HIP and VALLEY ROOFING

The text provides subject matter related to more detailed hip and valley roofs. It builds on knowledge and skills acquired during basic roof framing.

There are two parts to the text, PART 1 – Hip and Valley Roofs and PART 2 – Broken Hip and Valley Roofs, which address the following:

Roof types, development of plan shapes and member positions are explained. Methods for determining lengths of members, setting out, cutting and erection processes are covered for hip & valley and broken hip & valley roof types.

Surface development and an introduction to roof geometry is covered.

The unit also covers calculation of members, their lengths, quantities and costs.

Note: *Only conventionally pitched roofs are dealt with in this unit, as Trussed roofing will be dealt with in a separate Unit.*

A comprehensive 'Glossary of Terms' is included at the end of this unit, which provides a detailed description of trade terms, technical content and some trade jargon.

PART 1 : HIP and VALLEY ROOFS

These roof types are similar to the gable roof as they have two equal sloping surfaces joined on a common ridge, but they have the addition of two sloping surfaces on either end. The framing members are similar also with the addition of several new members such as hips.
The common plumb and level bevels will now make up 2 of the 8 bevels required to pitch these roof shapes.

A hip roof has four sloping or pitched sides and a rectangular base. The hip ends are triangular in shape and the sides have a trapezoid shape. The inclined rafters at either end of the ridge will brace the roof.

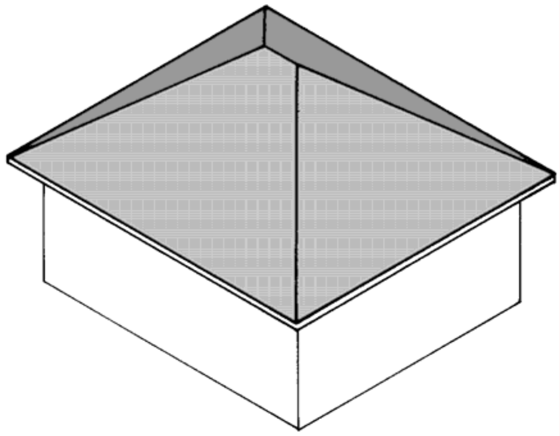


Fig. 1 The hip roof

A hip & valley roof is simply a modified or extended hip roof. The shape and pitch of the surfaces are basically the same, however the base shape changes from a simple rectangle to a ‘T’ or ‘L’ shape, on plan.
The hip & valley roof has an additional ridge, which joins the main roof ridge at the same height, which creates a single valley for an ‘L’ shaped roof. It may also join the roof surface at the same height or at a lower level on a side or end, without connection to a hip, creating two valleys for a ‘T’ shaped roof.

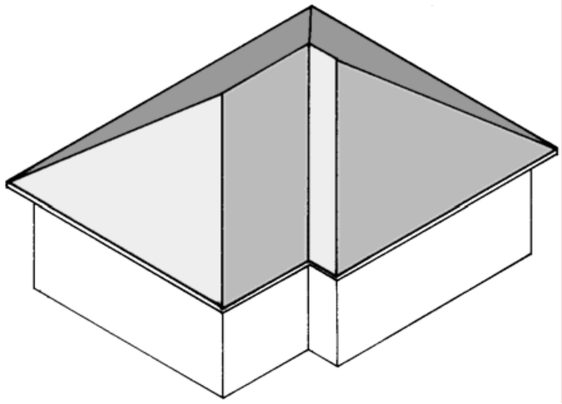


Fig. 2 The hip & valley roof

PRINCIPLES of ROOFING

There are three main principles related to roofing, which are critical to the accurate construction of roofs in general:

1. ***All ridges must be level and parallel to wall plates;***
2. ***All rafters must be placed at 90° to the wall plates, regardless of the roof shape; and***
3. ***All external and internal corners must be bisected to allow for correct placement of hips and valleys, regardless of the angle.***

PARTS, PROPORTIONS and DEFINITIONS

Span: This is the horizontal width of the roof, measured overall the wall plates.

Half span or Run of rafter: This is the horizontal distance measured from the centre of the ridge to the outside of the wall plate. It is also the plan length of the rafter.

Centre line length of rafter: This is measured along the top edge of the rafter taken from the centre of the ridge to plumb over the outside of the wall plate. It is equal to the length of the hypotenuse of the right-angled triangle formed by the rise and half span.

Rise: This is the vertical distance between the 'X-Y' line and where the hypotenuse meets the centre of the ridge.

X-Y line: This is an imaginary horizontal line, which passes through the position where the outside of the walls is plumbed up to meet the hypotenuse or top edge of the rafter. It is used to identify the centre line positions for the purpose of calculating rafter set out length and the rise of the roof.

Eaves width: This is the horizontal distance measured between the outside face of the wall frame, for a timber-framed cottage, or the outside face of the brickwork, for a brick veneer and cavity brick cottage, to the plumb cut on the rafter end .

Eaves overhang: This is the distance measured along the top edge of the rafter from the position plumb up from the outside of the wall frame, where the X-Y line passes through the hypotenuse, to the short edge of the plumb cut on the end of the rafter.

Birdsmouth: This is a right-angled notch taken out of the lower edge of the rafter, where it rests on the top wall plate. The purpose of the birdsmouth is to locate the bottom of the rafter over the wall plate and to provide an equal amount left-on so the top edges of the rafters will all be the same. This is only necessary when rough sawn timber is used. The depth of the notch should not be greater than $^2/_3$ the width or depth of the rafter, to prevent it from being weakened.

Height of the roof: This is the vertical distance taken from the top of the wall plates to the top of the rafters where they butt against the ridge.
Note: *this should not be confused with the 'Rise' of the roof.*

Plumb bevel: (1) This is the angle found at the top of the right-angled triangle, formed by the rise, half span and top of rafter edge. This bevel is used for the angled cut on the top end of the common rafters.

Level bevel: (2) This is the angle found at the bottom of the right-angled triangle, formed by the rise, half span and top of rafter edge. This bevel is used for the angled cut on the foot of the common rafters, where they rest on the wall plates.

Edge bevel creeper: (3) This is the angle found at the top corner of a right-angled triangle, formed by the proportionate size of the true length of hip and the half span.
This bevel is used for the angled cut on the top edge of the creeper rafters, where they cut against the hip.

Edge bevel purlin: (4) This is the angle found at the bottom corner of a right-angled triangle, formed by the proportionate size of the true length of hip and the half span.
This bevel is used for the angled cut on the top edge of the purlin ends, where they join under the hip.

Plumb bevel hip: (5) This is the angle found at the top corner of a right-angled triangle, formed by the proportionate size of the plan length of hip and the rise.
This bevel is used for the angled cut on the face of the hip rafters, where they cut against the centring and crown end rafters.

Level bevel hip: (6) This is the angle found at the bottom of the right-angled triangle, formed by the proportionate size of the plan length of hip and the rise. This bevel is used for the angled cut on the foot of the hip rafters, where they rest on the wall plates at the external corners.

Edge bevel hip: (7) This is the angle found at the top corner of a right-angled triangle, formed by the proportionate size of the true length of hip and the plan length of hip.
This bevel is used for the angled cut on the top edge of the hip rafters, where they cut between the centering and crown end rafters.

Face bevel purlin: (8) This is the angle found at the top corner of a right-angled triangle, formed by the proportionate size of the true length of common rafter and the rise.
This bevel is used for the angled cut on the face of the purlins, where they join under the hip.

Note: *The hip bevels may also be used for the cuts on the valley*

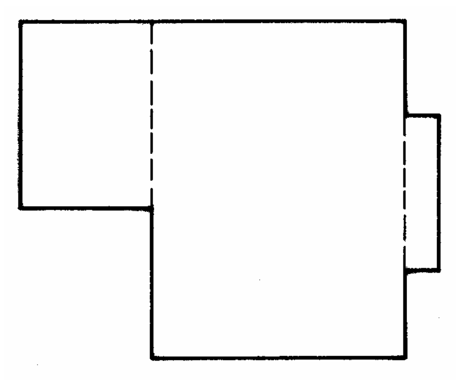
ROOF PLANS

The following rules should be adopted, when determining the position of plan roof members:

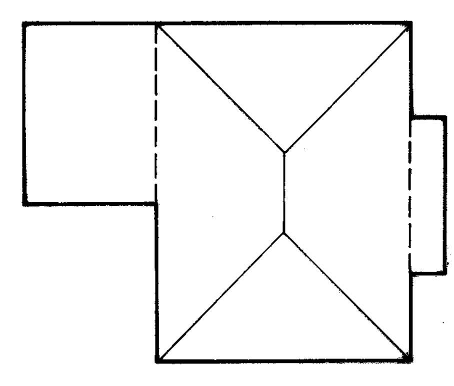
1. All angles formed by the external wall plates must be bisected;
2. Only one member is drawn from any one corner;
3. Hips are formed where the wall plates create an external corner;
4. Valleys are created where an internal corner is formed by two plates;
5. Rafters are always set at 90° to the wall plates; and
6. A ridge will always be level and parallel to the external wall plates.

PLANNING the ROOF SHAPE

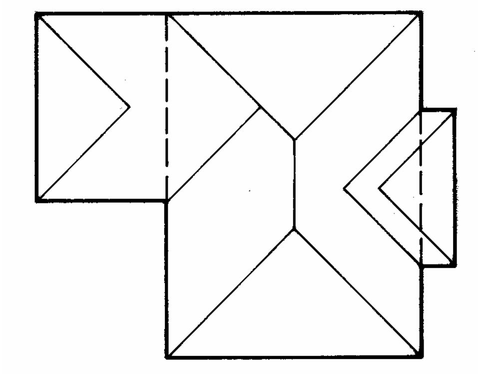
STEP 1 Select the largest rectangular area and mark its outline.



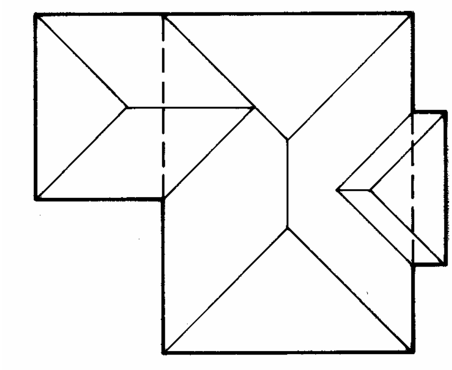
STEP 2 Lightly draw the outline of a hip roof on this area



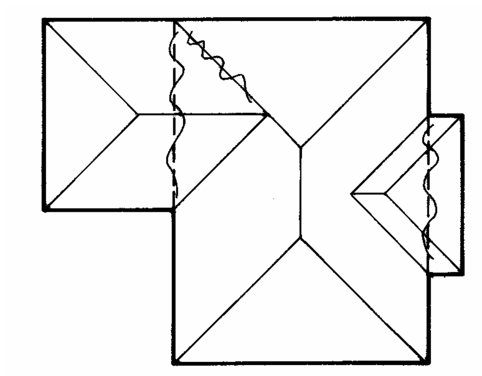
STEP 3 Bisect all other external and internal corners.



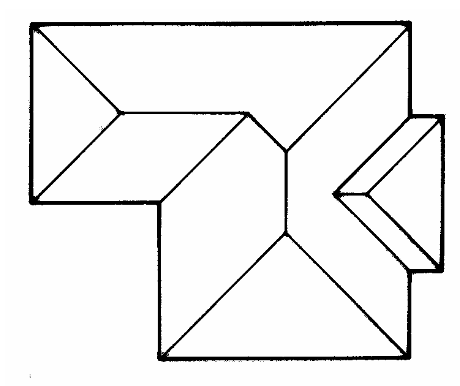
STEP 4 Draw in ridge positions for each extension.



STEP 5 Remove any unwanted lines.



STEP 6 Firm in the roof plan to ensure correct intersection connections.



ROOF PLANS and ELEVATIONS

The details below show the position of the hips, ridges, valleys and elevations for 'L and 'T'-shaped' roofs. The roofs are pitched at 30°

EXAMPLE 1:

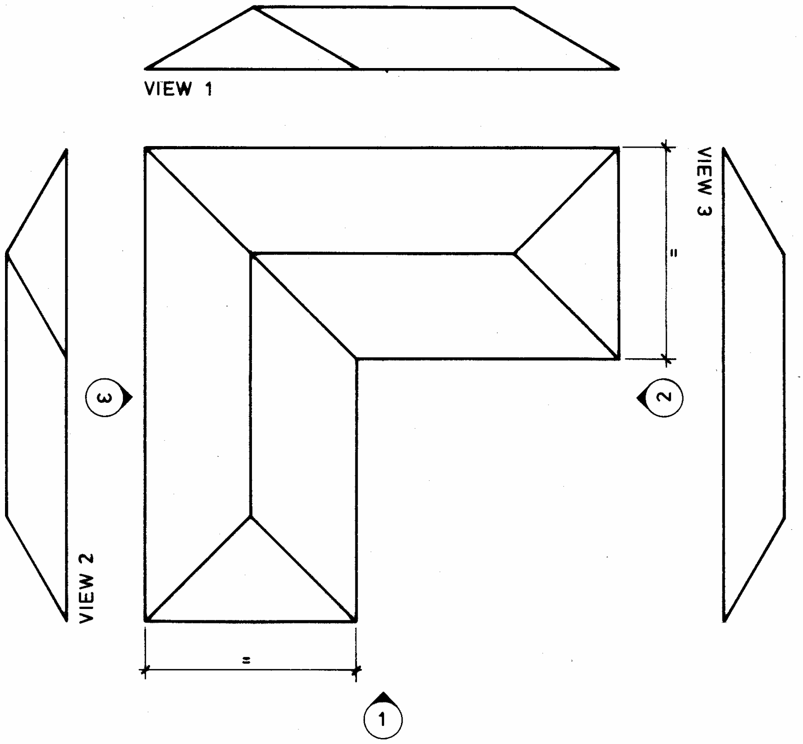


Fig. 3 'L-shaped' roof

EXAMPLE 2:

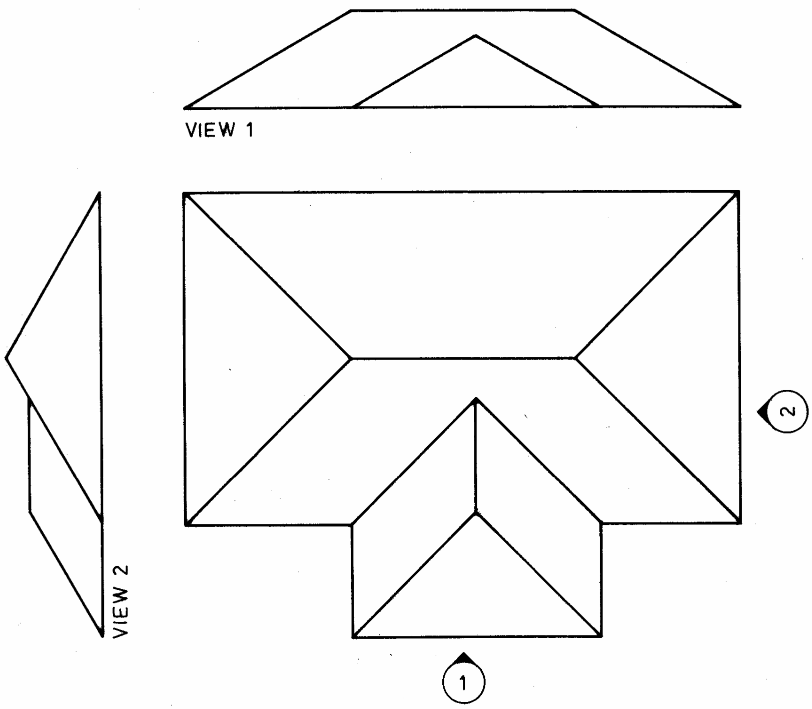


Fig. 4 'T-shaped' roof

The details below show the position of the hips, ridges and valleys and elevations for double-fronted and triple-fronted roofs. The roofs are pitched at 30°

EXAMPLE 3:

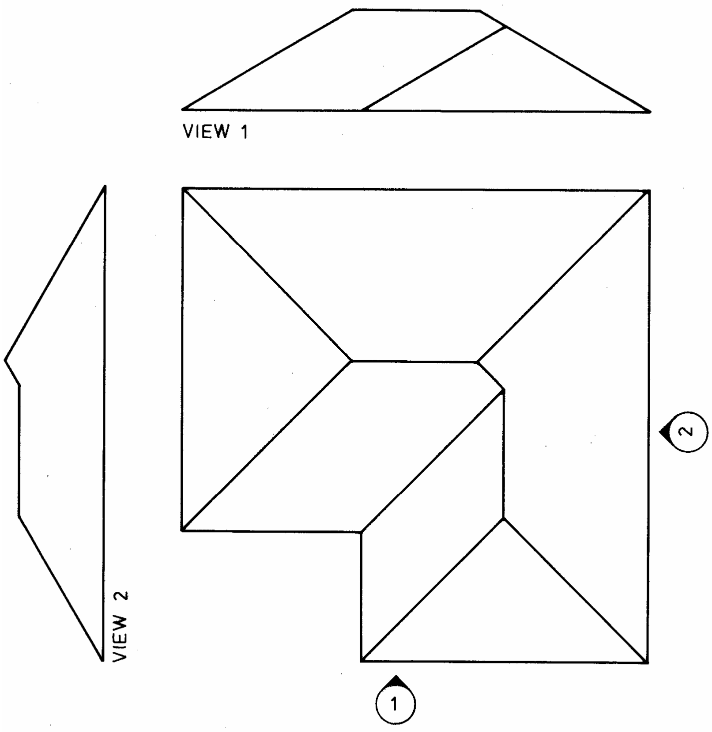


Fig. 5 Double-fronted roof

EXAMPLE 4:

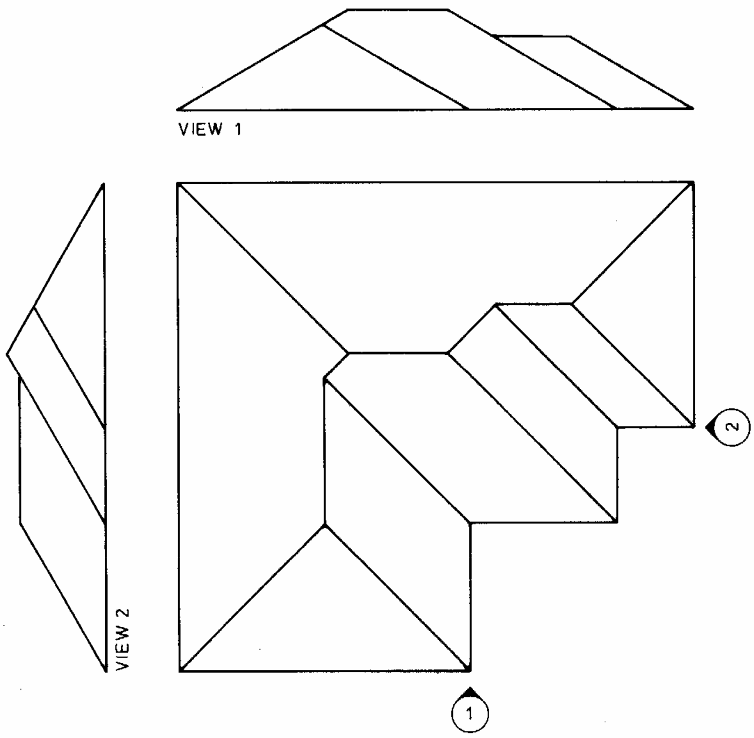


Fig. 6 Triple-fronted roof

GEOMETRY

This section looks at basic solid geometry and how the surfaces are developed.

COMMON SOLID FORMS

PRISMS

These are solid objects with two ends formed by straight sided figures which are identical and parallel to one another. The sides of the prisms become *parallelograms*. The ends may be formed by common plane geometric shapes such as the square, rectangle, triangle, pentagon, hexagon, octagon, etc.

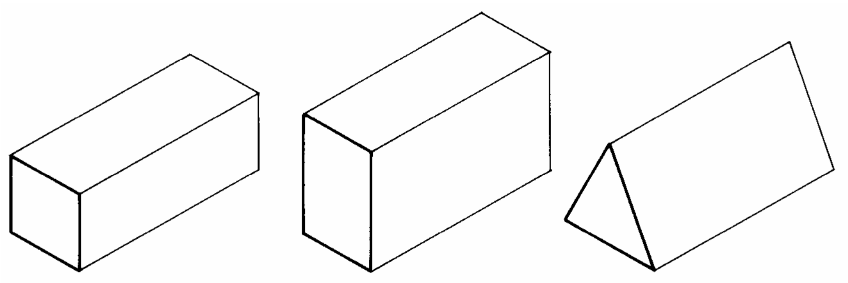


Fig. 7 The Prism

CYLINDERS

These have their ends formed by circles of equal diameter. The ends are parallel and joined by a uniformly curved surface.

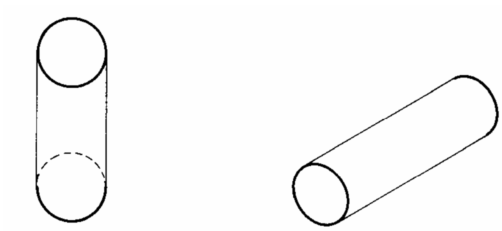


Fig. 8 The Cylinder

CONES

These have a circular base and a uniformly curved surface which tapers to a point called the *apex.*

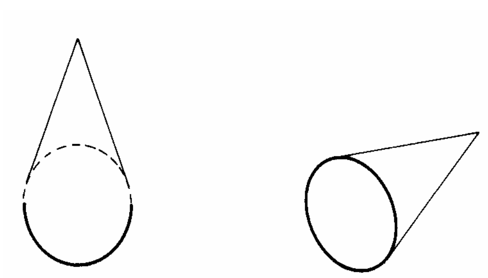


Fig. 9 The Cone

PYRAMIDS

These are solid shapes with a base consisting of a straight sided figure and triangular sides which terminate in a common point, called the apex.

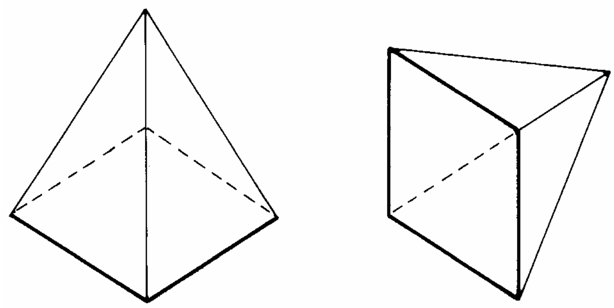
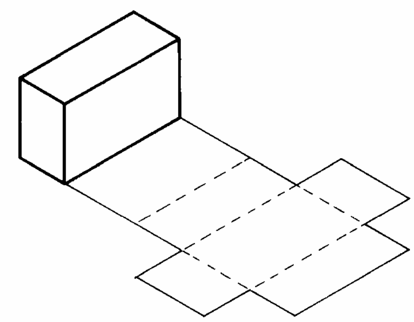


Fig. 10 The Pyramid

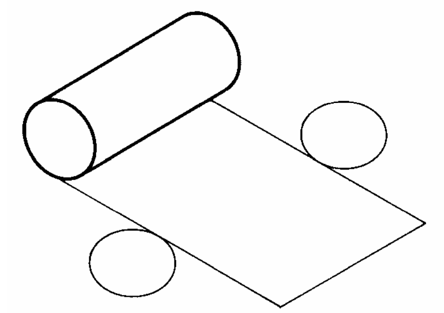
SURFACE DEVEOPMENT OF SOLID SHAPES

When the surface of a solid object requires measuring or a true shape is required to create a template, then the simplest way to provide an accurate detail is to develop the surface. This requires the true shape of all the sides to be laid out flat in a continuous surface, similar to the result of a sheet of wrapping paper being removed from a box and laid out flat, but the folds of the edges are still visible. In this case the true shape of all the sides of the box may be seen at the one time and the folds provide the outline.

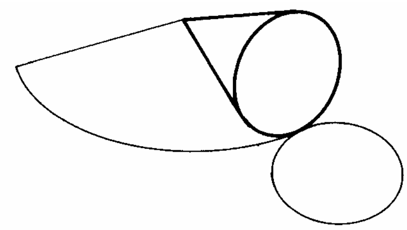
The true shape of the four common solid forms is shown below, including the formula required to measure the total surface area of each:



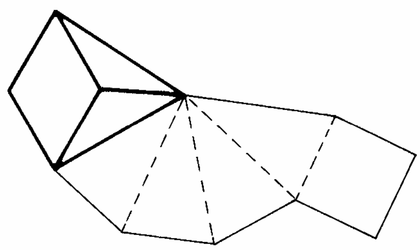
Prism
Area = (Area of base x 2)+(Area of 1 side x 2) +(Area of 1 end x 2)
= (LxWx2)+(LxWx2)+(LxWx2)



Cylinder
Area = (Area of 1 end x 2)+(Area of surface)
= (πr^2x2)+(2πr x height)



Cone
Area = (πr Length of incline)+(πr^2base)
= (πrL)+(πr^2)



Pyramid
Area = (Area of base)+[(Area of 1 side)x 4]
= (LxW)+[(½base x height)x4]

Fig. 11 Surface development of common solid shapes

Common Building Structure Surfaces

Many surfaces of buildings and associated structures require accurate measuring so that specific materials may be ordered to carry out the project. These include concrete or terra cotta tiles for roof surfaces, lining boards and weatherboards for walls, plasterboard sheets for walls and ceilings, tongue and grooved strip and sheet flooring for floors, paint for walls and ceilings, grass to be laid over the yards, corrugated or flat iron to form water tanks, glass to enclose a conservatory area, cement render for walls or the surface of a chimney, etc.
To allow accurate measuring of these surfaces, a true shape needs to be provided so the sides may be multiplied to find the total surface area. Some examples of these developed surfaces are shown below:

