Study of Different Pitched Roof Types

Bassam Abu Awwad [1*] Manal O. Suliman[2*] Mansour Safran [1]

1. Department Of Architecture, College of Engineering, Jaresh University-Jaresh- Jordan

*E-mail of the corresponding authors: 3.bassam@gmail.com , safranmansour@gmail.com

2. Civil Engineering Department, College of Engineering, Jerash University, Jerash, Jordan

* E-mail of the corresponding author: Manal2015sd@gmail.com

Abstract

The roof is part of a buildings outer skin, and fulfils a range of functions: first it protects the space below it, open or closed, from the weather. Here the most important aspects are drainage precipitation effectively, providing protection from sun and wind, and affording privacy.

Different roof structures can be used according to functional requirements or the design approach. In this paper, different Pitched roofs types were reviewed and compared and their advantages and disadvantages according to several comparison criteria were present. The Parameters of each of the systems, roof structure, roof battens, water proofing, thermal insulation methodologies, and Types of Finish are discussed.

Keywords: Pitched roof, Mono pitch Roof, Gable roof, Mansard Roof

1. Introduction

Various forces act on the roof must be conducted to the ground directly, or via outside walls, columns or foundations. A number of factors are involved in choosing a suitable roof. Appearance is probably the most important criterion. Then come to the configuration and size of the plan view; construction costs and relevant building regulations play a crucial role.

The choice of structure and materials should be appropriate to the project in hand: elaborate prefabricated steel constructions are rarely used to provide for private houses, and hand-finished on-site detailing is avoided for industrial buildings were possible.

Choosing the most appropriate type of roofs depends immensely on weather condition of a place where the buildings are constructed. But buildings' functions have also produced typical roof shapes. For example, indoor tennis courts have vaulted barrel roofs that follow the flight of the ball; with normal events halls have flat roofs to facilitated flexible use.

Different roof types can be combined, but this often produces a complicated geometry of details. Simple structures are therefore preferable, to avoid leakage.

The main distinction in roof types is between pitched and flat roofs; generally speaking a roof is considered pitch if it inclines by more than 5 degrees. These two roof forms are clearly distinct in structure and function, and pitched roof will be considered in this paper in details.

2. Laws and Forces

The statics of a building deal with its structural stability: the forces acting on it and their affects have to be calculated. Newton's law says: force equal mass by acceleration. As a rule, forces cannot be identified directly, but only indirectly by their affects. For example, if we observe the acceleration of a body, we will establish that one or more forces are at work. But in the building, statics is the theory of the equilibrium of forces: the various parts of the buildings should be at rest. Its also essential to insure that the internal forces are also in equilibrium, which means that each component part has to withstand load. Its ability to do this depends on its thickness or dimensions, and on the solidity and elasticity of the material.

If a load compresses a construction element, compresses forces are generated. If the forces affecting the element are pulling it apart, tensile forces are generated. If opposing forces affect and element at different points, the element tries to twist. The building industry applies the technical term momentum or torque to this torsion. The sum of the maximum forces that could be exerted identifies the overall forces that have to be directed into the construction below and absorbed by it.

The forces affecting a building or a construction element are also defined according to their direction. A distinction is made between longitudinal forces and lateral forces.

Various forces act on buildings. They must be identified at the planning stage and plans must be made for

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transferring them into the ground in longitudinal, transverse directions, and vertically. Identifying the individual load forms the basis for dimensioning the roof construction. Planners must first decide which materials to use, so that the buildings' self-weight can be determined. The dead load is a permanent load. It acts vertically downwards. Imposed loads are the next factor. These can be movable objects, such as furniture, or people but it not necessary to list every object individually and take it into account when dimensioning the structure. Mean values are available for different types, e.g. dwellings, factories and warehouses. Individual specifications are required only in exceptional cases.
If a structural element is not planned to be generally accessible, a diagonal roof section, for example, it is still necessary to ensure that a person could walk on it for maintenance purposes, or assembly process. This is known as a point load. As a rule, imposed loads act vertically downwards, like dead load.
Wind, snow and ice loads act on the roof from the outside. Snow and ice exert pressure on the roof because of their weight, and so also create vertical forces, but wind can act both horizontally and vertically. These forces are identified as wind suction and wind pressure. Wind suction acts as lifting structural elements that are so loaded mush be appropriately protected against being blown away.

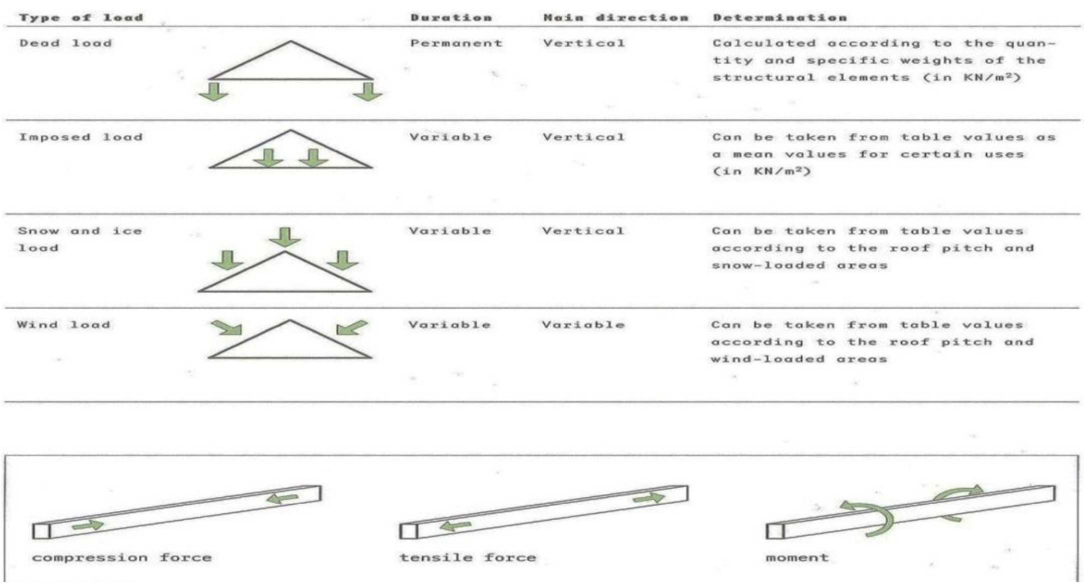

Figure 1. Type of Load

3. Pitched Roofs

By far the most roofs for detached dwelling are pitched. Pitched roofs are exceptionally well suited to draining precipitation of buildings. The load bearing structure is usually of wood and is made by hand, although steel and concrete are also possible. The triangular cross-sections under the roof surface absorb horizontal wind forces well and conduct them into the structure.
The highest point of the roof is known as the ridge and the lower edge as the eaves. The diagonal link on the wall of the house at the gable forms the verge.
When two roof surfaces intersect, the intersection line pointing outward is known as the arris and the internal line as the valley. It the roof is set on a wall that raises higher than the topmost ceiling in the house, this wall is called jump wall. The roof pitch is defined by the angle between the roof surface and the horizontal. This dimension is always given as the inside angle and is measured in degrees. For gutters and waterproofing element the term slope is used. This is usually given as a percentage.

