Slate and Stone Roofing in Wales and the Marches

SPAB Technical Advice Note
Terry Hughes BSc (Hons), FIoR Dp Man
Richard Jordan FIoR SPAB William Morris Craft Fellow

The Society for the Protection of Ancient Buildings
37 Spital Square
London E1 6DY
020 7377 1644
info@spab.org.uk
www.spab.org.uk

Contents

This Advice Note describes the production and use of slates and stone slates in Wales, west Gloucestershire, and the counties of Herefordshire, Worcestershire and Shropshire, and deals with the maintenance and repair of roofs and wall cladding. It explains the basics of the region's slating practices, including many of the local variations, and considers details specific to the traditions of roofing and cladding in the region. Additionally, it discusses adaptations, where appropriate, to incorporate modern requirements such as improved thermal performance. It includes brief explanations of novel but now rare slating systems, which were developed or promoted by the slate industry in response to mill fires and war time materials shortages as well as to expand the market for slate. Videos illustrating some of the slating techniques are linked from the text.

Cover image: Field shelter, Cwm Nantcol,
Snowdonia National Park

Photo Terry Hughes

1 Introduction

1.1 Development of the slate and stone slate industries

Today the term Welsh slate implies a roof of single sized, fairly thin and fairly smooth-textured slates originating from the huge quarries and mines of north-west Wales. This disregards the wide variety of products which were produced in hundreds of quarries working stone, shale and slate prior to the 20th, century and the diversity of roofs created using them. It also overlooks the special slate types, such as Colloidal slates and Patent slating, which were promoted by the major quarries to expand their markets.

There is archaeological evidence throughout the region of roofing slates found in excavations of Romano-British sites such as the fort at Segontium, Caernarfon and the bathhouse at Tremadoc, Gwynedd (see figure 1) and stone slates on villas at Ely near Cardiff and Llantwit Major in South Glamorgan. However, the earliest post-Roman records of slate quarrying date from the 13th century, when Edward I used slate to roof parts of his castles at Caernarfon, Conway and Carmarthen.

By the 15th century there is evidence that slate was being quarried in the Nantlle, Ogwen, Llanberis and Conway valleys of Caernarfonshire (see figure 2); in the Berwyn range near Llangollen; at Aberllefenni in south

Figure 1: Hexagonal slates excavated from the remains of a Roman bathhouse near Tremadoc Gwynedd still in perfect condition after being buried for 2000 years. Produced from the Nantlle to Bethesda slate belt, they are examples of diagonal slating (see section 5.9).
Photo: © Gwynedd Archaeological Trust,

Merionethshire and in mid and south Wales, especially in Pembrokeshire. By 1583 slate had become the principal export from Wales to Ireland.

Vernacular slates and stones are the product of small quarries. They are all random-sized and generally rough-textured. They include the shales and slates produced in south-west, mid- and north Wales, and the stone slates of south Wales and the border region (see figure 3). So the region's roofscape falls largely into three categories: the vernacular or preindustrial slates and stones; modern slates developed

Figure 2: Barnacle-encrusted slates from the Pwll Fanog wreck in the Menai Strait near Bangor Gwynedd. The slates, approximately 10 x 4 inch, originate from the Cambrian age, Nantlle to Bethesda slate belt. The wreck was carbon dated to the latter half of the 15th century.

Photo: Terry Hughes

Terminology

Technical terms used in this Advice Note and not explained here or in the text are included in an online glossary (see section 10.5). The meanings of some words are variable and need to be understood before reading on (see video 0).

Slate - Strictly, this term should be applied only to stones derived from sediments which have undergone low-grade metamorphism - the process of compression and heating under which the sedimentary minerals are recrystalised and re-orientated perpendicular to the compression. They can be split into thin, strong and flexible sheets, which are not parallel to the original sedimentary layers. In practice, where the specific type of rock is not relevant or is obvious, the term slate can be used to mean other roofing stones such as shales or sedimentary sandstones and limestones.

Shales - These are splittable rocks which have not undergone metamorphism, or less so than true slates.

Stone slates - A commonly used, but geologically deprecated, term for splittable sedimentary rocks. In geology texts, the term tilestone is often used instead.

Tilestone - When capitalised Tilestone is used for a specific stone slate exploited along the Tilestone Formation on the north side of the South-Wales coalfield and north-eastwards towards Ludlow in Shropshire.

Cleavage - The property of true slates which allows them to be split. Also, a verb, to cleave. In quarries, the synonyms rive or riving are more common.

Fissile, fissility -The property of sedimentary stones which allows them to be split along bedding planes.

Random slates - Slates with a variety of lengths and widths sold by weight. They are usually described in the form longest to shortest lengths by random width, for example, 24 - 12 x R inches. They are sold by weight with an estimated coverage.

Tally slates - All slates in a consignment of the same length and width. Sold by count.

Slate length - The length of slates sold by quarries is the overall dimension from the tail to the head (bottom edge to top edge). But for top-fixed slates the effective length is the dimension from the tail to the bottom of the fixing hole and this is typically 25 mm (1”) less than the overall length. This is important because it is the length to the fixing hole which is used to establish the gauging of the roof and hence the area that can be covered with a given quantity or weight of slates. Failure to appreciate this can result in expensive under-estimates of the cost of a roof. When carrying out random roof surveys or recording, it is the length to the fixing hole which should be measured.

Proportionation - Any system for setting out the slating - gauging the laths or battens - in which the gauge is determined by dividing the slate lengths by a number.

Slating in thirds - Gauging by dividing the slates’ lengths by three.

Pin slating - In this proportionation system slates are laid triple-lapped and the lath gauge is determined by dividing the slates’ lengths by 3.5. Hence three-and-a-half pin slating.

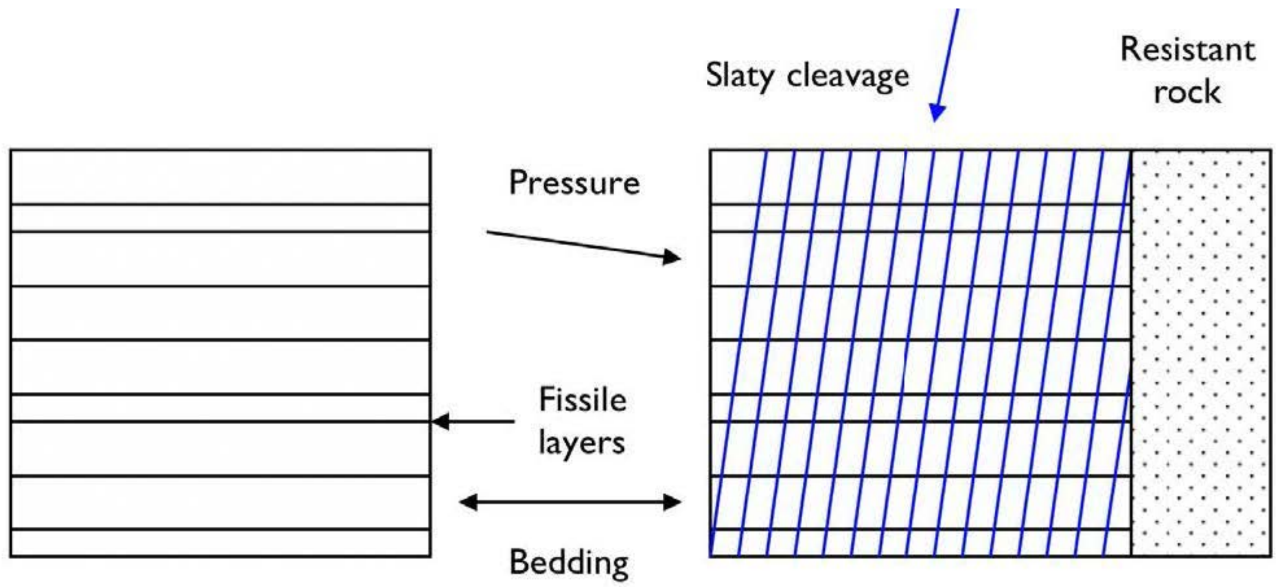


Figure 3: Bedding and cleavage. Sandstones and limestones are sedimentary rocks which are fissile along the bedding layers. Shales have been very slightly changed from sedimentary deposits, either under their own weight or by very low grade metamorphism. Although they have been described in the past as slates they are not slates geologically and many did not last long on a roof. True metamorphic rocks, such as slates, schists and phyllites, have been changed from sediments by pressure and heat in the earth's crust. They split along the resultant cleavage planes almost always at an angle to the bedding. This is known as slaty cleavage.
Illustration: Terry Hughes

during industrialisation; and specialised products and roofing techniques.

In the past there were hundreds of slate quarries in Wales. They too fall into three groups: the small operations supplying their immediate locality; the somewhat larger ones which supplied slates beyond the immediate area but only on a modest scale; and the major quarries and mines of the north-west which had national and international importance. Table 1 is based on Richards (see section 10.5 Richards) and shows the operations which he ranked as more significant within their locality. However they are not all of similar size: some, although important for vernacular buildings locally, were quite small. The major and nationally important examples are shown in bold.

As the major quarries developed they devised new products and novel, for the UK, methods of slating (see section 5). Slates gradually increased in size, eventually producing sizes up to 48″ (1.2 m) long, known variously as rags, queens and tons (see figure 4). The latter were so named because they were sold by weight.

By the mid-19th century, the north Wales quarries had grown large enough to be able to segregate slates into single sizes, known as tally slates to distinguish them from random slates sold by weight. It was cheaper to construct roofs with these and gradually single-sized slating displaced the older styles and those quarries which were too small to compete closed down. Despite attempts by the Arts and Crafts movement to encourage the use of vernacular slates and techniques, their use declined throughout the 19th and 20th centuries. Small and later large quarries closed until, by this century, only the major operations in north-west Wales at Bethesda near Bangor and at Blaenau Ffestiniog are still producing roofing slates.

Figure 4. As the major quarries developed and gained access to the deeper, better cleavage slate they were able to make larger slates. These were known as rags, queens or tons. As much as 48″ (1.2 m) long they were able to compete with the large sandstones slates of the Pennine counties.
Photo Terry Hughes

Alongside the introduction of tally slates, sawn battens became available and these allowed slates to be centre-nailed rather than top-fixed.

Slates nailed in this way do not need to be bedded in mortar because they are inherently resistant to wind uplift. Bedding therefore ceased for all but the smaller slates, which continued to be top-hung. Torching persisted as a means of draught-proofing and to prevent snow penetration, until the general adoption of roofing underlay from the mid-20th century. Today, for new buildings, the old styles of slating have been almost entirely supplanted by single-size slates, centre-nailed to sawn battens over underlay. Happily, many of the old roofs still survive to add variety to an increasingly bland roofscape. But their future is by no means secure. Roofs continue to be lost on the ill-informed assumption that modern slating is better than the traditional systems.

Specialised slate roofs are rare Indeed, some types may have disappeared long ago but they are important to the history of the industry and wherever they still exist they should be carefully conserved.

Modern (tally) slating is ubiquitous. It roofed the houses, factories, commercial buildings and chapels of the 19th and 20th centuries and continues to thrive in the 21st. It was only with the post-war availability of cheaper asbestos-

Formation	Region	Location	Slate quarries and mines
Silurian	North	Betws-y-Coed and Llanrwst	Rhos, Foel, Cwm Machno, Bwlch Gwyn, Hafod Las
		Ruthin, Corwen, Llangollen and the Tanat Valley	Craig Rhiwarth, Llangynog, Cwm Maengwynedd, Penarth, Moelfferna, Moel Fferna, Cambrian, Wynne
Ordovician	North	Bala to Ffestiniog	Braich Ddu, Aran
		Cwm Pennant to Porthmadog	Prince of Wales, Cwm Bach, Gorseddau
		Beddgelert to Porthmadog	Coesor, Rhosydd
		Blaenau Ffestiniog	Wrysgan, Cwmorthin, **Oakley**, **Llechwedd**, Bowydd, Diffwys, Maenofferen, Graig Ddu, Manod, Bwlch-y-Slaters, Cwt-y-Bugail, Rhiwbach
		Rhyd Ddu	Glanrafon, Rhos Clogwyn, Bwlch Cwmllan
	Mid	Coris & Aberlleffeni	Gaewern, Abercwmeiddaw, Braich Goch, Aberlleffenni, Cynerau, Ratgoed
		Twyn & Machynlleth	Allt Goch, Fron Goch, Bryn Eglwys, Glandyfi, Morben, Minllyn
		Dolgellau to Barmouth	Egryn, Henddol, Golwern, Arthog, Cefn Gam, Penrhyngwyn
	South	Carmarthen	Llwynpiod
		Cardigan and Fishguard	Rosebush and Bellstone, Fforest, Cilgerran, Gilfach, Glogau
Cambrian	North	Nantlle to Bethesda	**Penrhyn**, **Dinorwic**, Vivian, Glyn Rhonwy, Garreg Fawr, Treflan, Tal-y-Sarn, **Pen-yr-Orsedd**; **Dorothea**, Glanrafon, Moel Tryfan, Alexandra

Table 1: Historical sources of slates in Wales, after Richards. There were many other quarries which had a small production or a short duration. Richards lists most of them in The Gazetteer of the Welsh Slate Industry.

Geological age	Historical name	Bedrock source unit	Stone slate source
Jurassic	Early Lias		Cheshire: *Combermere Abbey*
			Gloucestershire: *Ashleworth; Tewkesbury*
Triassic		Tarporley Siltstone Formation	Shropshire: Grinshill
Carboniferous	Pennant	Pennant Sandstone Formation	Around Bristol; Iron Acton; Forest of Dean; north of the South Wales Coalfield
Devonian	Old Red Sandstone	Brownstones Formation	Shropshire: New Invention; *Forest of Dean*
			South Wales: Talgarth (Tredoman) quarry; Skokholm Island [1,2]
		Senni Formation	Near Cwmyoy [3]
		Freshwater West Formation (St Maughans Formation)	North of Hereford: Dinmore Hill; Kipperknoll; Garnons Hill
			Herefordshire: Olchon Valley to Golden Valley; north of Hay-on-Wye
		Moor Cliffs Sandstone Formation (formerly	Shropshire: Five Turnings
Silurian		Raglan Mudstone Formation)	Bettws-y-Crwyn
		Downton Castle Formation in the north (formerly Clun Forest Formation)	Shropshire: *Downton Castle; Ludlow*
		Tilestones Formation in the south	Wales: Llandybie; Onnen Fawr; Golden Grove; Long Quarry; Cilmaenllwydd; Pont ar Llechi; Mynedd Meddfai; Mynedd Eppynt; Brecon
Ordovician		Cheney Longville Formation	Shropshire: Cheney Longville; north and west of Wistanstow
		Alternata Limestone Formation	Shropshire: Soudley quarry
		Chatwell Sandstone and Chatwell Flags	Shropshire: Chatwell
		Hoar Edge Grit Formation	Shropshire: Ruckley near Acton Burnell to Harnage

Table 2: Historical sources of stone slates in South Wales and the Welsh Marches. Silurian and Devonian stratigraphy based on Barclay et al. (2015). Sources shown in italics have been recorded or are probable but are unconfirmed.

Howe J A (1910) *The Geology of Building Stones*, London: Edward Arnold.
Lawman J (1948) *Skokholm. an Island Remembered*. Tiverton: Halsgrove.
Davies J and Horak J (2009) *Building Stone Use in Brecon Beacons National Park*. Cardiff: National Museum Wales.

cement imitations and concrete tiles that their predominance faltered. Guidance on this type of slating is not included in this guide. It is available from manufacturers and in BS5534 Code of Practice for Slating and Tiling. It should be noted though that the scope of BS5534 explains that:

> 'This British Standard gives recommendations primarily intended for the design, performance and installation of new build pitched roofs, including vertical cladding, and for normal re-roofing work, including repairs, using slates, tiles, shingles and shakes and their associated components. This British Standard does not cover the structural design of the roof.
>
> The recommendations contained in this British Standard might not be appropriate for the re-slating or re-tiling of some old roofs, particularly where traditional and/or reclaimed materials are used. Users intending to adopt any of these recommendations for old roofs, and especially for historically or architecturally important buildings, are advised to consult with the local planning authority or an appropriate conservation organization to check their suitability. '

Stone slate sources are shown in table 2. They nearly all worked sandstones across south Wales and in the border counties, serving local markets. The production of stone slates, which had a similarly long history to slates in the region had ceased entirely during the 20th century but in recent years, due to work by Historic England (formerly English Heritage), continuous production has been re-established in some quarries or could be restarted elsewhere for specific projects, such as was done for Harnage (Hoar Edge) slates in Shropshire (see 10.5 Wood).

The techniques of stone slating are largely unchanged. Mortar is used for head-bedding and torching but not for tail-bedding. The main changes are the adoption of battens rather than laths, nails rather than pegs for fixing, and underlays.

Slate and stone slate producers are given in section 10.2.

1.2 Significance and conservation

Vernacular roofs are important elements in the character of historic buildings and settlements in the region, and give individual buildings, towns and villages their sense of place. This is in part due to the materials themselves, with their different colours, textures and sizes, but also to the way in which they are laid and detailed.

Because of the long availability of modern slates, vernacular slate and stone roofs now remain mainly on early religious buildings and manor houses, as well as farms and low status buildings in the more remote regions and especially in the uplands.

Where stone roofs have been conserved the techniques are usually applied correctly. Unfortunately, many are changed to different stones or even to slates or fake stone slates.

Welsh slate and stone roofs are predominantly double-lapped, but there are single-lapped examples and triple-lapping has been identified on some roofs (see figure 5(a - d)). A common form of double-lapping is slating in thirds where the slates' lengths are divided by three to set out the lathing (see figure 5(e) and video 1)

For many years, there have been misunderstandings of the traditional slating systems and confusion about their details, resulting in inappropriate repairs. In particular, where the roof includes curves, such as swept valleys, attempts to use large and wide modern slates are doomed to fail.

The techniques for producing weather-tight roofs were often local, expressing the individual way in which slaters made the slating work. They were based on skill, understanding of how water moves on a roof and experience. Sadly, many of today's slaters do not have these attributes and often a detail which has worked perfectly well is condemned out of ignorance or changed for lack of confidence to be able to do the work successfully (see figures 6 and 7).

Although most of these slate roofs have been lost to modern tally slating, many remain and recent researches have revealed a much greater variety of slating styles and techniques than had been recognised in the past. Many of these were constructed in response to the characteristics of the locally made slates; especially their sizes and

5(a). In double lap slating the third course overlaps the first, fourth overlaps the second and so on, usually by a specified amount - the head lap. This is how all new and many old roofs are constructed. (Ditherington Flax Mill, Shropshire).

5(d). In triple lap slating the fourth course overlaps the first and so on. This makes it possible to use slates which would be too narrow for double lap slating without risking leaks. It also improves the wind resistance. Less common in Wales than in south-west England, it has been identified only on a few roofs so far.

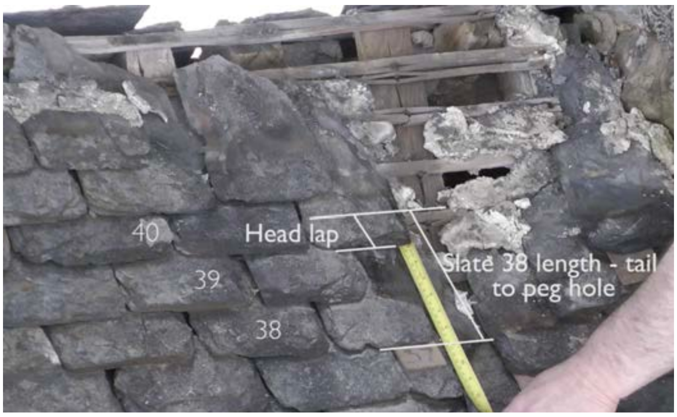
Figure 5. Welsh slate and stone roofs are predominantly double-lapped (a) but there are single-lapped examples (b) and (c) and triple-lapping has been identified on some roofs (d). A common form of double-lapping is slating in thirds where the slates' lengths are divided by three to set out the lathing (e).

All photos Terry Hughes

5(b) and (c). In single lap slating each course of slates overlaps only the one immediately below and the vertical sides are butted against each other. Consequently, the perpendicular joints are open and have to be weathered in some other way.

In Patent slating at St Georges Church, Everton, Merseyside, above, the perpendicular joints are sealed with slate cover strips bedded in a putty.

Close to quarries, very large slates, which would not survive haulage over a long distance, are often used single lapped on farm buildings or sheds. The perpendicular joints on this pig sty near Caernarfon are weathered with mortar fillets.