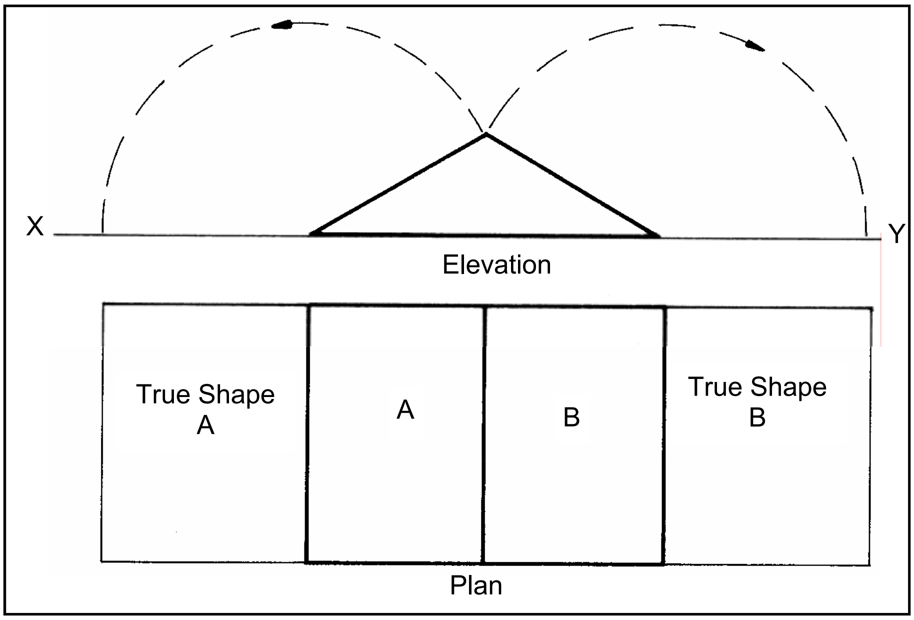


Fig. 12 Surface of a Gable roof

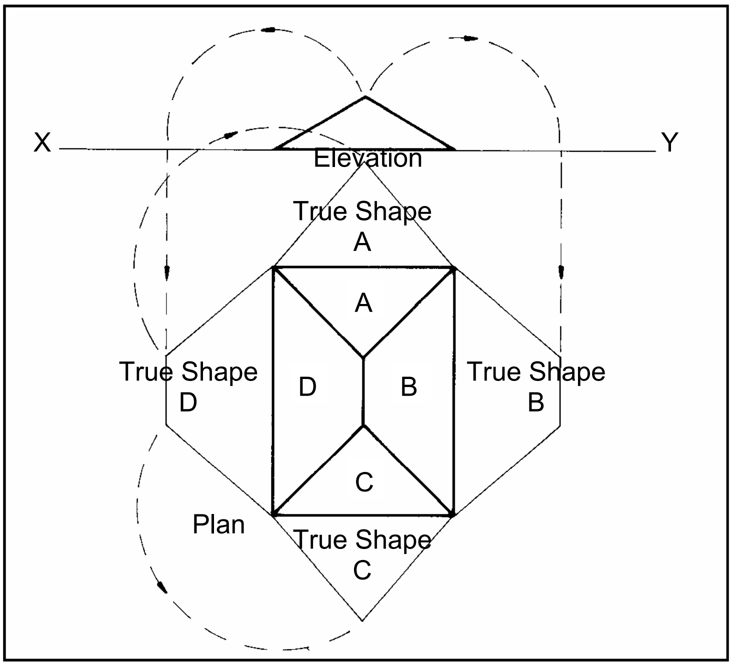


Fig. 13 Surface of a Hipped roof

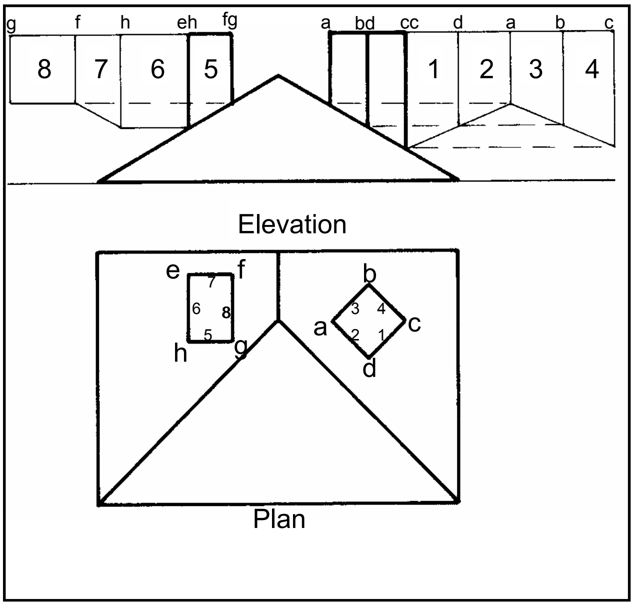


Fig. 14 Surface of a chimney

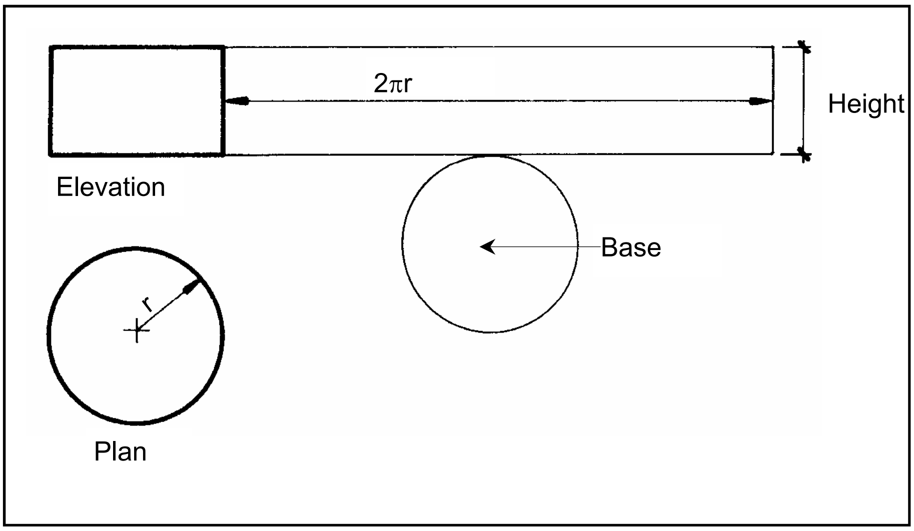


Fig. 15 Surface of a water tank

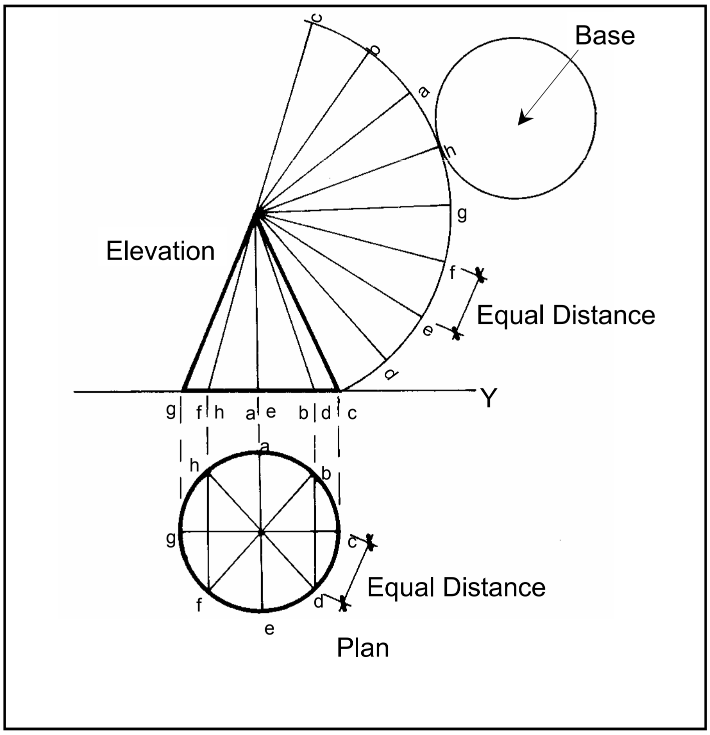


Fig. 16 Surface of a conical roof

STRUCTURAL ROOF MEMBERS

Apart from the fascia and trimmers, all the roof framing members would be considered to be of structural significance. Each member relies on the next for strength and support, which is why the roof frame must be correctly constructed with neat fitting joints and securely fixed connections.

The detail below shows the various members contained in a hip and a hip & valley roof frame:

LEGEND

1	Ridge board (Major roof)	**9**	Crown-end rafter
2	Collar tie	**10**	Creeper rafter
3	Common rafter	**11**	Valley rafter
4	Centring rafter	**12**	Ridge board (Minor roof)
5	Top plate	**13**	Common rafter (Minor roof)
6	Fascia	**14**	Valley creeper rafter
7	Hip rafter	**15**	Valley cripple creeper
8	Purlin	**16**	Trimmer for minor ridge fixing

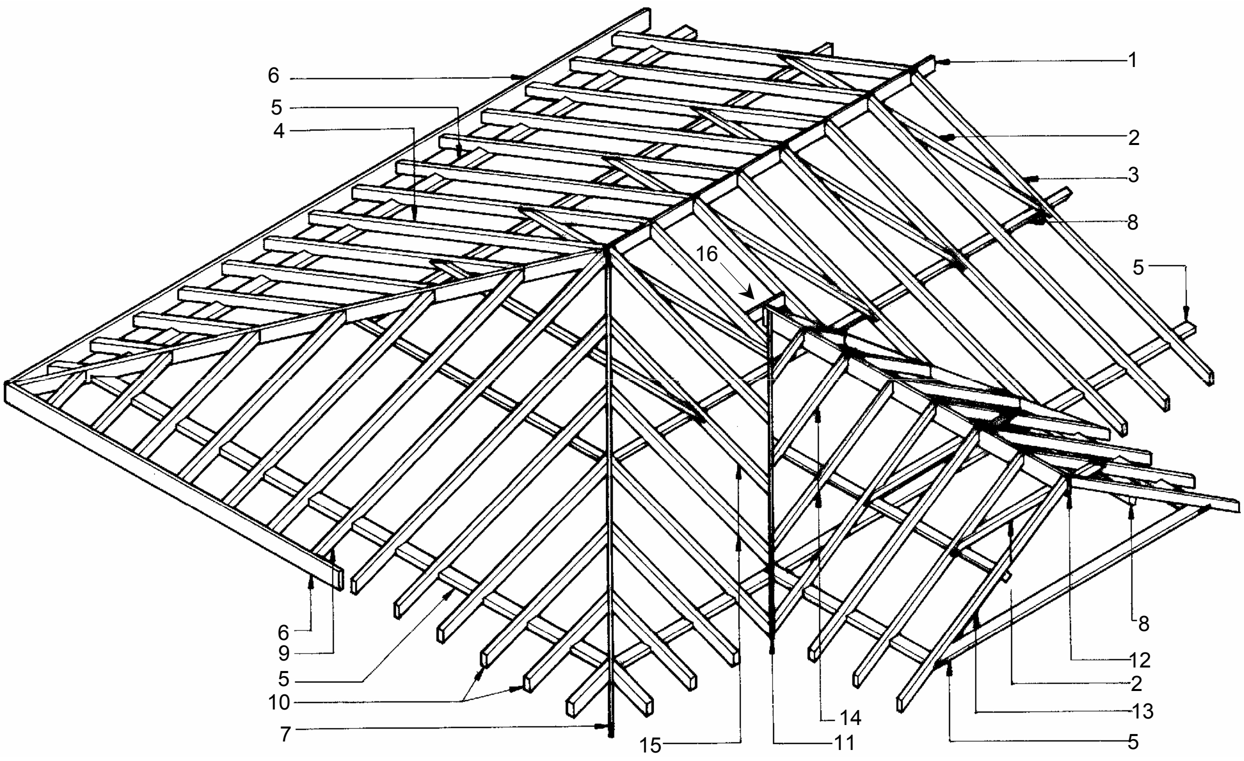


Fig. 17 Hip and valley roof members

COMMON RAFTERS

These are the main sloping members, which all have the same length, running from the wall plate to either side of the ridge. They are spaced at 450 to 600 mm centres for tiled roofs, and up to 900 mm centres for sheet roofs. They support the roof battens, which in turn support the roof covering.
The number of common rafters in a hip roof are restricted to the length of the ridge with the rafters on either side, at the end of the ridge, being referred to as centering rafters.
The rafters may be set out using a variety of methods including use of the steel square, full size set out and by calculation.
Since the rafters are all the same lengths, they are usually set out from a *pattern*. This pattern has the cutting length, plumb cuts and birdsmouth marked on it to allow for consistent accuracy during repetitive mark transfer.
Note: *The common rafters for the hip roof are set out the same as the gable roof. Section size, timber species and stress grades for rafters may be obtained from AS 1684.*

RIDGE

Usually a deep and narrow member, it is the highest member of the roof, which runs horizontally for the length of the roof, less twice the half span, plus one rafter thickness.
It must be level and parallel to wall plates for its length with the rafters being nail-fixed onto it on opposite sides. The ridge on a hip roof may be joined in length as for a gable roof.
The ridges are butt jointed together at the same height to form a hip & valley 'T' or 'L' shape. The length of the ridge forming the 'T' or 'L' shape will be equal to the length of the wall plate extension, plus half the thickness of a rafter, less half the thickness of the ridge.
Note: *Refer to AS 1684 or Timber framing manual for tie-down details.*

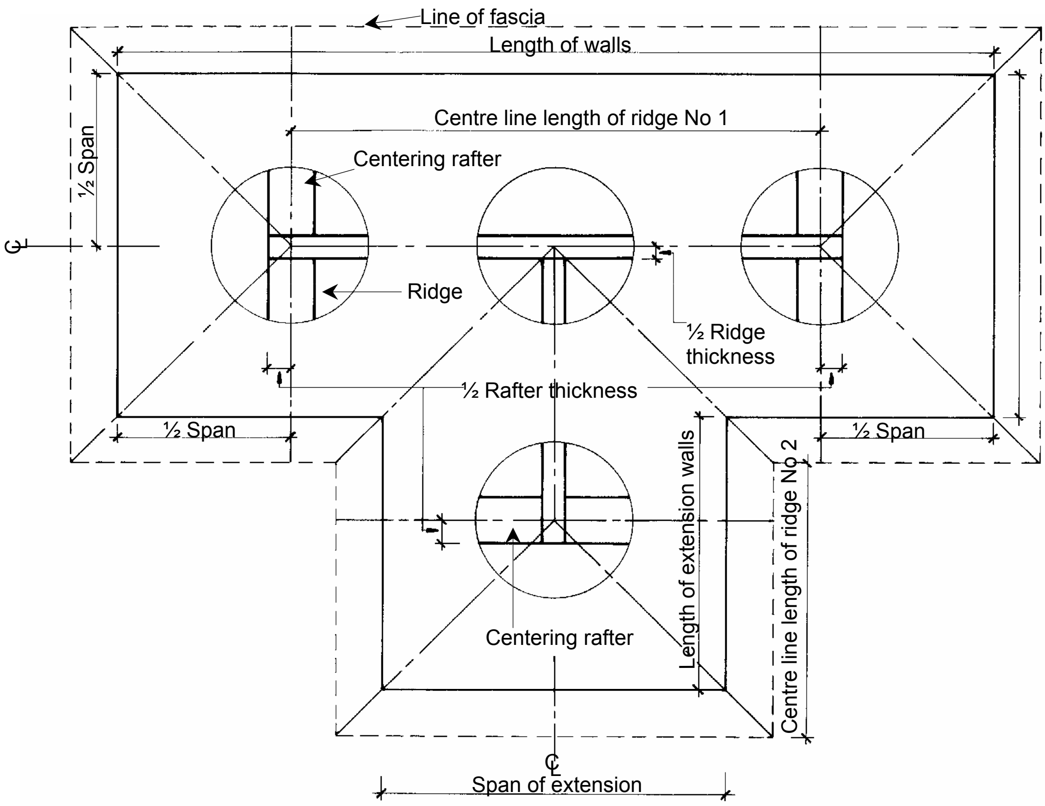


Fig. 18 Determining the length of the ridges

CENTERING RAFTERS

These are simply common rafters, which are used to position the ridge and form the first part of the apex cluster. They are called centring rafters because they centre the ridge and provide the basic pitch of the hip roof.

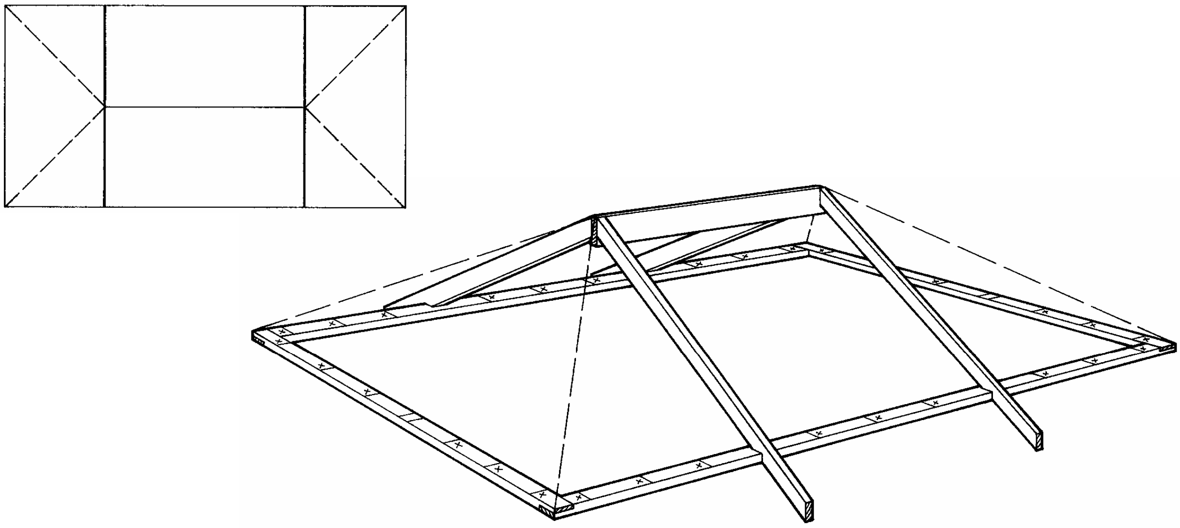
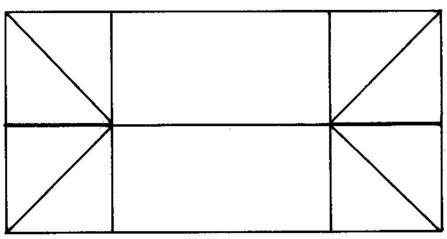


Fig. 19 Placement of centering rafters

CROWN END RAFTERS

The crown end rafters are cut and fitted against both ends of the ridge to form the sloping end sections. They act as opposing braces making the hip roof a strong self-braced frame.
The length of the crown end is similar to the common rafter, apart from the top end deduction, i.e. it is shortened by half the rafter thickness as opposed to the half ridge thickness of the common rafter.



PLAN

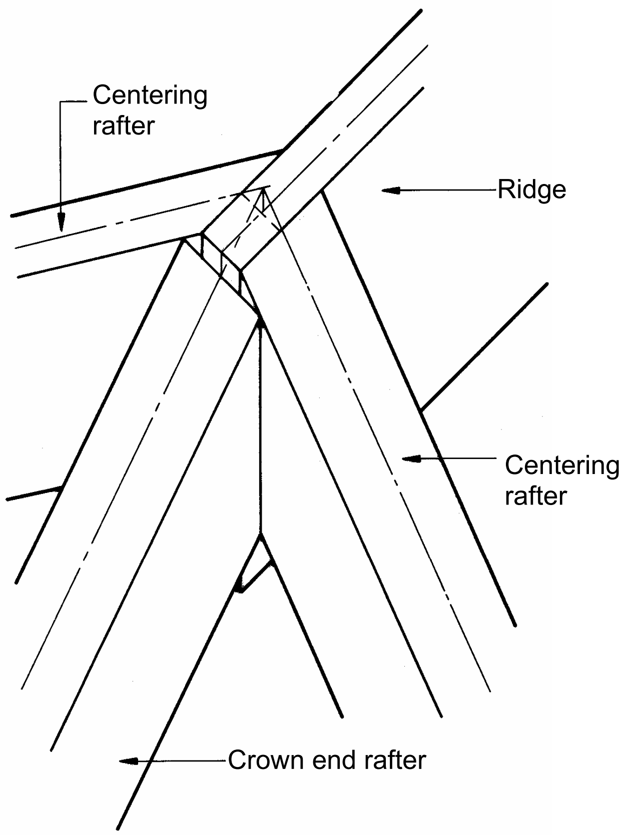


Fig. 20 Placement of crown end rafters

SHORTENING PROPORTIONS for the CROWN END RAFTER

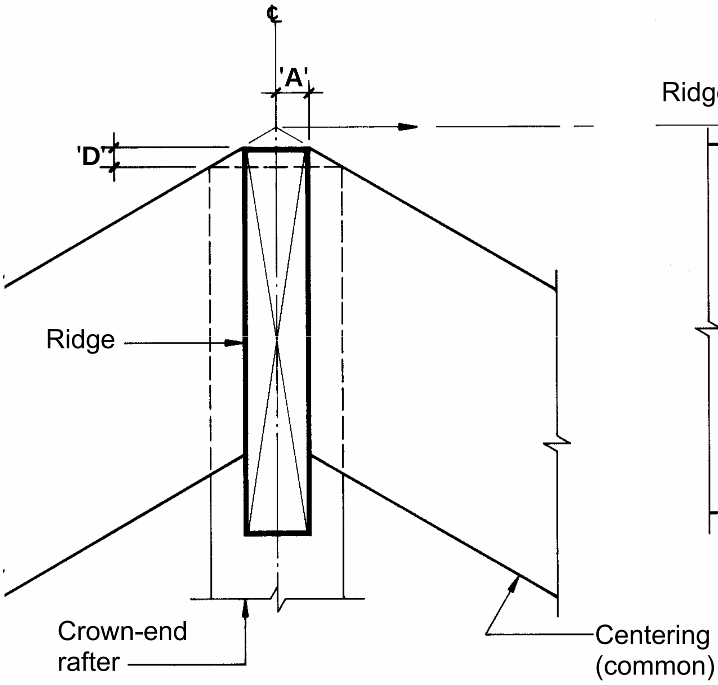


Fig. 21 Section Y-Y

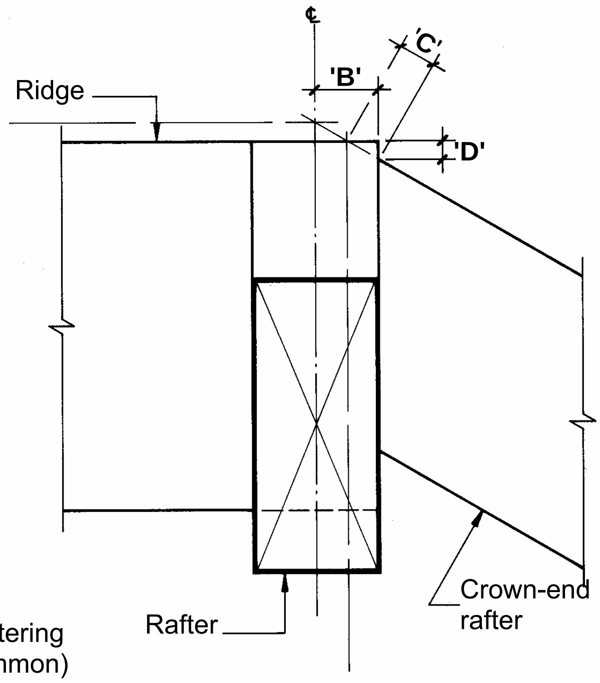


Fig. 22 Elevation

Shorten the run of the common or centering rafter by ½ the thickness of the ridge, marked **'A'**, as shown in Fig. 21.

Shorten the run of the crown end rafter by ½ the thickness of the centering rafter, marked **'B'**, as shown in Fig. 22.

Proportion **'C'** is the distance the centre line length of the crown end rafter is shorter than the centering or common rafter, as shown in Fig. 22.

Proportion **'D'** is the distance the crown end is set below the ridge and centering rafter as shown in Figs 21 & 22.

Proportion **'E'** is the distance the crown end rafter is shorter than the centering rafter, on plan, as shown in Fig. 23.

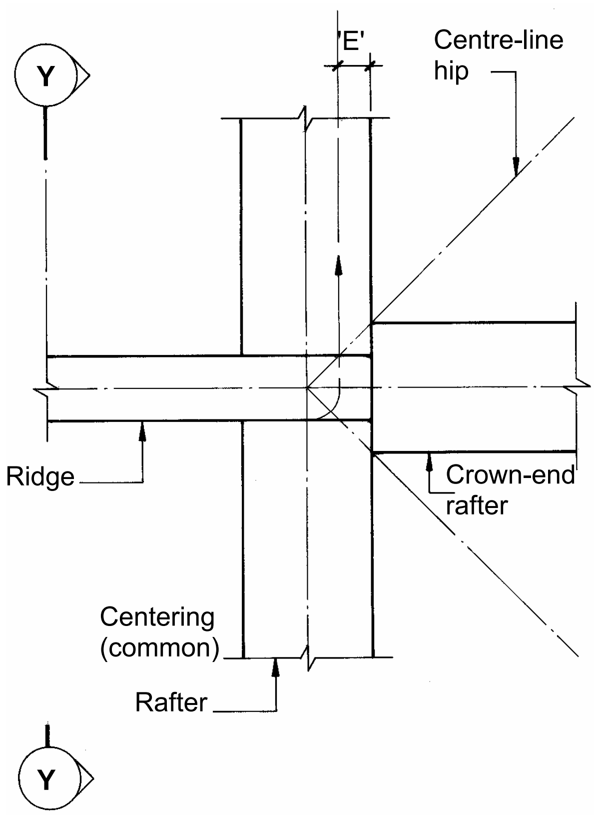


Fig. 23 Plan

HIPS

The hips are deep-sectioned members, which run from the external corners of the wall plates to the end of the corner formed between the centering rafter and the crown end rafter. The hips bisect the 90° external corners at 45°, when viewed on plan or are placed at the appropriate bisected angle for external corners other than 90°, as would be the case for a semi-octagonal ended hip roof.

Note: *Refer to AS 1684 or Timber framing manual for tie-down details.*

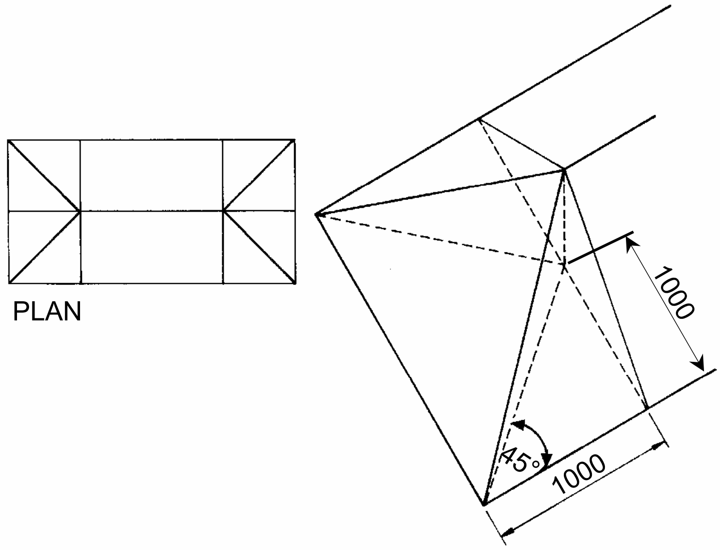


Fig. 24 Position of hips

PREPARING the EXTERNAL CORNERS

The external corner of the wall plates is cut square to receive the square-edged plumb cut of the hip. The thickness of the hip is marked on the corner of the plates, then the distance from the corner to the square mark is measured, equal to **'X'**, and deducted from the centre line length to establish the cutting position.

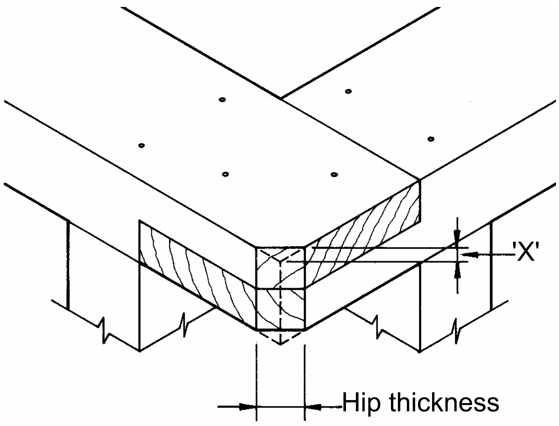


Fig. 25 Preparation for external plate corners

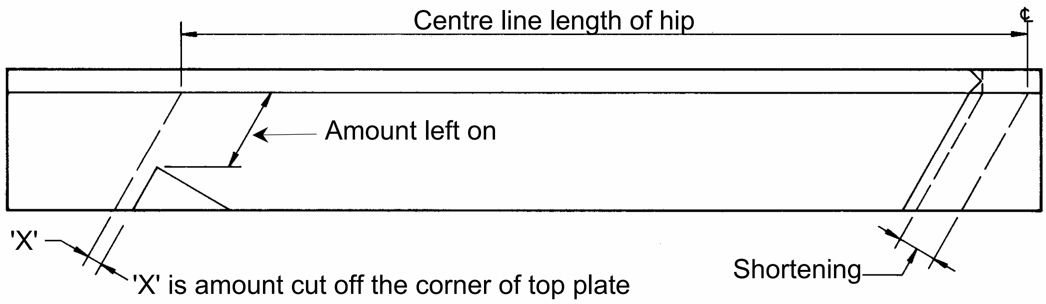


Fig. 26 Hip set out showing deduction for **'X'**

METHODS USED TO ESTABLISH HIP LENGTH

There are four methods used:
1. Scribing; 2. Measured in-situ; 3. Calculation; and 4. Steel square set out.

Method 1: Scribing

STEP 1 The top end is prepared using the plumb cut for hip on the face and the edge cut for hip from both sides of the centre, on the top edge.
The amount to be *'left-on'* the hip, which is equal to the amount left-on the common rafters, is gauged from the top edge at the top end of the hip. This marking is repeated at the approximate position of the birdsmouth.

STEP 2 The top cut end of the hip is laid between the centering and crown end rafters with the *'left-on'* gauge mark being placed in-line with the top edge of the rafters. The lower end of the hip is laid on top of the prepared external wall plates with at least part of the *'left-on'* gauge mark directly above the corner.

