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Digitally Surveying the Damage

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Building Conservation Journal

OPINION

Meet the membership



CPD lies at the heart of services and regulation in many professional bodies, as chartered building surveyor and past chair of the Institute of Historic Building Conservation (IHBC) Mike Brown, observed when leading IHBC's CPD programme.

"A professional body is defined by the skills of its membership, and by how that expertise develops," he said. "Members are required to maintain their professional competence throughout their working lives under the institute's code of conduct."

RICS also has excellent, concise guidance on CPD: "Members plan their own learning and development, and we recognise that there are many other relevant methods of learning."

A lot can be learned by exploring ideas of heritage values and conservation with people new to you or your practice. You may

start your conservation CPD by getting out and talking to people – for example, you might ask a new acquaintance about how much they would have missed St Pancras Station had it been demolished half a century ago. Speaking with people who are unfamiliar with heritage is critically important, not least as the public interest is a primary consideration in conservation practice.

Questioning people with specific but not specialist interests in heritage that are different from yours is the next step if you want to add real depth and diversity to your conservation CPD.

An easy way to accomplish this is to check out your local civic, community or history group and see what it is doing, for example in relation to current planning issues. You could also offer your skills to a group with heritage interests that differ from yours, to help you understand why their values are important to them.

CPD concerns practice as well as understanding, so for the next step, engage with people who have heritage-related knowledge or skills that are new to you. Conservation invariably entails more than one area of professional practice,

as recognised in the 1993 ICOMOS Guidelines on conservation training (<http://bit.ly/2mZiWOX>), the British Standard on conservation BS 7913, and the IHBC's membership standards and CPD support (www.ihbc.org.uk).

To satisfy those guidelines and standards, be sure to explore ideas on conservation from people with unfamiliar specialist backgrounds. These may include people from other trades and disciplines, those at different stages in their careers and, ideally, some with an alternative understanding of what the purpose of conservation is. Always start by trying to see their point of view rather than forcing your own on them.

Conservation perspectives from informed specialists with different approaches will help you refine, sharpen and strengthen your professional skills. That diversity of experience is especially useful in conservation CPD because it develops personal awareness and helps manage the most damaging of CPD tendencies, namely, peer reinforcement. Instead – or as well – challenge yourself to take up some proper conservation CPD. ●



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John Edwards explains how to manage risks in building conservation projects

Registering risks

A robust risk management strategy starts when one looks at a building for the first time, and does not end at the completion of a project, but continues into the use and occupation of a building.

A robust approach also involves employing a competent team, deploying the necessary activities and risk management tools, and then understanding that when one moves away from this ideal situation that risks are increased. However, one has to be proportionate, and through a cost–benefit analysis, the balance of what are deemed to be reasonable actions and activities can be ascertained.

There are many types of risk: although controlling costs and completion dates often steal the headlines, specifying the most appropriate work and making sure it is properly undertaken while optimum quality standards are achieved should also be considered part of evaluating risk.

The most critical initial stage starts with the appointment of the consultant or in-house team to follow the standard BS 7913: 2013: Guide to the Conservation of Historic Buildings, which sets out the overall process for undertaking work to historic and traditional older buildings. Describing competence and citing accreditations, also known as certifications, to identify suitable personnel is one way of minimising risk.

Understanding the building

There are greater risks in dealing with existing buildings than there are in constructing new ones. There can be uncertainty as to the exact design and condition, and we must also understand a building's historic significance.

It is not uncommon to find that a building's condition is worse than one thought, and to expose features that were previously unknown requires an awareness that more will be found

out about a structure as the project progresses. However, we should aim to keep the risk of these unknowns to an absolute minimum.

Such risks can be minimised if their possibility is understood at the outset, and a well thought-out strategy is developed at that stage. This needs to be properly resourced and implemented. The strategy should stretch into the ongoing management of a building and not end at the completion of a project.

At the outset, a risk management strategy must focus on the logical stages:

1. understanding the design and materials, as well as the chronological stages of its development
2. understanding the significance and vulnerability of the building
3. understanding the building's condition.

