CONCRETE ROOF TILES TECHNICAL MANUAL

QUALITY CAST IN CONCRETE

CONCRETE MANUFACTURERS ASSOCIATION (NPC)

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PREFACE

This manual has been compiled by the Concrete Manufacturers Association NPC (CMA) to promote good roofing practice. Good roofing practice necessitates correct design and detailing, the use of good quality materials and proper installation procedures. Provided that these are done correctly, a concrete roof tile roof will provide years of maintenance free service enhancing the aesthetic appeal of the building. This manual has been compiled in compliance with the National Building Regulations, SANS 10062 Code of practice for the fixing of concrete roof tiles and accepted good building practice.

ACKNOWLEDGEMENTS

The CMA acknowledges the help and assistance from MiTek South Africa (Pty) Ltd

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Alabama Housing, North West Province

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Luxury Houses

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Coastal Manors, Community Flats, KwaZulu-Natal

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1.1 TYPICAL APPLICATIONS (CONT..)

Luxury Housing Complexes

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1.1 TYPICAL APPLICATIONS (CONT..)

Community Buildings

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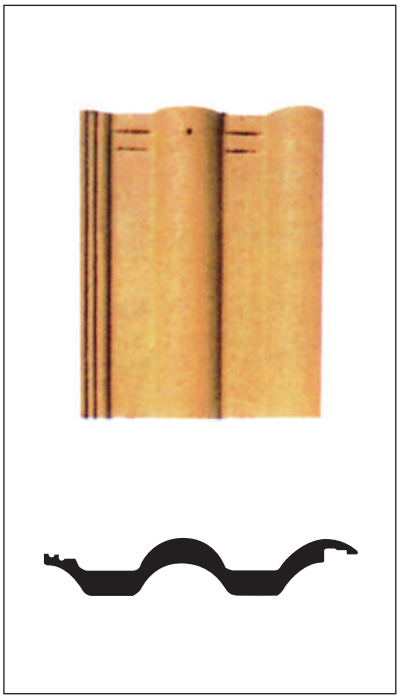
Kwa Mashu Police Station, KwaZulu-Natal

Tembisa Magistrates Court, Gauteng

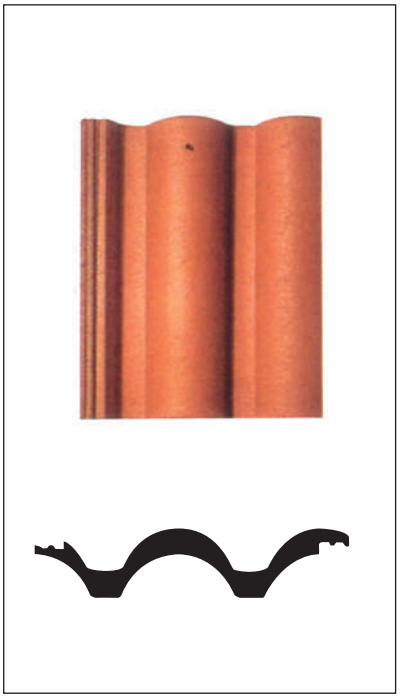
1.2 PRODUCT RANGE

a) Tile Profiles

Flat Double Roman Profile

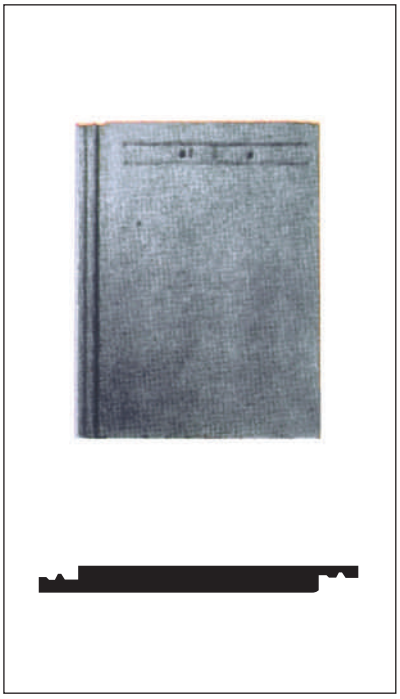


Bold Double Roman Profile



Bold Roll Profile

Marseilles Profile

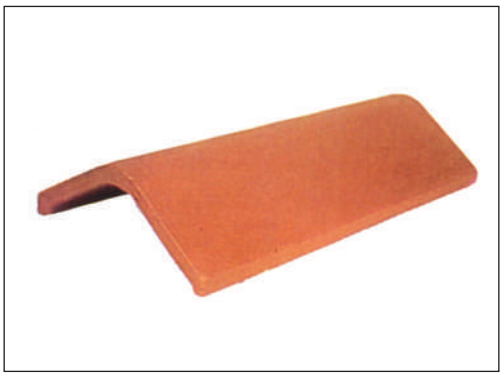


Flat Profile

Double Pan Profile

1.2 PRODUCT RANGE

b) Tile Fittings

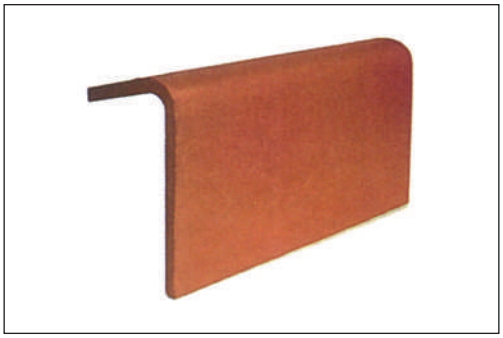


Butt Ridge

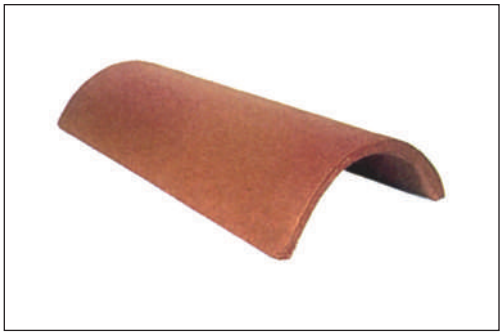
Hip Starter

Collar Mono Ridge

Rake Verge

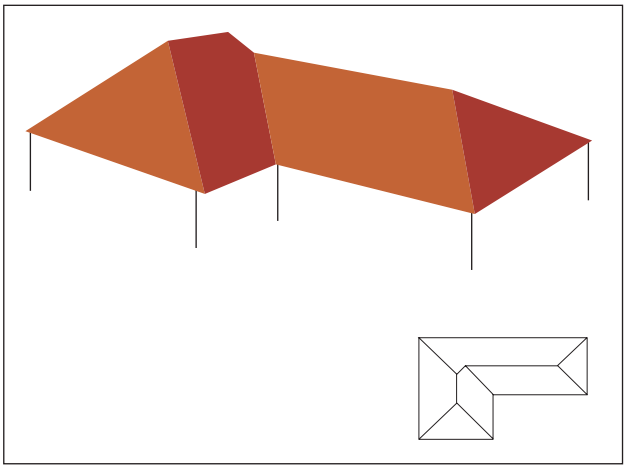


Butt Mono Ridge

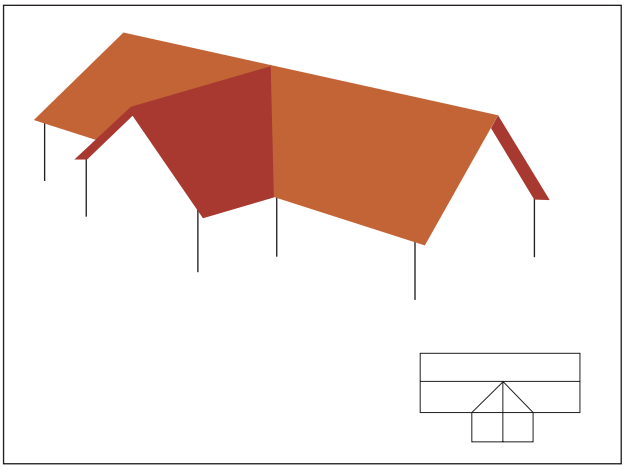


Taper Ridge

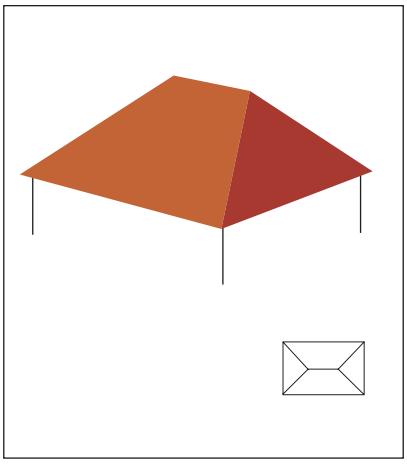
1.3 ROOF FORMS



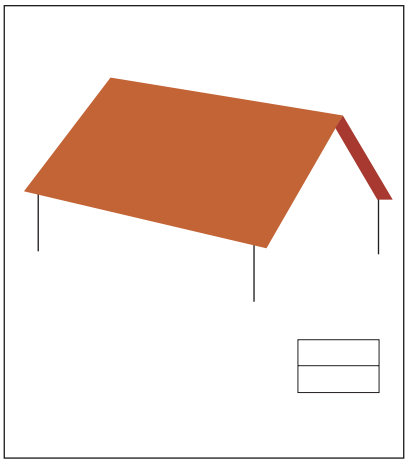
Intersecting hip roof



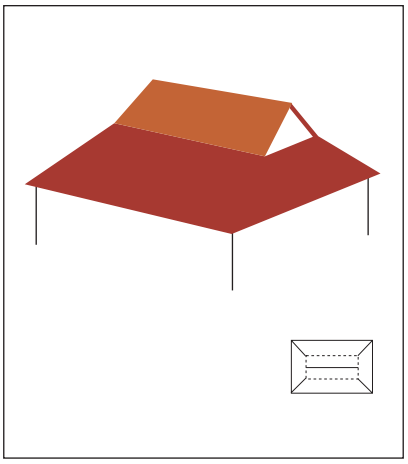
Intersecting gable roof



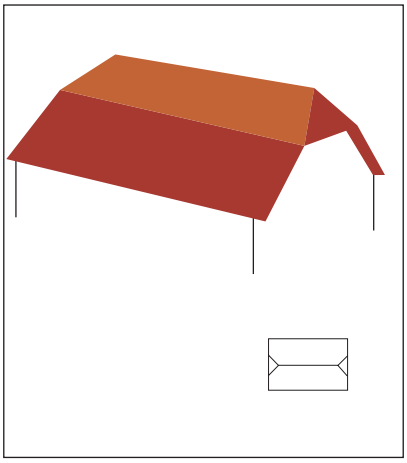
Hip to hip



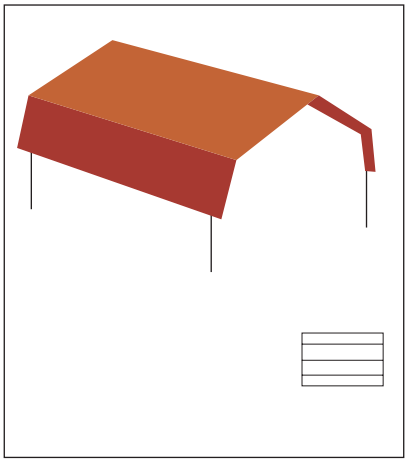
Gable to gable



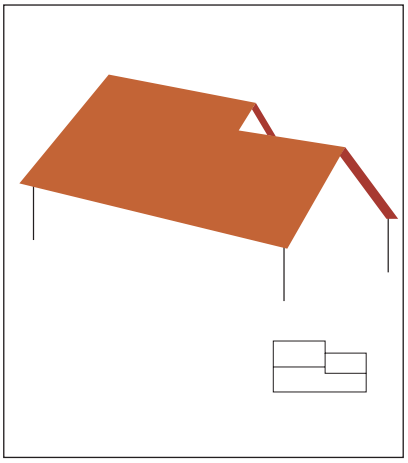
Dutch hip



Hip gable

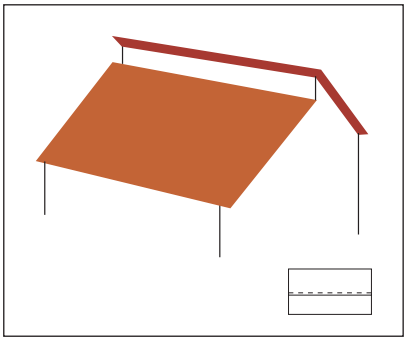


Mansard

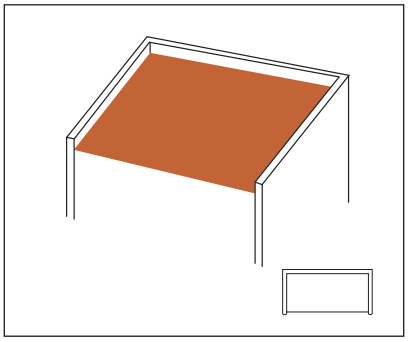


Split gable

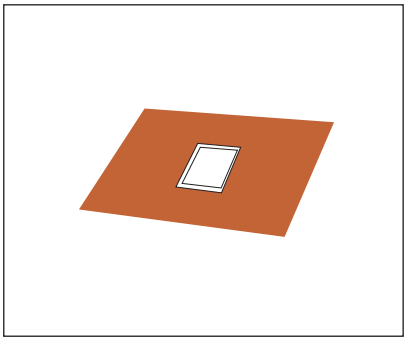
1.3 ROOF FORMS



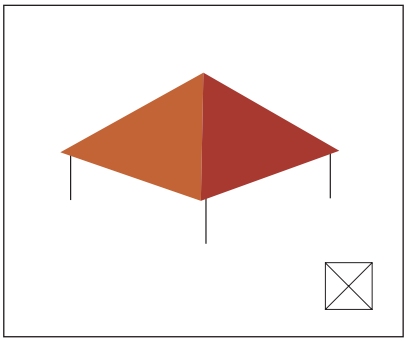
Double monopitch



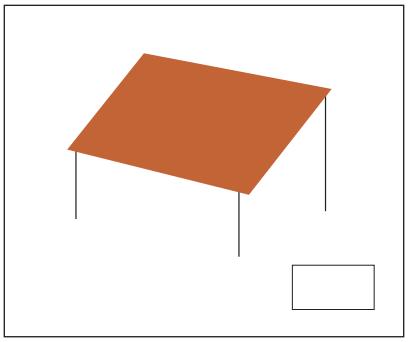
Parapet gable



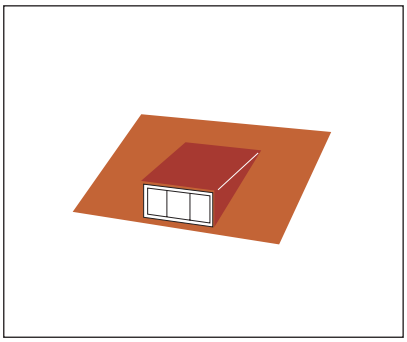
Flush roof window



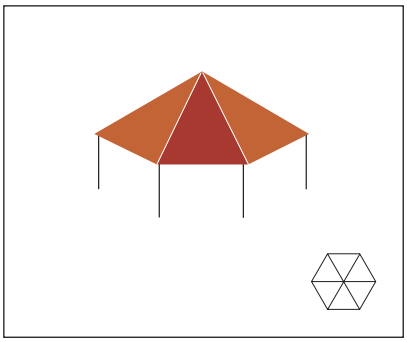
Pyramid (4 sided)



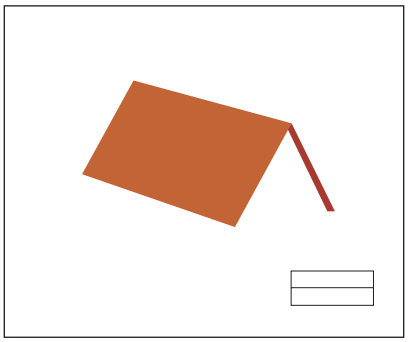
Monopitch / lean to



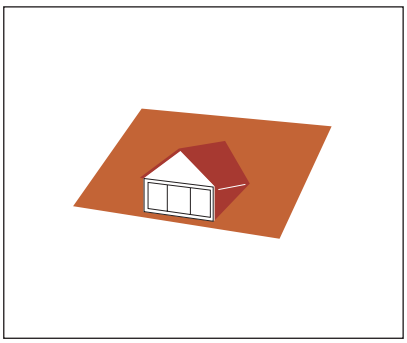
Sloping dormer



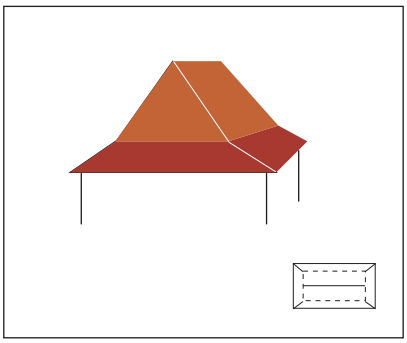
Pyramid (6 sided)



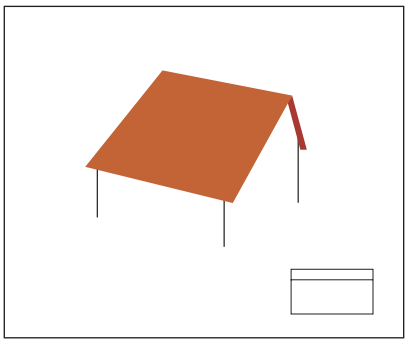
A-frame



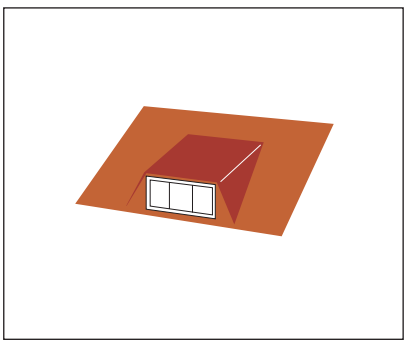
Straight dormer



Bali



Double pitch asymmetric



Sloping dormer with sloping cheeks

1.4 RELATIVE PERFORMANCE OF STANDARD ROOFING MATERIALS

Attributes	Concrete Roof Tiles	Galvanized Iron Sheeting	Corrugated Fibre Cement Sheeting	IBR Metal sheeting
Comparative cost	0%	28%	66%	62%
Durability	Life time	Reasonable	Reasonable	Reasonable
Life	50 yrs	5 yrs	15 yrs	5 yrs
Maintenance requirements	Minimal	Minimal	Minimal	Minimal
Aeshetics	Excellent	Poor	Poor	Poor
Hail resistance	Good	Good	Reasonable	Good
Noice resistance	Good	Very poor	Poor	Very poor
Fire resistance	Excellent	Good	Good	Good
Thermal Efficiency	Good	Poor	Good	Poor
Quality Standards	SANS 542	SANS 10237	SANS 685	SANS 10237
Ease of laying	Easy	Easy	Easy	Easy
Ease of repair	Easy	Reasonable	Reasonable	Reasonable
Wind resistance	Good	Reasonable	Reasonable	Reasonable

1.4 RELATIVE PERFORMANCE OF STANDARD ROOFING MATERIALS (CONT)

Pressed Metal Roof Tiles	Fibre Cement Slate	Natural Slate	Thatch	Coloured Metal Sheeting	Burnt Clay Roof Tiles
144%	175%	360%	60%	63%	300%
Reasonable	Reasonable	Reasonable	Poor	Reasonable	Reasonable
15 yrs	15 yrs	15 yrs	10 yrs	10 yrs	50yrs
Repaint every 15 yrs	Minimal	Annual service	Over thatch every 10 yrs	Repaint every 10 yrs	Minimal
Reasonable	Good	Excellent	Excellent	Good	Excellent
Good	Poor	Reasonable	Good	Good	Good
Very poor	Fair	Fair	Good	Very poor	Good
Good	Good	Good	Very poor	Good	Excellent
Poor	Good	Good	Excellent	Poor	Good
SANS 1022	SANS 803	No National Standard	No National Standard	No National Standard	No National Standard
Specialist	Specialist	Specialist	Specialist	Easy	Specialist
Specialist	Specialist	Specialist	Specialist	Reasonable	Specialist
Reasonable	Good	Good	Poor	Reasonable	Good

1.5 GENERAL INFORMATION

Concrete roof tiles are an outstanding example of a high quality, cost effective solution for roofing. They have proved their worth over many years of trouble free use, providing maximum protection against the elements. Concrete roof tiles are manufactured in an extensive range of profiles, colours and finishes which enhance the visual appearance of any roof and provide designers with a wide scope for expression.

a) Manufacture
Concrete roof tiles are manufactured from selected raw materials such as washed graded sand, Portland cement, inorganic pigments and water. The tiles are extruded under pressure resulting in a product of high quality.

b) Quality standards
Concrete roof tiles manufactured by members of the Concrete Manufacturers Association meet the requirements of SANS 542 Concrete roofing tiles. All members have an internationally recognized Quality Management System in place.

c) Surface coatings
Concrete roof tiles are manufactured in a vast range of finishes, which will vary from one manufacturer to another. Surface finishes for tiles are categorized in accordance with SANS specifications. All surface coatings are applied under factory-controlled conditions.

d) Colours
Large selections of standard colours are available. Fittings are available in colours to match tiles. For future information, colour charts, special colours and samples, contact the manufacturers.

Table 1: Categorisation of tiles in respect of body colour and surface coatings

Category	Body Colour	Surface Coating
1	No	No
2	No	Yes
3	Yes	No
4	Yes	Yes

Category 1 Plain concrete tiles, no body colour, no surface finish

Category 2 No body colour, the tile surface coating is applied in the manufacturing process.

Category 3 Body colour throughout. Colouring inorganic pigments are mixed in the concrete prior to the extrusion process.

Category 4 Body colour throughout. Coating, typically acrilic, is factory applied. This eliminates colour variation and efflorescence.

Note: A wide range of fittings are available to match all roof tiles.

e) Definitions

For the purpose of this publication, the following definitions shall apply:

Abutment. An intersection on the roof surface and a part of the structure that rises above it

Apex. The intersection of two or more roof slopes at the highest position of the roof.

Apron flashing. A flashing, the lower end of which is dressed over the roof covering, and the upper edge of which is dressed up a vertical surface.

Bargeboard. A component fixed along the edges of a gable and covering the ends of the horizontal roof members.

Battens. Timber or steel members of small section fixed parallel to the line of the eaves, at right angles to the rafters, onto which the tiles are fixed.

Bedding. The setting and pointing of tiles and fittings in mortar.

Bedding pieces. Small pieces of broken tile that are used to reinforce areas of bedding where excessive mortar shrinkage can occur.

Boards. Lengths of flat timber that are nailed to he rafters to form a soffit and act as a support for underlays.

Cleat. A specially formed strip of corrosion resistant material (e.g. of the same material as the valley liner) that is used to hold the valley liner in place.

Coastal area. The land area in proximity to the sea, i.e. those areas between the coastline and an imaginary line 30 km inland, parallel with the coastline, or the top of the escarpment or watershed of the first mountain range inland, if these are less than 30 km from the coastline. **NOTE:** The entire area of jurisdiction of any local authority, the area of which is cut by the line demarcating these coastal areas, is taken as falling within the coastal area.

Concealed gutter. A preformed channel (manufactured from a corrosion free material) that is overlapped by tiles and shaped to form a watertight joint at abutments (in conjunction with cover flashings).

Counter battens. Timber members of small section fixed between the battens and the under laying structure, normally at right angles to the direction of the battens onto which the tiles are laid.

Cover flashing. A flashing that is used in conjunction with other roof components (such as side gutters and apron flashings) and that overlaps any vertical parts of such components.

Eaves. The overhanging lower edge of a roof slope.

Dry ridging. The system involves an easy roll and clip installation on the ridge and hipline of the roof that allows for optimum air circulation and maximum protection against the elements.

Fascia board. A member cut from sheet material or timber that is fixed to the rafter ends, the wall face or the wall plate immediately below the eaves.

Flashing. A strip of flexible impervious material that is used to exclude water from the junction between a roof covering and another part of the structure.

Gable. The part of the wall above the general level of the eaves at the end of a ridge roof or of a partially hipped roof.

Gutter, Any form of roof water channel at eaves, verges and abutments.

Head lap. The distance by which one course of tiles overlaps the coarse immediately below it.

Hip. The sloping intersection of two inclined roof surfaces that meet at a reflex angle (greater than 180°).

Monoridge. The intersection of a single roof slope and a vertical masonry face at the highest part of the roof.

Mortar. A mixture of sharp plaster sand, cement and inorganic pigment (optional) used for bedding tiles, ridges and fittings.

Pitch. The angle of inclination to the horizontal of the rafters, or of the surface on which the tiles are laid.

Radiant barriers. Aluminium foil based underlay used for insulation in combination with air spaces. It also acts as a waterproofing, undertile wind and airflow retarder as well as a dustcover for the roof space

Rafter. A supported structural member, usually timber, establishing the slope of the roof to which the battens, counter battens, boards and underlays are fixed.

Rational design. Design by a competent person involving a process of reasoning and calculation and which may include a design based on the use of a standard or other suitable document.

Ridge. The horizontal junction between two roof slopes at the apex.

Ridge clips. Stove enamel aluminium clips that facilitate easy and rapid fixing of taper ridge tiles.

Ridge roll. Ventilated or un-ventilated roll used during the dry ridging process. The ridge roll is secured to the ridge batten supported by ridge truss bracket.

Soffit closure. A closure manufactured from rigid materials, fitted to the underside of the roof overhang at eaves and verges.

Tilting batten. A batten that is used at eaves to support the tiles in the correct plane relative to the roof structure.

Truss. A structural system of timber or metal members that supports the roof covering and forms part of the structure to support a ceiling.

Underlay. A flexible undertile membrane or foil fitted between the roof support structure and the battens.

Valley. The sloping intersection of two inclined roof surfaces that meet at a re-entrant angle (less than 180°).

Valley liner or gutter. A strip of impervious material that is used to exclude water at the sloping intersection of two intersecting roof surfaces.

Verge. The edge of a roof surface at a gable.

Welt. The edge of the valley liner that is so shaped that the cleats can hook on to it.

SECTION 2: TECHNICAL DATA

2.1 STRUCTURAL DATA

Table 2: Tiling data

	Flat Double Roman, Bold Double Roman, Bold Roll, Double Pan, Marseilles Profiles		**Flat Profile**	**Shingle Tile**
	Pitch 17 to 25 degrees	Pitch 26deg and above	Pitch 26deg and above	Pitch 17deg
Tile head lap (minimum) mm	100	75	100	100
Batten centers (maximum) mm	320	345	320	320
Length of battens in m per m^2 (average)	3,15	2,99	3,15	3,15
Tiles per m^2 (average) units	10,42	9,66	10,8	10,42
Mass of tiles per m^2 (average) kg	48	45	56	53

Table 3: Rafter and batten data, applies with timber roof structures

Nominal size of tiles	420mm x 330mm
Rafter centers (maximum)	760mm with 38 x 38mm battens 760-900mm with 38 x 50mm battens fixed flat 900-1000mm with 38 x 50mm battens fixed on edge
Note: Spacing of rafters beyond 760mm centers may only be increased with engineer designed trusses using 38 x 50mm battens of the correct grade. All structural timber to comply with SANS 1783 Part 2 and Part 4 and SANS 10149	
Distance from top edge of first batten to outside edge of fascia board. Refer to Figure 1	335-340mm depending on manufacturer's requirements
Distance from top edge of first batten to outside of rafter where no facia board is used. Refer to Figure 2	305mm
Distance from top edge to top batten to rafter apex. Refer to Figure 3	25mm (or flat profile 25-50mm - refer to manufacturer)

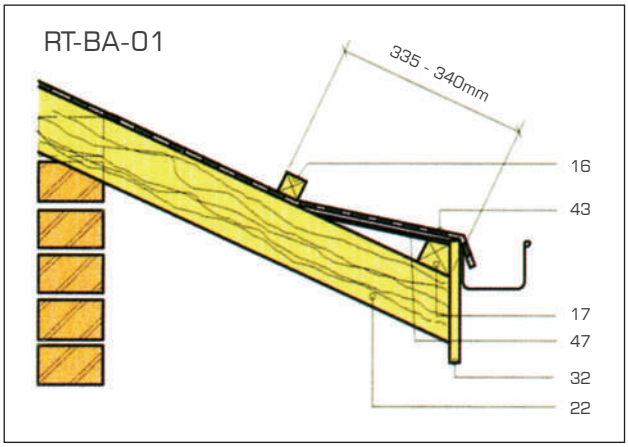


Figure 1: Eaves batten position using fascia

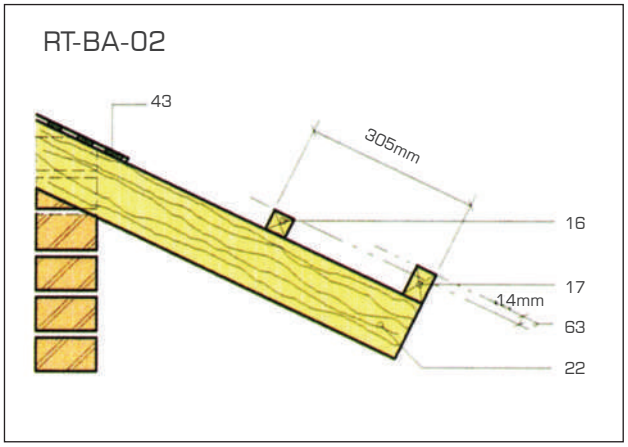
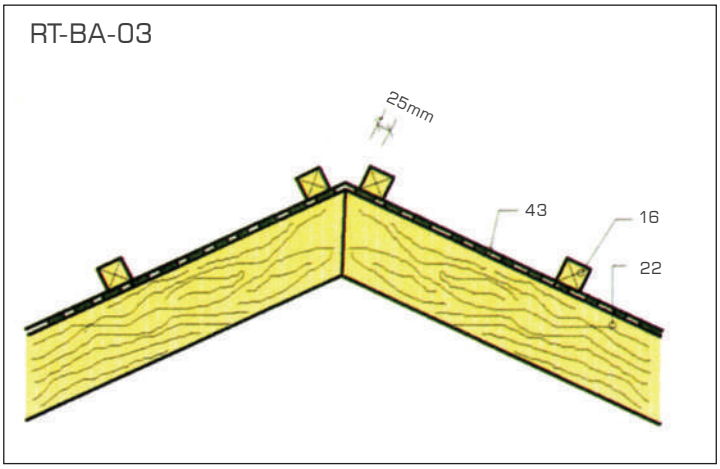


Figure 2: Eaves batten position without fascia



Legend

16 – Batten

17 – Tilting batten

22 – Rafter

32 – Fascia

43 – Undertile membrane

47 – Undertile membrane support

63 – Tilting dimension

Figure 3: Ridge batten position

2.2 PHYSICAL PROPERTIES

Table 4: Physical properties

Parameters	**Results**
Dimensional tolerances	Complies with SANS 542
Transverse strength	Complies with SANS 542 (minimum average breaking load 4,0 N/mm width)
Impact strength (hail resistance)	Tiles can withstand an impact energy of 20 Joule (equivalent to a 45mm diameter hail stone)
Permeability	Complies with SANS 542
Thermal properties	Conductivity: k = m.K Thermal resistance: R = m^2.K/W
Frost	Unaffected by frost
Fire	Non flammable, non combustible
Conductivity (lightning)	Concrete roof tiles are poor electric conductors
UV Radiation	Unaffected by UV radiation
Durability	Tile body: lifetime of building
TV Reception	Concrete roof tiles have virtually no effect on the television signal and permit the use of internal aerials in accordance with SANS 1061

2.3. UNDERLAYS

In current building practice, the underlays and radiant barriers have become an integral part of any tiled roof. When properly laid, they will provide a highly effective barrier against the ingress of wind-driven rain and dust, while at the same time, in the case of foils and radiant barriers, also provide an excellent insulation barrier. The pressures exerted by the wind forces will also be substantially be reduced due to the pressure equalization, greatly reducing the risk of wind uplift.

