Module 14: The roof structure (Part 1) – Roof shapes, pitch & anchoring

Module Objectives

By the end of this session, participants will understand:

1. The minimum requirements for a roof as prescribed by the NBR.
2. Different pitched roof shapes and structures
3. The importance and relevance of roof pitch
4. Roof anchoring basics

Module at a glance:

<table>
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<tr>
<th>Topic</th>
<th>You will learn</th>
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<tbody>
<tr>
<td>The National Building Regulations general roof specifications</td>
<td>- What are the basic features required by NBR of any roof</td>
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<td>How different shape roofs are designed and built</td>
<td>- The essential design of the roof timbers used to form different roof shapes</td>
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<td>- Roof anchoring</td>
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<td>- Roof pitch</td>
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Roof terminology

Roofs come in many shapes: Semi-flat, mono-pitched, gable style, hipped; tiled, thatched, slated or clad with metal sheeting.

The terms used to describe different parts of the external roof are shown in this diagramme. Learners should be familiar with all of these terms in order to identify to the client the aspect of the roof which is under discussion in the inspection report.

Essential properties for a roof

The South African National Building Regulations (SANS 4.2.) states that: Any roof covering and waterproofing system, or part thereof must:

- Resist the penetration of rain – at least to the extent that any water which may penetrate the roof is of insufficient intensity to run down the inside surface of the roof or walls, or drip onto the ceiling or floor. In other words there should be no roof leaks which allow water to penetrate the inside of the house.
- Be capable of being effectively repaired despite aging of the materials. Products used in roof coverings and waterproofing systems must preserve their properties satisfactorily with normal maintenance for at least 10 years for systems which can be readily repaired and 20 years for systems that are difficult to replace:
- Resist temperatures from -10 °C to +80 °C, and rapid reversals of temperature of the order of 60 °C, without deterioration of the roof’s essential properties;
- Resist the effects of standing water on the top surface, and condensation at the under surface;
- Accumulated hail on roofs after moderate hail storms must not result in water penetrating the interior of the building.

**Roof pitch (slope):** A roof must have some slope in order to shed rainwater. So in reality flat roofs are never totally flat but rather have a slight fall - the minimum of a “flat” roof is 1:50. It is more accurate to describe such a roof as “semi-flat”.

**Eaves (overhang):** The overhang of the roof at the wall is called the eaves. The eaves of a roof perform important practical functions. Eaves protect the walls from the rain and from the sun. Wide eaves help to keep the walls shaded and cool, reducing power use.

Eaves can be “open” (rafters visible) or “closed” (full boxed or partially enclosed with strips). The underside of the eaves is often referred to by roofers as the “soffit”. This can be confusing as the term “soffit” can also be used to describe the underside of a slab.

**Common roof structures:**

Above are some of the most commonly found shapes of pitched roofs
**Gabled roof**

This is the simplest roof shape with two roof surfaces of equal pitch meeting at a ridge along the middle of the building. The ridge runs the full length of the roof and the end walls (gable walls) run up to the underside of the roofing. (“Cape Dutch Gables” are an ornate form of the same structure – here the gable extends above the roofing as a curved parapet wall).

![Typical arrangement of gable roof trusses](image)

Typical arrangement of gable roof trusses. One of the diagonal braces under the top chords – used for tiled roofs is shown. Herringbone bracing is used for sheeted roofs.

Gable roofs are not as inherently stable as hipped roofs and are more prone to wind uplift. As a result the rafters of gable roofs must be braced on the undersides to provide additional strength – diagonal bracing for tiled roofs and herringbone bracing for sheeted roofs (See NHBRC 3:4.8). With a simple gable roof only one truss shape is required.

**Hipped roof**

Hipped roofs are inherently more stable than gable roofs. These roofs are self-bracing, less prone to wind uplift and can have gutters all the way around the eaves – resulting in more efficient drainage.