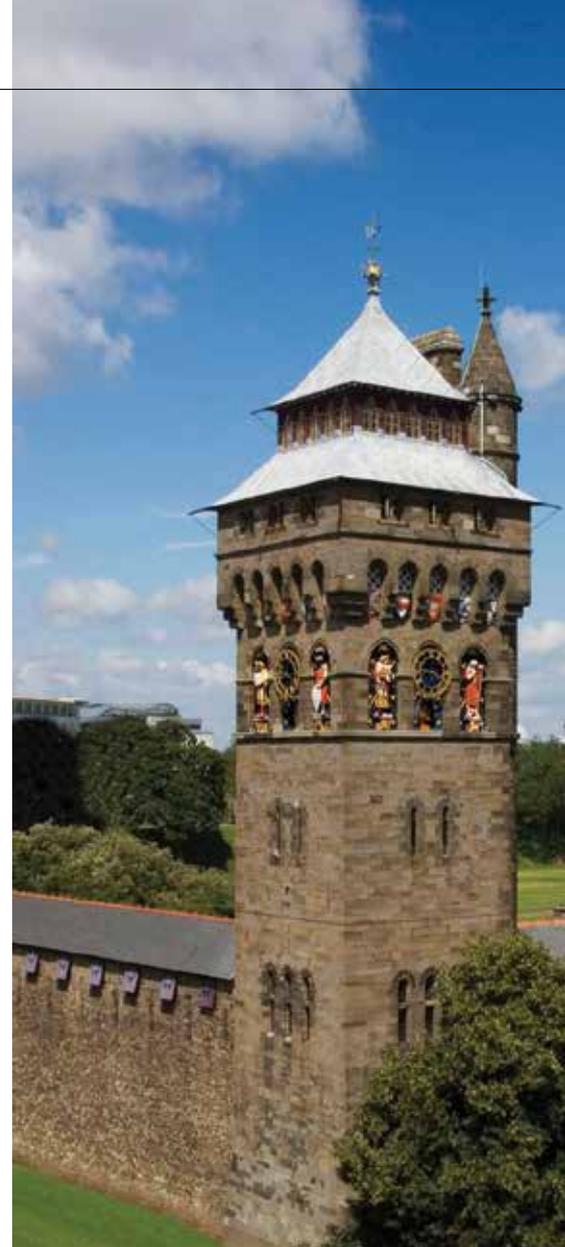
The more work that is put into comprehending these, the less risk one takes. One has to be proportionate and consider the cost–benefit analysis; there will be a limit to the amount of work that can be undertaken before this is considered unreasonable.

In relation to points 1 and 3 above, the amount and quality of information derived will depend on:

- **the type of building survey:** the choice between a purely visual inspection or a building pathological analysis
- **the competence of the surveyor:** whether they are accredited or certified for conservation work can make a very big difference to the outcome
- **the equipment used:** this can range from a simple electric moisture meter to surveying equipment that can test the strength of materials, analyse moisture sources and record true moisture levels as well as environmental conditions.

Interventions

All interventions will rely on these factors, and the extent to which the building is understood will have a huge bearing on the risks that are taken. Proper understanding of the impact of all the



types of possible intervention, including repair, is essential.

The problems that necessitate the repair should be the focus; if not, then there remains a possibility that they will occur again. If a repair is not on a like-for-like basis, it runs the risk of having an adverse effect on a building's historic significance. Therefore, a heritage impact assessment needs to be undertaken. If this process is properly followed by those with the required competence, the risk of inappropriate and technically unsound repairs will be minimised.

When planning to adapt a building, the same risks apply, but these can be even greater. Older buildings may have been performing in a reasonable way for a hundred years or more, but when adaptations are made, they can have a huge impact on that function, depending on the form of the adaptation. Risks can be managed if we understand the building and all the issues sufficiently.

Procurement

Selecting contractors that are specifically suitable for the project in question could



1 At Cardiff Castle, project risks were managed in several ways, including an extensive research and analysis programme, proactive quality management and an ongoing building management regime with environmental control

2 A major repair and refurbishment project at Trafalgar Square in Sunderland; the reintroduction of vapour permeability means managing the risk of residents applying impermeable decoration by having the landlord supply permeable paint to each resident regularly

go some way to minimise any potential risk. Look at a contractor's previous experience – both recent and historic – talk to its former clients, obtain the CVs of those working on the project and review the contractor's management structure and the expertise of its staff. The extent to which this is necessary will depend on the scale of the project: it could be that the contractors are so well known that not all of this would be required. However, overlooking any of the above will increase risks.

Procurement options have particular advantages and disadvantages, so it is important to choose one that can provide

the best results for the least risk, as it is to ensure that responsibilities are clearly understood and backed up in contracts.

The contractor will always be taking some risk in terms of its tender and allowances. Such risk needs to be reasonable because if excessive risk is put on the contractor then a higher tender sum may result, or tenders may not even be received.

