

Pitched Roof



In this brief guide, we will explain what kind of the physical processes occurs inside the construction of the pitched roof and what is essential to building it sound and stable.

With regards to the maintenance and the use of the building, the thermal insulation plays the vital role. It is estimated that in pitched roofs approximately 30% of the heat energy generated by heating systems escapes easily. This significant amount comes from thermal bridging mainly due to the massive beams running through the roof structure via which the heat moves faster. Moreover, the moisture condensation in case of the poor ventilation might lead to the accumulation of moisture inside the roof and thus to the lowering of the thermal efficiency of the building.

Evaluation of the existing roof condition

Often roofs' construction of the existing UK houses are already heavily worn-out with air or wa-

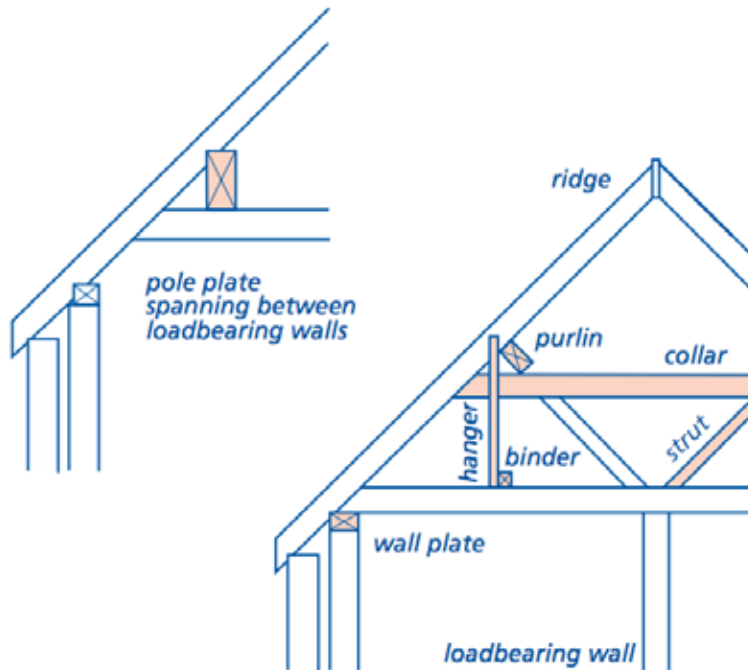
ter leaks, smaller or larger damages due to age and exploitation. It is necessary to either completely replace the roof structure or roof covering or refurbish the damaged part. It is recommended to employ the surveyor to assess the condition of the roof. The specialist will check the roof covering, guttering, airtightness, ventilation and insulation efficiency. Moreover, he will be able to assess the condition of the ridge, battens and rafters.

Pitched roof components include:

- **RIDGE** - the top of the roof constructed by the inclined surfaces at the top of the slope.
- **VALLEY** - place where two sloping surfaces intersect and the exterior angle is less than 180
- **VERGE** - the edge of the roof which run between ridges and eaves
- **COMMON RAFTERS** - run from ridge to the eaves at spacing of 30 to 45 cm
- **TRUSS** - it is the frame constructed of the triangles to support the roof top
- **EAVES BOARD** - ends of lower roof covering materials are rest on eaves boards, which is made of wood and placed at the bottom of rafters
- **POST PLATES** - are laid parallel to the face of the wall and support rafters
- **BATTENS** - made of wood and nailed to the rafters to give support for the roof covering
- **PURLINES** - wooden or steel parts by truss or wall, used to support rafters
- **STRUTS** - give support to purlins to prevent deflection and transmit roof loading to loadbearing structure below.
- **COLLAR** - ties the roof at the purlin level
- **CEILING BINDERS/HANGERS** - support long span ceiling joists

We can distinguish between single roofs, double roofs, trussed roofs or trussed rafter roof. The position of the rafters make a huge difference in the roof construction. The standard fink roof truss is common for 35 percent degrees pitch or less, but does not allow for loft accommodation. In the case of attic truss roof the beam and struts make a wide opening easy to convert to living space.

Generally the spacing of rafters and ceiling joists should be not more than 600mm. The size and spacing of tile battens should be in accordance with the roof covering manufacturer's recommen-



(Illustration source: NHBC, Part 7 Roofs, Chapter 7.2, p.9)

The optimal thickness of insulation for the attic purposes is approx 25-30 cm of panel stone wool laid in two layers. Reduce the negative impact of thermal bridges by fully covering the roof slope with the insulation layer, limit the size and number of fasteners and other elements passing through the thermal insulation layers, but also to ensure the proper air circulation that will allow any moisture to vapour.

The underlay should not be exposed at eaves where the proprietary eaves guards can be used to protect it.