5(e). A system of slating in thirds where the head lap and the lath gauge are equal to the slate length (from tail to peg hole) divided by three. The method uses a divider rather than mathematical division, similar to the techniques of mediaeval masons (video 1).

the range of lengths in which they were made. Some were sold in just two or three lengths which was critical to how, for example, valleys were laid (see section 6.7). The key problems for the conservation of these roofs are that:

- They are not inspected properly before stripping.
- The vernacular techniques are not understood.
- Most slaters are not experienced or trained in the techniques.
- New slates and stones in vernacular sizes are assumed to be unavailable (see section 10.2) and tally slates or other stone slates are specified instead of the originals.

As roofs were renewed the vernacular systems were changed to the modern system even when laying random slates. Modern slating recommendations and detailing as exemplified by British Standards together with modern slates, have been applied to historic roofs without regard to their visual and technical needs. This is inappropriate for conservation, not least because the standards omit vernacular techniques. The issue of the differences between modern and historic slating should be dealt with at the design stage of a project.

Whilst the slates and stone slates themselves are durable and may last hundreds of years, the roofs have a finite life determined by the fixings used to support them. Pegs and laths rot and nails rust. Roofs are known that may be between 150 and 200 years old, but there will be very few *in situ* any older than this. Older buildings may well have had their roofs renewed two, three or more times during their existence, and whilst the original slates may be salvaged and reused once or twice, the act of stripping and relaying a roof destroys most of the evidence of the earlier roofing techniques.

It is very important that the details of roofs are recorded before the slating is stripped, and that the information obtained is used to derive appropriate specifications for re-slating (see

Figures 6 and 7. The Welsh slate valley in the top photo which had been satisfactory for at least 100 years was changed to a lead lined type for no good reason.

Photos Terry Hughes

Figure 8. Recording the way a roof was slated can be difficult, perhaps involving several measurements on each of 50 or more courses. Equipment should be chosen to be convenient when working on a roof ladder. Photography and voice recordings will ensure details are not lost or recorded for the wrong course. Also, every slate removed destroys it’s relationship with the surrounding slates, so if a video recording can be made it allows the stripping to be ‘reversed’ to check the details subsequently.

Photo Terry Hughes

figure 8). Each surviving example is likely to contain valuable information about traditional craft techniques and local variations.

In general, the existing form and details of each historic building should be respected and retained during any campaign of repair. This extends not only to the overall appearance of the building but also to the construction methods employed.

The broad principle of retaining existing details does not mean that they should simply be replicated without thought. There are situations where details may need to be sensitively adapted to improve performance but, if so, this should follow careful analysis in such a way that the traditional local style and appearance is maintained, and be within appropriate statutory consents.

2 Recording and assessment

2.1 Recording and condition surveys

Any work on historic roofs should always be based on an understanding of the existing roof and how well it has performed. Each surviving example is likely to contain valuable information about historic craft techniques. Many of these techniques and details cannot be seen externally, but unless their presence is known and understood, the roof cannot be repaired or renewed authentically. So it is essential that the recording of such information is undertaken before or as the slating is stripped and the results used to develop a specification for the re-slating. This will minimise the possibility of delays and errors in the ordering of any new slates, and, importantly, will give the owner of the building more certainty over the final cost. If no survey is done, assumptions about the quantities of slates needed will have to be made at the time of specifying the work in order to obtain prices.

Where defects occur, they are frequently down to poor maintenance, unsuitable alterations or inadequately sized members, and result in decay or distortion of the roof. It is important to distinguish these factors from inherently poor design or construction.

2.2 Structural deterioration, rafter settlement and deflection

Most historic roofs will have moved during their life. Commonly, because of inadequate restraint by couples etc, the eaves may have spread, pushing out the walls, and the ridge may have settled. Rafters may also have settled along their length or adjacent to walls. These features give roofs much of their character and should not be rectified unless there is a clear structural reason to do so.

Some roofs were constructed with a concave curve in the rafters, either deliberately or simply because they had a natural curve. This should not be misinterpreted as settlement. It helps the slates to sit tightly together. Also, rafters may have been raised at abutments to turn water away from the vulnerable junction. For the same reason valley boards may be offset from the centre line (see figure 9).

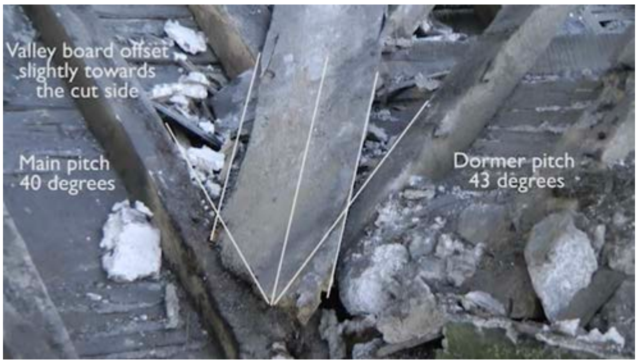


Figure 9. The structure of a roof is part of how the slating works. Rafters and valley boards were placed to tilt the slates and direct water away from vulnerable junctions such as abutments and valleys.

Photo Terry Hughes

Every effort should be made to conserve the structure that supports the roof covering. It is frequently one of the least altered parts of an old building and may provide valuable clues about its history. These range from smoke-blackened timbers where a medieval open hall preceded a chimney, to remnants of early decoration and evidence of smoke bays or louvres. Many old roof structures also constitute fine examples of craftsmanship, jointing is often exemplary and features such as crown posts, moulded beams and traceried

Slate durability

There have been problems with imported slates in recent years. These are caused by inclusions - carbonates (calcite etc) or metallic minerals, collectively known as pyrite or pyrites. They can be present in the slate as distinct crystals or veins, or be dispersed within the slate's structure. When exposed on a roof, expansive reactions take place, converting pyrite to iron oxide and carbonate to bicarbonate or sulfate. These can result in staining, cracking, flaking or blistering of the roofing slate. Some forms of pyrite can be stable so its susceptibility cannot be decided visually. Other failures have been the result of mudstones and siltstones being sold as slates. These disintegrate very quickly on roofs.

Slates should conform to BS EN 12326-1 Product Specification and should be tested by the quarry once a year or for every 25 000 tonnes of finished slates they produce. It is particularly important that they conform to the scope of the standard which defines a slate geologically. Quarries must provide attestations of conformity to the standard (Known as Verification of Constancy of Performance in the Construction Products Directive).

Specifiers should be aware that it is not safe to simply specify 'slates conforming to BS EN 12326-1'. This is because the durability tests in the standard have more than one level of conformity and such a specification allows slate with any of the conformity levels to be supplied. The range of conformity levels was necessary to accommodate all the slates produced throughout Europe, some of which are less durable than is acceptable in the UK market. A specification should state the conformity level for three of the tests: water absorption – less than 0.6% or more than 0.6%; thermal cycling - T1, T2 or T3; and sulfur dioxide exposure - S1, S2 or S3. (The S1 and T1 categories and the lower the water absorption - ideally lower than 0.3% - are the most durable.) There are other tests which need to be considered as well. Further explanation is available (see the link below).

Rust-staining indicates the presence of oxidising metallic minerals and a general whitening of the slates will usually be the result of a high carbonate content, although this can also be caused by carbonates leaching out of mortar or by lead-staining. A specialist report will be needed to determine whether the slates already on a roof should be replaced. It is important to understand that while oxidation of pyrite can be a serious problem (which in recent times has been mainly associated with imported slates) not all pyrite oxidises and some will do so without causing problems.

Slate breakage can be due to wind forces, roof settlement or imposed loads, such as people walking on the roof or, more importantly, because the slates are inherently weak. Wind damage is usually localised on the lee side of hips, ridges or other changes in the roof shape. Broken slates can be replaced individually but if the cause is wind damage a review of the fixing method or slating technique or the slate's strength is advisable. Failure due to inherent weakness is usually a symptom of imported slates which are too thin. A roofing slate's strength is a function of its thickness and the inherent strength of the rock, known as its modulus of rupture (MoR). Hence an inherently weak rock will be satisfactory only if it is made thicker than one with a higher MoR. BS EN 12326-1 specifies the minimum thickness for slates in relation to their MoR and size. The minimum thickness for specific slates should be declared by the manufacturer.

The slate standard itself does not contain a classification of slate durabilities but an explanation of the tests is available at www.stoneroof.org.uk/tests2.html and two organisations - the NHBC and the NFRC - have established their own requirements or guides - see section 10.5.
The roofing slate standard is revised from time to time. The BSI and the NFRC can advise on the latest version.

early spandrels may be found.

A technical assessment will often indicate that stabilisation of the structure is all that is necessary. However, deflection or settlement of the structure may have created undulations in the roof slope which are impossible to slate without gaps, especially for larger slates or stones. In this case, when reslating it is acceptable (and essential) to ease the undulations by packing the rafters or similar. Where settlement is less severe, gaps under the slates can be reduced by using narrow slates which will fit more tightly across the undulations (see figure 10).

2.3 Nail failure

Rusting of iron nails used to fix laths or slates is the main cause of slates becoming detached from the roof. Loss of slates individually indicates that it is the slate nails which are failing (see figure 11(a)). This will be a gradual process and they can be re-fixed for a time. If lath nails fail, several slates in a course will slip (see figure 11(b)).

2.4 Lath failure

Lath failure is indicated by courses of dropped slates or undulations in the roof plane. If the failure is extensive then the roof will need to be reslated. Laths may be unable to carry the weight of the slates, if they have been weakened by rot or insect attack, or if the slating has been grouted and slurried. Repeated slurrying increases the load on the laths and when it becomes too heavy for the lath nails large cracks form (see figure 12(a)). In Pembrokeshire, Anglesey and elsewhere, to overcome the slippage barbed wire is laid over the ridge and turned under the eaves slates or nailed into the rafters and covered with a mortar fillet (see figure 12(b)). This is only a temporary solution. Slurrying reduces the roof's ability to breathe, resulting in rotting of the laths and structural timber.

2.5 Slate failure

Slates currently sourced from Wales are durable and will reach the end of their lives only after many, commonly hundreds, of years. Typically, the process of slate ageing is a general softening in the overlapping parts of the slates. Less durable slates may fail for three main reasons: the presence of deleterious minerals; inherent weakness; or because of mechanical stress (see box page 12).

3 Work in general

3.1 Conservation approach

The demands of conservation impose additional considerations when working on an old building. In particular, a number of overriding principles should be borne in mind when dealing with vernacular slate roofs, in addition to the specific practices described in sections 4 to 7. These are set out in the 'SPAB Approach' (see 10.5 Slocombe).

The SPAB exists foremost to promote the care and protection of old buildings through maintenance and 'conservative repair'. For the Society, old buildings are best safeguarded and enjoyed by maximising the retention of their historic fabric. Through maintaining historic fabric, it is possible to retain character, history

Dimensions

Although metric dimensions were adopted long ago, many slaters still work in inches and some slate manufacturers still make imperial size slates and quote approximate metric equivalents. In this guide, where past practices are described and where direct quotations are provided from historic documents, the inch dimensions are used. Otherwise, and for descriptions of modern practice, approximate metric equivalents are given with the imperial dimensions in brackets.

It is important to understand that so-called metric equivalents made by some quarries are not exact. A 500 x 300 mm slate is not the same size as a 20 x 12" slate (508 x 305 mm) and this can result in problems if they are mixed on a roof. Additionally, some Welsh quarries made their slates oversize so a nominal 20 x 12" slate was actually 20.25 x 12.25" equal to 514 x 311 mm.

10(a)

10(b)

Figures 10. Often structural movement will require only stabilisation. Undulations in the roof can make it difficult to lay slates without gaps. Often, for random slating, the use of narrow slates will overcome the problem.

Photos Terry Hughes.

11(a)

11(b)

Figures 11 If slate nails rust and fail, individual slates will slip **(a)**. If the lath nails fail, whole courses of slates will collapse **(b)**.

Photos Terry Hughes.

12(a)

12(b)

Figures 12. The use of mortar can prolong the life of a failing roof but the weight of repeated slurrys will eventually overwhelm the fixings and large areas will slip **(a)**. In some regions barbed wire from eaves to eaves and nailed to the roof structure is used to resist slippage **(b)**.

Photos Terry Hughes.

and interest. This does not rule out change, but change should be carefully considered, respectful and should add interest or assist long-term care.

The SPAB Approach is achieved by following these key principles:

- Carrying out work essential to the long-term well-being of an old building.
- Employing compatible methods and materials.
- Obtaining sound information about the history, construction and condition of an old building, as well as user needs, before undertaking serious interventions.

3.2 Selecting an architect or surveyor

An architect or building surveyor may be employed on larger, more complex projects, or projects where the re-slating is only part of the work. This should give the client protection if things go wrong, and a competitive tendering procedure should ensure that value for money is obtained. Professional advisors should be selected who have the right knowledge and experience to specify and inspect the work. For sources of names (see section 10.1).

3.3 Selecting a slater or slating company

It is most important to ask skilled and knowledgeable slaters to tender for the work. The key is to ensure parity of tendering. Then the lower price can be chosen. It is usually unwise to make a selection based on cost alone, as an inexperienced slater may simply have underestimated the cost after inadvertently leaving out a step in the slating process. Problems can also arise if the main contractor is allowed to choose the slater because this too may be primarily based on cost.

The National Federation of Roofing Contractors (NFRC) operates an accreditation scheme for heritage roofing companies which includes those working with stone roofs and slates in tally, random and Patent formats.

There are national vocational qualifications (NVQs) for roof slating and tiling, and construction site management (conservation) (see table 4). Older but highly skilled slaters may not have such qualifications, but this should not disqualify them from consideration.

These qualifications may be required by clients or be included in grant conditions.

A slater should be able to show roofs which they have worked on successfully and provide references. It is wise to view roofs that a company has repaired or reslated, preferably recently. Although an external view cannot reveal all the mistakes which may have been made, examples of good workmanship to look out for include:

- Evenly diminishing margins – no margins taller (longer) than ones lower in the slope. Do not mistake undulations caused by wavy laths with bad setting out.
- Perpendicular joints roughly central on the slate below – any joints lying closely above each other are a serious fault. In tally slating the joints should be central on the slate below and straight up the roof.
- Tidy mortar – neatly finished at the tails of the slates, verges and abutments
- Ridge tiles fitting closely onto the slating without large mortar beds except where the roof undulations make this difficult. In stone roofing it can be difficult to avoid mortar showing, but it should be minimised.
- In the roof space there should be no signs of leaks or dampness but these might be visible only if there is no underlay.
- Similarly, no tail bedding mortar should be visible from the underside of the roof but do not confuse this with head-bedding or torching (see figure 13).

The slater should be asked to provide a statement covering all the steps in reslating the roof including:

- Survey and recording – how the roof will be inspected before and during stripping, to ensure historical details will be conserved and technical detailing will be replicated or if necessary changed. This may be subcontracted to a specialist and may have been carried out prior to tendering.
- Specification review – advising on unsuitable or impractical aspects of the specification.
- Method statement – a description of how

13(a)

13(b)

Figures 13. Head bedding **(a)** and torching **(b)** will be visible inside a roof. This is normal and not a problem.
Photos Terry Hughes

the work will be organised and executed

- The re-slating process - a description of the process of carrying out the work. This aspect is important because comparison between tenderers will highlight any steps which have been omitted.
- How they will deal with any faults or damage caused, for example, when dismantling scaffolding.

Quotations should state the total area of the slating work to be done so that differences can be checked; and any aspects which are unknown until the roof is stripped should be clearly explained. It is also very important that all quotes are based on the correct gauging system. A price mistakenly based on slating at double-lap when three-and-a-half-pin is specified is going to seriously underestimate labour and materials.

3.4 Specifications

Any work on historic roofs should always be based on an understanding of the existing roof and how well it has performed. Ideally, a survey to record and photograph the constructional details should be carried out prior to writing the specification. This will involve some opening-up of the roof. The survey should cover the slate sizes, their condition and gauging and lapping system, and the details for eaves, valleys, verges, abutments, hips, ridges and dormers. It should also assess whether the roof has performed satisfactorily or if it has deteriorated prematurely because of some inherent defect. Care and experience are needed to differentiate between cause and effect. The survey should be carried out by a

NVQ Title	S/NVQ level	CSCS card
Roof Slating and Tiling	2	Blue
Roof Slating and Tiling (including random slating)	3	Gold
Diploma in Heritage Skills Roof Slating and Tiling	3	Gold + Heritage Skills
Construction Site Supervisor Conservation	3	Gold
Construction Site Management Conservation	6	Platinum
Conservation Consultancy	7	Black

Table 4: Vocational Qualifications in roofing.

slating consultant, contractor, conservation accredited architect or building surveyor, provided they are experienced in the local slating styles and detailing.

The specification can be prepared based on the survey findings. Where modifications are required to fulfil other objectives such as environmental performance, they should be based on sound information. In particular, care should be taken where insulation is introduced and where a method for venting any moisture from the batten space may need to be provided.

This Advice Note includes roof details which vary across the region and should be replicated during repairs or re-slating. However, the location and geographical extent of their use is not necessarily known, so their application on a particular roof should be based on research, a survey or other reliable information rather than assumptions.

A written specification will allow the work to be detailed and the standards of materials and workmanship to be set out, so that all slaters who are pricing the work can do so against the same document. The prices can then be judged on an equal basis. If the work includes more than slating, and is to be managed by a main contractor, a good specification will ensure that the method and standard of slating can be understood by all who tender and can be met by the main or slating subcontractor. Under certain contracts a particular slating firm can be nominated. The specification should cover the following issues.

- Survey and recording if required.
- Policy on retention of historic details and materials.
- Slate source, size or size range, thickness and colour.
- Gauging. For pin slating the slate length divisor should be stated: 3.5 for roofing and 2.5 for cladding are typical. For slating in thirds, the gauge divisor is 3.
- Side lap. For random slating the requirement is to set perpendicular joints approximately central over the slate below;.
- Battens or laths and fixings – sizes and materials.
- Slate fixing method – nailed or peg-hung.
- Slate fixings – nails or pegs, sizes and materials.
- Mortar, if required, including any preparation procedures and precautions to ensure satisfactory curing
- Underlay if required
- Insulation and means of ventilation if required
- Details for eaves, verges, hips, valleys, dormers and ridges.

3.5 Listed building consent

For listed buildings, most changes to the construction details will require listed building consent from the local authority. Relevant changes will include:

- Reslating of a roof at the end of its life, where renewal would affect the building's character.
- Removal and alteration of material and/or detail of archaeological or historic importance.
- Alteration of a detail affecting, for example, ridges, valleys, hips, abutments verges or the style or size of dormer windows.
- Change from one slate or stone type to any other slate, stone or to clay or concrete tiles, imitation slates or sheet products.
- Use of slate or stone of a different geological type, including another source quarry within a particular geological type.
- Change from riven laths to sawn battens or the reverse.
- Introduction of underlay.
- Introduction of counter-battens which raise the roof line.
- Change of slate fixing method, for example, top-hung to centre-nailed.
- Change in the overall range of slate lengths which would significantly affect the roof's character.
- Use of new slates or stones that have been prepared using non-traditional methods, such as sawn edges which have not been dressed to give a bevelled edge.
- Change of ridge or hip material, such as from one stone type to another or to reconstituted stone, concrete or clay ridges.
- Introduction of building services or ventilation details that would significantly alter the character of the building.

Local policy on these issues should be checked before making proposals for alterations. The policy is likely to cover three main options.

- Completely authentic reslating – an exact replication of the existing style and techniques.
- External appearance authentic, but modern methods adopted, for example, nailing rather than peg hanging.
- Either of the other two but including modern innovations like insulation.

The third option is most likely to be driven by the building regulations.

3.6 Building regulations and other controls on roofing work

In addition to listed building consent, building regulation or, for many places of worship - a faculty, building regulations approval will be required for any increase or decrease to the weight of the roof covering. This will include a change from a slurried to a normal roof.

'If you want to carry out repairs on or re-cover less than 25 per cent of the area of a pitch or flat roof, you will not normally need to submit a building regulations application. You will need approval, however, if:

- You carry out structural alterations
- The performance of the new covering will be significantly different to that of the existing covering in the event of a fire
- You are replacing/repairing more than 25 per cent of the roof area, in which case, the roof thermal insulation would normally have to be improved.
- Where more than 25% of the roof area is to be replaced, the person intending to do the work has a legal obligation to contact the local authority building control department in relation to the upgrading of insulation to comply with the Part L of the Building Regulations (see section 7.6).'