Programming

Clients and their consultant team will program a project before appointing a contractor – it is wise to be aware that there are many preparations needed before the commencement of a project, and these may take longer than expected. Examples may include consenting to undertake work, though using competent advisors will help to reduce the risk of uncertainty. It is always possible, too, that the scope may change as the work progresses, especially if the client is relying on occupying the building soon after the project's completion. Factors such as weather can affect the work; choosing the most appropriate



time of year to begin will reduce this risk, although specifying protection measures will also help.

Cost management

Controlling the scope of a project is essential if costs are to be managed. The risk that the work will change and budgets may have to be increased must be accepted at the outset and a framework put in place to ensure that the cost of the work, including any variation, is fairly tendered. Any extension of a contract owing to an increase or variation of work should be on the basis of the original tender sum or done pro rata.

This means that sums received from each tendering contractor should be broken down consistently. The only way of doing so is for a measured schedule of works to be produced for all competing contractors to price. This may include provisional quantities, which are an estimate of what might be required. This will help to manage the risks of the client paying inflated prices for additional works to those previously specified.

Quality management

Ensuring that the contractor complies with the specification is essential, and BS 7913: 2913 contains advice through project supervision. This emphasises that simply checking over the work on completion may not always be adequate. Bearing in mind that some defects resulting from failure to comply with the specification may not themselves become obvious for many years – a more concerted approach is necessary in order to reduce these risks.

It is a contractor's responsibility to ensure specification compliance, and not that of a clerk of works, architect or any other member of the design team. Work should only be certified as complete on either an interim or final basis if it complies with the specification.

BS 7913: 2013 highlights a risk management approach to ensuring specification compliance and quality. From the outset, it requires the specifiers to detail areas of work that are high priority in terms of quality.

It means that, where it is not possible to determine whether an item of work has been properly implemented through inspection on completion, the contractor has to propose a method in a project execution plan by which they will manage the quality of work and demonstrate this to the architect, building surveyor or other client representative.

It is the responsibility of the architect or building surveyor to be satisfied, and they can undertake their own inspections and tests as necessary. In this way, the risk of non-compliance with the specification can be reduced.

There are many activities that one would expect to see in a contractor's project execution plan that include inspections at certain times, tests, managing materials storage and such like.

Soft landing

If a project has been properly initiated and completed, with all risks understood and managed, then the building should be appropriate for its intended occupation. If there are any limitations on this, then they must be understood by the building's occupants and managers.

It is also important from the inception stage that appropriate expertise is deployed in the use and operation of the building, as this will minimise the risk of adapting a building in a way that renders it unsuitable. Such expertise may cover both operational and commercial factors.

Implementing mitigation

All the various possible risks need listing collectively at the very beginning of a project in a risk register. In this way, they can be assessed, mitigatory approaches determined and recommendations made.

These may include the ideal means of managing the risks along with second, third and perhaps further options. There will no doubt be instances when implementing risk mitigation may depend on the client's willingness to put in sufficient resources. ●



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Digitally surveying damage

Assessing maintenance needs can be a time-consuming task, so recent research looked at digital techniques to survey structures. **Alan Forster, Fred Bosche** and **Enrique Valero** explain their results

Maintenance of the external fabric of buildings represents a large portion of their lifecycle costs. Access is an important aspect of such inspection and intervention, with scaffolding accounting for a significant proportion of the project budget. Obviating the need for scaffold for inspection would logically be cheaper and safer, and was an important motivation for research we undertook to survey buildings' maintenance needs digitally.

Digital data capture – that is, scanning and photogrammetry – is commonplace and used extensively for historic recordings, although largely in visualisation and manual assessment. An important component of our Historic Digital Survey project was to evaluate the efficacy of certain forms of certain technologies, mainly various photogrammetry and laser scanning set-ups, highlighting both their benefits and drawbacks. Importantly, the project also developed novel algorithms to extract primary survey information automatically. Both project components aim to help those entrusted with survey operations to move beyond digitally recording historic structures, for instance, using scan to building information modelling (BIM) applications.

Figure 1

Point cloud of the rampart wall facing the east garden and (inset) detail of a blocked-up window



▶ A pilot study was conducted with a 10m-high section of rampart random rubble masonry wall (see [Figure 1](#)) facing the east garden of Craigmillar Castle in Edinburgh. The wall was ideal for study due to its relative complexity; specifically:

- the random nature of its stonework
- the variation in width and depth of mortar joint
- its planar and curved surfaces
- blocked window openings and masonry dressings
- stone soiling and associate colour and texture variation
- difficulty of access to upper parts of the wall.