STEP 3 Place a rule or spirit level plumb against the external plate corner and scribe a plumb line up to the *'left-on'* gauge mark. Mark a 90° line from this intersection to form the birdsmouth for the hip.

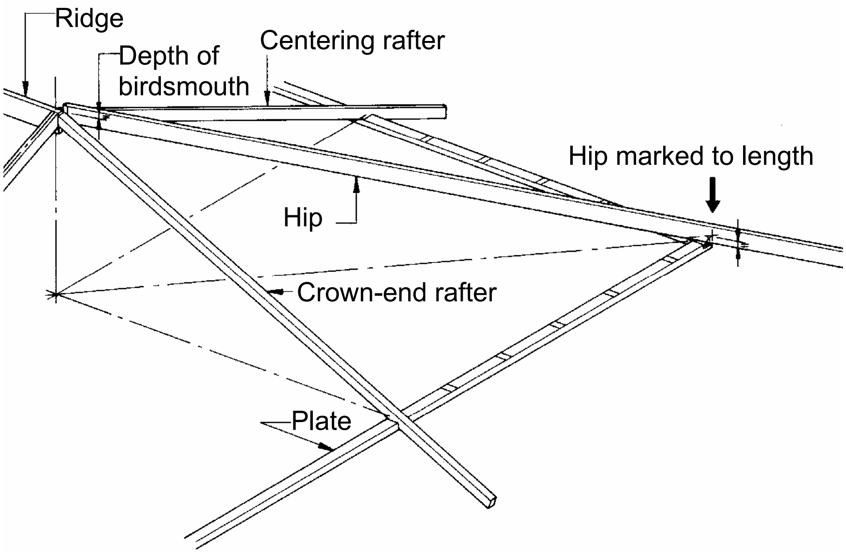


Fig. 27 Hip being scribed in position

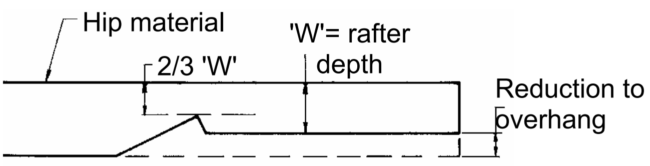


Fig. 28 Gauging for hip birdsmouth

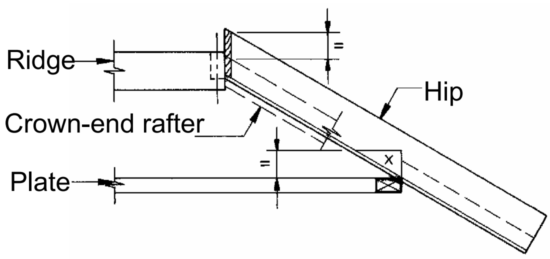


Fig. 29 Set out for hip birdsmouth

Method 2: Measured in-situ

This method involves a direct measurement being taken in-situ and transferred onto the hip rafter.

STEP 1 The top end is prepared using the plumb cut for hip on the face and the edge cut for hip from both sides of the centre, on the top edge.

STEP 2 The amount to be *'left-on'* the hip, which is equal to the amount left-on the common rafters, is gauged from the top edge of the hip above the approximate position of the birdsmouth.

STEP 3 A measuring tape is held at the intersection of the centering and crown end rafters and extended down to the square cut at the external corner of the wall plates.

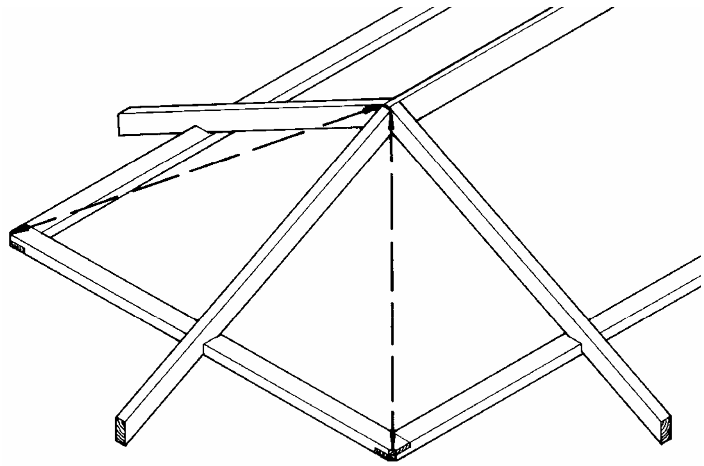


Fig. 30 Measuring the length of the hip in-situ

STEP 4 Lay the tape along the side of hip from the plumb cut at the top to the gauged *'left-on'* position marked at the approximate birdsmouth position. Mark the length and set out the birdsmouth, using plumb and level bevel hip, ready to cut.

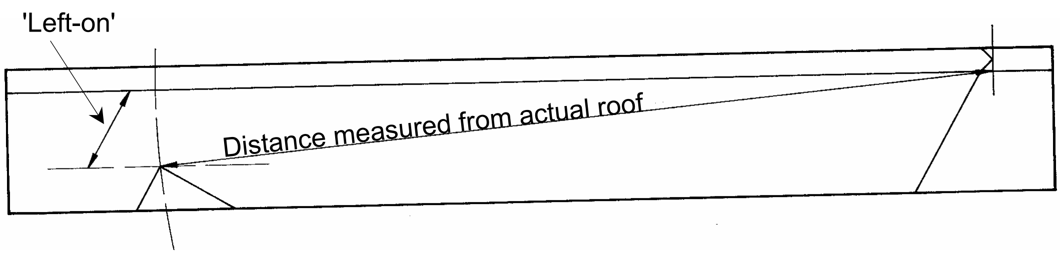


Fig. 31 Marking the face of the hip

Method 3: Calculation

Note: This method is included as an option only, but is not normally used.

The length of the hip is calculated using the same method as for common rafters. A new 'true length per metre run' must be established as the pitch is lower due to the hip being placed at 45° to the plates.

Example 1:
Calculate the length of the hip for a roof with a pitch of 1 : 1.732 or 30° and a half span of 2700 mm.

STEP 1 Rise per metre run $= \dfrac{1.000}{1.732}$

$= \mathbf{0.577m}$

This is the rise per metre run for all members, i.e. common rafters, hips, etc., which runs at 90° to the walls plates.
The next step is to establish the run or plan length of the hip, which is at 45° to the wall plates. This requires a *constant* to be calculated based on a metre run.
Note: *The rise remains unchanged, i.e. 0.577m*

STEP 2 Calculate a *constant* per metre run $= \mathbf{a^2 = b^2 + c^2}$

$= \mathbf{a^2} = 1.0^2 + 1.0^2$

$= \mathbf{a^2} = 1.0 + 1.0$

$= \mathbf{a^2} = \sqrt{2}$

Therefore: **'a'** $= \mathbf{1.414m}$

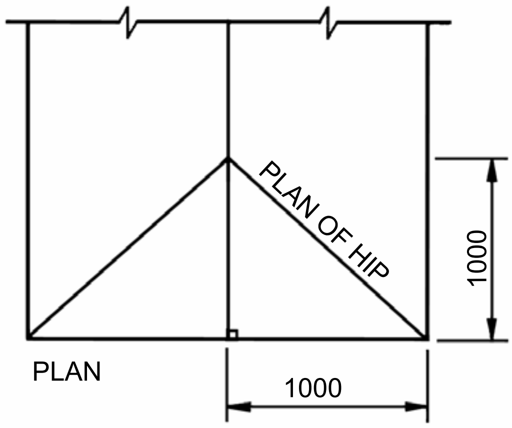


Fig. 32 Plan length of hip per metre run

STEP 3 Calculate the true length per 1.414 of run $= \mathbf{a^2 = b^2 + c^2}$

$\mathbf{a^2} = 1.414^2 + 0.577^2$

$\mathbf{a^2} = 1.999 + 0.333$

Therefore, **'a'** $= \sqrt{2.332}$

$= \mathbf{1.527m}$

Therefore, for every 1.0m of run or half span the true length of the hip will be ***<u>1.527m</u>***

Centre Line Length of Hip

STEP 4 Find the centre line length of the hip, i.e. **half span** x **true length hip**

= 1.700 x 1.527

= ***4.123m***

Cutting Length of Hip

To calculate the actual cutting length of the hip, deductions need to be made from the run or plan length, when the run or plan length of the roof is 2700 mm:

Apex

STEP 5 Deduct half the thickness of centring rafter, when the centring rafter is 50 mm thick. The length will be 25 mm as the side of the right-angled triangle formed will be equal to half the thickness of the centring rafter.

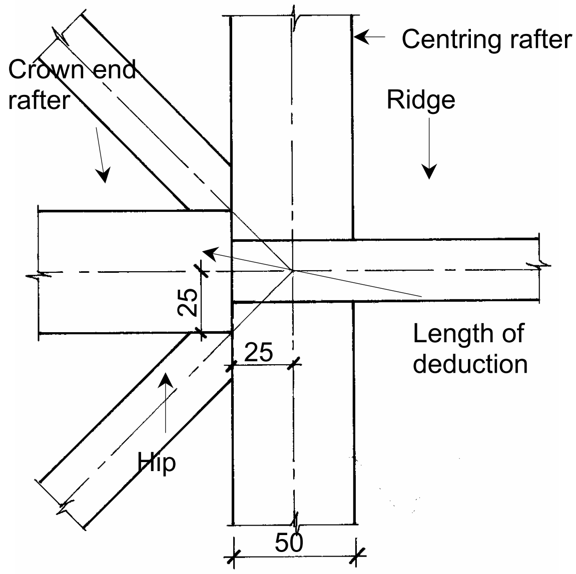


Fig. 33 Plan view of apex cluster

Corner of Plates

STEP 6 Deduct the wall plate corner shortening, when the ridge is 30 mm thick. The length will be half of 1.414 times 15 mm, as the side of the right-angled triangle formed will be equal to the length of the hypotenuse.

$$= \frac{0.015 \times 1.414}{2}$$

= 0.011m or **11mm**

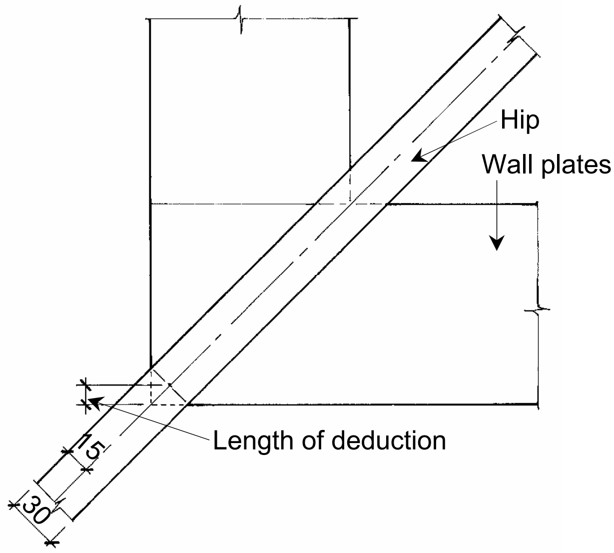


Fig. 34 Plan view of external corner of wall plates

STEP 7 Deduct both shortenings from the run or plan length and multiply it by the true length per metre run.

New plan length	=	(Plan length – deductions) x true length per metre run
	=	2.700 – (0.025 + 0.011) x 1.527
	=	(2.700 – 0.036) x 1.527
	=	2.664 x 1.527
	=	**4.068m**

STEP 8 To calculate the ‘total’ cutting length of hip, add the eaves width to the run or plan length, less deductions. When the eaves width is 400 mm.

Total cutting length	=	(Plan length – deductions + eaves width) x true length per metre run
	=	(2.664 + 0.400) x 1.527
	=	3.064 x 1.527
	=	**4.679m**

Therefore, the actual total cutting length of the hip = ***<u>4.679m</u>***

Method 4: Steel square method

This method is similar to setting out the common rafter with the steel square, except the proportions on the square are changed. The tongue will have the rise per metre, i.e. 577 mm, but the blade will have the *constant* for the plan length of hip, i.e. 1414 mm.

These two measurements are scaled down to fit onto the square:

$\frac{577}{3}$ = ***192 mm*** and $\frac{1414}{3}$ = ***471 mm***

The number of times the square is stepped down will be equal to the run or half span less deductions, divided by the blade length = $\frac{4.384}{0.471}$ = approx. 9 times.

Proportions for the Steel Square

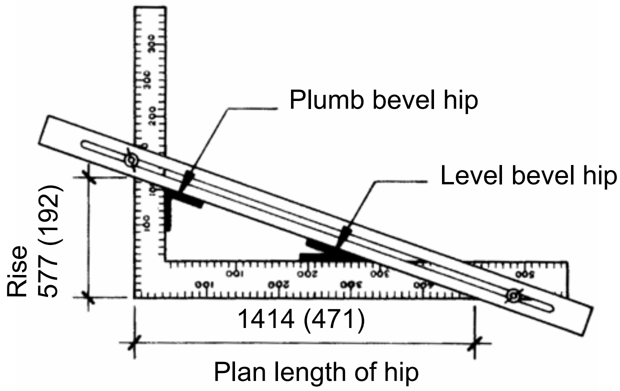
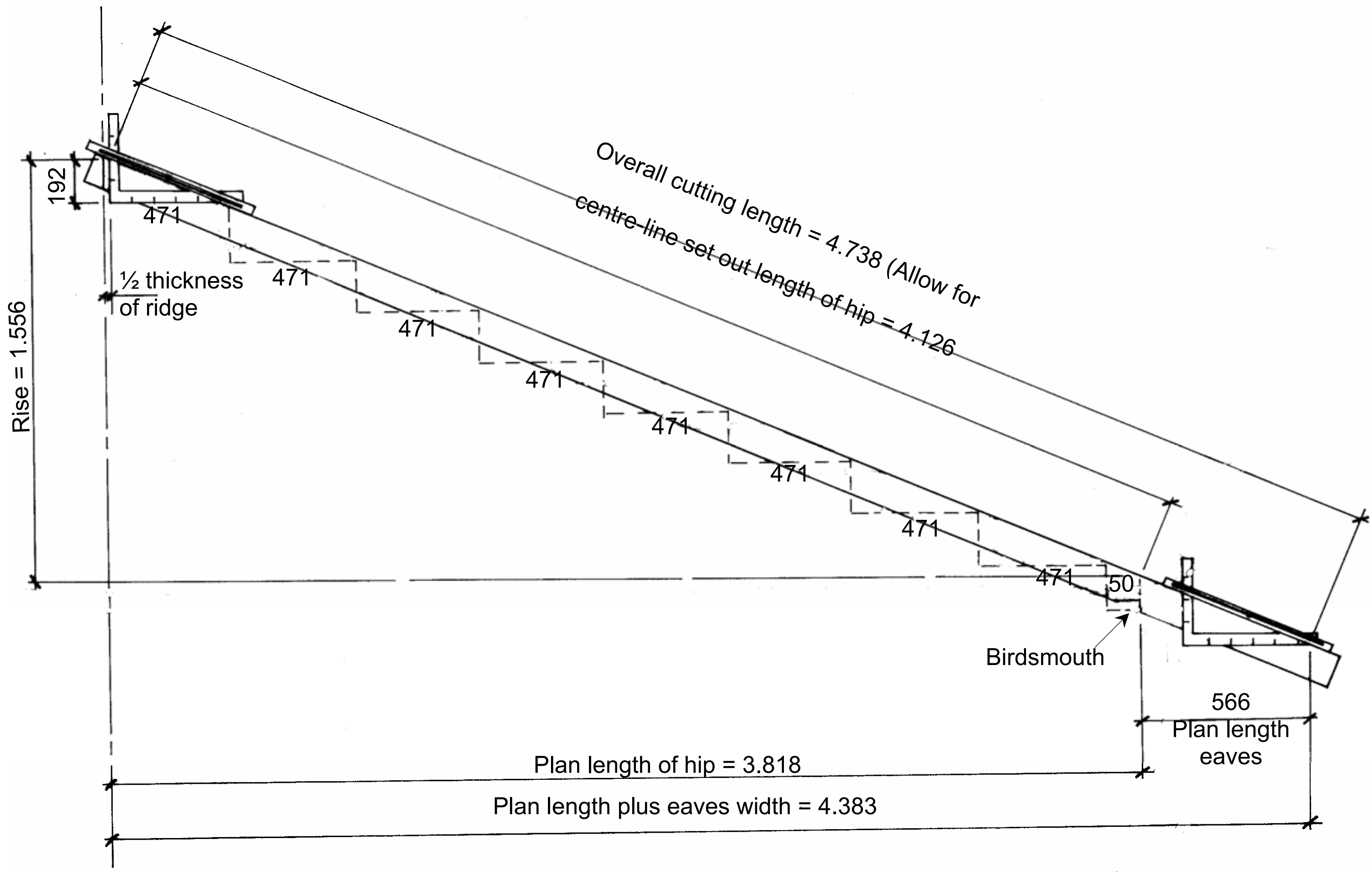


Fig. 35 Setting up the steel square

* See the set out of the hip using the steel square on the following page.


Overall cutting length = 4.738 (Allow for
centre-line set out length of hip = 4.126
192
471
471
471
471
471
471
471
471
½ thickness
of ridge
Rise = 1.556
50
Birdsmouth
566
Plan length
eaves
Plan length of hip = 3.818
Plan length plus eaves width = 4.383

CREEPER RAFTERS

These are basically common rafters, which are shortened by equal amounts to fit against the face of the hips at the maximum rafter spacing. The lower end is identical to the common rafters but the top end has a compound cut, i.e. face and edge cuts, which is formed by the plumb bevel for common rafter and the edge bevel for creeper.

They are usually set out from a pattern rafter and cut in pairs to fit on either side of the hips.

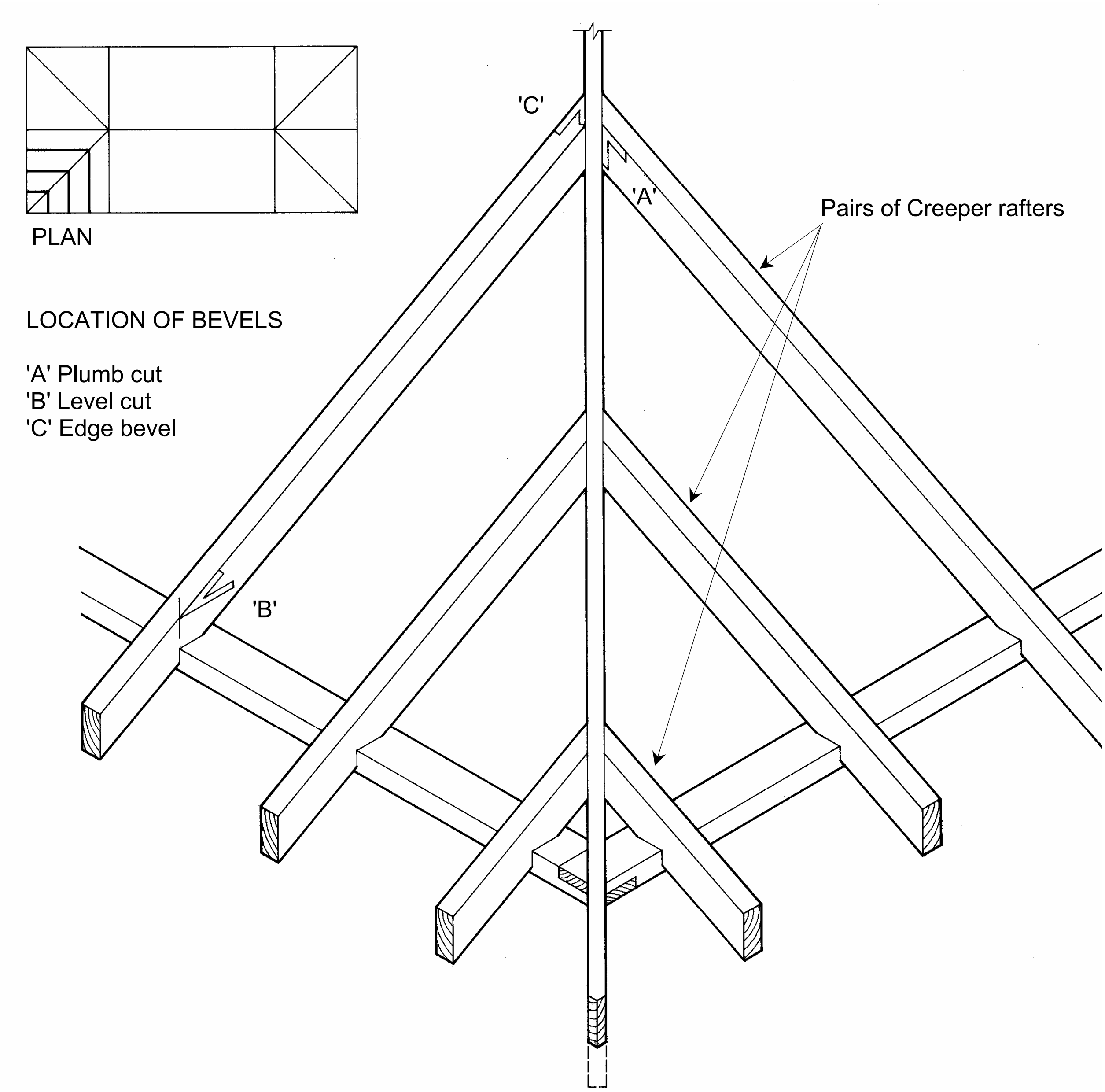


Fig. 37 Placement of creeper rafters and bevels required

Determining the length of the first creeper

Method 1: Set out from the centring rafter

Measure the rafter spacing from the centre line of the centring rafter, deduct half the hip mitre thickness to bring it to the outside of the hip on centre line, then add half the rafter thickness to take it to the long point on the outside face of the longest creeper.

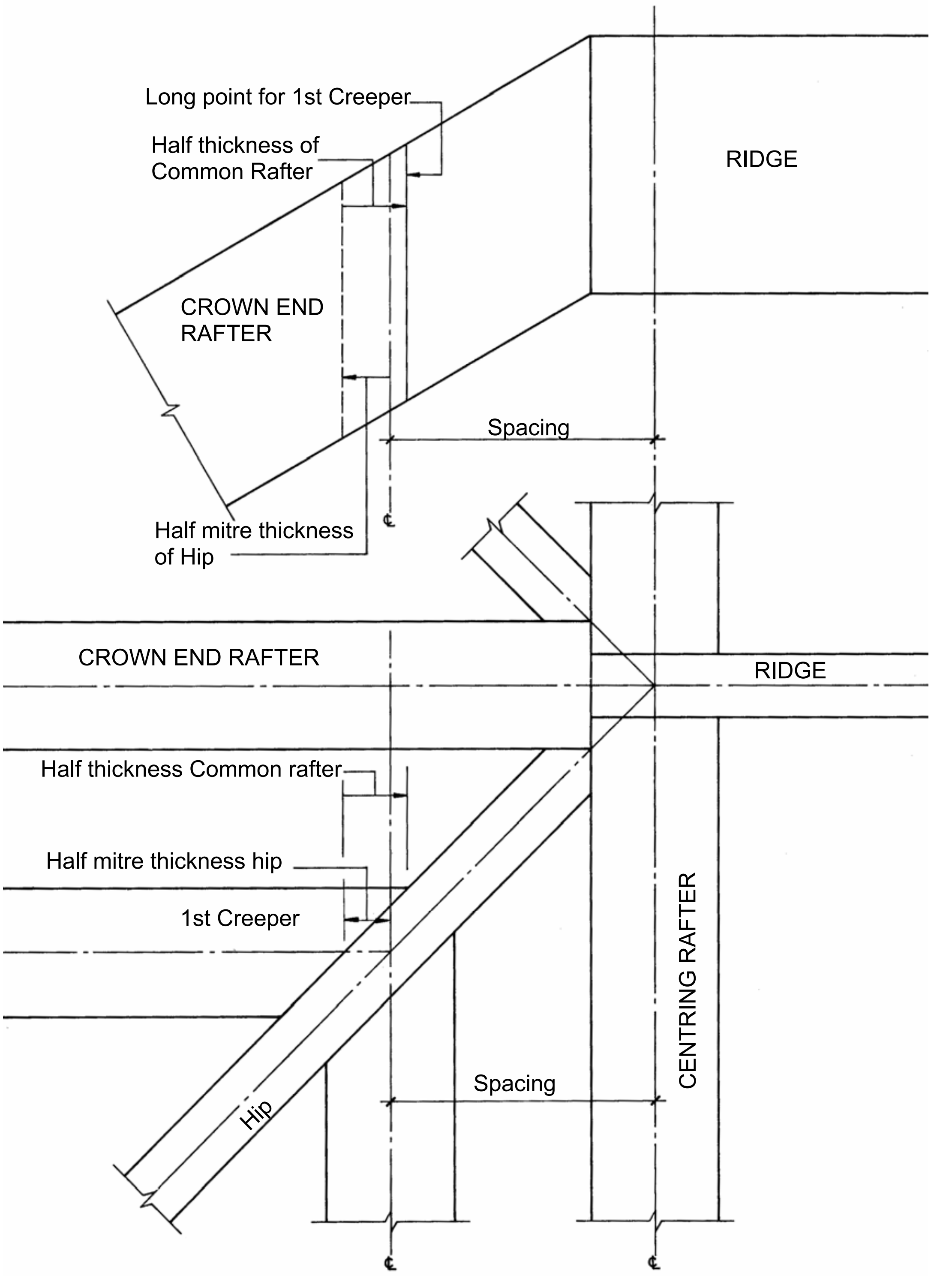


Fig. 38 First creeper set out from centring rafter

PATTERN RAFTER SHOWING CREEPER POSITIONS - *Method 1*

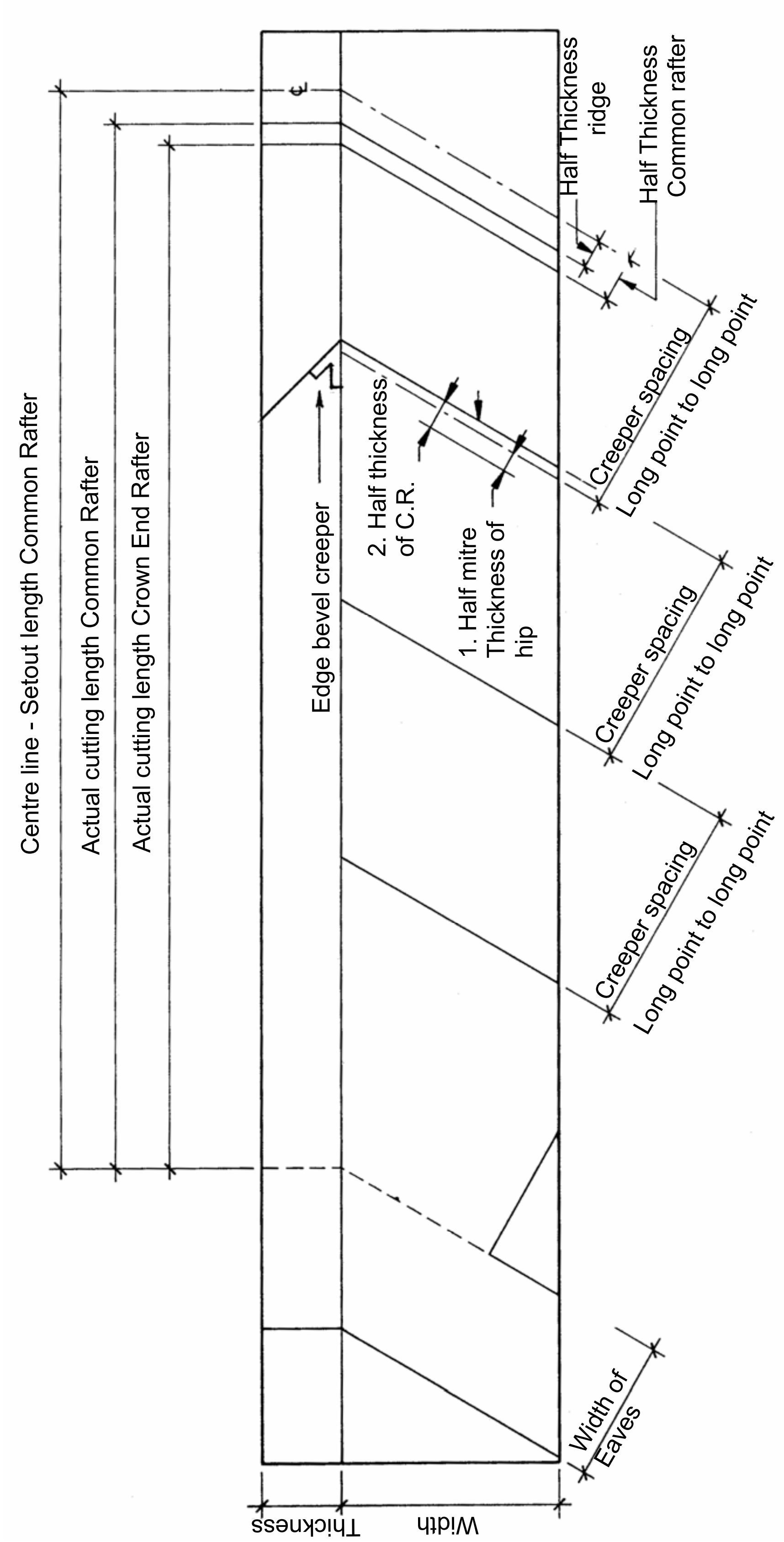


Fig. 39 Pattern rafter – Method 1

Method 2: Set out from the outside of the wall plate corner

The long point of the shortest creeper is set out first by measuring the rafter spacing from the outside of the wall plates to the long point side of the first creeper.