Section 3.5 in Part L2B of the Building Regulations states that listed and other historic buildings and places of worship are exempt from the need to conform with the energy requirements (see 10.5 Historic England).

All bats and some birds and plants which live on or in roofs are protected. This will often limit the time of year when work can be done. There are controls on the type of underlay where bats are present. Currently only bituminous roofing felt known generally as BS747 1F may be used, but it must be hessian reinforced and not contain polypropylene fibres. The county wildlife trusts will be able to advise (see section 10.4).

4 Repairs and re-slating

4.1 Alteration of details

It is normally assumed that a like-for-like repair or re-slating – same slates, same slating system and gauging, same bedding if originally used, etc – will perform satisfactorily in the future. However, the implications of the increasing incidence of deluge rain and more severe storm force winds consequent on climate change should be considered in deciding on the gauging and the fixing method. An improved specification can usually be adopted without impact on the appearance of the roof, but specialist advice may be needed so that all the implications of changes are considered and an integrated solution achieved. Simply applying the recommendations for each element in isolation is unlikely to be successful.

4.2 Structural repairs

All roof-work should be carried out from a safe means of access that does not damage the

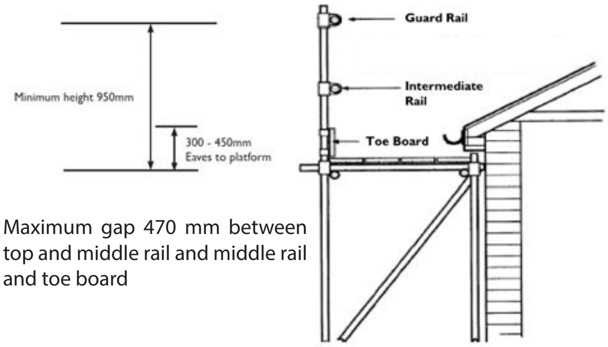


Figure 14. Roof work should be carried out from a scaffold designed for safe access and able to carry the weight of the slates.

Illustration NFRC

roof. Scaffolds should be designed to carry the weight of stacked slates or stones and to be wide enough to allow sorting and redressing. The NFRC provides guidance publications - (see figure 14 and 10.5 National Federation of Roofing Contractors, 2009).

It is better to repair rather than replace roof timbers. Consult a suitably experienced structural engineer where necessary (SPAB may be able to suggest names) and leave only minor repairs to roofers. Whilst conventional carpentry techniques alone will frequently be suitable, strengthening using steel may be justified where it allows more timber to be retained than would otherwise be possible. Resins and consolidants should be used with great care, and other means of reinforcement, such as plastic rods, should be employed only where they can be justified. For more about work to roof structures (see 10.5 Boutwood).

Where active decay exists, the first priority is to eliminate causes of dampness and promote drying. Chemical treatments are frequently unnecessary and should only be used judiciously where justified as a secondary measure, for example, when it is difficult to reduce moisture levels sufficiently. Degraded surface material should not be removed (defrassed) without good reason. Serious mutilation can result.

Keeping roof spaces clear of rubbish and debris discourages decay. Timbers may be vacuumed or brushed down – though take care not to remove any medieval smoke blackening or evidence of early decoration that is of archaeological value.

4.3 Slates

Although slate and stone roofs which are reaching the end of their life can be kept weather-tight for many years by regular maintenance, eventually they will have to be stripped and reslated, typically when 5-10% of the slates have slipped or been lost. The decision to reslate is often precipitated by the repeated cost of scaffolding for repairs.

When carrying out repairs the primary aim should be to retain the maximum amount of historic fabric without compromising the effectiveness of the roof. The existing slates should be reused if they are still sound or if they are damaged or softened, they may be dressed down to remove any defective areas.

Only slates or stones from the local sources can produce an authentic appearance. Those from other locations should not be used unless there is no local source. For extensive re-slating, new slates should be used to make up any shortfall. This may be local authority policy and a condition of any grant-supported works.

Claims of unavailability or long delivery times should always be checked with the quarries. It may be worth delaying the project for a few months until the right slates can be produced, since the life of a well-slated roof is likely to be more than 100 years. Only where it is impossible to obtain suitable new slates should the use of slates reclaimed from other buildings be considered and these should be from a known source to discourage theft. Reclaimed slates will not last as long as new ones and their use inevitably means some other building will have lost its historic roof. Often, they are sourced from several other roof,s so their remaining life will be mixed. They should be checked for softening and damage, especially around the fixing holes. Affected areas can be dressed off but this may result in a shortage of the longer sizes, with a consequent change in the appearance of the roof. It is better for appearance and for reasons of durability to consolidate old slates on to one or more slopes and to use the new ones on others.

When stripping and reslating random roofs any shortfall should be made up with new slates supplied in a mix as they arise in the quarry, with an appropriate mix of widths. Using a few lengths and widths selected from a quarry's standard sizes will not produce an authentic roof.

Normally, the new and old slates should be fixed on separate slopes. When the existing slates are consolidated and sorted into lengths, the number of courses of each length can be calculated.

Large slates and stones slates are not always immediately available, and have to be specially ordered. Suitable block for such large slates may not be readily available so the order should be discussed with the quarry as early as possible.

The quarries are always willing to make special slates, such as for Patent slating (see video 2), but they will need a detailed specification of what is required and almost always time to organise production of any special slates (see figure 15). An order might include sizes, quantities, colour, texture, and most importantly the date work is to commence, as well as the scheduling for each stage of large projects. It is always wise to discuss the order and work programme well in advance. If a roof is to be stripped and re-slated, there will inevitably be uncertainty about the quantities of slates needed until the numbers of reusable slates are known. Experienced slaters or independent consultants can advise on this before stripping commences.

The individuality of random roofs derives from the mix of slate sizes (see figure 16) . Historically, no attempt was made to supply a specific mix of sizes and this policy should be respected for most re-slating work today (see figure 17). How the slates were fixed, their laps and the detailing was mainly a response to the climate and roof pitch.

Generally, metamorphic slates should conform to the highest level of BSEN12326-1 - S1, T 1 and water absorption no greater than 0.3% (see box page 12). Slates specially produced from historic sources might not conform to the standard but if they have a long history of successful use this may be convincing.

There are no formal standards for stone slates. Again, any produced from an historic source may be able to show long and successful use. Otherwise, for slates from a new source the best advice is to store them on edge off the ground outside or on a trial roof which can be quite small - ideally for a year - and then inspect them for cracks and delamination etc.

Colloidal slates

In the 1930s the Oakley Quarries Group developed a process for colouring natural slates by coating them with sols - a colloid of solids suspended in liquid - and baking it on. Available in a range of earth colours (see figure 18(a)) the coating was claimed to be 'absolutely fast even if boiled in concentrated acids or alkalies. A promotional leaflet listed 71 buildings in Wales and England slated with them and many can still

Figure 15. Quarries can make slates to specific sizes or formats given reasonable warning. These slates measuring 1350 x 950 mm were made by Welsh Slate for the Patent slating of St George's church, Everton, Merseyside.

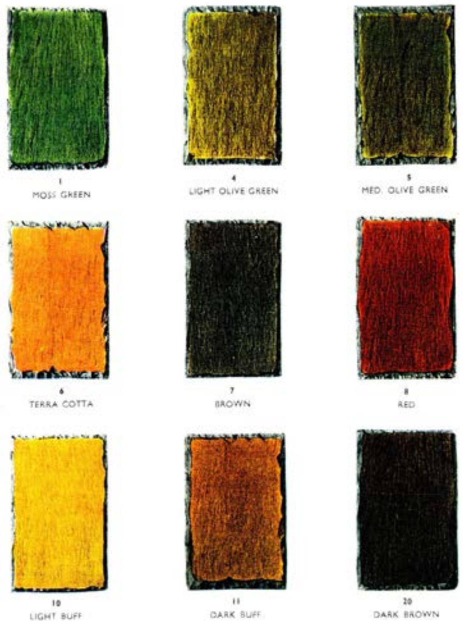
Photo Terry Hughes

Figure 16. The appearance of slate and stone roofs depends on the mix of sizes which the quarry can produce. St Mary's Church, Kempley, Gloucestershire

Photo Terry Hughes

Figure 17. Orders for new slates should not ask for specific sizes. The correct way is to specify the longest and shortest and allow the quarry to produce a natural mix of sizes. It is the slater's job to produce an effective roof from the mix supplied. Hereford stone slates made for St Mary's Church, Portbury, Somerset

Photo Terry Hughes



18(a)

18(b)

Figure 18. Colloidally coloured slates produced by Oakley Quarry in the 1930s **(a)** are still visible on roofs today. The example in **18(b)** is near Llandudno, Conwy.

Photo Terry Hughes

be seen (see figure18(b)).

4.4 Slate repairs

The thickness and size of missing or damaged slates must be determined and matched and this will probably involve opening up the slating.

If the slates are pegged it may be possible to swing adjacent slates aside and hang the new slate. If the slates are nailed or if the slating has to be opened for another reason, such as renewing a horizontal lead gutter then, if they can not be swung aside, it may be necessary to remove a triangle of slates, so that each one can be accessed for re-fixing and the last one can be fixed with a copper tingle (see figure 19). Inevitably, any bedding or torching will be damaged and this should be renewed.

Re-fixing slates by simply bedding them in mortar should be avoided but is sometimes necessary as an emergency and purely temporary measure. Cement mortar should not be used as any water which gets behind it cannot evaporate through it and more damage will ensue. Lime mortar of the torching type (see Table 5) placed on the slates where water can not reach it is preferable. Slates fixed in this way will not be fully secure.

Roofs near the coast have often been repaired in the past by grouting and slurrying with mortar (see figures 12(a) and 12(b)). This is most common in Pembrokeshire where there is specific conservation control on such roofs. It is also seen in other coastal counties but has rarely been conserved in the past. However, the issue should be discussed with the local conservation officer or Cadw when repairs are necessary. Grouting or slurrying leads to structural deterioration and will eventually cost far more than if the roof had been re-

Figure 19. Slipped slates can be refixed with a tingle. Copper is better than lead, which tends to unroll.

Photos Terry Hughes

slated instead. Although slurried roofs are a distinctive feature, of Pembrokeshire in particular, they are a last resort for a roof which has failed.

Covering slates with hessian and bitumen - Turnerising - or spraying foam on the slates' undersides is also damaging. These techniques make it expensive or impossible to re-use the slates and reduce the ventilation through the roof, increasing the risk of rot or insect attack (see 7.5 Roof maintenance). This will be aggravated where insulation is installed in the roof.

4.5 Thatch legacy

Many of the vernacular roofs we see today would have been thatched before they were slated - outside the slate producing areas probably not before the late 19th century - and some of their original features persist simply because it was difficult or costly to change them.

The most obvious legacy is the roof pitch. Thatched roofs need a much steeper roof than slates to shed water but it is rare that the pitch would have been reduced for a change to slating.

In Waunfawr and Rhos Tryfan near Caernarfon there are examples of slates laid on turf on loosely laid birch branches on pole rafters (see figures 20(a -c)). It has been speculated that the use of slates in this way from small quarries close at hand, was a continuation of the process of regularly renewing the thatch weather coat but using slate instead. However they could equally well have been laid directly to a turf roof.

The outer leaves of gable walls are often raised with the slates butted up to them (see figures 21(a) and 21(b). This is often only on the wind exposed end of the roof. This is unnecessary for slating so it is thought to have originally been to prevent thatch being blown off. It is an awkward detail for slating (see 6.3).

Thatched roofs sometimes have slates or stones at the eaves (see figure 22). This can be to support the thatch without the need for sprocketed rafters or may reflect extensions to

20(a)

20(b)

20(c)

Figure 20. The roof of the Caer Adda cow shed **(a)** in Waunfawr near Caernarfon and **(b)** inside in 2005 before it was moved to St Fagans museum (**c**). Relaying the the roof **(c)**.
Photos Terry Hughes

21(a)

Figure 21 (The raised outer leaf of a gable wall **(a)** and **(b)** was originally to prevent thatch being blown off. It is unnecessary for slating but has persisted.

Gable support for thatch **(c)**. Kennexiton farmhouse Gower. Now at St Fagans museum. https://museum.wales/stfagans/buildings/kennixton/

Photo Terry Hughes

21(c)

21(b)

the building. It has also been suggested that, for very low eaves, it was to prevent livestock pulling the thatch off.

Eyebrow dormers are a natural technique for thatch which fits easily to curves. This is not so for slates so perhaps on older buildings slated eyebrows are a replacement for thatch.

As most of these details are unnecessary or awkward for slating it is difficult to understand why they are so often adopted for buildings that were never thatched. Maybe architectural style has taken precedence over practicality.

4.6 Fixings

Lath nails should be no less durable than galvanised or sheradised and sized to suit the laths or battens. Stainless steel nails are sometimes specified, especially in marine situations, but not all types are equally durable. There have been failures associated with AISI grade 304 slate hooks in coastal areas and current advice is to avoid this grade for roofs and only use 316. However, standards and grades of stainless steel are changing and the NFRC technical bulletin 11 should be consulted for full details.

For fixing 50 x 25 mm softwood battens a 3.35 mm shank diameter nail is recommended in BS 5534. Shank length and diameter should be chosen to provide adequate pull-out resistance for the building's situation, height etc. BS 5534 provides further guidance. Smaller nails will be needed for fixing thin riven laths to avoid splitting them or the laths can be pre-drilled. Alternatively cleats (cooper's hooks) can be used (see figure 23).

Pre-drilling may be necessary when nailing into old hardwood rafters or where a fragile ceiling is fixed to the rafters.

Historically, the most common fixings for slates and stones were soft- or hard-wood pegs, but many other materials, including animal bones, were used (see figure 24). Wood pegs were roughly square section, whittled to a slight taper and forced into the hole until almost flush with the surface of the slate. Peg making

Figure 22. Slates below thatch. Roson farm, Pembrokeshire.
Photo Terry Hughes

would be a wet day task and they would be allowed to dry naturally or be dried in an oven the day before using them (see figure 25). Once inserted in the slate they would absorb moisture and swell to fit tightly in the peg hole.

On a pegged roof where the underside of the roof is to be visible, wooden or the existing type of pegs should be used; they will be prevented from twisting or falling out by

Figure 23. Riven laths nailed to rafters might not be able to support the weight of large slates or stones. Cleats **(a)** driven in below the lath **(b)** ensured the slates were supported by the full width of the lath.

Photo and image Terry Hughes

Figure 24. Bone pegs. These are believed to be sheep's metatarsals. Chicken bones were also used, probably for smaller slates.

Photos Doug Waugh

Figure 25. Wooden pegs are made slightly over-size for the peg hole and driven in to make a tight fit (see video 3)

Photo Terry Hughes

the addition of a small dab of mortar (pin pointing), by torching (see figures 26(a) and 26(b) and video 4) or by head bedding (see video 5).

Otherwise, nails can be used in the same way as pegs.

26(a)

26(b)

Figures 26. Pegs can be secured by head-bedding **(a)**, torching **(b)**, or with a dab of mortar. (See video 4)
Photos Terry Hughes

Where wood or metal pegs are used over underlay, they must not be so long as to risk puncturing it, especially close to the rafters. Counter-battens may be necessary to ensure they are well away from the underlay. But these can create other problems at abutments ,etc (see 6.4).

For slate nailing, copper or, in salty air exposed situations bronze nails are the most durable option. Aluminium nails are also suitable but should be avoided where they might be in contact with lime mortar. Ring-shanked nails should not be used as it will be impossible to remove the slates in the future for reuse without breaking them. Stainless steel nails are too smooth to provide adequate pull-out resistance in many situations. Small nails - 2.65 mm shank diameter - are satisfactory for small slates but because the heads are only 8 mm diameter the nail holes must be similarly small. For larger sizes the BS 5534 recommended 3.35 mm shank diameter is appropriate.

Hook-fixing is not traditional and should not be used on old roofs. There is no situation where hooks are necessary, however exposed the building.

4.7 Laths, battens and sarking boards

The earliest ground work for slating seems to have been wattle or other randomly laid brushwood. Examples have been found on Roman archaeological sites and are known on vernacular buildings in north Wales (see figures 20(a) and 20(b)) More recently, riven laths were used for all types of slating and are satisfactory for peg-hanging all the slating types in this Advice Note. Made from a variety of woods, including oak and sweet chestnut, they are typically 25 mm wide by at least 6 mm thick and 900 to 1800 mm long. They are available from specialist suppliers. Being riven, they are not straight and impart undulations to the slating, which gives a livelier and less mechanical appearance to the roof than is effected by sawn battens. They are also less prone to beetle attack. For small peg-fixed slates, battens need to be narrower near the ridge where the gauge reduces, to allow space to insert the pegs between them.

Formal guidance for slating, such as BS 5534, recommends thicker battens of 50 x 25 mm, which are regarded as providing a safe platform for slaters to work on. If riven laths are used, a risk assessment may be needed to justify their use. If judged necessary a slater's heel is a suitable way of working over thin laths (see figure 27 and 10.5 NFRC 2009). Changing from riven laths to thicker sawn battens will raise the roof level and may lead to problems at abutments and verges. Listed building consent will be required where a building is listed.

Slating was often laid over sarking boards and these should be retained wherever possible. They fulfil most of the functions of underlay in keeping out draughts, powdery snow and dust, reducing the wind uplift force on slates and acting as a moisture buffer.

Under correctly laid slating there is no need

Figure 27. A platform, known as a slater's heel, is used for access on tall roofs provided it can carry the weight of the slater(s) and the slates. It can be a simple scaffold **(a)**. Larger works might justify a more substantial platform using Youngman boards **(b)**.

Photo Richard Jordan

to include an underlay over boarding and its addition will reduce the ventilation of moisture from the roof space. Even the addition of a vapour permeable membrane will lead to a lower rate of ventilation of moisture than no membrane at all. To ensure ventilation and to allow for thermal and moisture movement through the boarding, they can be laid with penny gaps.

If an underlay is needed to provide temporary weather protection it can be removed as slating progresses.

4.8 Underlays

The gappy nature of slating is a benefit in allowing ventilation but it is draughty and susceptible to powdery snow being blown in. Snow in the attic space can form drifts and look alarming but all that is really necessary is to spread it around to help it to slowly melt and then dry up.

In the past these problems were often tolerated but from at least the 15th century draughts were reduced by laying slates or stones on vegetable material. Hay, straw or more commonly sphagnum moss was used, especially in the uplands areas of Wales. A trade in moss developed. Some quarries sold moss with 'moss slates'. The moss eventually rotted and the moss man would visit to force fresh moss between the slates with a mossing iron. In time mossing became obsolete and pointing with mortar supplanted it (see section 6.10).

Once roof spaces came to be adapted for accommodation - either as bedrooms or workshops, the need to make them warmer and less draughty led to the adoption of torching - applying haired lime mortar to the underside of the slates (see figure 26(b)). This persisted until the development of underlays, which were a cheaper option. Initially underlays were know as felt made of animal hair or what was loosely described as oakum - jute, flax or hemp; literally felts in the textile meaning of the word (see figure 28). These were intended to insulate roofs. Unlike more recent reinforced underlays, they were not self-supporting and could be laid only on expensive boarding. So were used only on higher specification buildings.

Early hair types were contaminated with anthrax spores which are very long lived - possibly many decades - so a health assessment may be necessary before work is carried out. The Health and Safety Executive has published advice (see 10.5 HSE). Later types were sterilised.

Figure 28. The earliest underlays were based on vegetable fibres or hair and were intended to insulate roofs.

Photo Terry Hughes

Underlays developed over the years and their purposes changed from insulation and draught-proofing to secondary leak and condensation protection, and today wind uplift resistance and water vapour dispersal. Most of the early types are no longer available but BS747 1F reinforced bitumen type (now specified in BS 8747) which came into common use during the mid-20th century, is still made. It is the only one (as of March 2020) suitable for use where bats are present, provided it is reinforced with vegetable fibres, not polypropylene. It is perfectly suitable for use when reslating roofs. It is virtually permanent in normal use but will deteriorate if regularly wetted by leaks or where it is exposed to sunlight at the eaves. For the latter situation, a more durable type such as BS747 5U or an eaves tray should be used.

Underlays should not be laid on top of the eaves slate, because they will rapidly deteriorate under the perpendicular joints of the first course slates, resulting in leaks. Instead support should be provided by an arris cut board or similar which can also provide the eaves tilt for the slating.

There are many vapour permeable membranes on the market for use where the thermal performance of the roof is to be changed. They have different levels of performance and limitations. Their use with insulation should always be an integrated solution, rather than adopting each product's recommendations individually (see 10.5 Historic England 2016).

