Vernacular Slating in the East Midlands

SPAB Regional Technical Advice Note

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Contents

This advice note describes the production and use of the roofing slates and stones of the East Midlands of England.

It includes the metamorphic Swithland slates, the Jurassic limestones - Collyweston slates and similar stones from the Northampton and Banbury area and briefly, the Magnesian Limestones. It deals with the maintenance and repair of roofs, considers details specific to the traditions of roofing in the region and explains, where appropriate, adaptations to incorporate modern requirements such as improved thermal performance.

Cover image:
Mid C19 cottages, Woodhouse Eaves. Swithland slates with mitred and Welsh valley.
Terry Hughes

1 Introduction

In the roofscape of the English Midlands which is otherwise dominated by tiles and Welsh slates four areas still display vernacular stone roofs: Swithland slate in and around Leicester; Magnesian limestones to a small extent between Mansfield and Doncaster; Collyweston stone slate near Stamford in Lincolnshire but used over a much wider area, even as far away as New York state and other Jurassic stones in the Northampton area. The products of small quarries and mines, they are all random sized with distinctive features and are formed into roofs with characteristic techniques which are regionally important.

Swithland slate is a true metamorphic slate of Cambrian age (Swithland Formation). Fissile beds of limestone were worked in the Magnesian Limestone - Cadeby Formation, the Middle lias, Northampton Sand and Lincolnshire Limestone Formations and in the Great Oolite Group (Table 1). Some were split by natural frost action.

Table 1: Historical Sources of Stone Slates in the East Midlands

Formation			Stone Slate Sources
Jurassic	Great Oolite Group	Oxford Clay	
		Kellaways sand and clay	
		Cornbrash	
		Blisworth Limestone*	Oundle (possibly Yardley Chase)
		Rutland Formation (Upper Estuarine Series)	Pytchley, Hoping Hill, Helmdon, Kettering, Wellingborough, Northampton, Duston
	Lincolnshire Limestone Formation	Upper	
		Lower (Collyweston Slate)	Wothorpe, Burghley Park, Wittering, Collyweston, Duddington, Deene Park
		Grantham, Formation (Lower Estuarine Series)	
	Northampton Sand Formation	Variable Beds	Ducton, Harlestone, Pitsford, Weston Favell
		Ironstone	
	Middle Lias		Sulgrave, Chacombe, Banbury
Permian	Magnesium Limestone	Cadeby Formation	Steetley, Bakestone Moor, Whitwell (possibly Worksop)

* Blisworth Limestone is known locally as Oundle Limestone

Specialised slate and stone roofs are rare. Indeed, some types may have disappeared long ago but they are important to the history of local economies and cultural heritage and wherever they still exist they should be carefully conserved. They are important elements in the character of historic buildings and settlements and help 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.

This advice note explains the basics of Swithland, Collyweston and other limestone slating practices and the local variations.

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 potentially 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. Surviving examples are 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 form and appearance is maintained and with appropriate statutory consents.

Unfortunately, many roofs mistakenly deemed to be inadequate even though they have performed satisfactorily for more than a hundred years and have only reached the point of needing repair because of iron nail failure are simply stripped and discarded with no attempt to understand their construction and detailing. Also in recent years there has been a tendency to use modern slating recommendations and detailing as exemplified by British Standards to historic roofs without regard to their visual and technical needs. This is not appropriate for conservation not least because the standards do not cover vernacular techniques. The issue of differences between modern and historic slating should be dealt with at the design stage of a project.

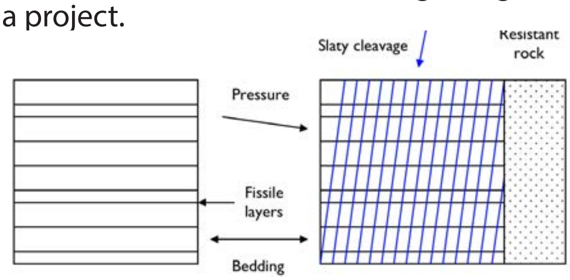


Figure 1: Bedding and cleavage
Sandstones and limestones are sedimetary rocks which are fissile along the bedding layers. Metamorphic rocks such as slates, schists and phylites have been changed from sediments by pressure and heat in the Earth's crust. They split along the resultant cleavage planes almost always at an angle to the bedding. Terry Hughes

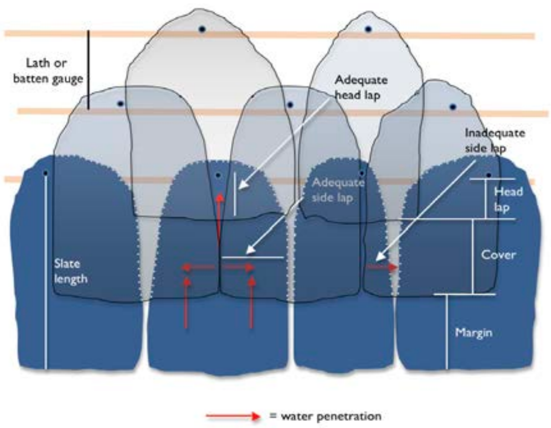


Figure 2: Laps and gauges
Quarries describe and sell slates by their overall length from the head to the tail. The effective length of top fixed slates is about one inch (25 mm) less because the distance above the fixing hole has to be discounted when setting out the roof. Failure to appreciate this can result in expensive under-estimates of the cost of a roof. Terry Hughes

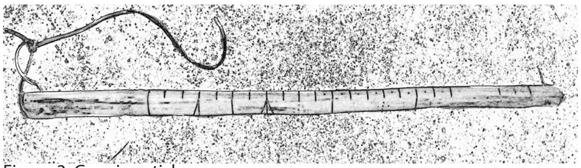


Figure 3: Gauging stick
Slater's marking sticks vary regionally but all have a mark for each slate length and a pin at one end. The marks can be numbers or symbols and do not necessarily designate inch lengths. Some also include head lap marks - usually one, two and three inches - or lath gauges corresponding to each slate length. Terry Hughes

Figure 4: Gauging
The stick is used to set out the margins and the lath gauges and these diminishes all the way up the roof. Terry Hughes

Metamorphic slate durability

The current standards for roofing slates are BS EN 12326-1 Product Specification and BS EN 12326-2 Test methods. They are revised from time to time. BSI and the NFRC can advise on the latest versions. They do not apply to stone slates.

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 reaction take place converting pyrite to iron oxide and carbonate to bicarbonate or sulphate. 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. Some of these disintegrate very quickly on the roof.

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 whichever arises soonest. It is particularly important that they conform to the scope of the standard which defines a slate geologically. Quarries must provide a Declaration of Performance based on the Assessment and Verification of Constancy of Performance (AVCP) of the slate. This was formerly known as a certificate of conformity.

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 were 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 sulphur dioxide exposure - S1, S2 or S3. (The lower categories and the lower the water absorption - lower than 0.3% ideally, are the most durable). There are other tests which need to be considered as well.

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 although oxidisation 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 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 only be satisfactory 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.

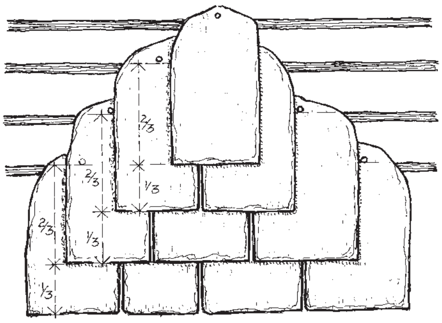


Figure 5: Slating in thirds
In the proportioning system slating in thirds the slate length is divided by three.
Terry Hughes

Vernacular slates and British Standards

Durability

Swithland slates

In principle BS12326-1 the product standard for metamorphic roofing slates could be used to test Swithland slates but the test methods (water absorption, thermal cycling and sulphur dioxide exposure) are intended for newly manufactured slate so reclaimed slates cannot be expected to pass. For reclaimed slates it is normal to test for soundness by tapping with a hammer and dressing off any softened parts. New facsimile slates or slates from other sources should have a declaration of performance - see Metamorphic slate durability below.

Limestones

There are no formal tests for limestone roofing slates. The best guide to durability of new slates is evidence of succesful use of slates from the same source over a long period of time.

Strength

BSEN12326 requires the bending strength (Modulus of Rupture) of slates to be tested across and along the slate's long dimensions (longitudinal and transverse orientation) and from this a slate's minimum individual thickness is calculated. This could be applied to confirm the strength of reclaimed Swithland slates but because they are so thick it is probably pointless.

Grain

Some slate has bending strengths which are significantly different in the longitudinal and transverse directions. This is known a grain. It has nothing to do with surface texture or mineral veins in a slate. BS680:1944, the former roofing slate standard, required the grain to be longitudinal in the slates (parallel to the long edge). This was to ensure that the maximum strength was in the direction which best resisted loadings on a roof such as wind forces or roof settlement. It is not sensible to apply this to all slates. Swithlands have such coarse cleavage that they can only be split so thickly that they have more than adequate strength irrespective of the grain direction. Other slates have almost equal strength in the two orientations, so they have no grain. Grain orientation is not a requirement in BS12326-1 although the direction of maximum strength should be declared.

Minimum width

BS680 also set a limit on the width of slates - they should be no narrower than half their length. This was because the design recommendations for sizes of slates and their minimum head laps, which were set in relation to roof pitch and the rain exposure of the building, assumed the width of the slates. This limit came to be adopted by all slate quarries but not for stone slates (BS680 didn't apply to them anyway) and narrower slates fell out of production. This limitation also assumed the slates would be centre fixed, that is, fixed with nails roughly half way up the slates, one on each side. This had become standard practice for new slating by 1944. However vernacular slates and stones always were and still are head fixed. The difference this makes for driving rain resistance is that centre fixing reduces the effective width of the slate by the distance of the nails from the edges - about 25 mm but can be larger. - consequently they are effectively 50 mm narrower than top fixed (Fig XX). So top fixed slates with widths less than half their length are satisfactory. BSEN12326-1 does not set a minimum width limit but BS5534 Code of Practice for Slating and Tiling includes recommendations and a means for calculating minimum widths for top fixed metamorphic slates.

Other dimensions

BSEN12326-1 also includes limitations for deviations from length, width, edge straightness, rectangularity and flatness none of which should be applied to reclaimed Swithland slates or limestones.

Fire and dangerous substances

Swithland slate would be deemed to satisfy fire requirements and even though BSEN12326-1 does not apply to them so would limestone slates. Neither release dangerous substances.

BS5534 Code of Practice for Slating and Tiling

This is primarily a code for new roofing. The scope states '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 the local planning authority or an appropriate conservation organization to check their suitability.'

1.1 Terminology

The meanings of some words are variable and need to be understood before reading on:

- Slate. Strictly, this term should only be applied 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 bedding 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, limestones or sandstones.

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

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

- 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 also common (Figure 1).

- Fissile, fissility. The property of sedimentary stones which allows them to be split along bedding planes (Figure 1). In Collyweston the fissile stone is known as log.

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

- Tally slates. All slates in a consignment or on a roof 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 - all the slates in this guide, the effective length is the dimension from the tail to the bottom of the fixing hole and this is typically 25 mm or one inch less than the overall length (Figure 2). 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 which can be covered with a given quantity 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.

- Gauge. The spacing of laths or battens up the roof slope. In random slating the gauge is variable and is proportional to the slate length. There are several systems -

1. Proportionation. Any system for setting out the slating - gauging the laths or battens - in which the gauge is determined by dividing the slate length by a number. This is usually done with a slater's stick (Figures 2 - 4). Examples of proportioning include dividing by 3 - slating in thirds (Figure 5) or 3.5 - three and a half pin slating.
2. Calculating the gauge from a specified head lap using the equation:
   Gauge = (length - head lap)/2
   This is the system universally applied totally (single size) and some random slating.

- 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 were 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.

Using a slater's marking stick to gauge a roof

All the slate types in this guide were traditionally set out with a slater's marking stick and this should continue. Sticks vary regionally but all have a mark for each slate length and a pin at one end (Figure 3). The marks can be numbers or symbols and do not necessarily designate inch lengths. Some also include head lap marks - usually one, two and three inches - or lath gauges corresponding to each slate length.

The stick is first used to sort the slates into length sets known as a parting in Collyweston. Usually in inch or half inch steps. 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.

The stick is then used to set out or gauge the roof. This process can be difficult to understand (deliberately so in the past to protect the trade from outsiders) but is second nature to a slater. The position of all the laths on the roof is set out to margins (skirts in Collyweston terminology) and these and the lath gauges diminishes 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 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.

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 the same slate length or 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, because every mark affects every subsequent one up the rod and 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.

2 Work in general

2.1 Conservation approach

Conservation imposes additional requirements on building work over and above those required for new construction. Whilst the specific ways in which these requirements can be met will vary greatly from case to case, as will the reason for undertaking the work, the underlying principles advocated by the SPAB remain the same.

The Society believes above all that it is vital to maximise the retention of a building's authentic fabric and minimise the disturbance to this to keep its integrity. This is achieved by carrying out essential work coupled with using compatible methods and materials. Obtaining sound information about a building's history, construction and condition before embarking on any major work is an essential prerequisite. The level of recording entailed should be proportional to the significance of the building.

2.2 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 14.

2.3 Selecting a slater or slating company

It is most important to ask skilled and knowledgeable slaters to tender for the work. The primary consideration should be that they will take a conservation approach to the work. All too often slaters will strip a roof without looking at its materials, gauging and detailing and then replace it inappropriately.

It is usually unwise to make a selection based on cost alone as an inexperienced slater may simply have underestimated the cost because they left out a step in the slating process. Problems can also arise if the main contractor is allowed to choose the slater because they too may be primarily concerned with cost. Rather, a shortlist of suitable roofers should be established and within these the key is to ensure parity of tendering and tenders checked for completeness. Only then can a choice be made and it should not necessarily be the lower price.

The National Federation of Roofing Contractors operates an accreditation scheme for heritage roofing companies which includes Swithland slates Collyweston and other limestones. If you intend using an unaccredited company you should do your own checks for their competence.

There are vocational qualifications (VQ) for roof slating and tiling and construction site management (conservation) (Table 2)[1] These qualifications may be required by clients or be included in grant conditions.