Comparing 3D reality capture technologies

The study compared four 3D “reality capture” technologies:

- two terrestrial laser scanners (TLSs)
- a pole-mounted single-camera photogrammetric (PG) system
- a single-camera PG system mounted on an unmanned aerial vehicle (UAV), or drone
- a pole-mounted stereo camera PG system.

This stage compared the relative merits of commonly available technologies and considered the accuracy and completeness of the acquired data, as well as the efficiency of data acquisition and preprocessing. The results confirmed the overall superiority of TLS to PG systems in terms of accuracy. However, the far cheaper pole-mounted PG system performed remarkably well, with results close to one of the TLS systems. The UAV PG system’s performance was poorer than that of the pole-mounted one, but this was probably the result of an inadequate flight path – that is, one that provided incomplete or insufficiently accurate data – as well as using a lens with an overly large focal length, which resulted in insufficient overlap between images.

Focusing on completeness, the limitations of a ground-based TLS were noted at the top of the rampart, at which point the stones occluded the mortar joint areas. In contrast, the mobility of the UAV, and to a lesser extent the use of the pole, ensured that all parts of the wall were recorded with the same level of point density as by PG systems.

All systems were found to be equally efficient, at least for survey jobs of this size. Furthermore, data acquisition typically required similar amounts of time for preprocessing – cleaning and merging scans or conducting the PG reconstructions. UAV-based data acquisition seemed somewhat slower than with a pole-mounted system due to the need to change the battery frequently. Overall, for larger projects, a TLS may perform better if access is adequate. Yet the pole-mounted system can be a reasonable, cheaper alternative, and the UAV may in other contexts be the only option, provided the issues identified in this pilot study are addressed.

Developing automated data processing

The use of scan data for BIM or its enhancement, as in scan to BIM for instance, is generally undertaken manually and is therefore costly and prone to human error. Practically, efficient and effective methods to process data from modern reality capture technologies semi-automatically enable surveyors to focus on value-adding activities, such as identifying defects and developing repair strategies.

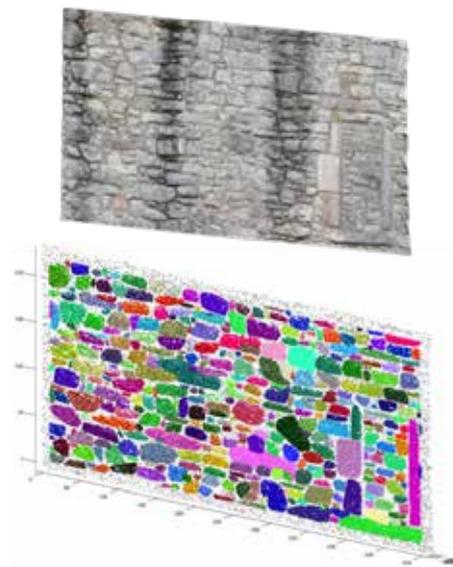
The evaluation of complex masonry such as random rubble walls has been particularly difficult due to differently sized stones, a lack of uniform coursing and bonding, and the walls themselves not being planar. This research evaluated the feasibility and value of developing and using bespoke, highly novel automated data processing algorithms for 3D point clouds of stone masonry walls. These support the evaluation of specific



Craigmillar Castle,
Edinburgh

Figure 2

Wall stone segmentation results in the 3D view; each compact coloured region is a detected stone



features of masonry walls such as labelling individual stones, identifying and quantifying recessed mortar joints that require repointing, and ascertaining the volume of pinning stones, also known as gallets, to be rebuilt into the masonry.

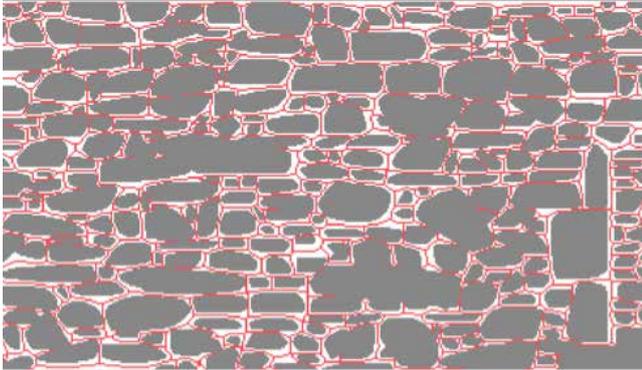
The system developed in this initial project segmented the wall into individual stones and mortar regions and reported on the length of mortar joints, their depth, and thus whether there are recessed zones, and where pinning should be considered during repointing. This helps surveyors to assess and quantify targeted repair needs accurately.