The use of suitable underlays, complying with the relevant National Standards or Agrément Approval Certificates is deemed required for all pitches in all areas.

Underlays must be fixed, prior to battening, horizontally over the rafters with a minimum overlap of 150mm and secured to the centre of the rafters with the minimum number of noncorrodible clout nails or other suitable fixtures. The vertical laps must be secured over a rafter with a minimum overlap of 150mm.

At closed eaves, the underlays must extend over the tilting batten and fascia board to allow drainage of water into the gutter.

A rigid board behind the fascia board to prevent the underlay from sagging and forming a water trap should suitably support the underlay. Refer to Figure 4.

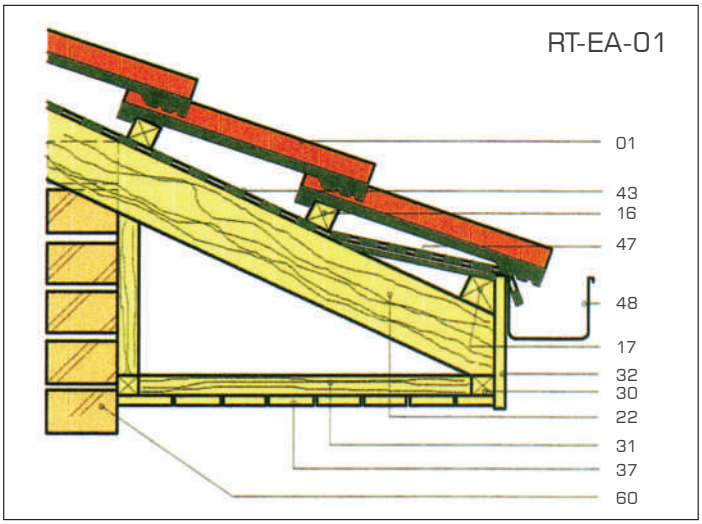


Figure 4: Undertile membrane closed eaves

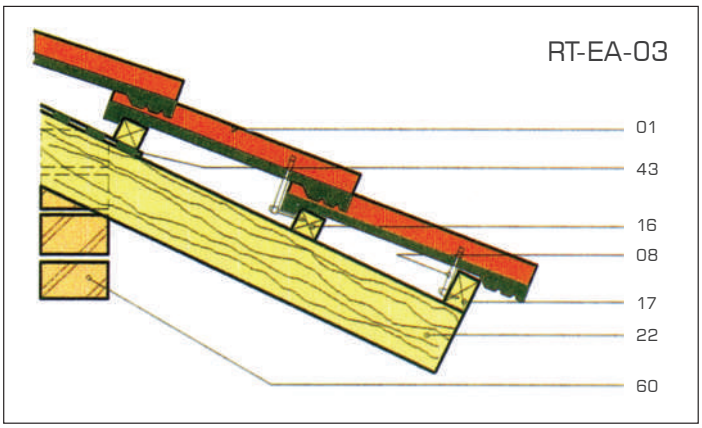


Figure 5: Undertile membrane open eaves

Legend

01 – Roof tile

08 – Storm clip

16 – Batten

17 – Tilting batten

22 – Rafter

30 – Timber support

31 –Timber framing

32 – Fascia

37 – Eaves lining

43 – Undertile membrane

47 – Undertile membrane support

48 – Gutter

60 – Masonry wall

At open eaves, the underlay extends at least 20mm over the beam filling on the exterior wall. Refer to Figure 5.

Over hips, a strip of underlay, 600mm wide should be laid overlapping the undertile foil and membrane of the main roof. Refer to figure 6.

In valleys, a similar strip of 600mm wide underlay should be used and tucked under the underlays of the main roof. Refer to figure 7.

To avoid any damage to the underlay by UV radiation, the foils and membranes should not be left exposed to sunlight for any length of time.

Exposed underlays can be damaged by excessive UV radiation, strong wind, heavy rain and traffic on the roof.

In exposed areas it is recommended that the eaves and verges be closed. The underlay must therefore be extended to the full overhang of the roof. Refer to Figure 4.

If underlays are damaged, they should be repaired by lifting the battens for the full width of the underlay and over a distance of two rafters. The replacement underlay must be tucked under the top layer above by at least 150mm and brought over the bottom layer below by 150mm and have a vertical overlap of 150mm on either side of the rafter. It should be secured to the top of the rafters with clout nails. Refer to Figures 8 and 9.

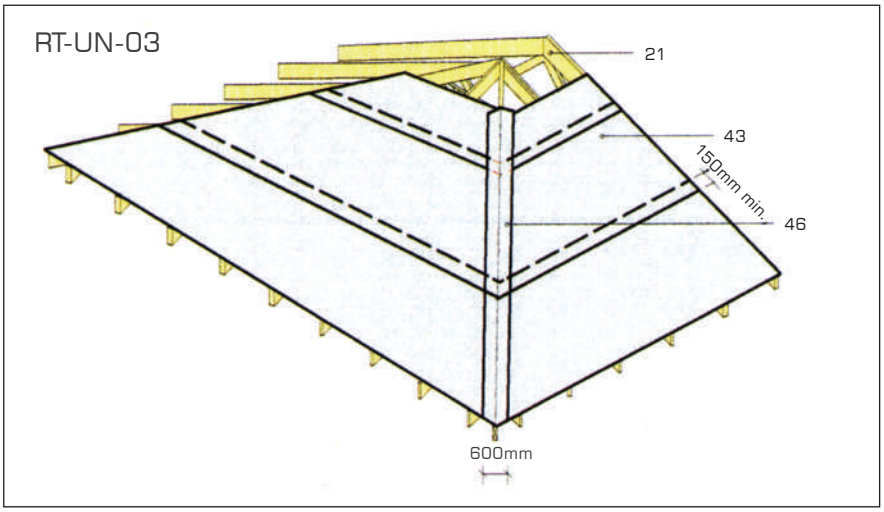


Figure 6: Hip 600mm overlay strip

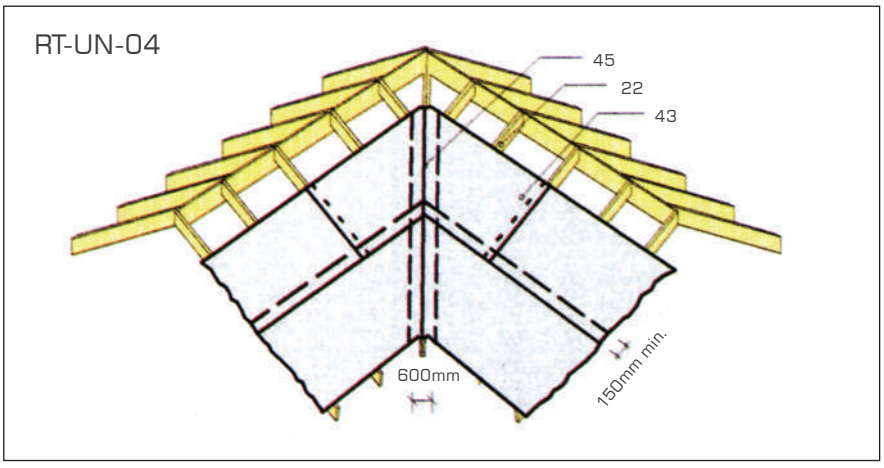


Figure 7: Valley 600mm underlay strip

Legend

21 – Truss

22 – Rafter

43 – Undertile membrane

45 – Underlay strip

46 – Overlay strip

In house designs where the ceiling boards or boarding are fixed to the top of the rafters, counter battens must be fixed on top of the ceiling boards directly above the rafters.

The underlay should then be laid horizontally over the counter battens resting on top of the ceiling boards. The battens are fixed to the counter battens at the required spacing.

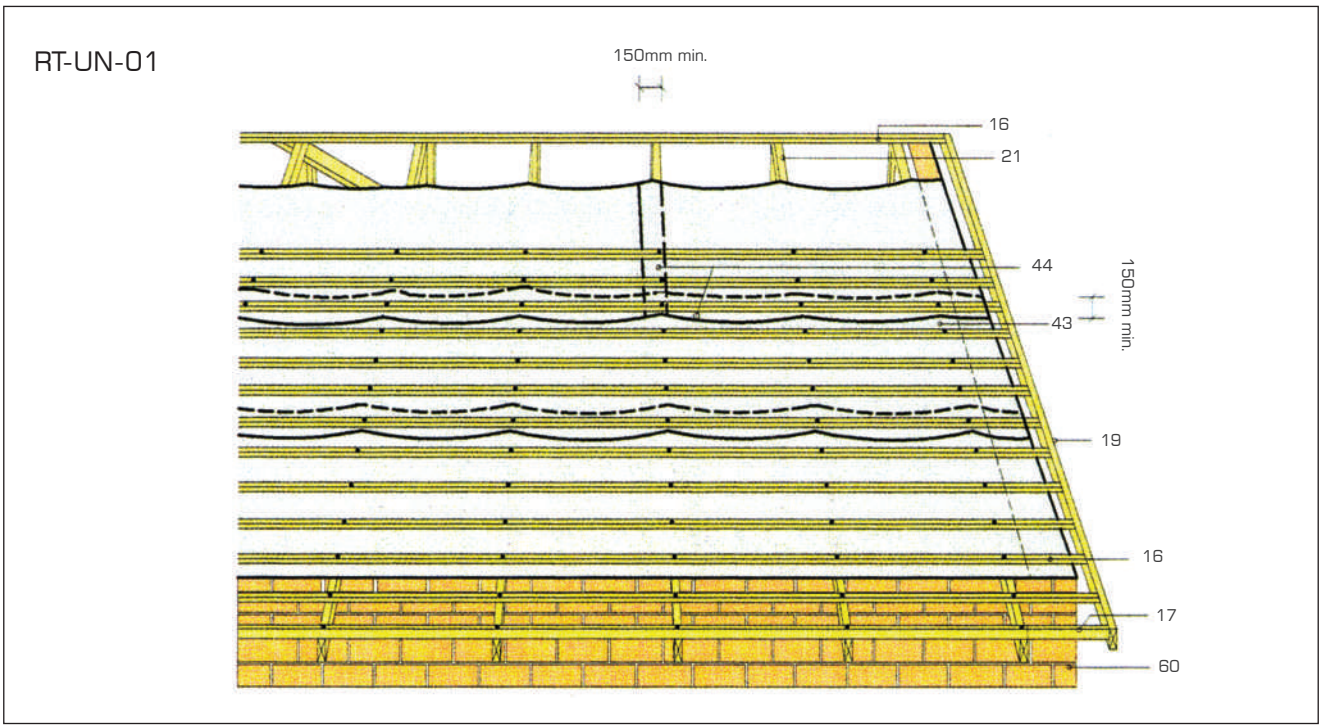


Figure 8: Undertile membrane over pitched roof illustrating laps

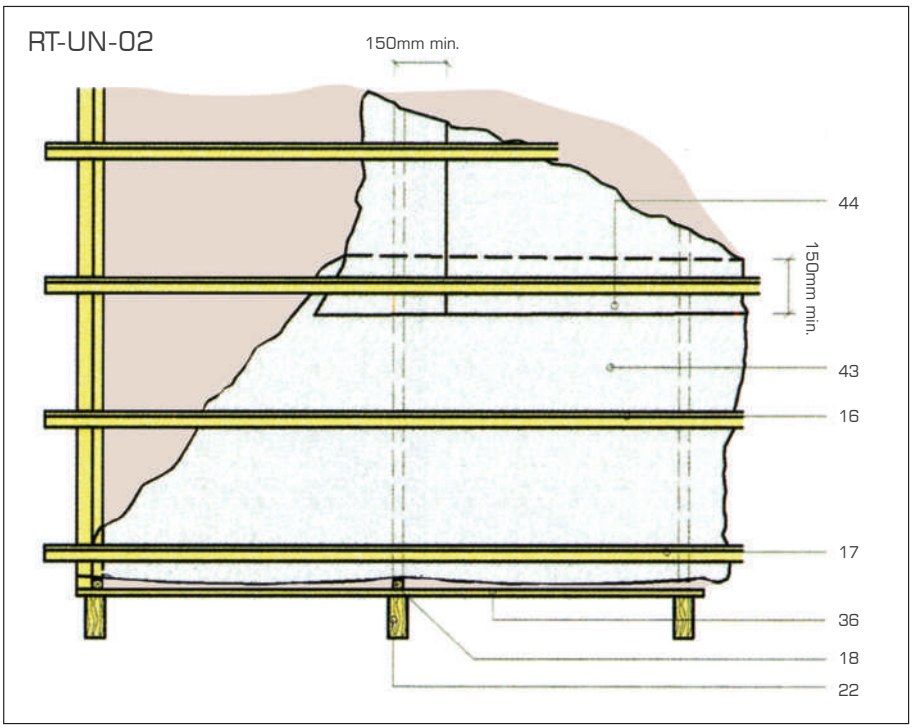


Figure 9: Undertile membrane over boarded roof illustrating laps

Legend

01 – Roof tile

16 – Batten

17 – Tilting batten

18 – Couner batten

19 – Verge counter batten

21 – Truss

22 – Rafter

36 – Boarding

43 – Undertile membrane

44 – Underlay overlap

60 – Masonry wall

2.4 BELOW MINIMUM PITCH SPECIFICATION

Minimum Pitch and Lap Specifications

As part of the manufacturer's specification, each roof tile design size has a minimum pitch, which may be associated with a particular surface finish, rafter length, and severity of exposure or head lap.

For further information related to the performance of particular tiles please refer to the manufacturer's technical literature.

Below Pitch Specification

Application. In certain instances the specifier has little option but to construct a roof below the minimum recommended pitch of the roof covering. These situations may include, for example, an extension to an existing property where an upper window and minimum headroom requirements or a requirement to match the existing roof covering/structure predetermines the pitch.

A roof designed below the minimum roof pitch should have a functional weatherproof sub roof system capable of collecting any ingressed rainwater and discharging it from the building. This sub roof system should meet the recommendations for strength, water resistance, nail tear resistance, water vapour resistance (where required) and durability as a deemed to satisfy requirement by SANS 10400-L Roofs.

Specification. Although roof tile manufacturers are unable to provide assurance of the performance of their roofing products in this situation, and any decision to proceed is at the specifier's own risk, the following specification aims to limit the risk of water ingress and might be considered suitable for smaller areas, such as extensions to existing domestic properties. To achieve this, the "groundwork"

beneath the tiles must be improved: in effect becoming an "inclined flat roof".

We would recommend that this specification is limited to a minimum pitch of 12.5° for interlocking concrete tiles.

The proposed work will be subject to the requirements of the National Building Regulations (SANS 10400 The application of the National Building Regulations).

We would recommend approval be obtained in the first instance from the relevant Local Authorities

The Below pitch specification should include the following:

- Laying 15mm external quality plywood boarding, selected to comply with SANS 929 Plywood and composite board, over the rafters with joints supported by rafters.
- Tape all plywood joints with 50mm wide strips of duct tape.
- Nail one layer of 1200mm wide roofing felt, to SANS 92 Bituminous roofing felt, to the taped plywood. The number of joints should be minimized by using continuous length of felt from the roll, with each layer overlapping the layer below
- Fully bond a second layer of roofing felt over the first layer using a torch on bitumen and staggering all joints between the first and second layers.
- The roofing felt is then overlaid with well-fixed 38 x 19mm timber counter battens to SANS 1783 Sawn soft wood timber, at spacings to suit the rafters.
- Lay one layer of undertile membrane to SANS 952 Polyolefin film for damp proofing and waterproofing in buildings, or Agrément approved undertile membrane over the counter battens with a minimum horizontal lap of 200mm and a vertical lap of 200mm. This underlay must be allowed to sag between the battens and not be pulled tight
- **Interlocking Tiles:** Fix 38 x 38mm (up to 760mm rafter centres) or 38 x 50mm (760mm to 900mm rafter centres) tiling battens (SANS1783 Sawn soft wood timber) at maximum gauge necessary to provide a minimum 100mm head lap. Battens to be preservative treated as per statutory requirements in accordance with SANS 10005 The preservative treatment of timber, in the prescribed areas. The minimum fixing for all tiles is to nail every third course and the full roof overhang. See SANS 10062 Fixing of interlocking roof tiles for further details.

2.5 CONDENSATION AND VENTILATION

Condensation occurs when warm moisture laden air meets a surface, which has a temperature below the dewpoint of the ambient air.

Where underlays are used, condensation may occur on the underside of the underlay. It should be prevented by the provision of adequate ventilation at eaves, ridges and gable walls where applicable.

Research has shown that a variable, but significant, proportion of dwelling heat can accumulate in the roof space. It is therefore important to ensure that all entries from the dwelling to the roof space, for instance around access hatches and service pipes and wires, are tightly sealed.

a) Eaves to eaves ventilation.

It should be noted that eaves to eaves roof ventilation might be insufficient for certain climatic conditions. For example this ventilation only functions when there is external air movement directed at right angles to the eaves of the building. Consequently there is a danger of stagnant, warm, moist air being trapped in the apex of the roof. When no air movement occurs, such as on cold, frosty nights in winter, temperature levels drop dramatically, causing condensation to form on the underside of the underlay.

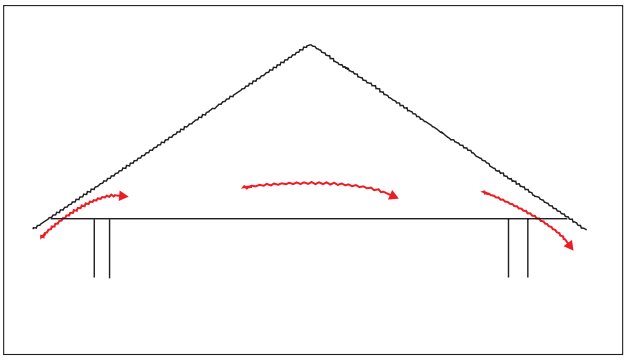


Figure 10: Eaves to eaves ventilation

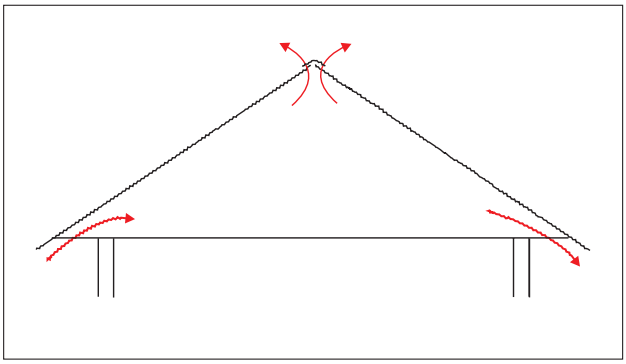


Figure 11: Eaves to ridge ventilation

b) Eaves to ridge ventilation

The most effective way to eliminate any con-densation problems is to supplement eaves to eaves ventilation with ridge ventilation through “dry ridging”. Refer to Figure 11. This method has the benefit of ensuring an efficient ventilation flow in all climatic condition by convection when no external air movement is present. To all pitched roofs dry ridging brings an effective solution to condensation problems by allowing a constant airflow in the roof space, preventing heat build-up. The complete dry ridge system consists of:

a. A ventilating hip and ridge roll, to allow the hot air to escape through the roof ridges

b. A ridge and hip tree device for alignment of the batten for better airflow

c. Sturdy fastening clips for ridge and hips to secure the roof in all weather conditions

Together the system is able to create a natural ventilation stream removing the hot and moist air trapped under the roof.

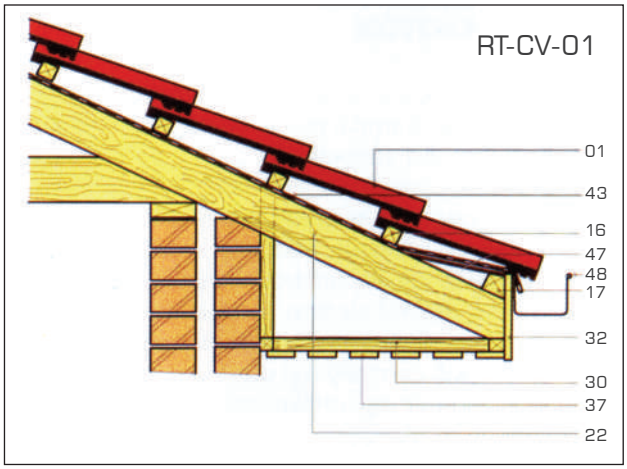


Figure 12: Ventilated closed eaves

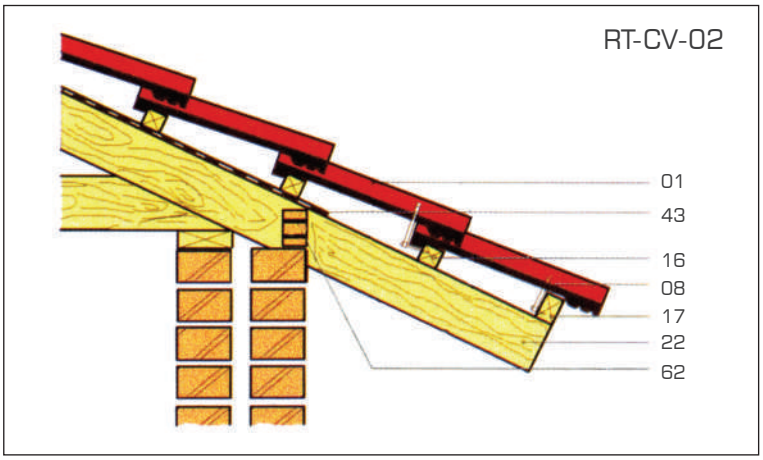


Figure 13: Open eaves with air brick

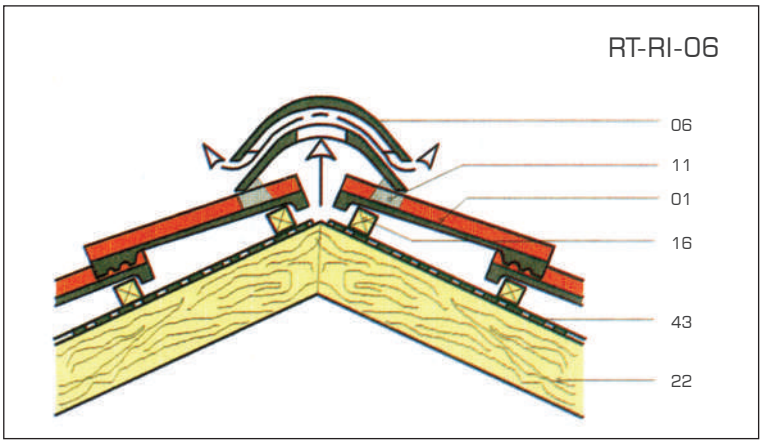


Figure 14a: Ventilated ridge tile

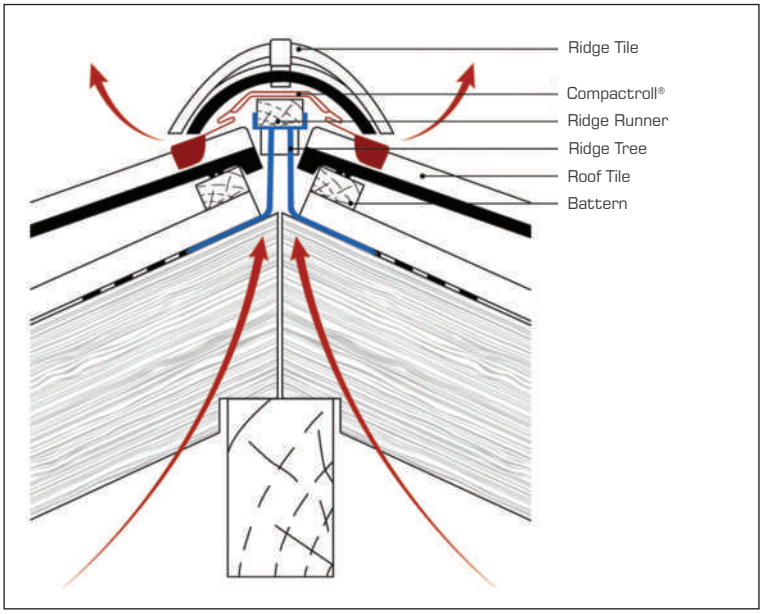


Figure 14b: Ventilated ridge tile

Legend

01 – Roof tile
06 – Ventilated ridge
08 – Storm clip
11 – Mortar bed
16 – Batten
17 – Tilting batten
22 – Rafter
30 – Timber support
32 – Fascia
37 – Eaves lining
43 – Undertile membrane
47 – Undertile membrane support
48 – Gutter
62 – Air brick

2.6 ROOF PITCH, WIND FORCES AND FIXING RECOMMENDATIONS

a) Roof pitch

The basic principle to be considered in roof design is that the roof pitch should be adequate to discharge rainwater in the shortest time possible.

An important factor, which should be considered when choosing a pitch for the roof, is the effect wind forces have on roofs.

These forces vary according to the speed and direction of the wind, the degree of exposure, the height and pitch of the roof. The uplift or suction created by the wind forces is greater on lower roof pitches.

The minimum roof pitch and the minimum head lap as specified in Table 2 must therefore not be reduced under any circumstances. It is preferable to raise the safety factor of the roof by adding a full course of tiles and increasing the tile head lap evenly on the rafter length

While the tile head lap may be increased, on exposed sites, greater lap is not as effective as a steeper pitch.

In certain coastal areas where rain and wind conditions are known to be severe, it is good practice to increase the roof pitch by 5° above the minimum pitches in addition to providing adequate fixing methods. For roof pitches above 45°, and for vertical cladding, the roof tiles must be nailed and clipped.

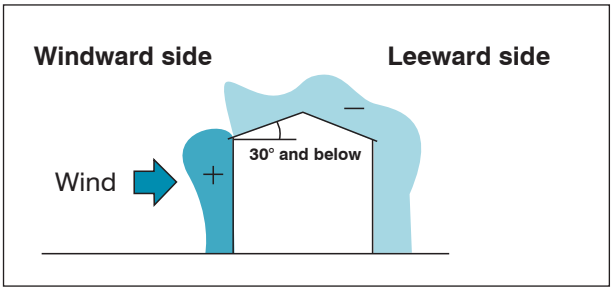


Figure 15: Wind forces on flat pitches

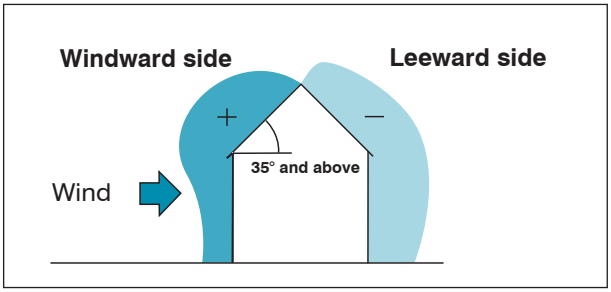


Figure 16: Wind forces on steep pitches

b) Wind forces and fixing recommendations

To ensure the satisfactory performance of a roof, the following factors should be taken into consideration:

- Type of building
- Pitch of roof
- Terrain category
- Basic wind speed
- Height of roof from ground to ridge
- Length of the roof slope

There are three minimum fixing specifications, A, B and C for concrete roof tiles, which are suitable for all normal roofing situations.