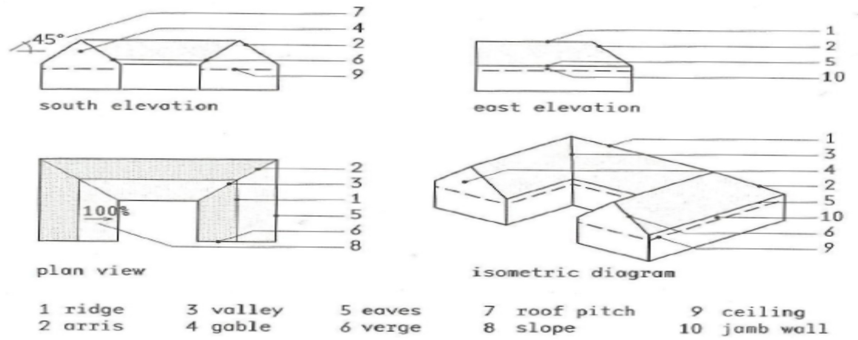

Figure 2. Elements of Pitched Roof

3. Pitched Roof Types

The different roof forms have names that define the nature of the roof and gable pitch.

3.1Monopitch Roof

A single inclined area is called a mono-pitch roof. This form produces walls of different height at the ridge and eaves, so is particularly suitable if a building in intending to face in a particular direction, e.g. toward the garden (for dwelling) or toward the street (for prominent public buildings).

3.2 Gable Roof

Two juxtaposed inclined planes form a gable roof. This and the mono-pitch roofs are the simplest pitched roof forms.

3.3Mansard Roof

A mansard roof has to juxtapose roof planes of different pitches, and is now less commonly used. It was intended to give more headroom if the roof space were to be used.
If the end wall under the pitched roof areas is upright, it forms a gable. If this area faces a street or square, the building can is said to stand gable-on to the street. The opposite, eaves-on is less common.

3.4 Hipped Roof

If the roof slopes on all four sides it's known as a hipped roof.

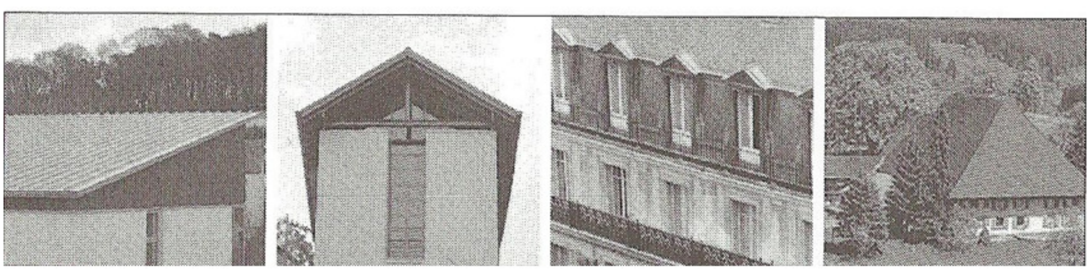

Figure 3. Mono-pitch Roof, Gable Roof, Mansard Roof, Hipped Roof

3-5 Pavilion Roof

A pavilion roof has all its roof planes pitched, with outside walls of equal length. The roof planes meet at a single point.

3-6 Half-Hipped Roof

If a roof has a gable and a pitched roof plane on the end wall, it's known as half-hip.

3-7 Barrel Roof

Roof can be built with cylindrical vaulting as a barrel roof. Roofs that are curved on all sides are domes.

3-8 Shed Roof

Shed roofs have small mono-pitch roofs or gables roofs aligned like the teeth of a saw; the steeper plane usually glazed. Fully glazed version is common. They are often used to light large spaces such as production halls.

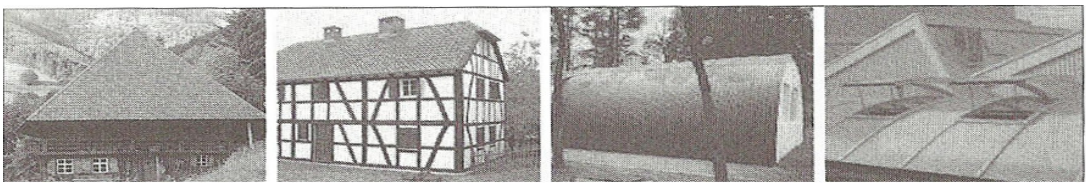

Figure 4. Pavilion Roof, Half-Hipped Roof, Barrel Roof, Shed Roof

4. Roof Structure

As well as roof forms, we distinguish between different roof constructions. For small roof intended for private houses, for example, wood is still the pre-eminent material it absorbs compression and tensile forces well, and is reasonably priced and easy to work with on site. Load bearing structures on steel or pre-stressed concrete beams are used when larger spans are involved, they can also be adopted for domestic building to achieve a particular design effect.
There are three basic load bearing systems for pitched roofs: Couple roof, collar roof and purlin roof.

4.1 Couple Roof

The couple roof is a simple triple frame form: if the structure is viewed in cross section it consists of two beams leaning against each other, the rafters, connected to the floor below or to the tie beam to form a triangle.The triangular frame work is called a pair of rafters. The beams are securely fixed at the connection points, but can turn freely, which is why such a frame is set to be hinged. A couple roof consists of several pair of rafters in a row, they should be 70-80 m apart, up to a maximum of 90 cm. the rafters are subject to load from self-weight, snow etc. the tie beam linking them absorbs the tensile forces that are trying to pull the pair of rafters apart. Hence the connection between the rafters and the tie beam of ceiling must allow the forces generated to be transferred into the wall or supporting member below. In the traditional craft design, the tie beam projects beyond the triangular frame at the eaves. The projection is called verge member.