This gives the centre line length only, therefore to find the long point on the outside face of the hip deduct half the mitre thickness of the hip.

The resultant distance in this case will be referred to as *Distance 'X'*.

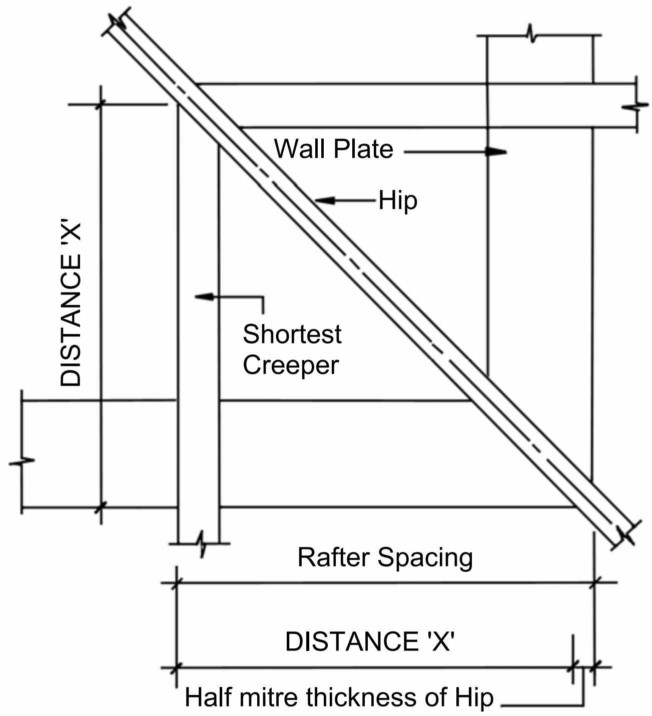


Fig. 40 Plan of Corner detail

Once the position of the outside face and long point for the first short creeper is established, the remainder of creepers are set out towards the crown end rafter.
Add *distance 'X'* to the previous rafter to increase it to the correct next length.

The last spacing, on either side of the crown end, may be very close as this method does not allow all spacings to end up the same distance apart due to the starting point.
This does tend to be a simpler method as there is only one deduction to be made to establish the first creeper.

The shortening distances for both methods is dependant upon the thickness of rafter and hip material being used for that particular job. Calculation of the shortening distance should be carried out for each job or change in material thickness.

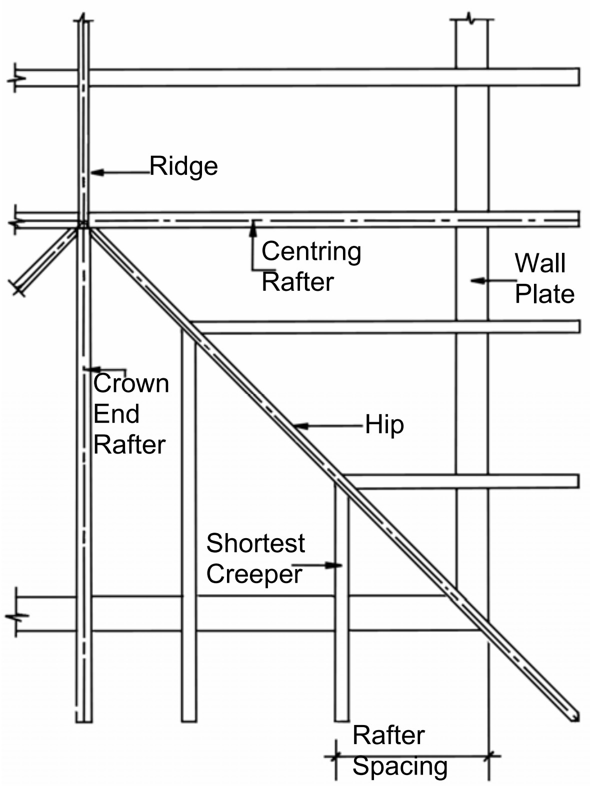


Fig. 41 Part plan showing creeper positions

PATTERN RAFTER SHOWING CREEPER POSITIONS - *Method 2*

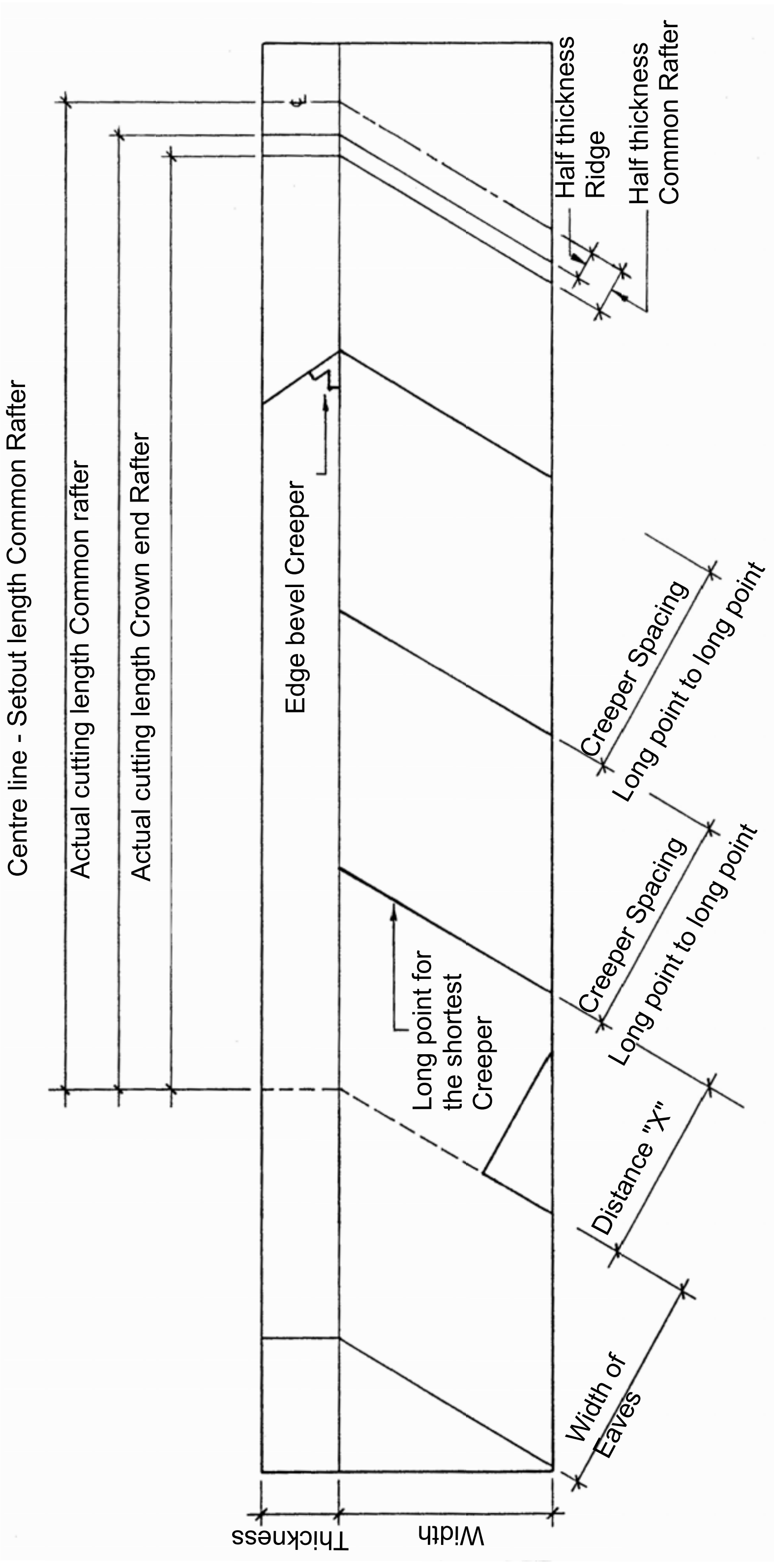


Fig. 42 Pattern rafter – Method 2

PURLINS

Purlins, also known as *underpurlins*, are fixed to the underside of the rafters parallel to the ridge and wall plates. They provide continuous support under the rafters similar to bearers under joists in a floor frame.
They are normally spaced at 2100 mm centres, but this will depend on their section size and stress grade, including the section size and stress grade of the rafters.
They are placed in a continuous line around the four sides of the hip roof and joined at external corners, under the hips.
The ends of the purlins, under the hip, have a compound cut consisting of the face bevel purlin and edge bevel purlin. The ends may be cut tight against the face of the hip on either side or have a notch taken out of the edge of both lengths so they fit tightly under the bottom edge of the hip for extra support.

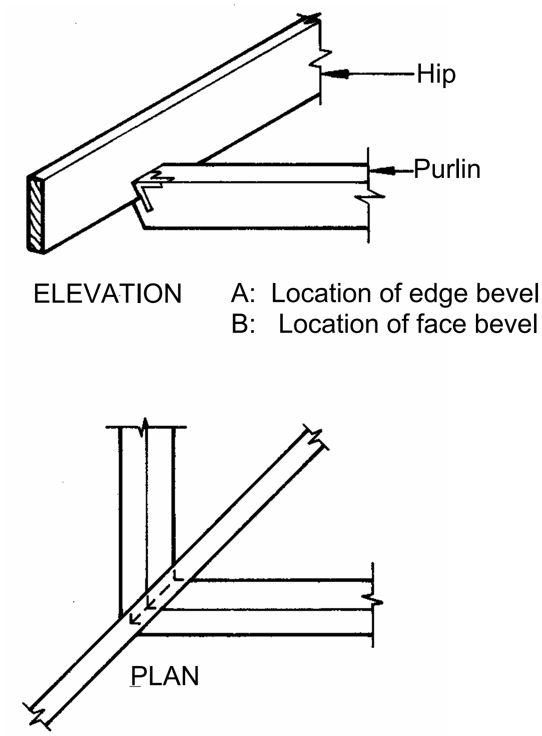


Fig. 43 Purlin detail

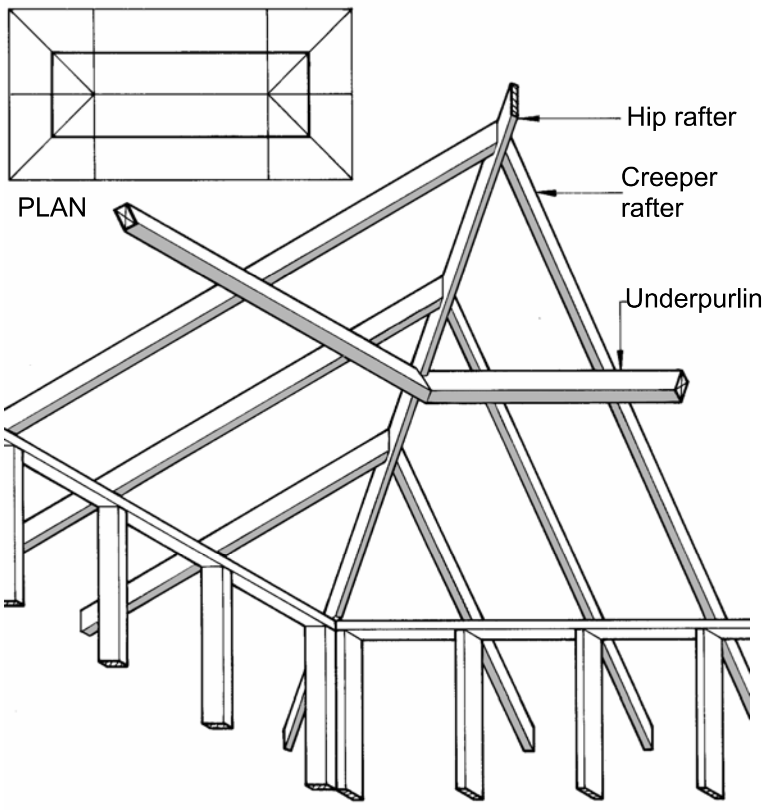


Fig. 44 Underside view of purlins under the hip

Strutting to underside of purlins

Inclined struts, including fan or flying struts, are cut and fitted the same as for the gable roof. Alternative strutting methods may also be used, as for the gable roof, such as the cable and the '*Barap'* brace systems.
One or two adjustable fulcrums may be used, depending on the length of the member being strutted, under the length of the purlin or under the length of the hips.

Where inclined strut support is not available under the hip connection, a patent type strutting system is commonly used.

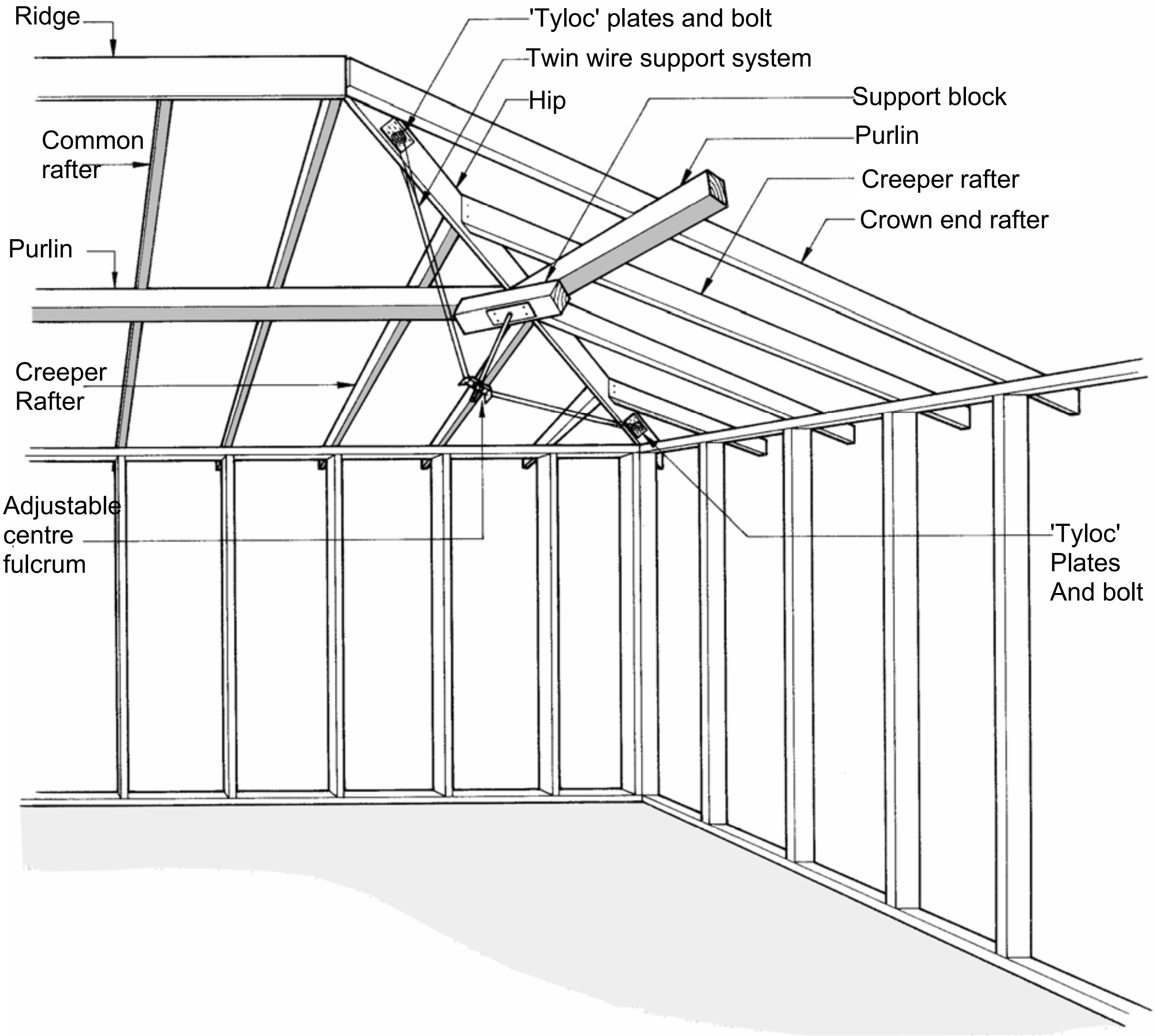


Fig. 45 Patent type cable strutting system under the hip

COLLAR TIES

These members are placed every second pair of rafters, as for the gable roof, and either scarfed around the common rafters or bolted to them.

VALLEYS

A valley is formed where a secondary ridge abuts a main ridge or is cut into the surface of one or more sides at a lower level than the main ridge.

This occurs in an ‘L’-shaped hip or gable roof, which will have one valley, or in a ‘T’-shaped hip or gable roof, which will have two valleys.

The valley is set out, cut and fitted in a similar way to the hips with valley creepers cut onto either side, similar to hip creepers.

A typical detail is shown below for an ‘L’-shaped hip roof outlining the valley members and the detail of the apex cluster:

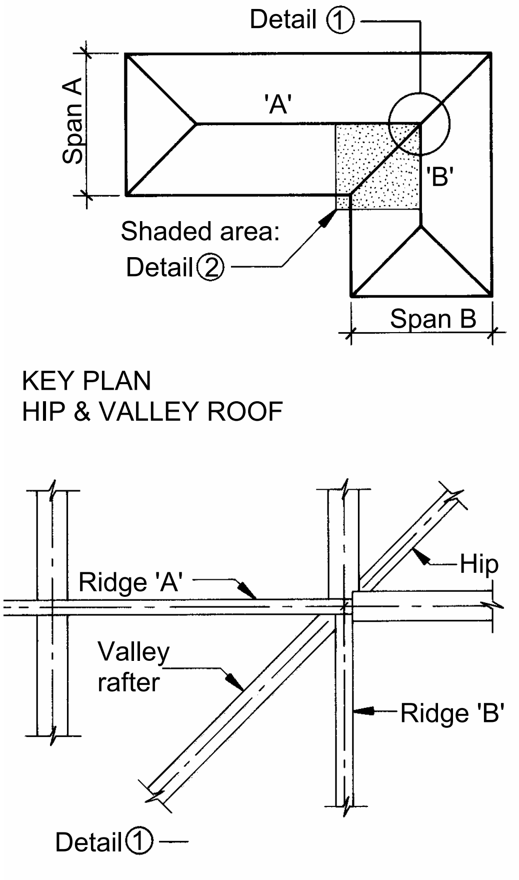


Fig. 46 Plan and detail of apex cluster

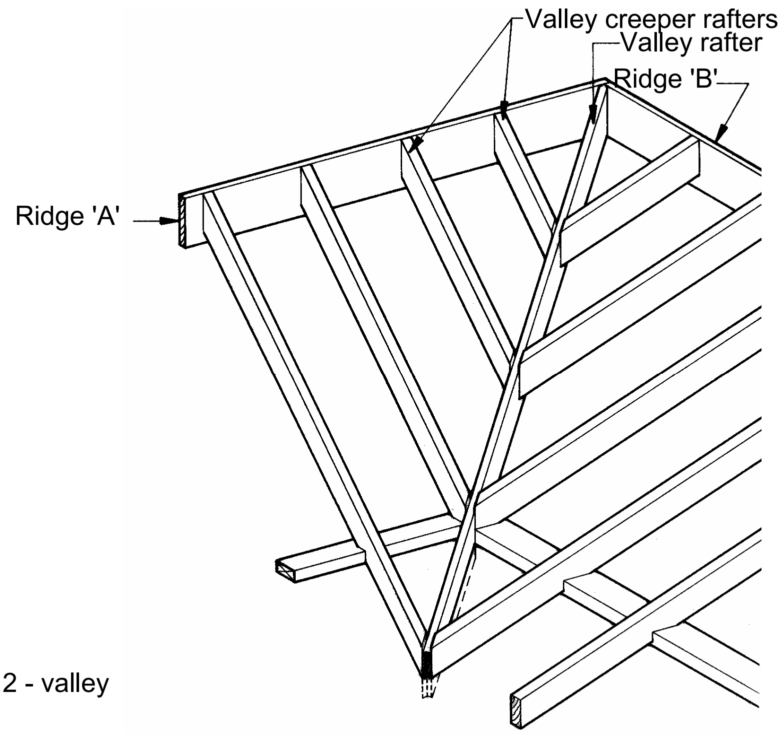


Fig. 47 Detail 2 - valley members

Methods used to establish valley length

Generally, the same methods may be used as for the hip length, however the method shown here is the simplest for marking the valley length.

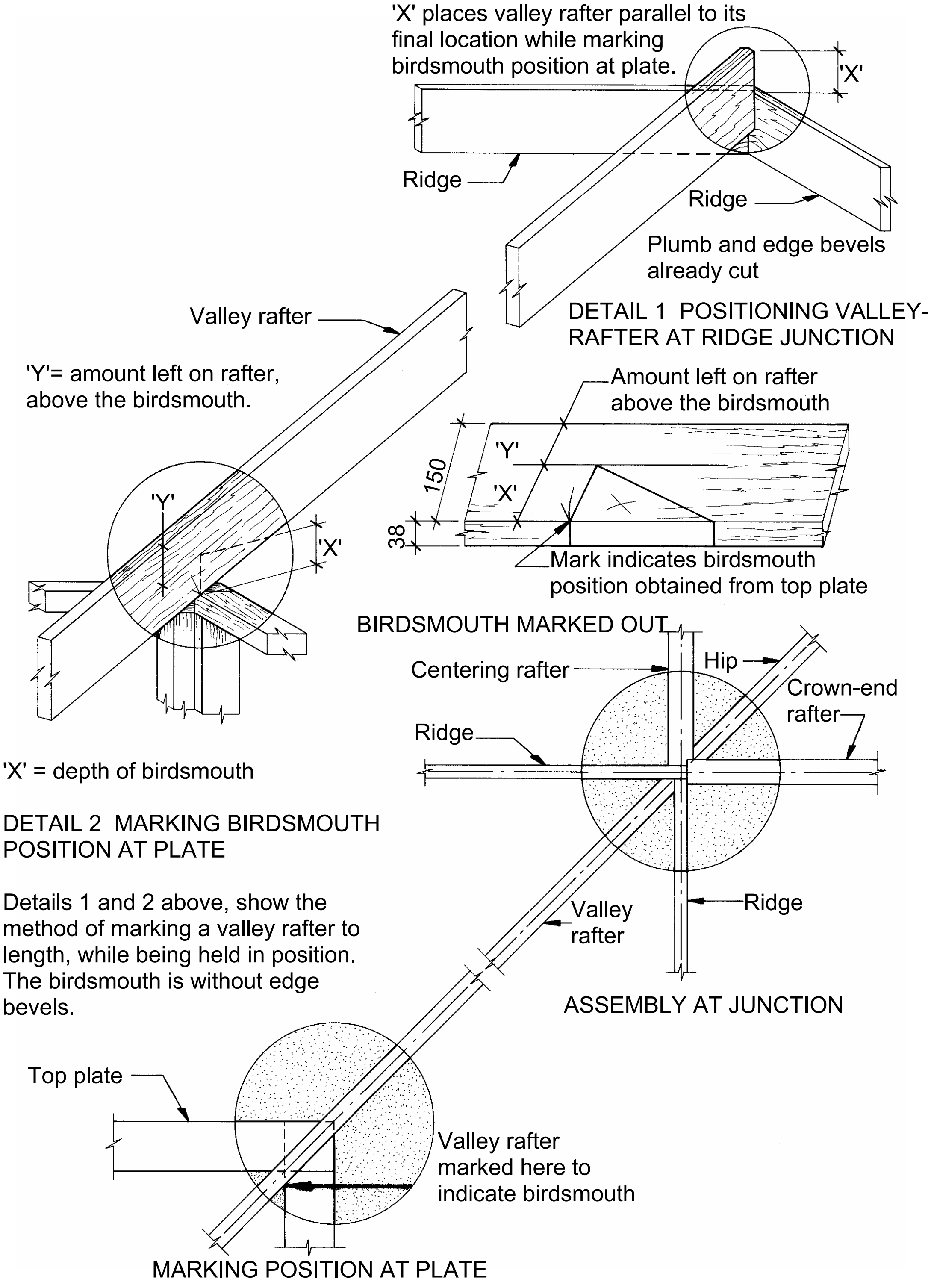


Fig. 48 Scribing the length of the valley in-situ

VALLEY CREEPERS

These are the members, which run between the ridges and both sides of the valley. They have a plumb bevel for common rafter at the top and a compound cut at the bottom end consisting of a plumb bevel for common rafter on the face and edge bevel for creeper, on the edge.

The length of the valley creepers is produced similar to that of the hip creepers. They may be set out from the top or the bottom of the valley.