A hip runs up from each corner of the roof to the ridge. A special truss, called a truncated girder truss is placed between the end wall and the apex of the roof. The truncated girder truss supports the jack and hip trusses that form the hip end framing. The girder truss is a
stronger truss member (often a double truss bolted together) and it derives its name because it supports the other hip and jack trusses.

The front of each of the roofs illustrated above shows different types of hipped roof truss systems (the back of each of the illustrated roofs are gable truss systems). Various standard hip layouts are commonly used depending on truss span, loading and pitch. Typical examples are: (Top Left) Small Hip System - suitable for low pitch roofs. (Top Right): Truncated Hip System - suitable for larger spans but not well suited to low pitches. (Bottom left): 45° Hip System - A versatile full girder system simple to erect but not generally viable at spans over 10m (under tiles). (Bottom right): Dutch Hip System - Dutch or louvered hip system. The red trusses are girder trusses (designed to carry the hip and jack trusses (coloured green and blue).
A Dutch hipped roof – also known as a louvered hip roof

**Roof valleys**

Where the building has an internal corner (at a roof intersection) a valley makes the join between the intersecting slopes. Hips and valleys run at 45° to the eaves and walls below.
Here is an L-shaped roof incorporating a hip end on the one side and a gable on the other. T-shaped roofs, which follow similar principles, are also often encountered.

Roof intersections are achieved through the use of span-diminishing valley trusses. These rest on the main roof trusses, and are normally from the apex of the valley towards the valley girder or wall. Where there is no load bearing wall through the intersection, a girder truss will be required to carry the roof trusses over the opening.
Cross-section of a roof valley on a tiled roof. Note that some modern roofs omit the valley boards – this is acceptable but results in a weaker construction.

Valleys are one of the most vulnerable places of a roof as regards roof leaks. A build-up of leaves can cause the valley to overflow. The same leaves hold moisture for long periods and so accelerate rusting in the valley flashing, or valley gutter. People are always told to keep their gutters clean, and rightly so, but a clean valley is far more important.

Valleys must be sufficient to handle the anticipated flow of water off the adjacent roof planes, without the water overflowing over the valley gutter into the roof cavity.

**Did you know...**
Valleys are an important part of the roof drainage system. Valleys are lined with flashing (gutters) – either galvanised and preferably aluminium and this flashing is supported by the valley rafter, counter battens and often valley boards.
National Building Regulations (RR3.1): Any valley or gutter shall have a cross-sectional area per m² of roof to be drained of not less than 140 mm² for summer rainfall areas and 115 mm² for year round rainfall areas.

An increasingly common practice for architects (and builders) is to close the valleys of tiled roofs in the pursuit of a neater look. This is very often self-defeating, because few roofers seem able to cut the tiles so that they butt neatly together. The NHBRC Manual (7:4.3.5) states that valleys should either be “open” by at least 50mm or “closed” by means of a butt joint. The manual goes on to say that the cutting of the valley tiles shall be neat and form a straight line. Tiles must overhang valleys by a sufficient distance to be weather proofed.

The problem with narrow, crooked or partially closed valleys, is that these drainage channels are prone to blocking with wind-blown debris (or debris left behind by the roofer or other tradesmen) and it is also not readily apparent whether the cross sectional area of the valley is sufficiently large to comply with the NBR “deemed to satisfy” regulation of a minimum of 140mm² (summer rainfall), and 115mm² (year round rainfall) per 1m² of the roof to be drained by the valley.

Clean open valleys of 50 – 100 mm width are desirable.

**Wall plates & roof anchoring**

**Wall plates**

Trusses, rafters and purlin beams must be supported on wall plates of minimum size 38 mm x 76 mm timber, or similar flat bearing surfaces which have been leveled. Wall plates are installed on the external walls – nailed to the top of the inner skin of bricks. NHBRC 3:4.5.5: Trusses must be supported only at the heel joints and not on internal walls.