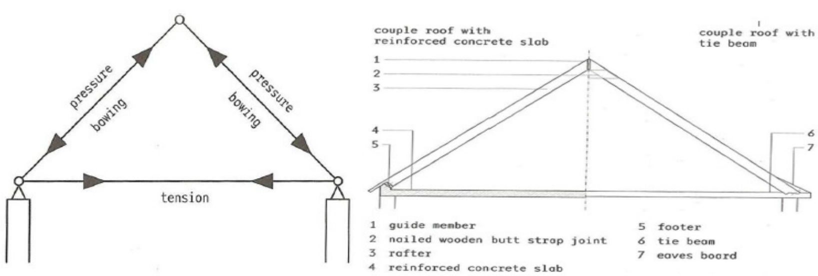

Figure 5. Load Scheme and Cross Section of Couple Roof

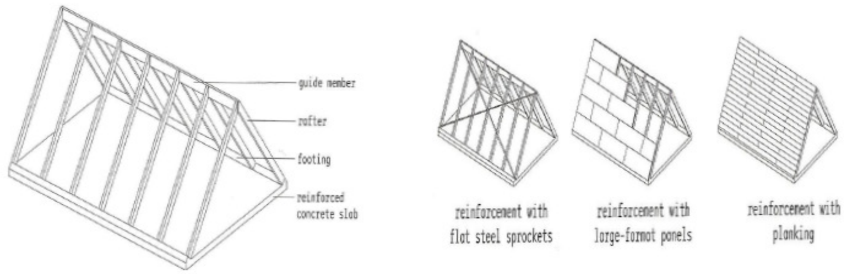

Figure 6. Isometric Diagram and Couple Roof as an Example of Reinforcement

4.2 Collar Roof

The collar roof, like the couple roof, is triangular frame work bowing of the rafters is reduced by an arrangement of horizontal ties, the collar ties, so that greater spans can be bridged. For structural reasons, the collar ties are usually arranged in pairs, as horizontal ties, and fixed to the sides of the rafters; they are best positioned statically in the middle of the rafter. The collar ties can also be arranged at a height 65-75 % of the total roof height to make the roof space accessible and provide more headroom. The design of ridge and eaves points and longitudinal reinforcement can be treated in the same way as for couple roofs. Collar roof are most economical at a roof pitch at more than 45 degree, and are suitable for spans of 10-15 m.

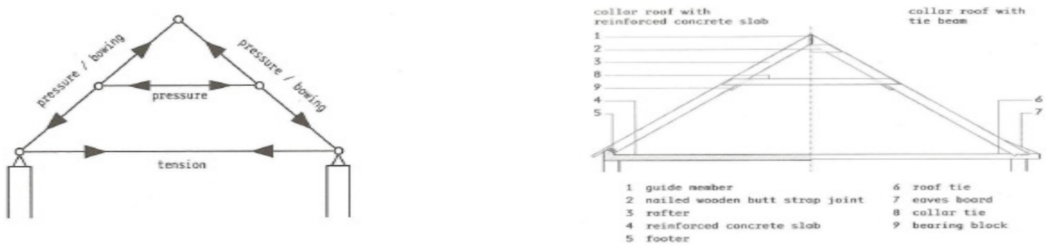

Figure 7. Load Scheme and Cross Section of Collar Roof

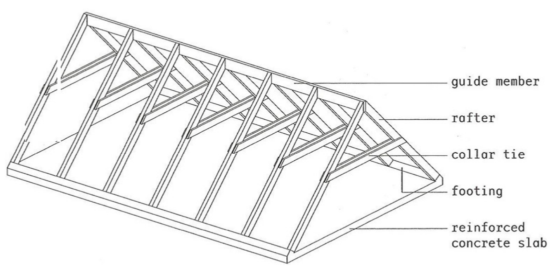

Figure 8. Isometric Diagram of Collar Roof

4.3 Purlin Roof

A purlin roof has horizontal members-purlins-supporting the rafters. The purlin can be supported by the outside walls or by uprights, the posts, or stays. Rafters are subject or building loads which are transferred to the purlins. The posts have to be braced so that they can also absorb horizontal wind load. The props run parallel to the roof pitch, with a space between them and the rafters. They are attached to the outside of the posts and make the roof better able to absorb transverse forces. The basic form is the simple purlin roof. Here, rafters are placed on the ridge purlin (at the ridge) and the east purlin (at the eaves) loads in the ridge purlin area are transferred through posts. The simple support structure gives the expression simple or single, purlin roof. In a double purlin roof, the rafters are supported by the eaves purlin and a central purlin (preferable in the middle of the eaves). As the span of the rafters is shortened they less like to sag.

Collar ties can be used for transverse reinforcement. If the ground plane is particularly large, a triple purlin roof can be constructed with eaves, center and ridge purlin.

The purlin roof is the most versatile classical roof structure form. The rafter system is independent, in the wide variety of irregular and composite roofs can be constructed, chimneys and windows can easily be fitted.

Roof pitch can be selected at will for purlin roofs. Good rafter lengths are up to 4.5 m between the purlins.

It's important when using this structure tat the loads from the posts can be transferred into the buildings load bearing system. The posts should be positioned on load bearing walls, joists or upright members below them.If the rafters are longer than 7 m there should be a ridge purlin as well as the eaves and center purlin. This then also transfers forces directed down into the load bearing walls by upright members. If this is not possible because of the ground layout of the floor below, a truss can be deployed.

Here, the upright members below the ridge purlin are taken only to collar or horizontal ties, where the vertical loads are transferred horizontally. The triangle of rafters, horizontal ties and upright then forms a frame comparable with a couple roofs.