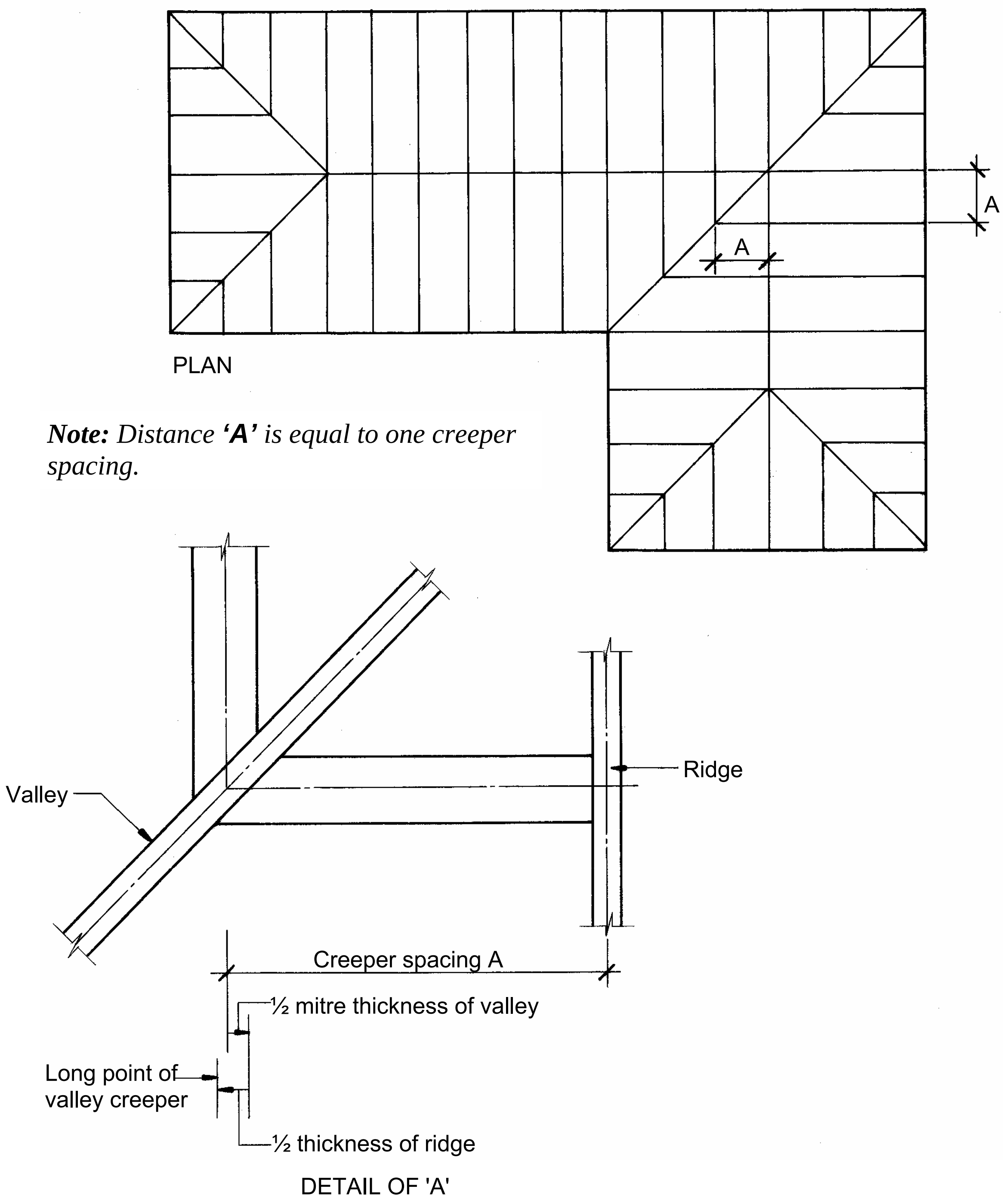


Fig. 49 Valley creeper set out from top of valley

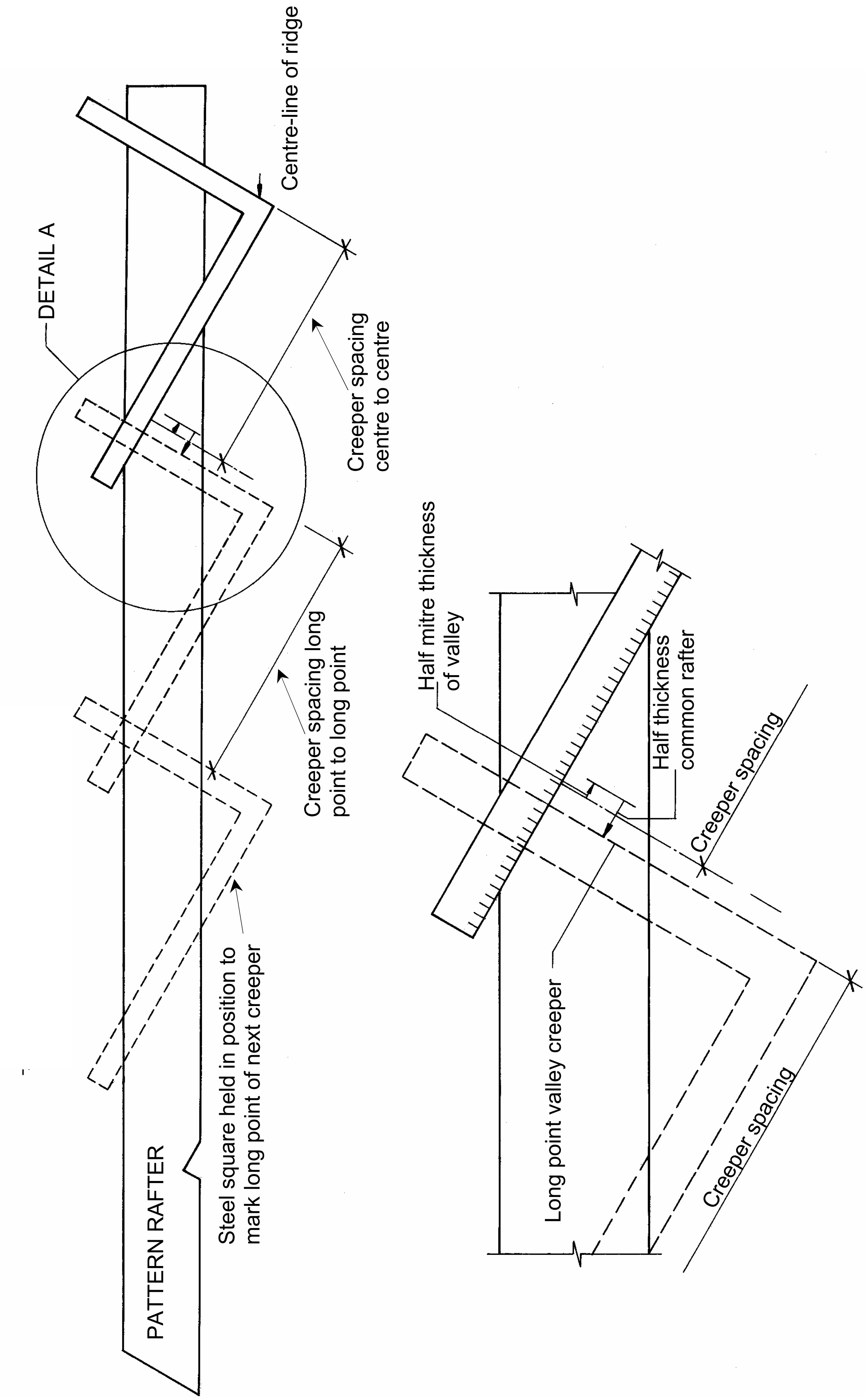


Fig. 50 Valley creeper set out from top of valley on a pattern rafter using steel square method

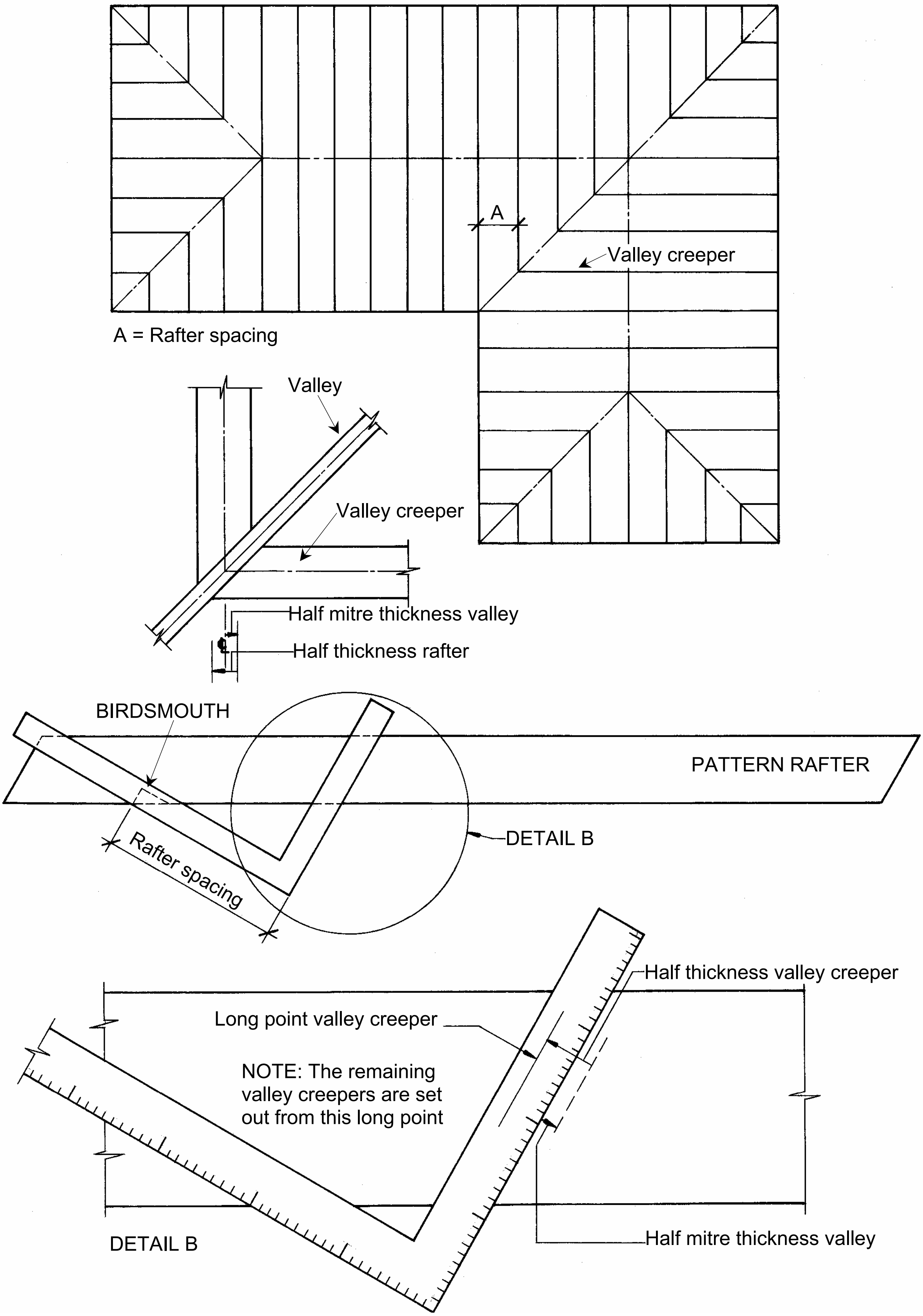


Fig. 51 Valley creeper set out from bottom of valley

HIP ROOF BEVELS

GEOMETRIC BEVEL DEVELOPMENT

Hip roof surface development

Before the roof bevels can be developed, it will be necessary to develop the true shape of all the hip roof surfaces. This is done, by rotating the proportions found on the elevation or section and the plan view.
This gives the impression that the solid roof shape has been cut and folded flat, which produces the true shape and true lengths of all the sides. Once this is achieved the true shape of the roof bevels may be identified.

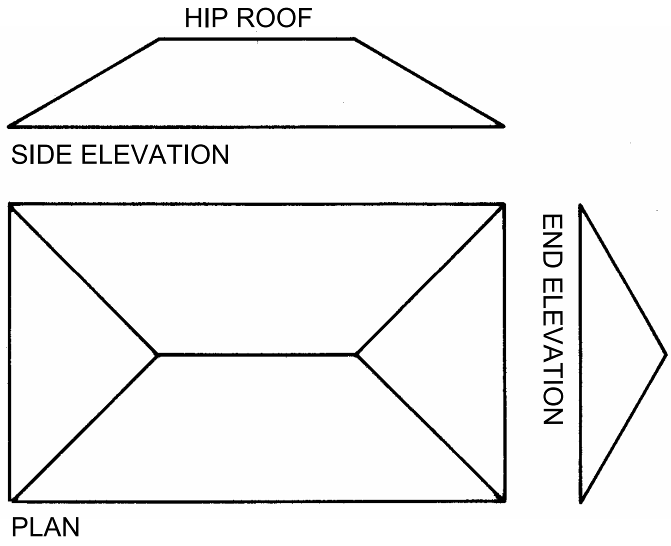


Fig. 52 Basic shape of the hip roof

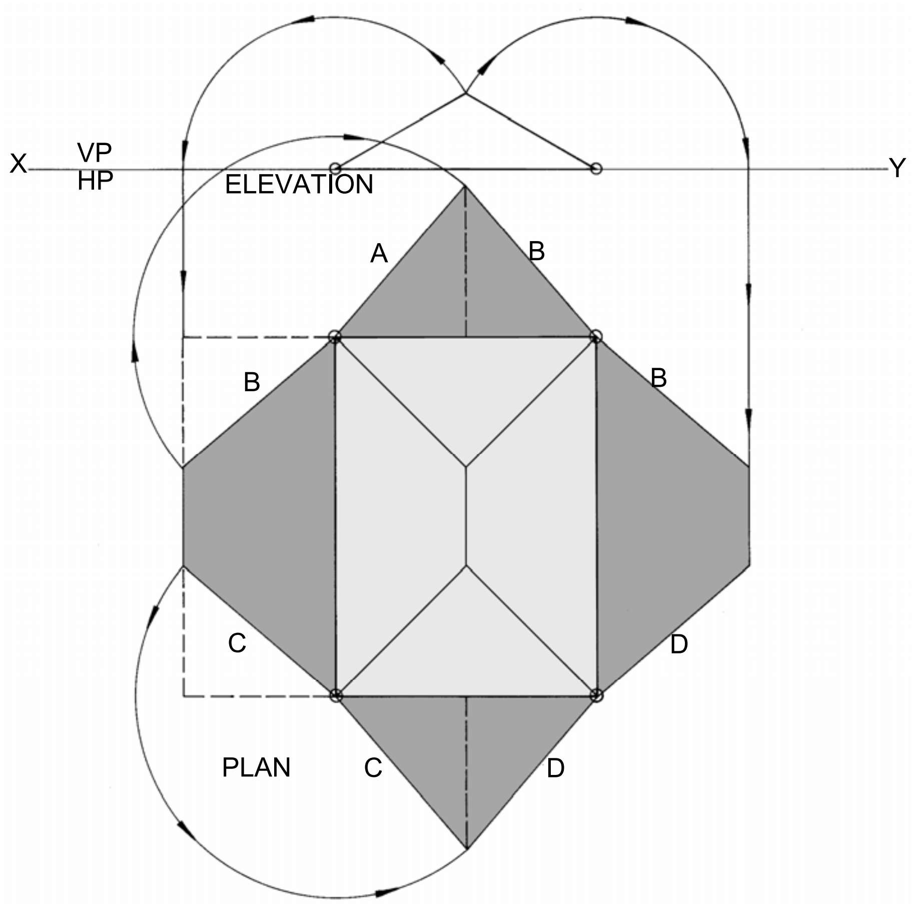
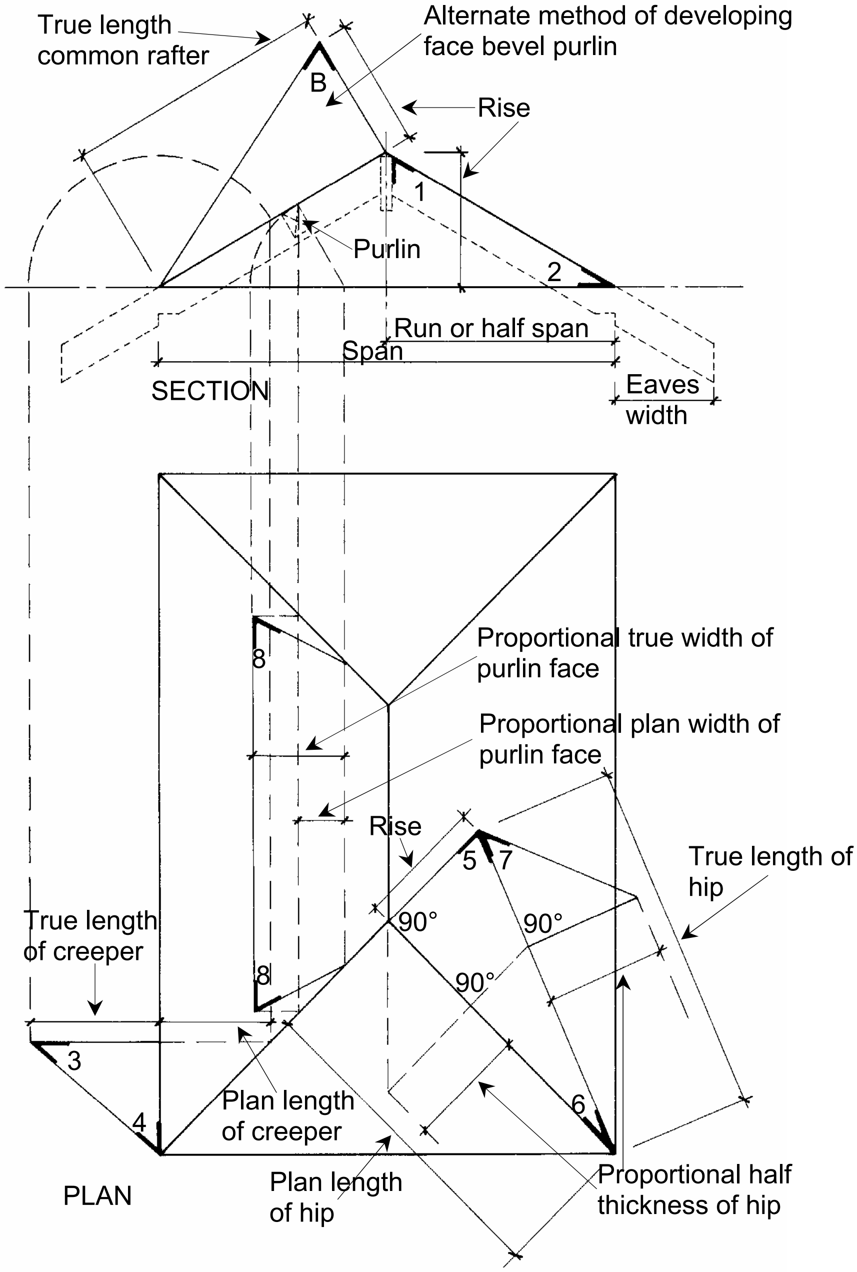


Fig. 53 Development by rotation of roof surfaces

DEVELOPING BEVELS GEOMETRICALLY

The geometric development below shows all 8 bevels and proportions required to pitch a hip roof.



LEGEND

1	Plumb bevel common rafter	5	Plumb bevel hip
2	Level bevel common rafter	6	Level bevel hip
3	Edge bevel creeper	7	Edge bevel hip
4	Edge bevel purlin	8	Face bevel purlin

Fig. 54 Geometric hip roof bevel development

Plumb and Level bevel common rafter

These bevels are formed in a 90° triangle consisting of the *rise* and *run or half span*. (Proportions of both these lengths may also be used)

LEGEND

1	Plumb bevel common rafter
2	Level bevel common rafter

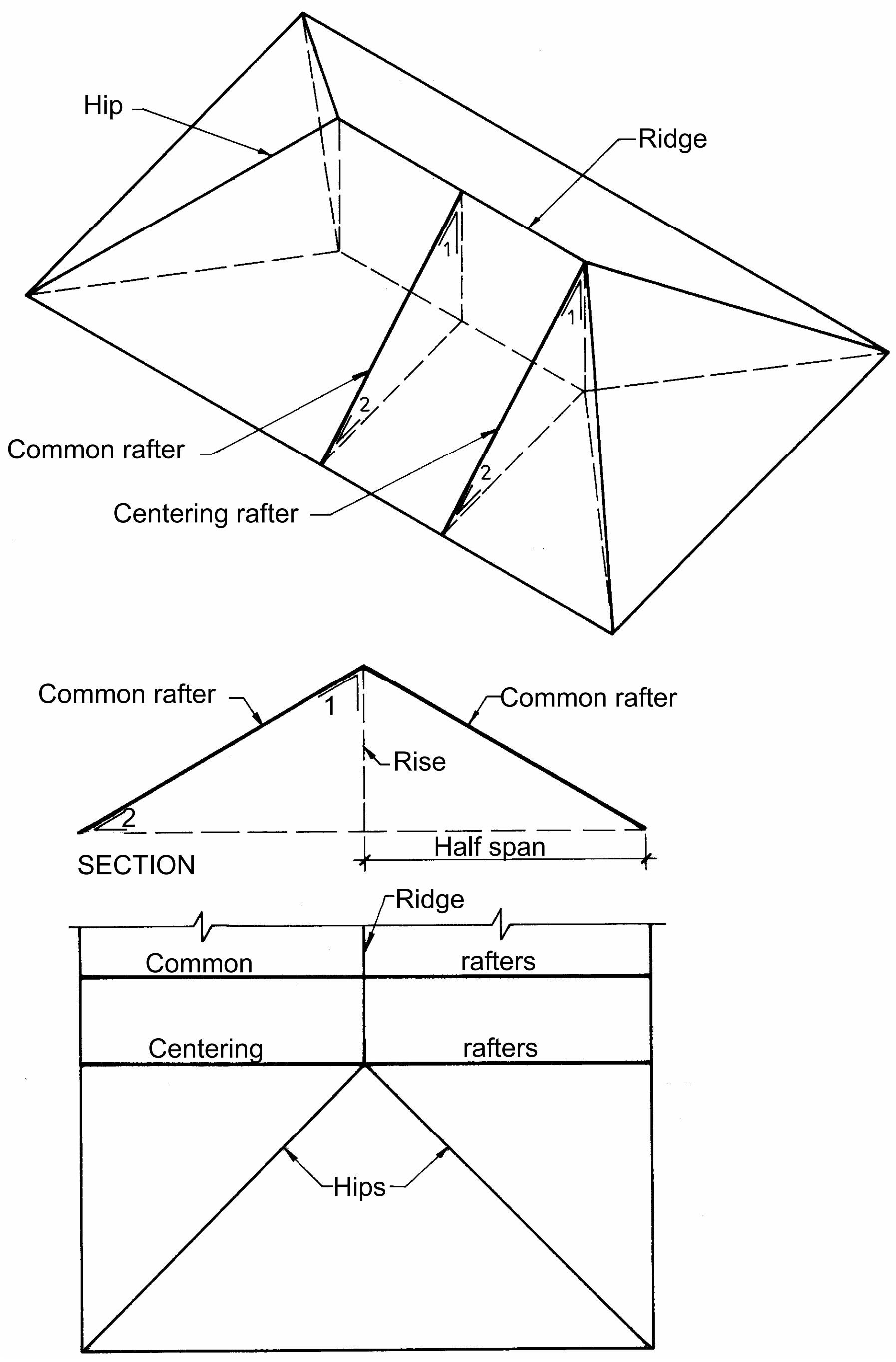


Fig. 55 Geometric plumb and level bevel development

Edge bevel creeper rafter

This bevel is formed in a 90° triangle consisting of the *true length of common rafter* and *run or half span.*
(Proportions of both these lengths may also be used)

LEGEND

3	Edge bevel creeper

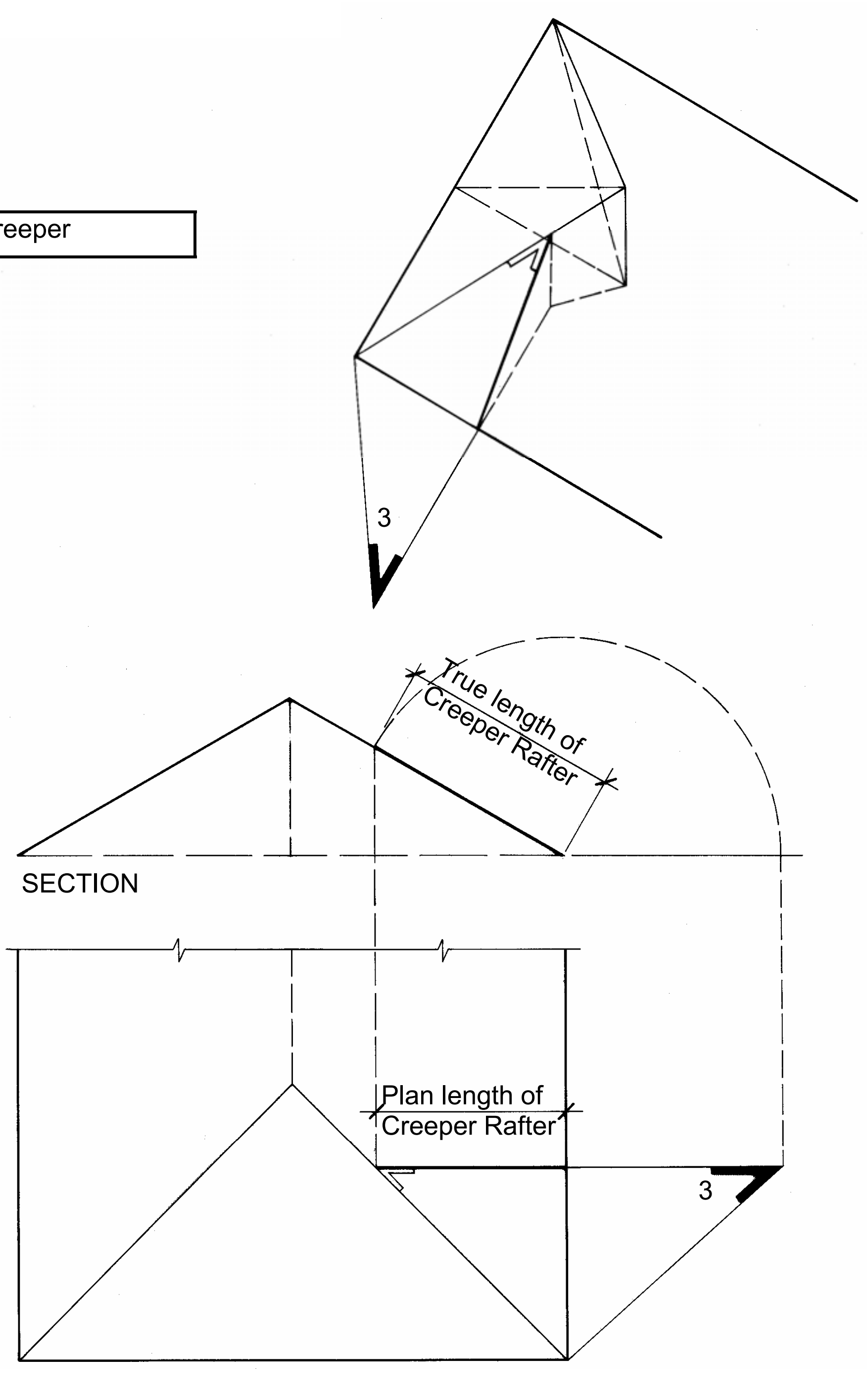


Fig. 56 Geometric edge bevel creeper development

Edge bevel purlin

This bevel is formed in a 90° triangle consisting of the *true length of common rafter* and *run or half span.* (Proportions of both these lengths may also be used)