The training and tests in roofing VQs are practical in nature but do not encompass conservation per se and options selected by trainees on VQ courses may not cover the East Midland roof types. So even for companies with these qualifications it would still be wise to confirm and ensure that they will take a conservation approach to the works and apply authentic techniques and detailing based on an examination of the roof during stripping. Specifically, for the roofs covered by this guide the options selected by trainees on VQ courses may not cover the Swithland or Collyweston slating.

Table 2: Vocational Qualifications in roofing

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

Older but highly skilled slaters may not have such qualifications, but this should not disqualify them from consideration.
A slater should be able to show roofs which they have successfully worked on and provide references. It is wise to view roofs which 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.
- Tidy mortar – neatly finished at the ridge, hips, verges and where appropriate at the slates' tails, verges and abutments.
- Ridge tiles fitting closely onto the slating without large mortar beds. Roof undulations, curves in the ridge tiles and uneven stone roofing can make it difficult to avoid mortar showing but it should be minimised.
- In the roof space there should be no

sign of leaks or dampness but these would only be visible if there is no underlay.

- Similarly, tail bedding mortar should not be visible from the underside but head bedding would be. Do not confuse either with torching.
- 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 improved. This may be subcontracted to a specialist surveyor 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 the work will be organised and executed.
- An explanation or ideally a demonstration of how the slating will be set out on the roof (lath gauging). This can be done by demonstrating making the marking rod which will be used on the roof.
- 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 step which has 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.

2.4 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 general slating and eaves, valley, verge, abutment, hip, ridge and dormer window details and the slate sizes, their condition and gauging. 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 could be carried out by a slating consultant, an experienced contractor, architect or surveyor.

Based on the survey findings the specification can be prepared. 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/or where a method for venting any moisture from the batten space should be provided. It would be wise to discuss the practical and technical implications of any innovations with the appointed slater before confirming the specification.

This advice note includes roof details which vary across the region and which should be replicated during repairs or re-slating. In the Northampton area there is a cross over between Collyweston and Cotswold roofing styles and details so those which ought to be applied on a particular roof should be based on research, 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, and the prices can 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 sub-contractor. 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, sizes range, thickness;
- gauging and head lap;

- side lap – for random slating the requirement is to set perpendicular joints approximately central over the slate below; for larger slates a minimum side lap can be stated;
- 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;
- insulation and means of ventilation;
- details for eaves, verges, abutments, hips, valleys, dormer windows and ridges;

2.5 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:

- re-slating 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 such as 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 significantly 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 service 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; or
- either of the other two but including modern innovations like insulation.

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

2.6 Building regulations and other controls on roofing work

In addition to listed building consent, building regulation or, for many places of worship, faculty approval will be required for any increase or decrease to the weight of the roof covering.

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 4.8.

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. The county wildlife trusts will be able to advise and other sources of information are given in Section 14. Currently (2018) only BS747 1F bitumen roofing felt is permitted in roofs where bats are present.

In fully bedded roofs such as Collyweston slates bats will not be able to get in unless the mortar has fallen away. However, if access is necessary for small bats it is possible to leave small areas of the tail bedding open.

3 Recording and Assessment

3.1 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. It is important that the recording of such information is undertaken before 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 from inherently poor design or construction.

3.2 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 will have spread, pushing out the walls, and the ridge will 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 upwards curve in the rafters which helps the slates to sit tightly together. This should not be misinterpreted as settlement. 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 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 it is acceptable (and essential) to ease the undulations by packing under the laths or similar (Figure 6). Where settlement is less severe, gaps under the slates can be reduced by using narrow slates which will fit more tightly across the undulations.

3.3 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. This will be a gradual process and they can be refixed for a time. If lath nails fail several slates in a course or several courses will slip (Figure 7).

3.4 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 re-slated. Laths may be unable to carry the slates' weight if they have been weakened by rot or insect attack.

3.5 Slate failure

All the slates and stones covered by this advice note are durable and will only reach the end of their lives after many, commonly hundreds, of years. Typically, the process of slate ageing is a general softening in the

Figure 6a
Movement of the roof structure may not require any correction or perhaps just stabilising. But if there are severe or abrupt undulations they can be impossible to slate over without the slates gapping even if small or narrow slates are used. In this case the undulations can be eased.
Terry Hughes

Figure 6b
If undulations are only eased by the minimum to allow tight slating the roof's charm will be conserved.
Terry Hughes

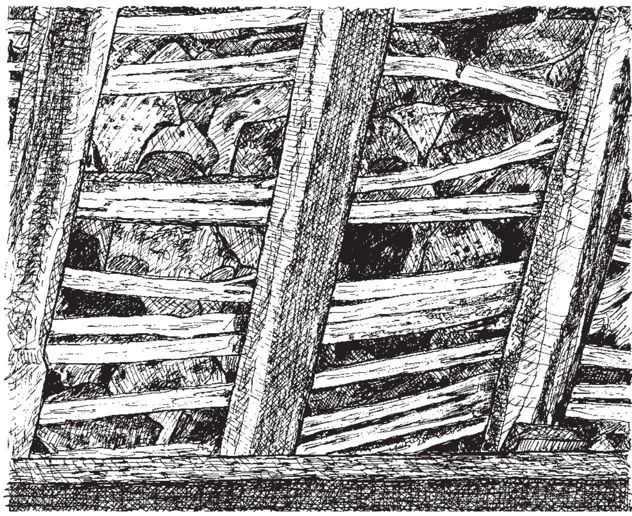


Figure 7
If whole courses of slates have slipped the cause is usually failed lath nails.
Ray Harrison

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 Metamorphic Slate Durability page 5). The stone slates in this guide which are currently produced are from long established mines or quarries. The Stone Roofing Association can provide advice if stone from a new source is being considered.

4 Repairs and reslating

4.1 Alteration of details

It is normally assumed that a like-for-like repair or re-slating – same slates, same gauging, same bedding if originally used, etc – will perform satisfactorily in the future. However, the implications of the recent increasing incidence of deluge rain and more severe storm force winds 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 taken into account 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 roof. Scaffolds should be designed to carry the weight of stacked slates or stones and with a wide area to allow sorting and redressing. Otherwise the slates will need to be taken to the ground for sorting. The NFRC provides guidance publications.
It is better to repair rather than replace roof timbers. Consult a structural engineer where necessary and leave only minor repairs to roofers. Whilst conventional carpentry techniques alone will frequently be suitable, strengthening using stainless 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. Plastic reinforcing rods should be avoided.

Keeping roof spaces clear of rubbish and debris discourages decay. 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. 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. For further advice on work to roof structures see SPAB Technical Pamphlet 12.[2]

4.3 Slates

Although slate 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 can be dressed down to remove any defective areas. They are then sorted into length sets and the number of courses of each length can be calculated.
The individuality of these roofs derives from the mix of slate sizes. Historically, no attempt was made to supply a specific mix of sizes and this policy should be respected for most re-roofing work today. How the slates were positioned and the detailing was mainly a response to the weather. Only slates from the local sources can produce an authentic appearance. Slates from other locations should not be used unless there is no local source and only after careful assessment of their suitability and durability.[3]

Slate and stone availability

This is the situation in late 2018.

Swithland slates

There has been no production since 1887 and since then there has been constant removal of slates from old roofs to slate new. This is unsatisfactory anyway, but it is a rapidly declining source even for repairs. The best option at present is to obtain facsimile slates using rock from a UK quarry but these will need to be carefully specified and made to have similar sizes, shapes, thickness, colour and texture to real Swithlands. Mixtures of a selection of stock sizes from normal production will not produce a convincing appearance.

Magnesian Limestone

There is no production of magnesian stone slates but because they are visually almost indistinguishable from Cotswolds slates, producers in that region are the best option for repairs. There are several sources and the slates' visual characteristics vary so matching as above is essential. Because it is possible to replace these limestones with similar limestones it is not appropriate to substitute them with other products such as clay tiles even though these are traditional in the region.

Collyweston slates

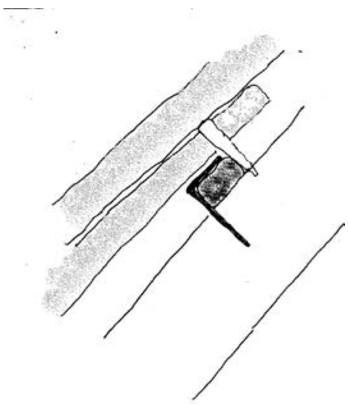
Until recently there had been almost no production of Collyweston slates since the 1950s (check this). Happily, there are now two companies making new slates: Claude Smith and Messengers [See 10.3]. Nonetheless fluctuations in demand can result in temporarily extended availability so manufacturers should be contacted as early as possible.

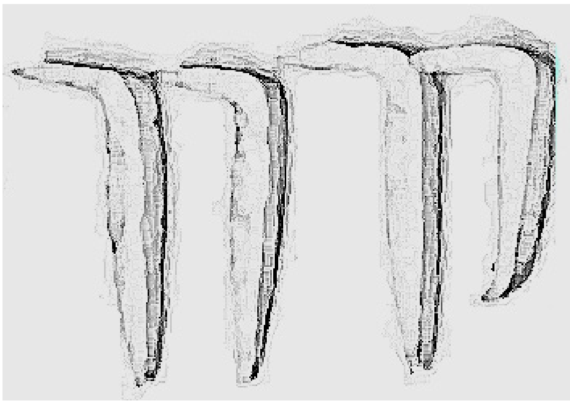
Other limestones

There is no production of limestone slates from any of the historical sources in the Northampton region. Repairs and renewals of roofs have sourced stone slates from Collyweston and the Cotswold region including all types from the latter even using reclaimed Stonesfield and Collywestons on the same building. This has resulted in a confused roofscape from Oundel (clearly Collyweston) to Banbury and Brackley (predominately Cotswolds) with originals and substitutes from both sources in some places. As none of the original slates from this region are available and using reclaimed slates is unsatisfactory in almost all cases, the best option for repairs is to obtain a geological identification of the slates on the roof and choose the same if they are available. If a geological approach isn't possible visual matching as above should be adopted.

Imports

In recent years there have been attempts to import substitutes for Swithland and Collyweston slates but these proved to be badly organised even including importing 'Swithland' which was not slate (it was an unmetamorphosed siltstone - and which contained pyrites and badly stained roofs can now be seen in Swithland village) and 'Collywestons' which were not even limestones. Any claims of authenticity for imports should be thoroughly checked preferably with an independent geologist.





Figures 8a and 8b
Cleats, also known as cooper's hooks, support the whole width of a lath and hence the weight of heavy slates. They can be made by blacksmiths or nail manufacturers.
Terry Hughes

For extensive re-slating, new slates should be used to make up any shortfall and supplied in a mix of sizes as they arise in the quarry or mine. This may be local authority policy and a condition for 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 in excess of 100 years.

If slates need to be specially made the producer will need a detailed specification of what is required and almost always time to organise production. An order might include sizes, quantities, colour, texture, and most importantly the date work is to commence and, for large projects, the scheduling for each stage. 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.

Only where it is impossible to obtain suitable new slates should the use of reclaimed slates from other buildings be considered and these should always be from a known source to discourage theft. These will not last as long as new and their use inevitably means some other building will have lost its historic roof. Often, they are sourced from several other roofs so their remaining life will be mixed. They should be checked for softening and damage especially around the fixing hole. Affected areas can be dressed off but this may result in a shortage of the longer sizes with a consequent change in the roof's appearance. It is better for appearance and durability reasons to consolidate old slates on to one or more slopes and to use the new ones on others.

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 head fixed it may be possible to swing adjacent slates aside to hang the new slate.

If Swithland slates are centre nailed (which is not traditional) a triangle of slates should be removed so that each one can be accessed for refixing and the last one can be slid up fixed with a tingle. Inevitably any head bedding, tail bedding for Collywestons or torching will be damaged and this should be renewed.

Collyweston roofs are always wet laid ie tail bedded in mortar (see section 10.7). Inevitably this will deteriorate eventually and need to be renewed. It is possible to do this by raking out the old mortar and pointing in new but this is a stop gap repair and will need to be repeated within 10 years.

4.5 Lath and batten 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 in coastal areas and current advice is to avoid this grade for roofs and only use grade 316. The NFRC technical bulletin 3 should be consulted for full details.[4]

Small 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 (Figure 8a&b).

For 50 x 25 mm softwood battens a 3.35 mm shank diameter 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.

4.6 Slate fixings

The traditional fixings for wet or dry laid slates were soft or hardwood pegs. They were a roughly square section and whittled to a slight taper and forced into the hole until almost flush with the slate's surface.

On a pegged roof where the underside of the roof is to be visible, wooden pegs should be used and will be prevented from twisting or falling out by the addition of a small dab of mortar on top (pin pointing) or by torching. Otherwise, nails can be used in the same way as pegs.

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 but these can create other problems at abutments etc.

For slate nailing, copper 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 for slating because 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 most situations.

BS 5534 recommends 3.35 mm shank diameter copper nails in part to ensure an adequate head diameter of 10 mm (3 x the shank diameter). If a thinner nail is necessary 3.00 mm shank copper nails are available to order with 10 mm heads. The nail length should provide a minimum of 15 mm penetration into the batten in addition to the thickness of the slate(s). BS5534 provides model calculations for determining slate nail dimensions for adequate pull out resistance.

Hook fixing is not traditional and should not be used on old roofs.

4.7 Laths, battens and sarking boards

Historically, 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 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. Also they are less prone to beetle attack than sawn battens. For small peg-fixed slates, battens need to be narrower near the ridge to allow space to insert the pegs between them as the gauge reduces.

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. Alternatively a cripple or slater’s heel is a suitable working platform.[2] 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.

Slating was commonly fixed directly to sarking boards and they 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 acting on slates and acting as a moisture buffer.

Under correctly laid slating there is no need 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 have a lower rate of ventilation of moisture than no membrane at all. To ensure ventilation 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 Insulation and ventilation

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 they 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.

Part L of the building regulations requires the addition of roof insulation for most substantial repairs to habitable or heated buildings, including partial re-slating. The threshold for substantial is 25% of the roof repaired or replaced. However listed buildings, buildings in conservation areas, Ancient Monuments, places of worship and most unheated non-domestic buildings are exempt. Full explanations are given in the Building Regulations Part L.[5]

Installing insulation can increase the condensation risk in the roof structure and affect other parts of the building unless precautions are taken. BS 5250 The Control of Condensation in Buildings provides advice on how to minimise the risk.