Fixing Tables

The procedure for using these tables is as follows:

Select the building type

- Double pitch roof on a single storey
- Double pitch roof on two storeys
- Double pitch roof on three storeys
- Monopitch roof

Select the appropriate roof pitch

- Determine the terrain category
- Determine the height from ground to ridge
- Determine the basic wind speed for the terrain from the map
- Read off specification A, B or C

In case of complex roof designs, exceptionally long rafter lengths (exceeding 8.0m) or buildings located in areas where extreme wind conditions prevail, more stringent fixing specifications may be required. For advice contact the manufacturer.

When considering the wind forces acting on the windward slope of pitched roofs, the pressure is dependant on the pitch. When the roof angle is less than 30°, the windward slope can be subjected to severe suction or negative pressure. Roofs steeper than 35° generally present sufficient obstruction to the wind for a positive pressure to be developed on their windward slopes. Even here,

though, there is an area near the ridge where suction is developed.

The leeward slopes are always subject to suction, though this is not usually as strong as that produced near the windward edge. Refer to Figures 15 and 16.

Under strong gusting wind conditions, the suction force on the roof tiles may be in excess of the mass of the tiles, thus requiring them to be securely fixed to prevent them from being lifted from the building. Wind tunnel tests have also shown the benefits provided by the underlay in resisting uprated wind loads.

No reliance should be placed on the shear or tensile strength of mortar to hold monoridge tiles and ridge tiles on steep or vertical hips, or at any place where there is a risk of differential movement. This means that mechanical fixing is necessary to prevent them from being dislodged.

Within the general roof area the tensile strength and pull out resistance of nails become important. At lower pitches tile clips provide resistance to the applied lifting force more successfully than nails, which due to their closeness to the pivot line where the nib touches the batten, cannot resist the uplift force created at the tail. Refer to Figure 17. At steeper pitches it is important to prevent the tiles being dislodged and from rattling under wind gusting.

Storm damage due to excessive wind gusting occurs in most instances at eaves, verges and under ridges.

It is therefore recommended that, in semi exposed and exposed roof situation, the mechanical fixing in these particular areas of the roof is to be improved. Rake verge tiles should be used at gable ends to secure the verges.

Storm damage due to excessive wind gusting seldom occurs at hips and valleys and additional mechanical fixing other than specified is not necessary. At valleys it is more important to ensure the correct width for the valley liner and good installation to prevent water overflow getting in the roof space.

c) Additional fixing

In severe or adverse wind load situation, special fixing specifications are required.

These situations are:

- Complex roof designs in semi-exposed or exposed areas.
- Steep pitches, vertical tiling and monopitched roofs (shopping malls, schools, etc.)

The special fixing specifications may include:

- Use of serrated nails or screws instead of normal fixing nails.
- Double fixing (in addition to normal fixing) in the pan of the tile. Additional fixing holes in tiles and fittings must be drilled on site as required.
- An alternative to the drilling of additional holes in tiles and fittings is the use of storm clips for additional fixing.

d) Exceptional rafter lengths

On very long rafter length, over 8m, the tile head lap must be increased as required, especially as the lower part of the roof sheds a large volume of rainwater.

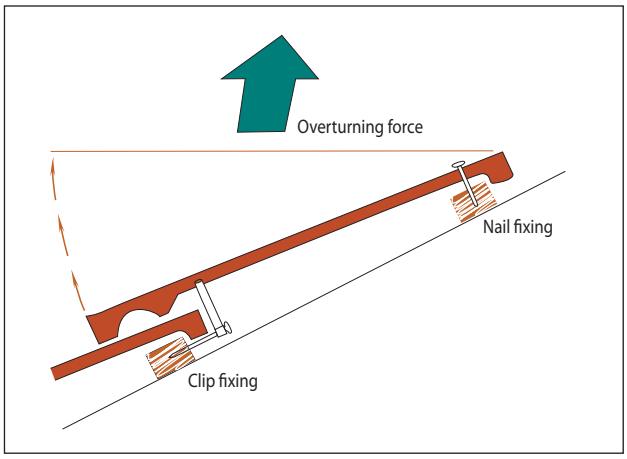
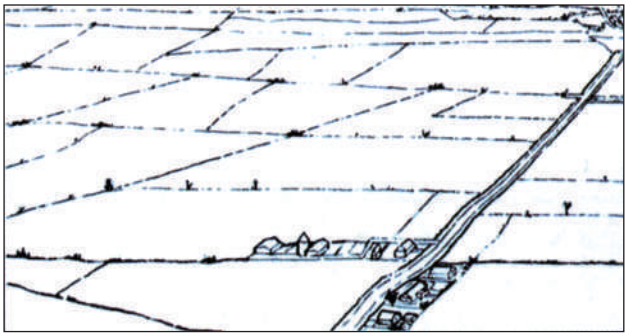


Figure 17: Clip fixing / Nail fixing

e) Terrain categories

Terrain category 1

Exposed open terrain with few or no obstructions and in which the average height of an object surrounding the structure is less than 1.5m in height. This category includes open seacoast and flat, treeless plains with little vegetation other than grass.



Terrain category 2

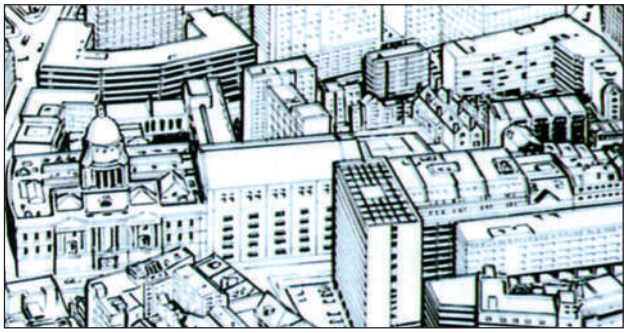
Open terrain with well-scattered obstructions having height generally between 1.5m and 10m. This category includes most parklands and undeveloped sparsely built-up outskirts of towns and suburbs.

Terrain category 3

Terrain with numerous closely spaced obstructions, the size of domestic houses. This category includes well-wooded areas and suburbs, town and industrial areas.

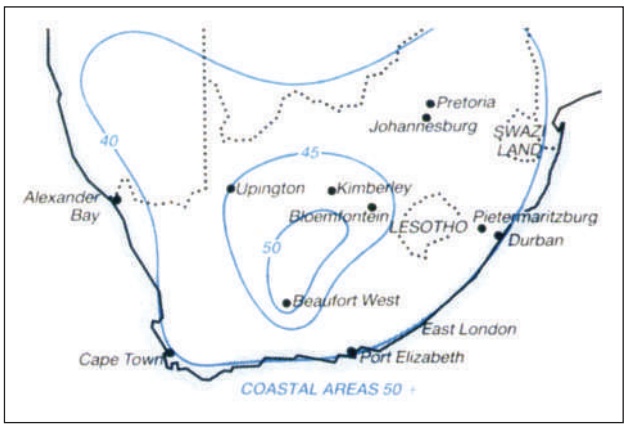
Terrain category 4

Terrain with numerous large, high, closely spaced obstructions. This category includes large city centres.



f) Regional basic design wind speed (as defined in SANS 10160 The general procedures and loadings to be adopted in the design of buildings).

The values given here are based on a statistical analysis of data gathered by the Weather Bureau of the Department of Transport over many years at a number of stations throughout the Republic. To obtain wind speeds for intermediate locations, either use linear interpolation or use the higher value isopleth.



Where local wind speed records of sufficient duration and reliability are available to the designer of a building in a given locality, these may be used to determine the regional basic wind speed instead of the value derived from this map, provided that the lower wind speeds are not adopted without the approval of the local authority.

In local areas where there is knowledge of the occurrence of high wind gusts and severe lifting forces (i.e. certain coastal areas, high veld storm areas, wind funnelling or other effects) interpolation must be done to the highest value.

g) Minimum fixing specifications

Fixing specification A (Unexposed roof situations)
Mechanically fix two courses of tiles at eaves and verges for the full overhang, whichever is greater and at ridges, and one adjacent full tile at valleys, hips and abutments. Cut tiles at valleys, hips and abutments are to be secured by nailing or wiring, as required. The use of cut tile clamps is recommended.

Roof pitches from 17° up to 26°
Underlay mandatory

Roof pitches from 26° up to 45°
Underlay recommended

Roof pitches from 45° up to 55°
Each tile to be nailed or clipped
Underlay recommended

Roof pitches from 55° up to 90°
Each tile to be nailed or clipped
Underlay mandatory

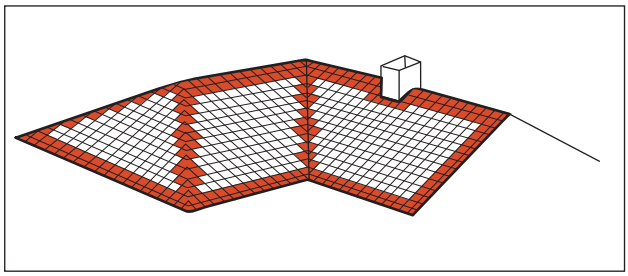


Figure 18: Fixing requirements – Specification A

Fixing specification B (Semi-exposed roof situations)
Mechanically fix a band of tiles (x) equal to a fifth of the number of courses on the rafter length at eaves and verges or the full overhang, whichever is the greater, and at ridges and abutments and one adjacent full tile at hips and valleys, and every third tile on the rest of the roof. Cut tiles at hips, valleys and abutments to be secured by nailing or wiring as required.

Example: 15 courses on the rafter: x = 3 courses, Soffits should be closed at eaves and verge overhangs

Roof pitches from 17° up to 26°
Underlay mandatory

Roof pitches from 26° up to 45°
Underlay recommended

Roof pitches from 45° up to 90°
Each tile to be nailed or clipped
Underlay mandatory

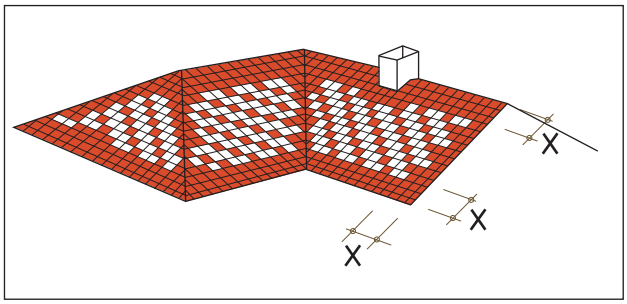


Figure 19: Fixing requirements – Specification B

Fixing specification C (Exposed roof situations and roof in coastal areas)

Each tile fixed.
Soffits closed at eaves and verge overhangs.

Roof pitches from 17° up to 45°
Each tile to be nailed or clipped
Underlay mandatory

Roof pitches from 45° up to 90°
Each tile to be nailed or clipped
Underlay mandatory

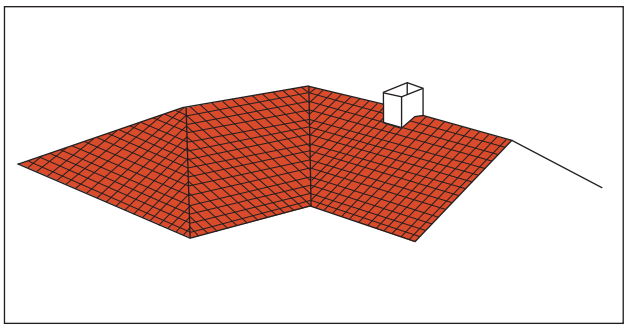


Figure 20: Fixing requirments –Specification C

Table 5: Minimum fixing recommendations for roofs on single storey buildings

17° ≤ Pitch < 22°

Terrain Category	h \ w	38	40	42	44	46	48	50	52	54	56
1	3	B	B	B	B	C	C	C	C	C	C
	5	B	B	B	C	C	C	C	C	C	C
	10	B	C	C	C	C	C	C	C	C	C
2	3	A	A	A	A	B	B	B	C	C	C
	5	A	A	B	B	B	C	C	C	C	C
	10	B	C	C	C	C	C	C	C	C	C
3	3	A	A	A	A	A	A	B	B	B	B
	5	A	A	A	A	B	B	B	C	C	C
	10	A	B	B	B	B	C	C	C	C	C
4	3	A	A	A	A	A	A	A	A	A	B
	5	A	A	A	A	A	A	A	B	B	B
	10	A	A	A	A	A	B	B	B	B	C

22° ≤ Pitch < 26°

Terrain Category	h \ w	38	40	42	44	46	48	50	52	54	56
1	3	B	B	B	B	B	C	C	C	C	C
	5	B	B	B	B	C	C	C	C	C	C
	10	B	B	C	C	C	C	C	C	C	C
2	3	A	A	A	A	B	B	B	B	C	C
	5	A	A	B	B	B	B	C	C	C	C
	10	B	B	C	C	C	C	C	C	C	C
3	3	A	A	A	A	A	B	B	B	B	B
	5	A	A	A	B	B	B	B	B	B	C
	10	A	B	B	B	B	B	C	C	C	C
4	3	A	A	A	A	A	A	A	A	A	B
	5	A	A	A	A	A	A	B	B	B	B
	10	A	A	A	A	B	B	B	B	B	C

26° ≤ Pitch < 30°

Terrain Category	h \ w	38	40	42	44	46	48	50	52	54	56
1	3	B	B	B	B	B	C	C	C	C	C
	5	B	B	B	C	C	C	C	C	C	C
	10	B	C	C	C	C	C	C	C	C	C
2	3	A	A	A	A	B	B	B	B	C	C
	5	A	A	B	B	B	B	C	C	C	C
	10	B	B	C	C	C	C	C	C	C	C
3	3	A	A	A	A	A	B	B	B	B	B
	5	A	A	A	B	B	B	B	B	B	C
	10	A	B	B	B	B	B	C	C	C	C
4	3	A	A	A	A	A	A	A	A	A	B
	5	A	A	A	A	A	A	A	B	B	B
	10	A	A	A	B	A	B	B	B	B	C

30° ≤ Pitch < 35°

Terrain Category	h \ w	38	40	42	44	46	48	50	52	54	56
1	3	B	B	B	B	C	C	C	C	C	C
	5	B	B	B	B	C	C	C	C	C	C
	10	C	C	C	C	C	C	C	C	C	C
2	3	A	A	B	B	B	B	B	B	C	C
	5	B	B	B	B	B	C	C	C	C	C
	10	B	B	C	C	C	C	C	C	C	C
3	3	A	A	A	A	A	B	B	B	B	B
	5	A	A	A	B	B	B	B	B	C	C
	10	A	B	B	B	B	B	C	C	C	C
4	3	A	A	A	A	A	A	A	A	B	B
	5	A	A	A	A	A	A	B	B	B	B
	10	A	A	A	A	B	B	B	B	B	B

25° ≤ Pitch <40°

Terrain Category	h \ w	38	40	42	44	46	48	50	52	54	56
1	3	B	B	B	B	C	C	C	C	C	C
	5	B	B	C	C	C	C	C	C	C	C
	10	C	C	C	C	C	C	C	C	C	C
2	3	A	A	B	B	B	B	B	C	C	C
	5	B	B	B	B	B	C	C	C	C	C
	10	B	C	C	C	C	C	C	C	C	C
3	3	A	A	A	A	B	B	B	B	B	C
	5	A	A	B	B	B	B	B	B	C	C
	10	B	B	B	B	B	C	C	C	C	C
4	3	A	A	A	A	A	A	A	A	B	B
	5	A	A	A	A	A	A	B	B	B	B
	10	A	A	A	B	B	B	B	B	B	C

40° ≤ Pitch < 45°

Terrain Category	h \ w	38	40	42	44	46	48	50	52	54	56
1	3	B	B	C	C	C	C	C	C	C	C
	5	B	C	C	C	C	C	C	C	C	C
	10	C	C	C	C	C	C	C	C	C	C
2	3	A	B	B	B	B	C	C	C	C	C
	5	B	B	B	C	C	C	C	C	C	C
	10	C	C	C	C	C	C	C	C	C	C
3	3	A	A	A	A	B	B	B	B	C	C
	5	A	A	B	B	B	B	C	C	C	C
	10	B	B	B	B	C	C	C	C	C	C
4	3	A	A	A	A	A	A	A	B	B	B
	5	A	A	A	A	A	A	B	B	B	B
	10	A	A	A	B	B	B	B	C	C	C

A = Perimeter only

B = Perimeter and local roof area

C = Each tile fixed

h = Height from ground to ridge, m

w = Basic wind speed on terrain, m/s

Unshaded areas: Undertile membrane essential

Shaded areas: Undertile membrane recommended

Table 6: Minimum fixing recommendations for roofs on two storey buildings

17° ≤ Pitch < 22°

Terrain Category	w / h	38	40	42	44	46	48	50	52	54	56
1	5	B	C	C	C	C	C	C	C	C	C
	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
2	5	B	B	B	C	C	C	C	C	C	C
	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
3	5	A	A	B	B	B	B	B	C	C	C
	10	B	B	B	C	C	C	C	C	C	C
	15	A	C	C	C	C	C	C	C	C	C
4	5	A	A	A	A	A	B	B	B	B	B
	10	A	A	B	B	B	B	B	C	C	C
	15	B	B	B	B	B	C	C	C	C	C

22° ≤ Pitch < 26°

Terrain Category	w / h	38	40	42	44	46	48	50	52	54	56
1	5	B	B	C	C	C	C	C	C	C	C
	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
2	5	B	B	B	B	C	C	C	C	C	C
	10	B	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
3	5	A	A	B	B	B	B	B	C	C	C
	10	B	B	B	B	B	B	C	C	C	C
	15	B	B	C	C	C	C	C	C	C	C
4	5	A	A	A	A	A	A	B	B	B	B
	10	A	A	A	B	B	B	B	B	C	C
	15	A	B	B	B	B	B	C	C	C	C

26° ≤ Pitch < 30°

Terrain Category	w / h	38	40	42	44	46	48	50	52	54	56
1	5	B	B	C	C	C	C	C	C	C	C
	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
2	5	B	B	B	B	B	C	C	C	C	C
	10	B	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
3	5	A	A	A	B	B	B	B	B	C	C
	10	A	B	B	B	B	C	C	C	C	C
	15	B	B	C	C	C	C	C	C	C	C
4	5	A	A	A	A	A	A	B	B	B	B
	10	A	A	A	A	B	B	B	B	B	C
	15	A	A	B	B	B	B	C	C	C	C

30° ≤ Pitch < 35°

Terrain Category	w / h	38	40	42	44	46	48	50	52	54	56
1	5	B	B	C	C	C	C	C	C	C	C
	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
2	5	B	B	B	B	B	C	C	C	C	C
	10	B	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
3	5	A	A	A	B	B	B	B	C	C	C
	10	A	B	B	B	B	C	C	C	C	C
	15	B	B	C	C	C	C	C	C	C	C
4	5	A	A	A	A	A	A	B	B	B	B
	10	A	A	A	A	B	B	B	B	B	C
	15	A	A	B	B	B	B	C	C	C	C

35° ≤ Pitch < 40°

Terrain Category	w / h	38	40	42	44	46	48	50	52	54	56
1	5	B	B	C	C	C	C	C	C	C	C
	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
2	5	B	B	B	B	C	C	C	C	C	C
	10	B	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
3	5	A	A	B	B	B	B	B	C	C	C
	10	B	B	B	B	C	C	C	C	C	C
	15	B	B	C	C	C	C	C	C	C	C
4	5	A	A	A	A	A	A	B	B	B	B
	10	A	A	B	B	B	B	B	B	C	C
	15	A	B	B	B	B	C	C	C	C	C

40° ≤ Pitch < 45°

Terrain Category	w / h	38	40	42	44	46	48	50	52	54	56
1	5	B	C	C	C	C	C	C	C	C	C
	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
2	5	A	B	B	C	C	C	C	C	C	C
	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
3	5	A	A	B	B	B	B	C	C	C	C
	10	B	B	B	B	C	C	C	C	C	C
	15	B	C	C	C	C	C	C	C	C	C
4	5	A	A	A	A	A	A	B	B	B	B
	10	A	A	A	B	B	B	B	C	C	C
	15	A	B	B	B	B	C	C	C	C	C

A = Perimeter only

B = Perimeter and local roof area

C = Each tile fixed

h = Height from ground to ridge, m

w = Basic wind speed on terrain, m/s

Unshaded areas: Undertile membrane essential

Shaded areas: Undertile membrane recommended

Table 7: Minimum fixing recommendations for roofs on three storey buildings

17° ≤ Pitch < 22°

Terrain Category	h \ w	38	40	42	44	46	48	50	52	54	56
1	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
	20	C	C	C	C	C	C	C	C	C	C
2	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
	20	C	C	C	C	C	C	C	C	C	C
3	10	B	B	B	B	C	C	C	C	C	C
	15	B	C	C	C	C	C	C	C	C	C
	20	C	C	C	C	C	C	C	C	C	C
4	10	A	A	B	B	B	B	B	C	C	C
	15	B	B	B	B	B	C	C	C	C	C
	20	B	B	B	C	C	C	C	C	C	C

22° ≤ Pitch < 26°

Terrain Category	h \ w	38	40	42	44	46	48	50	52	54	56
1	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
	20	C	C	C	C	C	C	C	C	C	C
2	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
	20	C	C	C	C	C	C	C	C	C	C
3	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
	20	C	C	C	C	C	C	C	C	C	C
4	10	A	A	A	B	B	B	C	C	C	C
	15	A	B	B	B	C	C	C	C	C	C
	20	B	B	C	C	C	C	C	C	C	C

26° ≤ Pitch < 30°

Terrain Category	h \ w	38	40	42	44	46	48	50	52	54	56
1	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
	20	C	C	C	C	C	C	C	C	C	C
2	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
	20	C	C	C	C	C	C	C	C	C	C
3	10	B	B	B	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
	20	C	C	C	C	C	C	C	C	C	C
4	10	A	A	A	B	B	B	C	C	C	C
	15	A	B	B	B	C	C	C	C	C	C
	20	B	B	C	C	C	C	C	C	C	C

30° ≤ Pitch < 35°

Terrain Category	h \ w	38	40	42	44	46	48	50	52	54	56
1	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
	20	C	C	C	C	C	C	C	C	C	C
2	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
	20	C	C	C	C	C	C	C	C	C	C
3	10	B	B	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
	20	C	C	C	C	C	C	C	C	C	C
4	10	A	A	B	B	B	C	C	C	C	C
	15	B	B	B	C	C	C	C	C	C	C
	20	B	C	C	C	C	C	C	C	C	C

35° ≤ Pitch < 40°

Terrain Category	h \ w	38	40	42	44	46	48	50	52	54	56
1	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
	20	C	C	C	C	C	C	C	C	C	C
2	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
	20	C	C	C	C	C	C	C	C	C	C
3	10	B	B	B	B	C	C	C	C	C	C
	15	B	C	C	C	C	C	C	C	C	C
	20	C	C	C	C	C	C	C	C	C	C
4	10	A	A	A	B	B	B	B	C	C	C
	15	A	B	B	B	B	B	C	C	C	C
	20	B	B	B	C	C	C	C	C	C	C

40° ≤ Pitch < 45°

Terrain Category	h \ w	38	40	42	44	46	48	50	52	54	56
1	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
	20	C	C	C	C	C	C	C	C	C	C
2	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
	20	C	C	C	C	C	C	C	C	C	C
3	10	B	B	B	B	C	C	C	C	C	C
	15	B	C	C	C	C	C	C	C	C	C
	20	C	C	C	C	C	C	C	C	C	C
4	10	A	A	A	B	B	B	B	C	C	C
	15	A	B	B	B	B	C	C	C	C	C
	20	B	B	B	C	C	C	C	C	C	C

A = Perimeter only

B = Perimeter and local roof area

C = Each tile fixed

h = Height from ground to ridge, m

w = Basic wind speed on terrain, m/s

Unshaded areas: Undertile membrane essential

Shaded areas: Undertile membrane recommended

Table 8: Minimum fixing recommendations for monopitch roofs

17° ≤ Pitch < 22°

Terrain Category	h \ w	38	40	42	44	46	48	50	52	54	56
1	5	C	C	C	C	C	C	C	C	C	C
	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
2	5	B	B	C	C	C	C	C	C	C	C
	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
3	5	B	B	B	B	B	C	C	C	C	C
	10	B	B	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
4	5	A	A	A	A	A	B	B	B	B	C
	10	A	B	B	B	B	B	C	C	C	C
	15	B	B	B	C	C	C	C	C	C	C

22° ≤ Pitch < 26°

Terrain Category	h \ w	38	40	42	44	46	48	50	52	54	56
1	5	C	C	C	C	C	C	C	C	C	C
	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
2	5	B	B	C	C	C	C	C	C	C	C
	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
3	5	B	B	B	B	C	C	C	C	C	C
	10	B	B	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
4	5	A	A	A	B	B	B	B	B	C	C
	10	A	B	B	B	B	B	C	C	C	C
	15	B	B	B	B	C	C	C	C	C	C

26° ≤ Pitch < 30°

Terrain Category	h \ w	38	40	42	44	46	48	50	52	54	56
1	5	C	C	C	C	C	C	C	C	C	C
	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
2	5	B	B	C	C	C	C	C	C	C	C
	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
3	5	B	B	B	B	C	C	C	C	C	C
	10	B	B	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
4	5	A	A	A	B	B	B	B	B	C	C
	10	A	B	B	B	B	C	C	C	C	C
	15	B	B	B	C	C	C	C	C	C	C

30° ≤ Pitch < 35°

Terrain Category	h \ w	38	40	42	44	46	48	50	52	54	56
1	5	C	C	C	C	C	C	C	C	C	C
	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
2	5	B	C	C	C	C	C	C	C	C	C
	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
3	5	B	B	B	B	C	C	C	C	C	C
	10	B	B	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
4	5	A	A	A	B	B	B	B	B	C	C
	10	A	B	B	B	B	C	C	C	C	C
	15	B	B	B	C	C	C	C	C	C	C

35° ≤ Pitch < 40°

Terrain Category	h \ w	38	40	42	44	46	48	50	52	54	56
1	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
	20	C	C	C	C	C	C	C	C	C	C
2	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
	20	C	C	C	C	C	C	C	C	C	C
3	10	B	B	B	B	C	C	C	C	C	C
	15	B	C	C	C	C	C	C	C	C	C
	20	C	C	C	C	C	C	C	C	C	C
4	10	A	A	A	B	B	B	B	C	C	C
	15	A	B	B	B	B	B	C	C	C	C
	20	B	B	B	C	C	C	C	C	C	C

40° ≤ Pitch < 45°

Terrain Category	h \ w	38	40	42	44	46	48	50	52	54	56
1	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
	20	C	C	C	C	C	C	C	C	C	C
2	10	C	C	C	C	C	C	C	C	C	C
	15	C	C	C	C	C	C	C	C	C	C
	20	C	C	C	C	C	C	C	C	C	C
3	10	B	B	B	B	C	C	C	C	C	C
	15	B	C	C	C	C	C	C	C	C	C
	20	C	C	C	C	C	C	C	C	C	C
4	10	A	A	A	B	B	B	B	C	C	C
	15	A	B	B	B	B	C	C	C	C	C
	20	B	B	B	C	C	C	C	C	C	C

A = Perimeter only

B = Perimeter and local roof area

C = Each tile fixed

h = Height from ground to ridge, m

w = Basic wind speed on terrain, m/s

Unshaded areas: Undertile membrane essential

Shaded areas: Undertile membrane recommended

2.7 ESTIMATING

This guide has been compiled to estimate concrete roof tile quantities. To use this guide one should acquaint oneself with the roofing terminology used in the concrete roof tile industry. Reference should also be made to the definitions of building terms and of roof forms, which can be found in Section 1.

Eaves length. The total length of the roof eaves including verge overhangs.

Roof span. The projected span of the roof on the plan, including eaves overhangs.

Rafter span. The projected span of a rafter length, equal to half the roof span, for a symmetrical double-pitched roof.

Rafter length. The distance measured on top of the rafter, between the rafter apex and the end of the rafter at eaves, or the outside of the facia board, if any.

Roof plan area. The flat surface area on the plan calculated from the roofline.

Roof area to slope. The actual area to be tiled.

Roof pitch. The angle between the rafter and the horizontal. Rafter Pitch = Roof Pitch.

Roof constant multipliers. Constant factors used in roof calculations. Refer to Table 9.

The head lap. The distance by which the tiles overlap one another.

Roofline on the plan. The projected line of the roof perimeter on the plan, including verge eaves and gutter overhang.

Gutter overhang. The distance by which the tiles overhang the facial board over the gutter. For estimating purposes (standard 100mm gutter) this distance is assumed at: 50mm on the plan, 60mm on the slope.

Tile pitch. The angle between the tile when laid on a roof and the horizontal. The tile pitch is generally 50 lower than the roof pitch.

Batten centres. The distance by which the battens are spaced, measured from top of batten to top of batten, or from centre to centre.

Ridge length. The horizontal length of the roof apex.

Hip and valley length. The length of a hip or valley measured from eaves to apex.