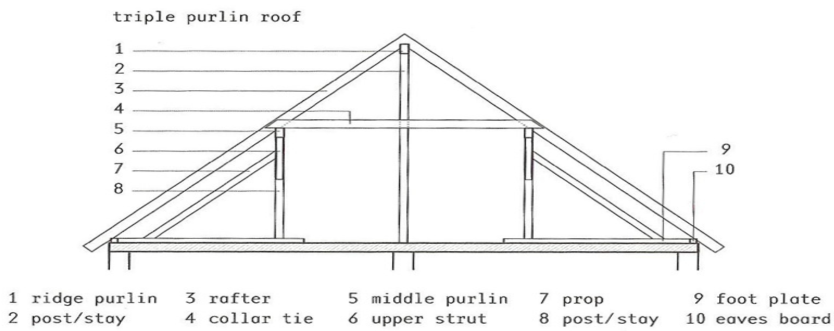

Figure 5. Cross Section of Purlin Roof

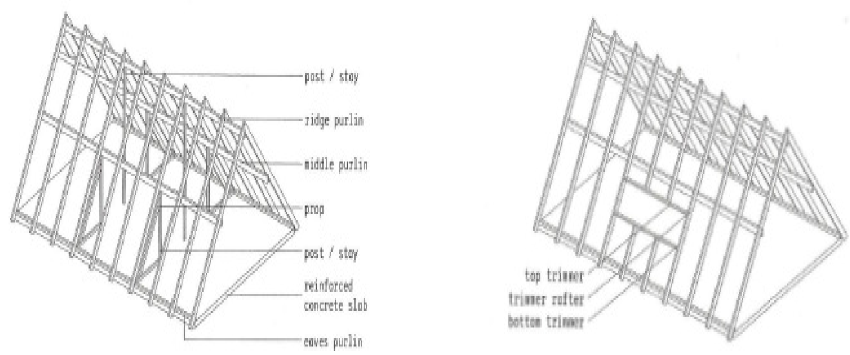

Figure 6. Isometric Diagram and trimmers in Purlin Roof

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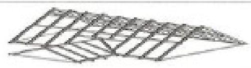
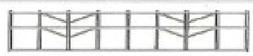
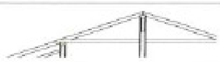
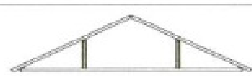
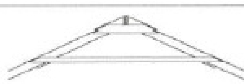
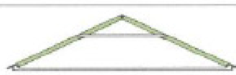
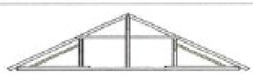
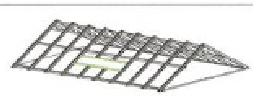
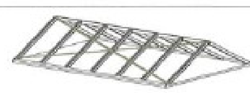
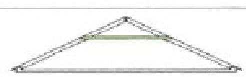
Table 1. Structural Elements for Pitced Roofs

Structural elements	Illustrations	Hints	Usual dimensions for average roofs
Eaves board		For couple roofs	8/12–10/22
Tie beam		For couple roofs	12/12–14/14
Ridge purlin		On walls or posts	14/16–16/22
Eaves purlin		On the ceiling or external wall	10/10–14/16
Collar tie		Usually in the form of a binding tie	8/14–10/20
Collar rafter		Internal curb	8/14–8/22
Angle clip		For tie bars	
Angle brace ties		Strut on post in longitudinal direction	10/10–10/12
Middle purlin		Under the rafters	12/20–14/20
Post		Supports purlins	12/12–14/14
Guide member		For simple assembly	Thicknesses from 22 mm
Rafter		Supports roof covering	8/14–8/22
Brace		For transverse reinforcements	14/16
Verge member		For couple roof	Length 20 cm
Trimmer		For apertures	8/14–8/22
Sprocket		Reinforcement	In flat steel
Binding tie		Horizontal reinforcement, in pairs	6/14–8/16

5. Layers of Structural Elements

5.1Roof Coverings

The roof coverings; principle function is to allow precipitation to drain away reliable and to prevent moisture penetration from driven snow, for example. Roof covering should be rain-and weather proof, and also fire proof. They must also guarantee moisture transfer from the inside to the outside, and protect the structural element underneath them from the wind. Key features in the choice of a suitable covering are design, and then the roof pitch and the shape of the roof. Valley or angles are more easily created with small-format materials such as flat tails. Large straight areas of roof are more easily and economically created with pan tiles. However many coverings work only up to a certain minimum roof pitches. The manufacturer's stipulated roof pitch for particular roofing material always relays to the minimum pitch unless otherwise stated. If this is not reached in some places, water or dust can be prevented from penetrating the structural or insulation course by an underlay. Various types of roofs covering material are available, again in different materials.

5.1.1Thatched Roof

One ancient form of covering that is now found only regionally or sporadically is read or straw thatch. It should be applied at an angle greater than 45 degrees. At an ideal 50 degrees the wind passes the thatch against the substructure and the proportion of lifting force is low. The covering is attached to a framework in several super imposed bundles.

5.1.2Flat Elements

Flat roof covering elements can be in wood (shingles), stone, concrete or clay. The standard roof pitch for shingles depends on the length of the shingles, the overlap for the individual shingles and the number of courses. Simple two dash course shingle roofs can be constructed only if the pitch is minimum of 70 degrees, in other words almost horizontal, while the more elaborated three dash course version goes to 22 degrees. Flat stone elements are usually made of slate. The come in the form of rectangular, acute-angled, scalloped or scale tiles and are pinned to a framework in the overlay area, following individual rules. The standard roof pitch for slate is 25 – 30 degrees.

Concrete or clay tiles are produced industrially. The advantage is that they can be bought to suit specific situation, such as edging or penetrations. An up stand can also be created if the tiles are to be laid on roof lathing. The standard pitch for concrete and clay tiles is between 25 – 40 degrees.

5.1.3Profile Tiles

Profiled roof tiled in their various forms are made of clay or concrete. Just like the industrially produced flat tiles, special shapes can be pre-fabricated for many particular situations. Unlike flat tiles, profile tiles overlap on three sides.