It will be difficult for many older buildings to achieve statutory target U-values without compromising their appearance and it may be impossible. Part L allows for exemptions and special consideration for historic buildings to enable building control officers to take a sensible view in order to conserve the appearance and character of the building and not introduce technical risks. Historic England has published guidance on complying with Part L.[6]

To prevent condensation problems, the first step should always be to reduce the amount of moisture reaching the roof. This has two concerns: 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 retrofit.

Having minimised the moisture reaching the roof space it is important to ventilate any which does. 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. Where Agrement Certificates are available they should always be checked for the limitations applying to their products. For example, many vapour permeable membranes will only achieve adequate performance 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 via eaves to eaves, 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, below copings and at verges. Secret gutters at abutments can be used to avoid the need to cut into the wall to reposition flashings or a string course. But they will need regular maintenance to avoid blocking by leaves or other debris.

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.

Collyweston slating is a sealed system so if there is any sort of membrane or underlay installed or a ceiling is 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. This constitutes a change of appearance and will require listed building consent.

4.9 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 or flaunches.

Although every repair to an old building is best approached as an individual case, there are often common factors. Roofs move under the influence of wind and temperature so it is essential to use a flexible bedding mortar to avoid cracking. Movement can be due to climatic and building exposure and can be caused by:

- differential thermal gain (expansion and contraction)
- wind (differential pressures and tile uplift
- driving rain (humidity and leaks)
- snow load
- freeze-thaw cycles

- structural movement (roof timbers and wall instability)
- swelling and shrinkage of timber (joinery to dormer windows etc).
-

If there is slight differential movement for any of the above reasons, rigid and impermeable mortar at junctions will crack or part from one or both attached elements – the slating, masonry or timber. This may be a microscopic hairline crack, or a few millimetres wide or more. It will allow water into the fabric where it will be trapped and cause decay.

Lime takes time to set so the use of a quick-setting Portland cement binder for bedding slates, pointing, gable ends and flaunching is attractive in the short term but, in addition to its inflexibility, a mortar of this nature is extremely adhesive so damage and loss of the slates during repair is difficult to avoid and may be extensive. Where they are bedded and pointed with lime mortar, roofs can be repaired or re-slated without, or with very little, loss.

During, and prior to, the 18th century it was common practice to select Grey Chalk and Blue Lias limes for external mortars in central and southern England. Because they are 'feebly' or 'moderately' hydraulic, they withstand exposed conditions better than non-hydraulic limes. Some degree of hydraulic set may also be achieved with non-hydraulic limes when used in quicklime form with aggregates having a mineralogy that combines with the lime to form compounds of calcium silicate and aluminate.

Among the benefits of using lime mortar with roof slating are that it:

- enables reuse of original slates during repair or re-slating and avoids partial or complete loss due to overstrong mortar
- allows autogenous healing (self-healing) of fine cracks
- imparts vapour permeability, so does not trap moisture
- offers flexibility, if the mix is well haired.

The disadvantage of using lime mortar in this instance is that it takes time to cure. It also needs to be designed to be suitable for the level of environmental exposure which varies. So 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 the roof structure.

A non-hydraulic lime may be satisfactory for sheltered locations, particularly if it is used in quicklime form and with an aggregate that will provide a hydraulic set. Traditional feebly hydraulic lime previously used extensively for external pointing in the UK is, at present, no longer available.

A close match to this may be obtained by blending a non-hydraulic quicklime with an NHL2 or NHL3.5 hydraulic lime. However, arriving at the precise chemistry to match a traditional feebly hydraulic lime in this way requires a specialist supplier or analytical chemist for verification. The traditional moderately hydraulic limes such as Blue Lias were used for positions of moderate exposure. Specified mixes were 1 of blue Lias to 2 sand and these were often mixed in quicklime form.

Table 3[7] indicates typical lime-based mixes that can be used for work on old slate roofs in different exposure conditions. It is not exhaustive. For example, hot lime is now sometimes 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 will bind well 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 due to the unevenness of some slate surfaces. The size of the largest aggregate particles should normally be about one-third of the mortar bed thickness. But, where thicker beds are unavoidable, it is important to keep the aggregate size sufficiently large to prevent cracking.

Increasing strength ↓	Roofing application	Mortar mix (ratio by volume)	Comments	↑ Increasing permeability and flexibility
	Torching, except on exposed roof slopes or where lap is not ideal	1:3 non-hydraulic lime:soft sand plus hair	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 wet laid scantle, ridge or hip bedding, 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	

Table 3: Selection of mortars

Notes

(i) NHL denotes a natural hydraulic lime. Natural hydraulic limes are classified under BS EN 459: Part 1: 2015 Building Lime17 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 (approxomiately 1:1 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 minimize 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.

The mortar should be mixed in a pan, paddle or drum 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 safely be knocked up without the need to add further water. Non-hydraulic lime that is kept damp can usually be left overnight, as sometimes it can certain weaker hydraulic limes. 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.

To gain the benefits of lime mortar in connection with roof slating, the normal recommendations for curing and tending apply. Protection of all new lime-work against the weather is almost always required. This requires planning ahead and arranging the access, provided for the roofer to carry out his work, to remain in place, or accessible for at least two, preferably four weeks following completion of the slating. Protection and tending of the mortar may then continue in the normal way.

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 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 climate that encourages carbonation. A fine mist spray applied daily for a minimum of four weeks where this is practical is also beneficial.

Further advice on selecting mortars is included in:

Allen, G C, Allen, J, Elton, N J et al (2003) *Hydraulic Lime for Stone, Brick and Block Masonry*. Shaftesbury: Donhead Publishing Ltd. A range of mixes for varying exposure conditions is set out in 'Hydraulic Lime Mortar for Stone, Brick and Block Masonry' on tables 9 and 10, pages 36 and 39. The effect of blending different hydraulic limes with non-hydraulic limes is given in *Building with Lime* at Appendix 7 page 293.
Holmes, S and Wingate, M (2002) *Building with Lime: A Practical Introduction*, revised edition, London: Intermediate Technology Publications (now Practical Action). Chapter 5 is particularly relevant. The effect of blending different hydraulic limes with non-hydraulic limes is given in in Appendix 7.
British Standards Institution (2015) *Building Lime – Part 1: Definitions, Specifications and Conformity Criteria*, BS EN 459-1, London: BSI

The English Heritage *Practical Building Conservation*, volume on 'Roofing' includes a section on 'Mortar for Roofing' pages 51 to 55. This advises on the range of building limes, from non-hydraulic to NHL5, and their use for varying levels of exposure.

5 Specifications and detailing

5.1 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 resist wind uplift and to provide adequate head, side and shoulder laps to resist driving rain (Figure 2). 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 or stones because they have to be positioned on the slope where their length dictates. They can be sorted across the roof in each course - thick to thin from left to right and right to left on alternate courses or thick to thin from verges to the middle. This is known for Swithlands but is not done for wet-laid Collywestons where the mortar bedding takes up any variation. Alternatively, they must be selected as they are laid to ensure adjacent slates are equally thick.

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 such as a hip or a close mitred valley. In those cases the margins should be coursed across the pitch change. To do this the gauging is worked out on the lowest pitch (because it is the most vulnerable to driving rain) and then the lines of the tails are struck across to the steep side and slates long enough to provide the required lap are selected for each course and the laths fixed to suit (Figure 9). This can also be worked out by calculation or scale drawing.

5.2 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. If

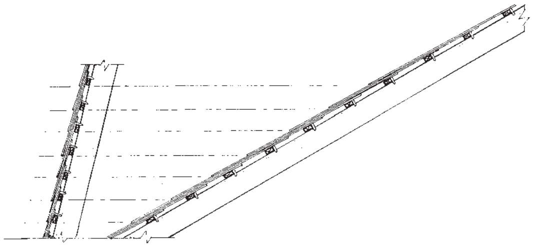


Figure 9
Where hip or valley slating on two slopes of different pitches is to be close mitred the gauging and margins worked out for the lower pitch. The margins should then be replicated for the corresponding courses on the steeper and the slates lengths selected to ensure adequate head laps.
Ray Harrison

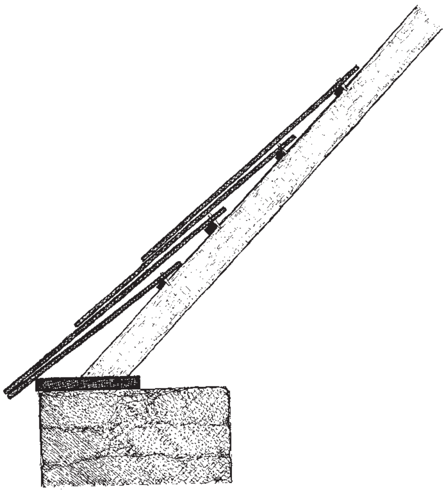


Figure 10
A tilt must be provided to lift the tail of the under eaves slates to ensure the subsequent courses lie tightly onto each other. There are a number of ways this can be done: by fixing a tilting fillet, by raising a fascia board or, if the rafter is set back on the wallhead, by packing up the masonry. If the rafter is well back from the outer face of the wall it may provide sufficient tilt.
Ray Harrison

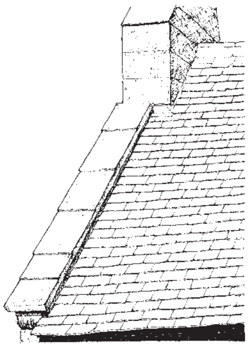


Figure 11
Verge slating can oversail the wall head by one or two inches but on later roofs it finishes against a raised outer wall leaf which is coped. The latter is thought to be intended to prevent wind damage and is probably a legacy of thatching. On vernacular buildings the abutment is often only applied to the most wind susceptible gable but is common on all gables of designed buildings such as churches. It is often difficult to make a water tight joint resulting in the adoption of secret gutters which need regular claening to prevent them becoming blocked with leaves and othe debris and leaking.
Ray Harrison

Figure 12
Before the availability or affordability of lead for soakers abutments were weathered with simple mortar flaunches.
Terry Hughes

Figure 13
Mortar flaunches are prone to cracking and leaking. One technique to help prevent this is to bed slates, thin stones or tiles into the flaunch. In some regions these are known as listings.

Terry Hughes

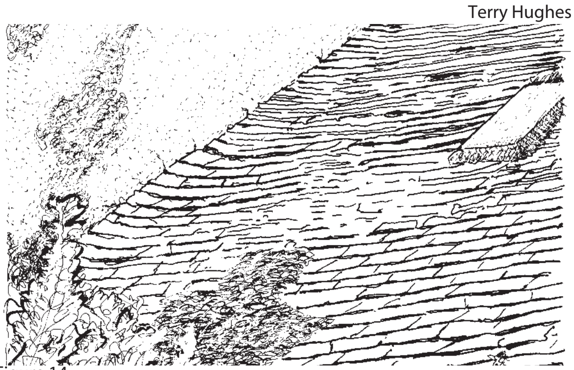


Figure 14
To reduce the amount of water abutments had to resist the abutting slating was raised by bedding up the slates or packing up the laths. This is surprisingly effective.
Ray Harrison

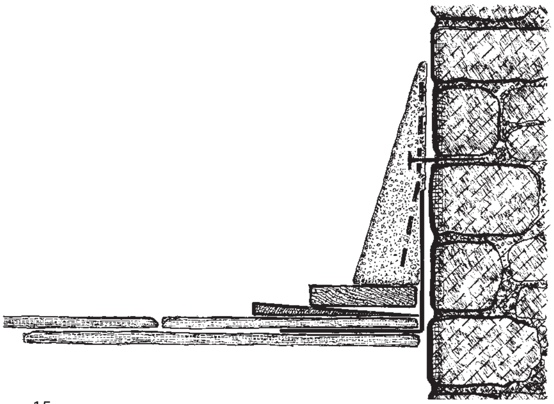


Figure 15
Another method to prevent flaunches cracking is to incorporate stainless steel mesh screwed into the mortar joints.

Ray Harrison

Figure 16a
Where dormer ridges run into the main slating they are either swept up into the main slope or the junction is weathered with a lead saddle.

Terry Hughes and Ray Harrison

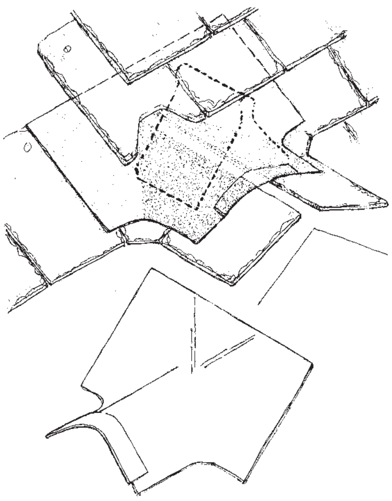


Figure 16b
Where dormer ridges run into the main slating they are either swept up into the main slope or the junction is weathered with a lead saddle.

Terry Hughes and Ray Harrison

Figure 17
Mitred hips are vulnerable to wind so wide slate should be used to ensure sufficient width and therefore strength at the top of the raking cut.

Terry Hughes

Figure 18
An alternative wind resistant hip is achieved by bedding on heavy ridge tiles supported by a hip iron at the eave.

Terry Hughes

Figure 19
There are very few pre-ninteenth century Swithland roofs and those that still exist do not genrally include valleys (or hips). So the valleys that are seen today - Welsh and a swept type - seem to be none-vernacular innovations. Later still even these have regretably been replaced with open lead and close mitred types.

Terry Hughes

there is no gutter 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 other. 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. If the rafter is well back from the outer face of the wall it may provide sufficient tilt (Figure 10). If rafters extend beyond the wall, the slating can be protected by soffit boards.

5.3 Verges

Verge slating is traditionally finished with a slight overhang to the gable wall with a mortar fillet under the slates or abutting a raised coping (Figurer 11). On later buildings barge boards or external rafters were adopted. The slating is often raised slightly to direct water back onto the roof slope.