4.9 Insulation and ventilation

Part L of the building regulations requires the addition of roof insulation for most substantial repairs, including partial re-slating but there are exemptions for protected buildings (see 10.5 Historic England 2016 and SPAB 2014). Installing insulation can increase the condensation risk in the roof structure unless precautions are taken (see 10.5 British Standards 2011).

Vernacular roofs were built with inherently good ventilation, which prevented moisture build-up and condensation in all but the most adverse conditions. This is one of the main reasons such roofs survive for so long. Underlays were not included in old roofs and draught-proofing was provided by lime mortar torching. This would temporarily absorb moisture and release it when the weather was more favourable.

It will be difficult, if not impossible, for many older buildings to achieve statutory target U-values without compromising the appearance of their roofs. Part L allows exemptions and special consideration for historic buildings, so enabling building control officers to take a sensible view to conserve the appearance and character of the building and not introduce technical risks. Historic England has published guidance on complying with Part L and Cadw recommends its use (see 10.5 Historic England 2016).

To prevent condensation problems, the first step should always be to reduce the amount of moisture reaching the roof. This has two aspects: elimination at source, especially for bathrooms and kitchens, and the installation of a vapour control layer at the top floor ceiling or at the rafters. To be effective, a vapour control layer must be sealed at all joints, perimeters and penetrations, but this can be very difficult as a retro fit.

Having minimised the moisture reaching the roof space it is important to ventilate any that does occur there. This can be done with eaves, high-level or ridge ventilators or with vapour permeable membranes. Ventilation product manufacturers provide guidance on the amount of ventilation required, and the levels their products achieve under ideal conditions. These may be inadequate under worst case conditions. Where Agrément Certificates are available they should **always** be checked for the limitations applying to the product. For example, many vapour permeable membranes will achieve adequate performance only provided a vapour control layer is installed below the roof.

It is preferable to place insulation at ceiling level rather than in the rafter depth, because it is easier to provide ventilation through the roof space from eaves to eaves, or eaves to ridge or through gable walls. However, this may be undesirable where there is an historic ceiling or lining.

Providing ventilation for insulation placed in, or above, the rafters can involve raising the slating on counter-battens, leading to problems of detailing and changes to the building's appearance at eaves, abutments, ridges, below copings and at verges. Listed building consent will be required. Secret gutters at abutments can be used to avoid the need to cut into the wall to reposition flashings or string courses. They are prone, though, to blockage by leaves or other debris, so regular maintenance is essential (see figures 29(a) and 29(b)).

Figure 29. Secret gutters are notorious for becoming blocked by debris. Regular maintenance is essential to prevent leaks

Photo Terry Hughes

Figure 30. Stainless steel under-ridge vents can be used where it is important to conserve the appearance of the ridge line.

Photo Terry Hughes

Where there is natural ventilation, at the eaves, for example, it is important that it should not be impaired by the insulation. Roofing specialists are the best sources of advice on this, rather than insulation installers who probably know little about roof construction.

It may be necessary to install vents at the eaves, ridge or in the slating. Proprietary eaves vents are easy to include and clay vent ridges may be acceptable. In-slope vents are intrusive and should be avoided. It is possible to install stainless steel vents under any ridge. They raise the ridge only by a few millimetres, forming a shadow line (see figure 30).

Wet-laid slating, where the slates are bedded across the tail and the lower part of the perpendicular joints, is rare in the region; it is, however, a sealed system, so if it is to be applied over any sort of membrane or underlay, or a ceiling is to be fixed to the rafters, it is vital that the batten space is ventilated. This will usually necessitate eaves ventilators and high-level vent(s) in the roof slope or at the ridge.

4.10 Mortar

The use of mortar has a long history in roofing. It has been applied to improve the wind resistance of slates and prevent draughts, as well as for bedding slates, ridges and hips, pointing verges and forming abutment fillets.

Roofing application	Mortar mix (ratio by volume	Comments
Torching except on exposed roof slopes or where the lap is not ideal	1:3 lime putty:soft sand plus fibres	The bedding mix immediately below is likely to be more suitable for torching on exposed roof slopes, especially where not heated from the underside. This also applies where slates are being reused or an ideal lap cannot be achieved for various reasons
Bedding for slates, ridges or hips, forming fillets and pointing verges and flashings.	1:2 NHL 3.5:aggregate	For use in sheltered and moderately exposed locations in reasonable weather
	1:2 NHL 5:aggregate	For use in very exposed locations or cold weather

Increasing strength and flexibility

Increasing permeability and flexibility

Table 5 : Selection of mortars

Notes

(i) NHL denotes a natural hydraulic lime. Natural hydraulic limes are classified under BS EN 459-1:2015 as NHL 2, NHL 3.5 and NHL 5 in order of increasing strength. The classes refer to the compressive strength in megapascals of a 1:3 lime:sand mix by mass approximately 1:1.5 by volume) after 28 days. Users should be aware, however, that the strength continues to grow considerably over the first couple of years, so the final result may be a much stronger mortar. It is also important to note that the NHL classification accommodates a wide range of strength within each class.

(ii) Cement:lime:aggregate mortars are often used for work on the roofs of old buildings but great care must be taken to control the mix proportions on site to avoid the problems associated with excessive strength.

(iii) Pre-mixed lime mortars are available that minimise material handling and quality control problems on site. It is advisable to clarify with the manufacturer, though, whether any additives are present, as some will be unsuitable for conservation work.

(iv) The inclusion of well-graded crushed limestone for, or as part, of, the aggregate will aid moisture entrainment and carbonation, and enhance frost resistance.

(v) Where lime mortar is applied in thicknesses greater than 15 mm, the same principles should be followed as with external lime render, ie use more than one coat, incorporate hair in the first of these and ensure the aggregate is sufficiently coarse.

Mortar is important in some slating. If the slates are short and the gauging small, the slates' heads tend to be lifted away from the laths, especially in the upper courses. This makes them susceptible to wind-lift but is overcome by bedding the tails of the slates, tipping the heads onto the laths or head-bedding. Tail-bedding is less common in the region than head-bedding (see 6.10).

Lime rather than cement was the binder for most roofing mortars before the early 20th century and is being used increasingly for this purpose again today. Roofs move under the influence of wind and temperature so it is essential to use a flexible bedding mortar to avoid cracking. Strong cement mortars (1:3 or 1:4 cement:aggregate) should be avoided because of their inherent rigidity and impermeability. This results in cracking and loss of adhesion, which can allow water into the fabric where it will be trapped and cause decay. Old roofing slates (sometimes irreplaceable) are likely to be damaged beyond repair when later rebedding or re-laying is necessary if they have previously been laid in cement mortar. Where they are bedded and pointed with lime mortar, roofs can be repaired or reslated without, or with very little, loss.

The recent resurgence of hydraulic limes in Britain, and their development and increased use in both conservation and new-build work, now makes it possible to use lime mortars which are durable in exposed conditions. Although historically mortars for bedding slates may have been non-hydraulic or only weakly hydraulic, hydraulic lime mortars are more commonly specified today to give a speedier set and greater durability.

There is a wide variation of mixes using different strengths of hydraulic lime and varying proportions of aggregate. These need to be selected to suit local weather and building exposure conditions. The ideal is to keep a balance between a mortar that is robust enough to withstand the level of exposure, but at the same time remains sufficiently soft and flexible to avoid causing damage to the slates or roof structure.

Due to the level of exposure to wind, rain and sun to which roofs are naturally subject, various levels of movement of slates are inevitable. The softer, richer and more flexible mortars (possibly also containing fibres) are likely to cope best with movement, but the tougher and harder mortars will tolerate conditions of extreme exposure better. The type of lime and form in which it is used will also affect adhesion. Hydraulic lime is less 'sticky' than non-hydraulic lime. Lime may be included in the form of quicklime, lime putty or bagged dry hydrate. Generally, working from the former to the latter of the three, the extent of adhesion and workability will be in descending order. Sources of information on mortar are given in 10.5 Allen et seq, Holmes, SPAB and British Standards 2015.

Table 4 indicates typical lime-based mixes that can be used for work on old slate roofs in Wales and the Marches. It is not exhaustive. For example, hot lime is being increasingly used for roofing, and should be considered where investigation of the roof indicates it was originally used successfully.

The aggregate should be a clean and well graded sharp sand with angular particles, which bind closely with the lime and leave minimal voids. Generally, the thickness of mortar beds for slating should be no more than 5 mm but inevitably may be thicker, due to the unevenness of some slate surfaces. Where thicker beds are unavoidable, it is important to keep the aggregate size sufficiently large to prevent cracking. The size of the largest aggregate particles should normally be about one-third of the mortar bed thickness. Where thicker beds are unavoidable, it is important to keep the aggregate size sufficiently large to prevent cracking.

The mortar should be mixed in a pan or forced action mixer for a minimum of 30 minutes. Only mix sufficient quantities for immediate use unless trials have been carried out to show that they may be knocked-up safely without the need to add further water. Non-hydraulic lime that is kept damp may be left overnight. Certain weaker hydraulic limes can be similarly knocked-up at times. This is inadvisable, however, with NHL 5 and some NHL 3.5 limes.

The principle of mixing is to achieve a good dispersion of lime and other constituents with the dry sand before any water is added. Once the dry mix is fully dispersed water should be added slowly, allowing time for this to become fully mixed before deciding on the amount needed to achieve good workability. Bear in mind that too much water will decrease the mortar strength by holding the grains apart, thus leaving an open structure when dry.

Lime takes time to cure. To gain the benefits of lime mortar in connection with roof slating, the normal recommendations for curing and tending apply. This requires planning ahead and arranging for the access to remain in place for at least two, preferably four, weeks following completion of the slating.

Protection of all new lime-work against the weather is almost always required. If possible, working should be avoided in the winter months when there is a risk of frost, because freezing and expansion of water can damage uncarbonated areas. To prevent this, layers of hessian or another insulating material must cover the roof (leaving air gaps). The use of anti-freezing agents in mortars is not recommended.

Rapid drying of the mortar by the wind or sun will produce a light-coloured surface with an increase in the deposition of lime binder and risk of cracking and powdering; when

Slate type	Slating type	Lapping	Characteristics
Random		Double	Head-hung to laths or hung or nailed to battens at diminishing head laps or gauges
		Double in thirds	Head-hung to laths or hung or nailed to battens at gauges of one third of the slate lengths
		Double in three and a half pin	Head-hung to laths or hung or nailed to battens and double-lapped at gauges of two sevenths (length / 3.5) of the slate lengths. Rare
Moss		Double, thirds and three-and-a -half-pin	Small, coarse textured, cheap slates. Used on farm and other low-status buildings.
Tally		Double	Single size slates typically sold as 10 x 6" to 26 x 14". Centre-nailed to battens at a defined head lap. Now as specified in BS5534: gauge = 0.5 (length - head lap)
Queen		Double	Large random-sized head or centre fixed at defined head laps. Various lengths, such as 24-44". Finer texture and thinner than tons. Dry laid and torched.
Ton		Double	Large random-sized head- or centre-fixed at defined head laps. Various lengths such as 36-44". Coarser texture and thicker than queens. Dry-laid and torched
Shales		Double, thirds and three-and-a -half-pin	Shales and other slightly metamorphosed stones often worked and sold as slates. Random-sized double-lapped often in thirds.
Stones		Double	Random-sized in length ranges dependent on the rock properties.
Specialised slating			
Colloidal		Double	Tally slates artificially coloured
	Open	Double	Slates laid with wider perpendicular joints for ventilation. Used on animal housing, chemical factories, distilleries and retort houses etc.
	Patent	Single	Perpendicular joints weathered with over-seal slates bedded in putty or similar. Rare in the region but many examples outside Wales. Several similar systems were devised by the Welsh slate industry, but none had commercial success
	Fireproof	Double	Slating fixed to metal grids. Mainly used on industrial and commercial buildings
	Diamond or diagonal	Diagonal	Hexagonal single-size slates laid point down. An ancient system known from Roman archaeological sites
	Swiss Pattern	Diagonal and square	Very rare. Only one example known to survive in Wales
	Resurgam	Diagonal	Rare. Also known as diagonal pattern.

Table 3: Types of slates, slating styles and their lapping systems. Size ranges for large randoms varied from quarry to quarry and some quarries sold more than one range. Many of the slate types were also laid on boards.

this occurs, the work will have to be redone. All lime mortars must harden in the presence of moisture. Covering with polythene over damp hessian will provide a microclimate that encourages carbonation. A fine mist spray applied daily for a minimum of four weeks, where this is practical, is also beneficial.

5 Slating systems and techniques

Historically, all the region's systems used slates or stones from the nearest sources within their own districts (see tables 1 and 2). As transport systems improved and quarries closed, they were obtained from more distant sources.

It is a feature of the historically remote regions with poor transport links that local methods were developed to deal with common roof features such as valleys and abutments. In particular, the arrangement of the slates in valleys was dictated by the size and especially the width of slates available locally and the gauging system used.

The region's vernacular slate roofs use a variety of slating systems based on proportionation: determining the lath gauging by dividing the slate length by a fixed number, rather than by the modern method based on a defined head lap dimension. The older methods use a compass or divider to gauge the roof, a geometric method similar to that of medieval masons (see figure 5). The two primary methods are slating in thirds (length divided by three) and three-and-a-half pin (length divided by three and a half producing a gauge equal to two sevenths of the length). These automatically reduce the head lap and the margins of diminishing length slates from eaves to ridge, so that there are large head laps on the lower courses, which carry the most water, and adequate laps on the upper courses.

The margins determined in this way for each slate length are their basic lath gauges, but the gauge is reduced at a change from a longer to a shorter slate (see figures 31 and 32). In practice the compass is used to transfer these

Figure 31. Where the slating changes from a longer to a shorter slate the batten gauge is reduced. The drop courses are marked red.

Photo Terry Hughes

Figure 32. If the batten gauge is not adjusted at change courses, there will be long margins above short ones indicating that the head lap will probably be inadequate.

Photo Terry Hughes

to a rod for the whole roof (see page 37).

The geographical extent of the two systems is generally unrecorded and their boundaries may be blurred. Slating in thirds is common in north, mid Wales and Pembrokeshire, but the extent of its use elsewhere still needs to be established. Three-and-a-half pin slating similar to dry-laid scantle slating in south-west England, has been recorded on a few roofs. But, because roofs have seldom been properly investigated before renewing them, its use will have been largely unrecognised and therefore under-recorded and the evidence lost.

Hand in hand with these lapping systems techniques evolved for forming watertight valleys, abutments etc usually including mortar and without the inclusion of lead. Regretably, as these roofs needed repair, often after long periods of neglect and lack of maintenance or because of rusted nails, they were deemed to be defective even though they had performed perfectly well for a hundred years or more. For no good reason they have been replaced with modern techniques and details. They are simply stripped and discarded with no attempt to understand their perfectly satisfactory construction and detailing.

Stone slate roofing techniques are less variable than those employing metamorphic slates, generally being laid to a proportional head lap for small sizes and a defined lap for larger varieties. They are always laid double lapped.

5.1 Slating styles

Welsh slate or stone roofs are distinctive because of their materials, the slating techniques employed, their detailing and the repair methods sometimes used to prolong their life.

Figure 33. Most Welsh slates are shades of grey and purple, but in the past a wider range of colours were available. These are the colours sold by Dinorwic quarry in Llanberis, Gwynedd.
Photo Terry Hughes

Older roofs will have used slates or stone slates from sources fairly close by. They are random-sized and the size mix, colour, texture and the way they weather is distinctive for each quarry. Only truly randomly-sized slates ideally from the original quarries can provide an authentic appearance. They should always have edges dressed in the traditional way (see video 6) and never have sawn edges.

Figure 34. Smaller quarries usually working near-surface slates produced so-called rustic slates which were iron-stained. This example is near Llanrwst, Gwynedd.
Photo Terry Hughes

The predominant Welsh slate colours are shades of purple in Cambrian age slate and grey in all the others, but both are described as blue or blue shades. In the past, a wider range of colours has been available in Cambrian slates including red(ish) green and blue(ish) (see figure 33) and in many smaller quarries shades of brown due to iron staining, usually described as rustic (see figure 34). Coloured slates have been used in decorative patterns in tally slating (see figure 35). Green slates are worked out in the operating Welsh quarries so unfading Vermont Green slates are commonly chosen for repairs.

The detailing at hips, valleys, verges and abutments is distinctive and varies within the

Figure 35. Coloured slates have been used to produce decorative roofs. This building is in Nantlle near Caernarfon, Gwynedd but there are similar roofs throughout Wales and England.
Photo Terry Hughes

Figure 36. Slate cladding to protect a south-west facing gable in Welshpool.

Photo Terry Hughes

Figure 37. Almost all region's stone slates are sandstones. Pennant sandstone from near Pontardawe.

Photo Terry Hughes

region. The collar and tie valley for example, is known only in Pembrokeshire and south-west England. Other valleys types such as Welsh in slate and stone and single-cut in slate may be unique to Wales. None of these would have used lead soakers.

Slate cladding, to protect south- and west-facing walls from the prevailing rain, is also a distinctive feature of the region (see figure 36). A wide range of sizes are used although the largest less often because of the weight they impose on the pegs or nails. Cladding with stone slates is done only on small areas such as dormer cheeks.

5.2 Stone slating styles

All the stone slates used in the region are shales, sandstones (see figure 37) or similar, except for the Alternata Limestone in Shropshire, and a few limestones which were specified by architects and imported from the English Midlands. They are typically random-sized, flat, rectangular but with un-squared heads and of a medium range of sizes (see figures 38 (a - e)). Colours are most commonly various shades of grey to brown but with some more purple examples produced in Herefordshire. Edges should be dressed as shown in the video 5.

5.3 Slating techniques

Almost all slating in the region is double-or tripple-lapped, the exceptions being single-lapped Patent, Swiss Pattern and diamond slating, which are rare. Recent research has demonstrated that triple lap slating is more common than had been realised.

For all techniques, slates are set out to achieve head and side laps of sufficient size to resist the penetration of driving rain over the their heads or sides or through the fixing hole (see figure 39).

Tally slating and slating in thirds (see figure 5(e)) are double-lapped – each course is overlapped by the next but one course above. Three-and-a-half-pin slating is triple-lapped – courses are lapped by both the third and fourth courses above (see figure 5(d). This means there is an extra layer of slates throughout the roof, compared with double-lapped slating, making the roof more resistant to driving rain and wind and able to use narrower slates and side laps without leaking.

Head lap can be specified either as a dimension – typically 75 or 100 mm (3 or 4 inches) – or, as when slating in thirds, by setting it as a proportion of the slates' lengths

Figure 38. Most stone slates in the region are shades of grey to brown but there are some purple types in Herefordshire.

Forest of Dean sandstone at All Saints' church, Newlands **(a)**. Shropshire stones in Clunbury (**b**) and Colebatch (**c**).

Harnage stones from the Hoar Edge Grit Formation (**d**) are distinctly different ,being paler coloured and with a very rough surface.

The distinctive Alternata Limestone (**e**) was worked in the past but the extent of its use on roofs is unknown.

Photos Terry Hughes

38(a)

38(b)

38(c)

38(d)

38(e)

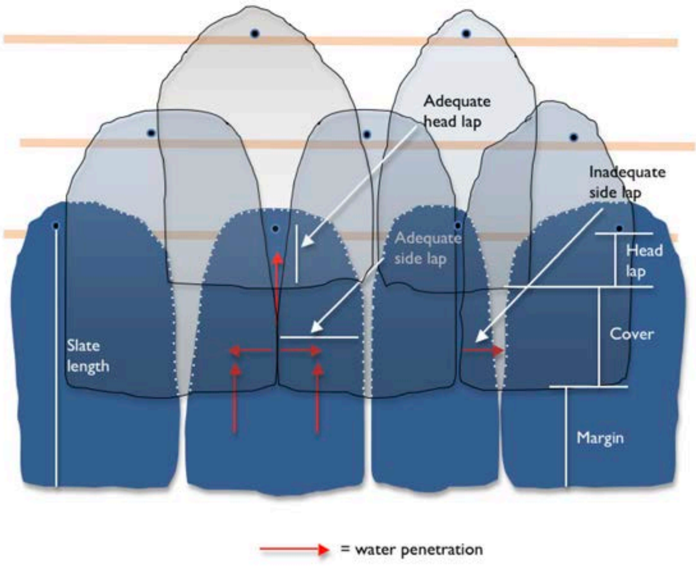


Figure 39. Head, side laps are set to resist rain water penetration.

Illustration Terry Hughes

as described above. A smaller head lap is used for vertical cladding – typically about 2 inches (51 mm).