We can distinguish between two types of the insulation of the pitched roof- warm deck and cold deck. Warm deck is where the insulation is placed on top of the rafters/joists, and the roof covering, for instance, felt or tiles are then placed over the insulation. The battening and tiling is then fixed down over. The thickness of insulation will vary depending on the manufacturer's specification. A cold deck is where the insulation is placed between the joists/rafters or in between the ceiling joists in the case of a pitched roof. Ventilation is required for these roofs. The thickness of insulation in both cases will vary depending on the material you use and the manu-

datations. Battens and counter battens should be as specified in the engineer design. Nails for fixing battens should be 3.35mm (10 gauge) x 65mm long. For trussed rafter roofs not subject to uplift, the minimum fixing should be two 4.5mm x 100mm long galvanized round wire nails, skew nailed, one from each side of the trussed rafter. Alternatively, truss clips can be used. Metal straps might be required in some cases. Lateral restraint straps should have a minimum cross section of 30mm x 5mm and a minimum anchorage downturn of 100mm.

Insulation

How to insulate the pitched roof to allow for ventilation and prevent the moisture condensation? It is the complex task as it is necessary to apply insulation that features the low thermal conductivity, allowing to maintain the U values max heat transfer coefficient ≤ 0.18 (W / m²K), but also one that will effectively secure roof truss elements. In this respect rigid insulation with low density and disturbed fibres structure is perfect. Such insulation not only fits easily between the elements of the structure and fills the voids, but additionally increases the level of protection of the wooden truss against fire. Still a lot depends on the thickness of the insulating material.



facturer's specification. The roof should have vents installed along the eaves to both front and rear or from side to side. In the case where the insulation is placed between the rafters then vents should also be placed along the ridge.

In case of the roof refurbishments, it is necessary to assess the risk of the damp or mild forming on the surface of building partitions. It can be done by measuring the temperature coefficient fR_{Si} defining the difference between the surface temperature and the outside air temperature, divided by the temperature difference between indoor and outdoor air. The temperature coefficient fR_{Si} should not exceed the value of the critical factor $fR_{Si, max}$. The air condition in rooms vary but the commonly accepted minimum value of $fR_{Si} = 0.72$ for rooms with an average monthly air temperature of $20^{\circ}C$ and an average relative humidity of 50%. In practice, such parameters can only be achieved in air-conditioned rooms. In residential buildings, with gravitational ventilation, the relative humidity of the air can be very different and usually significantly exceeds that 50%. It should not exceed 80%. In the general case of a roof insulated with rigid insulation panels, the amount of condensed dew should not exceed $0.5 \text{ kg} / \text{m}^2$. Rigid insulation to be effective requires the proper joining and sealing of the gaps.

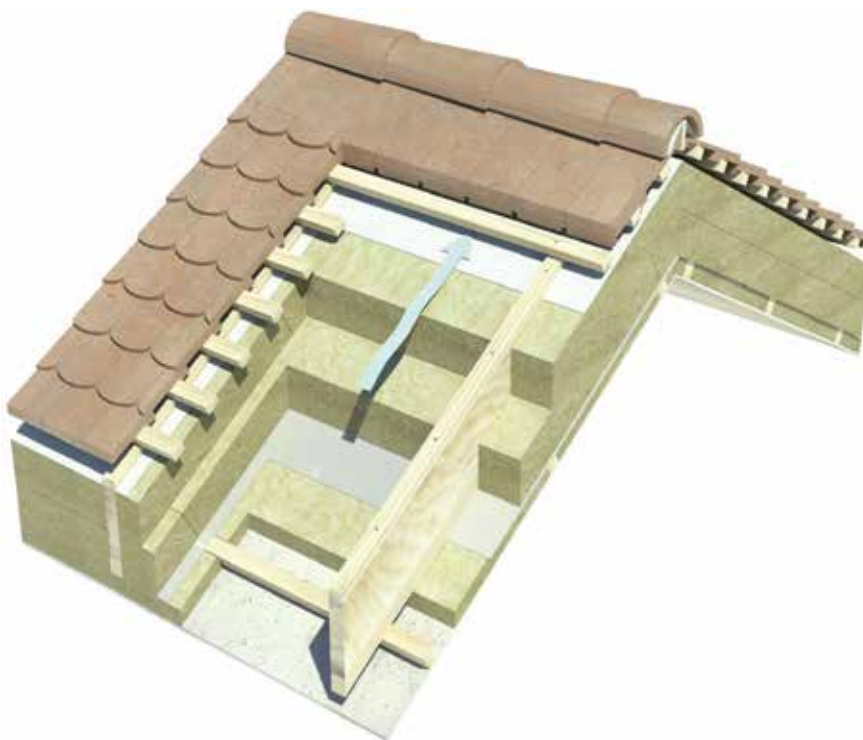
Ventilation

BS 5250 sets out the minimum requirements for roof space ventilation. The design of the roof dictates the choice of the ventilation system or products. The ventilation requirements depend on the type of roof membrane used under the tiles or slates and battens. If the roof membrane (underlay) features a high moisture resistance, then the building regulations require a 50mm wide ventilation gap beneath the roof covering and tiles. In the case of the ventilation of the pitched roof is ensured by leaving the void left between the insulation layers. This allows removing the excess moisture from the structure thanks to the air stream.