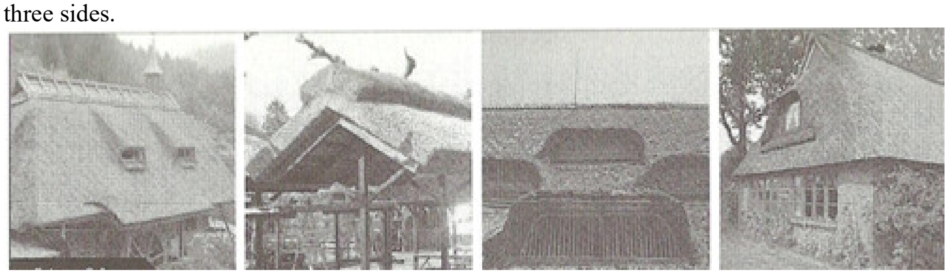


Figure 7. Thatched roofs

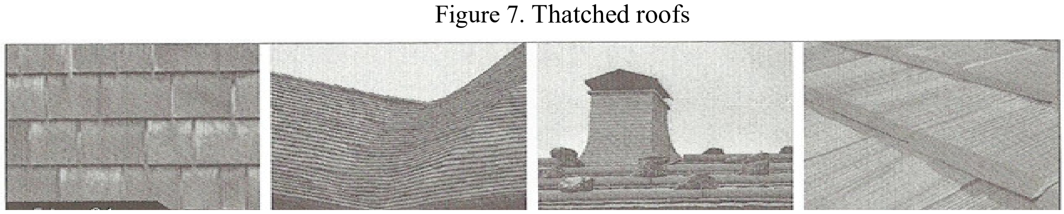


Figure 8. Flat Roof Covering Slates

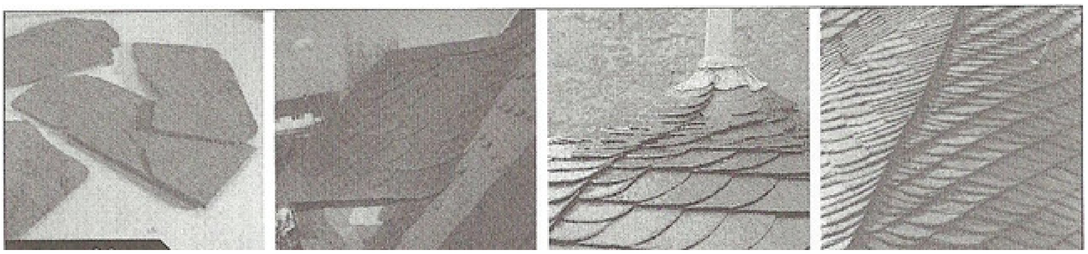


Figure 8. Flat Roof Covering Wood Shingles

5.1.4 Under-and-Over tiles

The oldest profile tiles are the under-and-over tile: conical hollow tiles are placed so that they interlock. The upper tile is concave, and takes the water into the lower, convex, tiles, which drain the water into the gutter. They have no rims or ribs. Modern tiles' up stands are shaped to interlock at the top and sides, to prevent water penetration. The standard roof pitch are profiled tiles is 22 – 40 degrees according to type. There are also profile tiles, such as corrugated tiles, available in various materials for large-format roof coverings. The fiber-cement corrugated tile is a simple example. These are laid over lapping on battens, it runs about one meter wide. Various manufacturers supply versions for edges, intersections and up stands. They can be used for roof pitches or less than 12 degrees. Lower roof pitches are permissible for corrugated bitumen roof coverings. Here, edges or connections are usually constructed using sheet metal angles.

5.1.5 Industrial Construction

Some profiled metal elements can be used for standard roof pitches of up to five degrees. These metal coverings are usually made of galvanized steel, copper or aluminum alloys. They are laid as corrugated profile sheets, following the same principles as fiber cement or bitumen coverings, or as trapezoidal profile sheets. Trapezoidal metal sheets are available in various shapes and sizes. They are made of thin, folded metal sheeting. The edges are optimized in terms of load bearing properties and can carry load over long spans. Trapezoidal sheets are supplied as composite sheets with thermal insulation, for industrial construction in particular. The edges of the sheets must overlap and interlock through up stands in order to guarantee the roof's impermeability. They are fixed to the supporting battens with screws, bolts or clips. When working with metal coverings it is important to insure that no contact corrosion with other metals ensues. E separating course should therefore be placed under the covering if the purlins are made of a different metal, or of concrete.

5.1.6 Strips

Strips are another form of metal covering. They are made of lead, aluminum, copper or stainless steel or galvanized steel. The strips are usually 500 – 1500 mm wide. They are laid in rows, or course. The side edges are joined with a welt, a role or an overlap. The horizontal ends of the sheets are finished with overlaps or transverse welts. Connections to other structural elements or ends are created by hand from turn-over sheet metal.The standard pitch for this kind of roofs covering is 5 degree. Additional persuasion never than less recommended for lower pitches.

5.2 Roof Battens

Flat roof covering materials are fixed to the battens with screws, nails, bolts or clips but roof tiles with an up stand are lead on battens.

The dimension of the battens depends on the weight of the covering and rafter spacing. The following longitudinal cross sections are recommended for average covering: up to 30 cm between rafters-> 24/48 mm battens, 80 cm between rafters-> 30/50 mm battens, 100 between rafters-> 40/60 mm battens. The quality grading of the timber should also be taken into account.

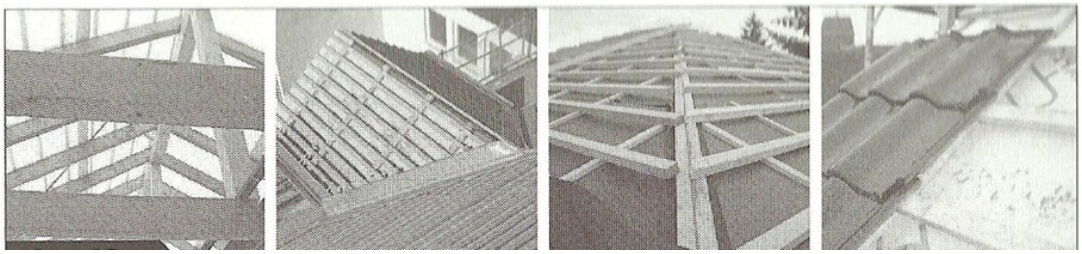


Figure 9. Roof Battens

Table 2. Roof Batten Cross Sections

Batten cross sections in mm	Axis width in m	DIN 4074 timber grades
24/48	up to 0.70	S 13
24/60	up to 0.80	S 13
30/50	up to 0.80	S 10
40/60	up to 1.00	S 10
A statical examination should be conducted for all other spacings between rafters or batten cross sections.		