5.4 Abutments

The junction between the slating and abutting walls and chimneys can be difficult to make water tight. Historically, they did not include soakers and relied on mortar fillets (flaunches) to prevent water penetration (Figure 12) or slates bedded into the mortar to protect it (Figure 13).

These were known as listings in some regions. Also the slating might be tilted slightly by raising the last rafter, packing the laths or bedding up the slates to direct water away from the junction (Figure 14).

It is possible to conserve the appearance of abutments but to include concealed lead soakers. These and cover flashings became common once lead became economical, but the latter can be visually intrusive and mortar flaunchings are preferred. Nonetheless the flaunchings can be problematical as they often crack and leak. Listings reduce this. Alternatively, when renewing fillets the risk of cracking can be reduced by avoiding hard mortar, separating it from the slating and incorporating stainless steel mesh screwed to the masonry joints (Figure 15).

5.5 Ridges

Ridges are closed with stone or clay ridge tiles or crests which are sometimes decorative. They should be back-bedded in mortar which should not show at the long edges as far as possible and not be pointed. Roof undulations, curves in the ridge tiles and uneven stone roofing can make it difficult to avoid mortar showing but it should be minimised.

Where dormer ridges run into the main slating they are either swept up into the main slope or the junction is weathered with a lead saddle (Figure 16a & 16b).

5.6 Hips

Before lead and ridge tiles became commonly available hip slates were mitred and bedded with clay or mortar. (Figure 17) but they are susceptible to wind damage and therefore are not common in the region. To reduce the risk of wind damage wider slates are selected for the raking cut. An alternative wind-resistant option is to use clay or stone ridge tiles (Figure 18). Today, if the hip is mitred it is normally weathered with lead soakers and 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 (Figure 9).

5.7 Valleys

The difficulty of making a watertight valley has been tackled with ingenuity, especially before the ready availability of lead for soakers. Various methods relying on slates laid up the centre of the valley, 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 and if their effectiveness is in doubt lead soakers can be unobtrusively interleaved in each course.

On an old roof this is far preferable to an open lead valley.

On Swithland roofs two valley types are seen: Welsh and a swept version (Fig 19) but there are very few examples and these may be no vernacular later innovations. Today, non-traditional lead lined and close mitred

Figure 20
Collyweston slate valleys are always laced.
Terry Hughes

Figure 21
Collyweston dormers can be below, braking and above the eaves and monopitch, gabled or hipped. Terry Hughes

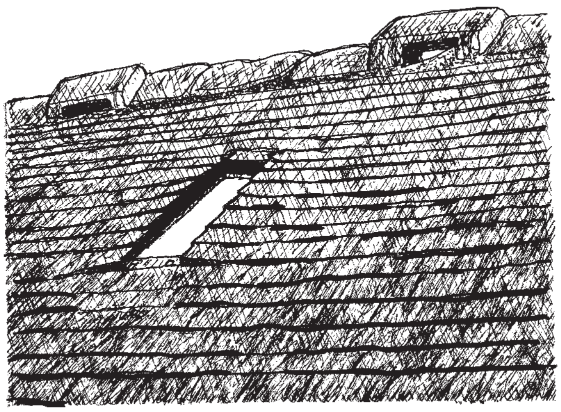


Figure 22a
In their simplest form rooflights are just a sheet of glass substituted for a slate or inserted into the slope and the slating overlaid. These are common on farm buildings. Ray Harrison

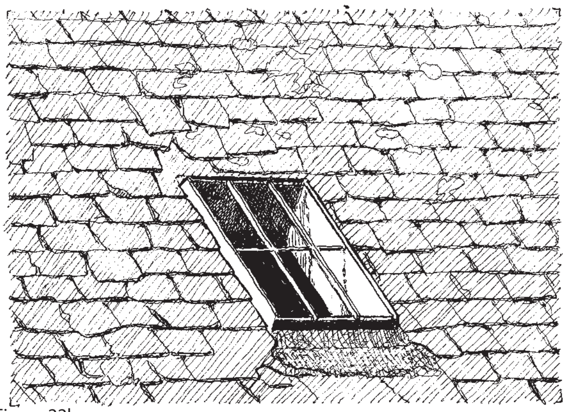


Figure 22b
Where the extra cost was acceptable cast iron lights are used.
Ray Harrison

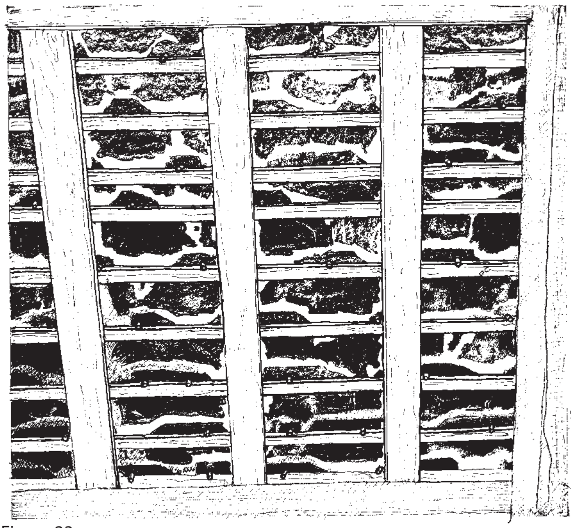


Figure 23a
Torching is applied to the underside of the slates and may just cover the top of the slates (single torching) or their backs completely between the laths (full torching). Ray Harrison

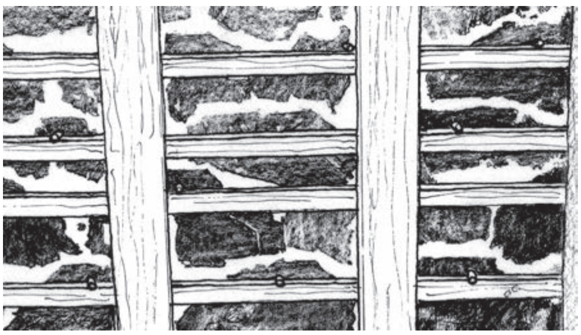


Figure 23b
Torching is applied to the underside of the slates and may just cover the top of the slates (single torching) or their backs completely between the laths (full torching). Ray Harrison

types are most common. Collyweston valleys are always laced (Figure 20).

There are many subtleties in the way valleys are constructed. Some, for example, slightly raise the slating at the valley to turn water away from the junction so when they are repaired or renewed this possibility should be checked. The existing details should always be reinstated.

The pitch of a valley is lower than the main slopes so longer slates are needed to be able to course the slating across. Even longer slates are an advantage because they will provide a larger head lap. Suitable sizes should be put on one side during the preparation stage. In Collyweston valleys the diagonal dimension of the roughly square slates laid point down give extra length and lap.

5.8 Dormer windows and rooflights

The position of dormer windows can be below, through or above the eaves or wholly within the roof slope (Figure 21). The cheeks are sometimes slate clad or covered with single slate panels (Figure 16a). Traditionally ridges were swept up into the main slating but now the alternative of lead saddles is common (Figure 16a & 16b).

Rooflights are an alternative to dormers and being much cheaper to install are common on industrial, farm and similar buildings. They are an important feature of many farm buildings but are usually quite small. In their simplest form a sheet of glass is substituted for a slate or is inserted into the slope and the slating overlaid (Figure 22(a)). Where the extra cost was acceptable cast iron lights are used (Figure 22(b)). The scale of the rooflights in relation to the roof slope is an important consideration in roof renewal. The provision of new glazing at roof level is one of the most sensitive issues involving work to old buildings. They can be very intrusive especially if they are large and dominate the roof slope. They should be positioned to minimise disturbance of existing roof timbers. Conservation types which emulate the look of traditional cast iron rooflights will generally be preferable with slender section steel with a vertical emphasis. 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.

5.9 Torching

Torching stabilises the slate heads and pegs; closes the roof against draughts and powdery snow blowing into the roof; and conserves the historic appearance of the roof from the inside. It should never be omitted from any repair work unless underlay is installed.

It is applied to the underside of the slates and may just cover the top of the slates (single torching) or their backs completely between the laths (full torching) and, if a second coat is applied, this may be trowelled or floated as the background of laths and pegs will be sufficiently covered to allow this. It is very important that torching is not forced too far down between the slates to avoid drawing water to the laths and rafters (Figure 23).

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 home workshops or other accommodation. In shippons or cow houses it was used because cattle will not tolerate drips.

5.10 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 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 or by installing small cast iron rooflights rather than dormer windows (Figure 22). 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.

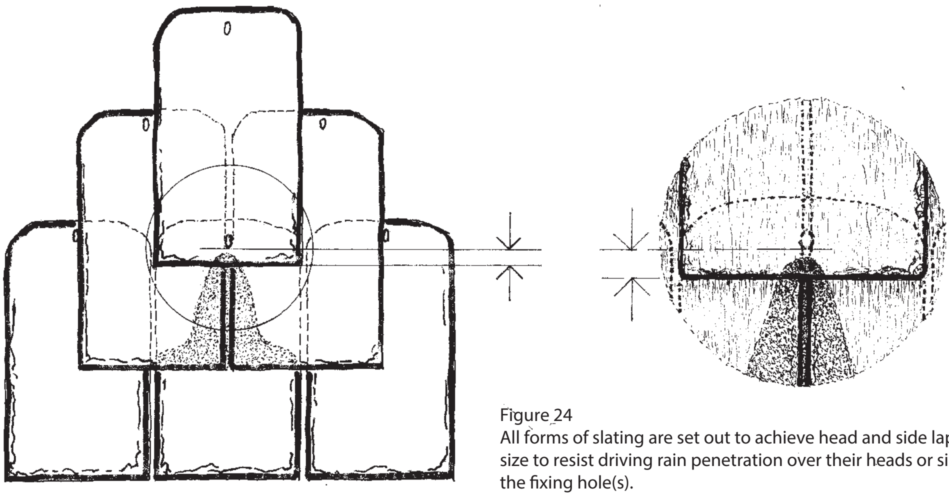


Figure 24
All forms of slating are set out to achieve head and side laps of sufficient size to resist driving rain penetration over their heads or sides or through the fixing hole(s). Ray Harrison

6 Random slating

6.1 Random slating

All the slates in this guide are random sized and are always double lapped so that each course is overlapped by the next but one course above. They are laid in courses of equal slate length but diminishing in length from eaves to ridge. There may be one or several courses of a given slate length depending on the mix of slates and the roof's dimensions (See Box out page 5).

All forms of slating are set out to achieve head and side laps of sufficient size to resist driving rain penetration over their heads or sides or through the fixing hole(s) (Figure 24). The head laps can be specified as a fixed or varying dimension or set as a proportion of the slates' lengths (Figures 2&5). In random slating they always reduce up slope. This is economical because the head lap reduces as the slate lengths reduce and is satisfactory because slates near the ridge and carry less water.

The region's four vernacular slate roofs use their own slating systems. Swithland and Collyweston roofs are set out as described on page 5. For Magnesian limestones and some roofs around Northampton, the existing details should always be checked. A Cotswold style is the most likely unless the slates are Collywestons.

Swithland slates are narrow and limestones are heavily shouldered so, for the laps to be effective they are all laid at comparatively steep roof pitches. Certainly, 40º and more commonly 45º to 55º.

As well as the slating techniques which apply, some of the detailing at hips, valleys, verges and abutments is specific to the slates or the locality. Slate wall cladding is uncommon.

6.2 The slating process

The steps in random head fixed slating are:

- For reclaimed slates, check the slates for softness and damage and dress off to sound slate.
- Hole the slates and check for any damage.
- Sort the slates into length sets, usually at the same time as holing - see box out page 5.
- Typically for Swithland slates these are in half inch or inch steps. For Collywestons it is one inch in the lower courses and half inch in the upper.
- Set the first batten to provide the required eaves over hang.
- Fix a lath or batten for the under-eaves slate.
- Lath the remainder of roof at the appropriate gauges for the reducing slate length and head lap making adjustments at change courses.
- Carry the slates onto the roof
- Fix the slates.

6.3 Preparing the slates

Any slates which are to be reused must be checked for damage or softened areas and dressed off. They are then holed about 25 mm (one inch) from the top and the length measured from the hole to the tail (Figure 2). At the same time they are sorted into inch or half inch length sets.

The total width is measured or estimated for each length and these values are divided by the roof's width to give the number of courses available for each slate length. Left-over slates are added to a course higher up the roof. If the slates are to be fixed with wooden pegs these can be inserted before taking them up to the roof.

6.4 Fixing the slates

The slates are hung on the laths with a wooden or metal peg or nailed working one or several courses progressively across the roof. Each slate is selected and laid so that the perpendicular joints are approximately central over the slates below (Figure 2).

Wind uplift is mainly resisted in top fixed slates by their weight and their overlapping arrangement rather than by the peg or nail but head bedding with a small amount of mortar helps with this.

7 Swithland slating

7.1. Swithland history

The first evidence of their use for roofing is from Roman archaeological sites including at Narborough, West Langton and Haceby and as far as 50 miles away from the quarries at Great Staughton in Cambridgeshire (Figure 25)[8]. As at other Roman sites the slates are hexagonal (Figure 26). These are often described as diamond shaped or four-sided but the actual hexagonal shape is fundamental to the way they are laid to form a water tight roof.

There appears to have been no post Roman quarrying until the seventeenth century (or at least no evidence of it). But from then and especially from the mid-eighteenth century there was a substantial local industry which took advantage of river transport along the Soar and the Trent and ultimately along the Grand Union canal to London. But it was the canals and later the railways which brought about its demise by allowing access for cheaper Welsh slates. The last operations, Northern Pit and Great Pit in Swithland Wood closed in 1838 and 1887. Ironically, what was probably Swithland's greatest roof was a product of the railways when slates from Groby Park were taken by canal for London's St Pancras station hotel. Sadly, it has been mainly replaced with Westmorland Green slate.

7.2 Swithland sources

Swithland slate was quarried in and around Charnwood Forest in the area between Leicester, Loughborough and Coalville. There were three areas of production: to the west of Swithland village at the Brand Estate and in Swithland Wood; in the Hangingstone Hills north-west of Woodhouse; and at Groby (Figures 27a &27b).