Note: The length of the hip or valley cannot be measured off the plan and must always be calculated.

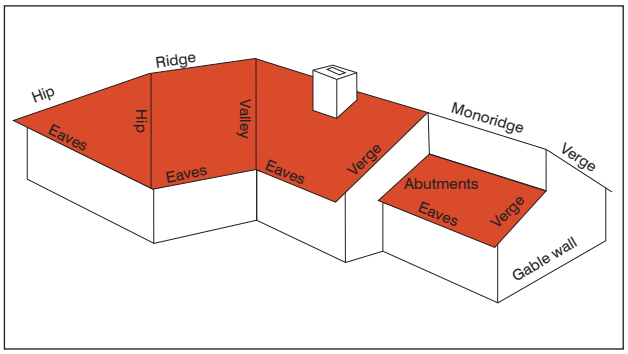


Figure 22: Roof terminology

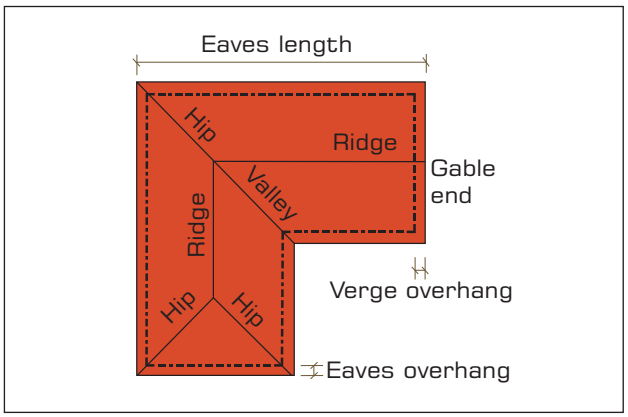


Figure 23: Roof plan

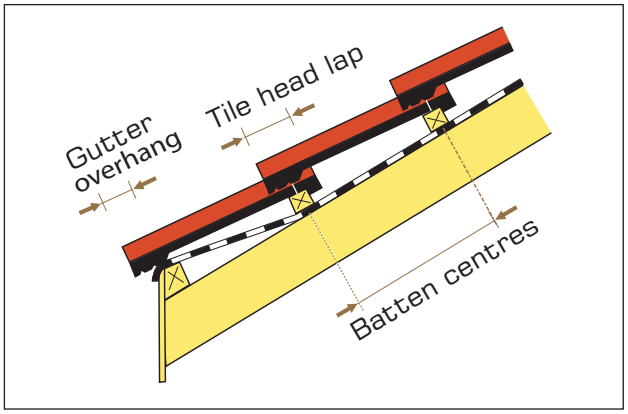


Figure 24: Tile head lap

Calculating roof tile quantities

The two methods of calculating roof tile quantities are:
a) Eaves length/rafter length method.
b) Roof area method.

To calculate the number of tiles required, it is necessary to have working drawings showing lengths of eaves, rafters and roof pitch. Roofs having the same eaves overhang and rafter length and roof pitch will have the same roof area regardless of whether the roof has hipped or gabled ends. If rafter lengths cannot be taken off the drawings they can be calculated as follows:

To calculate the rafter length at a given pitch, multiply the rafter span (including the eaves overhang) by the appropriate rafter constant. Refer to table 9.

Rafter length = rafter span x rafter constant

To calculate the valley or hip length multiply the rafter span by the appropriate valley/hip constant:

Valley/hip rafter length = rafter span x valley/hip constant

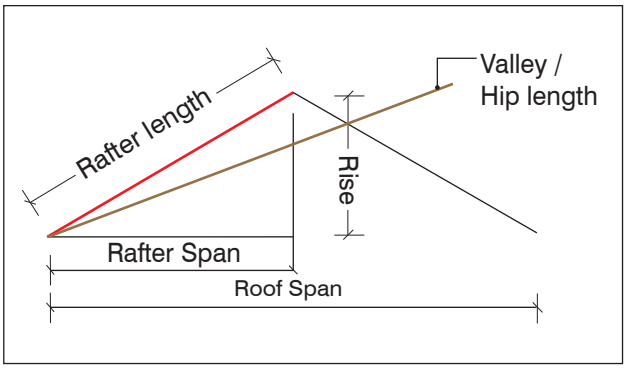


Figure 25: Calculating length of rafter, valley or hip

a) Eaves length/rafter length method

This is an accurate method and is recommended when calculating quantities of tiles required.

a. Using Table 10 Column 4 read off number of tiles required along the length of the eaves. Round up to the nearest full tile.

b. Using Table 10 read off the number of courses required on the rafter length at the relevant tile head lap. Round up to the nearest full tile.

c. Multiply the number of tiles along the eaves by the number of courses on the rafter length for each roof area. Add the total together.

d. Add 2% of total for wastage.

b) Roof area method
Reduce the roof plan to basic areas.

a. Calculate each roof area on plan by multiplying eaves length of each roof area by the roof span.

b. Total area of roof to be tiled = sum of various areas on plan x constant for the appropriate roof pitch. Refer to Table 9.

c. If the roof has different pitches for the various areas, than each area should be calculated separately.

d. As this roof area method is only approximate add 5% for wastage.

e. Valleys and hips: extra tiles for cutting.
Length of hips and valleys = number of hips/valleys x rafter span x hip/valley constant. Refer to Table 9.
Extra tiles for hips = length of hips x 3.
Extra tiles for valleys = length of valleys x 4.

f. Add 2% for wastage. Round up to nearest 10.

g. Ridge tile quantities for ridges and hips. Total ridge hip tiles required = length of ridge/hip x number of ridge/hip tiles/m. Refer to manufacturer if in doubt. Add one ridge tile per length of ridge. Add one ridge tile per hip for mitring at ridge/hip junction.

h. Add 5% for wastage.

i. Verge. For each verge allow one rake verge tile for each course of tiling and one extra verge tile for mitring at the apex.

j. Add 5% for wastage.

Table 9: Roof rafter constant multipliers

Roof pitch	Rafter	Valley/Hip For calculations in between use the preceding higher constant.			Rise
		90° Standard	120°	150°	
17	1,049	1,450	1,197	1,082	0,315
18	1,051	1,451	1,200	1,085	0,325
19	1,058	1,456	1,205	1,091	0,344
20	1,064	1,460	1,211	1,097	0,364
21	1,071	1,465	1,217	1,104	0,384
22	1,079	1,471	1,224	1,111	0,404
23	1,086	1,476	1,230	1,118	0,424
24	1,095	1,482	1,238	1,127	0,445
25	1,103	1,488	1,246	1,135	0,466
26	1,113	1,496	1,254	1,144	0,488
27	1,122	1,503	1,263	1,154	0,510
28	1,133	1,511	1,272	1,164	0,532
29	1,143	1,519	1,281	1,174	0,554
30	1,155	1,528	1,291	1,185	0,577
31	1,167	1,537	1,302	1,197	0,601
32	1,179	1,546	1,313	1,209	0,625
33	1,192	1,556	1,325	1,220	0,649
34	1,206	1,567	1,338	1,236	0,675
35	1,221	1,578	1,351	1,294	0,700
36	1,236	1,590	1,365	1,265	0,727
37	1,252	1,602	1,379	1,281	0,754
38	1,269	1,616	1,394	1,297	0,781
39	1,287	1,630	1,411	1,314	0,810
40	1,305	1,644	1,428	1,332	0,839
41	1,325	1,660	1,445	1,351	0,869
42	1,346	1,677	1,464	1,372	0,900
43	1,367	1,695	1,484	1,393	0,933
44	1,390	1,712	1,506	1,416	0,966
45	1,414	1,732	1,528	1,439	1,000
46	1,440	1,753	1,552	1,464	1,036
47	1,466	1,775	1,576	1,490	1,072
48	1,494	1,798	1,603	1,518	1,111
49	1,524	1,823	1,630	1,547	1,150
50	1,556	1,850	1,660	1,579	1,192
51	1,589	1,877	1,690	1,611	1,235
52	1,624	1,907	1,724	1,646	1,280
53	1,662	1,940	1,759	1,683	1,327
54	1,701	1,973	1,797	1,722	1,376
55	1,743	1,009	1,837	1,764	1,428
56	1,788	2,049	1,880	1,808	1,483
57	1,836	2,091	1,925	1,855	1,540
58	1,887	2,136	1,973	1,906	1,600
59	1,942	2,184	2,026	1,960	1,664
60	2,000	2,236	2,082	2,018	1,732
54°	1,701	1,973	1,797	1,722	1,376
55°	1,743	1,009	1,837	1,764	1,428
56°	1,788	2,049	1,880	1,808	1,483
57°	1,836	2,091	1,925	1,855	1,540
57,5°	1,861	2,113	1,949	1,880	1,570
58°	1,887	2,136	1,973	1,906	1,600
59°	1,942	2,184	2,026	1,960	1,664
60°	2,000	2,236	2,082	2,018	1,732

Table 10: Tile cover - rafter/eaves

Number of tiles Nominal size of tiles 420 x 330mm	Rafter Roof pitch		Eaves
	17deg to 25deg 100mm head lap 320mm batten centres (m)	26deg and above 75mm head lap 345mm batten centres (m)	Nominal covering on eaves length (m)
1	0,36	0,360	0,322
2	0,68	0,705	0,633
3	1,00	1,050	0,934
4	1,32	1,395	1,235
5	1,64	1,740	1,536
6	1,96	2,085	1,837
7	2,28	2,430	2,138
8	2,60	2,775	2,439
9	2,92	3,120	2,740
10	3,24	3,465	3,041
11	3,56	3,810	3,342
12	3,88	4,155	3,643
13	4,20	4,500	3,944
14	4,52	4,845	4,245
15	4,84	5,190	4,546
16	5,16	5,535	4,847
17	5,48	5,880	5,148
18	5,80	6,225	5,449
19	6,12	6,570	5,750
20	6,44	6,915	6,051
21	6,76	7,260	6,352
22	7,08	7,605	6,653
23	7,40	7,950	6,954
24	7,72	8,295	7,255
25	8,04	8,640	7,556
26	8,36	8,985	7,857
27	8,68	9,330	8,158
28	9,00	9,675	8,459
29	9,32	10,020	8,760
30	9,64	10,365	9,061
31	9,96	10,710	9,362
32	10,28	11,055	9,663
33	10,60	11,400	9,964
34	10,92	11,745	10,265
35	11,24	12,090	10,566
36	11,56	12,435	10,867
37	11,88	12,780	11,168
38	12,20	13,125	11,469
39	12,52	13,470	11,770
40	12,84	13,815	12,071

2.8 TENDER SPECIFICATION AND BILL OF QUANTITIES

a) Preamble – roof measuring

Standard system for roof measuring of concrete roof tiles.

General

Roof covering is measured net and subject to remeasurement on completion of work. Wastage and breakage must always be added.

Tiling

Roof tiling with concrete roof tiles shall be given in square metres and must be separated into three categories:

1. Flat slope – not exceeding 25° from the horizontal
2. Steep slope – from 26° to 55°
3. Vertical – Exceeding 55°

Reference must be made in the bill of quantities to the height of the building, the number of storeys, the roof pitch and the batten centres (the tile head lap). For roof pitches from 17° to 25° tiles must be laid with a minimum head lap of 100mm (maximum batten centres 320mm) with underlay and foils mandatory. For roof pitches from 26° upwards tiles must be laid with a minimum head lap of 75mm (maximum batten centres 345mm), with underlay and foils recommended.

Note: For flat profile tiles contact the manufacturer for minimum roof pitch, overlaps and batten centres.

Mechanical fixing of tiles shall be done strictly in accordance with manufacturer's recommendations.

Coverings to dormers, turrets and the like shall be given separately. No deductions shall be made for openings, vents, etc. not exceeding 1m^2.

Raking and cutting.

Raking, cutting and waste at abutments, parapet walls, verges, skew eaves, etc. where not otherwise provided for shall be given in linear metres. Flashing material measured elsewhere.

Valleys

Close-cut and open-cut valleys shall be given in linear metres and the description shall include cutting of tiles and waste to both sides. Wiring of cut tiles, as in the case of an open valley, shall be included in the description. Valley liner measured elsewhere.

Hips

Close-cut and mitred hips shall be given in linear metres. The description shall include cutting of tiles and waste to sides, pigment bedding and pointing. Sand cement and DPC is to be provided by the main contractor, unless specified otherwise in the Bill of Quantities. Preference is given to mechanical fixing of the hip tiles over the use of mortar and shall be so described. Use only the recommended mortar mixes where mortar is specified. Recommended practice is to avoid the use of mortar wherever possible and instead use a dry fix system, which is more secure, durable and requires less maintenance.

Ridges

Ridges shall be given in linear metres. The description shall include ridge tiles, pigment bedding and pointing. Sand cement and DPC is to be provided by the main contractor, unless specified otherwise in the Bill of Quantities. Preference is given to mechanical fixing of the ridge tiles over the use of mortar and shall be so described. Use only the recommended mortar mixes where mortar is specified. Recommended practice is to avoid the use of mortar wherever possible and instead use a dry fix system, which is more secure, durable and requires less maintenance.

Verges

Verge installations formed with verge tiles shall be given in linear metres. The description shall include verge tiles, pigment bedding and pointing. Sand cement and DPC is to be provided by the main contractor, unless specified otherwise in the Bill of Quantities. Preference is given to mechanical fixing of the verge tiles over the use of mortar and shall be so described. Use only the recommended mortar mixes where mortar is specified. Recommended practice is to avoid the use of mortar wherever possible and instead use a dry fix system, which is more secure, durable and requires less maintenance.

Purpose made tiles

Purpose made tiles to ends, ridges and verge tiles, etc. shall be given in number. The description shall include all fixing materials.

b) Preamble – roof covering

Standard system for fixing of concrete roof tiles.

General

The following recommendations on installation shall be regarded as normal practice. Under certain circumstances material specifications may vary to suit local conditions of use.

Underlays

Prior to battening, a SANS compliant or Agrément approved underlay shall be laid horizontally over the rafters, with minimum overlaps of 150mm and secured with clout nails or other suitable fixtures to the rafter centres.

The underlay must allow drainage of water and should extend over the tilting batten or facial board into the gutter. Water traps behind the facia board must be avoided. Alternatively, in open eaves, the underlay should extend approximately 20mm over the beam filling on the exterior wall.

A strip of underlay, not less than 600mm wide, shall be laid over hips overlapping the underlay of the main roof. At valleys a similar strip, not less than 600mm wide shall be laid under the underlay of the main roof.

Battens

All timber used for battening shall be graded SA pine complying with SANS 653 Standard specifications for softwood brandering and battens.

The minimum batten sizes are:

- 38 x 38mm for rafter centres up to 760mm
- 38 x 50mm fixed flat for rafter centres from 760mm to 900mm
- 38 x 50 fixed on edge for rafter centres from 900mm to 1000mm

Note: The rafter centres can only be increased above 760mm when trusses are designed in accordance by a rational design. All structural timber to comply with SANS 1783-4 Sawn soft wood timber Part 4.

Battens shall be of sufficient length to be supported at each end and intermediately by a total of at least three rafters, trusses or walls. Counter battens must be installed at valleys and if necessary, at hips to support the cut ends of the battens.

The verge counter battens shall be in all instances be 38 x 50mm fitted on edge to the ends of the battens at the gable ends.

At vertical hips and at pitches above 45°, additional battens must be fixed on top of the hip rafter to form a life tree of sufficient height to permit mechanical fixing of the hip tiles.

At the ridge the top batten must be placed at a distance not exceeding 25mm from the rafter apex to ensure sufficient overlap of the ridge tiles over the top course of tiles. For slate tiles refer to the manufacturer.

The first batten at the eaves must be so positioned as to follow sufficient overhang of the tiles over the facia board or the tilting batten to ensure that water discharges into the centre of the gutter.

Battening on boarded roofs with underlay should be supported by counter battens to increase ventilation under the tiles and to allow free drainage of any water that may reach the underlay.

Minimum head laps of 100mm must be maintained at roof pitches from 17° up to 26° and minimum head laps of 75mm at roof pitches from 26° upwards Head laps can be increased to suit the rafter length in order to ensure that the last course of tile under the ridge is in all instances a full tile.

Concrete Roof Tiles

Large interlocking concrete roof tiles of nominal size 420x330mm shall comply with the requirements of SANS 542 Concrete roofing tiles and shall be of profile, colour and finish as agreed between the specifier and the supplier

Tiling

All tiling must be fixed in accordance with SANS 10062 Fixing of concrete interlocking roofing tiles and comply with the manufacturer's recommendations. All roof overhangs must be mechanically fixed with non-corrodible

clout nails or clips and the main body of the roof must be fixed in accordance with the manufacturer's specification applicable to locality and roof pitch. Nails or clips must penetrate battens to a minimum depth of 25mm.

Tiles (except flat tiles which are laid broken bond) are to be laid in straight bond with the vertical joints forming a straight line up the slope of the roof.

At all abutments where tiling meets walls or chimneys, adequate flashing material must be used. All tiles must be cut close to the abutment.

Verges

Unless otherwise specified, verges shall be formed with purpose made verge tiles of similar colour and finish to those of the main roof tiles and must be fixed strictly in accordance with the manufacturer's recommendations. Mechanically fix verge tiles using corrosion-resistant nails, screws or stainless spring steel clips.

Ridges

Ridges shall be covered with ridge tiles of similar colour and finish to the main tiles. All ridge tiles shall overlap the last course of tiling by a minimum of 75mm.

A strip of approved DPC sheeting 150mm wide should be placed lengthwise under the ridge tiles, overlapping the top course of tiling on each side of 25mm. Lapped ends must be supported underneath and the overlap should not be less than 150mm. Mechanically fix ridge tiles using a dry ridge system. Attach the ridge support device under topmost batten, onto counter batten. Bend the ridge support device in relation to the ridge and fix it to the ridge and hip runner. The ridge support device acts as a guide for optimal alignment for the fixing of ridge and hip runners, which aesthetically enhances the ridge and hip line. The steel is strong yet pliable for easy fixing with screws. Align and fix the ridge and hip tree around 600 mm of the bow-taut lace. The other ridge and hip trees must be aligned to the first one by means of a lace. At the ridge: one piece per cask of rafters (in average 1,4 pcs/m ridge). At the hip: one piece per 600 mm, 13 pieces per 10 m application. Then attach the dry ridge roll.

Roll out and align the dry ridge roll onto the ridge or hip batten (butyl strip down). Staple the middle along the hip batten following the white line. Pull off the adhesive strips, one side at a time, to expose the butyl glue (for example, starting with the left side then the right side). Stick butyl onto all high points of the tiles before moulding into the tile recesses. Repeat for the other side.

Where ridges and hips intersect, lay the dry ridge roll onto the hip/ridge end ensuring sufficient overlap.

After application of the dry ridge roll, fix the ridge hip starter using 4.5 mm diameter wood screws. Fix the ridge tiles together with the ridge clips using 4.5 mm diameter wood screws until ridge/hip is complete. 26 ridge clips are required per 10 m application.

Complete the ridge and/or hip with the ridge tile fittings. Clip on the hip and/or ridge fittings with the use of ridge clips. Replaced by V-seal clips in a V-ridge system. 22 V-seal clips are required per 10m.

All ridge tiles shall be neatly cut and mitred at intersections with hips, intersecting ridges, etc.

Monoridges are to be formed with purpose made monoridge tiles, mechanically fixed or edge-bedded onto the top course of tiling as described for ridge tiles, strictly in accordance with the manufacturer's recommendations.

Hips

Hips shall be covered with ridge tiles/hip tiles of similar colour and finish to those of the main roof tiles. The tile should be cut closely to the rake of the hip, and the hip tiles shall be mechanically fixed or edge-bedded onto the tiles as described for ridge tiles.

Mechanically fix hip tiles using a dry ridge system using corrosion-resistant nails, screws or stainless spring steel clips that fix tiles to the valleys and hips. Cut tiles with a thickness of 8-16 mm are fixed durably to the hip structure without drilling with 30 cm length corrosion resistant binding wire fixed from the cut tile clip to the hip batten/rafter. Hammer the cut-tile clip onto the cut tile, in the area of the tile's flat, as far as it will go. Hammer a screw or nail into the hip batten/ rafter. Firmly fix the clip's binding wire to it, tightening it.

The first hip tile at the foot to the line of tiling at the eaves and at the fair end should be a hip starter. Alter-

natively the first hip tile may be shaped and filled with mortar inset with pieces of the tile and neatly pointed.

For vertical hips and steep pitches above 45°, hip irons should be used and fixed to the hip tree with two screws or nails to support the first hip tile.

All other hip tiles must be nailed to the hip tree and fixed as detailed.

Valleys

A non-corrodible valley flashing, at least 300mm wide, preferably with a preformed centre gutter, must be installed on the roof before tiling.

For open valleys the adjacent tiling must be neatly cut on both sides to form an open channel of at least 100mm wide.

For closed valleys the adjacent tiles must be neatly cut on both sides to form a close fit and a straight line.

The cut tiles must be holed and secured by nailing. If the cut tiles are very small and cannot be nailed they must be secured to the battens by means of bailing wire.

Mechanically fix all mortar bedded ridge, hip and verge tiles, and tiles adjacent to valleys to meet the wind uplift requirements. Only use the recommended mortar mixes where mortar is specified. Recommended practice is to avoid the use of mortar wherever possible and instead use a dry fix system, which is more secure, durable and requires less maintenance.

Mortar (optional)

Bedding and pointing should be done in one operation and struck off at right angles to the roof plane to give a smooth finish. All ridges are to be soaked in water before bedding to achieve improved bonding to mortar.

Table 11: Typical tender specifications for concrete roof tiles

Item No	Roof coverings	Unit	Quantity	Rate	Amount
	Refer to preamble - roof covering. Concrete roof tiles (state name of manufacturer and profile) through colour interlocking roof tiles, size 420 x 330mm, manufactured in accordance with SANS 542, of approved colour with matching fittings and accessories. All tiling to be done in accordance with SANS 10062 and to comply with the manufacturer's recommendations. Tiling at 25deg pitch with minimum head lap of 100mm and maximum batten centres of 320mm to single storey. All perimeter tiles must be mechanically fixed and the main body of the roof must be fixed in accordance with the manufacturer's recommendations applicable to the locality and roof pitch.				
1	**Tiling** to be (state name ans profile) tiles laid straight bond to steep slope of 25deg, fixed to battens at 320mm batten centres (maximum), battens and underlay measured elsewhere. Note: broken bond for flat tiles.	m^2			
2	**Tiling** to be (state name and profile) tiles laid straight bond to flat slope of 35°, fixed to battens at 345mm batten centres (maximum) (battens and underlay elsewhere measured) *Note: Broken bond for flat tiles	m^2			
3	**Verges** to be formedwith VERGE TILES fixed in accordance with the manufacture's recommendations	m			
4	Extra over verge tiling to form mitred intersection of ridge tile and two verge tiles	No			
5	**Ridges** to be covered with RIDGE TILES mechanically fixed as dry ridge	No			
6	Extra over ridge tiles for solid beddingand pointing of fair ends at gables	No			
7	Extra over ridge tiles to form mitred intersection of two ridges	No			
8	**Monoridge** to be covered with MONORIDGE TILES mechanically fixed	m			
9	**Hips** to be covered with RIDGE/HIP mechanically fixed	m			
10	Extra over hip tiles to install HIP STARTER	No			
11	Extra over hip tiles for shaping first ridge tile at eaves	No			
12	Extra over hip tiles to form mitred intersection of ridge and two hips	No			
13	Extra over hip tiles to form mitred intersection of four hips	No			
14	**Close cut valley** with adjacent tiles neatly machine cut on both sides to form a neat butt joint over the valley centre. Valley liner measured elsewhere	m			
15	**Open cut valley** with adjacent tiles carburundum cut on both sides to form an open channel of at least 100mm. Valley linerv measured elsewhere	m			
16	**Raking, cutting and waste** at abutments, parapets and verges	m			
17	**Ventilated reidge terminals**	No			
	Total to summary				

2.9 GENERAL NOTES

Properly erected concrete roof tiles do not require any maintenance work or surface treatment to improve their durability or functional properties.

For aesthetic reasons however it may be necessary to carry out maintenance work where roofs have become unsightly due to a number of factors:

a) Efflorescence

Efflorescence, often referred to as "lime bloom", is a natural phenomenon found in cementitious products so as concrete roof tiles. The cause lies in the chemical composition of the cement. When water is added to cement a series of chemical reactions take place resulting in the setting and hardening of the concrete. One product of these reactions is "lime" in the form of calcium hydroxide, which is slightly soluble in water and under certain conditions can migrate via capillaries in the concrete tile to the surface. There it reacts with the carbon dioxide from the atmosphere forming a white powder deposit of calcium carbonate crystals, which is referred to as efflorescence.

Whilst the white deposit may appear unsightly, it is a temporary phenomenon and should not be treated. With time and the natural process of weathering it will disappear restoring the true colour of the tile. This process can take up to three or four normal rain seasons. This condition is purely superficial and does not affect the durability, the strength or the original colour of the tile.

b) Fungal growth on roofs

Small deposits of fungal lichen or moss on a fairly new roof can be removed by using water and a hard brittle brush.

Where lichen has been prevalent for a number of years, it should be treated with approximately 2% copper sulphate solution to kill the growth. The roof should ten be washed with a high-pressure water spray and a hard bristle brush.

SECTION 3: TILING PROCEDURE

3.1 INSPECTION BEFORE TILING

To ensure that a high standard of roof construction is achieved, it is essential that the structure is sound. It is therefore important that the following pre-tiling inspection be completed:

- Batten spacing must conform to the manufacturer's specification and recommendations.
- Roof trusses are properly spaced, secured and adequately braced.
- Underlays must be properly installed.
- Hip and valley underlay/overlay strips are properly installed.
- Trusses and battens must be true and level.
- Battens have been fixed at valleys to support the valley flashing.
- 38 x 50mm verge counter battens have been installed.
- An additional batten has been fixed on top of the hip rafter to form a hip tree for the fixing of hip tiles at roof pitches above 45°.
- The position of the first batten must be accurately established to ensure the correct overhang of the rooftiles into the gutter. Refer to Figures 26 and 27.
- The top batten must be positioned not more than 25mm from the rafter apex to ensure sufficient overlap of the ridge tile over the top course of tiling. Refer to Figure 28. For flat tiles this dimension varies from 25 to 50 mm. Refer to the manufacturer.
- Fascias, gutters and valley gutters have been installed.
- Parapet walls or any walls extending above the roof have been completed (including plastering and painting).
- Abutment flashings have been installed. Refer to Figures 62 to 66.
- Beam fillings have been completed.

Note: Ensure that all other trades are completed before tiling commences.

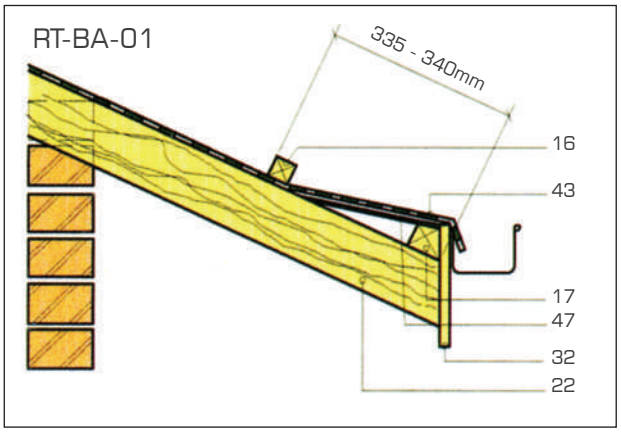


Figure 26: Eaves batten position with fascia

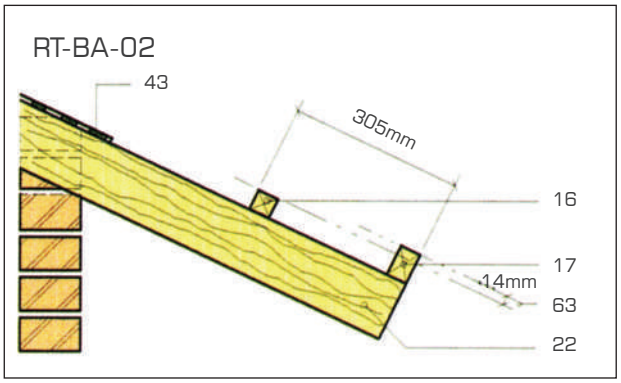


Figure 27: Eaves batten position without fascia

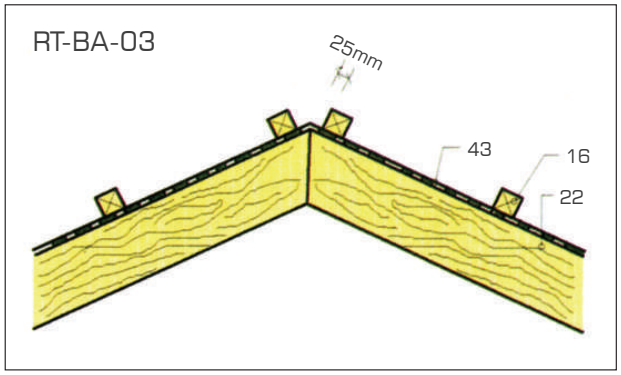


Figure 28: Top batten to apex distance

Legend

16 – Batten
17 – Tilting batten
22 – Rafter
32 – Fascia
43 – Undertile membrane
47 – Undertile membrane support
63 – Tilting dimension

3.2 SETTING OUT FOR TILING

Set out one course of tiles from right to left along the eaves and along the ridge in order to achieve an equal overhang at both verges. Slightly adjusting the verge overhang and using the tolerance in the side interlock of the tile can achieve the linear coverage of the roof achieved with full tiles. Refer to Figure 29.

