half tile to move the last tile over and create a larger cut.

Tile Fixings

British Standard 5534: The code of practice for Slating and Tiling requires all perimeter tiles to be mechanically fixed. At the hip this requirement applies to the end tile that is in contact with a tiling batten, any small tile cuts will be held in place by the mortar bedding.

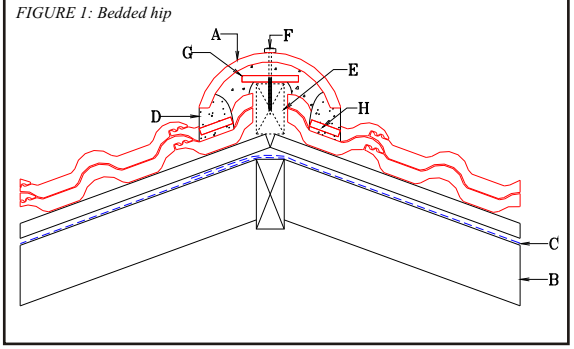
Ridge Tile Fixings

Mortar bedding **(D)** is by its very nature, rigid. However timber and steel roof structures can expand, shrink and deflect depending upon the humidity, temperature, and loads experienced during their lifetime. Where the roof comes into contact with a rigid wall or chimney the situation is at its worst. The stresses generated at a rigid wall support, onto a less rigid timber or steel support, can cause differential movement and the mortar to fail. It is for this reason that the end 900mm of any hip, or where it meets, or crosses, a rigid support such as a gable end wall, party wall/fire break wall or a chimney, the hip tiles, should additionally be mechanically fixed to comply with BS 5534. Where the calculated wind uplift on the hip tiles is greater than the ability of the mortar to adhere it to the tiles mechanical hip tile fixings will be required; in these instances it will be necessary to mechanically fix every hip tile.

The mechanical fixing of the hip tile may be one of the following types: -

- One screw/nail fixing through the

FIGURE 1: Bedded hip



CONCRETE TILE MANUFACTURERS ASSOCIATION

Construction Notes - No 11 Mortar bedded hip

centre of the hip tiles.

- One screw/nail through each end of the hip tile.
- One screw/nail through a plate at the cross bed joint.
- An embedded wire at one end of the hip tile.

For each of these options there should be a hip rafter/batten **(E)** of adequate width and height, to allow the fixing screw/nail **(F)** to penetrate the hip rafter/batten by an amount sufficient to resist the wind uplift forces. The nail point penetration into the batten should be calculated using BS 5268Structural use of timber part 2 Code of practice for permissible stress design, materials and workmanship, as the penetration will vary with diameter and type of nail. A screw/nail length of 100mm is normally used for fixing hip tiles, as longer than this they become difficult to install without bending them. The height of the hip batten is determined by how far it is above the apex of the roof and will depend upon the pitch of the roof, the profile/thickness of the roof tile being used and the length of the fixing nail.
Where a hip batten is being used with timber trussed rafters, the batten will need to be securely screwed or strapped to the hip rafter, and extend at least 80 mm beyond the end fixing screws/nails. Where the imbedded wire method of fixing is used, the wires should be nailed to the hip rafter/batten on the upward slope side.

Mortar Bedding
The use of mortar to bed hip tiles onto the cut tiles adjacent to the hip to weather the hip junction is very traditional. If done correctly, the method can be very effective. If not done correctly it will allow rainwater to penetrate the tile covering, or allow the hip tiles to blow off in severe gales. The mortar mix should be either 1:3 cement to sharp sand, where no mechanical fixings are used to hold the hip tiles to the structure, or 1:4 cement to soft sand, where additional mechanical fixings are used to hold down the hip tiles to the structure. The higher cement ratio and coarser sands will produce a stronger bond. The lower cement ratio with soft sand provides an effective filler to prevent rain and insects entering the roof covering. To determine the required mortar bond strength with any given sand, mortar mix, admixture and tile surface, the test method in BS 5534 should be used. The mortar should be placed, prior to the hip tiles being laid, onto dampened roof tiles to ensure that the water in the mortar is not sucked into the dry roof tile, this will affect the chemical reaction of the mortar setting. The width of the mortar should be approx. 50 mm along the continuous edge bedding, and 100 mm (50 mm either side) at the cross bed joint, where the hip tile abuts the next hip tile. The thickness of the mortar should be sufficient to produce a 50mm surface contact with the underside of the ridge tile, once the hip tile has been bedded into its final position. Where the roof tiles have a profile with a corrugation greater than 25mm, dentil slips should be bedded into the corrugation prior to the edge bedding being laid. Dentil slips are narrow widths of plain tile, which are sized to fit within the corrugation. The visible exposed length is at the discretion of the specifier, and may be flush with the face of the mortar bed.
At the cross bed joint the mortar may need to be supported and thinned out with pieces of broken tile **(G),** to prevent the mortar from slumping onto the sarking felt and loosing contact with the underside of the hip tile.
The hip tiles should be bedded into position by pressing or tapping the hip tiles until they are aligned both horizontally and along the centreline of the hip, showing a 10-15mm mortar joint. The practice of pointing the cross bed joints of the hip tiles, once the hip tile has been bedded is not acceptable, as little or no mortar contact will occur under the tile being pointed, and in time the mortar joint will crack, allowing rainwater to enter the roof.

Hip Junctions
Where a hip meets another feature such as a ridge, valley, top edge abutment or side abutment, a code 4 lead saddle needs to be installed. It should be positioned either under the mortar bedding, or over the hip tile, depending upon the direction of the water run off. The positioning of the saddle under the mortar is visually more acceptable.
Where the lead saddle is positioned under the mortar, the size of the saddle will depend upon the lap of the lead onto the head of the tiles on each slope. For a rafter pitch of 17.5 degrees, the true tile pitch is likely to be 12.5 degrees, and the lead saddle headlap length is likely to be 350mm for each of the top tiles, plus the distance between the top tiles, which comes to approx. 800 mm. The width of the saddle will depend upon the proximity of the adjacent roof slope and its relative rafter pitch. The minimum size of lead saddle, 450 mm x 450 mm, should therefore not be used on rafter pitches below 35 degrees. The practice of trimming the lead saddle back to the line of the mortar bed is technically incorrect, as it will reduce the effective headlap to approx. 75mm.
Where the lead saddle is positioned over a mortar bedded hip tile the lead needs to be dressed neatly over the hip tile and onto the surface of the top tiles by 50mm. Depending upon the size of the hip tile the lead sheet width is likely to be between 450 - 550 mm, regardless of the rafter pitch. On tall buildings, or where the hip is very exposed, clipping the edge of the lead saddle should be undertaken to hold it down onto the hip tile.
Depending upon the complexity of the junction, it may be appropriate to cut and lead weld in gussets to the saddle, rather than boss the lead sheet into shape

SUMMARY

- Mortar bedding of hip tiles, when done correctly, has been shown over many centuries to be very effective at resisting the weather. If the mortar bedding of hip tiles is not done correctly, the roof will deteriorate relatively quickly, especially during, or after, periods of extreme weather.
- The Hip Iron stops the hip tiles sliding off the roof. The hip iron needs to be securely fixed.
- Where the hip meets another feature of the roof, such as a ridge or valley, a lead saddle should be installed at the junction.
- Dentil slips should be used to thin out the mortar where the tile corrugation height is greater than 25mm.