Roof trusses must be tied down to the supporting walls and columns, by means of a galvanized steel strap or galvanized steel wires which have been built into the walls.

SANS 10400 KK13.2, 3: Such strap or wire shall extend into the wall to a depth of at least 300 mm in the case of a heavy roof (concrete or clay tiles or slate) or at least 600 mm in the case of a sheeted roof except that in the case where the depth of the masonry or in-situ
concrete is less than 300 mm and 600 mm, respectively, such strap or wire shall extend as far as possible into such masonry or concrete.

Galvanized steel strap anchors must be taken up over the top of the rafter or tie beam, bent down on the other side and nailed down from both sides. Ties made up of two strands of 4mm wire, built into the wall as above, can be used as an alternative to hoop iron on tiled roofs (but not sheeted roofs – unless the maximum truss spacing is 760mm. This would be a very unusual spacing for lightweight sheeted roofs). Wire ties must be taken up on either side of the rafter or tie beam, then twisted together so as to have no slack, but not so as to overstrain the wire, and the free ends then nailed down to prevent untwisting.
Builders often fail to calculate correctly the positioning of the roof anchors in the walls, with the result that some of the built-in roof anchors are located too far from the trusses when the roof is to be erected. The ITC specifies a maximum tolerance of 200mm between the built-in roof anchor and the truss which is to be tied down.

Any greater error on the part of the builder requires one of the following two remedial measures in order to ensure that the roof is properly tied down, with no slack in the anchor ties:

- A hoop iron strap extending 600mm down the wall can be fixed to the wall with five evenly spaced masonry pins and plastered over, OR
• A vertical shelf, equal in size to the top chord of the truss can be fixed between the trusses with hurricane clips and the built-in anchor can be used to tie down the vertical shelf.

Roof pitch

One of the main reasons for having a roof is to keep out the elements - especially rainwater. The way that this is done is to provide a slope (pitch) to the surface of the roof. Roofs are almost never designed to be waterproof, but are rather weather proof. In other words roofs are designed to shed rain water quickly enough to ensure water does is not able to penetrate the roof covering. In South Africa the pitch is defined in degrees. So a 5° pitch is semi flat, and a 45° pitch is very steep. Architects divide pitch into three categories:

• Low – 17° to 25°.
• Normal – 26° to 35°
• Steep – 36° to 45°

The pitch determines what materials can be used for the covering.
The NBR specify the minimum roof pitches for various coverings as follows:

<table>
<thead>
<tr>
<th>Type of covering</th>
<th>Minimum Pitch Degrees</th>
<th>Pitch</th>
<th>Min End Lap (mm)</th>
<th>Min End Lap (mm)</th>
<th>Min. End Lap (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheetling: Corrugated (incl. Box Rib) &amp; Profile (Incl. galvanised iron, fibre cement, polycarbonate &amp; fibre glass)</td>
<td>11</td>
<td>150</td>
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<td>250</td>
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<td>22</td>
<td>150</td>
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<td>150</td>
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<tr>
<td>Corrugated fibre cement sheets</td>
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<td></td>
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<td>26</td>
<td>150</td>
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<td>Specialised long span sheets (metal &amp; fibre cement)</td>
<td>3-5</td>
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<td>Manufacturer’s specifications</td>
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<tr>
<td>Fibre cement slates: with underlay</td>
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<tr>
<td>Fibre cement slates: no underlay</td>
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<td>Concrete &amp; clay tiles &amp; shingles: with underlay</td>
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<td>Concrete &amp; clay tiles &amp; shingles: no underlay</td>
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<td>Metal tiles: with underlay</td>
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<td>When metal tiles are used over an existing roof then the existing roof slope can be retained</td>
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<tr>
<td>Metal tiles: no underlay</td>
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<td>Natural slate on open battens: with underlay</td>
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<tr>
<td>Natural slate on open battens: no underlay</td>
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<tr>
<td>Thatch</td>
<td>45</td>
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<td>40° over dormer windows</td>
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