While most of the analysis was conducted using point clouds – a set of data points in a coordinate system such as X, Y and Z, obtained using laser scanning technologies – 3D reality capture technologies could be used.

The results obtained for the algorithm effectively detect individual stones and mortar joints of various shapes and profiles (see [Figure 2](#)). A quantitative assessment of the segmentation

Figure 3

Centre lines of the mortar areas are shown in red



accuracy was undertaken by comparing the results obtained with the algorithm against those acquired through a meticulous manual segmentation in the section's orthophoto. The segmentation performance results were good, although the size of the stones seems slightly overestimated by the current algorithm. Most stones were typically well segmented, with ratios over 90% for the majority.

The automatically segmented data of each stone and mortar joint enables reporting of the mortar in linear metres and gives accurate depth profiles along the mortar lines (see Figures 3 and 4). This information enables an accurate estimate of the quantity of repointing to be undertaken and is a visual indicator of undercutting mortar (see Figure 4). The algorithm automatically measures the length, width and depth of mortar joints, initially detecting the mortar area's centre lines or skeleton (see Figure 3). From these centre lines, the length of mortar joints in the wall can be obtained exactly. An accuracy of around 90% was obtained for an actual mortar length of 125m. This is promising, and extremely valuable given current valuation methods that are inherently more laborious and imprecise.

The knowledge of the joint width of the mortar can also be used to quantify automatically the amount of pinning normally used to fill large lime mortar joints between masonry units; Figure 5 strikingly illustrates the number of pinning stones that would be required to repoint repair. This is a visual reminder of the scope necessary for effective lime works.

Conclusions

It is essential that both the capabilities and limitations of digital technologies are better understood. The results show the strengths of modern laser scanners in terms of data precision,

Figure 4

Automatic measurement of the depth of mortar recess along the mortar centre lines [in centimetres]

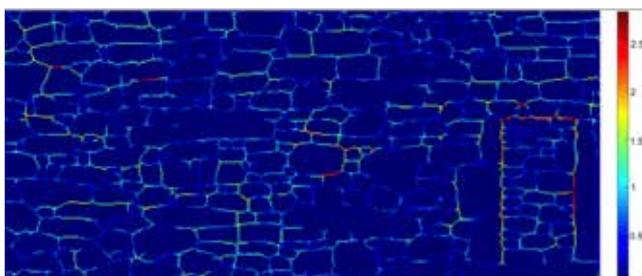
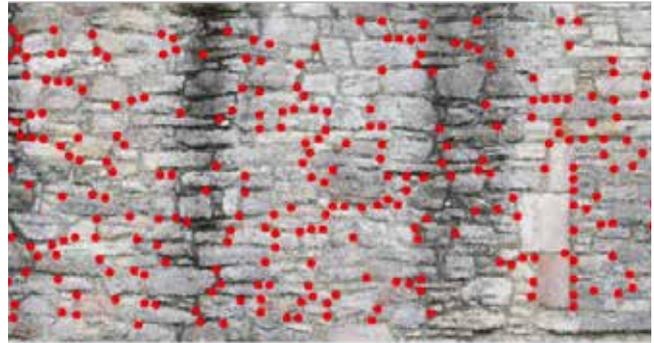


Figure 5

Automated detection of potential pinning stone locations [in red] overlaid on point cloud



but also confirm their limitations in terms of access. PG systems seem generally inferior, although not always significantly, but offer great potential in terms of access, efficiency and cost.

The results support the idea that well-crafted algorithms can constitute powerful tools for extracting significant additional value from reality capture data. This will help surveyors to achieve more complete, objective and efficient surveys. We do not suggest that such algorithms could replace surveyors, but they could reduce the amount of painstaking tasks conducted by surveyors that add little value, such as measurement, thereby freeing time for them to focus on value-adding tasks such as defect analysis and the development of repair strategies. It is envisaged that these techniques will have a significant impact on proactive maintenance programmes and broader building portfolio management. ●



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For a full version of this report, please see Bosché, FN, Forster, AM and Valero, E (2015), *3D Survey Technologies and Applications: Point Clouds and Beyond: Technical Report*, Historic Environment Scotland
<http://bit.ly/2mHdRiV>



Related competencies include
Building information modelling [BIM] management, Building pathology, Conservation and restoration, Inspection, Maintenance management

UPDATE

Heritage Agenda is compiled by Henry Russell OBE FRICS, School of Real Estate and Planning, University of Reading and Chair of the Heritage Alliance's Spatial Planning Advocacy Group
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Repointing historic structures



Repointing – renewing the pointing, the external part of mortar joints of a wall – seems a simple task. However, when dealing with an historic structure, certain precautions have to be taken.