For large slates a proportional head lap would be very large and wasteful – 200 mm (8 inches) for a slate 600 mm (24 inch) long for example. Nonetheless proportional laps are known exceptionally for slates up to 457 mm (18 inches) long but for slates longer than about 405 mm (16 inches) it is common for the head lap to be specified and the gauging calculated from that.

5.4 Random slating

Random slates are all laid in courses of equal slate length but diminishing in length from eaves to ridge (see figure 39). There may be one or several courses of a given slate length, depending on the mix of slate sizes and the roof's dimensions.

There are several ways the courses can be set out to accommodate their reducing length. The basic lath or batten gauge can be determined as a proportion of the slates' lengths (say one third) or from a defined head lap. The traditional method is based on geometry rather than calculation, and is similar to medieval masons' techniques. It uses a slater's stick to set out the laths - (see page 37). This is actually easier and quicker than the modern arithmetical method using a defined head lap.

If a defined head lap or a fixed proportion of the length is used the slating will be in bands of equal length and the gauge has to be reduced each time a course of shorter slates is introduced (see figure 31). This ensures the margins diminish regularly, and an adequate head lap is always achieved.

5.5 Tally slating

With the general adoption of tally slates and the availability of sawn battens from about the late 18th century, slate roofs started to loose their vernacular character and local techniques were displaced by the standard centre-nailed double-lap system, which is now ubiquitous on new and sadly, very many old buildings.

Tally slates are set out using a defined head lap dependent on their length and width, the roof pitch and the driving rain exposure of the site using the equation

Gauge = 0.5(length - head lap).

Normally, the gauge is the same over the whole roof slope.

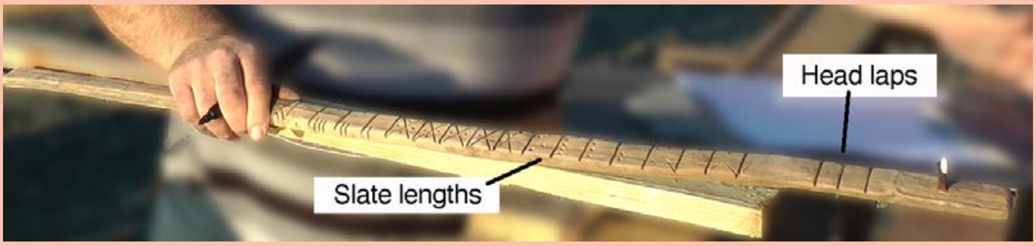
5.6 Single-lap slating

Single-lapping where the slates only overlap the slates immediately below, is not common

Using a slater's stick to gauge a roof

All the vernacular slate types in this Advice Note would have been set out with a slater's marking stick when they were first slated. Sticks vary nationally but all have a mark for each slate length and a pin at one end (see figure 40(a)). The marks can be numbers or symbols, and historically they might have been finger widths roughly equal to one, two or three inches. They could have included some head lap marks also roughly equal to one to three inch intervals. Alternatively, they might have lath gauges corresponding to each slate length for a chosen gauge, such as thirds or three-and-a-half pin.

The stick is first used to sort the slates into length sets (see figure 40(b)). The slater has to make a decision about the size of the length sets. They could be small - half inch stets - or inch sets or larger for very long slates.



40(a)

40(b)

Once complete the total width of each length is measured or estimated, and these are divided by the roof width to determine how many courses can be laid in each length (see figure (40(c)).

The stick is then used to mark the position of each course of slates. It can be done either directly on the rafters or on a rod or a pair of rods, which are placed on the rafters at either side of the roof and a string line snapped across (see figure 40(d)).

The positions of all the laths on the roof are set out to margins and these and the lath gauges diminish all the way up the roof. This is different to modern tally slating which calculates lath or batten gauges starting with a specified head lap.

The process involves using the slate lengths on the stick to mark lath gauges onto one or a pair of rods, which are the length of the rafter plus the eaves overhang. These are then placed on either side of the roof and a string line snapped across the rafters to mark the top of the laths.

Courses	Slate Lengtrhs	Gauge	Margin	Head Lap
22	**10½**	3¾		
21	**10½**	3½	3¾	
20	**11**	4	4	3¼
19	**11**	3¼	4	3
18	**12½**	4¾	4¾	3¾
17	**12½**	4½	4¾	3
16	**13**	5	5	3
15	**13**	4½	5	3
14	**14**	5	5½	3½
13	**15**	6	6	3½
12	**15**	6	6	3
11	**15**	6	6	3
10	**15**	5½	6	3
9	**16**	6½	6½	3½
8	**16**	5½	6½	3
7	**18**	7½	7¼	4
6	**18**	7¼	7½	3
5	**18½**	7½	7¾	3¼
4	**19**	7¾	8	3⅛
3	**19½**	8¼	8¼	3⅛
2	**19½**	8	8¼	3
1	**20**	20	8½	3

40(c)

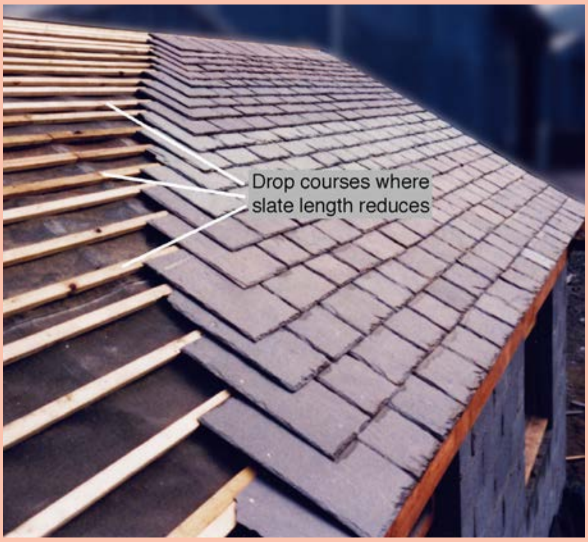
The eaves course mark for the longest slate is positioned on the rod, allowing for the eaves overhang. The second and third course marks, which might each be for equal slate lengths, or the second might be shorter, are placed for the appropriate head lap and to give equal or diminishing margins.

All the subsequent gauges are similarly marked, but always keeping an eye on whether any have produced a longer margin (a pig course or gaper) or too small a head lap. If so, the mark is lowered on the rod. Inevitably, every mark affects every subsequent one up the roof, so the gauging might not reach the ridge at the first attempt. It is quite normal to repeat the process to get the whole rod right.

On the roof the drop courses can be seen where there is a reduced gauge (see figure 40(e)). If a roof hasn't been set out correctly with drop courses, long margins can be seen above shorter ones (see figure (40(f)).

Photos Terry Hughes

40(d)



40(e)

40(f)

in Wales, being largely restricted to the use of very large or very wide slates on simple buildings such as pigsties close to the quarry (see figure 5(c)). These were too big to carry further afield without breaking.

Patent slating

A more formal use of single-lapping, Patent slating, was 'invented' by Charles Rawlinson of Lostwithiel in Cornwall. He was granted Letters Patent for a New Invented Method of Covering Roofs with Slates in 1772. It may derive from a vernacular technique seen on larger buildings in Scotland, the north of England, Ireland and Norway (see 10.5 Hughes 2012 and 2020).

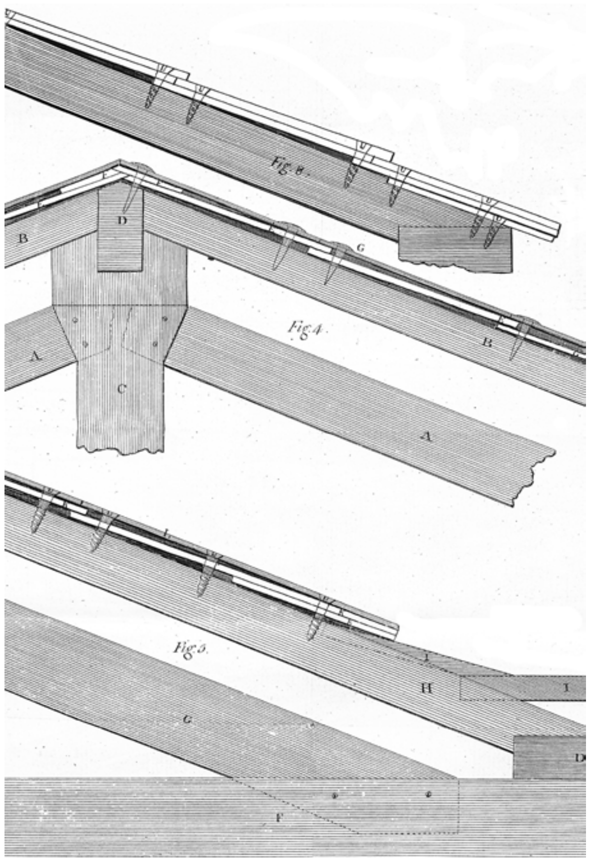
The method was promoted (and possibly independently 'invented') by the architect James Wyatt, and used on many buildings in the UK. Its use is rare in Wales, the only known example being the 1848 Penoyre House near Brecon by Anthony Salvin (see figure 41(a)).

By laying the slates single lapped and simply butting up the sides, the perpendicular joints are left open but leaks are prevented by over-sealing - bedding slate strips onto them in a 'mastic' or glaziers' putty (see figure 41(b)). There are two styles which can be distinguished by the over-seal slates which weather the open butt joints. The original Rawlinson system used flat slate strips (see figure 41(c)) whereas the later system, believed to have been devised by James Wyatt in co-operation with Penrhyn Quarry, uses slate 'rolls' (see figure 41(a)) which resemble the appearance of a lead roof. For authenticity and historical accuracy the two methods should never be substituted for each other. Despite the technique's apparent regional rarity, it is nationally important.

The system is perfectly successful until the old mastic hardens and cracks. So these roofs

41(a)

41(c)



41(b)

Figure 41. In Patent slating the perpendicular joints are oversealed with slate rolls (**a**) or flat slate strips (**b and c**). Rawlinson's original design is shown in (**b**).
Photos (**a**) Camilleri Roofing, (**b**) Terry Hughes

should always be conserved, albeit with a modern, non-hardening sealant. Although the slabs look strong they usually span a metre or more so they should not be walked on to avoid cracking them.

Swiss Pattern

In this system, which is widely used in several European countries, each course is single lapped vertically but each slate overlaps the adjacent slate laterally. The slates could be laid with their long edges parallel or perpendicular to the battens. In the post war period when there was a government drive to devise novel building, methods to overcome shortages of materials including timber for roof construction, it was promoted by the Oakley Slate Company, using traditional fixing to wooden battens or hooked to iron battens (see figure 42). A roof in Church Stretton, Shropshire is still performing well after 70 years (see figure 43).

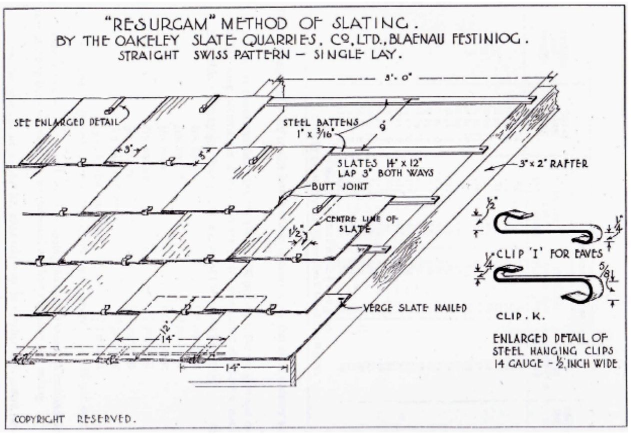


Figure 42. The Oakley Slate Company's Resurgam Swiss pattern slating hook fixed to steel laths.
Illustration Oakley Quarry

Figure 43. Resurgam Swiss pattern slating in Church Stretton.
Photo Church Stretton Golf Club

5.7 Double-lap slating

Double-lapping is used for tally and random slates. Head lap can be specified either as a dimension – typically 3 or 4 inches (75 or 100 mm) (see figure 44) – or, as in, for example, slating in thirds, by setting it as a proportion of the slates' lengths. The latter is economical because it automatically reduces as the slates' lengths reduce. This is satisfactory, because the smaller slates with smaller laps laid near the ridge carry less water. Proportional gauging is not appropriate for larger slates because the head laps would be wastefully large. Therefore for slates longer than about 16 or 18 inches (400 or 450 mm) it is more appropriate to specify the head lap and calculate the gauging from that.

A smaller head lap is often used for vertical cladding – typically about 2 inches (51mm).

Slating in thirds

Slating in thirds is a particular form of double lapping, using proportional gauging of one third of the slates' lengths (see figure 5(e)). It is used with random and small tally slates. With larger slates the head lap would be excessive and wasteful.

5.8 Triple lap slating

In this system slates overlap those next but two below, so that over the whole roof there are three layers and at the head lap, four (see figure 5(d)). Only a few roofs using this system have been confirmed in Wales: at Tremeirchion in Denbighshire and Edern in Gwynedd. Because it only becomes apparent when a roof is carefully recorded, other instances may have simply been unrecognised and lost. The system is common in Devon and Cornwall and as there are other similarities between the slating techniques in these counties and in west Wales, its use here is likely to have been more extensive.

5.9 Diamond or diagonal slating

This is an ancient technique known mainly from archaeological excavations of Romano-

Less than 56.5 l/m² per spell

Size (Nominal) mm	Minimum Rafter Pitch 20°	22.5°	25°	27.5°	30°	35°	40°	45° to 75°	85°
600 x 350	115*	105*	95*	85*	80*	70*	60*	55*	50*
600 x 300	-	-	95*	85*	80*	70*	60*	55*	50*
550 x 300	-	105*	95*	85*	80*	70*	60*	55*	50*
500 x 300	115*	105	95	85	80	70	60	55	50*
500 x 250	-	-	95	85	80	70	60	55	50
450 x 300	-	-	-	-	80	70	60	55	50
450 x 250	-	-	-	-	80	70	60	55	50
400 x 300	-	-	-	-	80	70	60	55	50
400 x 250	-	-	-	-	80	70	60	55	50
400 x 200	-	-	-	-	80	70	60	55	50
350 x 300	-	-	-	-	80	70	60	55	50
350 x 250	-	-	-	-	80	70	60	55	50
350 x 200	-	-	-	-	80	70	60	55	50
300 x 200	-	-	-	-	80	70	60	55	50
270 x 180	-	-	-	-	80	70	60	55	50

56.5 l/m² or greater per spell

Size (Nominal) mm	Minimum Rafter Pitch 20°	22.5°	25°	27.5°	30°	35°	40°	45° to 75°	85°
600 x 350	150*	130*	120*	110*	100*	85*	80*	70*	65*
600 x 300	-	-	120*	110*	100*	85*	80*	70*	65*
550 x 300	-	130*	120*	110*	100*	85*	80*	70*	65*
500 x 300	-	130*	120*	110*	100*	85*	80*	70*	65*
500 x 250	-	-	-	110*	100*	85*	80*	70*	65*
450 x 300	-	-	-	-	100*	85*	80*	70*	65*
450 x 250	-	-	-	-	100*	85	80	70	65
400 x 300	-	-	-	-	100*	85	80	70	65
400 x 250	-	-	-	-	100	85	80	70	65
400 x 200	-	-	-	-	100	85	80	70	65
350 x 300	-	-	-	-	100	85	80	70	65
350 x 250	-	-	-	-	100	85	80	70	65
350 x 200	-	-	-	-	100	85	80	70	65
300 x 200	-	-	-	-	100	85	80	70	65
270 x 180	-	-	-	-	100	85	80	70	65

Figure 44. For tally slating to BS5534 recommendations, slate manufacturers provide tables of head laps production slate sizes. Many are reliable but some do not give adequate side laps, so it is wise to check these.

Illustration Welsh Slate Ltd

British sites (see figure 1). Slates are roughly hexagonal and laid point down. With the name Resurgam, Oakley Quarry promoted a diagonal version of their Swiss Pattern system described above (see figures 1 and 45(b)). It may have been based on Moses Kellow's patented system (see figure 45(b). It was promoted by several companies. One was Richard Fletcher of Blackburn, the self-proclaimed 'oldest slating firm in the country,' which also claimed to have patented the system and used it on a Government factory at Yate near Bristol (see figure 46). The system lives on in fibre-cement slating.

5.10 Fire-proof slating and grillage systems

Developed in response to mill fires from the late 18th century, the slates were fixed to flat wrought iron or angle iron laths on cast iron trusses or rafters (see figures 47(a and b)). The laths were often set into saddles or notches at fixed positions in the trusses or rafters which dictated the size of slates which would be used.

In response to the wartime shortage of timber, alternative methods of building construction were investigated from the early 1940s by the National Pitched Roofing Council which included all the slate and tile trade associations and the London Federation of Slaters and Tilers. Steel was proposed as an available substitute for timber roof structures and two systems were presented: the Oakley Slate Quarries' Resurgam and E Hillson's Prefabric Steel Grillage. Both involved steel grids with the 'laths' welded at the slating gauge and the slates fixed with clips (see figure 48). There is an example on an estate house in Vaynol Park, Bangor.

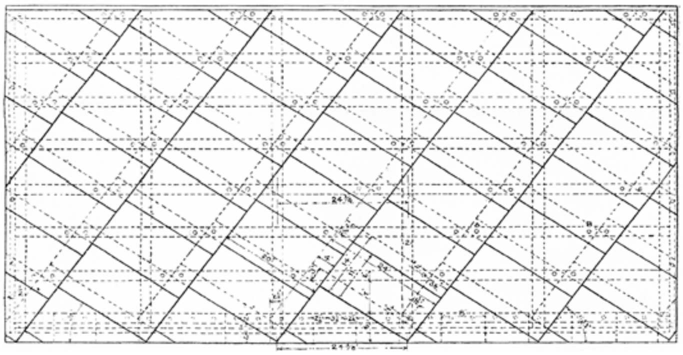
Dorothea Quarry had investigated a similar system of angle iron 'laths' fixed to steel trusses on behalf of the Associated Slate Quarries in 1939. This was primarily directed at the War Office for hutments and prisoner of war camps but was unsuccessful. It was taken up by the Manchester Slate Company and promoted as the Slategrip and Prefabric systems.

The grillage system was eventually successful commercially. In the 1950s, for example, Precision Roofs Ltd of Sheffield advertised its system, showing the large number of local authorities which had used it on many schools and similar large buildings (see figure 48).

5.11 Economy or open slating

On buildings such as animal housing, distilleries and retort houses, where good ventilation is needed, the slates were spaced out horizontally giving the roofs a distinctive appearance. They are quite common in Wales known as *tor brat* (see figure 49). Provided the slates have adequate head and side laps this is satisfactory.

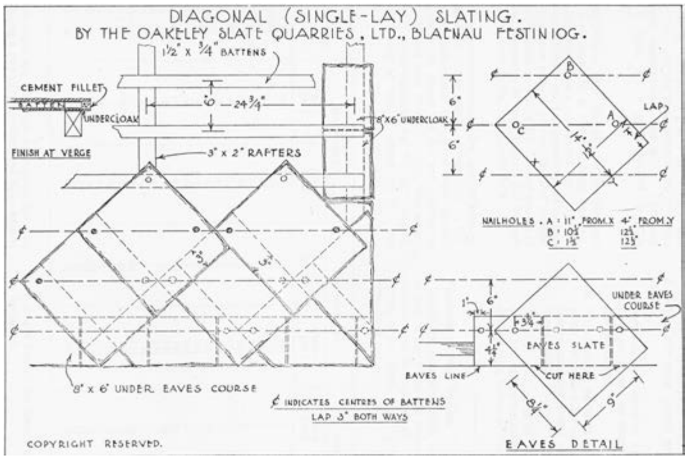
As animal housing the occasional leak during severe weather would be acceptable, so they can be repaired as found. If however there is to be a change where this wouldn't be acceptable the slating can be adapted to provide normal



45(a).

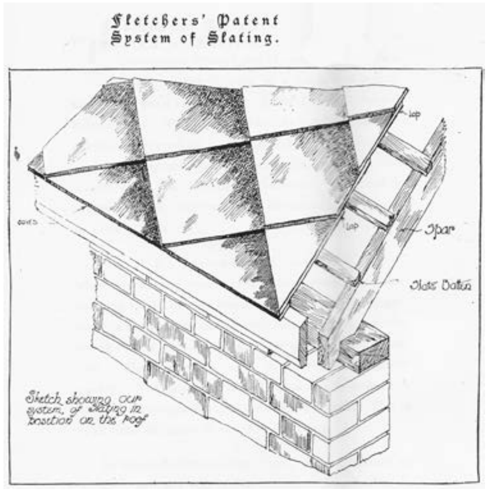
Figure 45. (**a**)Kellow's system of diagonal slating. "Plan of roof with 24in. by 14in. slates laid diagonally for main cover , and a 6in. by 6in. straight course at the eaves. Vertical rafters and horizontal battens. (**b**) Oakley quarries diagonal version of their Resurgam slating system (**a**).