Where this is not possible, for instance between two parapet walls, cut tiles might have to be used at each end. Cut tiles should be of a size that can be securely fixed.

Chalk lines are then struck from eaves to ridge at three tile intervals to guide tiling. Refer to Figure 31.

Note: When setting out battens, the batten centres should be established from top batten to the eaves batten. This will ensure that the top course of tiles at the ridge as well as the bottom course at the eaves will always be made up of full tiles.

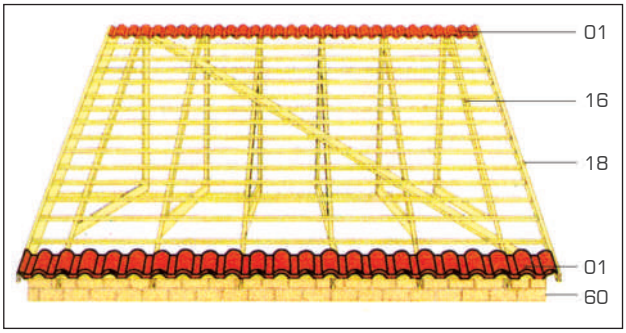


Figure 29: Setting out of tiles at ridges and eaves

3.3 LOADING OF THE TILES ON TO THE ROOF

Care must be taken to avoid any damage to the undertile membrane or foil during the loading of the roof tiles. The roof should be loaded evenly on either side from top to bottom by placing stacks of six tiles between every second batten on top of the rafters. Refer to Figure 30.

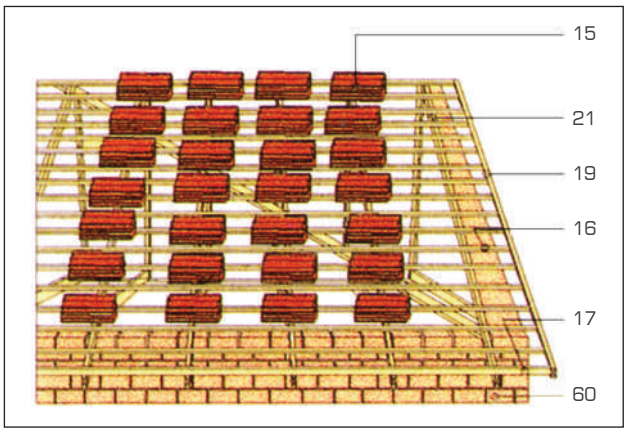


Figure 30: Loading diagram

Legend

01 – Roof tile
15 – Tile stack
16 – Batten
17 – Tilting batten
19 – Verge counter batten
21 – Truss
60 – Masonry wall

3.4 LAYING OF TILES

On completion of setting out, the tiling work can proceed. Ensure that the first course at the eaves overhang passes the fascia board by an amount sufficient to ensure that water discharges freely into the centre of the gutter (min 50mm).

For positive location of the tiles, ensure that the tiles are fully supported by the battens on the batten bearers and that the lugs of the tile butt up squarely against the top edge of the battens. This will ensure that the tiles are in straight courses horizontally and vertically.

Standard interlocking tiles should be laid from right to left, from eaves to ridge, taking three rows at a time in straight bond. Flat tiles should be laid in broken bond. Refer to figure 32.

Work according to the chalk lines marked during setting out. The chalk lines will assist in keeping the vertical rows of tiles in straight parallel lines.

Tiles must be laid loose and not tight against each other to allow for thermal movement.

Certain tiles, such as flat tiles, must be laid in a broken bond, requiring half tiles in every second course at the gable ends. Refer to Figure 32.

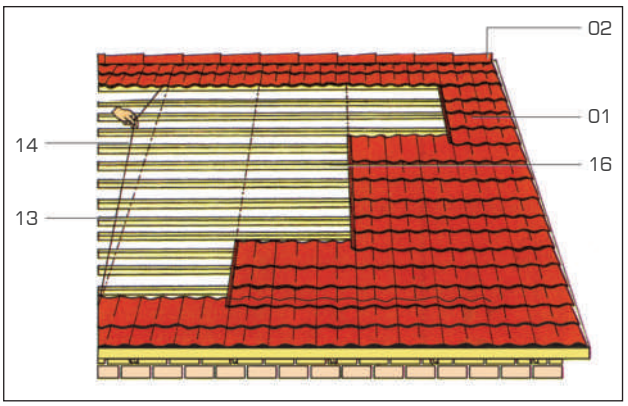


Figure 31: Laying of tiles-straight bond

These tiles, due to their flat design, do not have the inherent strength of profiled tiles and may be damaged or broken if walked upon after installation. Care should therefore be taken when carrying out maintenance work. For further information on these tiles contact the manufacturer.

Nailing or clipping tiles and fixing of storm clips where appropriate must be carried out as work proceeds. For detailed information on appropriate fixing methods refer to Section 2 for roof pitch, wind forces and nailing recommendations.

Nails used for the fixing of tiles should be non-corrosive clout nails of sufficient length to penetrate the battens to a depth of at least 25mm.

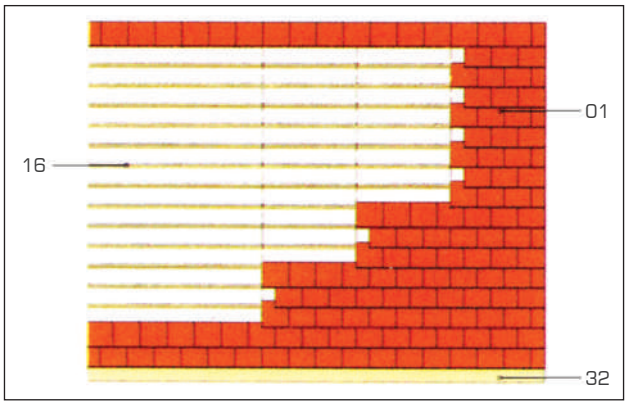


Figure 32: Laying of tiles-broken bond

Legend

01 – Roof tile
02 – Taper ridge
13 – Chalk line
14 – Striking chalk line
16 – Batten
32 – Fascia

3.5 EAVES

The first course of the tiles at the eaves must be in the same plane as the remainder of the roof. To achieve this it must be supported by a continuous tilting batten and not by fascia board. The average tilting dimension at the eaves course is ±14mm. Placing a straightedge over the last three courses of tiles can check this dimension. Refer to figure 34.

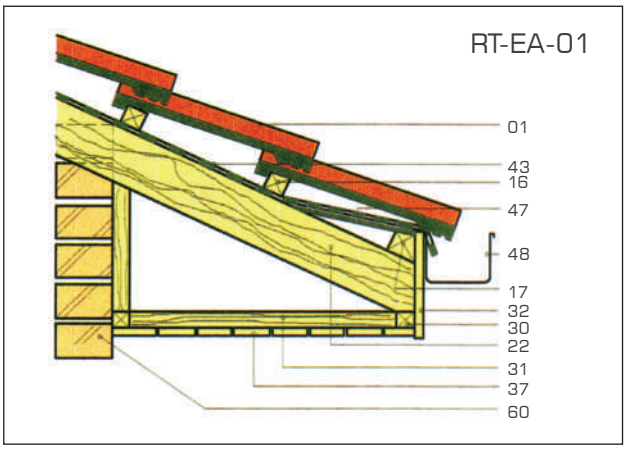


Figure 33: Ventilalted closed eaves

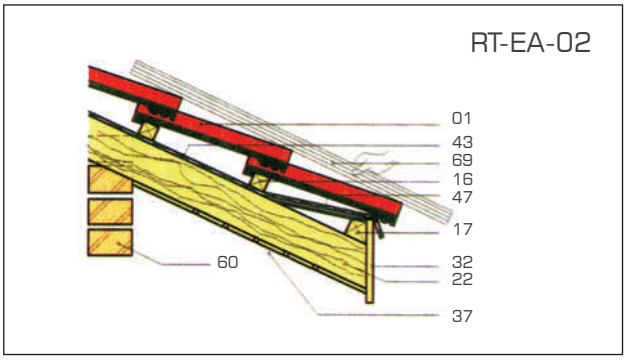


Figure 34: Eaves course must neither tilt nor droop

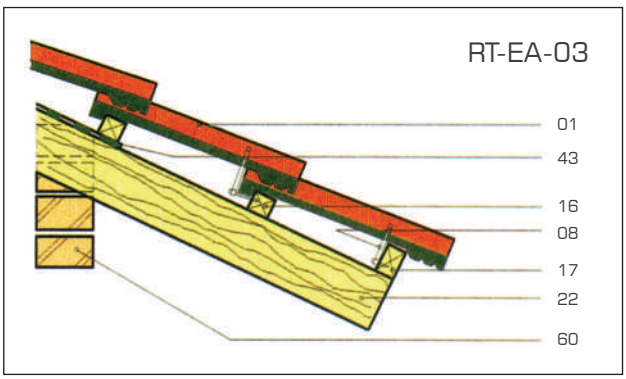


Figure 35: Open eaves

Eaves can either be closed or open. In exposed high wind areas, it is recommended, to close of the eaves to prevent tiles from being blown of the roof. Under 26° pitch the underlay must be supported between the tilting batten and the first batten.

If no fascias or gutters are used the rafter should be cut at right angles so that the rainwater discharging from the tiles will not rot the rafter ends. Refer to Figure 35.

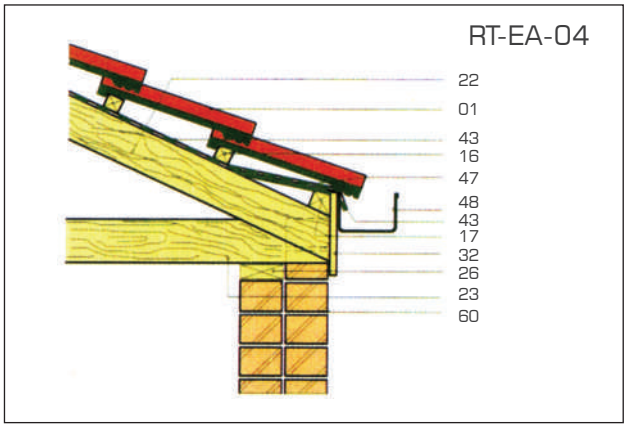


Figure 36: Eaves flush with wall

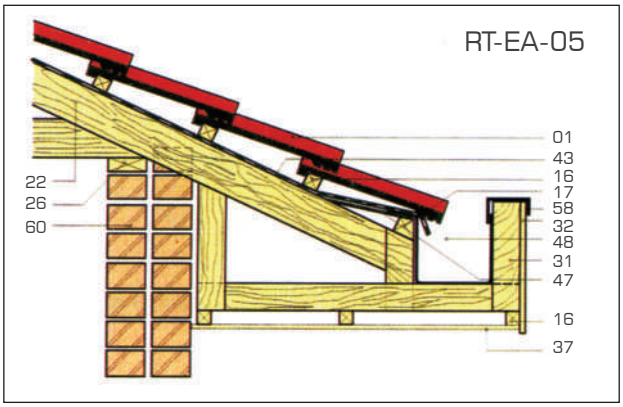


Figure 37: Eaves with concealed gutter

Legend

01 –	Roof tile	32 –	Fascia
16 –	Batten	37 –	Eaves lining
17 –	Tilting batten	43 –	Undertile membrane
22 –	Rafter	47 –	Undertile membrane support
23 –	Tie Beam	48 –	Gutter
26 –	Wall plate	58 –	Cover flashing
30 –	Timber support	60 –	Masonry wall
31 –	Timber framing	69 –	Straight edge

3.6 VALLEYS

The size of the valley gutter will depend on the area of the roof section, which discharges the rainwater to the valley gutter. Valleys can either be closed or preferably open to avoid blockages by leaves etc. stopping the flow of water. Refer to Figures 38-40.

The tiles on both sides of the valley must be neatly cut, holed and secured to the counter batten by means of baling wire.

Where a valley forms a junction between roof slopes of different pitches (known as a bastard valley), a special valley gutter is recommended. Refer to Figure 42.

The raised section in the centre of the valley gutter is to prevent water discharging from the steeper slope of the roof from spilling over the apron of the gutter on the shallower slope of the roof. This raised section should be a minimum of 75mm high.

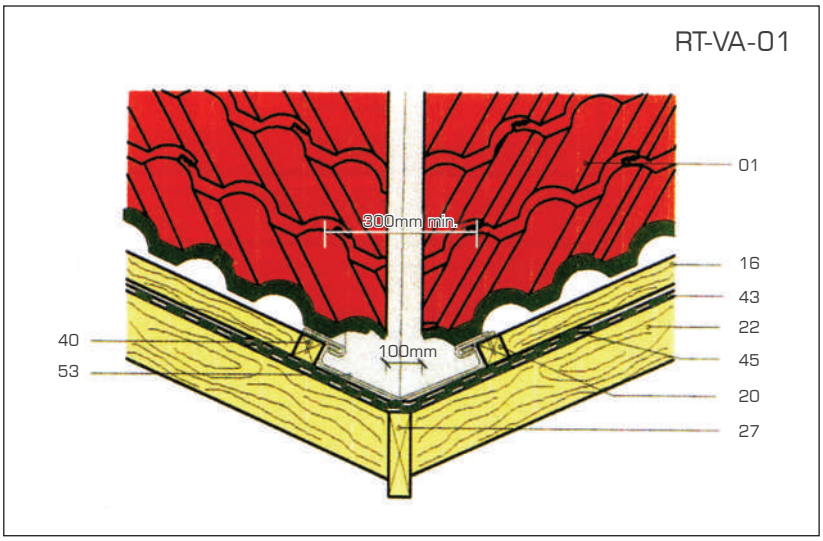


Figure 38: Open valley

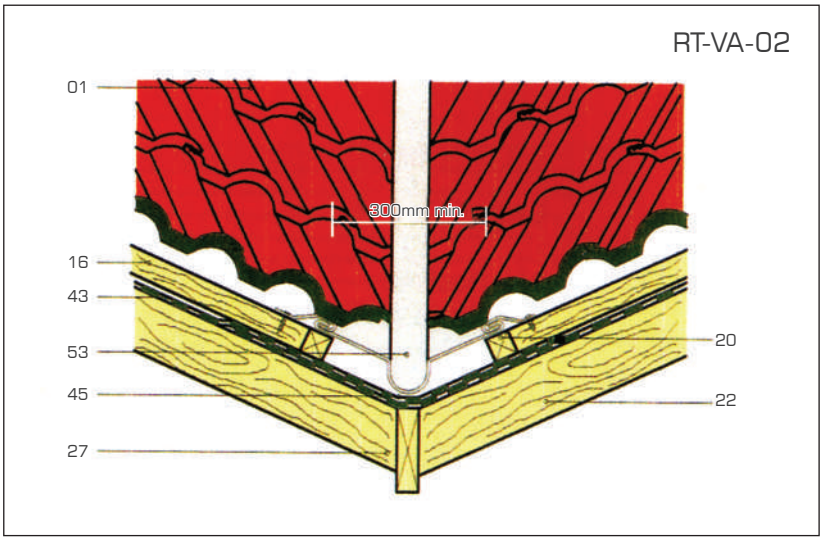


Figure 39: Open valley with preformed gutter

Legend

01 – Roof tile
16 – Batten
20 – Valley counter batten
22 – Rafter
27 – Valley rafter
40 – Fixing nail
43 – Undertile membrane
45 – Underlay strip
53 – Valley gutter

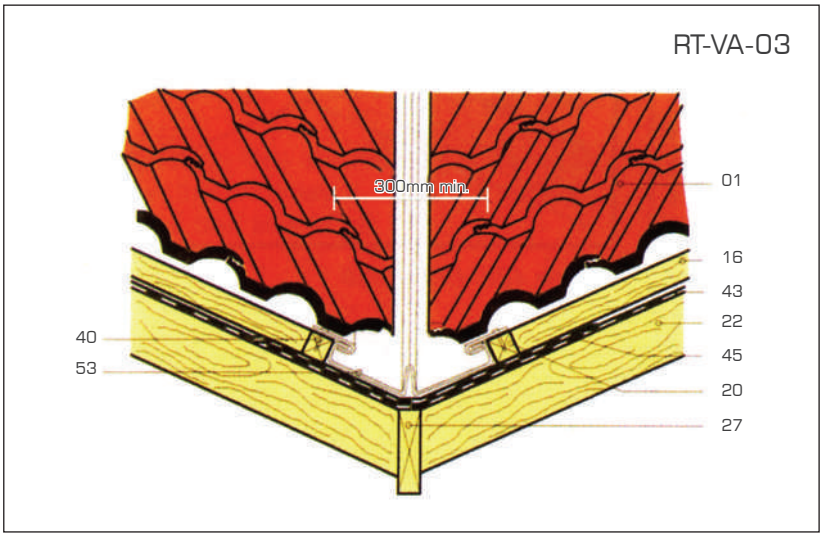


Figure 40: Open valley with special gutter

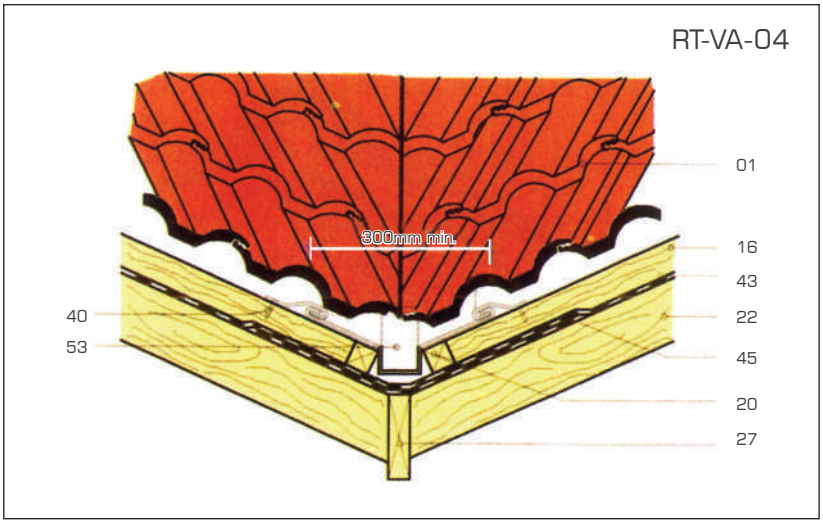


Figure 41: Closed valley with preformed gutter

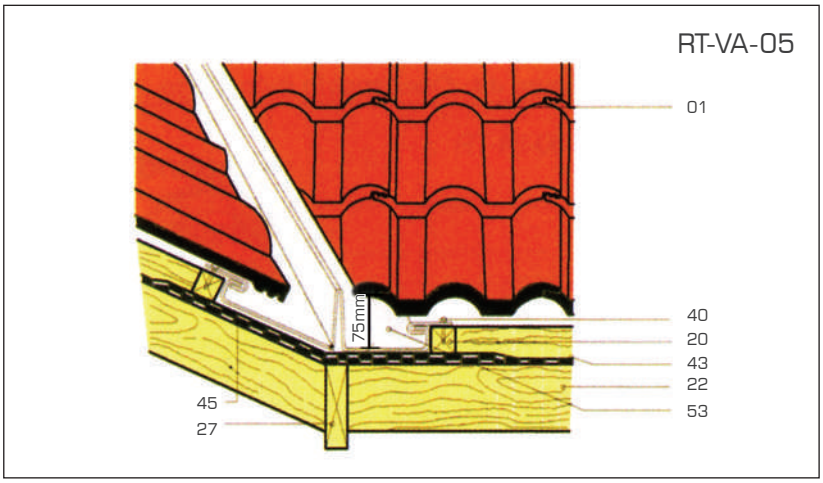


Figure 42: Bastard valley with special gutter

Legend

01 – Roof tile
16 – Batten
20 – Valley counter batten
22 – Rafter
27 – Valley rafter
40 – Fixing nail
43 – Undertile membrane
45 – Underlay strip
53 – Valley gutter

3.7 RIDGES

a) Tapered ridge tiles

A 150mm wide strip of damp-proof course sheeting is recommended under the ridge overlapping the top course of tiles by at least 25mm on either side. Set out the full ridge length before fixing the ridge tiles. Tapered ridge tiles have a variable overlap and no cutting is required. By increasing the overlap slightly between the ridge tiles the whole ridge can be covered with full tiles. The ridge tiles should overlap the top course of tiling by at least 75mm. Neatly cut and mitre ridge tiles at intersections with hip etc.

b) Butt ridge tiles

Edge beds the butt ridge tiles and solid bed at the joints in mortar over a strip of damp proof course sheeting. The joints between the ridge tiles must be filled with mortar supported by broken tile pieces, struck flush with the ridge tiles and wet brushed to a smooth finish. Cut and mitre the tiles where necessary. At the gable ends fill with mortar inset with broken tile pieces cut off excess mortar and smooth with a wet brush.

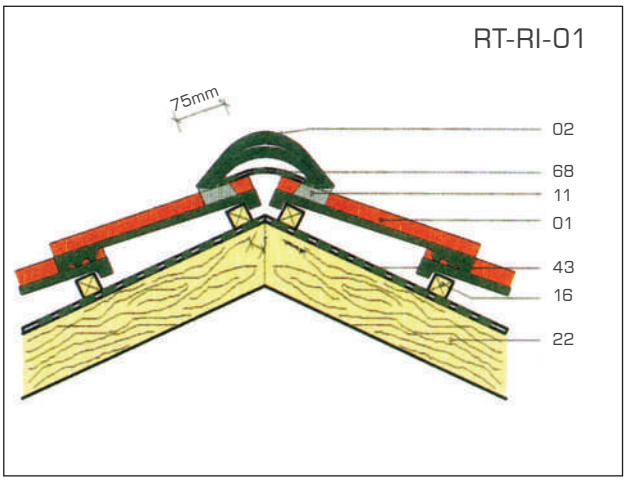


Figure 43: Tapered ridge

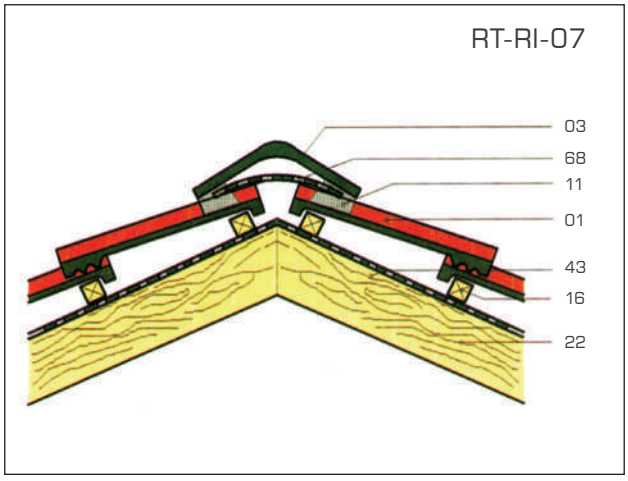


Figure 43a: Butt ridge

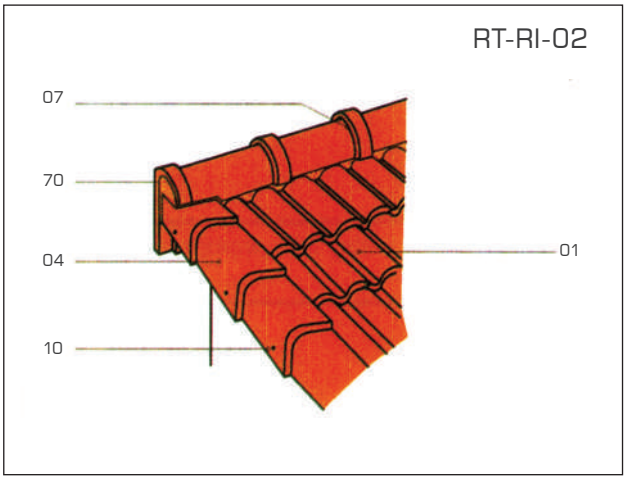


Figure 44: Overlapping monoridge

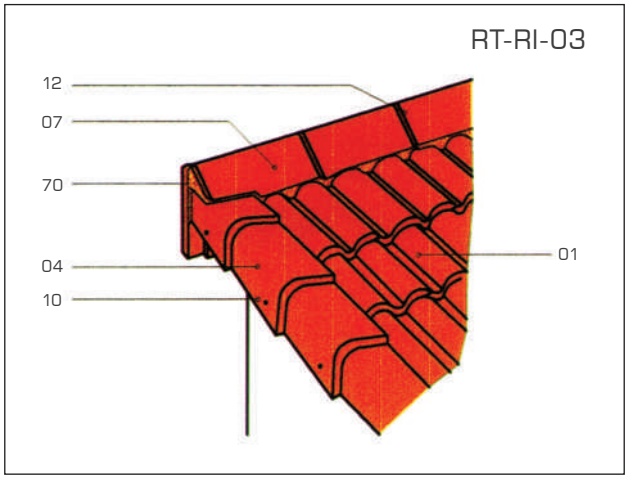


Figure 45: Butt monoridge

c) Butt monoridge tiles

Butt monoridge tiles must be edge bedded in mortar on the top course of roof tiles over a strip of damp proof course. The damp proof course should be bent over and taken down inside the vertical leg of the monoridge. The vertical leg of the monoridge must be fixed with non-corrosive screws or nails. The joints between the monoridges must be filled with mortar supported on broken tile pieces, struck flush with the monoridges and wet brushed to a smooth finish. The monoridges must be neatly cut and mitred at intersections with verges. The ends must be filled with mortar, struck flush with the verge tiles and wet brushed to a smooth finish.

d) Capped monoridge tiles

Capped monoridge tiles are fixed in the same manner as butt monoridges. The capped ends and at intersections with verges must be filled with mortar, struck and wet brushed to a smooth finish.

Note: Mortar (See paragraph of page 41)

Mortar, when used for bedding and pointing for ridges and hips, should consist of 3 parts clean plaster sand to 1 part of Ordinary Portland Cement tinted with an inorganic pigment to blend in with the colour of the roof tiles.

All fittings to be bedded in mortar should be soaked in water to ensure a good bond.

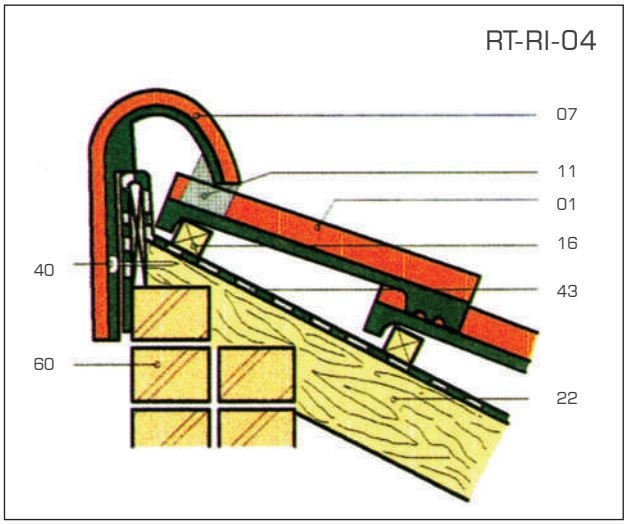


Figure 46: Section through overlapping monoridge

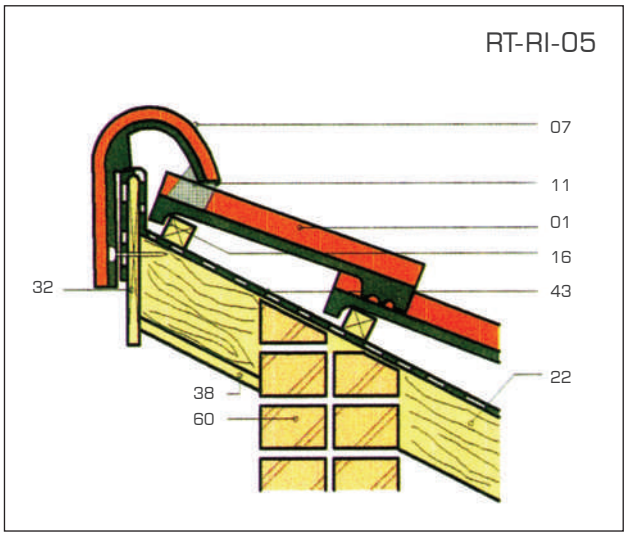


Figure 47: Section through monoridge/soffit lining

Legend

01 – Roof tile
02 – Taper ridge
03 – Butt ridge
04 – Verge tile
06 – Ventilated ridge
07 – Monopitch ridge
10 – Fixing point
11 – Mortar bed
12 – Mortar joint
16 – Batten
22 – Rafter
32 – Fascia
38 – Soffit lining
40 – Fixing nail
43 – Undertile membrane
46 – Overlay strip
60 – Masonry wall
68 – DPC 150mm wide
70 – Mortar closure

3.8 HIPS

Tiles of the main roof must be cut closely to the rake of the hip. Refer to Figure 49. The hips can be covered with either overlapping or butt jointed ridge tiles.

a) Hips using taper ridge tiles

When used on hips taper ridge tiles are suitable for any pitch of roof up to vertical.