LEGEND

4	Edge bevel purlin

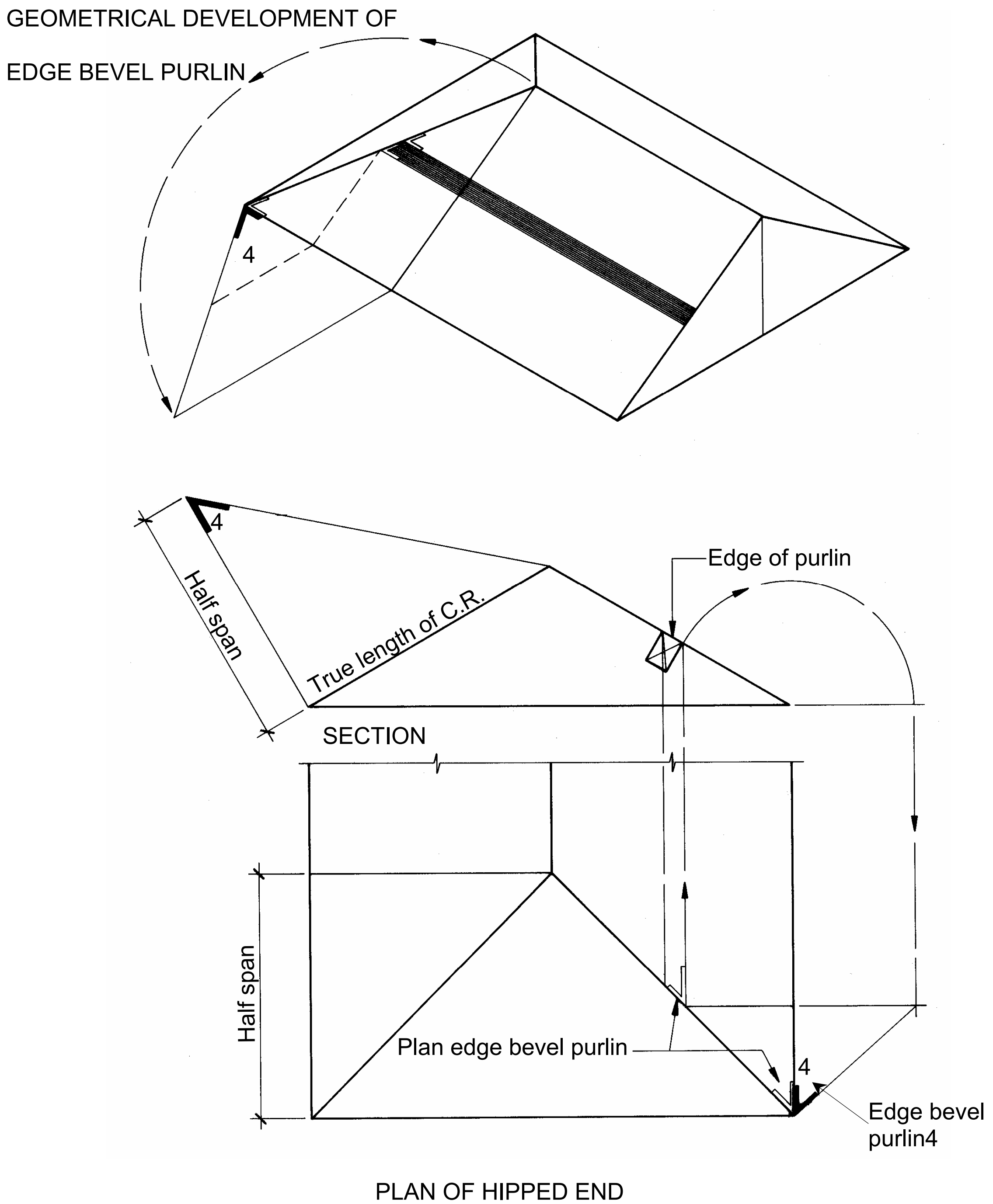


Fig. 57 Geometric edge bevel purlin development

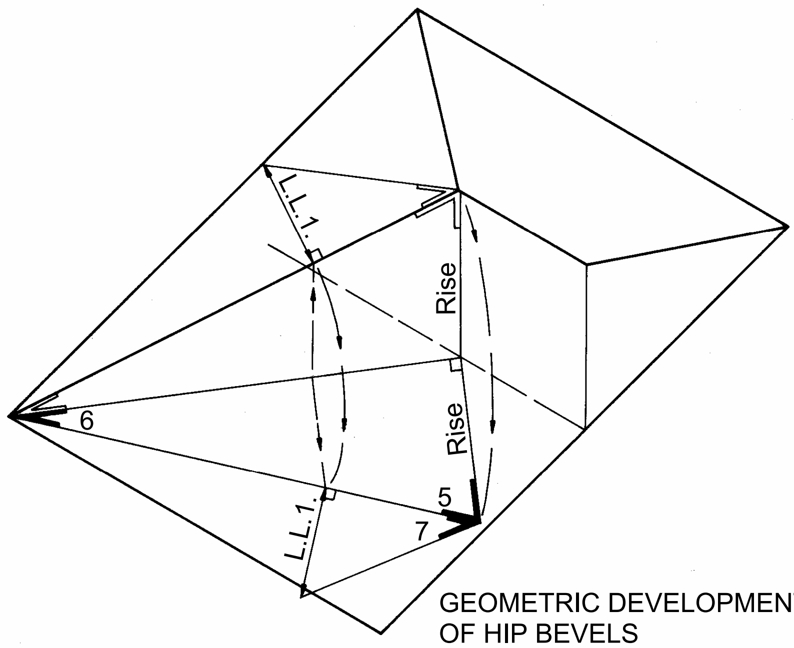
Plumb, Level and Edge bevel hip

The plumb and level bevels are formed in a 90° triangle consisting of the *plan length of hip rafter* and the *rise.* (Proportions of both these lengths may also be used)

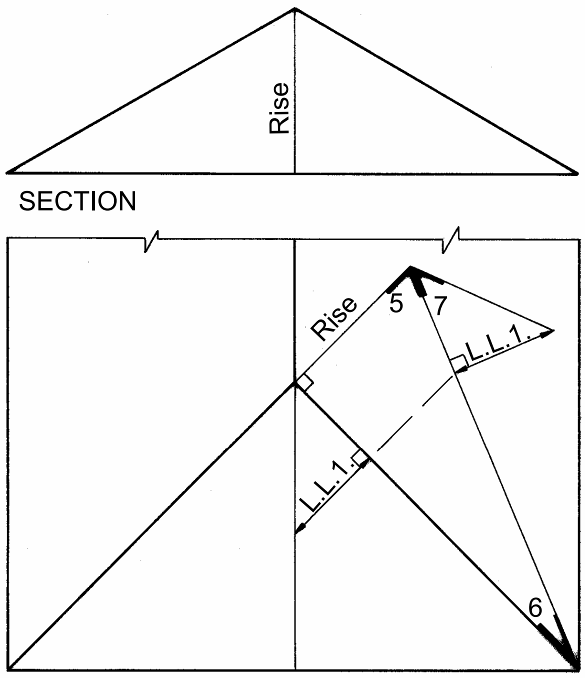
The edge bevel is formed in a 90° triangle consisting of the *plan length of hip rafter* and the *true length of hip rafter.* (Proportions of both these lengths may also be used)

LEGEND

5	Plumb bevel hip
6	Level bevel hip
7	Edge bevel hip



GEOMETRIC DEVELOPMENT OF HIP BEVELS

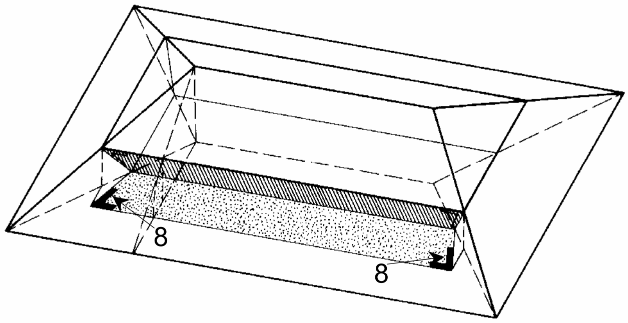


PLAN OF HIPPED END - METHOD OF DEVELOPMENT

Fig. 58 Geometric plumb, level and edge bevel hip development

Face bevel purlin

This bevel is formed in a 90° triangle consisting of the *true length of common rafter* and *rise of roof.*
(Proportions of both these lengths may also be used)



LEGEND

8	Face bevel purlin

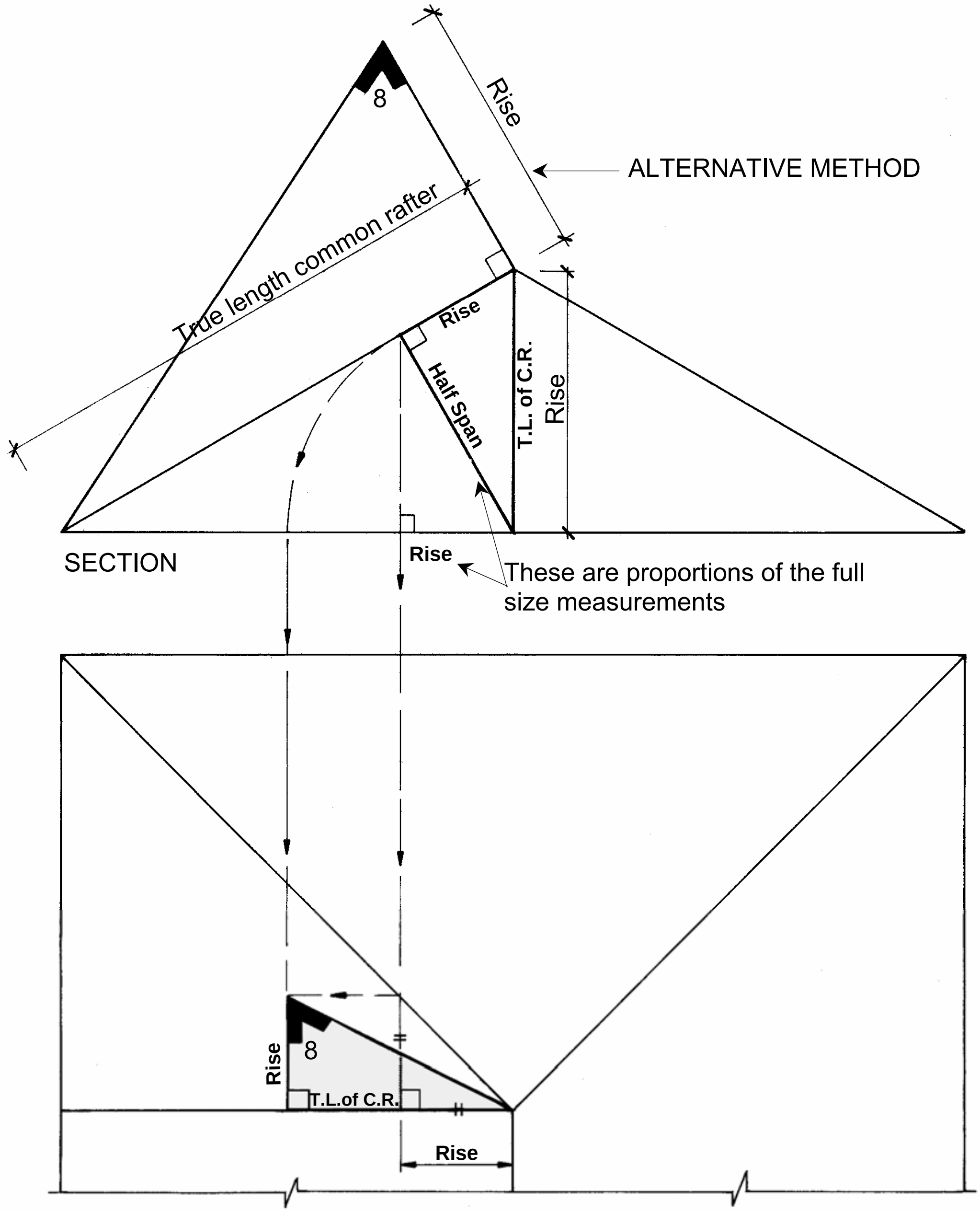


Fig. 59 Geometric face bevel purlin development

DEVELOPING BEVELS on the STEEL SQUARE

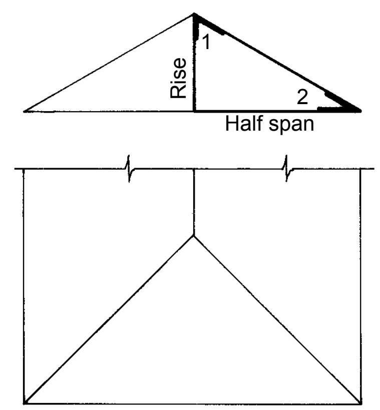
This method allows all the roof bevels to be produced on the steel square, shown as proportional lengths, and then some of the set positions may also be used to step out the lengths of the rafters.
For example, when the steel square has the plumb and level bevels for common rafter set it may be used to set out the common rafters and all the hip and valley creepers. Also, when the steel square has the plumb and level bevels for hip rafter set it may be used to set out the length of the hip and valley rafters.
Setting out these lengths will depend on the measurement used on the blade of the square, as this measurement is divided into the run or plan length to determine the number of times the square is moved along the rafter.

PRODUCING BEVELS

The 8 bevels are produced based on the *rise per metre run* proportions, which is dependent upon the pitch of the roof. The proportions are calculated and then reduced, proportionately, to fit onto the blade and tongue of the square. The position of the proportions on the square will be the same as they occur in their actual position in the roof, based on the right-angled triangle proportions previously stated in the *Geometric method*.

Example 1:
Set the bevels on the steel square based on a hip roof, which has a pitch of 1 : 1.732 or 30°, and a run or half span of 2700 mm.

Plumb and Level bevel common rafter

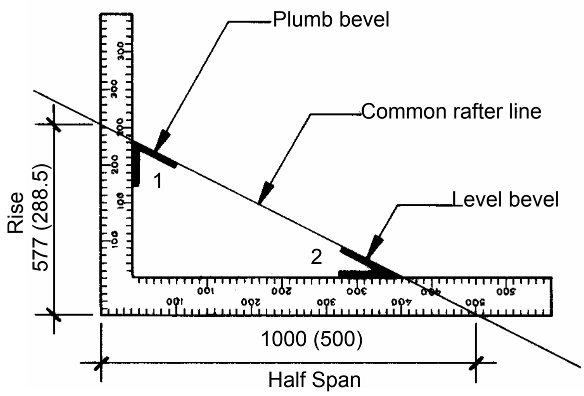


These bevels are formed in a 90° triangle consisting of the *rise* and *run or half span*. (Proportions of both these lengths may also be used)

STEP 1	Rise per metre run	=	$\frac{1.000}{1.732}$
		=	0.577m

To fit the measurements onto the steel square, divide both by 2

STEP 2	Divide rise by 2	=	$\frac{577}{2}$ = **288.5**
	Divide run or ½ span by 2	=	$\frac{1000}{2}$ = **500**



Edge bevels for Creeper and Purlin

These bevels are formed in a 90° triangle consisting of the *true length common rafter* and *run or half span.*
(Proportions of both these lengths may also be used)

STEP 1 Calculate true length C.R.
$= \mathbf{a^2 = b^2 + c^2}$
$= 577^2 + 1000^2$
$= 0.333 + 1.0$
$= \sqrt{1.333}$

$= 1.155\text{m}$

To fit the measurements onto the steel square, divide both by 3

STEP 2 Divide T. L. C.R. by 3 $= \dfrac{1.155}{3} = \mathbf{385}$
Divide ½ span by 3 $= \dfrac{1000}{3} = \mathbf{333}$

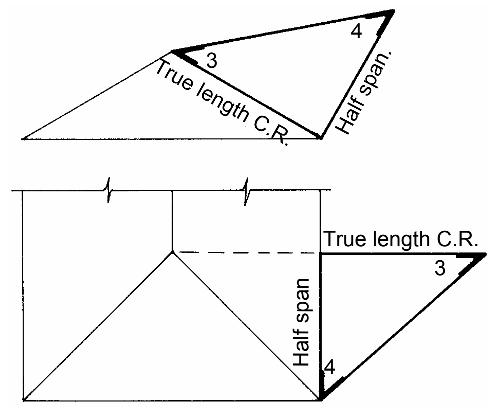
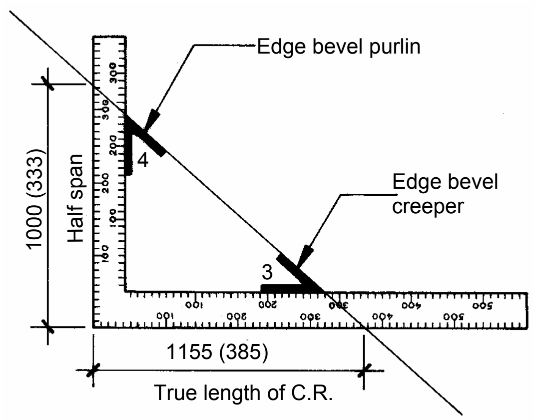


Fig. Edge bevels for creeper and purlin 61



Plumb and Level bevel hip rafter

These bevels are formed in a 90° triangle consisting of the *rise* and *plan length of hip*.
(Proportions of both these lengths may also be used)

STEP 1 Plan length of hip
$= \text{Run} \times 1.414$
$= 1.0 \times 1.414$

$= 1.414\text{m}$

To fit the measurements onto the steel square, divide both by 3

STEP 2 Divide rise by 3 $= \dfrac{577}{3} = \mathbf{192}$

Divide plan length hip by 3 $= \dfrac{1414}{3} = \mathbf{471}$

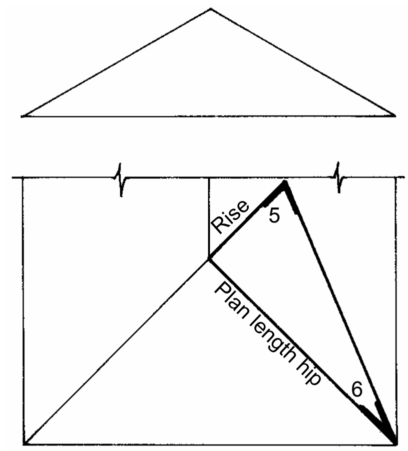
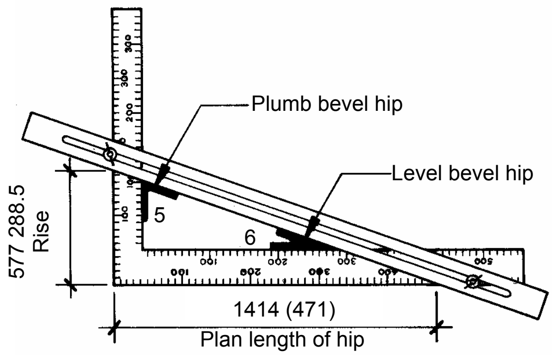


Fig Plumb and bevel hip 62 level



Edge bevel for hip

These bevels are formed in a 90° triangle consisting of the *plan length hip* and *true length hip.*
(Proportions of both these lengths may also be used)

STEP 1	Calculate	=	**$a^2 = b^2 + c^2$**
	true	=	$577^2 + 1414^2$
	length	=	0.333 + 1.999
	hip	=	v2.332
		=	1.527m

To fit the measurements onto the steel square, divide both by 4

STEP 2	Divide P.L. hip by 4	=	$\frac{1.414}{4}$ = **354**
	Divide T.L. hip by 4	=	$\frac{1.527}{4}$ = **382**

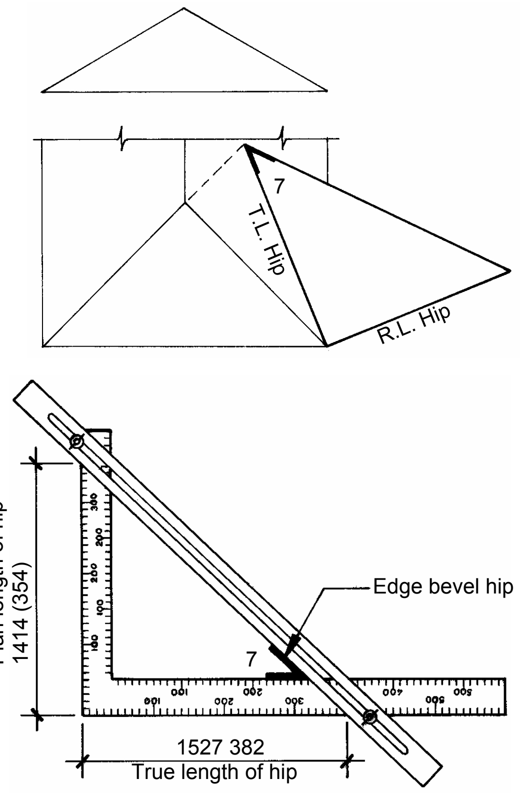


Fig. 63 Edge bevel for hip

Face bevel purlin

These bevels are formed in a 90° triangle consisting of the *rise* and *true length C.R.*.
(Proportions of both these lengths may also be used)

STEP 1	Calculate	=	**$a^2 = b^2 + c^2$**
	true	=	$577^2 + 1000^2$
	length	=	0.333 + 1.0
	C.R.	=	v1.333
		=	1.155m

To fit the measurements onto the steel square, divide both by 3

STEP 2	Divide rise by 2	=	$\frac{577}{2}$ = **288.5**
	Divide true length C.R. by 2	=	$\frac{1.155}{2}$ = **578**

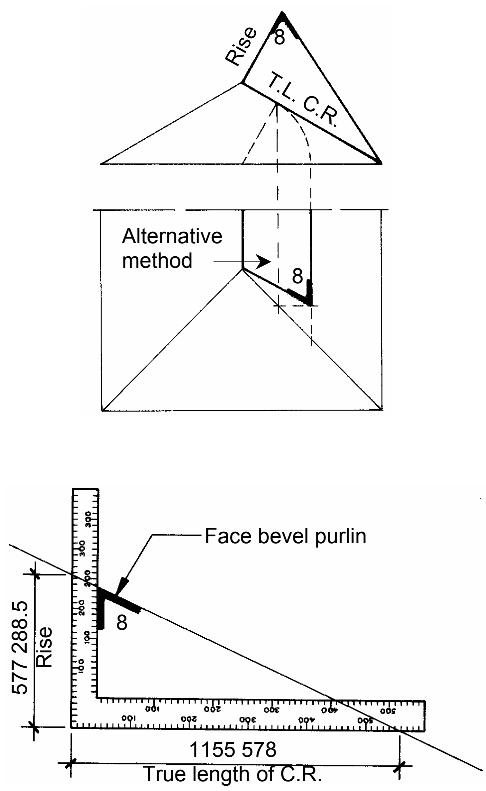


Fig. Face bevel purlin

SUMMARY OF STEEL SQUARE BEVELS

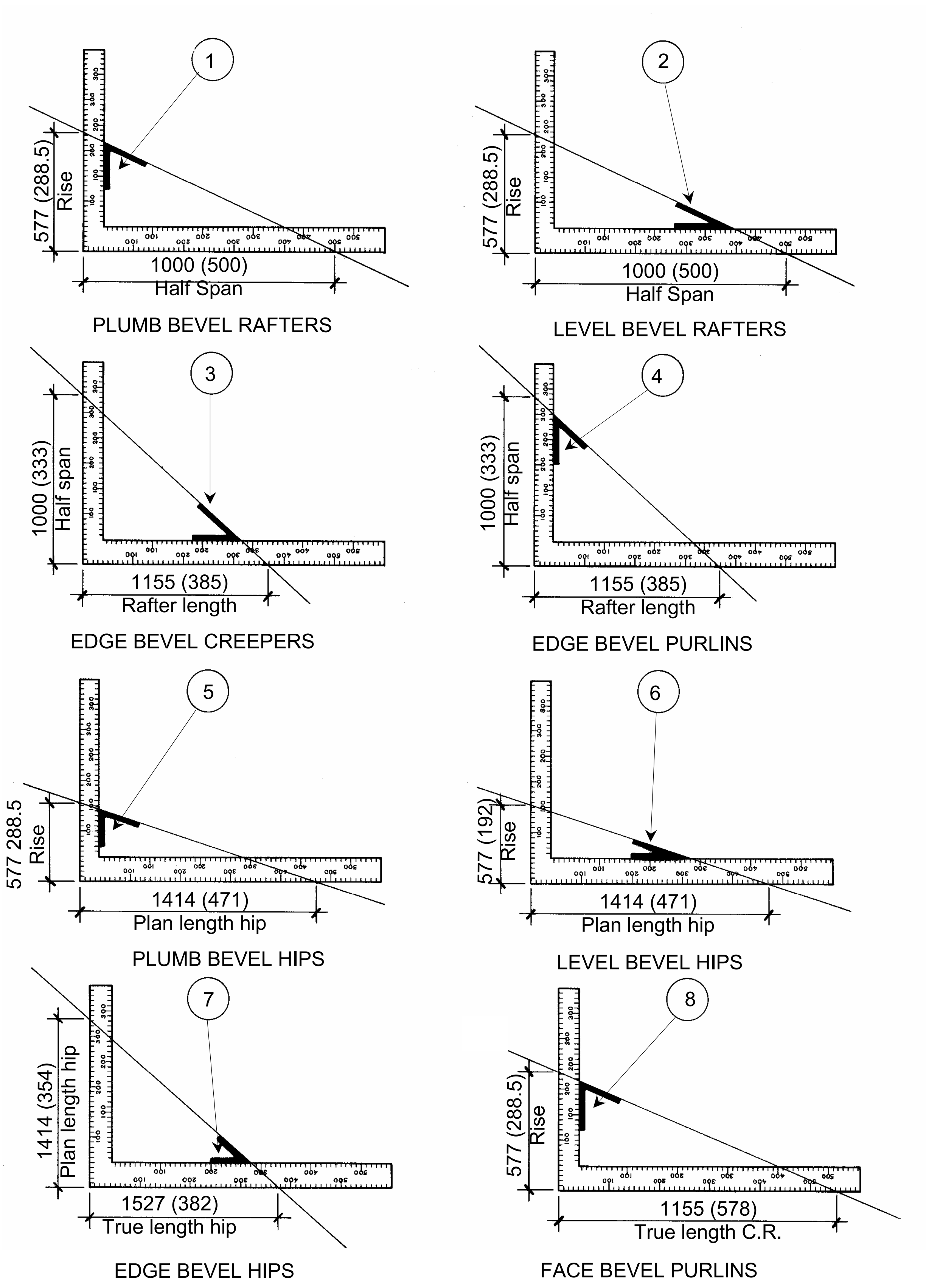


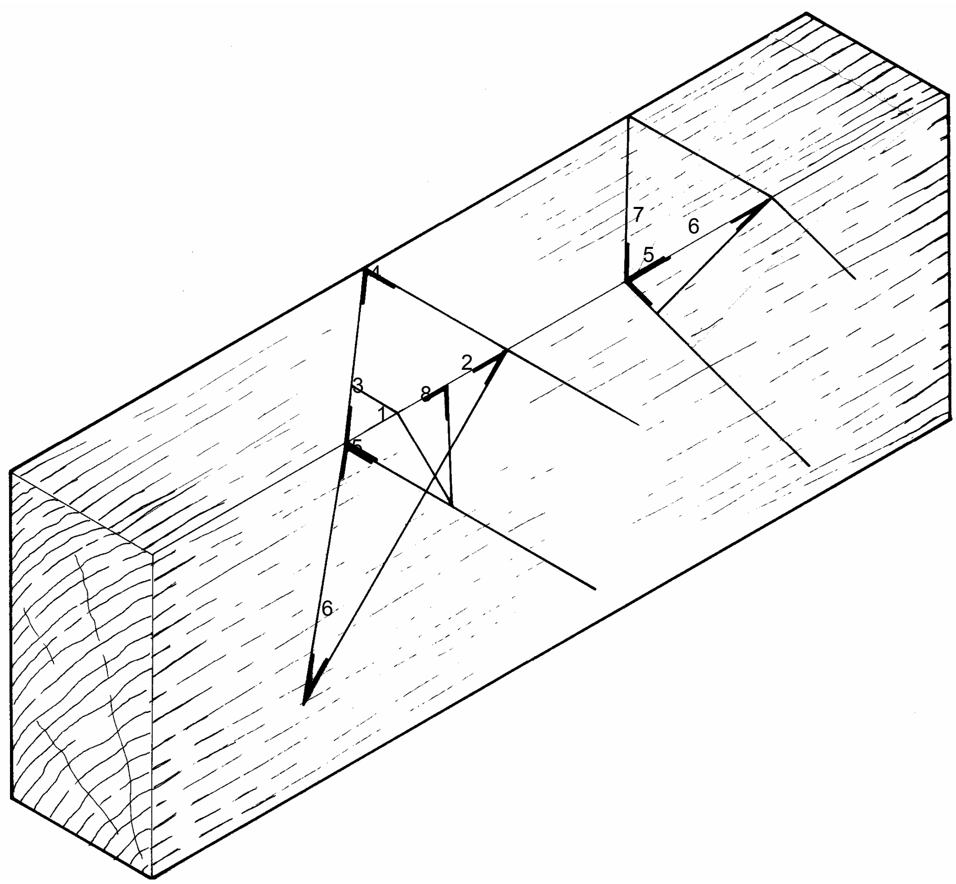
Fig. 65 Summary of steel square bevels

DEVELOPING BEVELS using the DIRECT METHOD

The direct method is similar to the geometric method, except it may be applied in a practical setting.

Select a length of timber, preferably dressed with square edges, approximately 300 to 400 mm long. The accuracy of the bevels will depend on the accuracy of the set out and the size of the timber selected. The section size should be at least 90 mm wide x 45 mm thick, however it is more accurate to set a sliding bevel to thicker timber, say 70 mm thick.

Once the bevels are set they may be used for any job with the same pitch and may be kept in the tool box or the back of the car for easy re-use.



LEGEND

1	Plumb bevel common rafter	5	Plumb bevel hip
2	Level bevel common rafter	6	Level bevel hip
3	Edge bevel creeper	7	Edge bevel hip
4	Edge bevel purlin	8	Face bevel purlin

Fig. 66 Direct method of hip roof bevel development

METHOD OF PRODUCING BEVELS

STEP 1 After selecting a suitable piece of timber, set a sliding bevel to the plumb cut for common rafter, from a pitch board set out.
Start at least 100 mm in from one end, lay the bevel on the edge and mark a plumb line down the face of the timber.