Illustrations (**a**) Railways Supplies Journal (**b**) Oakley Quarry



45(b).

Figure 46. The diagonal system was taken up by a number of companies, often claiming it as their own invention and that it was patented.



47(a)

47(b)

Figure 47. The development of iron framed buildings to resist fires eventually included the roof structure with iron trusses and laths (**a**). The laths were often set into notches in the rafters (**b**). This dictated the length of slate which would be used.

Photos Terry Hughes

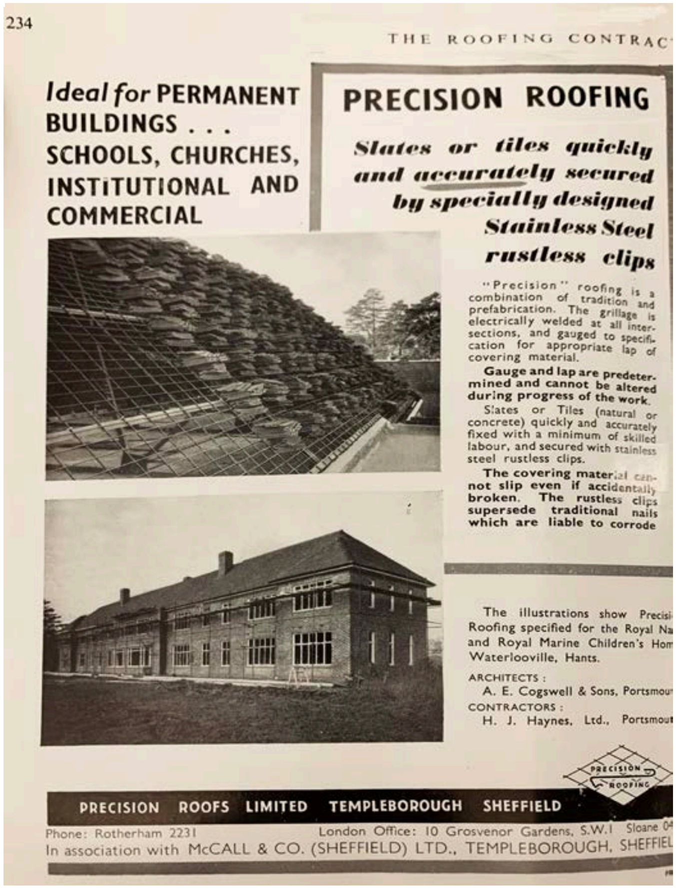


Figure 48. Grillage systems had some commercial success from the mid-20th century. They continue to be re-invented today.

Illustration The Roofing Contractor journal

Figure 49. Open slating to provide good ventilation is fairly common on animal housing in the region.
Photos Adam Burnett

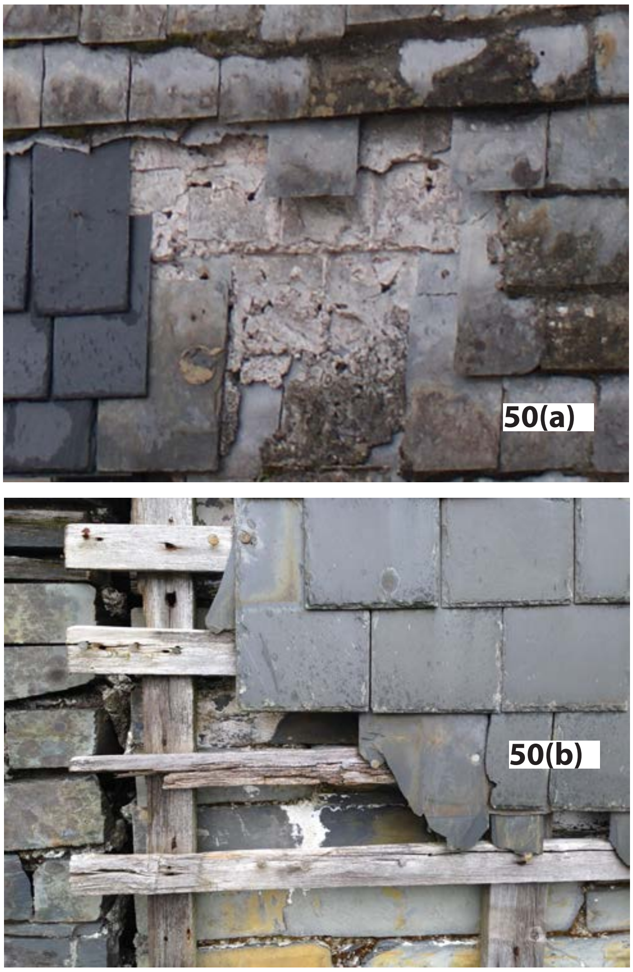


Figure 50. Cladding slates were either pegged into two layers of mortar **(a)** or peg hung or nailed to battens (**b**).
Photos Terry Hughes

weather resistance. Specialist advice should be obtained.

5.12 Wall cladding

Slate cladding to protect south- and west-facing walls from the prevailing driving rain is common throughout the region (see figure 36). It is rarely done with stone slates, because they are too heavy. In slate a wide range of sizes were used and they are usually laid closely together laterally but are sometimes spaced out to promote air circulation behind them. Many examples were not original features of the building but were added to alleviate damp walls.

The slates are fixed directly to mortar render (see figure 50(a) and video 7) or to laths or battens which in turn are nailed directly into the mortar joints, or to counter-battens nailed to the wall (see figure 50(b)). Historically, wrought iron nails were used for batten or counter-batten fixing which held well when they rusted but eventually corroded away or failed due to rust-jacking.

The slates are pegged or nailed directly to the mortar, or to the battens, and bedded in mortar. Mortar for direct fixing is laid in two coats. The first is allowed to set, the second is then applied either, onto the first coat or onto the back of the slates and they are pressed on and pegged or nailed into the first coat. The mortar mix is critically important to ensure good wind-resistance.

The eaves are given a large kick, to cast water well away from the wall and to allow the slates in successive courses to sit tightly together. Historically, the slates at external angles were not soakered but were carried slightly beyond the opposite face. Soakers should be used today.

6 Specifications and detailing

6.1 Slating specifications

Specifications should include the materials to be used, methods to be applied and the detailing of local areas such as eaves hips and valleys etc.

All slating should be specified and constructed to provide adequate head, side and shoulder laps to resist driving rain and be fixed to resist wind uplift. If the survey or investigation of the roof has confirmed that the existing laps were satisfactory, they should be replicated. They should be changed only if there is a technical reason to do so. Increasing deluge rain may be one reason but there is no need to automatically change to BS5534 laps (see page 8). The various slating systems described in the previous section achieve these objectives in different ways. Most importantly, some details such as particular valley types can only work with the appropriate lapping system, such as thirds or three and a half pin.

There is little reason for variation in the general slating. The gauging rules are normally applied consistently to all slopes, unless there are different pitches across an intersection, for example, a close mitred hip or a valley (see 6.6).

Slates should be laid without gaps underneath them. For single sized (tally) slates this is done by sorting them into sets of equal thickness and laying them with the thickest at the eaves grading down to the thinnest at the ridge. This is not possible for random-sized slates because they have to be positioned on the slope where their length dictates. Therefore they must be selected as they are laid, to ensure adjacent slates are equally thick or they can be sorted for thickness from side to side.

6.2 Eaves

The slating should overhang at the eaves to discharge water into the gutter where there is one or well away from the wall if not. Where there are no gutters long slates will be needed to give an adequate throw.

A tilt must be provided to lift the tail of the under eaves slates to ensure the subsequent courses lie tightly onto each (see figure 51). This is done either by fixing a tilting fillet, by raising a fascia board or, if the rafter is set back on the wallhead, by packing up the masonry. Where the slates are laid directly on an uneven wall head without a wall plate, a double undereaves course is used to level the wall and provide tilt (see figure 52).

Figure 51. To ensure slates in each course lie closely onto each other the eave is tilted slightly.

Photo Terry Hughes

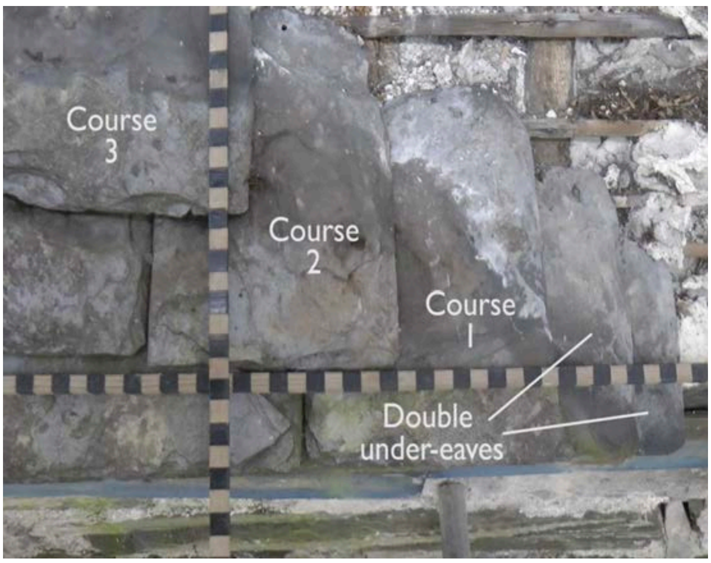


Figure 52. Where the roof does not include a wall plate, a double eaves course is sometimes used to level the slating.

Photo Terry Hughes

Figure54. Verges are susceptible to wind damage, especially where the bond is closed with a narrow or half-width slates as on the furthest gable in **(a)**. Several techniques have been used to overcome the problem. In **(a)** the nearest verge is held down with a slate slab, and on the middle gable the original half slates have been replaced with the modern solution: slate-and-a-half slates, when the roof was reslated. These is not traditional.

Verges formed by butting the slating against a raised outer leaf of the gable (**b**) can be difficult to make water tight even if lead soakers are incorporated. Tilting the slating upwards can help by directing water away from the junction (**c**).

Traditionally verge slating was held down by bedding on stone (**d**), rough slate blocks (**e**), or sawn slate slates (**f**).

Photos Terry Hughes

54(a).

54(b).

54(c).

54(d).

54(e).

54(f).

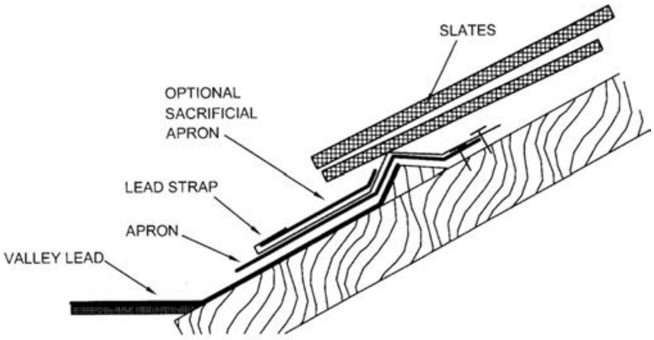


Figure 53. For the future, the need to remove the lower course(s) of slates over a horizontal lead valley can be avoided if a lead apron is substituted for the first course.

Illustration Terry Hughes

In horizontal valleys the lead is laid underneath the eaves slates. When it needs to be repaired or replaced, the lower courses of slates have to be removed, which is awkward. To avoid this a lead apron can be installed which can be folded back the next time the valley needs repair (see figure 53).

6.3 Verges

Verge slating is finished with either a slight overhang to the gable wall or cladding and a mortar fillet under the slates; an external rafter or barge board; or an abutment (see figure 54(a) and 21(a)). Barge boards, although common, are not a vernacular detail. The slating is often raised slightly by setting up the rafter, packing up the laths or bedding up the slates to direct water away from the verge or abutment and back onto the roof slope (see figure 54(b) and video 8).

Slating is often finished against a raised outer leaf of the gable wall, sometimes below a cope (see figure 54(c)) and sealed with a mortar fillet. Probably inherited from thatching, when applied to slating, it is a weak detail susceptible to leaks. To overcome this lead soakers are commonly incorporated during reslating but this is not effective in all cases because dampness can still penetrate through the raised wall or butted cope joints.

Verges are susceptible to wind damage. Localised techniques to overcome this include, bedding stones onto the slates (see figure 54(d)). In the slate quarrying regions sawn slabs or small rough blocks were used; (see figure 54(d) and 54(e)) and in north Wales 90° ridge tiles were popular. The similar technique - fixing a verge board over the slates - is a later innovation. Today, plastic verge covers are being used increasingly, even on completely secure modern slating. They are unnecessary and are not appropriate for historic roofs. Listed building consent would be needed for plastic fascias and is unlikely to be given.

Often there is very little upstand between the slates and the coping so, if the roof is raised, for example, to accommodate insulation, it may be impossible to weather the junction without recourse to a secret valley (see 6.7.8}.

Where there are external rafters, they, and any exposed purlin ends, are often protected with barge slates (see figure 55) and are sometimes decoratively shaped. They are either overlapped by about one-third to protect the nails or butted end to end with the nails exposed or covered with a mortar fillet.

Figure 55. Where an external rafter is installed it is often protected with barge slates.

Photo Terry Hughes

6.4 Abutments

The junctions between the slating and abutting walls and chimneys can be difficult to make watertight. Historically, abutments did not include soakers and relied on mortar fillets which are prone to cracking (see figure 56(a)), or slates bedded in mortar or nailed onto the wall to prevent water penetration (see figures 56(b) and 56(c)). These were often protected by slates set into the wall (see figure 56(d)); and the roof slating might be tilted slightly, by raising the last rafter, packing the laths, or by bedding the slates up on mortar, to direct water away from the junction (see figure 56(e).

56(a)

56(b)

56(c)

56(d)

56(e)

Figure 56. Abutments are commonly weathered with mortar fillets but they are prone to cracking **(a)**. To help prevent water penetration, slates were bedded over the junction **(b)** or nailed to the wall and **(c)**.

The abutment was often protected with slates or slabs set into the wall above, which cast water away (**d**) or by raising the slating (**e**).

Photos Terry Hughes

It is possible to conserve the appearance of abutments but to include concealed lead soakers. These and cover flashings became common once lead was economical, but the latter can be visually intrusive and mortar fillets are preferred. The technique of bedding slates into the mortar to prevent cracking is surprisingly rare in the region except in Pembrokeshire and not used at all on stone roofs. When renewing fillets the risk of cracking can be reduced by avoiding hard mortar, by forming the fillet in two or three coats of well-haired mortar or by separating it from the slating and incorporating stainless steel mesh screwed to the masonry joints (see figure 57).

Figure 57. Cracking of mortar fillets can be reduced by incorporating fibre in the mix or with expanded metal reinforcement.

Photo Terry Hughes

If the roof level is raised, for example, under a label course to accommodate insulation, it can become impossible to form a weather-tight junction except with a secret valley or gutter (see section 6.7.8).

6.5 Ridges

The earliest ridges were finished with a clay or turf capping, by carrying the windward side slates above the opposite slope or with wrestlers (see figure 58).

On metamorphic slate roofs, the 18th and 19th centuries saw the adoption of clay tiles, lead, and less commonly, stone ridges. Patent slate ridges and hips were made by slate quarries (see figure 59) often with decorative crests (see figure 60). Iron foundries also made elaborate ridges, which are a feature of civic

Figure 58. Wrestler ridge on a shed at Kennixton Farmhouse from Llangennith, Gower, Glamorgan. Now at St Fagans museum, Cardiff.

Photo terry Hughes

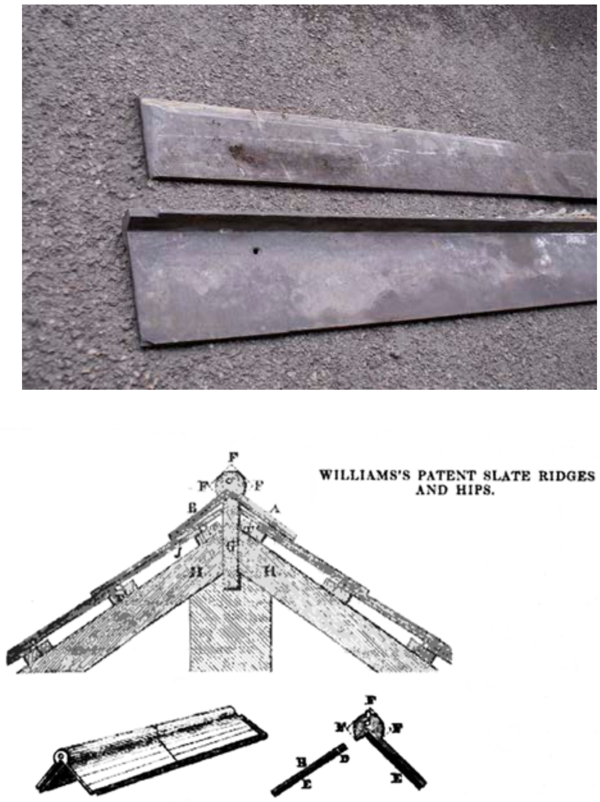


Figure 59. One- and two-piece ridges and hips were frequently claimed to be 'patented.

Photo Terry Hughes

Figure 60. Decorative crests for "Patent' ridges.

Photo Terry Hughes

buildings in the region (see figure 61). Stone roofs are usually finished with stone ridges cut from freestone (see figure 62). For all these ridge types, new pieces to replace any broken sections can be manufactured to order

Clay and stone ridge tiles should be back-bedded in mortar which should not show at the long edges as far as possible. They should not be pointed (see figure 63). The butt joints of plain ridge tiles were weathered with small slate slips (see figure 64).

Where dormer ridges run into the main slating, the slates and the ridge tile are swept up into the main slope (see figure 65) or the junction is weathered with an upturned ridge tile, or today, with a lead saddle.

Under lead ridges or aprons and over the lower

Figure 61 . Cast iron ridge on Chester town hall.
Photo John Greenough,

Figure 62. Stone ridges (**b**) were also made in single pieces from freestone.
Photo Terry Hughes

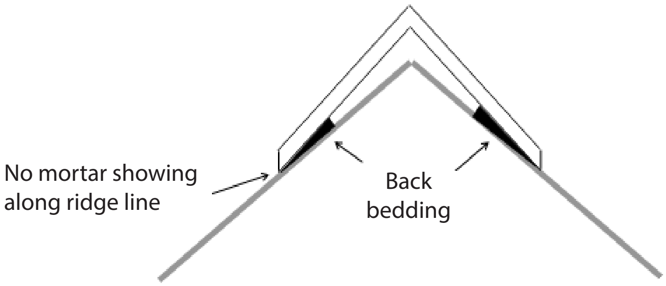


Figure 63. Ridges should always be back-bedded (**f**) and should not be pointed along the long edges. Ideally, they should not show mortar under the long edge but this is not always possible if the ridge is uneven.
Illustration Terry Hughes

Figure 64. The butt joints of plain ridge tiles were weathered with small slate slips.
Photo Terry Hughes

Figure 65. Before the use of lead saddles, the difficult junction between a dormer ridge and the main slope was weathered by sweeping the slates and the ridge up into it.
Photo Terry Hughes

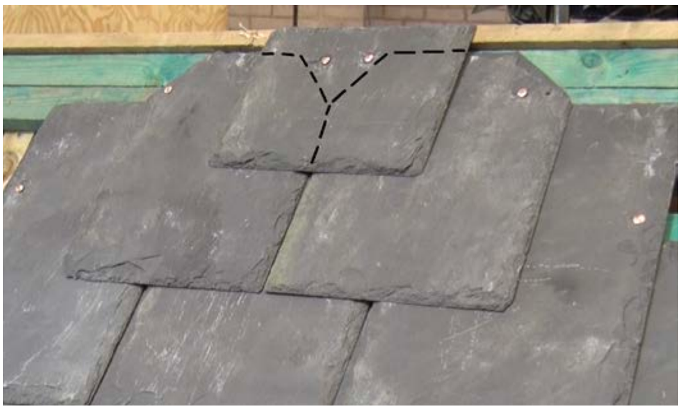


Figure 66. Under lead ridges or aprons, the heads of top course slates must be supported on a thicker batten and ideally, nailed as low as possible (see video 9).
Photo Terry Hughes

slope of mansard roofs, the top course of light-weight slates must be properly supported to resist wind uplift (see figure 66 and video 9)

6.6 Hips

Before lead and ridge tiles became commonly available hip slates were mitred and bedded on clay or mortar. Today the mitre is normally weathered with lead soakers. If the adjacent slopes have unequal pitches it is good practice to adjust the gauging and hence the margins so that they course across the hip (see figure 67) but this may not have been traditional practice. Provided the hip is water tight the original detail can be reinstated.