At vertical hips and pitches above 45° all ridge tiles must be mechanically secured. To secure the ridge tiles additional battens must be fixed on top of the hip rafter to form a hip tree of sufficient height to permit the mechanical fixing of the ridge tiles. Refer to Figure 51.

The tape ridge tiles are fixed in the overlap by nailing to the hip tree using non-corrosive nails. Cutting of ridge tiles can usually be eliminated as the tiles have a variable overlap. Only the end ridge tile, which forms an intersection with the ridge, is mitred to fit.

Hip irons must be used at pitches above 45° to secure the hip starter to the hip tree using two non-corrosive nails or screws. Hip irons are bent to shape using 32mm x 3mm galvanized steel. Refer to detail of hip iron in Figure 51.

b) Hips using butt ridge tiles

When used on hips, butt ridge tiles should only be used on roof pitches below 45°. Hip irons are recommended to secure the starter ridge tiles.

Purpose made hip starters should be used at the start of each hip. Alternatively the first ridge tile can be shaped to line up with the eaves courses. Refer to Figure 50.

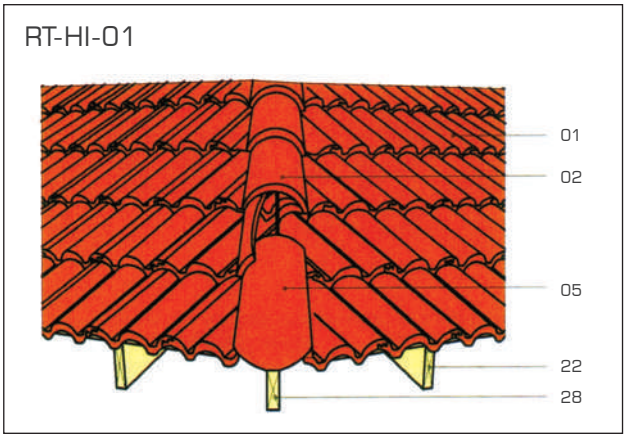


Figure 49: Hip using taper ridge/hip starter

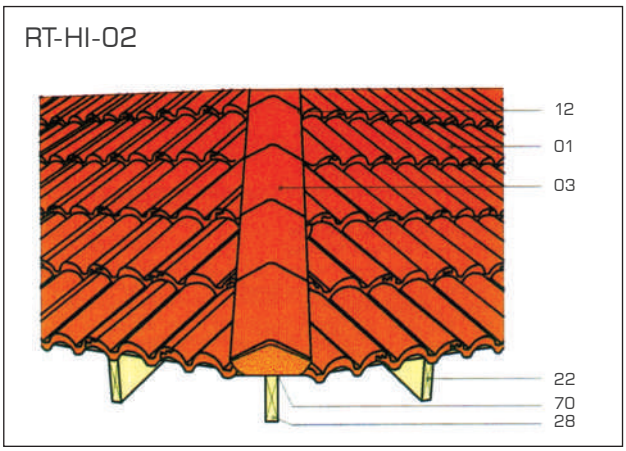


Figure 50: Hip using butt ridge

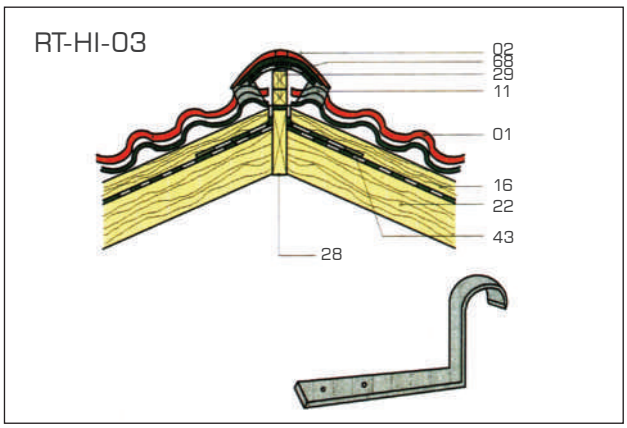


Figure 51: Section through hip showing hip tree and hip iron

Legend

01 – Roof tile
02 – Taper ridge
03 – Butt ridge
05 – Hip starter
11 – Mortar bed
12 – Mortar joint
16 – Batten
22 – Rafter
28 – Hip rafter
29 – Hip tree
43 – Undertile membrane
68 – DPC 150mm wide
70 – Mortar closure

3.9 VERGES

Verge tiles must be mechanically fixed on the vertical face to a 38-x 50mm counter batten placed on edge with non-corrodible screws or serrated nails.

With bold contoured roof tiles the verge counter batten must be raised above the batten line to ensure good fixing of the verge tile. Refer to Figure 52.

With standard profile of roof tiles the verge counter batten must be positioned flush with the top of the tiling batten. Refer to Figure 53.

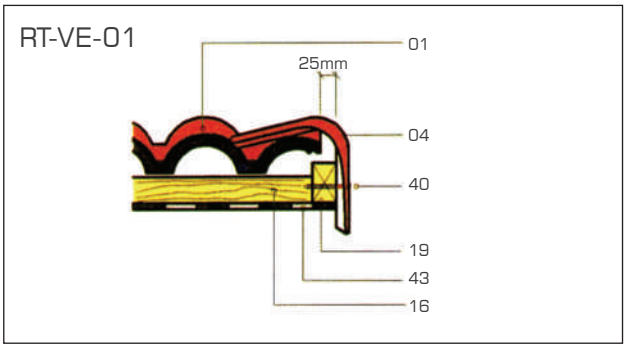


Figure 52: Verge counter batten – bold profile

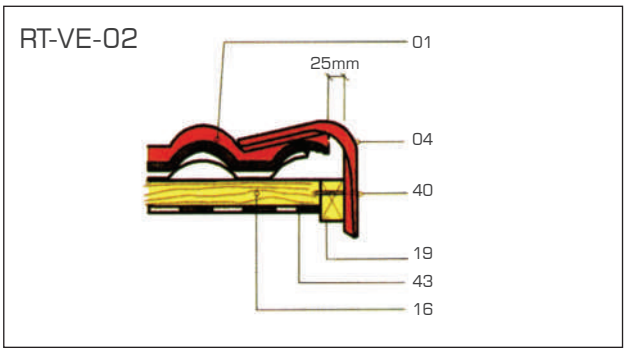


Figure 53: Verge counter batten – flat profile

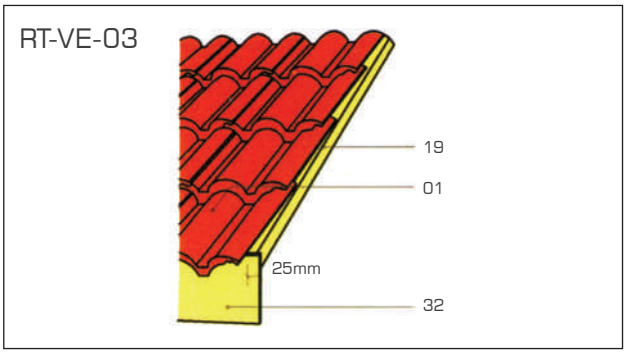


Figure 54: Verge detail with fascia

The first verge tiles should have a 25mm tilt at the start to compensate for the overlap and obtain the correct alignment. This is achieved by extending the fascia board or the tilting batten by 25mm. Refer to Figures 54 and 55.

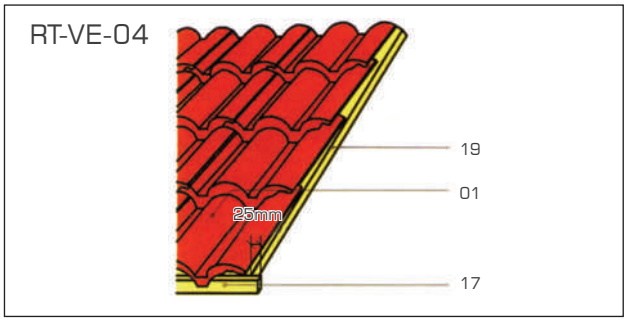


Figure 55: Verge detail without fascia

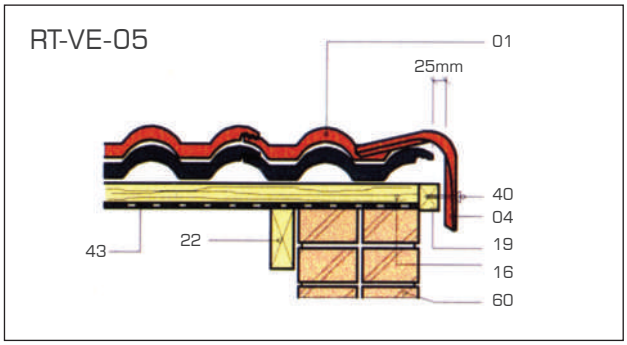


Figure 56: Flush verge

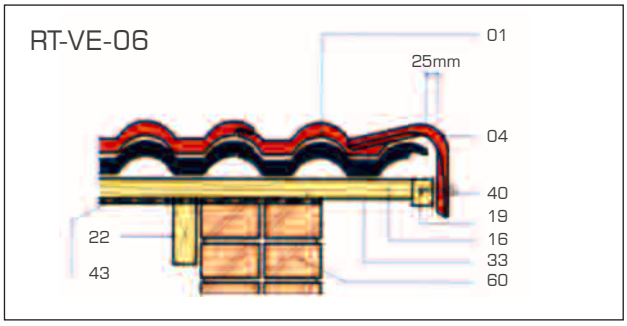


Figure 57: Overhanging verge with closed soffit

Legend

01 –	Roof tile	22 –	Rafter
04 –	Verge tile	32 –	Fascia
16 –	Batten	38 –	Soffit lining
17 –	Tilting batten	40 –	Fixing nail
18 –	Counter batten	43 –	Undertile membrane
19 –	Verge counter batten	60 –	Masonry wall

The verge can be a flush verge, refer to Figure 56, or an overhanging verge, refer to Figure 57.

In exposed areas it is recommended that the verges should be closed. The undertile membrane or foil should therefore be extended to the full overhang of the verge

The first verge tile is positioned to abut against the second course of tiles. Mark the front side to line up with the eaves course and cut to the required length. Refer to Figures 58 and 59.

Thereafter each following verge tile is fitted butting against the next course of tiles above and overlapping the verge tile below. Refer to Figure 61.

The top verge tiles are mitred with the ridge tile. Refer to Figure 60.

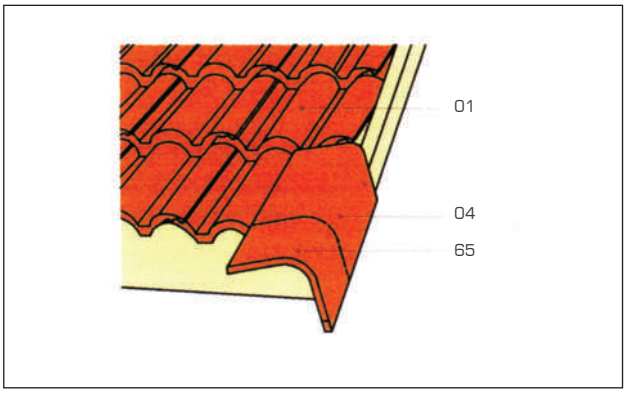


Figure 58: First verge tile

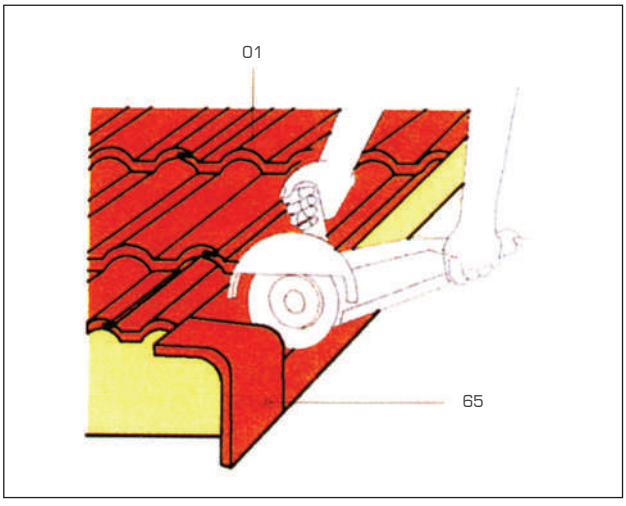


Figure 59: Cut first verge tile

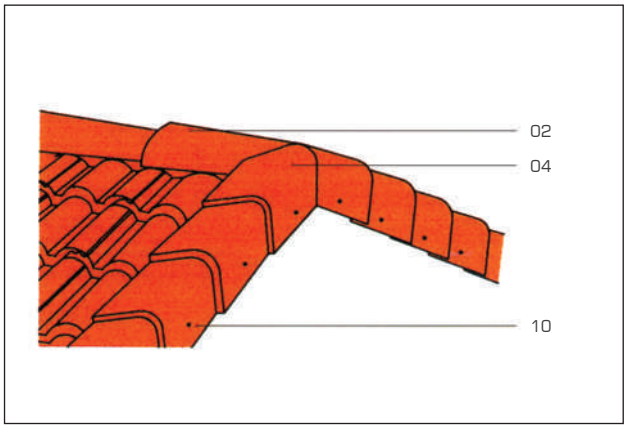


Figure 60: Verge/ridge junction

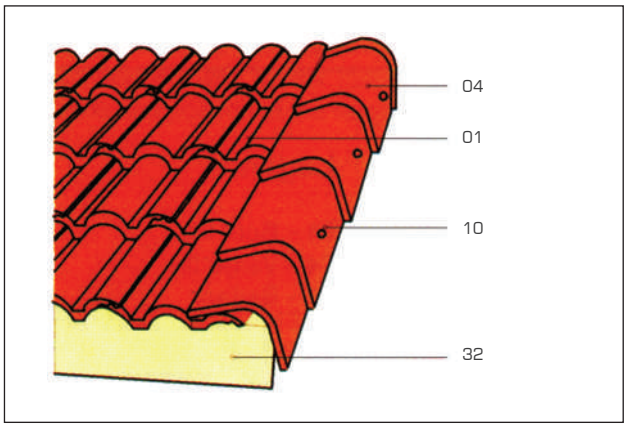


Figure 61: Illustrating positions of verge tiles

Legend

01 – Roof tile
02 – Taper ridge
04 – Verge tile
05 – Hip starter
10 – Fixing point
32 – Fascia
65 – Off-cut

3.10 ABUTMENTS AND FLASHINGS

Adequate flashing must be provided where roof tiling meets abutments, protrusions and where changes in roof pitch occur. The flashing material must be weather resistant and durable. The correct choice of flashing material depends on the corrosion risk.

Materials considered suitable for flashing are zinc, zinc alloy, aluminium alloy, galvanized iron, copper and lead. The flashing and cover flashing should be of the same material to avoid any electrolytic corrosion.

It should be noted however, that aluminium and galvanized steel react to some degree when in contact with cement based products, mortar and plaster. To prevent any reaction it is recommended that two coats of bituminous or other suitable paint be applied to the contact surfaces.

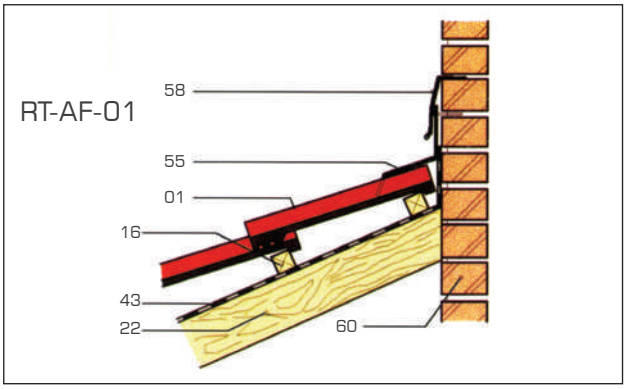


Figure 62: Apron flashing

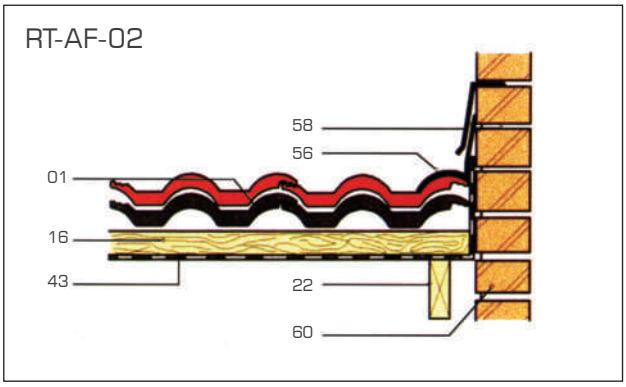


Figure 63: Side flashing

a) Apron flashing

Flashing material should be dressed over the tiles and fixed to the wall face, overlapping the tiles by at least 150mm. A suitable material should be lead, as it is easily dressed into the profile of the roof tiles. Refer to Figure 62.

b) Side flashing

Flashing material must be dressed over the tiles and fixed against the wall face. It must be carried over the first tile contour into the pan of the roof tile. The underlay should be carried up above the roof tiles. Refer to Figure 63.

c) Concealed gutter flashing

The preformed gutter must be supported by a timber fillet and fixed against the wall face. Refer to Figure 64.

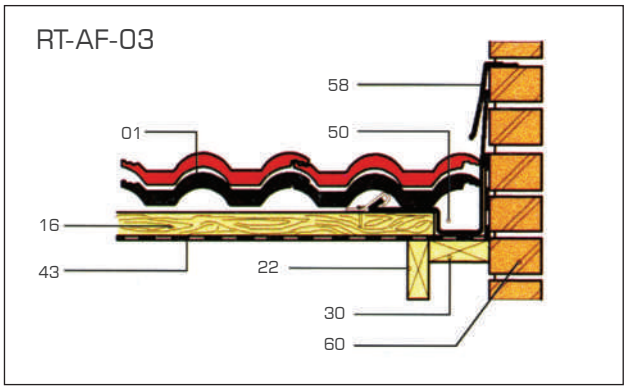


Figure 64: Concealed gutter flashing

Legend

01 – Roof tile	50 – Concealed gutter
16 – Batten	55 – Apron flashing
22 – Rafter	56 – Side wall flashing
30 – Timber support	58 – Cover flashing
43 – Undertile membrane	60 – Masonry wall

d) Back gutter

The size of the back gutter should be calculated in relation of its length and the volume of water it will receive. It should be at least 200mm wide and have a minimum thickness of 0.6mm flashing material.

The detail of the underlay, battening and overhang of the tiles into the gutter should be the same as the eaves detail. A timber fillet, cut to shape, must be installed to support the back gutter. Refer to Figure 65.

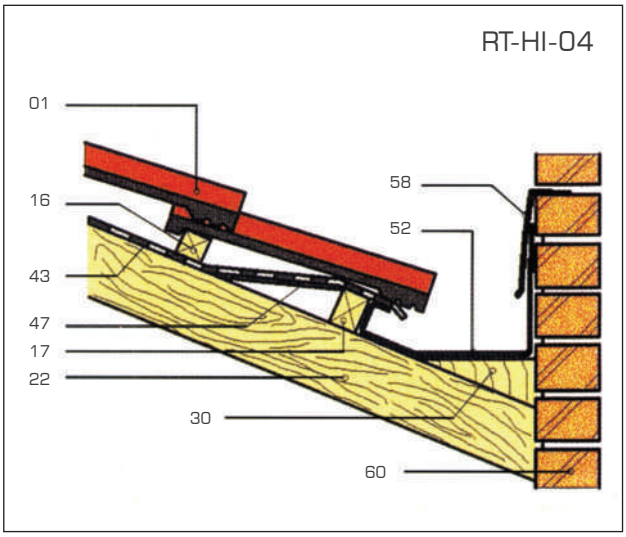


Figure 65: Back gutter

e) Box gutters

The box gutter must be supported by a continuous timber support. The underlay from the roof must extend into the gutter and the tiles must be tilted up to the wall and should be in the same plane as the roof. To prevent any water entering between the gutter and the masonry wall, special attention should be given to the cover flashing which must be cut into the wall, wedged and sealed, the vertical leg extending into the gutter and sealed against the side wall of the gutter.

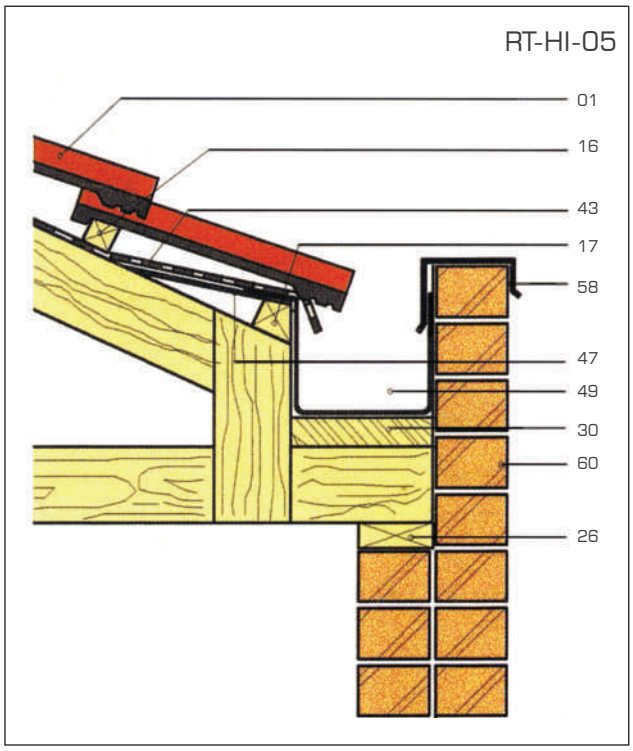


Figure 66: Box gutter

Legend

01 –	Roof tile	43 –	Undertile membrane
16 –	Batten	47 –	Undertile membrane support
17 –	Tilting batten	49 –	Box gutter
22 –	Rafter	52 –	Chimney back gutter
26 –	Wall plate	58 –	Cover flashing
30 –	Timber support	60 –	Masonry wall

f) Chimney flashing

Flashing to chimneystacks comprises apron flashing, side flashing, cover flashing and back gutter flashing. Lead is the most suitable material for chimney flashing, as it lends itself to close dressing at angles and contours of the roof tiles. When a more ridged material is used, care should be taken at the watershed points of the back gutter to ensure a completely waterproof junction.

For the chimney back gutter, full timber support must be provided. Refer to Figures 67 – 70.

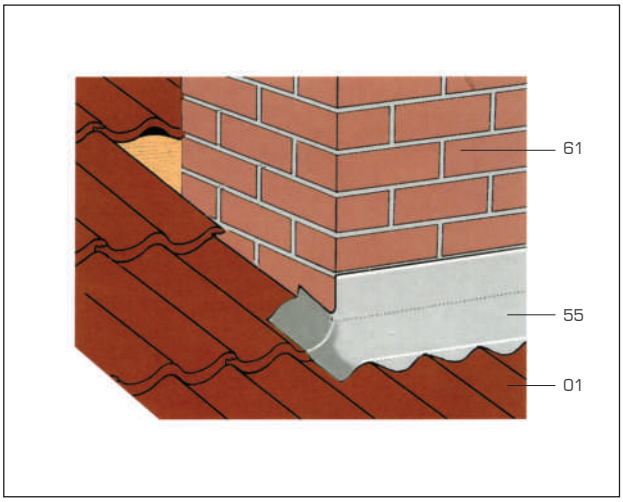


Figure 67: Apron flashing

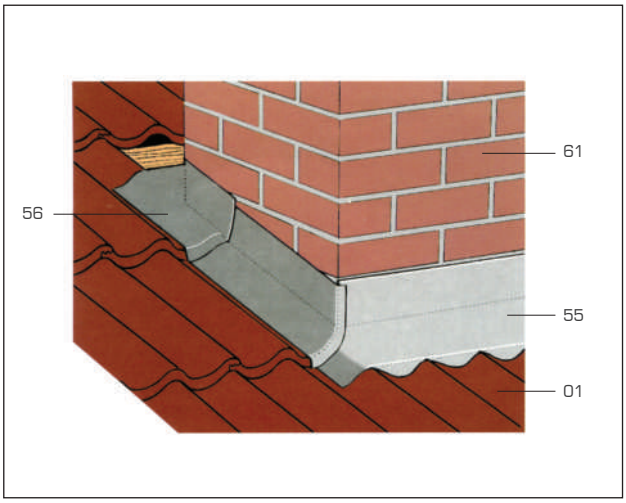


Figure 68: Apron/side flashing

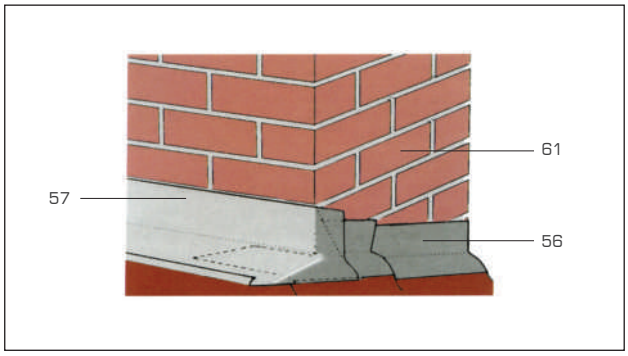


Figure 69: Back/side wall flashing

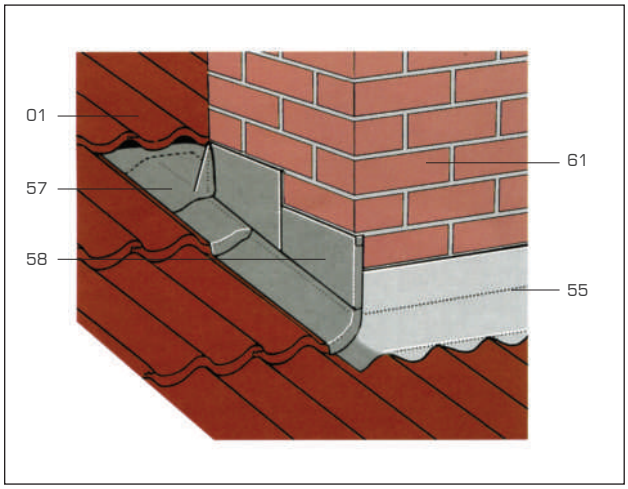


Figure 70: Chimney cover flashing

Legend

01 – Roof tile	57 – Back gutter flashing
55 – Apron flashing	58 – Cover flashing
56 – Side wall flashing	61 – Chimney stack

g) Vent pipes

Preformed fitting for vent pipes and other similar protrusions are available. Alternatively lead can be used successfully. Refer to Figures 712 and 72.

h) Mansard roofs.

Mansard is a form of roof in which two slopes, the lower being steeper than the upper roof, meet. At the intersection of the two roof planes where purpose made tiles are not used, the tiles should be nailed and clipped.

Lead flashing should be installed to prevent wind driven rain from entering into the roof space. If the tiles are positioned correctly at the junction, the weather head of the upper tile will form a perfect closure with the tile beneath it. Refer to Figure 73.

i) Change in pitch

Where a change in roof pitch occurs (as in the case of a sloping dormer) sheet lead flashing should be placed at the intersection. The lead should be dressed over the contours of the lower tiles and turned up under the upper tiles. Refer to Figure 74.

j) Skylights

The treatment of skylights should be similar to that described for abutments and chimneys.