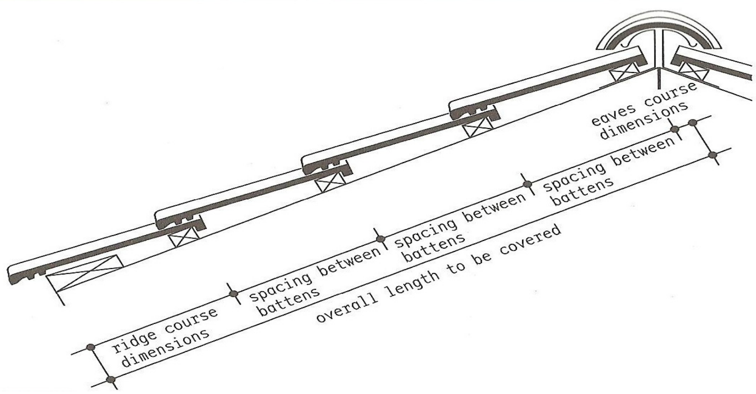


Figure 9. Roof Batten Cross-section

6. Water proofing

The roof covering usually insures that the roof is rain proof. However in particularly acute situation, additional planning measures should be taken to obviate spray penetration in cases of high wind or driven snow. Acute situation can be caused by an unduly low proof pitch, highly structured roof surfaces, special roof forms, the adaptation of the roof for living space etc. special climatic condition can also make additional measures necessary, for example, an exposed position, or areas subject to high wind for frequent heavy snow.

6.1 Underlay

The simplest additional element is an underlay. This is fitted as a ventilated sheet structure, i.e. the sheeting is not supported below, but hangs freely between the rafters. Underlay is supplied in rolls, and is usually in the form of reinforced plastic sheeting.

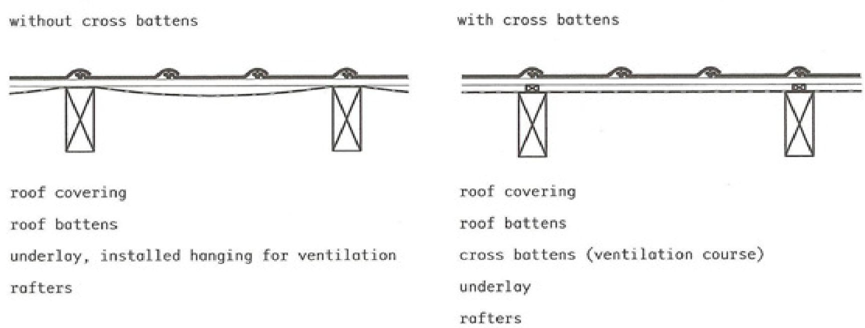


Figure 9. Underlay Courses

Table 3. Extra Requirements for Roof Covering

Roof pitch	Special requirements relating to use, structure or climate			
	No special requirements	One additional requirement	Two additional requirements	Three additional requirements
> standard roof pitch	-	Underlay	Underlay	Supported overlapping course
> 6° below standard roof pitch	Underlay	Underlay	Supported over-lapping course	Separate welded / glued course
> 10° below standard roof pitch	Rainproof underlay	Rainproof underlay	Rainproof underlay	Waterproof underlay
< 10° below standard roof pitch	Rainproof underlay	Waterproof underlay	Waterproof underlay	Waterproof underlay

6.2 Supported layer

Here the sheets are laid over a support, such as a timber structure. Different qualities are achieved through the nature of the seams. Such supported layers are classed as rainproof. They are fitted below the battens and counter battens.

6.3 Sewn welded underlay

These consist of waterproofing sheets joined by welding or gluing to make the waterproof. We distinguish between rainproof and waterproof underlay. A rainproof underlay may include structurally required apertures. The sheets are positioned under the battens and cross battens. No apertures are permitted in a waterproof underlay. The counter battens are an integral part, i.e. the sheets are fitted between the battens and counter battens. Close attention must be paid when fitting to ensure that water accumulation on the sheets can drain away into the gutter at the eaves. Adequate ventilation must be provided in the roof space under the underlay.

7. Insulation

If roof spaces are ventilated and not used as living space, the building below is usually insulated on or under the last ceiling. This saves insulation material, in contrast with an insulated roof, and is easier to install. However, roof spaces are increasingly being developed to take advantage of the additional space they can provide. In such cases the roof is included in the heated area of the house and all the structural elements enclosing the used section must meet the appropriate thermal insulation standards.It is important to ensure that the insulation course joins with the exterior wall insulation course, to avoid cold bridges.

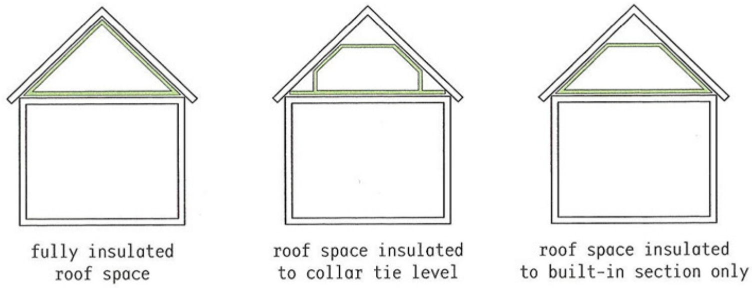


Figure 10. Insulating Roof Space

8. Thermal insulation

Mineral wool, rigid polystyrene foam boards (PS), rigid polyurethane foam sheeting (PU), cork, lightweight wood wool sheets and pouring-type granular insulation material are available for thermal insulation. The individual insulation materials are offered with different thermal conductivity ratings. Insulating materials with particularly poor thermal conductivity insulate correspondingly well, and can be thinner than materials with good conductivity, while still providing the same level of insulation. Thermal conductivity, the transmission constant (k), is given in watts per square meter Kelvin (W/m2K) and the lower the value of (k), the better insulation properties.

Thermal insulation can be fitted between the rafters, which must be high enough to provide a sufficiently thick insulation course. A higher rafter than statically necessary to provide the necessary space may be selected or an additional insulating course can be fitted to the rafters from inside the space. The timber used for the rafters is such poor conductor that thermal bridges are not created even if the insulating course is interrupted.