Cut slates on mitred hips are vulnerable to wind damage, so to reduce this risk wider slates were selected for the raking cut (see figure 68). Alternative wind-resistant options

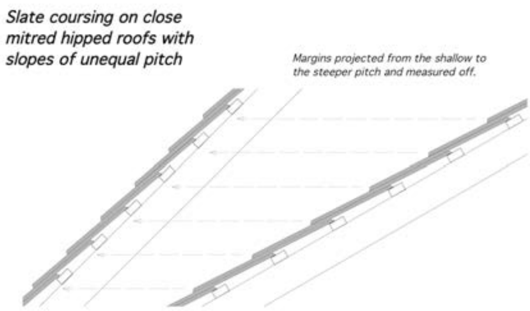


Figure 67. On unevenly-pitched mitred hips the gauging and/or the slate length can be adjusted on the steeper pitch to match the margins on the lower pitch so that they course across.

Illustration Terry Hughes

Figure 68. Wide slates are used on mitred hips to reduce the risk of wind damage. Hereford stone on St Mary's church, Kempley

Photo Terry Hughes

Figure 69. Slate ridges were equally suitable for hips.

Photo Terry Hughes

Figure 70. Cast iron hip at Bridge Street, Dolgellau..

Photo Terry Hughes

are to cover the hip with lead or clay tile, stone, slate or cast-iron ridges. (see figures 69 and 70) The latter three can all be made to order.

6.7 Valleys

6.7.1 General

The difficulty of making a watertight valley has been tackled with ingenuity, especially before the ready availability of lead for soakers. Various methods, sometimes bedded in clay or mortar, have been used in the past and these add to the character of the building. There is no reason why they cannot be replicated when reslating a roof.

The examples given here and their region of use may be incomplete. Several variations have been recorded in north and mid Wales over recent years, and further research is needed. The types traditionally used and the regions where they have been recorded are shown in Table 6. In the stone slate regions, the valley type is dictated by the stone's properties. The larger or thicker stones, such as Pennant, Hereford sandstone and the Tilestones do not suit curves or sweeps, so Welsh valleys are typical (see video 10). The thinner Silurian and Ordovician stones, but not Harnage, can be laid to curves and may be formed to single cut or swept valleys, as well as the more common Welsh type.

There are many subtleties in the way vernacular valleys are constructed. Each type will work only with their traditional lapping system (see figure 71(a)).

To perform well, valleys have to deal with some constraints: the narrowness of small vernacular slates; their limited range of lengths; and, as is normal for all valleys, the fact that the valley rafter is longer than the common rafters. A variety of valley types tackle these issues in different ways. Also, besides the way the slates are arranged in each type, there are some techniques which are applied more generally. These are:

- The phenomenon whereby water clings to the edges of the slates. Advantage of this is taken by shaping the slates to a point, to direct the flow of water to where it will not leak into the roof; usually, onto the centre of a slate below. Chevrons and shales are examples of this technique.
- The use of shales, small pieces of slate which cover or underlay gaps in the slating. They are always shaped with a point at the bottom and placed so the point directs water onto the slate below.
- Tilting slates at a valley so that water running down the roof is turned away from the vulnerable junction (see the video in 6.7.5).

Valleys can be classified in two main types. Those that carry the slating across the junction in the same curved plane - swept and collar-and-tie, for example - and those where the valley slates are set below the main areas on either side with the main slating laid over them - the Welsh valley is one example. There is also at least one hybrid where only one side is over laid - the single cut.

Welsh, single cut valleys and shale all tilt the slating on either side of the intersection to turn water away from the vulnerable area. They do this by offsetting the valley board and/or by the slates overlying each other. In a single cut valley for example, the cut side slates are tilted because they lie on top of the swept side slates.

A valley rafter is longer than the common rafters. So, if the slating is to course across the valley in the same plan, longer slates are needed in the valley so that there will be the same number of courses and the margins will be the same height. If there is a wide range of slate lengths in the consignment, the longer ones can be selected for the valley. But some small quarries supplied slates in just a few lengths and only a few of the longer ones. So a roof would have maybe two or three courses of 16 and 14 inch (405 and 355 mm) long slates, and the rest of the roof could be all 12 inch (305 mm). In this case, where the slates available for the valley do not fit the intended gauge perfectly, the valley slates are gauged for the required head lap and the gauge of the slating on both main areas is decreased to suit. In this way, the main areas which would otherwise be slated in thirds might become

Valley type	Slate or stone	Locality
Swept	Slate	Mid-Wales
Mitred slate-lined	Slate	North Wales
Collar and tie	Slate	Pembrokeshire
Shale	Slate	North Wales
Single cut	Slate	Mid-Wales and Marches
Welsh	Both	Mid- and south Wales, Marches
Welsh mitred	Slate	North Wales
Mitred lead-lined	Slate	Not vernacular but common as replacements of traditional valleys
Open lead-lined	Both	

Table 6. Traditional valley types and their known locations

three-and-a-half pin; because the gauge has been reduced.

Lead-lined valleys are not vernacular and laced slate valleys are not traditional in Wales (see 10.5 Hughes 2019).

More information and videos of valley construction can be seen here.

6.7.2 Swept valleys

Swept valleys of the Cotswold type are not common in Wales (see figure 71(b)). Normally, these valleys are formed by selecting longer and wider slates from the stock and dressing them to taper from head to tail (see figure 71(c)) or selecting suitably shaped ones. Many Welsh vernacular slates were narrow and supplied in just two or three lengths so they could not be dressed to a wide enough inverted triangle, or provide the necessary head lap in the valley without reducing the gauge on both slopes which would be costly. Where they are seen, they use many narrow slates to get round the intersection, eight or more compared with three and four slates wide in alternate courses, for example, in the Cotswolds.

6.7.3 Collar and tie valleys

Collar and tie valleys are more common in south-west England than in Wales where they are known only from Pembrokeshire (see figure 71(c)).

The valley slates are longer than the main slates which compensates for their narrowness. These are a swept valley type but they work differently from conventional swept valleys, and to be effective the roof has to be set out for at least slating in thirds.

Alternate courses are close mitred (the collars) and swept (the ties). The joints in the close mitred (collar) courses are weathered by the slate in the next course down. The central slates in the tie courses need to be even longer than is simply needed, to ensure the margins match, so that they are triple lapped. So even if their very narrow side laps leak, there is an extra slate underneath to catch the water and carry it back out of the slating. Also of note, the tails of the tie slates are cut to carry water away from the mitre junction in the course below (see video 11).

6.7.4 Shale valleys

Shale valleys are very complicated and require great skill. It is essential that the main slating is set out for three-and-a-half pin gauge for the valley to work. The valley is built up in three layers: a wood valley board; a lining of chevron shaped slates laid single lapped on the board; and the valley slates (also chevron shaped) on the linings with shales interleaved between them (see figure 72(a)).

The lining slates raise the main slates on either side, turning water away from the valley. They also carry any condensation or water that might get through the valley slates down the valley and out at the bottom.

These valleys tackle the narrow slate problem in a different way. The valleys are only a few slates wide and are laid in the same way as a swept valley, but they overcome the problem of the gap at their top corners by inserting shales between the slates at their shoulders. These are pointed to direct any water onto the valley slate below (see video 12).

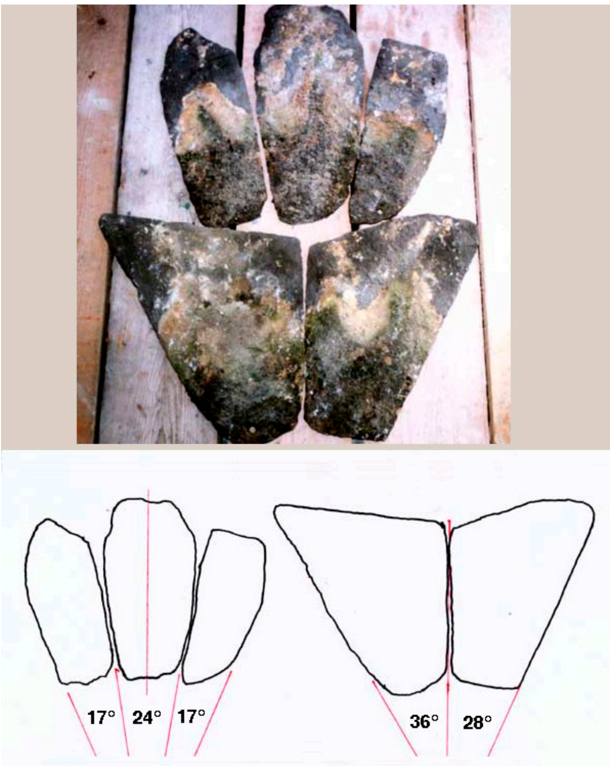
Surface tension at the chevron edges of the lining and valley slates holds any water that reaches them, and directs it to the point at the bottom and onto the centre of the slate below. This is an effective way of controlling the movement of water and preventing leaks into the roof (see video 13).

6.7.5 Welsh or double-cut valleys

Seen in slate over most of mid and eastern Wales and in stone in south Wales, the Forest of Dean and Herefordshire, Welsh or double-cut valleys, are best suited to roofs where the intersecting slopes are of equal pitch or no more than 15° different. The whole valley is in effect a narrow roof laid in the same way as the main slating, but with longer slates than those on the adjacent slopes. The slates on either side lap onto the valley slates by about 180 mm (7 inches) for a typical pitch of more that 35° and consequently are tipped up slightly to direct water away from the valley (see figures

71(**a**).

71(**b**).



71(**c**).

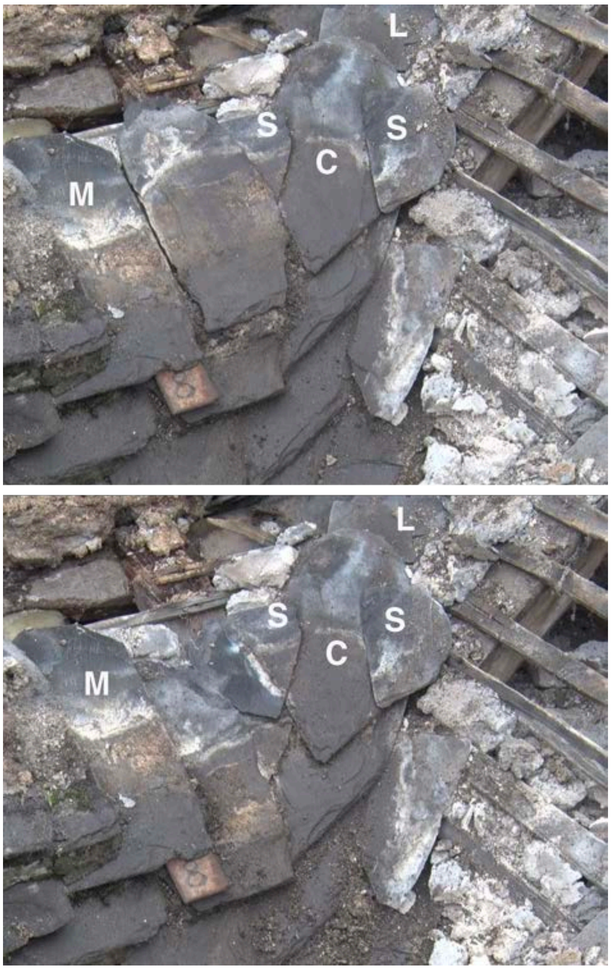
71(**d**).

Figure 71
In valleys where the slating course across the intersection (swept, shale and collar and tie for example) they will work only at their traditional gauge. In (**a**) the slating is laid at three-and-half pin, producing margins of 2/7ths of the slates' lengths and is essential for the the shale valley shown in 72(b).

Swept valleys are not common in Wales and where they do exist they reuire a wide sweep to work with the generally narrow slates produced in many Welsh quarries **(b)**. They contrast with the Cotswolds swept valleys, where wide slates (**c**) are plentiful and can be formed to work well in sets of two and three slates in alternate courses (**b**).

Collar and tie valleys **(c)** need very long slates centrally to prevent leaks.

Photos Terry Hughes



72(a).

72(b).

72(c).

72(d).

Figure 72.
In shale valleys (**a**) the vulnerable gap at the top corners of the chevron-shaped valley slates (C) and the main slates (M)are weathered with shales (S). The left shale is arranged with the main slate and the valley slate, so that any water reaching it is directed via the point onto the shale and chevron in the next course below.

Welsh valleys in Hereford stone **(b)** and slate **(c)**. Like single-cut and shale valleys, because the main slates overlie the valley slates, water is turned away from the vulnerable junction.

In a variation on the Welsh valley the slates from either side are mitred on the centre line (**d**)

Photos Terry Hughes

Figure 73. Succesful valleys often combine the kill of the joiner (a) and the Figure 66.slater (b). Working together they ensure that water flowing over the slating moves away from the vulnerable junction (c)
Photos Terry Hughes

72(b) and 72(c)). Provided the slating in each is appropriately lapped and the overlap of the sides over the valley is adequate, they work perfectly.

There is a variation on the Welsh valley where the slates from either side are mitred on the centre line (see figure72(d)). Because they look like an modern mitred valley externally, they may be common but unrecognised (see video 14).

6.7.6 Single-cut valleys

Single-cut or half swept valleys are suitable for roofs where the intersecting slopes' pitches differ by more than 15°. The valley boards are offset to the steeper or longer side which carries the most water (see figure 73).

The slates on the lower or shorter pitch are swept up under those on the other side, so that they and the offset of the board tilts the overlying slates, directing water onto the main slating parallel to the valley (see figures 74(a), 74(b) and video 15).

On the swept side the slating dips before sweeping across, which also directs water away from the valley line (see figure 74(c) and video 16). Also the side laps are set to be wider down the tilt, to compensate for the diagonal flow of water.

74(a)

74(b)

74(c)

Figure 74.
In single cut valleys water is turned away from the junction by tilting the slates on both sides.
Photos Terry Hughes

6.7.7 Close-mitred and open valleys

In Tremerchion near Denbigh there is what is probably a precursor to the modern lead-lined mitred valley. Instead of lead the lining is parallel-sided chevron-shaped slates (see figure 75(a) and video 17). These are single-lapped and are not interleaved with the main slating, so they carry water all the way down to the eave rather than directing it back out onto the main slating like lead soakers.

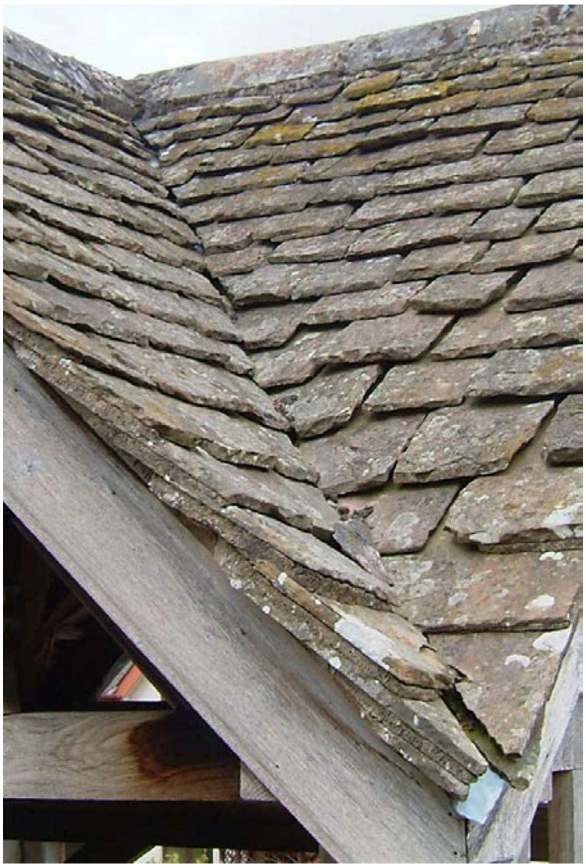
Although now common, lead-lined valleys are not vernacular and are included here only for completeness (see figures-75(b) and 75(c)). They are not an appropriate replacement for the vernacular valleys described above.

6.7.8 Secret valleys, secret gutters

At abutments if a mortar-flaunched junction

75(a)

75(b)



75(c)

Figure 75.
A close-mitred slate lined valley in Tremerchion, Denbighshire (**a**). These may be more common than realised because the slate lining is not visible until the valley is dismantled.

Lead-lined open (**b**) and close-mitred (**c**) valleys are not traditional and should not be substituted for vernacular types.

Photos Terry Hughes

cannot be formed it may be necessary to introduce a secret or hidden valley - usually a consequence of raising the roof surface to introduce insulation. These are prone to block with leaves and other debris, so it is essential to establish a maintenance plan to keep them clear (see figure 76(a)); ideally in the autumn after leaf fall. The slating can be carried tight up to the wall or held back. The former reduces but does not eliminate debris getting in and are more difficult to clear. The latter are easier to clear, but more visually intrusive. It is possible to form the valley at the original level over the gable wall (where insulation is required) and lay slates in the valley (see figure 76(b)).

6.7.9 Horizontal valleys

Lead-lined horizontal valleys are likely to need to be repaired or renewed sooner than the slate or stone roofs which discharge onto them. This usually means removing the lower courses of slating, but this can be avoided in future if a lead apron is included which can be folded back to renew the valley lead. (see figure77). A sacrificial apron can also be included.

6.7.10 Authentic reslating

All of the vernacular valleys described here were originally constructed in response to the available sizes of slates in their locality. They work with those sizes but usually cannot with other sizes (see figure 78). So to correctly relay and conserve them, the same slates must be used. If a roof with a swept valley laid to work with narrow slates is relaid in wide tally slates, simply because that is the default slate that a quarry makes today, then it will be impossible to conserve the valley, because these slates will not lie down tightly into the curve.

6.8 Dormers and rooflights

Dormer windows are uncommon in older buildings in Wales. Where they do exist, it is often

76(a).

76(b).

76(c).

Figure 76.
Secret valleys and gutters can be closed (**a**) or open (**b**). The former always become blocked eventually and leak. The latter are more visually intrusive especially if lead lined. The slate lined version near Corwen may be more visually acceptable.

Photos Terry Hughes

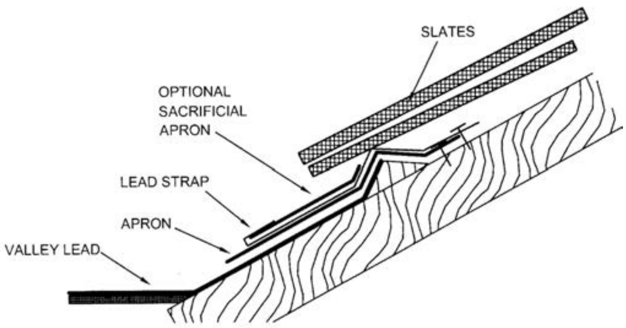


Figure 77 The inclusion of a lead apron when renewing a horizontal valley will avoid having to strip the slating next time it has to be done.

Illustration Terry Hughes.

78(**a**).

78(**b**).

Figure 78.
Reslating valleys. If large modern slates are used instead of the original small (random) sizes they will not sit down into the curve of coursed valleys. The consequence so often is to install a lead valley instead (**a**) and the original roof is lost completely - wrong slates, wrong detail and probably the wrong slater.

In coursed valleys (**b**) if long slates are not used to allow for the longer valley rafter, the valley slating will always lag behind the main areas going up the roof. To match the coursing and margins of the main slating to the valley, it will need to curve down towards the valley slates on each side, with the result that the valley will look as though it has sagged. This is a bad mistake, which is easily avoided as described in section 6.7.1.

Photos Cadw and Terry Hughes

the result of the adaptation of the roof space for domestic or workshops use, which may coincide with a change from thatch to slate. Sometimes this may have involved raising the walls or altering a couple or truss to provide head room (see figure 79).

The earliest, 18th-century, dormers are small and low or only partly within the roof expressing the low-ceilinged rooms they illuminated (see figures 80(a and 80(b)). Later windows are larger and

79(**a**).