***Note**: The detail shown below is based on 1 : 1.732 or 30°*

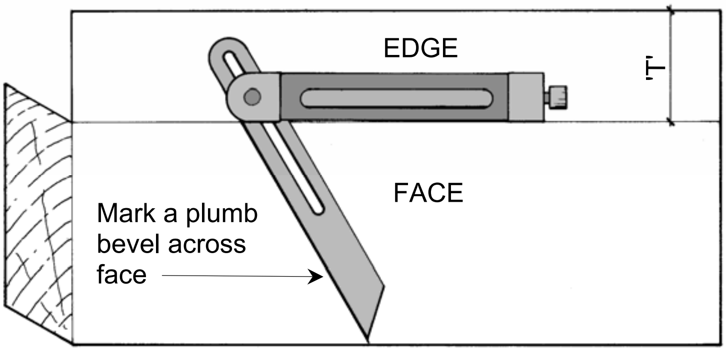


Fig. 67 Developing plumb bevel common rafter

STEP 2 Measure the thickness of the piece of timber, mark the distance parallel to the plumb bevel and extend this line down the face. Mark a 90° line to the original plumb bevel line and extend it across until it passes through the point where the thickness line intersects with the edge of the timber. This produces a right-angled triangle, which is in proportion to the *rise per metre run* of the roof.

***Note**: The thickness of the piece of timber represents the run or half span of the roof.*

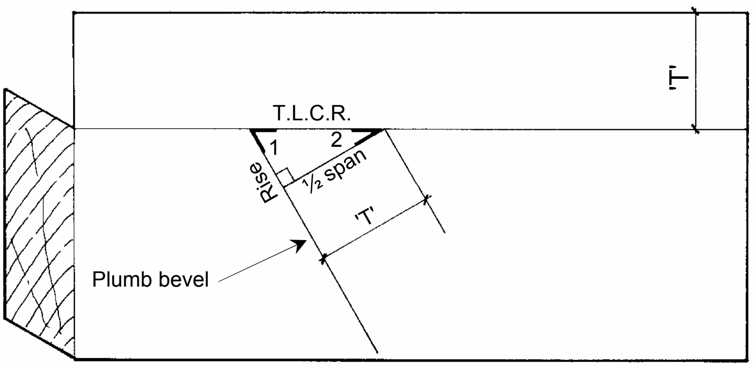


Fig. 68 Developing plumb and level bevel common rafter

STEP 3 Mark a square line across the thickness of the timber from the point of the level bevel common rafter.
Join the end of this line back to the point of the plumb bevel common rafter to form another right-angled triangle on the edge of the timber block.

The bevel at the top, adjacent to the plumb bevel common rafter, will be the edge bevel creeper and the complimentary angle in the same triangle will be the edge bevel purlin.

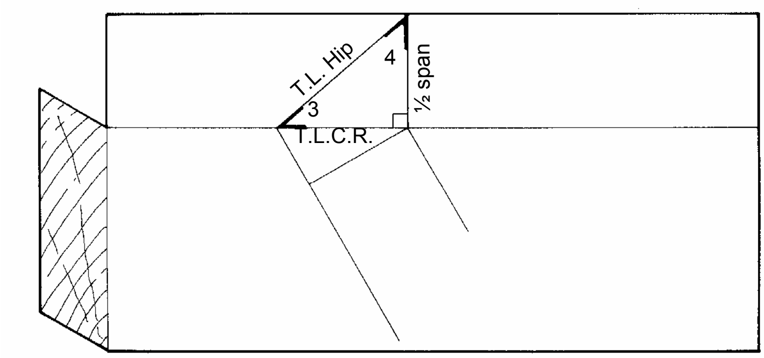


Fig. 69 Developing edge bevel creeper and edge bevel purlin

STEP 4 Extend the half span line at 90° to the rise on the opposite side to the common rafter bevel set out. This will represent the plan length of the hip.
The true length of the hip is also the hypotenuse of the edge bevel hip and purlin triangle, found on the edge of the timber.
Transfer the length of this line around to the face side by using a compass or simply measuring the length and laying the rule on the face until the desired measurement intersects with the plan length of hip line. Join this intersection point to the top of the rise. The plumb bevel hip is found at the top adjacent to the rise, with the level bevel being formed at the bottom by the complimentary angle.

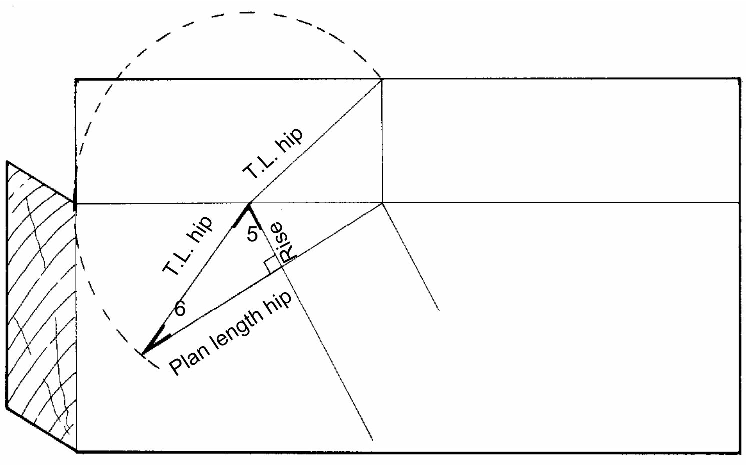


Fig. 70 Developing plumb and level bevel hip rafter

STEP 5 Transfer the plumb bevel hip to the other end of the timber by either a compass or by setting a sliding bevel to the plumb bevel hip.

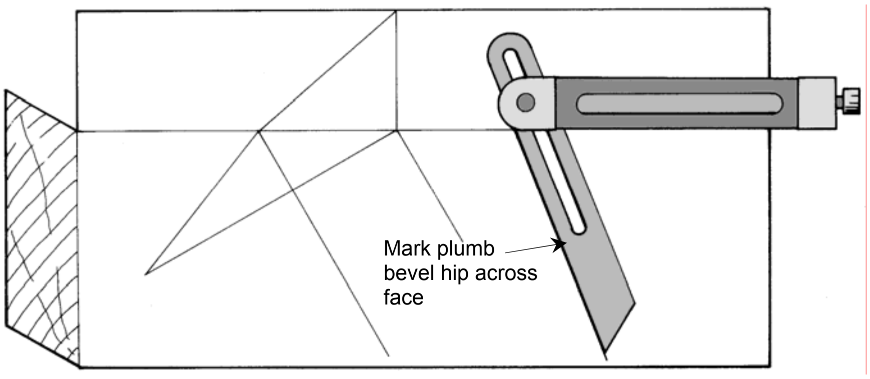


Fig. 71 Transferring plumb bevel hip

STEP 6 Mark the thickness of the timber parallel to the plumb cut. This will represent the plan length of hip. Create a right-angled triangle by joining the intersection of the thickness with the edge, back to the plumb cut mark at 90°.

Create another right-angled triangle on the edge by squaring across from the intersection point at 90° and then joining back to the top of the original plumb cut. The edge bevel hip is located at the top of this triangle adjacent to the plumb cut hip.

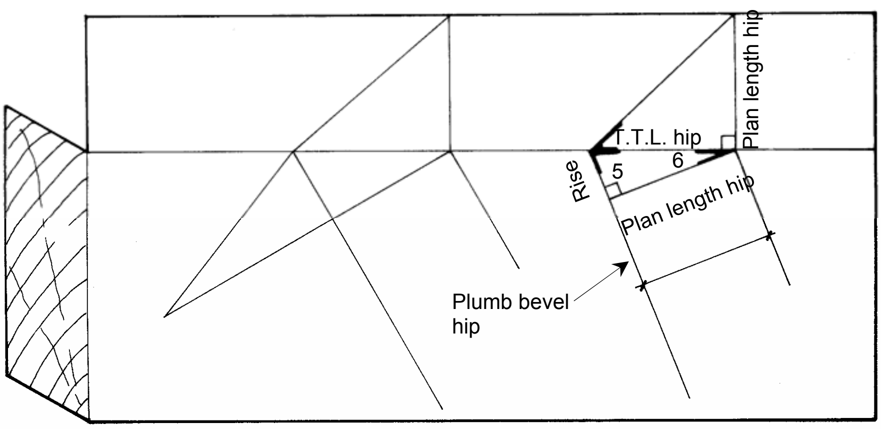


Fig. 72 Developing edge bevel hip

STEP 7 Select a point anywhere along the true length common rafter and mark a line down the face at 90° from the edge, until it intersects with the plumb cut common rafter.

Mark another line at 90° across the edge, from the selected point on the true length common rafter, until it intersects with the true length hip line.
Transfer the length of this line down onto the true length common rafter and then connect it back to the intersection point on the plumb cut common rafter.

The face bevel will be formed in the top corner of the triangle where it intersects with the true length common rafter.

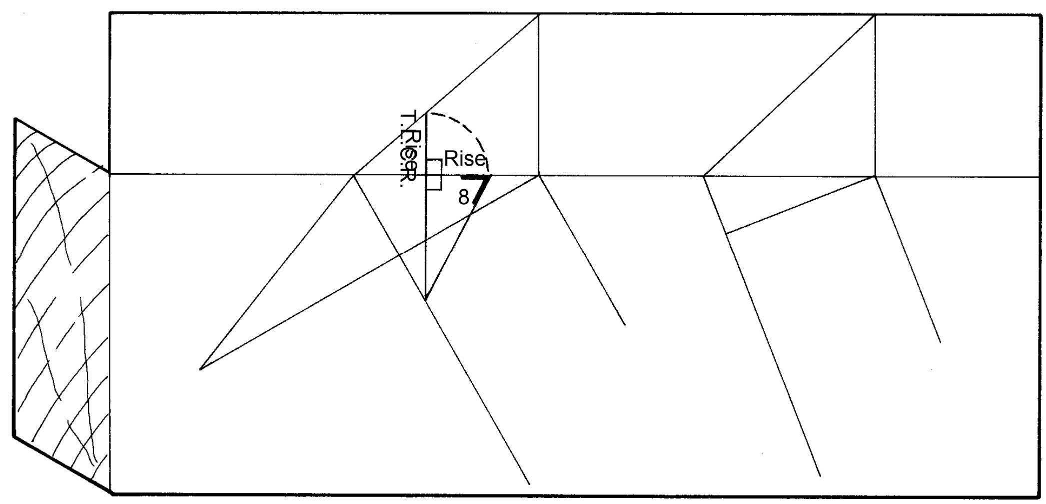


Fig. 73 Developing face bevel purlin

An alternative practical method to obtain face bevel purlin is to cut through the plumb and edge cut for the creeper, then cut off the point square across the edge and face. The shape formed will provide the face bevel purlin in the top corner

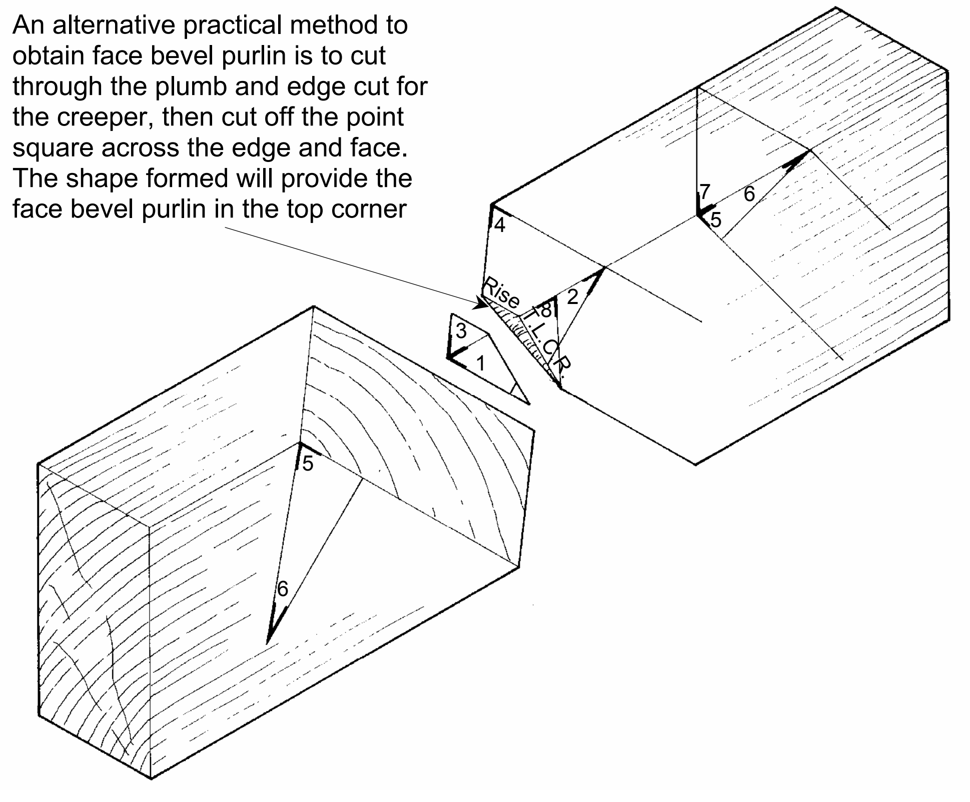


Fig. 74 Alternative method of developing face bevel purlin

ERECTION PROCEDURE for the HIP ROOF

Set out and construct the ceiling frame for the hip roof, ensure the rafters have been set out and cut, then follow the steps below:

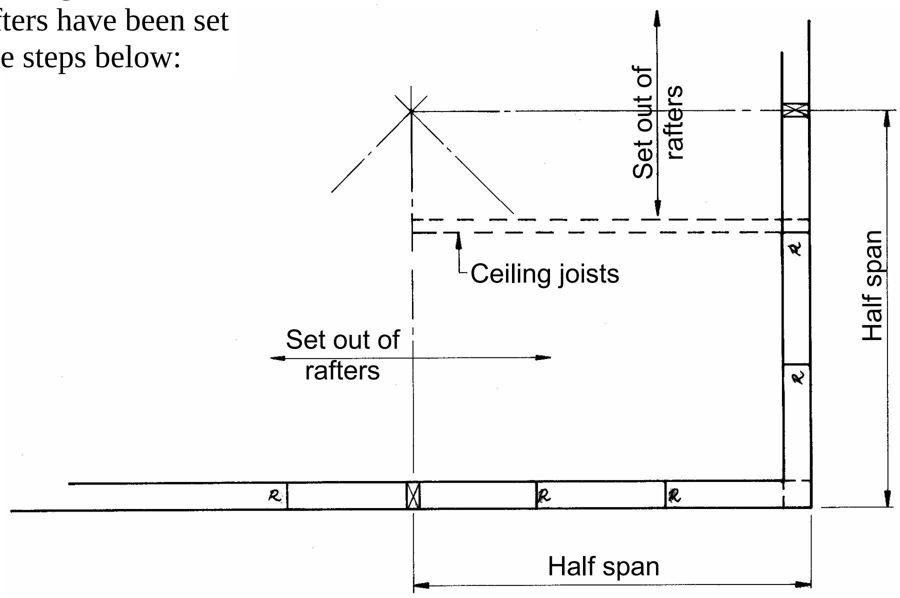


Fig. 75 Set out and complete the ceiling frame

STEP 1 Measure the length of the ridge/s and cut to length or join lengths together, as shown in the previous figure.

Lay the ridge on flat, with the top edge flush with the ends of the ceiling joists, aligning the ends with the outside faces of the centring rafter positions.
Using a square, transfer the rafter positions onto the edge of the ridge and square them down the face of one side.

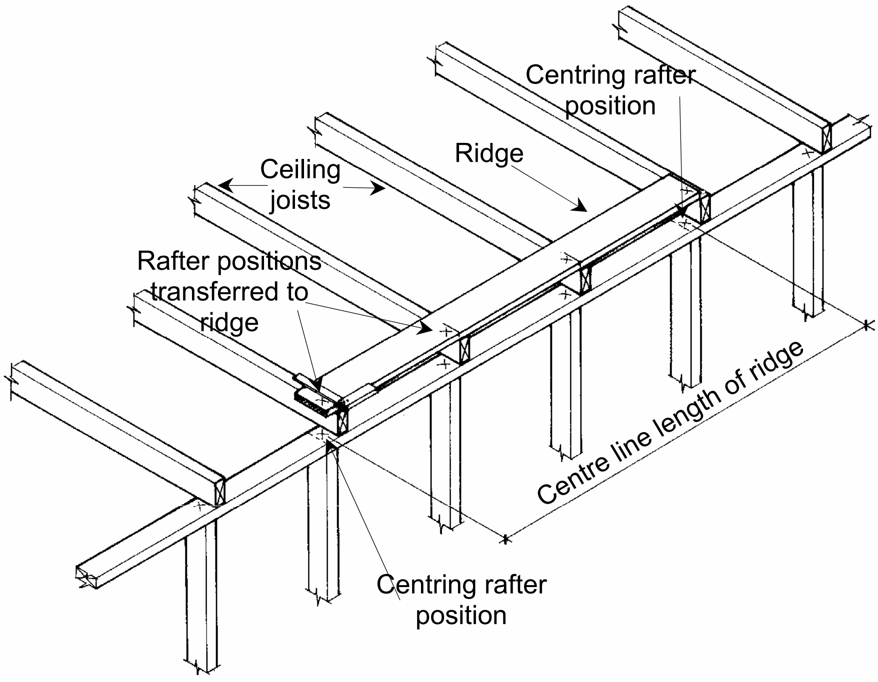


Fig. 76 Setting out rafter positions on the ridge board

STEP 2 Erect a pair of centring rafters at each end of the ridge. Nail the feet of each pair to the plate with the plumb cut ends butted together.

Place a temporary nail at the top of each pair of rafters for stability.

Lift the ridge up between the rafters until it is flush with the top edge, or to a marked straight line, then nail through from one side into the end of one rafter with 2/ 75 mm nails.

Align the opposing rafter and skew nail from the opposite side using 2/ 75 mm nails.

Note: *Refer to previous details for positioning of centring rafters.*

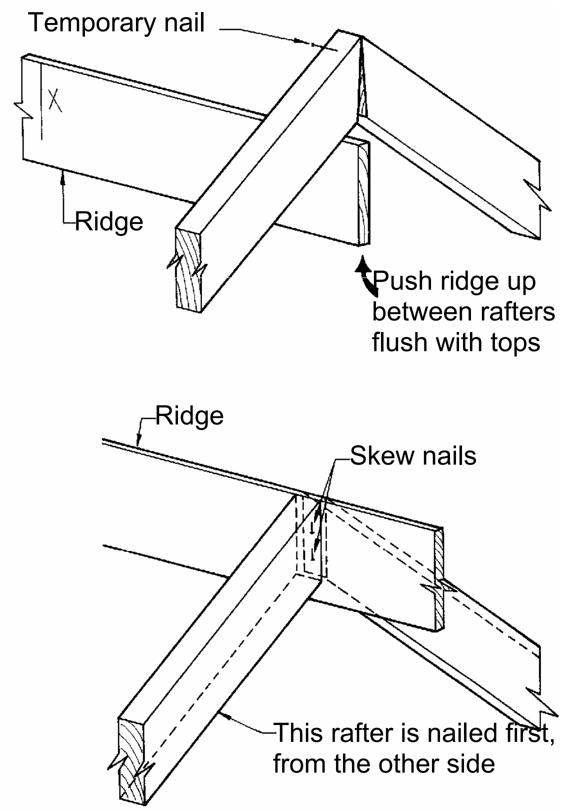


Fig. 77 Fixing the first pairs of rafters to the ridge

STEP 3 Fit a crown end rafter to both ends of the ridge ensuring the top edge aligns with the centre line height of the ridge.

Note: *Fitting the crown end rafters automatically plumbs and braces the skeleton framing ready for fitting of the other members.*

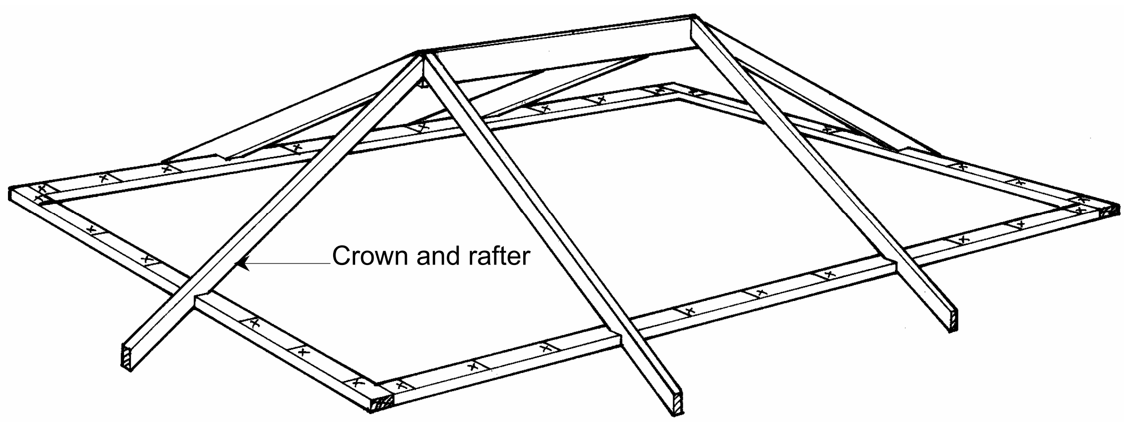


Fig. 78 Fitting the crown end rafters

STEP 4 Cut and fit the hips and install the remaining common rafters.
Use any preferred method to establish the hip length, as previously outlined.

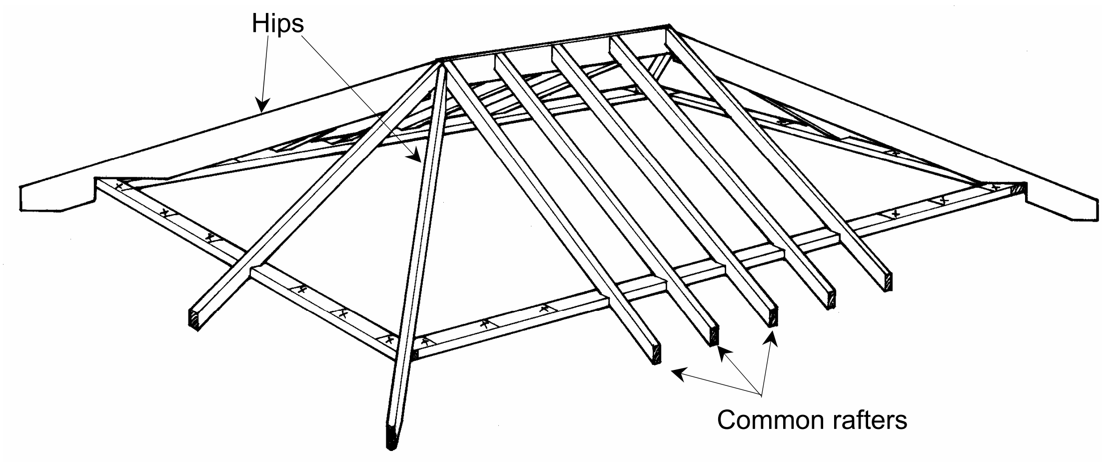


Fig. 79 Fit hips and fix off the remaining common rafters

STEP 5 Cut and fit pairs of creeper rafters to the hips.
They should be fixed off in pairs to ensure the hip remains straight on plan.
Long hips may require temporary propping to ensure they do not sag during the fixing of the creepers.
This may be done by using an adjustable steel prop, as shown in detail 'A', or by using a timber prop off the ceiling joists, as shown in detail 'B'.

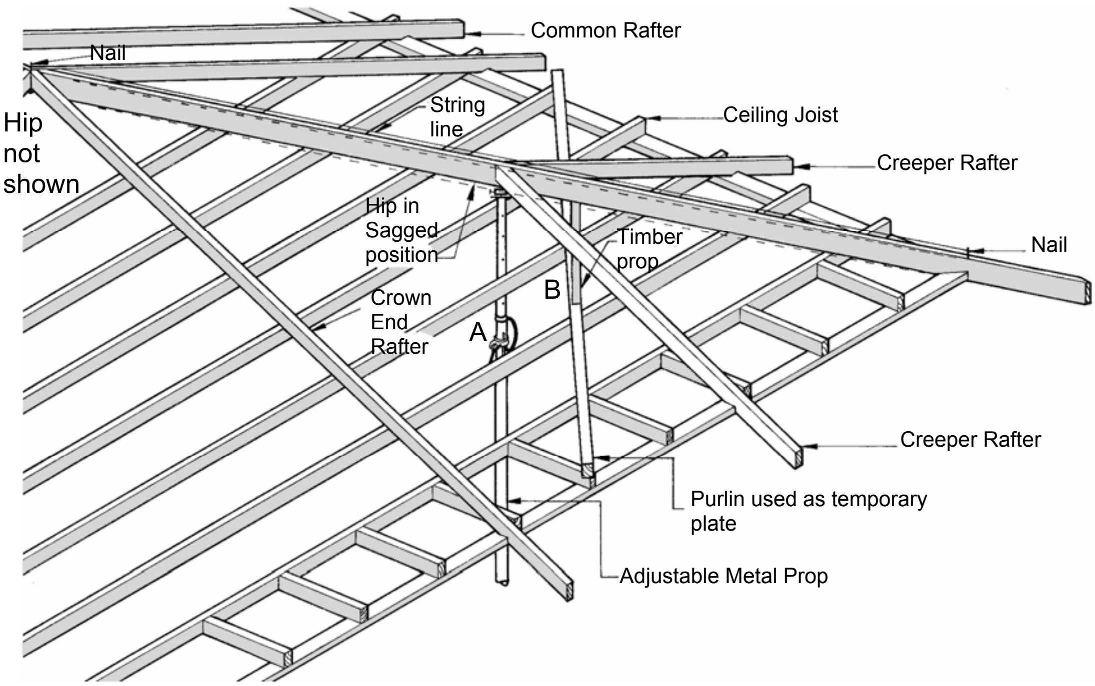


Fig. 80

Propping the hip and fixing pairs of creeper rafters

STEP 6 Complete the installation of all the creeper rafters, set out and fix purlins into position as required, then cut and fix the struts for the whole roof.

Note: *The strutting system chosen may be any of the types previously mentioned.*
Set out, cut and fix collar ties on top of purlins, bolting or nailing them as required.

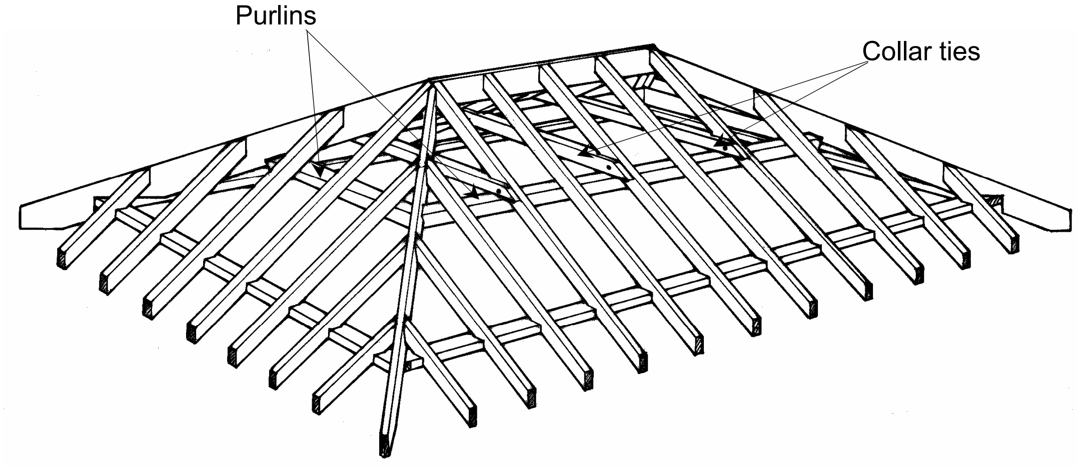


Fig. 81 Complete the assembly of the structural frame

Note: *Follow the same procedures and sequence for a hip & valley roof*

STEP 7 To determine the eaves width, it will be necessary to calculate the drop-off position, unless these dimensions are given. (*Refer to previous details relating to Drop off)*

Set out and mark the line of the overhang by measuring horizontally from the outside of the wall frame.
Plumb a line down the face of the rafter ready to cut.

STEP 8 Plumb a line down, the same distance out, at the other end of the roof and drive in two temporary nails on the top edge of the end rafters and attach a string line.

Work along the rafters marking plumb down from the string line with a spirit level.

STEP 9 After the ends of the rafters have been cut plumb to a straight line and the eaves soffit bearers fitted, cut and fit the timber or metal fascia ready to receive the gutter.

The top of the groove should be in-line with the top side of the eaves soffit sheet. The top of the fascia will project above the top edge of the rafters to provide a bellcast.