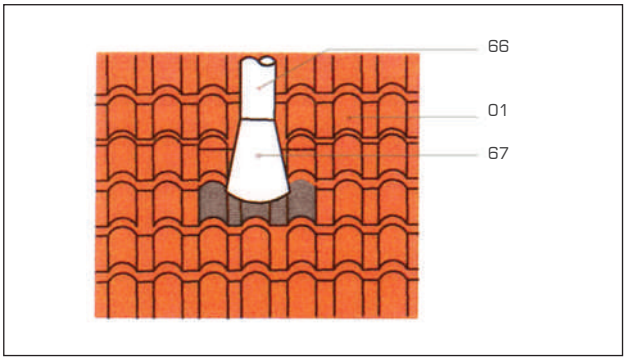


Figure 71: Vent pipe flashing

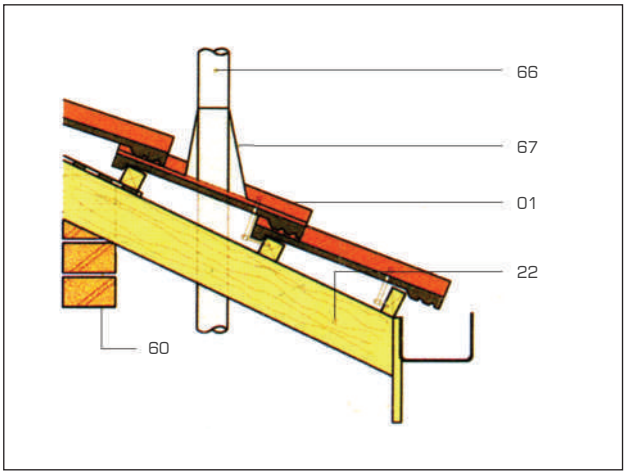


Figure 72: Vent pipe through roof

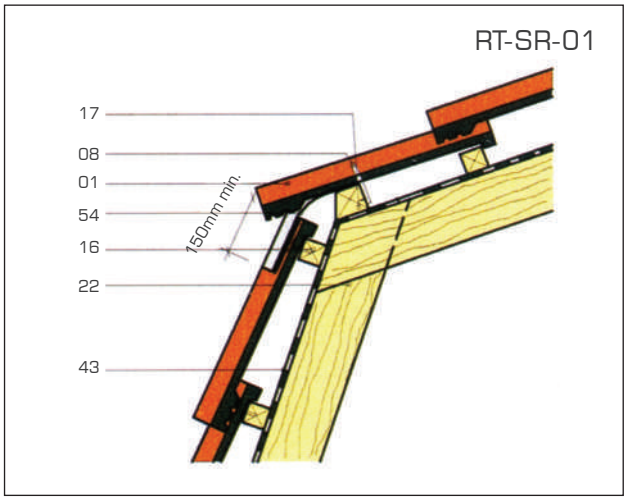


Figure 73: Mansard roof

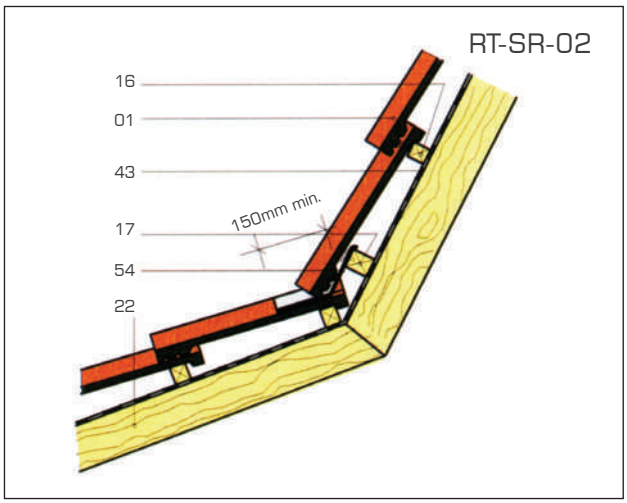


Figure 74: Change in pitch of roof

Legend

01 – Roof tile
08 – Storm clip
16 – Batten
17 – Tilting batten
22 – Rafter
43 – Undertile membrane
54 – Flashing
66 – Vent pipe
67 – Vent pipe flashing

3.11 INSPECTION AFTER TILING

- Roof level across the plain. No sagging visible (especially at eaves tiles).
- Roof pitch, truss spacing and batten spacing according to specification.
- Fixing of tiles carried out in accordance with recommendations in the Concrete Manufacturers Association's "Concrete Roof Tiles, Technical Manual".
- Underlays properly installed (especially at closed eaves)
- All parapet walls and abutments completed.
- Flashing to parapet walls, abutments and protrusions such as vent pipes properly carried out.
- Beam filling completed.
- Ridge and hip tiles properly fixed. Hip iron installed when required.
- Hip and ridge tiles neatly cut at junctions and solid bedded.
- Tiles in valleys neatly cut and properly secured.
- Verge tiles secured to verge counter battens.
- Roof left perfect and watertight on completion. All gutters and valleys cleaned out.
- All cracked tiles replaced.
- All tiles to be in straight courses horizontally and vertically.

SECTION 4: TIMBER ROOF CONSTRUCTION

4.1 GENERAL INFORMATION

This section is devoted to timber roof construction, setting out what is acceptable and established practice in the design and manufacture of timber roof trusses. It is intended as a guide only and does not relieve the designer of the need to make a thorough study in relation to specific designs, site conditions, local authority by-laws and National Building Regulations

In South Africa, under the NBR, there are only two legal methods by which to design and construct timber roofs:

i) Roof trusses manufactured in accordance with SANS 10400-L Roofs, "The Application of the National Building Regulations". This Standard outlines the "deemed to satisfy" requirements for nailed and bolted trusses.

ii) The second method is to engage the services of a professional engineer, as required in SANS 10400-B Design, The Application of the National Building Regulations, who would work strictly inaccordance with SANS 10160 Loading Code and SANS 10163 The structural use of timber, a "rational design".

Municipalities have given tacit approval in general to pre-fabricated truss fabricators who use a suite of design programs supplied by system suppliers to design roofs up to 10m in span for non-public buildings. The Institute for Timber Construction has accredited most of these system suppliers. Larger buildings and those to whom the public has access are designed under the supervision of professional engineers using the same design programs.

Trusses designed by a competent person in accordance with SANS 10400-B Design, the Application of the National Building Regulations are not limited to the span, pitch and geometric configuration of trusses specified in SANS 10400-L Roofs.

The Institute of Timber Construction have instituted a Certificate of Competence scheme for timber truss fabricators who design, manufacture and supply prefabricated nail-plated trusses.

Stringent auditing of the truss fabricators' operations and key personnel before the awarding these certificates is an assurance of quality trusses for specifiers and for the general public.

The accuracy and performance of prefabricated timber trusses exceeds that of bolted trusses and cost savings are often significant.

4.2 TIMBER QUALITY

All timber used for the construction of roof trusses, rafters and beams should be structural SA pine complying with the requirements of SANS 1783-2, SANS 1460 and SANS 10149, and bear the full standardisation mark. Timber used for roof battens should comply with SANS 1783-4 and bear the full standardisation mark.

Timber used for the construction of roofs on site must be ordered in the dimensions in which it will be used and must not be resawn into smaller cross sectional sizes on site, as this will cause the grade, strength and dimensional tolerances to change.

4.3 TIMBER SPECIFICATION

The various grades of timber as defined by different strength properties and allowable design stresses. The grades commercially available are: M4, M5/V5, M6/V6, M7/V7 and M8 (limited availability of grade 8).

Table 1: Nominal dimensions of rough sawn timber

Type	Width (mm)	Depth (mm)	Length
Rough-sawn timber	38	38, 50, 76, 114, 152, 228	From 2700mm to 6600mm in 300mm increments. Some lengths in excess of 3600mm may only have 600mm increments
	50	76, 152, 228	
	76	76, 152, 228	
SA pine Stocklam (planed)	32 (27) 45 (40) 70 (65) 100 (95) 140 (135)	100mm to 600mm in 33,3mm increments	Standard stock lengths are available in 600mm increments upto 18000mm long

4.4 TIMBER TREATMENT

In certain magisterial districts in South Africa it is illegal to use timber for structural purposes, which has not been treated against biological attack. Treatment can be either with CCA or Boron in accordance with SANS 10005 Treatment of timber.

The districts as listed under Annexure A of Government Gazette.

4.5 STORAGE OF TIMBER

Structural timber stored on site should be stacked on level ground on bearers and adequately protected against the weather by covering with a waterproof material. Air must be allowed to circulate through the timber stacks.

Strapping around bundles of battens should not be removed until the battens are to be fixed. This will prevent excessive warping of the battens.

4.6 UNDERLAY FOR ROOF TILES

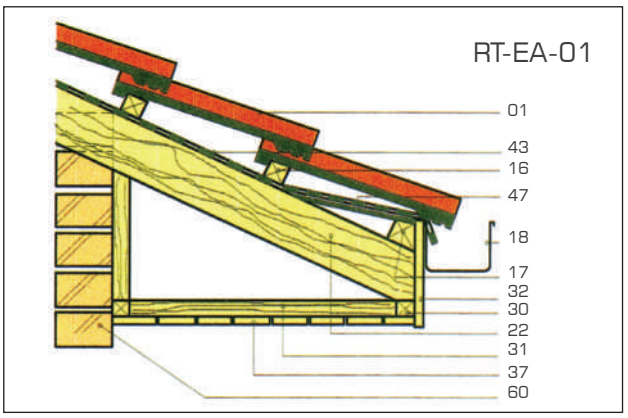


Figure 5: Closed eaves

In current building practice, the underlays have become an integral part of any tiled roof. When properly laid they will provide a highly effective barrier against the ingress of wind driven rain and dust. Pressures exerted by wind forces will be reduced substantially and the temperature gradient will be increased through the added insulation.

The use of a suitable underlay, which complies with requirement type E of SANS 952 or is approved by Agrément South Africa, having a nominal thickness of 250μm (0,25mm) is recommended for all pitches in all areas. **It is essential for roof pitches below 26° and above 45° and for all roof pitches in coastal and other exposed and windy areas.**

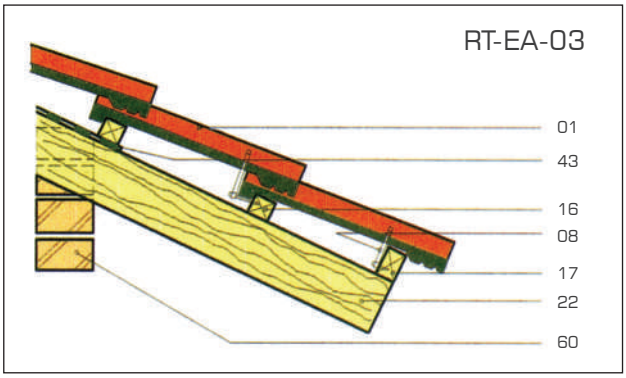


Figure 6: Open eaves

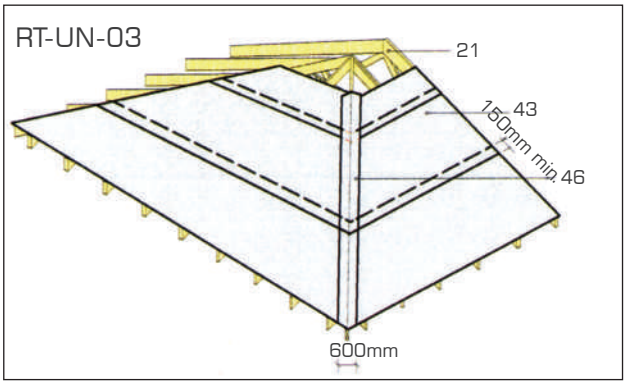


Figure 7: Overlay strip – hip

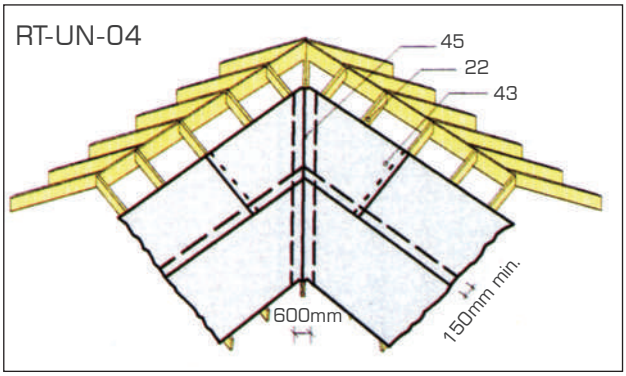


Figure 8: Underlay strip –valley

Underlays must be fixed horizontally over the rafters, prior to battening, with a minimum overlap of 150mm and secured to the centre of the rafters with the minimum number of non-corrosive clout nails. The vertical laps should be secured over the rafters. Do not try to pull the underlay tight.

At closed eaves, the underlay should extend over the tilting batten and fascia board to allow drainage of water into the gutter. It should be supported behind the fascia board to prevent it from sagging and forming a water trap. Refer to Figure 5,

At open eaves, the underlay should extend at least 20mm over the beam filling on the exterior wall. Refer to Figure 6.

Over a hip, a strip of underlay, 600mm wide, should be laid overlapping the undertile membrane or foil of the main roof. Refer to Figure 7

In valleys, a similar strip should be used and tucked under the undertile membrane or foil of the main roof. Refer to Figure 8.

Legend

01 – Roof tile
08 – Storm clip
16 – Batten
17 – Tilting batten
21 – Truss
28 – Hip rafter
30 – Timber support
31 – Timber framing
32 – Fascia
37 – Eaves lining
43 – Undertile membrane
45 – Underlay strip
46 – Overlay strip
47 – Undertile membrane support
48 – Gutter
60 – Masonry wall

4.6 UNDERLAY (CONTINUED) BOARDED RAFTERS

In house designs where the boarding or ceiling boards are fixed on top of the rafters, counter battens must be fixed on top of the ceiling boards directly above the rafters. The underlay should than be laid horizontally over the counter battens on top of the ceiling boards. The battens are than fixed to the counter battens at the required spacings. Refer to Figure 9.

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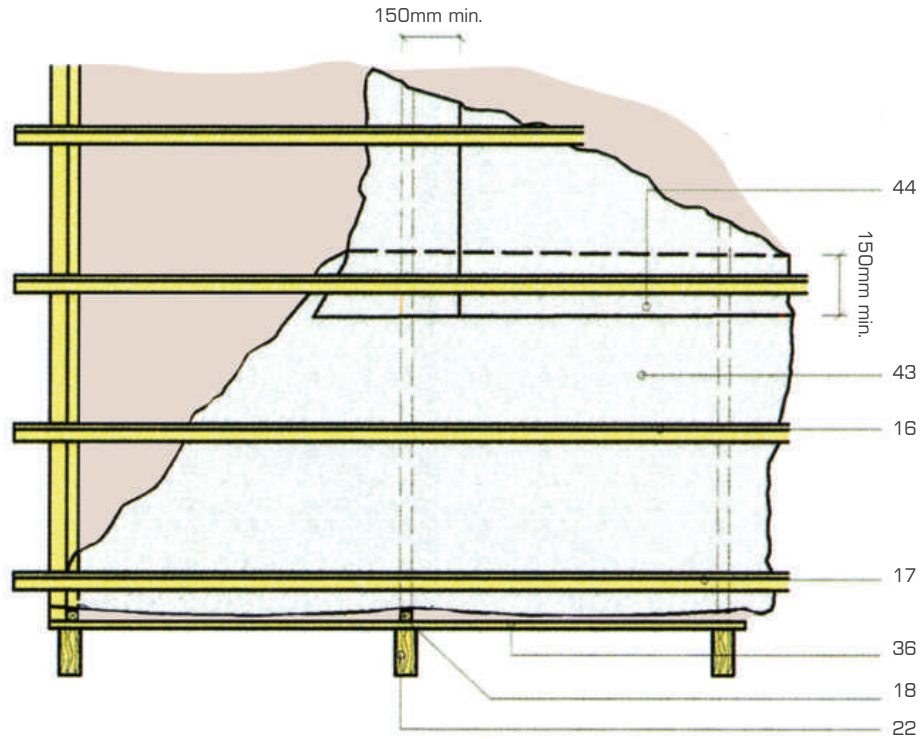


Figure 9: Undertile membrane over ceiling illustrating laps

Legend

16 – Batten
17 – Tilting batten
18 – Counter batten
22 – Rafter
36 – Boarding
43 – Undertile membrane
44 – Undertile membrane overlap

4.7 FACTORY ENGINEERED TRUSSES

A network of prefabricated timber roof truss manufacturers can be found throughout South Africa. These fabricators operate under licence to suppliers of nail plate connectors and use computer design programs devised by professional engineers.

These fabricators are trained and equipped to offer advice and solutions for any shape of roof, and pitch or span for new structures, or to match existing roofs.

For the purpose of municipal approval, design calculations may be issued in a computer output format, together with the appropriate roof layout, truss diagrams and any explanatory notes.

When placing orders with a truss fabricator, or when a quotation is required, the fabricator must be provided with the following minimum information of a detailed drawing:

- Overall span of roof
- Eaves overhang
- Pitch of roof
- Cantilever distance (if any)
- Truss spacing (can be optimized by the truss engineer), normally 760mm for concrete roof tiles
- Roofing materials plus any special load
- Ceiling materials plus any special loads
- Geyser position and capacity
- Hatch openings, size and position
- Special eaves details
- Other details, which may affect the design

Typical documentation to accompany truss delivery

Under the Institute of Timber Construction Certificate of Competence scheme, the following is the minimum information which is required to be send to site:

1. The roof layout drawings, which must be provided for each project and must show:
    a. Loading, maximum truss and batten centres
    b. The position of the trusses with their marks clearly indicated
    c. The position of the braced bays
    d. The type of bracing employed, cross referenced to the bracing details
    e. All erection details for hips and valleys
    f. The position of any special connections or cleats
2. The relevant bracing details, which must be included with the roof layout drawings
3. Standard notes regarding material specification, sundry timber and bracing connections, nailing and bolting, which should be send to the site whenever full engineering design drawings are not provided.

For further information and construction details pertaining to good practice in the manufacture, handling, erection and bracing of the roof structure, refer to various publications recommended under Appendix B: Source Documents.

4.8 SITE MANUFACTURED TRUSSES

Roof trusses manufactured on site must comply with the minimum "deemed to satisfy" requirements for nailed and bolted trusses of SANS 10400-L Roofs (the Application of the National Building Regulations) or be designed by a professional engineer or other competent person.

The requirements of the National Building Regulations are that the truss, single or double pitch, shall be of the "Howe" type truss with a span not exceeding 10m for double pitch trusses and 6m for single pitch trusses. The trusses must be supported at heel joints only and have bays of equal lengths not greater than 1.5m. Refer to Figures 14, 15 and 16.

a. Where the roof covering is concrete tiles the size of the rafter (top chord), and tie beam (bottom chord) and the grade of timber to be used shall be selected from Table 2 in such a way that the desired truss span does not exceed the relevant figure

b. All web members shall be at least 38 x 114mm Grade 4 Timber

c. Where the timber sizes are determined from Table 2, the pitch of the roof shall not be less than 17°.

Table 2: Maximum truss spans for various rafter and tie – beam sizes (Table 1 Part L SANS 10400)

Truss member	Nominal timber size mm	Max span m	
		Timber grade 4	Timber grade 6
Rafter	38 x114 38x152 38x228	6,0 8,2 10,0	9,0 10,0 10,0
Tie-Beam	38x114 38x152 38x228	4,7 5,9 7,2	6,7 8,5 10,0

a) Truss spacing for concrete tiles

The spacing of roof trusses in accordance with SANS 10400-L Roofs shall not exceed 760mm from centre to centre using 38 x38mm battens at maximum 345mm centres.

The truss spacing may be increased when using engineered trusses designed by a professional engineer in accordance with SANS 10163 and using battens to SANS 653 to suit the span as indicated in table 3.

Table 3: Truss spacing (Concrete roof tiles)

Max Truss Centres mm	Max Batten Centres mm	Size of Battens mm
760 900 1000	345 345 345	38x38 38x50 flat 38x50 on edge

b) Joints in trusses

The number of connecting devices to be used at each intersection between two members at any heel joint or any splice in a truss shall be determined from Table 4.

In the case of any joint other than a heel joint or splice. One 10mm bolt plus three 90 x 4mm nails shall be used.

Table 4: Number of connecting devices required in heel joints and splices (Table 2 Part L SANS 10400)

Truss Span m	3(90x4mm) nails plus 10mm bolts	16mm bolts only	50mm toothed ring connectors
	No. of Bolts	No. of Bolts	No of Connectors
3 4 5 6 7 8 9 10	1 2 2 3 3 4 4 5	1 2 2 2 2 3 3 3	1 1 1 2 2 2 2 2

c) Manufacture of trusses on site

To ensure a high standard of finish, it is essential that the roof structure be properly constructed. Poor workmanship and warped timber will reflect on the finished product and may result in deflection and distortion of the roof.

- Select a level surface to work on
- Set out the first truss according to span and roof
- Mark out the timber for various members of the truss and cut accurately
- Assemble the truss by nailing and bolting through the

two thicknesses of timber and clinch the nails over on the reverse side

- The bolts must have a washer on either end and should be tightened without crushing the timber under the washers.
- The completed truss can now be used as a jig for the construction of the remaining trusses of the same size

Note: Trusses can also be manufactured on site to an engineer's design using nail plate connectors. This method can show substantial savings in timber requirements

d) Illustrations of hips and valleys

For the construction of hips and valleys the services of a professional engineer should be engaged. This is a requirement of SANS 10400 (The Application of the National Building Regulations).

The following are illustrations only of some of the many types of hips and valleys and must not be used for construction purposes.

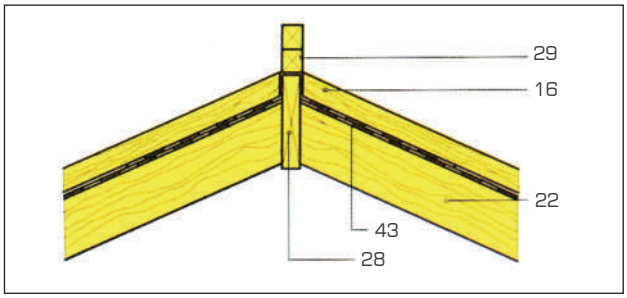


Figure 10: Hip tree

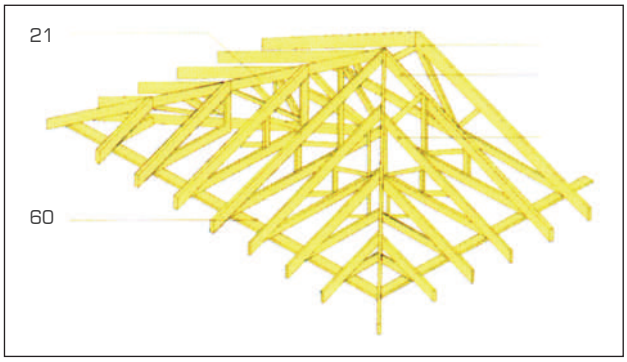


Figure 11: Hip and jack trusses

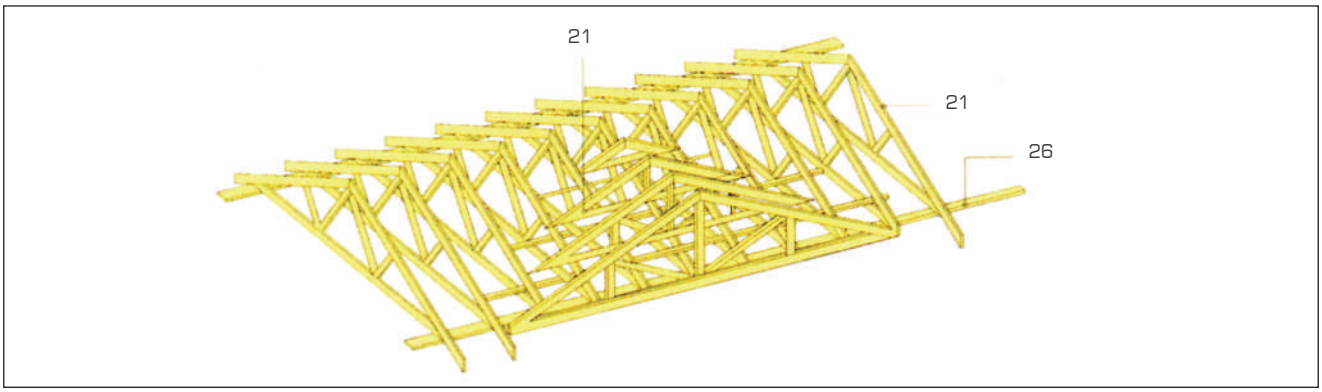


Figure 12: Using trusses ranging in spans to form a valley

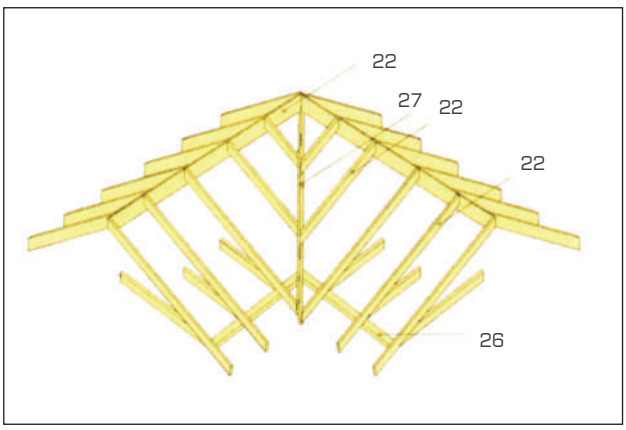


Figure 13: Valley using valley rafters

Where the pitch of a roof exceeds 40°, additional battens must be fixed on top of the hip rafter to form a hip tree of sufficient height to permit the mechanical fixing of the ridge tiles. Refer to Figure 10.

Where the pitch of a roof exceeds 40° additional battens must be fixed on top of the hip rafter to form a hip tree of sufficient height to permit the mechanical fixing of the ridge tiles. Refer to Figure 10

Legend

16 – Batten
21 – Truss
22 – Rafter
26 – Wall plate
27 – Valley rafter
28 – Hip rafter
29 – Hip tree
43 – Undertile membrane

e) Typical roof trusses for site manufacture

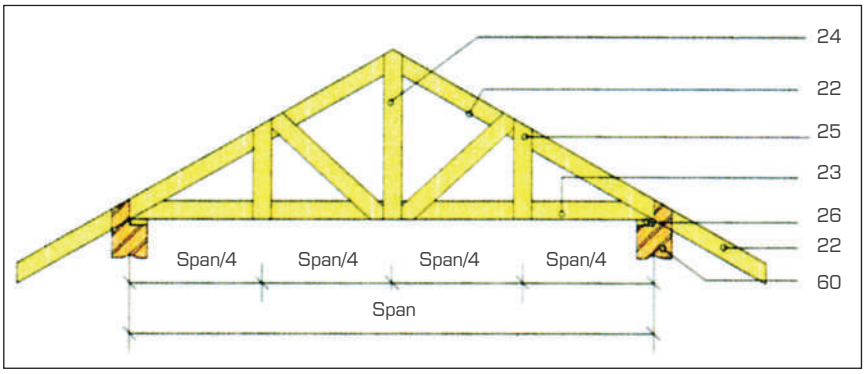


Figure 14: Howe truss 4 bay

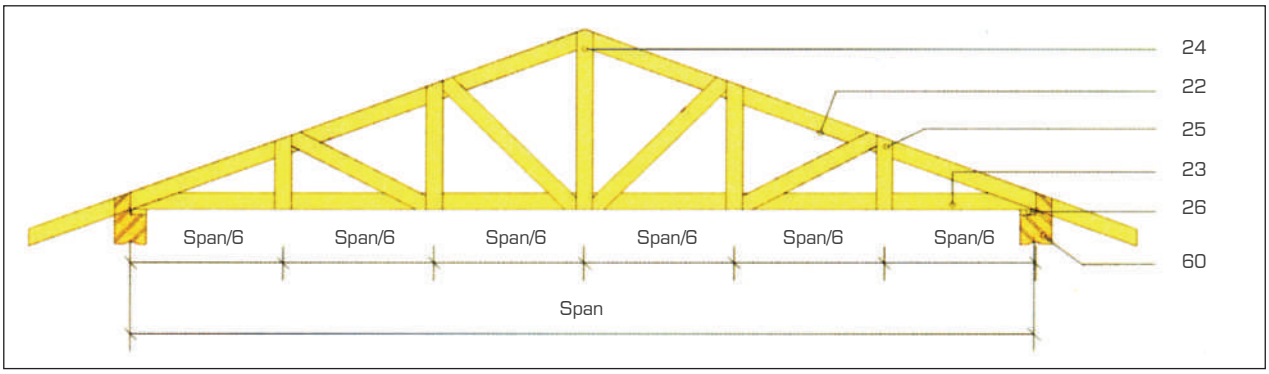


Figure 15: Howe truss 6 bay (can also be 8 bay with a maximum span of 10m)

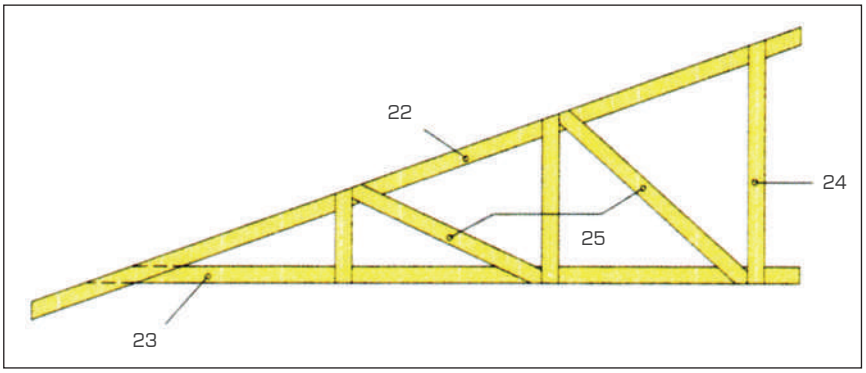


Figure 16: Half-Howe truss

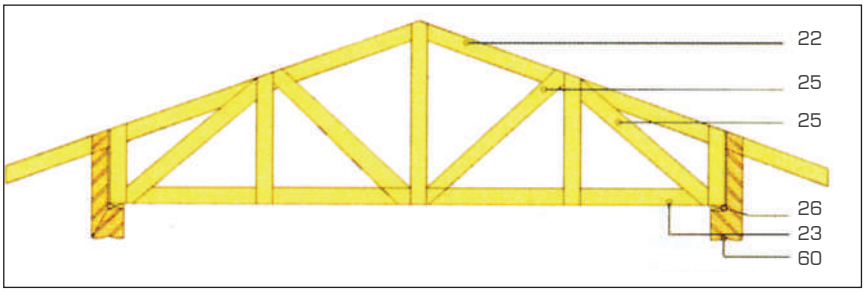


Figure 17: Stub end truss (must be designed by a professional engineer)

Legend

22 – Rafter
23 – Tie beam
24 – King post
25 – Web
26 – Wall plate
60 – Masonry wall

4.9 ERECTION OF TRUSSES

Failure of roofs can often be attributed to poor workmanship and the disregard of simple erection procedures.

Trusses should be protected against any damage on site whilst awaiting erection. They should be stacked on level ground on timber bearers and covered with a waterproof material but with adequate ventilation. When handling trusses care must be taken to avoid any damage to the timber and to the joints.