79(**b**)

79(**c**)

Figure 79. Evidence of a raised roof can be seen externally (**a**) or internally (**b**). In (**a**) the former chimney is now encorparated into the raised gable. In the roof (**b**) the position of the former couple has been raised to provide for a bedroom. In (**c**) a third floor has been added above the former eaves line, probably for a home workshop.

Photos Terry Hughes

placed higher in the walls or entirely in the roof (see figure 81).

Mono-pitched and gabled dormers are common in slate and stone but hipped versions are rare (see figure 82). Cheeks are either rendered or slate-clad but very rarely stone clad. On ridged dormers, before the general availability of lead, ridges were swept up into the main slating (see figure 68) or the junction was weathered with an upturned ridge tile. Where lead was available a saddle weathers the junction.

Bell vents and ventilation louvres are similar in style but are also sometimes lead-covered (see figure 83(a) and 83(b))

Rooflights are an alternative to dormers and, being much cheaper to install, are common on industrial, farm and similar buildings. They are an

Figure 81.
Dormer placed higher in the roof. Colebatch in Shropshire.
Photo Terry Hughes

Figure 82. Hiipped dormer in Arran Road Dolgellau.
Photo Terry Hughes

80.(**a**)

80.(**b**)

80.(**c**)

Figure 80. Early dormer windows are set below (**a**) or low in the roof (**b**). Gabled (**b**) and Mono-pitched version (**c**) are common.

Figure (**a**) near the Corndon Hill former small roofing quarry south-west of Shrewsbury (**b**) Finsbury Square, Dolgellau. Demolished in the 1950s. (**c**) inserted window in a house in Tremerchion, Denbighshire..
Photo (**b**) Francis Firth Collection www.francisfirth.com
remainder Photos Terry Hughes

important feature of many farm buildings. In their simplest form, sheets of glass are substituted for slates or are inserted into the slope and the slating overlaid (see figure 84). Where the extra cost was acceptable cast iron lights were used. They are usually quite small (see figure 85).

The scale of the rooflights in relation to the roof slope is an important consideration in roof renewal. If an existing light cannot be reused, the replacement should be of similar size and style. 'Conservation rooflights' will generally be preferable, and should be of slender section steel with a vertical emphasis. These lie flush and emulate the look of traditional cast iron. Bespoke sizes can be made where rooflights of standard dimensions are unsuitable. The use of excessive flashings between the rooflight and roof should be avoided to maintain the character of the building.

6.9 Limewash

It is a long-standing tradition to limewash buildings including the roof (see figure 86). This may seem a trivial aspect of roofing but it is important to an understanding of a roof's history and affects its performance and longevity.

For roofs, the original purpose was probably to protect thatch against both natural deterioration and fire, and its continuation on later slate roofs may be simply tradition and a matter of pride in a building's appearance. Limewashing was done annually and has been associated with the culture at the beginning of the yearly agricultural cycle in spring and especially as a preparation for Easter. Also, farm buildings and dairies were limewashed inside and out for reasons of hygiene

83(a).

83(b).

Figure 83. Sound vent. St Mary's church Kempley, Gloucestershire (**a**), Herefordshire. Dovecott=e in Richard's Castle, Shropshire (**b**).

Photo Terry Hughes

Figure 84. Farm buildings are often lit with sheets of glass which replace slates.

Photo Terry Hughes

Figure 85. Original rooflights were generally small and low profile, making a small impact on the appearance of the roof.

Photo Terry Hughes

but other than this it has no technical purpose for a roof until the roof is failing, when it becomes slurrying. The technique was to make a thick mix of quicklime and water in a bucket and apply it with a brush (https://youtu.be/s-JZjdCC7xs). It has become confused with slurrying, described below.

The white buildings and especially the white roofs, are an important landscape feature in Pembrokeshire, where its continuation and even conservation is supported (see figure 87). Attempts to replicate the roofs' appearance using lime mortar have not always been successful, probably because it was applied in one thick coat rather than several built-up over time. The more recent, unauthentic, use of cement mortar did not fail in itself provided a suitable mix was used - but there are many renewed roofs where a poor mix has fallen off except for the ribs (see figure 88). Also, the result is a grey rather than a bright white roof, so it fails in that objective too.

If white roofs are to continue to be a landscape feature, building owners will have to be persuaded or made to limewash their roofs and to do so every few years.

In regions other than Pembrokeshire where limewashing was recorded as a significant feature of the landscape in the past, it seems to have been largely unremarked for conservation and allowed to gradually disappear as roofs were reslated.

6.10 Uses of mortar

Mortar has many traditional uses in roofing and is applied at different stages of roofing work or during the life of the roof. They include bedding slates at the tail or head, torching the underside, pointing at verges, flaunching at abutments, and grouting.

The word grouting can mean forcing mortar or a sealant under the slates' tails or into the perpendicular joints ,or it can mean a thin layer of mortar applied to the roof's surface. To distinguish between these two, applying mortar to the surface is described below as slurrying.

6.10.1 Bedding

Bedding is applied as the slates are laid. In the region it is usually applied at their heads. Tail-bedding is uncommon except perhaps in Pembrokeshire, where the evidence is unclear because it is obscured by grouting and slurrying. Careful examination of the mortar and its shape under the slates will be necessary to decide whether a roof was originally tail-bedded or grouted later (see figure 89). Head- and tail-bedding both stabilise the slates, but head-bedding also secures the pegs in their holes (see figure 90). Tail-bedding risks trapping water behind the slates, so it is safer to apply a small dab rather than a bed right across the slate and up the perpendicular joint.

The techniques are important for smaller slates because their heads often do not lie closely onto the laths, especially in the upper courses where the head lap is a larger proportion of the length. If a slate's head does not touch the lath, the wind can lift its tail, resulting in rattle and eventually it falls off. Head-bedding was not intended to draught-proof a roof, although it may do so.

Head-bedding and torching are compatible but neither should extend too far down between the slates because of the risk of external moisture reaching the laths, leading to rotting and leaks. It is also dangerous to apply tail- and head-bedding together for the same reason - they may touch when the slates are pressed down. Anyway, there is no reason to do both together.

Where it was applied originally, bedding is a necessary part of the slating and should always be reinstated when a roof is repaired authentically. It is also essential for the conservation of the historic appearance of the underside. It is not necessary to omit bedding simply so that an underlay can be substituted.

6.10.2 Vaulting

Some vaulted roofs are covered with slating bedded directly onto the masonry without a timber structure. There are several examples in Pembrokeshire.

6.10.3 Torching

Torching is applied once the slating is complete to prevent draughts and powdery snow blowing into the roof (see figure 91). It is applied to the underside of the slates and may be a single coat of lime mortar which has been left rough, or in two coats, and may just

86(a).

86(b).

86(c).

Figure 86. There is a long history of limewashing roofs, but the original purpose has become confused with efforts to prolong the life of failing slating by grouting and slurrying. (**a**) Limewashing for decoration on a roof with tail bedded slates, Aberdaron, Gwynedd in 1875. Slurried roofs in (**b**) Pembrokeshire today and (**c**) in Aberdaron, 1875

Photo (**a**) and (**c**) Llyfrgell Genedlaethol Cymru – The National Library of Wales (**b**)Terry Hughes

Figure 87. Slurried roofs, such as these at Abereiddy, are an important landscape feature in Pembrokeshire. Although formerly common in many exposed regions of Wales, they have not been conserved in the same way as in Pembrokeshire

Photo Terry Hughes

Figure 88. Confusion about the technique of slurrying, and the suitability of different mortars, has resulted in roofs rapidly loosing their slurry with only the ribs remaining. Rhodiad-y-brenin.

Photo Terry Hughes

cover the top of the slates (single-torching) or their backs completely between the laths (full-torching). If a second coat is applied covering the laths and pegs, it may be trowelled to form a tidy ceiling. It is very important that torching is not forced too far down between the slates, to avoid drawing water to the laths and rafters.

Both domestic and agricultural buildings are found with two-coat work, which indicates its importance. It became more common in houses when roof spaces were adapted for accommodation or home workshops. In shippons, or cow houses, it was used because cattle will not tolerate drips.

It can be reapplied during re-slating, but there may be some areas which are now inaccessible, for example, at the eaves, because the ceiling is in the way. Head-bedding should be used in those areas instead.

6.10.4 Grouting

The term grouting can mean forcing mortar into a crack or a void or applying a thin coating (slurrying) to a surface. Both are applied long after the construction of the roof. Slurrying is described below.

Forcing mortar, or today, some sort of sealant or mastic under the slates and/or into the perpendicular joints appears to be done for two reasons: to prevent draughts on a roof without bedding, torching or underlay; or over a gable wall below a chimney where the inside of the wall is wet and it is assumed, incorrectly, that the roof is leaking (see figure 92). The latter is actually caused either because the wall has been cement mortar rendered or because of hygroscopic salts which leak into the wall's plaster from unlined chimney flues. These absorb water and release it later when the atmospheric conditions change, producing damp patches along the line of the flue.

Also, where slates have slipped, they are often temporarily repaired by bedding them onto mortar. This will not last. It is better to refix the slate properly (see 7.2) or if this isn't possible to hang the slate on a copper tingle.

Grouting is unlikely to be necessary when reslating.

6.10.5 Slurrying

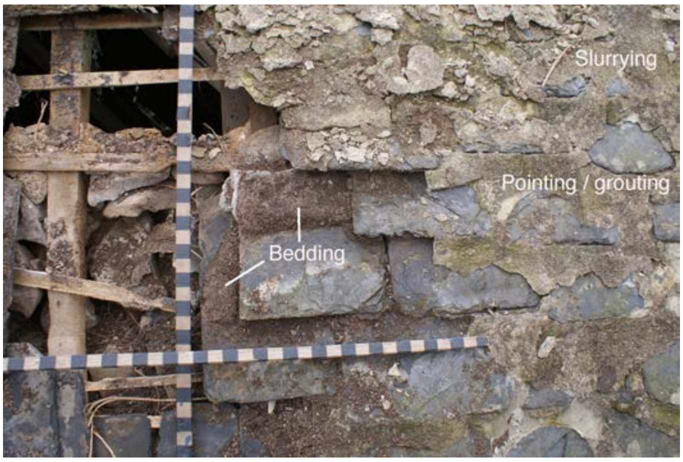


Figure 89. Tail bedding is applied as the slates are laid and should not spread beyond the tail onto the slate below. Pointing, grouting and slurrying are applied long after the slating was laid. Pointing and grouting are spread along the slates tails and forced up under the slate. Slurrying is spread all over the slates. Pembrokeshire.
Photo Terry Hughes

Figure 90. Head bedding is applied as the slates are laid.
Photo Terry Hughes

Slurries of various mortars, based on lime or cement, are applied all over a roof. Slurrying is seen throughout west Wales, especially near the coast and in exposed upland areas (see figure 93). This process was no different from, and almost certainly a continuation of, decorative limewashing described above, and it would have been applied in the same way, by brushing on. However, its purpose is different. Where poor durability slates are failing (often the case in Pembrokeshire) or the fixings are failing and slates are slipping, it is used to keep the roof going for

Figure 91. Two coat torching in a cow shed.
Photo Terry Hughes

a bit longer. It is only a temporary solution and inevitably has to be repeated frequently - typically, annually. And that is what finally brings about the roof's demise. The increasing weight of slurry eventually overwhelms the slate, or the lath fixings, and large areas become detached (see figures 12(a) and 94). To prevent the roof covering falling away entirely, lengths of barbed wire are hung over the roof from eave to ridge to opposite eave, and a mortar fillet rendered over them, producing a distinctive feature (see figures 12(b) and 95).

Figure 92. Mastic grouting in an ill-conceived attempt to prevent damp walls. Near Caernarfon. Photo Terry Hughes

This technique today has become conflated with the limewash tradition described above. Slurrying is primarily a temporary repair and so, when a roof finally fails, the logical step is to renew the slating and apply slurrying only if and when it is needed in the future. But this will not conserve the white roofs because the original poor durability slates are no longer available, either new or as reclaimed. And who would choose to use them today anyway? And those slates which are manufactured will last very much longer - a hundred years or more. To slurry a new slate roof is understandably unpopular with the building owners, and has been a contentious issue in the past.

Figure 93. Slurried roof at Rhosgadfan, near Caernarfon.
Photos Terry Hughes

6.11 Farm buildings

These tend to remain unaltered for long periods and are often the best source of information on early roof structures and slating techniques. Their detailing is less elaborate than in domestic buildings and this should be respected in repairs. Verges and eaves often have little overhang and gutters are seldom included. Lighting for storage areas or livestock was not important, so it was often provided by replacing a few slates with glass (see figure 84) or by installing small cast iron rooflights rather than dormer windows (see figure 85). Good ventilation is important for livestock, but this was usually provided by openings in walls rather than roofs or by raising a few ridge tiles.

7 Maintenance

7.1 Deterioration

Slate roof deterioration is usually a long-term process and, even though repairs can be carried out for many years, routine maintenance will significantly delay the need to strip and re-slate. The key is to check often, perhaps twice a year, inside and out if at all possible, and to act quickly. An unattended leak can result in timber rotting or other fabric damage which will seriously exceed the cost of repairs. It is particularly important to keep rainwater gutters - especially horizontal lead gutters - and downpipes clear of debris.

Insulation is also a potential source of dampness because it can cause moist air to condense onto woodwork so it should not be assumed that dampness always indicates a slating problem.

7.2 Repairs

Missing, slipped or broken slates should be replaced as soon as possible. If they are pegged it will probably be possible to lift or rotate adjacent slates, to slide a new slate of similar thickness into place. However, this will break any torching, so this should be replaced as well. If the slates are nailed, then a slater's ripper should be used to cut or drag out the nail. The replacement can be fixed with a peg or copper tingle (see figure 19). For repairs to large areas a triangle of slates should be stripped so that all except the apex can be re-fixed with

Figure 94. Eventually the weight of slurries overcomes their adhesion, and large sections fall away. Pembrokeshire.
Photo Terry Hughes

pegs or nails and only the top one(s) will need a tingle or similar fixing.

7.3 Mortar

Where long-established mortar bedding is crumbling or falling away it can be repointed, but this is usually only a temporary reprieve, as the lath nails are probably failing as well and repointing places more stress on them.

Slurrying roofs is a policy of last resort. Although it is traditional in the region it is not a good technique, because it can eventually cause the complete failure of the roof, with collapsed battens and rotting of the structure and will be far more costly to repair than reslating. When the battens fail, large areas of slating will slip. At this point the roof will be beyond practical repair, and should be stripped and reslated.

Fallen torching should be renewed, because it holds pegs in place, helps prevent slates being lifted by high winds and protects laths from water damage. Ridge and hip tiles may need re-bedding and, if the bed is not exposed along the edges, an NHL 3.5 mortar is suitable. Where it is exposed it will need to be stronger, an NHL 5, for example, or the NHL 3.5 bedding mix can be pointed-up.

7.4 Bi-annual checklist

Twice a year:

- Check internally for water-staining or other signs of leaks. These may be much lower on the roof than the leak.
- Clear gutters and downpipes, pitched and horizontal valleys and secret gutters.
- Replace slipped, broken or missing slates.
- Check if ridges and hips are secure.
- Check leadwork – look for wrinkles and cracks, cuts from slipped slates and flashings coming out of chases.
- See whether mortar beds, fillets or flaunchings are cracking or insecure.
- Look for leaks around roof penetrations such as rooflights or solar panels.
- Ensure insulation is not blocking ventilation routes, for example, at the eaves or ridge.

Figure 95. Reinforcing ribs on a Pembrokeshire roof.
Photo Terry Hughes

8 References

National Vocational Qualifications

The Level 3 NVQ Diploma Roof slating and Tiling and construction site management (conservation). Successful completion entitles candidates to apply for the Construction Skills Certification Scheme (CSCS) Gold Card covering craft skill, job knowledge and understanding. They can extend this with the Level 3 Heritage Special Apprenticeship Programme for Roof Slating and Tiling. This covers the historical, theoretical and technical knowledge and practical skills in historic building conservation, repair and restoration which lead to the CSCS Card endorsement Heritage Skills. These are the appropriate qualifications for slaters who work on historic roofs, especially those in random slates. There are similar systems for construction site management of conservation work and for conservation

Thermal performance

Historic England has published a series of guides on compliance with Part L Conservation of fuel and power generally and for roofs (see 10.5 Historic England 2016). CADW has not published its own guide, but recommends using the Historic England guides.

9 Video links

The videos can be seen here or individually below.

Section	Page	Topic	Video link
1	4	0 Terminology	https://vimeo.com/channels/spabwelshslating/455181486
1.2	8	1 Gauging in thirds	https://vimeo.com/channels/spabwelshslating/441544639
4.3	20	2 Making Patent slates	https://vimeo.com/channels/spabwelshslating/441959219
4.6	24	3 Peg fixing	https://vimeo.com/channels/spabwelshslating/441949200
4.6	24	4 Torching	https://vimeo.com/channels/spabwelshslating/439956741
4.6	24	5 Head bedding	https://vimeo.com/channels/spabwelshslating/453197671
5.1	33	6 Dressing slates	https://vimeo.com/channels/spabwelshslating/442334568
5.12	43	7 Cladding	https://www.youtube.com/channel/UCNeM10EH7n5r3LQxwIl38Yw
6.3	46	8 Abutment water	https://vimeo.com/channels/spabwelshslating/443654802
6.5	49	9 Secure top courses	https://vimeo.com/channels/spabwelshslating/443965108
6.7.1	50	10 Welsh Valley	https://vimeo.com/channels/spabwelshslating/452816845
6.7.3	52	11 Collar & tie valley	https://vimeo.com/channels/spabwelshslating/453190042
6.7.4	52	12 Shale valley	https://vimeo.com/channels/spabwelshslating/452986149
6.7.4	52	13 Surface tension	https://vimeo.com/channels/spabwelshslating/444489893
6.7.5	55	14 Welsh valley	https://vimeo.com/channels/spabwelshslating/452816845
6.7.6	55	15 Single cut valley	https://vimeo.com/channels/spabwelshslating/452800401
6.7.6	55	16 Single cut water flow	https://vimeo.com/channels/spabwelshslating/443652699
6.7.7	55	17 Chevron valley	https://vimeo.com/channels/spabwelshslating/453000731

10 Other advice

10.1 Consultants and contractors

Where slating work is being considered, the SPAB may be able to suggest the names of suitable contractors and professionals or advise on courses that teach practical skills. Local authorities may also have lists of architects, surveyors and slaters with experience in local slating.

The names of professionals accredited in building conservation be obtained from the relevant accreditation bodies:

- Architects (AABC Register)
www.aabc-register.co.uk/

- Building Surveyors (Conservation-Accredited)
www.rics.org/

- Structural Engineers (Conservation Accreditation Register for Engineers)
www.istructe.org

- The names of contractors accredited in heritage roofing can be obtained from: The National Federation of Roofing Contractors
020 7638 7663
www.nfrc.co.uk/heritage-roof-specialists

10.2 Slate and stone slate producers

Slates

- The Traditional Slate Company
07771 552321
enquiries@thetraditionalslatecompany.co.uk
www.traditionalslatecompany.co.uk

- Welsh Slate Ltd, Penrhyn Quarry, Bethesda, Bangor, Gwynedd LL57 4YG
01248 600656
enquiries@welshslate.com
www.welshslate.com

Stone slates

- Hay Stone
Coed Major Farm,
Craswell, Herefordshire HR2 0PX
07773 778118
enquiries@hay-stone.com
https://hay-stone.com

- Hereford Sandstone Supplies Ltd
Springfield, Longtown, Hereford HR2 0NA
07814 220657
herefordshiresandstone@yahoo.co.uk

10.3 Advice on conservation

- Cadw Plas Carew, Unit 5/7 Cefn Coed, Parc Nantgarw, Cardiff CF15 7QQ
0300 0256000
cadw@gov.wales
https://cadw.gov.wales

- Historic England Midlands, The Axis, 10 Holliday Street, Birmingham B1 1TF
0121 625 6888
midlands@HistoricEngland.org.uk
https://historicengland.org.uk/about/contact-us/local-offices/midlands/

- Stone Roofing Association
tech@slateroof.co.uk
www.stoneroof.org.uk

10.4 Advice on protection of animals and plants

- Natural England
0300 060 3900
www.gov.uk/government/organisations/natural-england

- The Bat Conservation Trust
0345 1300 228
http://www.bats.org.uk/

- The Barn Owl Trust
01364 653026
www.barnowltrust.org.uk

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37 Spital Square, London E1 6DY
Tel 020 7377 1644
info@spab.org.uk www.spab.org.uk
A charitable company limited by guarantee
registered in England and Wales
Company No 5743962
Charity No 111 3753
VAT No 577 4276 02