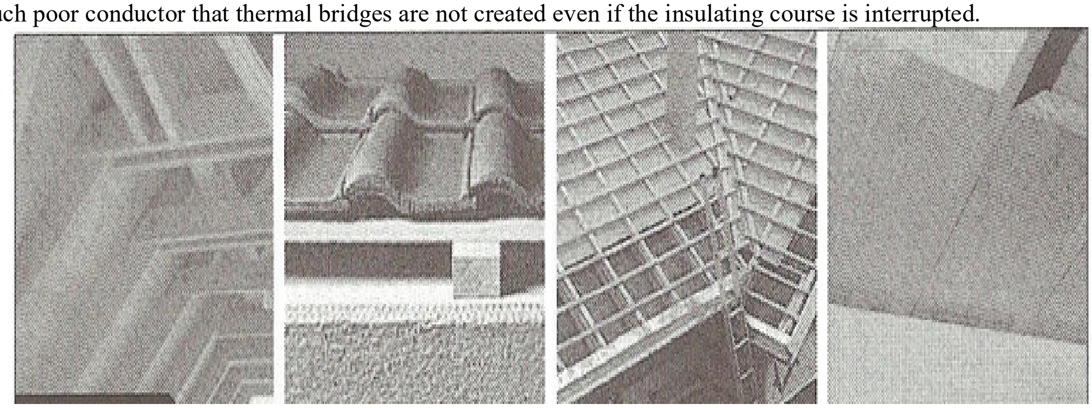


Figure 11. Thermal Insulation of Pitched Roof

9. Insulation between rafters – full rafter insulation – insulation on rafters

Insulation between rafters means that there is an air space between the thermal insulation course and the underlay sheeting, to ventilate the structure. If the height of the rafters is exactly the same as the thickness of the insulating material, the term full rafter insulation is used. If the rafters are to remain visible on the inside, the insulation can be fitted to the roof on the outside, with boarding, as insulation on rafters.

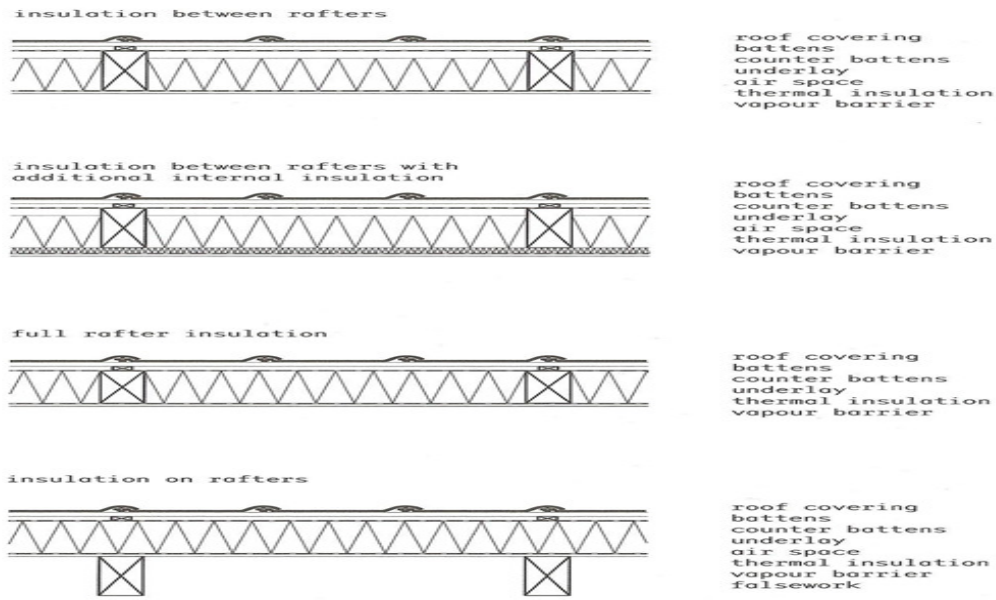


Figure 12. Types of Structures for Pitched Roofs

10. Vapor barriers

A vapor barrier is essential for thermally insulated roofs. It is always positioned on the inside of the space, below the thermal insulation. It must cover the full area, and be attached at the edges in such a way that it is airtight. Vapor barriers prevent moisture in the air inside the space from penetrating the thermal insulation or the roof structure through diffusion.
The appropriate insulation rating for the vapor barrier sheeting is determined according to the roof pitch and the length of the rafters. The vapor insulation rating gives the equivalent diffused air space depth (Sd) for the layer of air. This measure the resistance the material offers to water vapor transmission. Vapor barriers can be fitted in elastomeric sheeting or in plastic versions.
To sum up: the structure and the thermal insulation course in particular, must be protected against water penetration. This is achieved on the inside by fitting vapor barriers, which prevent penetration by moisture in the air. Outside, moisture in the air can evaporate above the ridge drained into the gutters via the underlay sheeting.

11. Types of Finish

11.1 Unventilated roof structure
Unventilated roof structures are constructed with full rafter insulation. The insulation is fitted between the vapor barriers (on the inside) and the underlay (on the outside). Counter battens should be placed on top of the underlay, to ensure that any moisture that may penetrate into the gap can evaporate under the roof covering. This construction method is used when the structural element must be kept as thin as possible, or when a roof is having a structure inserted subsequently, and there is insufficient rafter height for a ventilated structure. But if ventilation for the thermal insulation is considered essential, the rafters can be doubled by fitting an additional lath to the rafters from the outside or by installing a second thermal insulation course inside.

11.2 Ventilated roof structure

If this approach is used, air is able to circulate below the underlay (roof membrane). The advantage is that any moisture present can evaporate from the insulation material and escape via the ridge joint. The air space also means that the less heat is absorbed into the roof space (in summer). The warm air rises and escapes through the ventilation apertures in the ridge. A suction effect is produced, as in a chimney. It is essential here that sufficient air can flow in through apertures in the eaves.
When planning the air space depth, care should be taken not to fit the insulation completely flat, so that it has room to swell subsequently. If the air is to circulate freely, it must be diverted around trimmers, roof windows, chimney or dormers, so counter battens should be fitted, enabling air to circulate between the eaves and the

ridge.

11.3 Supported thermal insulation

Structures with supported thermal insulation are not usually ventilated. Instead, the roof is covered with prefabricated elements supported by false work above the rafters. Prefabricated elements of this kind are usually supplied with a vapor barrier on the underside. As in full rafter insulation, the underlay or an appropriate material for draining water away is fitted directly on top of the thermal insulation. This finish reduces building time. The rafters can remain visible underneath, and be used as a design element. In this case the rafters should be finished with planed acing timbers, or with laminated timbers.