The bellcast ensures that the first course of tiles will have the same pitch as the remainder of the roof and the distance above the rafters should be equal to the thickness of a tile batten plus the thickness of one tile.

VALLEY BOARDS and GUTTERS

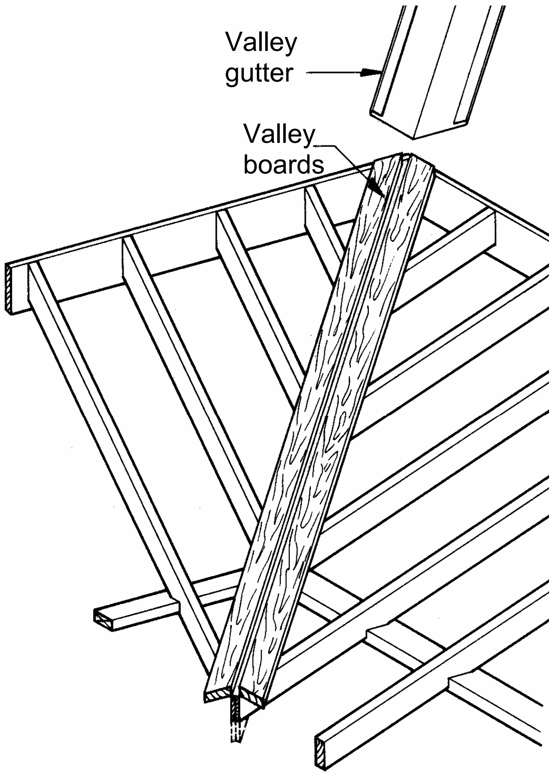
Valley gutters may be galvanised iron, *Zincalume®* or *Colorbond®* protective finish. They are available in 1.8 to 2.4m standard lengths.

The valley gutter must not be rigidly fixed down to the valley boards as it requires some allowance for movement due to expansion when heated up. Failure to allow for movement may result in the valley gutter buckling, in extreme conditions.

The best and simplest method of fixing valley gutter into place is to drive 75 mm nails into the valley boards on either side of the valley gutter and then bend them over the gutter's edge. This provides secure fixing to prevent the gutters lifting but allows for sliding length-ways at joins, when the gutters expand.

The bottom end of the valley gutter should extend 50 mm, ± 15 mm, into the eaves gutter to prevent water splashing over the back edge of the eaves gutter.

The tiles in an *open valley*, as shown in the section through roof valley, should have a horizontal distance of 125 m between the valley tiles. This allows leaves, sticks, debris, etc. to wash down into the gutter.



VALLEY & VALLEY BOARDS

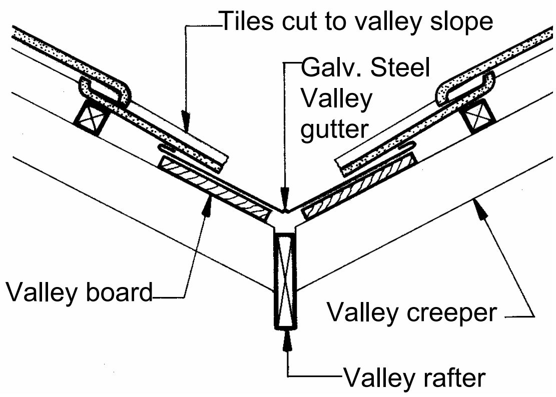


Fig. 82 Valley gutter installation

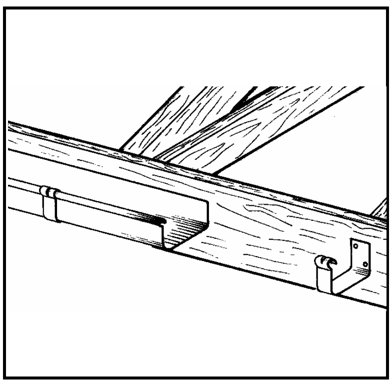


Fig. 83 Quadrant gutter

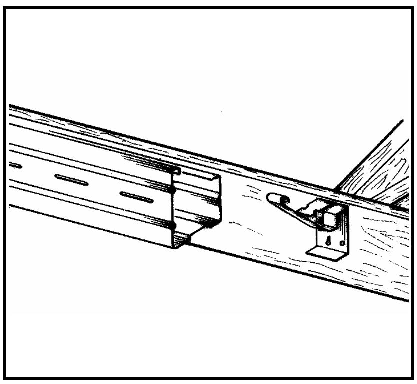


Fig. 84 'Squareline' gutter

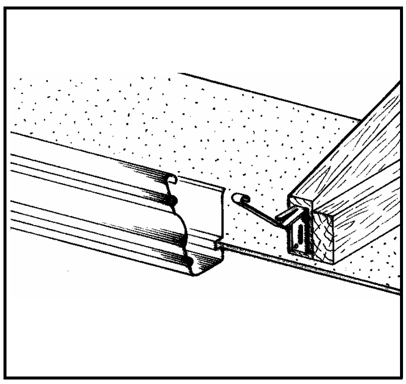


Fig. 85 Fascia gutter

EAVES FINISHES

The eaves of a cottage or structure are designed to shed water away from the walls below and at the same time provide shade and protection from other elements.

This style of eaves finish has been re-introduced in many contemporary residential

Eaves were not always a part of Australian architecture, as shown in this mid to late 1800's building in Adelaide city.
The roof surface would meet the external walls forming either a concealed gutter behind a *parapet* or a *corbelled* fascia with the gutter attached to it.

In earlier designs, i.e. the early 1800's, there were no eaves, no fascia and no gutter. The roof rainwater would be shed off the end of the roof covering by using steeply pitched roofs. In many cases this allowed the water to run down the walls and pool at the top of the footings, where it caused erosion and undermining of the footings.

Fig. 86 Jacobethan revival,
Circa 1850 – 1895

developments where the cottage is built on a small 350 – 450m² block, referred to as a 'smart block'. Where the walls are on the boundary no eaves are used.

Note: *Perimeter of the walls at the base should be protected with paving in these situations.*

Boxed eaves

This is probably the most commonly used method of constructing eaves for gable, hip and hip & valley roofs.
By enclosing the underside of the eaves, entry of the elements, pests and dust is prevented and the eaves soffit is easily maintained.

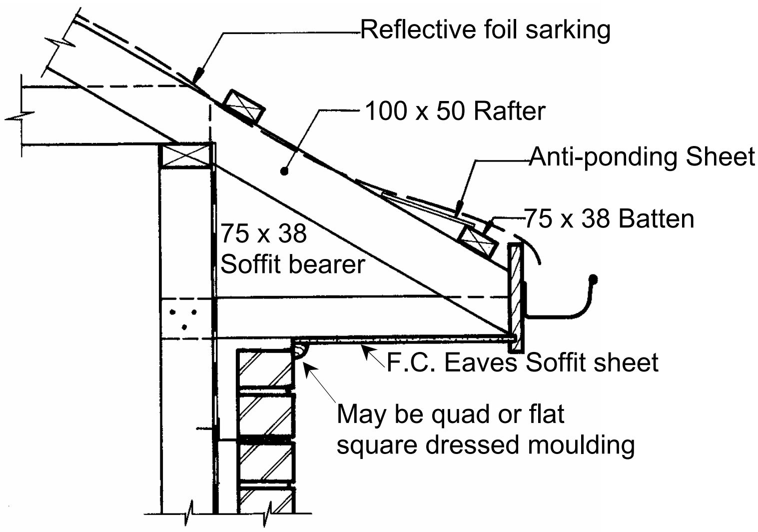


Fig. 87 Typical boxed eaves for brick veneer construction

Open eaves

This method is used where the tails of the rafters are to be exposed as a feature with a lining placed over the top, which is seen between the rafters from underneath.
The lining material may be F.C. sheeting, timber boarding, plywood, etc. The tails of the rafters are painted to protect them from the elements. The space between the rafters against the wall must be closed off to prevent the entry of birds or vermin to the roof void. This may be a timber or a birdwire barrier.

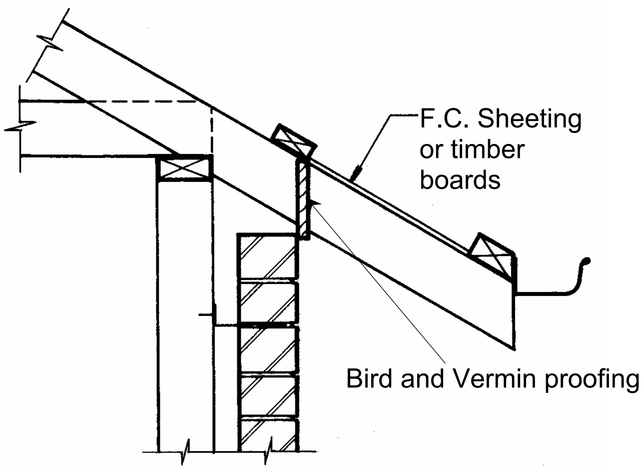


Fig. 88 Open eaves

Concealed gutter with open-slat eaves

This method is used to provide ventilation to the roof void allowing it to breathe. The slats must have an insect wire, of bronze, copper or poly-propylene, placed between them and the soffit bearers to prevent pests entering the roof void.

The concealed gutter method is not preferred as it is difficult and expensive to replace and difficult to successfully seal at joins.

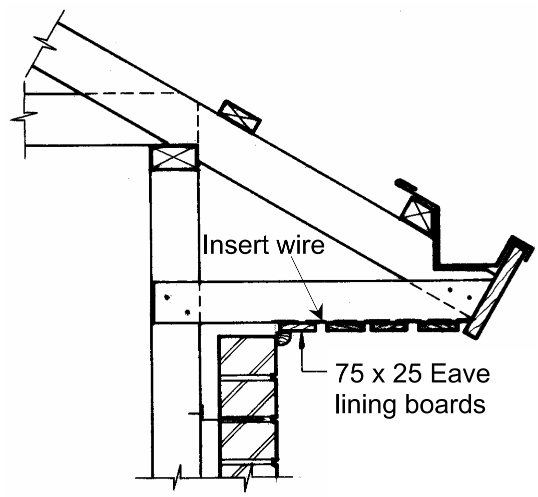


Fig. 89 Concealed gutter with open slats

Lined on-the-rake eaves

This method is used as an alternative to level eaves. The eaves soffit may be lined as for the open slat type or may be of the F.C. sheet type.

The gutter is mounted on the face of the fascia where it is more easily maintained or replaced.

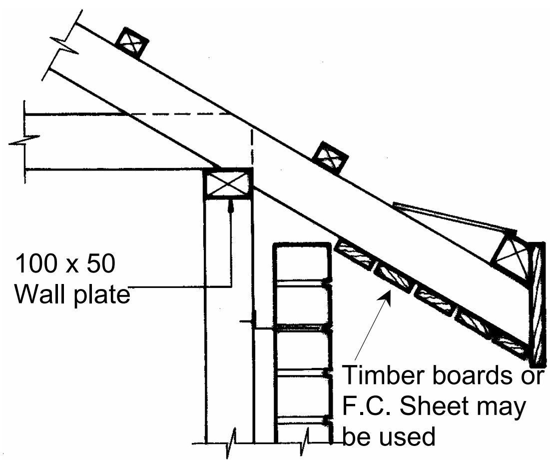


Fig.90 Lined on-the-rake

CALCULATING FRAME QUANTITIES

The following example outlines a method used to calculate framing member lengths, quantities and costs.

Example 1:

Calculate the roof frame members for the tiled hip roof shown below, which has a span of 5400 mm and a length of 7200 mm.
The pitch is 1 : 2.145 or 25°.
The member sizes and costs are as follows:

TABLE 3

MEMBER	SECTION SIZE	MATERIAL	SPACING	STRESS GRADE	COST
All Rafters	90 x 35	Radiata pine	600 c/c	F8	$2.10/m
Ridge	150 x 32	Oregon	-	F5	$4.00/m
Hips	150 x 32	Oregon	-	F5	$4.00/m
Purlins	125 x 75	Oregon	1800 c/c	F8	$9.00/m
Collar ties	70 x 35	Radiata pine	1200 c/c	F8	$1.90/m
Inclined struts	75 x 75	Oregon	2100 c/c	F7	$6.00/m
Soffit bearers	70 x 35	Radiata pine	600 c/c	F8	$1.90/m
Fascia	200 x 25	Primed Radiata pine	-		$7.00/m
Eaves soffit sheets	1800 x 1200 x 4.5	Fibre cement sheets	-		$15.00/ sheet

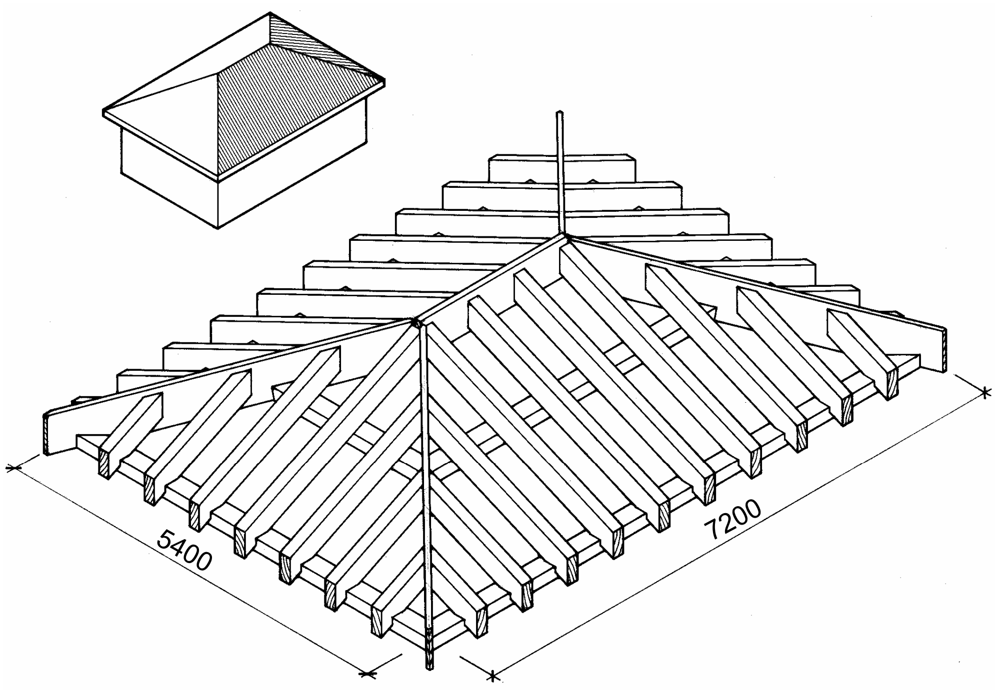


Fig. 91 Typical hip roof

Rafters

Order length of rafters

Calculate the ordering length of rafters for a pitch of 1 : 2.145

STEP 1 Rise per metre run $= \dfrac{1.000}{2.145}$

$= 0.466\text{m}$

STEP 2 Length of hypotenuse $=$ $\mathbf{a^2 = b^2 + c^2}$

$\mathbf{a^2} = 1.000^2 + 0.466^2$

$\mathbf{a^2} = 1.0 + 0.217$

Therefore, $\mathbf{a} = \sqrt{1.217}$

$= 1.103\text{m}$

Therefore, for every 1.0m of run or half span the hypotenuse or rafter length will be ***1.103m***

STEP 3 To find the centre line length of the rafter, simply multiply the run or half span by the constant, 1.103:

Centre line rafter length $= 2.700 \times 1.103$

$= \underline{\mathbf{2.978m}}$

STEP 4 To find the cutting length of the rafter, i.e. including eaves overhang, simply add the eaves width to the run or half span and multiply the answer by the constant 1.155, then deduct half the ridge thickness, when the ridge is 24 mm thick:

Cutting length of rafter $= \left[(2.700 + 0.400) - \dfrac{0.024}{2}\right] \times 1.103$

$= [3.100 - 0.012] \times 1.103$

$= 3.088 \times 1.103\text{m} = 3.406$

∴ Total cutting length of all the rafters will be ***3.406m***

∴ Total order length, to the nearest 300 mm increment, of all the rafters will be ***3.6m***

STEP 5 To find the ordering length it will be necessary to add 100 mm to the cutting length to allow for the plumb cut at the foot of the rafter:

Order length of rafter $= 3.406 + 100$

$= 3.506$

Quantity of rafters

The formula for the total number of rafters will be the same as for the gable roof:

$$\text{Number} = \left(\frac{\text{total length of roof}}{\text{rafter spacing}} + 1\right) \times 2 \text{ sides}$$

STEP 1	Roof length	=	Overall length of wall plates
		=	7.200m
STEP 2	Number of rafters	=	$\left(\frac{\text{total length of roof}}{\text{rafter spacing}} + 1\right) \times 2$ sides
		=	$\left(\frac{7.200}{0.600} + 1\right) \times 2$ sides
		=	(12 + 1) x 2 sides
		=	13 x 2 sides
		=	26

Order = 90 x 35 Radiata pine F8 – 26/ 3.6

Ridge

The length of the ridge will be equal to the total roof length, plus 300 mm joint length if required for ridges over 5.4 m long, less the full span.

Note: *Lengths greater than 5.4 m become difficult to handle, therefore it is common practice to join the ridge as previously described on page 13 of this unit.*

STEP 1	Ridge length	=	Length of roof – span
		=	7.200 – 5.400
		=	1.800
		=	1800mm or 1.8m (no join required in this case)

Order = 150 x 32 sawn Oregon F5 – 1/ 1.8

Hips

The length of the hips is calculated as previously shown on *page 71*.

STEP 1 Rise per metre run $= \frac{1.000}{2.145}$

$= \mathbf{0.466m}$

This is the rise per metre run for a member, i.e. common rafter, which runs at 90° to the wall plates. The next step is to establish the run or plan length of the hip, which is at 45° to the wall plates. This requires a *constant* to be calculated based on a metre run.

STEP 2 Calculate a *constant* per metre run $= \mathbf{a^2 = b^2 + c^2}$

$= \mathbf{a^2} = 1.0^2 + 1.0^2$

$= \mathbf{a^2} = 1.0 + 1.0$

$= \mathbf{a^2} = \sqrt{2}$

Therefore: $\mathbf{a} = \mathbf{1.414m}$

Note: *The rise remains unchanged, i.e. 0.577m*

STEP 3 Calculate the true length per 1.414 of run $= \mathbf{a^2 = b^2 + c^2}$

$= \mathbf{a^2} = 1.414^2 + 0.466^2$

$\mathbf{a^2} = \mathbf{a^2} = 1.999 + 0.217$

Therefore, $\mathbf{a} = \sqrt{2.216}$

$= \mathbf{1.489m}$

Therefore, for every 1.0m of run or half span the true length of the hip will be ***1.489m***

STEP 4 Find the centre line length of the hip

$= 2.700 \times 1.489$

$=$ ***4.020m***

To calculate the actual *cutting length* of the hip, deductions need to be made from the run or plan length, as previously shown.

STEP 5 Deduct both shortenings from the run or plan length and multiply it by the true length per metre run.

New plan length = (Plan length – deductions) x true length per metre run

= 2.700 – (0.025 + 0.011) x 1.489

= (2.700 – 0.036) x 1.489

= 2.664 x 1.489

= **3.967m**

Therefore, the actual cutting length of the hip to the birdsmouth = ***3.967m***

STEP 6 To calculate the total cutting length of hip, add the eaves width to the run or plan length, less deductions. When the eaves width is 400 mm.

Total cutting length = (Plan length – deductions + eaves width) x true length per metre run

(2.700 – 0.036 + 0.400) x 1.489

= (2.664 + 0.400) x 1.489

= 3.064 x 1.489

= **4.562m**

Therefore, the actual total cutting length of the hip = ***4.562m***

STEP 7 To find the ordering length it will be necessary to add 150 mm to the cutting length to allow for the plumb cut at the foot of the hip:

Order length of rafter = 4.562 + 0.150

= 4.712

∴ Total order length, to the nearest 300 mm increment, of all the hips will be ***4.8m***

Quantity of hips

There are only four hips in the hip roof, therefore:

Order = 150 x 32 Oregon F5 – 4/ 4.8

Purlins

These purlins are spaced at 1800 mm c/c, therefore there will be only one row around the perimeter of the roof. They will be mitred under the hips at all corners.
Note: *An allowance of 150 mm is added for every 5.4m of length for jointing, where required.*

The length of the purlins will be equal to the length at the centre of the rafter length when measured horizontally between the hips on each side.

STEP 1 Length to the long sides.

$$= \frac{\text{Plate length + ridge length}}{2}$$

$$= \frac{7.200 + 1.800}{2}$$

$$= \frac{9.000}{2}$$

$$= 4.500\text{m}$$

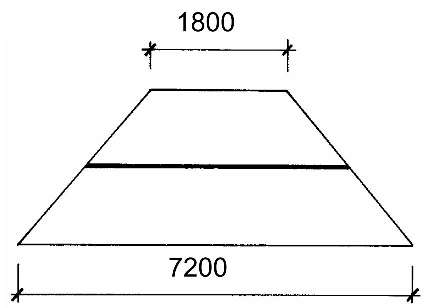


Fig. 92 Purlin length for long sides

STEP 2 Length to the short sides.

$$= \frac{\text{Plate length + ridge length}}{2}$$

$$= \frac{5.400 + 0}{2}$$

$$= \frac{5.400}{2}$$

$$= 2.700\text{m}$$

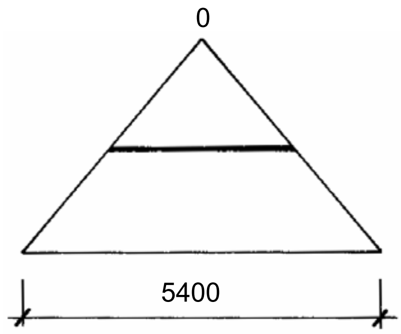


Fig. 93 Purlin length for short sides

Note: *Allow 1 length for each side of the roof.*

STEP 3 To find the ordering lengths it will be necessary to add 150 mm to the centre line length to allow for the edge cuts to the long points, under the hip:

Order length of purlins = 4.500 + 0.150 = 4.650, say 4.8m

= 2.700 + 0.150 = 2.850, say 3.0m

Order = 125 x 75 sawn Oregon F8 – 2/ 4.8, 2/ 3.0

Alternatively, the purlins may be butted against the sides of the hip, supported by a bearing block and strutted under the joint. This would allow 4.5 and 2.7 lengths to be used.

Collar ties

Collar ties are spaced every second pair of rafters, i.e. 1200 mm c/c, and it is assumed they will lie on top of the purlins at the centre of the roof rise.
Note: *They will only be necessary for the roof frame within the length of the purlins.*
Order = 70 x 35 Radiata pine F8 – 5/ 3.0

STEP 1 Collar tie length = Allow the same length as the short purlins

= 3000mm or 3.0m

STEP 2 Number of collar ties = $\frac{\text{Centre line length of long purlin}}{\text{spacing}} + 1$

$= \frac{4.500}{1200} + 1$

$= 3.75 + 1$

$= 5$

Inclined struts

The inclined struts will rest on supporting internal wall plates and run at 90° to the purlins. They are spaced, at maximum centres of 2100 mm, within the roof for the length of the purlins.

The length of the inclined struts will be equal to the rise of a right-angled triangle formed at half the length of the common rafter:

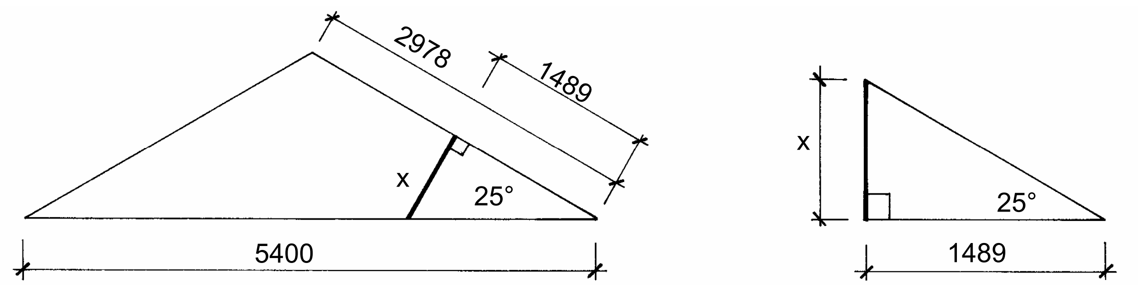


Fig. 94 'x' is equal to the length of the inclined struts

∴Allow 4 for each side + 1 for each end = 10 struts at 0.850m long.

STEP 1 Length = $\tan\theta\ 25° = \frac{x}{1.489}$

'x'= $\tan\theta\ 25° \times 1.489$

$= 0.466 \times 1.489$

= **0.694m**

STEP 2 Add extra length for struts to extend down onto wall plates, say add 150 mm.

= 0.694 + 0.150

= 0.844m, allow ***0.850m*** per strut

STEP 3 Number of struts for long side = $\frac{\text{Length of long purlin}}{\text{spacing}} + 1$

= $\frac{4.500}{2.100} + 1$

= 2.143 + 1
(say 3 + 1)

= 4 per side

STEP 4 Number of struts for short end = $\frac{\text{Length of short purlin}}{\text{spacing}} - 1$

= $\frac{2.700}{2.100} - 1$

= 1.286 –1
1.287 (say 2-1)

= 1 per end

Order = 75 x 75 sawn Oregon F7 – 1/ 4.5, 1/ 4.2

Soffit bearers

Divide the length of each side and end by the spacing of the bearers. The formula for the total number of soffit bearers for the sides will be:

$$\text{Number} = \left[\left(\frac{\text{length of side}}{\text{bearer spacing}}\right) + 1\right] \times 2 \text{ sides}$$

$$= \left[\left(\frac{7.200}{0.600}\right) + 1\right] \times 2$$

$$= [12 + 1] \times 2$$

$$= 13 \times 2$$

$\therefore$ $= 26$ 26 x 0.500 = 13.0m, say **2/ 4.5, 1/ 4.2**

(allow multiples of 0.650m for brick veneer construction)

$$\text{Number} = \left[\left(\frac{\text{length of end}}{\text{bearer spacing}}\right) + 1\right] \times 2 \text{ ends}$$

$$= \left[\left(\frac{5.400}{0.600}\right) + 1\right] \times 2 \text{ ends}$$

$$= [9 + 1] \times 2$$

$$= 10 \times 2$$

$$= 20$$

$\therefore$ 20 x 0.500 = 10.0m, say **2/ 5.1**

(allow multiples of 0.650m for brick veneer construction)

Order = 70 x 35 Radiata pine F8 – 2/ 5.1, 2/ 4.5, 1/ 4.2

Fascias

The fascia will run the full length and width of the roof, including eaves width.

Fascia length for sides = Length of wall + eaves width + allowance for mitres

= 7.200 + (0.400 x 2) + 0.050

= 7.200 + 0.800 + 0.050

= 8.050m

∴ Allow 1/ 4.2 and 1/ 3.9 per side

Fascia length for ends = Width of wall + eaves width + allowance for mitres

= 5.400 + (0.400 x 2) + 0.050

= 5.400 + 0.800 + 0.050

= 6.250m

∴ Allow 1/ 3.3 and 1/ 3.0 per side

Order = 200 x 25 Primed Radiata pine – 1/ 4.2, 1/ 3.9, 1/ 3.3, 1/ 3.0

Eaves soffit sheets

The eaves soffit strips will be cut from full 1800 x 1200 mm wide sheets.
Note: *The joint between the external wall cladding or brickwork and the soffit sheets will be covered with a 25 mm quad, or similar, during the Exterior cladding/ finishing stage.*

$$\text{Number of sheets for sides} = \left(\frac{\text{length of side + eaves width}}{\text{length of sheet}}\right) \div 3$$

(when '3' represents the number of strips cut from 1 sheet)

$$\text{Number of soffit strips per side} = \frac{7.200}{1.800}$$

= 4

= Say 4 strips per side

Number of soffit strips per end	=	$\frac{5.400}{1.800}$
	=	3
	=	Say 3 strips per side
Number of sheets (both sides)	=	(4 x 2) + (3 x 2) ÷ 3
	=	14 ÷ 3
	=	4.666, allow **5 sheets**

Order = 1800 x 1200 x 4.5 mm Fibre cement sheets – 5 off

Cost sheet