- If possible carry trusses vertically
- With large trusses, sufficient labour should be made available to provide full support avoiding any sagging or whipping when carrying the truss horizontally.
- Do not "see-saw" the truss across the walls or scaffolding
- Lift trusses onto the wall in an upright position

Erection procedure

a) Lay the wall plates in position and level. Mark truss centres on the wall plates on either side of the building and ensure that they are square with the gable end of the building

b) Lift the first truss on the marked position on the wall plate. Plumb the truss and secure in the position using temporary props. Refer to Figure 18.

c) A further two trusses can now be lifted into position, plumbed and fixed temporarily to them first truss using 38 x 38mm battens fixed on either side of the ridge keeping the trusses in a vertical position. Fix vertical cross bracing to either side of the king post using 38 x 76mm M4 grade timber, fixing each connection with two 75 x 3.5mm wire nails. The three trusses attached with cross bracing create a ridged unit to which the other trusses can be attached with temporary battens and bracing can be removed once all the permanent battens are fixed. Refer to Figure 19.

d) The remainder of the trusses can be erected, plumbed and attached to the three braced trusses using battens as temporary bracing.

e) Span a builder's string line across the rafters of the trusses to check alignment and adjust where necessary using hardboard wedges under the tie beams of the trusses and skew nail all trusses to the wall plate with 100mm nails.

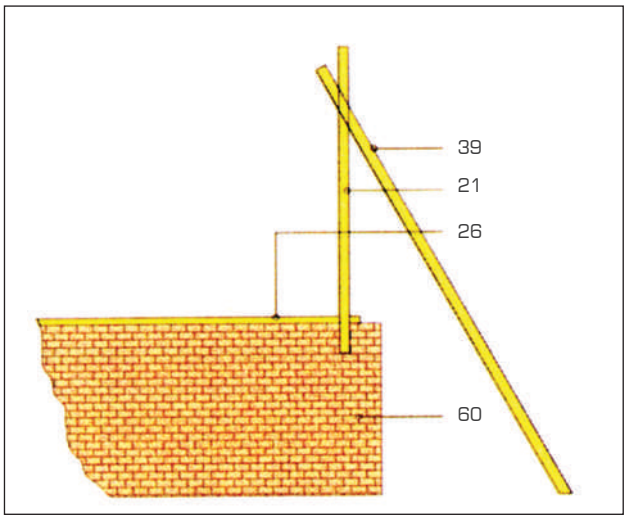


Figure 18: Position of first truss

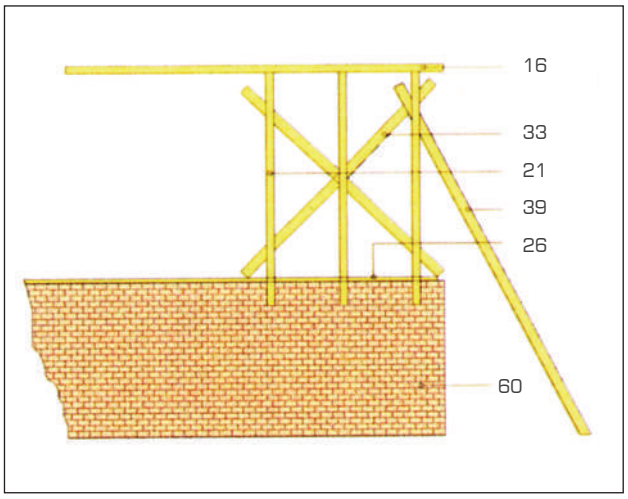


Figure 19: Illustrating vertical cross bracing

Legend

16 – Batten
21 – Truss
26 – Wall plate
33 – Cross bracing
39 – Prop
60 – Masonry wall

f) Permanent diagonal bracing must be installed at the gable ends of the roof. Bracing members must be minimum 38 x 76mm and should be nailed to the underside of rafters with 75 x 3.5mm wire nails. They must run in a straight line from the apex of the truss to the heel of the truss at approximately 45° and must be connected to the wall plate. Refer Figure 20.

For spans greater than 6ms use 38 x 114mm (Grade 4) bracing members bolted to the underside of shelf with two M12 bolts. Refer to Figure 20 detail standard – heel bracing.

g) To prevent buckling of the long webs (exceeding 1.8m), cantilever roofs and the tie beam where no ceiling battens are used, longitudinal runners should be fixed to the members. The runners must be 38 x 76mm nailed to each truss with two 75-x 3.5mm wire nails at each intersection. All longitudinal runner members must be cross-braced. Refer to Figure 21.

h) Having completed all the necessary bracing the trusses must be permanently anchored to the wall and wall plate with the metal straps or galvanized wire which have been build into the wall. Refer to Figure 22.

Note: Refer to SANS 10243 the design, manufacture and erection of timber trusses for an update of bracing details, which may supersede the details shown here.

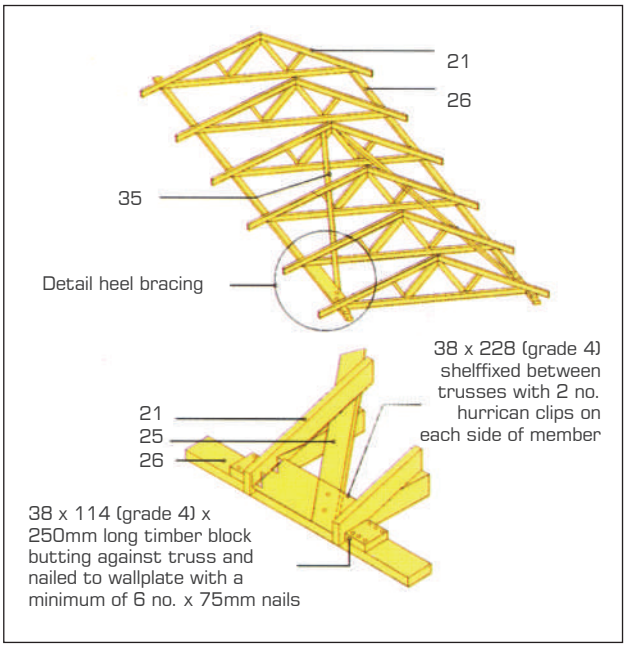


Figure 20: Diagonal bracing to rafter

Roof anchorage

To resist any uplift forces, it is essential that every truss or rafter be properly anchored to the supporting wall. This can be carried out by using galvanized steel straps 30 x 1.6mm or 4mm galvanized steel wire, embedded at least 300mm deep into the wall.

The 4mm diameter steel wire should consist of two stands which should be taken up on either side of the rafter, twisted together and nailed to prevent untwisting.

In the case of timber frame building, any roof truss, rafter or beam shall be securely fastened to the wall construction in accordance with SANS 10082 Timber buildings.

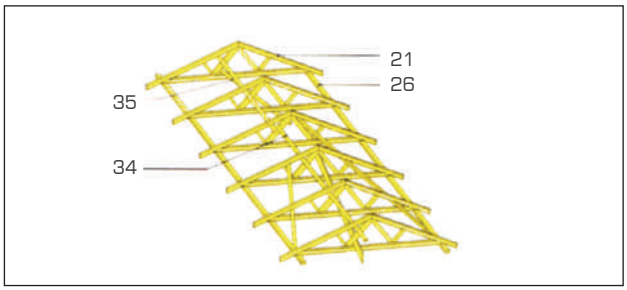


Figure 21: Longitudinal runner and cross bracing to long webs

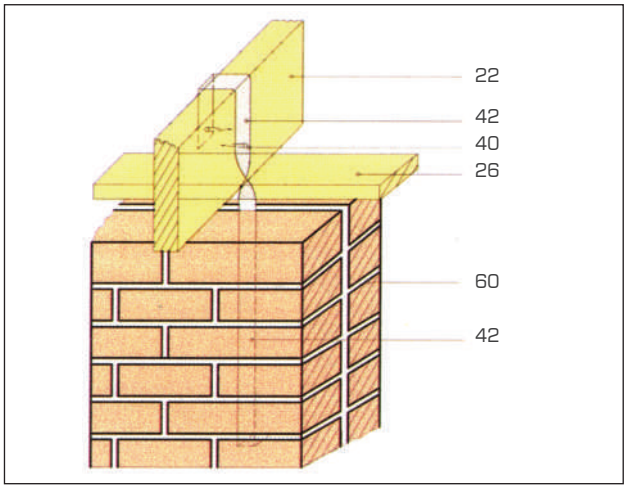


Figure 22: Roof anchorage

Legend

21 – Truss
22 – Rafter
26 – Wall plate
33 – Cross bracing
34 – Longitudinal runner bracing
35 – Diagonal bracing
40 – Fixing nail
42 – Metal strap
60 – Masonry wall

4.10 THE USE OF RAFTERS ONLY AS ROOF SUPPORTS

The use of rafters spanning from wall to wall is a regular feature of modern architecture. The ceiling follows the slope of the roof, or it can be fixed on top of the rafters. Refer to Figure 23.

The rafters and wall plate are anchored as previously described, using either 30 x 1.6mm metal straps or 4mm diameter galvanized wire built into the wall.

The rafters must be designed simply supported and the loading uniformly distributed over the full span, in accordance with SANS 10163 the structural use of timber. Timber quality is as specified in Section 5.2. The tile battens provide lateral stability for the beams.

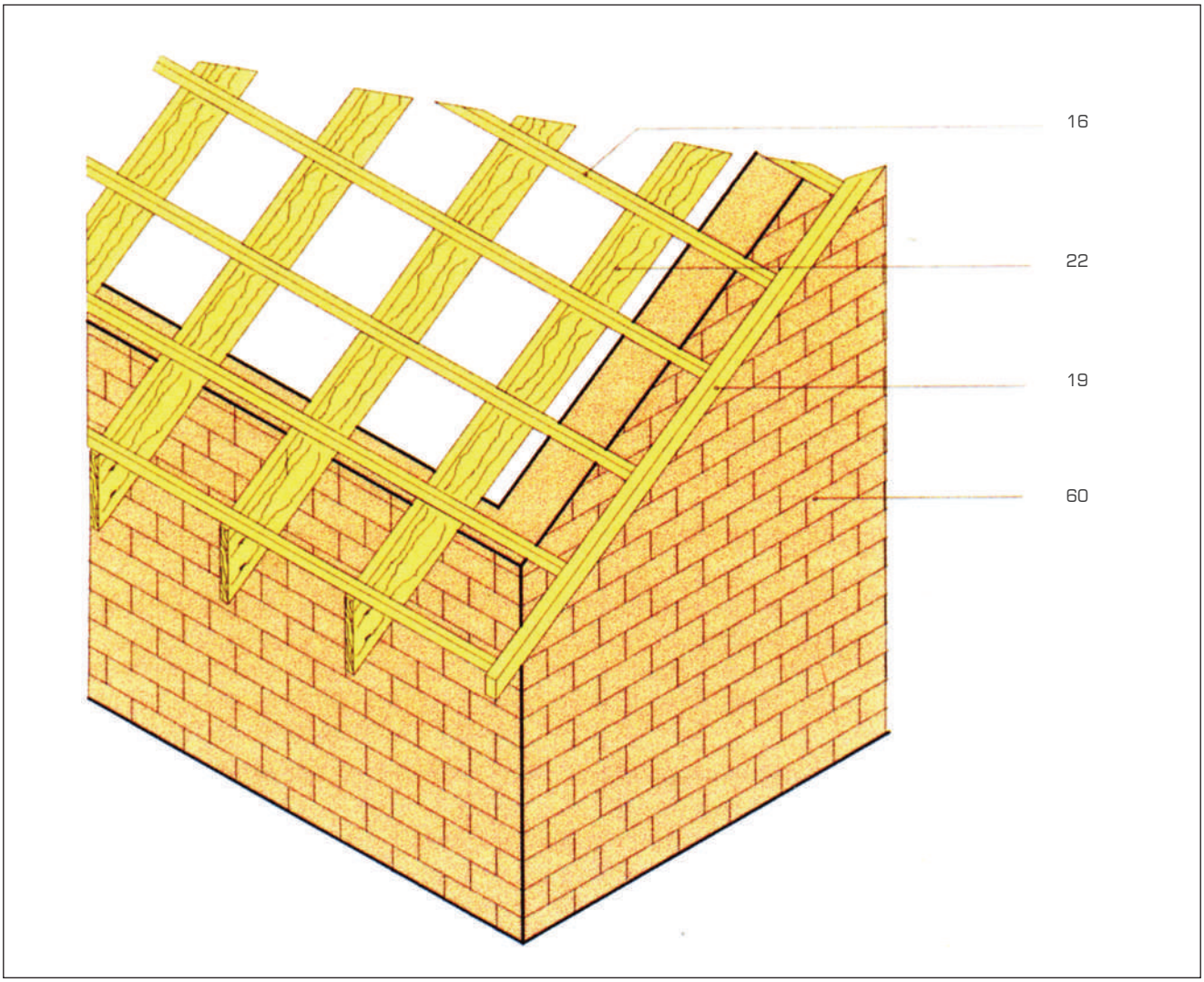


Figure 23: Use of rafters

Legend

16 – Batten
19 – Verge counter batten
22 – Rafter
60 – Masonry wall

Member sizes for tiled roofs

The following sizes of rafters are for tiled having a mass of 55kg/m^2 and are designed for 0.5kN/m^2 live load and a light ceiling and for pitches up to 25°. The following criteria have been applied, namely permissible stress and a final deflection of span/200.

The batten spacing is assumed to be less or equal to 360mm. Grade number (Gr#) in the table refers to the grade of timber. Only timber commonly available in commercial quantities is listed.

Table 5: Timber sizes and grades for concrete tiled roofs at maximum spans of rafters

Span of Rafters mm	**Spacing of Rafters mm**		
	760	900	1000
2000	38 x 152 Gr4 40 x 128 Lam	39 x 152 Gr4 40 x 128 Lam	40 x 152 Gr4 40 x 128 Lam
3000	38 x 228 Gr4 38 x 152 Gr7	38 x 228 Gr4	39 x 228 Gr4
4000	50 x 228 Gr5	50 x 228 Gr5 76 x228 Gr4	76 x 228 Gr4
5000	76 x 228 Gr4 65 x 195 Lam	65 x 228 Lam	66 x 228 Lam
6000	65 x 261 Lam	66 x 261 Lam	67 x 295 Lam

Note: Batten sizes must be in accordance with Table 3

4.11 FIXING OF BATTENS

Timber used for battens must comply with SANS 1783-4. The battens should be straight, free from major defects and in long lengths. Joints in battens should be staggered on rafters. Size of battens must be in accordance with spacing of trusses. Refer to Table 3.

Batten centres will depend on the type of concrete roof tile, which is to be used. For information on the full range of roof tiles refer to manufacture's literature. The following checks should be carried out before fixing of the battens commences.

Check:

- Trusses for alignment/straightness
- Truss spacing
- Truss anchorage to wall and wall plate
- Pitch of roof
- Construction of hips and valleys to engineer's details
- Bracing of trusses
- Squareness of roof
- Brickwork and plastering to gables. Parapets, chimney and beam filling have been completed.

Battening procedure:

a) Establish the roof eaves overhang. Work out the number of full roof tiles to cover the distance from eaves to ridge. To avoid cutting tiles, adjust the eaves overhang allowing for the thickness of fascia plus 50mm overhang of the first row of tiles past the fascia. Ensure that the last of the battens at the ridge is not more than 25mm (for flat profile 25 – 50mm – refer to manufacturer) from the apex Refer to Figure 26.

b) Trim rafters at the eaves and fix tilting batten and fascia board. The tilting batten is to be 14mm higher than the other battens to ensure roof tiles are in the same plane.

c) Fix underlay over trusses by nailing, with the minimum number of non-corrosive clout nails, to the centres of the rafters of the trusses. It is not necessary to fix the underlay tightly over the rafters.

d) Mark the batten centres at each end of the roof and strike a chalk line.

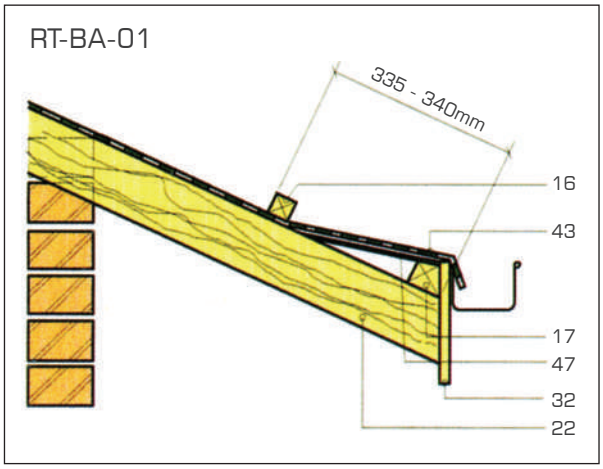


Figure 24: First batten with fascia

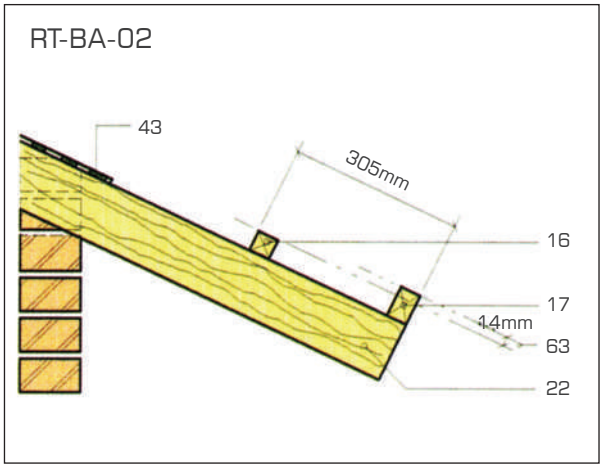


Figure 25: First batten without fascia

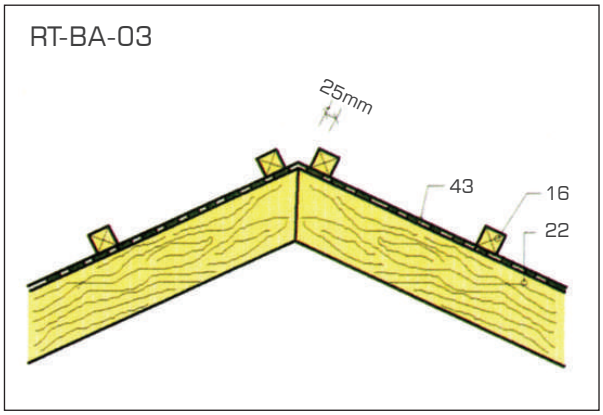


Figure 26: Ridge batten position

Legend

	32 – Fascia
16 – Batten	43 – Undertile membrane
17 – Tilting batten	47 – Undertile membrane support
22 – Rafter	63 – Tilting dimension

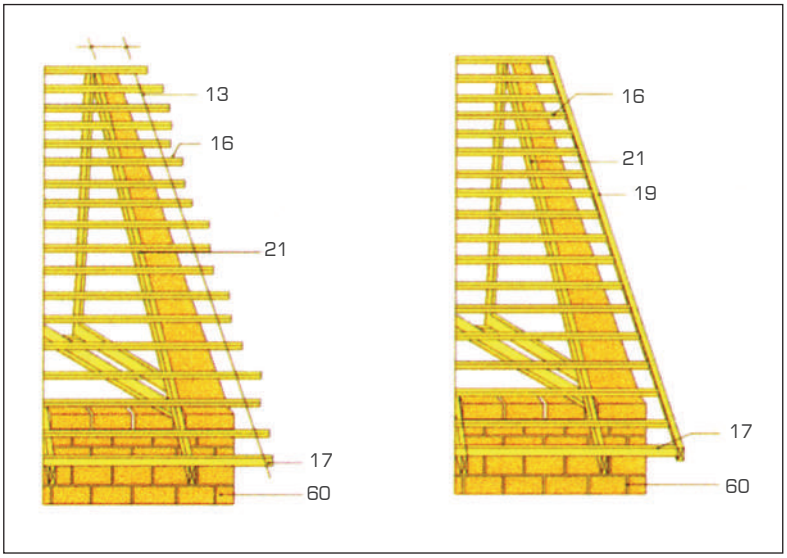
e) Fix battens according to the chalk lines allowing sufficient overhang at the gable ends for trimming. The length of nails for fixing battens should be batten thickness plus 40mm. For a neat fit where the battens intersect at hips and valleys, the battens should be mitred.

f) Establish verge overhang using width of full tiles along the eaves and along the ridge. Mark at top and tilting batten only. Strike a chalk line between the two points and cut the battens. Refer to Figure 27.

g) If verge tiles are used, the tilting batten and fascia board must extend past the verge counter batten by 25mm to allow for the tilt in the first verge tile.

h) With bold profile roof tiles the verge counter batten must be raised above the batten line to ensure good fixing of the verge tiles Refer to Figure 28. With all the profiles the verge counter batten must be positioned flush with the batten line. Refer to Figure 29.

The roof is now ready for tiling.



Legend

01 – Roof tile
04 – Verge tile
10 – Fixing point
13 – Chalk line
16 – Batten
17 – Tilting batten
19 – Verge counter batten
21 – Truss
40 – Fixing nail
43 – Undertile membrane
60 – Masonry wall

Figure 27: Setting out a verge

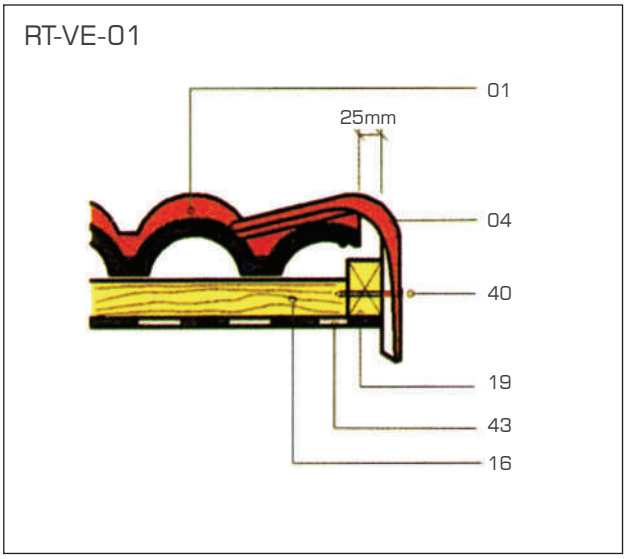


Figure 28: Verge counter batten for bold profile tiles

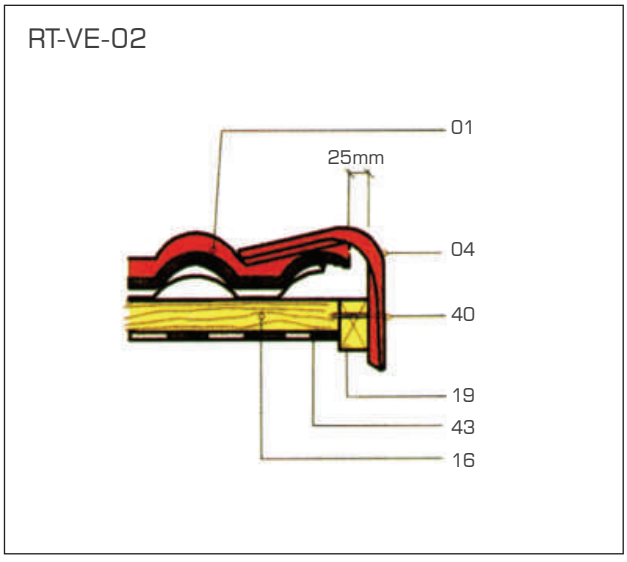


Figure 29: Verge counter batten for all other profiles

SECTION 5: STEEL ROOF CONSTRUCTION

5.1 GENERAL INFORMATION

Increasingly light steel frame trusses are being used for roofing solutions with concrete roof tiles. This section is devoted to steel roof construction, setting out what is acceptable and established practice in the design and manufacture of steel roof trusses. It is intended as a guide only and does not relieve the designer of the need to make a thorough study in relation to specific designs, site conditions, local authority by-laws and National Building Regulations

In South Africa, under the NBR, there is only one legal method by which to design and construct a steel roof structure:

The only method is to engage the services of a professional engineer, as required in SANS 10400-B Design, The Application of the National Building Regulations, who would work strictly in accordance with SANS 10160 Loading Code and undertake a "rational design". Materials used for light steel structures shall comply with the requirements of SANS 10237 Roof and side Cladding and SANS 517 Light steel frame building.

Municipalities have given tacit approval in general to pre-fabricated truss fabricators who use a suite of design programs supplied by system suppliers to design roofs up to 10m in span for non-public buildings. Larger buildings and those to whom the public has access are designed under the supervision of professional engineers often using similar design programs.

Trusses designed by a competent person in accordance with SANS 10400-B Design, the Application of the National Building Regulations are not limited to the span, pitch and geometric configuration of trusses specified in SANS 10400-L Roofs.

Stringent auditing of the truss fabricators' operations and key personnel before the awarding these certificates is an assurance of quality trusses for specifiers and for the general public.

5.2 FACTORY ENGINEERED STEEL TRUSSES

Steel structures, consisting of cold-formed steel sections, made using high strength thin gauge galvanised steel sheet. The sections are normally connected using self-tapping screws or rivets, to form joists, wall panels and roof structures.

Materials used for light steel structures shall comply with the requirements of SANS 10237 and SANS 517.

Manufacturers of these light steel structures have specialized erector teams available to install lightweight roof trusses.

5.3 SITE MANUFACTURED STEEL TRUSSES

It is not recommended to manufacture steel trusses on site.

APPENDIX A: LEGEND

01	Roof tile
02	Taper ridge
03	Butt ridge
04	Verge tile
05	Hip starter
06	Ventilatedridge
07	Monopitch ridge
08	Storm clip
09	Hip iron
10	Fixing point
11	Mortar bed
12	Mortar joint
13	Chalk line
14	Striking chalk line
15	Tile stack
16	Batten
17	Tilting batten
18	Counter batten
19	Verge counter batten
20	Valley counter batten
21	Truss
22	Rafter
23	Tie beam
24	King post
25	Web
26	Wall plate
27	Valley rafter
28	Hip rafter
29	Hip tree
30	Timber support
31	Timber framing
32	Fascia
33	Cross bracing
34	Longitudinal runner bracing
35	Diagonal bracing
36	Boarding
37	Eaves lining
38	Soffit lining
39	Prop
40	Fixing nail
41	Bolt
42	Metal strap
43	Undertile underlay
44	Undertile underlay overlap
45	Underlay strip
46	Overlay strip
47	Undertile underlay support
48	Gutter
49	Box gutter
50	Concealedgutter
51	Back gutter
52	Chimney back gutter
53	Valley gutter
54	Flashing
55	Apron flashing
56	Side wall flashing
57	Back gutter flashing
58	Cover flashing
59	Soakers
60	Masonry wall
61	Chimney stack
62	Air Brick
63	Tilting dimension
64	Cut-off mark
65	Off-cut
66	Vent pipe
67	Vent pipe flashing
68	Damp proof course (DPC)
69	Straight edge
70	Mortar closure

APPENDIX B: SOURCE DOCUMENTS

1 Mitek South Africa (Pty) Ltd, Timber Roof Truss Systems

2 The Institute for Timber Construction, Timber Truss Manual, Johannesburg

3 SANS 10062 Fixing of concrete interlocking roofing tiles

4 SANS 10082 Timber buildings

5 SANS 10163 The structural use of timber-Part 1 Limit state design and Part 2Allowable stress design

6 SANS 10400 -1990 The Application of the National Building Regulations

7 SANS 1783 Sawn softwood timber-Part 2 Stress-graded structural timber and Part 4 Brandering and battens

8 SANS 10149 The mechanical stress grading of softwood timber

9 SANS 1460 Laminated timber

10 National Building Regulations (Act. No 103 of 1977)

11 SANS 10160 The general procedures and loadings to be adopted in the design of buildings

12 SANS 10005 The preservative treatment of timber

13 Regulations in terms of the Forest Act, Government Gazette 10158, 27 March 1986 Annexure A of Regulation R602

14 SANS 517 Light steel frame building

NOTES

- The National Building Regulations and Building Standards Act (Regulation A19 of the National Building Regulations)
- The Housing Consumers Protection Measures Act
- SANS 10400 - Application of the National Building Regulations
- SANS 10160 - The loadings and procedures to be adopted in the design of buildings
- SANS 10163 - The structural use of timber.
- SANS 10243 - The manufacture and erection of timber trusses.
- SANS 1783 - Sawn Softwood Timber
- SANS 1460 - Laminated timber
- SANS 1005 - The preservative treatment of timber
- SANS 1082 - Timber buildings
- SANS 1096 - Manufacture of finger-jointed structural timber
- ITC Roof Erectors Handbook - Volume 1,
- ITC Roof Erectors Handbook - Volume 2
- ITC Estimator / Designer Handbook

Websites:

Institute for Timber Construction	www.itctruss.co.za
Engineering Council of South Africa	www.ecsa.co.za
National Home Builders Registration Council	www.nhbrc.co.za
South African Wood Preservers Association	www.sawpa.co.za
South African Timber Auditing Services	www.satas.co.za
South African Institute of Steel Construction	www.saisc.co.za
South African Bureau for Standards	www.sabs.co.za

Further Reading for interested students:

- The World of Roof Technology (www.mitek.com.uk)
- The Gang-Nail Truss System (www.mitek.com.au)

Please note that some of the components shown in these documents are not available in South Africa ~ for further information please contact your local MiTek office:

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