12. Internal surface

The internal surfaces of developed roof spaces should be clad with a material that can absorb moisture and release it again, to produce a pleasant atmosphere in the space. Wall rendering usually performs this function in space with masonry walls. Plasterboard sheets are customarily used for building inside the roof space. They are easy to work and adapt on the building site. Note here that slight movements in the structure can easily produce cracks. Another common wall cladding is produces using matchboard with tongue and groove. This will not crack easily, because the boards can shift in relation to each other. But in most cases the principal deciding factor when choosing interior wall cladding is appearance.

13. Drainage

Pitched roofs are drained towards the eaves via the roof surfaces and valleys. The precipitation water collects in gutters there, and is taken into the sewerage system via downpipes. The term combined system is used when the water feeds into the public sewerage grid, and separate system when the precipitation feeds into the local groundwater.

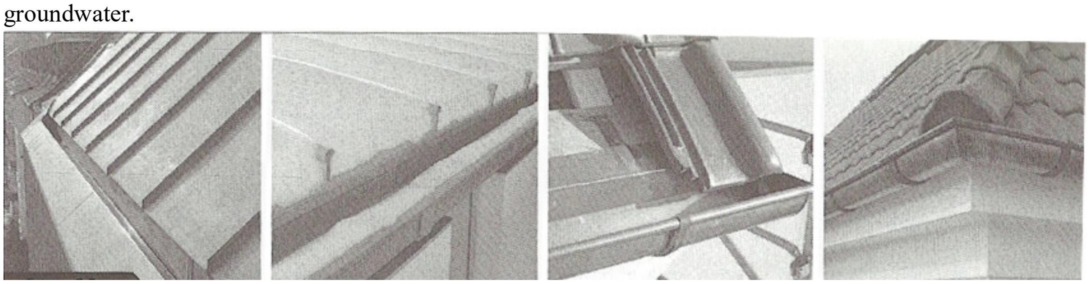


Figure 12. Drainage

13.1. Dimensioning

The assumed local rainfall load must be ascertained in order to dimension the gutters and pipes. The rainfall is calculated from the local rainfall load – generally at 300m per hectare – the runoff coefficient, which takes the roof pitch and the nature of the surface into consideration and the base roof area.

13.2. Gutters

Gutters are fitted to the eaves with height-adjustable gutter brackets. One bracket per rafter is fitted for timber roof structures, but the brackets should never be further than 90cm apart, depending on the structure.
The gutters are laid in the gutter brackets. Care should be taken here that the gutter slopes outwards, i.e. that it is higher on the building side than on the outside. Any water that may overflow in thus directed away from the building. The gutter should slope (minimum 2%) towards the drain pipes. Metal gutters in particular expand or contract if temperatures vary, so lengths of 15m should not be exceeded. Individual gutter sections are joined using connectors. Stop ends are fitted at the end of the gutters to see them off.

13.3 Downpipes

Gutter has prefabricated joints to which the downpipes are attached with elbows. Sections of pipe are connected by water proofing and connecting sockets. The pipes are attached to the building by brackets with pins or screws. The pipe should clear the building by more than 20 mm so that damp will not penetrate the wall if the pipe is damaged.

Gutters and pipes can be either angles or round. Various materials are available. Care should be taken that the materials cannot interact with each other to produce corrosion, for example, or create tension as a result of different expansion properties. So, for example, copper gutters and pipes can be assembles only with copper-clad steel brackets and clips. Brackets in galvanized steel or aluminum are recommended for aluminum gutters. Galvanized steel brackets and clips are available for zinc or galvanized steel gutters. PVC gutters can be fitted with galvanized steel or plastic-clad brackets.
It is also recommended that foliage interception grids be fitted to the gutters. These are supplied in the form of longitudinal baskets curving outwards, and increase cleaning intervals. Heated guttering can be installed at awkward placed, such as rising structural elements around an internal gutter; these will guarantee that water will drain off even in case of snow.

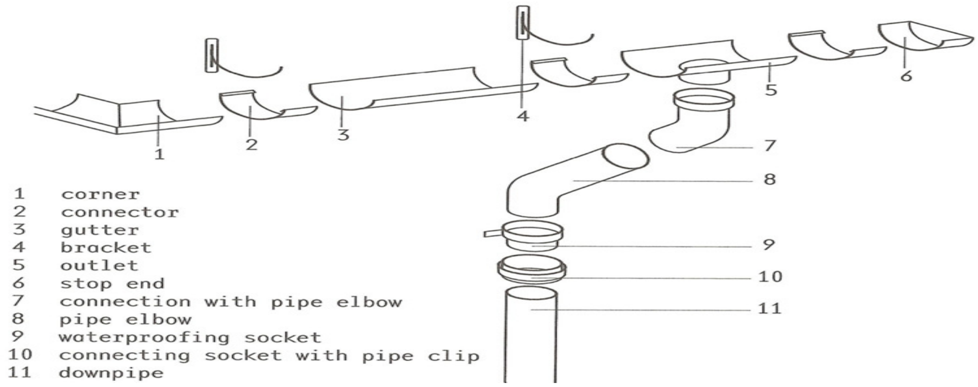


Figure 14. Gutter Kit with Suspended Gutter

13.4Internal Guttering

Internal guttering is the term used for gutters that are not suspended from the eaves, but positioned above the floor slab. This design is chosen if a roof overhang is not desired or not admissible. A safety gutter can be included so that even it leaks, water cannot penetrate the building. This can take the form of a waterproofing strip under the metal or plastic gutter. An emergency overflow spout can also be provided.

14. CONCLUSIONS

Pitched roof system allows for easy installationof framed and frameless photovoltaic modules on old and new buildings with all common kinds of roofing.
The pitched roof is architecturally diverse with many possible shapes, textures and colours, it is actually the fifth front of the building. This is supported by a range of clay tiles of formats and colours for all architectural audacities.
The pitched roof firmly has its place in modern architecture. Their versatility makes them ideally suited to create innovative design solutions, resulting where desired in futuristic-looking rooftops that reflect the modern world.
On an economic level pitched roofs provide particularly high value as they offer more living space compared to similarly-priced flat-roofed houses. Attic conversion is a perfect opportunity to create additional living space and it is cheaper than building an extension.
A well-designed pitched roof will last a lifetime and longer. This lengthy lifespan translates into economic savings for its owner, who will not be obliged to regularly pay for roof maintenance over the years. When maintenance is necessary, it is easy and requires only quick maintenance checks. Replacement of clay tiles is simple too.

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