Damage can be caused by using inappropriate materials or poor workmanship. Many types of brick and stone are soft and permeable. Repointing

with cement mortars or strong hydraulic lime mortars comes with a risk of damage. The principle is that mortar should be sacrificial, so that it, rather than the walling material, deteriorates. More historic fabric is preserved if the mortar erodes rather than brick or stone.

This issue's update offers advice on repointing historic buildings.

Mortar analysis

With buildings of major significance, repointing needs to be carefully specified on the basis of scientific mortar analysis. A specialist consultant will identify the binder – lime – and the aggregate. There will probably be a mixture of aggregate, varying in size, stone type and colour. For other buildings, premixed mortars can be bought from suppliers of traditional building materials.

The main difference between hydraulic and non-hydraulic limes is that hydraulic limes naturally include clays and other materials, which give a chemical set. They are identified as “hydraulic” as they set underwater.

Non-hydraulic limes, typically lime putty, are air-setting. Hydraulic qualities can be imparted with pozzolanic additives, named after the volcanic ash and pumice from Pozzuoli used by the Romans. Brick dust and pulverised fuel ash have similar effects, but should be specified by an expert.

The key stages to obtaining a good-quality finish are:

- taking care to remove old mortar and ensure the wall's edges or arrises are undamaged
- raking out to a depth of at least twice the width of the joint; all loose mortar must be removed
- joints should be wetted before applying mortar, and non-hydraulic mortar will need more aftercare by pressing back the mortar the next day; all mortars should have slow drying conditions, and this can be achieved by protecting the wall with damp hessian sheeting.

The Building Limes Forum lists organisations that provide training in lime, as well as sources of traditional materials.

● <http://bit.ly/2nZVZ2U>

Historic England guidance

New Historic England guidance includes *Repointing Brick and Stone Walls: Guidelines for Best Practice*. Aimed at homeowners and non-professionals, these documents offer some sound and basic advice.

The nature of the mortar will depend on the type of wall and the material from which it is made. It may be a rubble stone wall with a coarse aggregate, or a fine-gauged arch with mortar rich in lime putty and silver sand.

Historic pointing is usually flush with the surface of the wall and may have a variety of patterns, such as the penny-struck line common in the 18th century.

Poor-quality bricks could be given a fine finish with tuck pointing. With this technique, the bricks are first pointed with mortar coloured to match the brick. Then false jointing lines are incised for the horizontal joints and perpend, then carefully filled with lime putty. This is a highly skilled task.

● <http://bit.ly/2jTQSD>

More detailed advice on this subject is available in Historic England's Practical Building Conservation series. Relevant material in particular can be found in *Mortars, Renders & Plasters* and *Earth, Brick & Terracotta*.

● <http://bit.ly/2nEe8m8>

Scottish guidance

Historic Environment Scotland has published guidance, *Repointing Rubble Stonework*, as part of its Inform series of short guides.

● <http://bit.ly/2IYF6kP>

For more comprehensive information, see the technical advice note *Preparation and Use of Lime Mortars*.

● <http://bit.ly/2naDgxf>

SPAB advice

The Society for the Protection of Ancient Buildings (SPAB) has also published a series of technical pamphlets, including *Repointing Stone and Brick Walling*.

● <http://bit.ly/1JMjAKg>

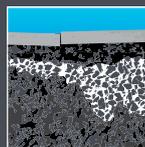
Also available is *The Old House Handbook*, a practical guide to the repair of old buildings by Roger Hunt and Marianne Suhr MRICS. These explain the principles of letting old structures breathe and the need to repoint with permeable materials

● <http://bit.ly/2n8CFMi>

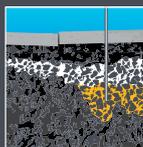
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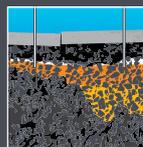
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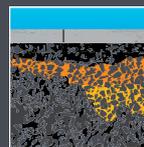
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