7.3 Swithland production

Post medieval working of Swithland slate was on a small scale, purely as a vernacular material. The small pits in Swithland Wood are thought to be early slate workings perhaps dating from the mid-thirteenth century. Eventually industrial scale production developed in the wood and at the Brand where some of the old quarries were worked to depth. These are now flooded. There is currently no production and initiatives to reopen a quarry have foundered for lack of commitment.

Roofing slates were sold in two classes. By the score for the large sort and by six score for the common kind.[10]

The quarries made a range of slate products besides roofing slates, famously including gravestones. But, except for St Pancras Station Hotel, they were limited to local markets by the cost of transport and from the nineteenth century by competition from the Welsh quarries. Even at St Pancras which had been intended to be a shop window for East Midland's manufacturing the developers decided to slate Barlow's engine shed with Welsh slate because of the cost saving.

Although there is no production of Swithland slates today, reasonable facsimiles matching purple or grey slates can be made using slate from Welsh quarries (see section 14). If these options are adopted a specification covering colour, thickness, and range of sizes should be agreed with the supplier. A mix of standard sizes from the quarries stock will not produce a convincing roof (Figure 28).

7.4 Swithland slates

Swithland slates have a distinctive texture due to their comparatively coarse cleavage. Their colour varies. Those from the Swithland quarries are grey, from Woodhouse Eaves they are purple and Groby slate is greenish. Colours are sometimes mixed on roofs probably because they have been sourced from several other roofs for re-slating.
They were made in random sizes ranging from 30 to 10 inch long and 14 to 3 inches wide. A distinctive feature is that many are very narrow for their length. This has implications for the roofs, primarily that they are steeply pitched, and how the slates were laid.

7.5 Swithland roofs

Random slates generally are laid to fairly steep pitches - at least 40° and as steep as 55°. This is especially important because of their coarse texture and because they include a significant proportion narrower than half their length. Low pitches such as on church aisles are vulnerable to leaks. Earlier roofs were simple in form - plain gable to gable with no hips or valleys. During the eighteenth and nineteenth centuries Swithland roofs were popular on higher status buildings and roof detailing changed. Valleys, hips and dormer windows became more common and decorative brickwork was introduced under eaves and verges. Designed buildings such as the National Trust's Stoneywell adopted details from other regions and traditions.

The process continues and even though the quality of slating work is often very good some non-traditional elements such as swept valleys, eyebrow dormers, large rooflights and conical hips have been introduced.

From the nineteenth century Welsh slates started to be used for repairs and new buildings and in the twentieth they replaced Swithland slate completely on some roofs. These were tally slates and are smoother and usually thinner so they are not a good substitute. However, it is possible to make truly random slates of similar colours from more coarsely cleaving Welsh slate.

7.6 Preparation and gauging

The slater sorts the slates and gauges the roof as described in section 2.

7.7 Fixing

The slates can be hung to the laths or battens with softwood, hardwood as traditionally or with metal pegs or nailed to battens.

If the slates are pegged, head bedding will secure the pegs and improve wind resistance. Metal pegs usually have heads which lock them in place.

In recent years top-fixed Swithland slates have been re-used with centre nailing. This is unnecessary and risks water leaking through the nail holes unless the laps are increased. If it is adopted the slates' tops must be dressed off to avoid the risk of leaks through the old holes and the head lap and minimum width specified to take into account that the centre nailing reduces the slates' effective width by about 50 mm (2 inches).

7.8 Eaves

On earlier buildings there would be no gutter and a large over hang to throw water away from the wall. The one or two much larger and thicker slates at the eaves give the roof a distinctive appearance (Figure 29). They would be heavy enough to resist wind uplift even when head fixed. To give

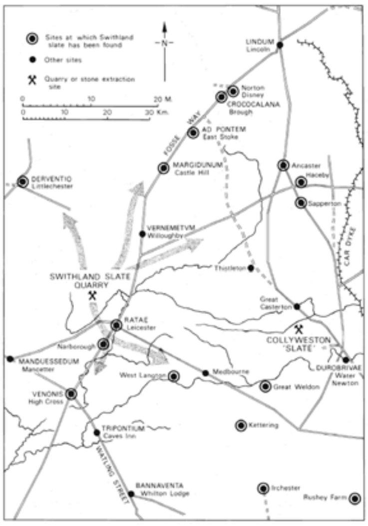


Figure 25
Swithland slates were used from Roman times and were so valued that they were carried as much as 50 miles away. McWhirr[9]

Figure 26
As at other Roman sites the slates are hexagonal. These are often described as diamond shaped or four sided but the actual hexagonal shape is fundamental to the way they are laid to form a water tight roof. McWhirr[9]

Figure 27a
There were three areas of production of Swithland slates: to the west of Swithland village at the Brand Estate and in Swithland Wood; in the Hangingstone Hills north-west of Woodhouse and at Groby.
National Library of Scotland https://maps.nls.uk/index.html

Figure 27b
There were three areas of production of Swithland slates: to the west of Swithland village at the Brand Estate and in Swithland Wood; in the Hangingstone Hills north-west of Woodhouse and at Groby.
National Library of Scotland https://maps.nls.uk/index.html

Figure 28
It is possible to obtain facsimile Swithland slates made from Welsh slate rock. However, a mix of standard sizes from the quarries stock will not produce a convincing roof. Terry Hughes

Figure 29
The eaves of swithland roofs are often formed with one or two courses of much larger and thicker slates giving the roofs a distinctive appearance.

Terry Hughes

Figure 30
During the ninteenth century a large eaves overhang was formed by corbelling the wall head with decorative brickwork.
Terry Hughes

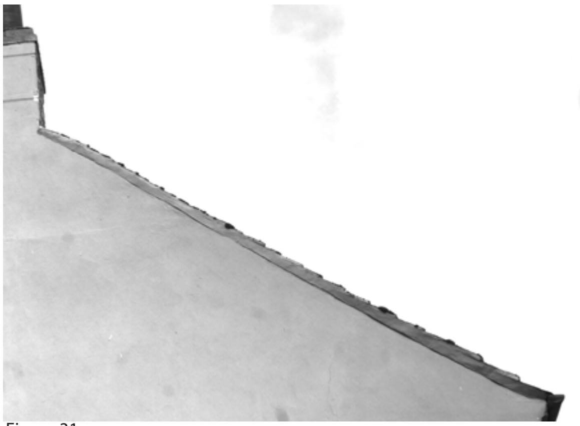


Figure 31
On early roofs verges simply oversailed the wall by a few inches with a mortar fillet under the slate. Terry Hughes

Figure 34
Curved Swithland slating is rare even though the log narrow slates are well suited to conical roofs. Terry Hughes

Figure 32
On later roofs verges were extended with decorative brickwork or terracotta. Terry Hughes

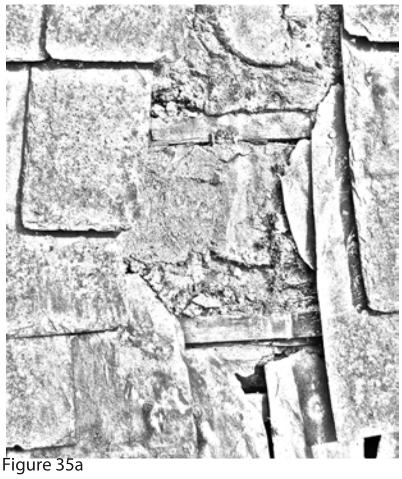


Figure 35a
Mortar is used for all the normal techniques of bedding and torching. One unusual example is known, at Thorpe Satchville Church, where the slating was solid bedded in hot lime onto the ceiling laths. This was renewed as found in 2015. Terry Hughes

Figure 33
On later roofs verges were extended with decorative brickwork or terracotta. Terry Hughes

Figure 35b
(See Figure 35b).

an even larger overhang the wall head was sometimes corbelled with decorative brickwork or terracotta (Figure 30).

Gutters on rise and fall brackets have often been added to earlier buildings and later buildings have fascia boards. Where there is a gutter, the under-eaves and eaves slates are positioned to give an overhang of typically 50 or 75 mm (two or three inches).

7.9 Verges

Like the eaves early verges simply oversailed the wall by a few inches with a mortar fillet under the slate. The slating is finished with wide and narrow slates from the stock. These are still to be seen on farms and outbuildings (Figure 31).

Later roofs include barge boards or raised parapets against which the slates are butted and mortared, especially on churches (Figure 11). Alternatively, the slating was carried well over the wall head with decorative brickwork or terracotta (Figures 32 & 33).

On some roofs the slating is tilted to turn water onto the roof rather than to run down the gable.

7.10 Abutments

Historically the joint between the slating and the wall was formed with a mortar fillet (flaunch) without lead soakers. Pieces of slate, known in some regions as listings, were bedded into the flaunches to protect them (Figure 13). The abutment slating was also raised to turn water away from the vulnerable junction (Figure 14).

Later lead soakers or secret gutters were introduced with mortar flaunches or cover flashings. Secret gutters are prone to blockage by leaves and other debris and need regular cleaning. They are best avoided if at all possible. Regrettably, they are often the only solution when insulation and/or ventilation is introduced which raises the roof surface too closely under a coping or moulding.

7.11 Valleys

Earlier (pre-eighteenth century) buildings would have avoided including valleys because of the difficulty of making them water-tight with narrow slates and without expensive lead. The few slate valleys known appear to be a swept type although they may include lead soakers (Figure 19).

7.12 Ridges and hips

Ridges would most commonly have been covered with angled or hogsback tiles but stone ridges have also been used. On later buildings roll top and decorative tiles were introduced.

Narrow slates do not lend themselves to raking cuts so hips are barely known on earlier roofs. Where they have been adopted wider slates are selected from the bulk and it is likely that the earliest – 17th century – would have been bedded onto mortar or clay rather than having lead soakers. This would have had a good chance of being successful because water flows away from the joint.

On later roofs hips are either covered with clay ridge tiles or lead or more rarely mitred and soakered (Figures 17 & 18). On mitred hips the slates need to be selected, cut and fixed carefully to avoid wind damage. On covered hips the heavy hip tiles ensure the slates are secure.

7.13 Curved slating

There are successful examples of conical roofs but they are not common (Figure 34).

7.14 Dormer windows and rooflights

Dormer windows are not common and the valleys are usually lead lined or mitred and soakered indicating that even on older roofs they are later introductions. Rooflights are not common. Where they exist and need attention they should be repaired or renewed to match the existing. If cast iron framed lights need to be replaced conservation types are the most suitable option.

7.15 Wall cladding

Cladding seems to be non-existent.

7.16 Mortar

Lime mortar is used for head bedding the slates and with hair for torching and as external pointing at verges and abutments. One example is known, Thorpe Satchville Church, where the head nailed slating was solid bedded in hot lime onto the ceiling laths (Figure 35a & b). This was renewed as found in 2015.

8 Limestone slating

8.1 Limestones appearance

The appearance of roofs made with different limestones varies in texture and colour; as a result of how the slates are made and laid' and the detailing at hips and valleys etc.

Thickness varies between stones, such as Collywestons, which are thinly split by frosting and the thicker hand split examples more common in the south of the region from Oxfordshire to Dorset.

Surfaces range from smooth, Collyweston for example (Figure 36), to quite heavily textured for Cotswold Forest Marble and Magnesian limestones (Figure 37). The form of the edges is a product of the traditional methods used to shape and size the slates and should always be conserved. Sawn edges are not acceptable.

The weathered colour of the stones can range from grey to yellow but this will often be masked by growths of white to grey lichens which are distinctive (and unlike those on acidic sandstones). There is one exception to this. Where cement mortar is used for tail bedding it promotes the growth of a black moss.

Although there is a large diversity of stone-slates in the UK, the majority fall into one of three types:

- small sizes producing roofs with many courses of each size;
- intermediate sizes with fewer courses but several of each size; and
- large sizes with few courses and often only one or two of each size.

All the limestone slates are small with many courses on a roof, as many as sixty.

Figure 36
The texture of limestone slates varies between quite smooth, Collyweston for example, and rough for some Cotswold types and magnesian limestone. Terry Hughes

Figure 37
(See Figure 36).

The type of roofing stone influences the style and appearance of a roofscape in two ways. Directly in the texture of the roof surface in terms of the width and height of the margins and in the number of courses, and indirectly in the way intersections such as hips and valleys can be constructed. The difficulty of constructing the latter with some slates also constrained planforms for historic buildings.

Being generally small limestones are amenable to laying to curves such as in laced or swept valleys and to domes and conical roofs where small and tapered slates are necessary to ensure a close fit.

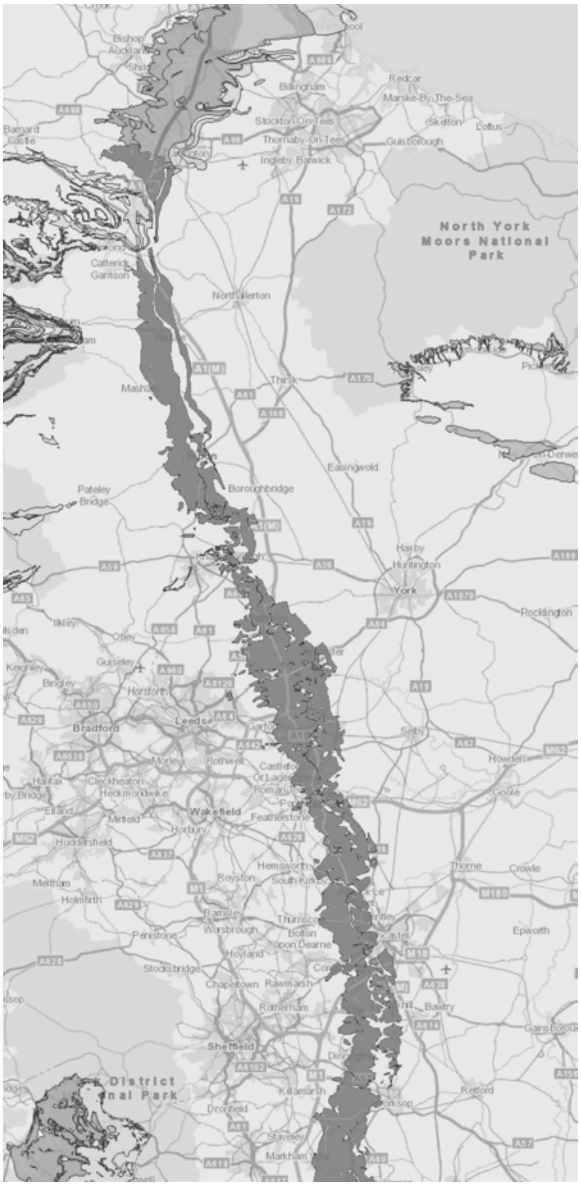


Figure 38
The Magnesian Limestone extends for 200 kilometres from Nottingham to Sunderland only a few roofs known today in an area from Mansfield to Doncaster - at Steetley, Barlborough and Whitwell.