We can distinguish between primary and secondary roof ventilators called voids. The central roof vent is below the rafter, while the secondary roof vent is higher, usually between the beams and roof plate. The position and type of the ventilation also depend on the degree of the roof slope. In all kinds of roof, ventilators have to run along the eaves and along the opposite sides of the roof to form the cross-flow ventilation.

The primary roof ventilators

In the standard pitched roof where the slope is of 15 degrees or greater, the airflow void should be



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of 10mm. In the case when the slope is of less than 15 degrees, the opening of at least 25mm should be left to allow the airflow. In the pitched roof with the accommodation on the attic, the airflow gap of 25mm is required. Such airflow void allows the air to heat up, absorb the moisture, and direct it upwards until it leaves the building through the bridge holes.

The secondary roof ventilators

In the case of the standard pitched roof, the ventilation has to run between the roof covering and the roof insulation. The ventilation has to be provided in a continuous way on both sides of the roof. The airflow void should be of at least 25mm in the case of both more than 15 degrees slopes or below 15 degrees roof slopes. However, when there is an accommodation in the attic the airflow opening of 50mm is required.

Air tightness

In most cases, there is overpressure in the upper parts of the building caused by large temperature differences between the outer and the inner side of the roof, which in part explains higher thermal losses than in case of external walls. In order to avoid condensation of water vapour, and consequently damages caused by moisture, the vapour barrier should be considered on the inside of the roof, and all connections, ducts and elements

connecting the roof trusses with ceilings and walls should be appropriately sealed. The tightness of the building envelope is measured with the standard pressure test. However, it is necessary to note that most of slates and tiles are sufficiently 'air open' to allow the adequate air movement through the void between the slate/tiles and the underlay. If the air flow is not known, it is necessary to allow for roof space ventilation or batten space ventilation for instance in the form of 25mm gap at eaves and 5 mm gap at ridge, with 25mm deep counter batten.

Some underlays or insulating breather membranes allow to upgrade insulation and manage condensation without raising the roofline. This option is particularly interesting in case of the roof retrofitting projects, as it can be done without any disturbance to the building occupants. The renovation works might reveal that the insulation may be limited based on the rafter depth and it may not be practical to put additional insulation under. Moreover, in case of the plaster ceiling or a lath applying the layer of the insulation into the rafter space may damage the ceiling below. New builds are fitted with the vapour control layer but in the case of the existing buildings the structure has to be checked to assess the need for a ventilated air void. In case where 50% of the roof is being refurbished, the insulation has to be upgraded too.



Loads

The pitch roof has to support loads coming from different sources, including:

- materials- tiles, battens, felt, insulation
- weather- wind, snow, rain
- additional weight- maintenance worker etc.

The strong wind need to be offset by the stable roof structure. This is achieved by using approx. 1.2m long straps with a cracked end which is fixed to the wall plate (to which the roof timbers are fixed) and then the inner skin of the wall at every 2.0 centres. Timbers in a pitch roof spread away if ceiling joists won't stop them. Ceiling joists should be fixed to the bottom end of the rafters. In case of opening in the roof the other system should be used to tie rafters to wall and stop from spreading. Holding down straps might be required in some cases and the roof covering manufacturer provide guidance on their installation.

Fire resistance

Roofs should adequately resist fire spread, so all components should be fire resistant or special treated including roof coverings, chimneys and flue pipes. Roof timber and felt should be kept away from heat sources. Junctions between roofs and walls shall resist fire spread.

Fascias and soffits

Timber used to construct fascias, bargeboards, soffits should be pre-treated with preservative



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against decay. All joints should be cut and fixed. Fascias should have two fixings into each rafter and should be fitted to accommodate the correct pitch.

Roof drainage

Roof drainage with rainwater gutters and downpipes of sufficient size should adequately carry rainwater away from the roof. Dormer and porch roofs might be fitted with a drainage system as well. Flashings and soakers should be of the same materials.

The pitched roof, from the structural and thermal point of view, is a highly sensitive place, which directly affects the energy standard of the finished

building. It is worth to take into consideration the proper functioning of the ventilation voids at the design stage, by choosing the right type of insulation and ensuring adequate airflow inside the structure.

For more details on the roof insulation materials or roof access we recommend our previous editions of IBB Builder. You will find there also detailed guidance on the flat roof construction.

For more information on pitched roofs, refer to Building Regulations or NHBC publications.

Disclaimer: Please note this article should not be taken as the professional advice but informative guidance only. Always follow the Building Regulations and other statutory requirements.