9 Magnesian limestone slating

9.1 Magnesian limestone history

The Magnesian Limestone extends for 200 kilometres from Nottingham to Sunderland (Figure 38). There are historical records that indicate it may have been a significant stone slate in the past but there are only a few roofs known today in an area from Mansfield to Doncaster - at Steetley, Barlborough and Whitwell. Excavations at Dale Abbey (1162) in Erewash, Derbyshire discovered Magnesian limestone roofing along with Swithland slates.

9.2 Magnesian limestone production

Quarrying for roofing is recorded at Steetley (Figure 39), Bakestone Moor; in at least one of the many small quarries around Gypsy (Gypsyhill) Lane in Whitwell (Figure 40) and possibly at a quarry near Gildingwells, Worksop. It was found in near surface workings in thicknesses suitable for roofing. Although there are many quarries working the stone for aggregates and several could potentially have fissile stone in their surface levels there are no active sources of stone slates at present (2018). Currently the most appropriate stone for repairs would be from one of the Cotswold or Wiltshire limestone quarries.

9.3 Magnesian limestone slates and roofs

There are so few roofs known that it is risky to draw general conclusions about the slates or the roofs. From what is known they are best described as similar to the coarser types of Cotswold stone slates such as Forest Marble and seem to have been laid in the same way and with similar detailing.

Figure 39

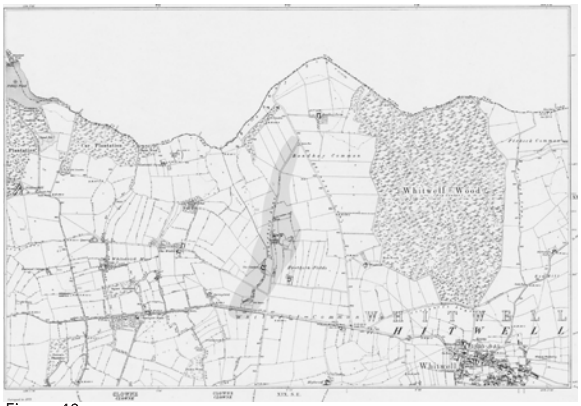
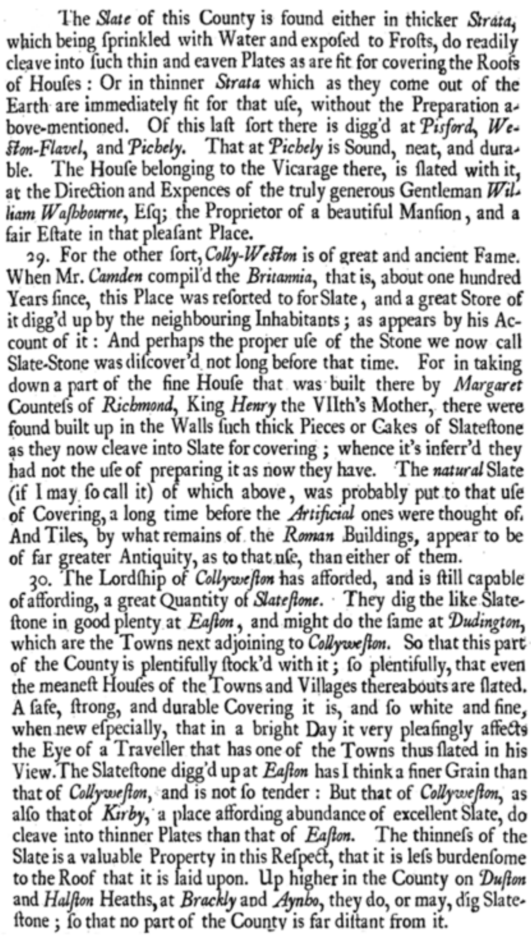


Figure 40

Figures 39 & 40
Magesian limestone was quarried for roofing at Steetley on Bakestone Moor and in at least one of the many small quarries around Gypsy (Gypsyhill) Lane in Whitwell.
National Library of Scotland https://maps.nls.uk/index.html



The *Slate* of this County is found either in thicker *Strata*, which being ſprinkled with Water and expoſed to Froſts, do readily cleave into ſuch thin and eaven Plates as are fit for covering the Roofs of Houſes: Or in thinner *Strata* which as they come out of the Earth are immediately fit for that uſe, without the Preparation above-mentioned. Of this laſt ſort there is digg'd at *Piſford*, *Weſton-Flavel*, and *Pichely*. That at *Pichely* is Sound, neat, and durable. The Houſe belonging to the Vicarage there, is ſlated with it, at the Direction and Expences of the truly generous Gentleman *William Waſhbourne*, Eſq; the Proprietor of a beautiful Manſion, and a fair Eſtate in that pleaſant Place.

29. For the other ſort, *Colly-Weſton* is of great and ancient Fame. When Mr. *Camden* compil'd the *Britannia*, that is, about one hundred Years ſince, this Place was reſorted to for Slate, and a great Store of it digg'd up by the neighbouring Inhabitants; as appears by his Account of it: And perhaps the proper uſe of the Stone we now call Slate-Stone was diſcover'd not long before that time. For in taking down a part of the fine Houſe that was built there by *Margaret* Counteſs of *Richmond*, King *Henry* the VIIth's Mother, there were found built up in the Walls ſuch thick Pieces or Cakes of Slateſtone as they now cleave into Slate for covering; whence it's inferr'd they had not the uſe of preparing it as now they have. The *natural* Slate (if I may ſo call it) of which above, was probably put to that uſe of Covering, a long time before the *Artificial* ones were thought of. And Tiles, by what remains of the *Roman* Buildings, appear to be of far greater Antiquity, as to that uſe, than either of them.

30. The Lordſhip of *Collyweſton* has afforded, and is ſtill capable of affording, a great Quantity of *Slateſtone*. They dig the like Slateſtone in good plenty at *Eaſton*, and might do the ſame at *Dudington*, which are the Towns next adjoining to *Collyweſton*. So that this part of the County is plentifully ſtock'd with it; ſo plentifully, that even the meaneſt Houſes of the Towns and Villages thereabouts are ſlated. A ſafe, ſtrong, and durable Covering it is, and ſo white and fine, when new eſpecially, that in a bright Day it very pleaſingly affects the Eye of a Traveller that has one of the Towns thus ſlated in his View. The Slateſtone digg'd up at *Eaſton* has I think a finer Grain than that of *Collyweſton*, and is not ſo tender: But that of *Collyweſton*, as alſo that of *Kirby*, a place affording abundance of excellent Slate, do cleave into thinner Plates than that of *Eaſton*. The thinneſs of the Slate is a valuable Property in this Reſpect, that it is leſs burdenſome to the Roof that it is laid upon. Up higher in the County on *Duſton* and *Halſton* Heaths, at *Brackly* and *Aynho*, they do, or may, dig Slateſtone; ſo that no part of the County is far diſtant from it.

Figure 42
The Natural History of Northamptonshire John Morton 1712

Figure 41
Once the easily accessed Collyweston slate outcrop was exhausted the rock had to be extracted from open quarries and ultimately, as the depth of overburden increased, from mines as here at Collyweston village.
National Library of Scotland https://maps.nls.uk/index.html

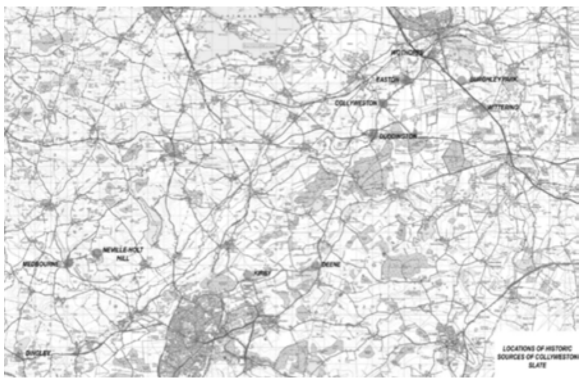


Figure 43
Once the easily accessed Collyweston slate outcrop was exhausted the rock had to be extracted from open quarries and ultimately, as the depth of overburden increased, from mines as here at Collyweston village.
National Library of Scotland https://maps.nls.uk/index.html

Figure 44
Historically Collyweston log mined by extracting the sand from below and propping the roof using a pick and the roof on temporary pillars until an area about 12 or 15 feet deep had been cleared. The pillars were then removed and the log allowed to fall. Terry Hughes

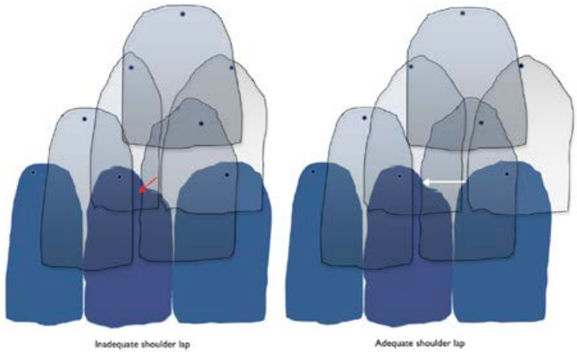


Figure 47
In common with most random slates the top are no squared off but are left with shoulders. It is essential that when they are laid the the perpendicular joints of overlying slates are positioned to prevent leaks over the shoulders of the slates below. Terry Hughes

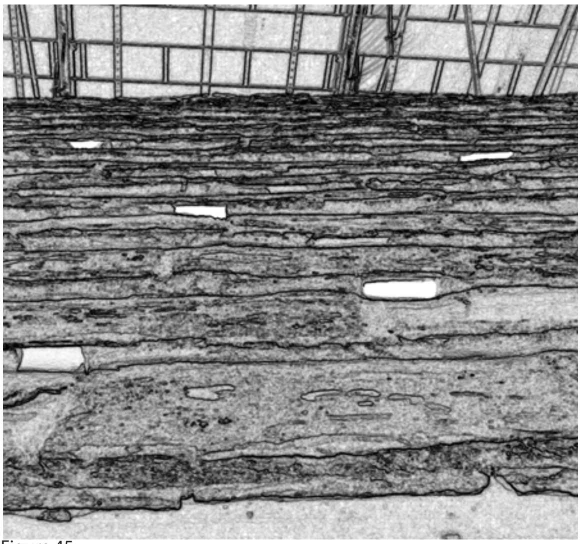


Figure 45
Fully bedded Collyweston slating is effectively sealed and cannot readily ventilate moisture from inside the roof. If ventilation is necessary small gaps can be left in the bedding. This also works as access for small bats.
Terry Hughes

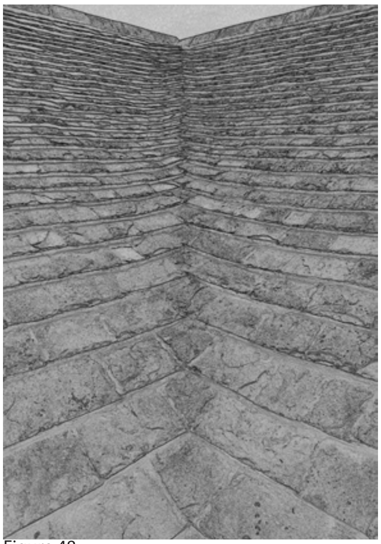


Figure 48
Collyweston valleys are always laced by laying a roughly square slates diagonally up the valley and turning the adjacent slates on each to butt up against them.
Terry Hughes

Figure 46
Shales or shadows are bedded in a small amount of mortar as the slates are laid to support their span from tail to head.
Terry Hughes

Figure 49
(See Figure 48).

10 Collyweston slating

10.1 Collyweston history

There is documentary evidence of the production of Collyweston slates for Cambridge Castle in 1286 and by the fourteenth century production was well established with records of 14,000 slates being supplied to Rockingham Castle in 1375 and 5,000 to Oakham Castle in 1383.[11] The earliest production would have been along the outcrop at the side of the Welland valley to the west of Collyweston and Easton on the Hill (Figure 41). However, once the easily accessed outcrop was exhausted the rock had to be extracted from open quarries and ultimately, as the depth of overburden increased, from mines (Figure 42). Mining continued until about the mid twentieth century.

During the twentieth century production declined partly because of a series of mild winters when frosting was unsuccessful and by the century end had effectively ceased. As production reduced the removal of slates from old buildings for resale and their replacement with unrealistic concrete facsimiles increased to the detriment of the region's unique roofscape. The threat to the more than 2000 Collyweston roofed listed buildings had become so serious that the Building Conservation and Research Team at Historic England instigated research into an artificial frosting process to obtain slates for the reslating of the Grade 1 Apethorpe Palace. This was the stimulus which resulted in the re-establishment of commercial production. There are now two companies producing slates (see Section 14).

10.2 Collyweston sources

Frost fissile Collyweston slate rock, known as log, was formed by the precipitation of calcium carbonate into sand and occurs as a distinct bed at the base of the Lincolnshire Limestone.

Although these roofing slates take their name from a single village and its many mines, the productive beds occur intermittently south-westward from Wothorpe, Burghley Park and Wittering through Collyweston and Duddington to Deene Park and Kirby Hall near Corby (Figure 43).[12]

Other sources have been suggested including from the Northampton quarries such as Duston, but this is because they were promoted using the Collyweston name even though they are from a different geology.

10.3 Collyweston production

The process of mining and converting Collyweston slate rock, known as log, into roofing slates has four stages: extraction of the log; freezing and cliving (splitting) to slate thickness; dressing the thin pieces to a roughly rectangular shape and sorting them by size known as parting.

Historically the log was extracted by hand. The sand was excavated from below the stone using a pick and the roof was propped on temporary pillars until an area about 12 or 15 feet deep had been cleared (Figure 44). The pillars were then removed and the log allowed to fall. It was stored, usually underground, until there was a period of frost. But the process was arduous, potentially dangerous and slow – taking up to two weeks to release 20 tons of log. It was so inherently dangerous that it would not be permitted today.

Collyweston log is converted to roofing slate thicknesses by exposing it to cycles of freezing and thawing all the time keeping it wet. It was therefore dependent on the arrival of a period of cold weather and had to be wetted by hand regularly night and day for several days. This provided the slater with enough slate for the next summer's roofing work.

During the twentieth century the reliability of suitably prolonged cold spells declined and production of slates almost ceased with a concomitant increase in the removal of slates from old buildings to be able to repair others.

If this situation had been allowed to continue all the Collyweston roofs would have eventually disappeared. To tackle the problem an artificial process was developed that exposes the log to a series of two to four periods of freezing and thawing in a commercial freezer. This exactly mimics the natural frosting process and is carried out continuously.

Besides the problem of the uncertainty of suitably cold winters even when everything was favourable the supply of log was intermittent and unsuitable for today's roofing industry. What was needed was a reliable, continuous supply.

To overcome these handicaps a method of extracting the log with a remotely controlled – and therefore safe – jack hammer has been developed and is in operation by Claude N Smith Ltd. This system undermines the log in the same way as traditionally but allows it to be dropped and removed for further processing several times a day. So frosting can be a continuous process.

Once the fissile beds in the log can be seen or tested to be ready for splitting the freezing cycles are stopped and the log is split (clived) with a traditional cliving hammer into individual pieces at least 9mm thick but with thinner areas such as near the edges. The split pieces are then reduced to a roughly rectangular shape either by hand dressing or use of a diamond saw. If sawing is used the edges are subsequently dressed by hand in the traditional way with a batting hammer. This is essential because it affects the appearance of the roof. Sawn edges are not acceptable for use on historic buildings. Only the bottom edge (the tail) and the two long sides are dressed, the top is left roughly tapered. It is important that the long sides are straight over at least 60% of the length to avoid difficulty with shoulder laps.

Once the slates are made a fixing hole for a peg or a nail is made about one inch from the top edge either with a metal pick known as a bill and helve or today with an electric drill which produces a satisfactory hole but is much quicker.

The final stage of production is parting, sorting the slates by length (to the peg hole). Traditionally into a set of lengths known as a heap or 'thousand' comprising about 840 slates plus thirteen large ones. It should cover about two squares of roof. A roofing square is 100 sq ft or 9.29 sq m.[13] The modern processing is essentially the same as the historic process producing traditional and durable Collyweston roofing slates.

10.4 Collyweston slates

Frost fissile Collyweston slate rock, known as log, was formed by the precipitation of calcium carbonate into sand and occurs as a distinct bed at the base of the Lincolnshire Limestone. The colour is buff to pale yellow and they are often blue-hearted. The fissile layers are thin so frosting produces thin slates normally more than 1/4 - 1/3 inch (6 - 9 mm) thick. Generally they range in size from 24 to 6 inches long (600 - 150 mm) but other sizes can be made if required. It is important that some are approximately square for use as laced valley slates. Bigger sizes are also useful for providing a good eaves overhang where there is no gutter.

10.5 Collyweston roofs

Taken together, the thinness of the slates, the mortar bedding and their laced valleys make Collyweston roofs distinctively different from those of all other limestone regions. Frost split slates were produced elsewhere in the Cotswold region and limestones are bedded in Purbeck and slates in Cornwall but even when Collywestons roofs are encountered well outside their natural early transport based region they are unmistakable.

The roofs are nearly always steep. Generally, more than 45° pitch and as much as 65°. This ensures water is quickly shed. Shallow pitches as sometimes seen on church aisles can be satisfactory as long as the mortar bedding is intact. The greatest risk to them is that they are easily walked on and the slates broken.

It is not clear why these roofs are always mortar bedded. The size and shape of the slates and the steepness of the roofs are little different to other limestones which are never bedded and which perform perfectly well. The bedding will make the slates' heads lay tight onto the laths rendering them less susceptible to wind damage and this may be the explanation. It also provides draft-proofing.

Slate roofs of any type which are fully bedded are effectively sealed so it is risky to install an underlay which could trap moisture in the batten space. This is especially so with a vapour permeable underlay which encourages moisture transfer from the roof space. Where bitumen underlay has been installed it is usually found to be rotted when the roof is stripped for reslating.

10.6 Preparation and gauging

Traditionally slates were supplied as a heap but now, because of the more reliable and continuous production, it is possible to supply a mix of lengths to match an existing roof. The slater sorts the slates and gauges the roof as described on page 5.

10.7 Fixing the slates

Historically slates were hung on riven or later sawn square laths with wooden pegs. Today they are also hung with metal pegs or nailed to battens. They are tail bedded in mortar (but see eaves below) which should reach no further up the slate than just to the tail of the overlying slate. It must not reach the laths or battens. The mortar is held or raked back at the slates' tails to provide a water drip and a shadow line which emphasises the diminishing coursing. The mortar effectively seals the roof preventing ventilation so it is better not to lay the slates over an underlay unless ventilation through the batten space can be provided (see section 4.8). Another option which has been adopted is to leave small gaps in the mortar bed at the slates' tails. This has also been done for bat access (Figure 45).

As the larger slates on the lower courses are laid, shales or shadows are bedded in the mortar underneath them to support their span (Figure 46). This is important because these roofs are often repointed working from ladders which could break unsupported slates.

Although the slates are sorted into length sets and the lath gauging is decided in advance, knowledge, experience and care are needed to make sure there will be no leaks. The principle is that slates should be chosen and placed so that the perpendicular joints are as close as possible on the centre of the slates below. However, Collyweston slates are shouldered so it is also essential to make sure the shoulder lap is adequate (Figure 47). To help with this, shales which cover a large shoulder can also be used.

10.8 Eaves

Slating is set out to give a good throw away from the wall or into the gutter if there is one. Unlike most slating the under eaves slates are laid with the bevelled edge upwards. Sometimes the bottom course is only spot bedded to encourage ventilation. Occasionally the bottom courses were laid with a large margin and a very small head lap or none at all apparently for decorative reasons. To prevent leaks on this technically bad detail large pieces of metamorphic slate were bedded across the top of every slate.

Where bitumen underlay was installed in the past it was sometimes laid over the under eaves slates to prevent it draping. This is always unsuccessful because the underlay is rotted by UV light and water at the slate joints.

10.9 Verges

Older, vernacular roofs have simple verges with the slating oversailing by 25 to 50 mm with a mortar fillet below. The slating is sometimes raised to turn water back onto the roof.

On more important buildings such as churches the slating often finishes against a raised parapet. The junction may be simply mortared especially where the slating is tight under the copes or soakered and mortar flaunched. Where there was room, a cover flashing might be installed and turned under the copes. A simple cover flashing onto the slates without soakers is not reliable as water can drive under them and they look ugly. It is preferable when reslating to install lead soakers, one per course. To ensure the soakers are properly supported slates with a small shoulder should be selected.

Figure 50
There are succesful examples of curved Collyweston slating but they are uncommon.
Terry Hughes

Figure 53
Dormer windows are common in Collyweston roofs and the full range of types - monopitch, gabled and hipped are common positioned below, breaking and above the eaves and in the roof slope. Terry Hughes

Figure 51
(See Figure 53).

Figure 54
Wall cladding is uncommon with Collyweston slates - mainly seen on dormer cheeks. Where it is applied it is good practice to match the coursing it with the adjacent slope.
Terry Hughes

Figure 52
Limestones were formerly mined and quarried for roofing around Northampton. Notably at Duston and New duston and in various geological formations from Oundle to Chacombe near Banbury.
Terry Hughes

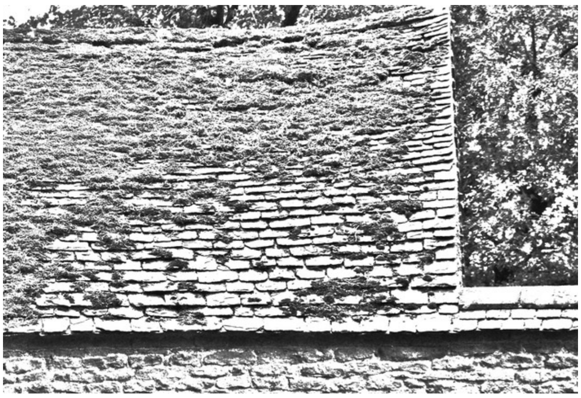


Figure 55
The roofscape of the Northampton area is confused because it includes original local stone slates, Collywestons and various Cotswold types. Many are not easily distinguished from each other without petrological analysis. Terry Hughes

On later or designed roofs the verges are carried over barge boards.

10.10 Abutments

The slating at abutments is often tilted by raising the batten ends to turn water away from the vulnerable junction. They are weathered with a simple mortar fillet (flaunch) or more effectively with soakers and a flaunch or cover flashing turned into the masonry. Lead cover flashings can be very large to reach a stone masonry bedding joint and look clumsy. For this reason mortar flaunches are preferred.

10.11 Valleys

The traditional Collyweston valleys are laced and are completely satisfactory if correctly laid (Figure 48). Lead valleys are alien and there is no reason why they should replace laced.

The roughly square valley slates are laid diagonally up the valley board and the main slates laid on each side turned to butt against them (Figure 49). The valley slates are wide so they sit up away from the valley board. They are supported with shales underneath.

Where two slopes with different slate lengths and therefore margins meet at a valley, it is good practice to adjust two courses of the shorter slates to match one longer slate.

If the roof has lead valleys or slating onto aprons the slating should not be bedded onto the lead. It will inevitably fall out.

10.12 Ridges and hips

Ridges are most commonly closed with hog's back clay tiles. More rarely with angular clay or stone ridges.

Hips are mitred and formed with wider slate selected from the stock. Historically they would have been simply mortar bedded but as lead became more affordable soakers were introduced.

10.13 Curved slating

There are successful examples of conical and domed roofs and long horizontal curves but they are not common (Figure 50).

10.14 Dormers and rooflights

Dormer windows are common and the full range of types - monopitch, gabled and hipped are common positioned below, breaking and above the eaves and in the roof slope (Figures 51 & 52).

On monopitches the roof is sometimes formed with one or a few large slates spanning the full width). The ridge is traditionally swept up into the slating above but today is often weathered with a lead saddle.

Rooflights are not common. Where they exist and need attention they should be repaired or renewed to match the existing. If cast iron framed lights need to be replaced conservation types are the most suitable option.

10.15 Wall cladding

Cladding is not common but is used on dormer cheeks sometimes as a single large piece of slate. Where it is coursed and lies against a roof slope it is good practice to match the gauging and margins to the roof slates (Figure 53).

The cladding slates are often found to have deteriorated much faster than the roofing.

10.16 Mortar

The use of non-hydraulic mixes is sometimes specified for bedding Collyweston slate but such mixes will generally lack the durability for the conditions to which the roof is exposed. For appropriate lime-based mixes (see section 4.9).

11 Northampton slating

11.1 Northampton history

It is probably that other Jurassic stones were being exploited for roofing as early as Collywestons. Archaeological sites in Northampton have produced stone slates from 1250 from the Upper Estuarine Limestone Rutland Formation probably worked at Duston and New Duston to the west of Northampton (Figure 54).

Nineteenth century geological studies have identified quarries or mines in the Blisworth Limestone at Oundle and Yardley Chase[14] the Rutland Formation at Pytchley and Helmdon; Northampton Sand Formation at Duston; and the Middle Lias at Sulgrave[15] and Chacombe near Banbury.[16] (Figure 55). There is more information on historic sources in Hughes 2003.[17]

It is not clear whether the stones were frost splittable, partly because some were often described and sold as Collyweston slates when they were not. Blisworth Limestone was called pendle by the miners but documentary records suggest it was not frost split but was suitable for roofs as dug (Morton)[18]. So the term should not be confused with its use in the Cotswold quarries where it is applied to frost fissile stones and slates suitable as dug which are called 'presents'.

All the operations closed many years ago. Consequently, there is a long history of re-slating with other stones or different roof products from about 100 years after they were last active. Stone slates from the Cotswolds, Wiltshire and Collyweston have been used for these repairs and their own regional details have been imported along with the slates. So now there is a confusing roofscape with for example Collyweston laced valleys present roughly to the north of Northampton and Cotswold swept to the south. Possibly none of these are historically authentic.

In some villages there are surprising numbers of old houses with asbestos roofs including corrugated sheets or diamond pattern slates. These probably replaced stone during the early decades of the twentieth century. The latter may well justify conservation in their own right.[19]

11.2 Northampton limestone production.

There is no production of the stone slates around and to the south-west of Northampton. Where roofs have been repaired or renewed with other stone slates (or asbestos) it would be appropriate to use the same products for future repairs.[20]

11.3 Northampton roofs

The present roofscape includes what may be authentic and original slates and details (Figure 56) mixed in with Collyweston and Cotswold types. Therefore, it is not possible to give clear guidance on their conservation save to look at a roof closely when it needs repair and to act appropriately choosing the same or a similar stone and replicating the details.

12 Maintenance

12.1 Deterioration

Slate roof deterioration is usually a long-term process. Routine maintenance and repairs can be carried out for many years and 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.

12.2 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 or bedding so these 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 hook, copper tingle or peg. For repairs to large areas a triangle of slates should be stripped so that all except the apex can be refixed with pegs or nails and only the top one(s) will need a tingle or similar fixing.

12.3 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.

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, NHL 5 for example, or the NHL 3.5 bedding mix can be pointed up.

12.4 Biannual checklist

- Internally check for water-staining or other signs of leaks. 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.
- Are mortar beds, fillets or flaunchings cracking or insecure?
- Are roof penetrations such as rooflights or solar panels leaking?
- Ensure insulation is not blocking ventilation routes for example at the eaves or ridge.

13 Notes and references

1 The Level 3 NVQ Diploma Roof Slating and Tiling includes random slating. 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 which covers the historical, theoretical and technical knowledge and practical skills in historic building conservation, repair and restoration which leads to the CSCS card endorsement Heritage Skills. These are the appropriate qualification for slaters who work on historic roofs. There are similar systems for construction site management of conservation work and for conservation consultancy.

2 National Federation of Roofing Contractors Health and Safety Guidance
Sheet A: Fall Protection and Prevention for Working on Roofs,
Sheet E: Slater's Heel
Sheet M: Working at Height.

3 SPAB Technical Pamphlet 12 T*he Repair of Timber Framed Roofs*.

4 Petrological examination of recently imported foreign stones sold as substitutes for Collyweston and Swithland slates proved to be completely unsuitable and not even the correct geology.

Collyweston slates
'The stone, suggested as a potential replacement for Collyweston Slate, is a completely different material. Whereas the Jurassic Collyweston stone is a siliceous limestone, the fissility in which can normally only be developed after a period of freezing and thawing, the potential replacement material is a purely siliceous and extremely fine-grained sedimentary stone, the fissility of which is due to thin laminae of fine-grained sandstone. There is a possibility that, after a period of time in service, the potential replacement stone would start to delaminate due to its petrographic structure. As a result of the completely different petrography of the two stones, their surface texture is completely different. Although light coloured, both stones being a pale buff, the chemical differences would result in completely different organic colonisation on the two materials.'

Swithland slate
'The stone, suggested as a potential replacement for Swithland Slate, is a completely different material to the stone from Charnwood Forest. Whereas the Precambrian Swithland stone is a regionally metamorphosed siltstone with tectonically developed slaty cleavage, the potential replacement material is an unaltered sedimentary stone which has been cleaved along the bedding planes. The surface texture of the two stones is different due to the different nature of these cleavages. The colour of the stones differs due to their different mineralogy. The presence of pyrite in the potential replacement stone could lead to iron staining of the surface as well as a reaction with the calcite in the material to form gypsum. The presence of calcite may also result in the colonisation of the surface by a different organic assemblage to that on the Swithland Slate. This, in turn, would lead to a different colour and texture on the weathered surface after a period of exposure.' The staining and deterioration of the stone can now be seen on roofs in Swithland village.

5 National Federation of Roofing Contractors Technical Bulletin 3 Selecting Hooks for Slating

6 Building Regulations Part L Conservation of Fuel and Power.
L1A New Buildings
L1B Existing Buildings
L2A New buildings other than dwellings
L2B Existing buildings other than dwellings
https://www.gov.uk/government/publications/conservation-of-fuel-and-power-approved-document-l

7 Historic England series Energy Efficiency in Historic Buildings:
Insulating pitched roofs at rafter level - warm roofs.
Insulating pitched roofs at ceiling level - cold roofs.
Insulating dormer windows.

8 Further advice on selecting mortars is included in Allen, G C, Allen, J, Elton, N J et al (2003) *Hydraulic Lime for Stone, Brick and Block Masonry.* Shaftesbury: Donhead Publishing Ltd. See particularly Tables 9 and 10 regarding mortar selection for durability giving durability classes.
Holmes, S and Wingate, M (2002) *Building with Lime: A Practical Introduction*, revised edition, London: Intermediate Technology Publications (now Practical Action). Chapter 5 is particularly relevant.
British Standards Institution (2015) Building Lime – Part 1: Definitions, Specifications and Conformity Criteria, BS EN 459-1, London: BSI

9 McWhirr, 1988, *The Roman Swithland Slate Industry*, Leicestershire Archaeological and Historical Society Transactions LXII, Leicester.

10 Figures 27a&b, 39, 40 and 42 are reproduced with the permission of the National Library of Scotland https://maps.nls.uk/index.html

11 Potter, T. R., 1842, The history and antiquities of Charnwood Forest, pp 12 - 13. The slates when quarried, split and trimmed are divided into large slates and small slates. All those whose surface exceeds one hundred square inches are called large, those below are called small. The large slates sell for 2s 6d a score the small for 2s 6d per hundred reckoning the long hundred or six score.

12 Ramsey, D A, 2002, *Slate Quarrying at Groby and Swithland*, Leicestershire Industrial History Society Bulletin 17, Leicester.

13 Woodward, H R, 1894, *The Jurassic Rocks of Britain,* vol IV The Lower Oolitic Rocks, pp 482-486, Memoir of the Geological Survey, HMSO, London.

14 A Collyweston heap is a quantity of dressed slates of all sizes on the ground made up of seven hundreds (120 slates). A hundred is forty cases of three slates. It should cover about two squares of roof.

15 Thompson quotes Sharp, describing a quarry west of Oundle where 'Pendle'- the quarrymen's term for any fissile limestone - occurs at the top of the section, and 'splits into thin flags or slates'. Thompson, B, 1927. Lime resources of Northamptonshire. Northamptonshire County Council, 88pp, quoted in Sutherland D S, 2003, Northamptonshire Stone, Dovecote Press, Wimborne.

16 Thompson noted that the Manor at Sulgrave was roofed with stone slates, 'probably supplied from Helmdon' Thompson, B, (1906). Quarries and mines in Victoria County History, Volume II, 298-303.
A slate from the manor roof was identified by the British Geological Survey as a yellow-brown, fine to medium grained, ferruginous, hard, carbonate-cemented sandstone. It showed fine parallel laminations, variably cemented, as is evident from the distinct hard 'ribs' that are developed on the weathered edge of the 'slate'. Very likely to be a Duston Slate.

17 The Historic England Northamptonshire Stone atlas describes Duston Pendle: 'Within central Northamptonshire, and particularly in an area stretching from the north and west of Northampton

across to the western margins of Wellingborough, limestones (termed 'Pendle') are present within the Northampton Sand Formation and have been used in buildings across much of this area. The limestones typically occur between the lower and upper sandstones of the Duston Member.

Around Duston, the limestones may be divided into two informal units. The upper is the Duston Pendle and consists of cross-bedded calcareous sandstones to sandy limestones with ooids and shell debris and may become an ooidal limestone. It was worked mainly in the 19C and used in pale, brick-sized blocks in local terraced cottages and some Victorian churches (e.g. St. Matthew's, Northampton).

The lower unit, or lower bed of the Pendle, has similarities with the Collyweston Slate and consist of cross-bedded units which split along the laminae formed by the fore-sets to form 'slates' that are generally thicker and therefore heavier than those from Collyweston. As with Collyweston Slates, they required winter frosting in order to split the rock. The laminae consist of layers that are alternatively sand-rich, or rich in shell debris, or ooids. This results in differing porosities in each layer, making some more susceptible to splitting after wetting and freezing. These slates were worked underground, and there are 17C references to workings at "Slate-pitt Piece" and around Harlestone and Duston in the 18C'.

18 Hughes T G, (2003) Stone Roofing in England in English Heritage Research Transactions, vol 9 Stone Roofing, London. www.stoneroof.org.uk/historic/Historic_Roofs/Publications.html

19 Morton, J., 1712, The Natural history of Northamptonshire, London quoted in Sutherland ibid.

20 The conservation of asbestos cement roofs is covered in Practical Building Conservation: Roofing, English Heritage, 2013, pp 587-594

14 Other advice

14.1 Contacts

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. Architects can be chosen from the list of Architects Accredited in Building Conservation (AABC) www.aabc-register.co.uk/ and conservation accredited surveyors from the RICS www.rics.org/ architects, surveyors and slaters with experience in local slating.

National Federation of Roofing Contractors
Roofing House
31 Worship Street
London, EC2A 2DY
020 7638 7663
www.nfrc.co.uk

14.2 Advice on protection of animals and plants

Natural England
County Hall, Spetchley Road
Worcester
WR5 2NP
0300 060 3900
www.gov.uk/government/organisations/natural-england
enquiries@naturalengland.org.uk

The Bat Conservation Trust
5th floor
Quadrant House
250 Kennington Lane
London SE11 5RD
0345 1300 228
http://www.bats.org.uk/
enquiries@bats.org.uk

The Barn Owl Trust
Waterleat
Ashburton
Devon TQ13 7HU
01364 653026
www.barnowltrust.org.uk
info@barnowltrust.org.uk

The Institution of Structural engineers CARE scheme lists structural engineers
www.istructe.org.

Historic England
National office
4th Floor
Cannon Bridge House
25 Dowgate Hill
London EC4R 2YA
020 7973 3700
0370 333 0607
www.historicengland.org.uk
customers@HistoricEngland.org.uk

East Midlands Office
2nd floor
Windsor House
Cliftonville
Northampton
NN1 5BE
01604 735460
www.eastmidlands@HistoricEngland.org.uk

Slate producers

Swithland slates
There are no operating Swithland slate quarries. The Traditional Slate Company can make slates in traditional formats from Welsh slate rock of similar colours.

The Traditional Slate Company
Enterprise House
Newton Road
Tibshelf
Derbyshire DE55 5PH
01773 549273

Collyweston slates
Claude N Smith Ltd
Slate Drift,
Collyweston,
Stamford PE9 3PG
01748 444627

Collyweston slates
Messenger BCR Group
Collyweston Heritage Centre
Main Road, Collyweston
Stamford PE9 3PQ
01780 239 800

15 Glossary

There is an SPAB glossary at https://www.spab.org.uk/advice/glossary

A fuller glossary of slate and stone roofing is available at
http://www.stoneroof.org.uk/historic/Historic_Roofs/Publications_files/Glossary%20v3%205-16.pdf

Backer: narrow slates laid roughly centrally over a wide slate to accommodate the increasing number of slates in each course as work progresses up the roof. Synonym bachelor.

Batten gauge, lath gauge: spacing of battens or laths up the rafter. In double lap slating it is equal to the slate length minus the head lap and divided by two. In random slating it varies in relation to the slate length and is reduced at change courses.

Bed, bedding:

- geological: defined horizon in a quarry or mine from which different products can be made.
    of rocks: a plane parallel to the surface of deposition of a rock. The plane along which stone
    slates often, but not invariably, split. The valuable fissile character of stone slate beds (especially limestones) is merely a local accident the consequence of depositional processes and is often intermittent or impersistent.
- under side of a slate when laid on the roof. Synonym back.
- of slates or stone slates: use of mortar in spots or fillets to prevent stone slates from rocking. In some areas, it is used to improve weather tightness. qv head bedding, tail bedding, full bedding.

Change course: in random slating the first course of a shorter set of slates where the batten or lath gauge is reduced to ensure the margins diminish evenly and an adequate head lap is achieved cf pig.

Centre nailing: slate fixing in double lap slating where the nails are positioned slightly above the head of the slate below cf batten gauge.

Cleavage: slaty cleavage is developed in fine grained rocks following metamorphism. Under the influence of pressure and heat the pre-existing minerals are partially re-crystallised and aligned perpendicular to the pressure. Slates cleave parallel to these platy minerals and almost always at an angle to the bedding. cf bedding.

Cleat: spike bent at right angles and driven into the rafter to hold thin laths without splitting them. Synonym, cask / barrel / cooper's hook, tenter hook.

Clive: setting frost cracked log (qv) on edge and gently tapping with a Collyweston slater's hammer on each side in turn until the splitting is complete. Synonym cleave (qv).

Dressing:

- shaping a stone slate and producing the edge detail using either a special hammer or a bladed tool. Regional differences exist for the edge detail which may be square or bevelled. Synonyms: trimming, fettling (Yorks, Lancs) crapping (Cots), napping.
- shaping and producing the bevelled edges of metamorphic slates by hand using a sax (qv) or similar tool or by rotary guillotine or other machine.

Frosting: exposing the log (qv) to frost to open the laminations.

Flaunch: mortar fillet to close an abutment and to direct water away from the junction.

Gauge, gauging: the spacing of laths or battens up the roof slope. In stone slating, the gauge is always variable.

Gauging or marking stick: wooden rod with traditional marks used to measure slate lengths and to gauge the lathing of the roof. The names of the slate sizes associated with each mark are traditional and regional. Synonym: slate rule, wippett qv www.stoneroof.org.uk/sticks.html

Gauging rod: batten or similar, the length of the rafter on which the lath or batten gauges are marked. A pair of rods are placed at either side of the roof and the gauges snapped onto the rafters with a chalk line.

Head: the top edge of a slate as laid.

Head lap: the length by which the tail of a slate overlaps a slate in a course below. Synonym: band, end lap. In head fixed slating it is the overlap of the peg hole or the top of the lath. In centre fixed slating it is the overlap of the head of the slate.

Lath, latt: split wooden support for hanging stone slates. Synonym: batten. In slate and stone roofing guides, the word batten is usually reserved for sawn supports.

Log: mined Collyweston stone which is suitable for frost splitting to make slates.
Listing: tiles, slates or stone pieces set into mortar flaunchings at abutments with walls to reduce cracking in the mortar.

Margin: strictly the area, but more commonly the length, of the exposed part of the slate.

Pig, pig course: a course with a larger margin than the course(s) below resulting from poor setting out and a failure to maintain adequate head laps. Synonym gaper.

Pitch: the angle of the rafters to the horizontal. For thicker stone slates the pitch will be significantly less than the rafter pitch because they are resting on each other, but this is taken into account by the traditional rafter pitch and lap relationship for the slate and the locality.

Skirt: the tail of a slate. The margin in Collyweston slating.

Stone slate names: each stone roofing region had its own system for naming slate lengths and within a region the names varied. Probably originally intended to keep the slating method secret from outsiders, the mix of sizes reflected what the local stone was able to produce. Where a size name is a number it indicates its relative position up the rafter rather than a length in inches. Most systems also included intermediate sizes such as ‘shorts’ in Collyweston slating and ‘half above’ for each size in the Pennine system.

Tail: the bottom edge of a slate as laid qv skirt.

Torching:
lime and hair mortar applied to the underside of stone slates to render them wind proof and to secure the fixing peg. Synonym: tiering.

half torching: application of mortar between the top edge of the lath or batten and the underside of the slates. Synonym: single torching.

double torching: mortar applied to the top and bottom of the laths
full torching: application of mortar to the underside of the slates between the top and bottom edges of the laths or battens.

The content of this advice note is offered in good faith but neither the author nor the Society can accept responsibility arising from incorrect or incomplete information that may be included. The use of traditional materials may incur risks different to those associated with modern materials. Manufacturers' and suppliers' guidelines should always be observed.

This document should be seen as a contribution to a continuing debate and we welcome comments.

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