Building stone as a resource
- finding stone for restoration projects

TIM YATES

Building stone is a resource for restoration projects and for new build, and practical guidance is presented here on the application of different test methods in choosing new stone for use in buildings. Three casestudies illustrate possible synergies and conflicts between building conservation policy and sustainability. The case studies are drawn from recent projects with which Buildings Research Establishment has been involved: Vimy Ridge Monument (France); Cathedral of the Immaculate Conception, Albany, New York (USA); and Gloucester Cathedral (UK). The final part of the paper describes a pilot study aimed at developing a methodology for recording the stones used in heritage buildings, the condition of the stone, and the likely requirements in terms of replacement stone over the next 50 years, with its implications for quarrying and minerals planning.

Our vernacular built heritage has been shaped by the materials that were available locally and those that could be transported to the site by river, rail or road. Local styles of architecture developed in response to the materials and the local environment. e ability to obtain materials that are sympathetic to the existing building is a key factor in any restoration project if the building is to maintain its appearance and remain in harmony with its landscape. In areas where the dominant material for construction is natural stone the stone used was o en very local – coming from a nearby estate, farm or village – resulting in very localised use of stones and many thousands of di erent stone types being used across the UK.

In the last 100 years many of these older quarries have fallen into disuse – sometimes because the stone was worked out but more o en because of economic pressure and the availability of stones foreign to the area at lower prices. In more recent times pressures have been increased further by concerns about the environment – both the retention of existing quarries and the re-opening of former quarries. Overall, this has greatly reduced the range of stones that are available for conservation and restoration projects – for example in the 1920s there were around 100 active quarries producing Magnesian Limestone and currently there are only four.

In any discussion of the reopening of old quarries or protection of existing quarries it is important to understand the extent to which materials were used in the past, which stones should be considered of greater importance, and which are likely to be required in the future for restoration projects. In order to make an objective decision a methodology is required to assess past and present use of stone on a county-by-county basis.

CONSERVATION PHILOSOPHY

If we are to justify the need to retain access to some stone types for the repair of our built heritage then we need to have a clear idea of what we are trying to achieve. ree terms are commonly used – o en interchangeably – but in reality each term has a di erent emphasis.

- **Preservation** seems to lie at one extreme – it conjures up an image of retaining what we have now, exactly as it, with the intention of keeping the building or monument just as it for as far as we can see into the future.

- **Restoration** has come to mean a far more radical approach – not just the retention of what we have but also the repair of a building that takes it back to some point in the past with the risk of loosing something of its history in order to achieve this.

- **Conservation** seems to lie between the extremes of preservation and restoration – keeping what we have, retaining as much as possible of the history of the building or structure whilst acknowledging that there are times when alterations and additions are necessary in order to secure a sustainable future for the building.

The actions and changes that are deemed acceptable are often embodied in a 'Conservation Philosophy' that contains views on the appropriateness of maintaining a 'like for like' replacement of materials, whether some degree of 'improvement' may be desirable (for example if the past use of a material or design has been unsuccessful should we repeat this 'mistake' knowing that it will fail again at some point or should we look for a degree of improvement?), and on the 'best practical options' including consideration of whether they can be achieved at no excessive cost.

Conservation Principles are often embodied within charters or policies, for example the Venice Charter (ICOMOS 1964); or the Stirling Charter (Historic Scotland 2000). Following the guidance in these documents will generally result in a holistic approach that encompasses the buildings and their setting. There is also an acknowledgement that whilst the historic environment must allow for new architecture and modern lifestyles there should be a presumption in favour of conservation. The charters also emphasise that conservation and restoration must have recourse to all the sciences and techniques, which can contribute to the study and safeguarding of the architectural heritage

In developing or following a conservation philosophy, particularly in relation to the choice of materials it is possible to identify a number of 'limiting factors' including:

1. Our ability to analyse existing materials
2. Identifying the original sources of stone, sand, lime / binder, etc.
3. Identifying current sources
4. Conservation guidance / listed building consent
5. Funding

Inevitability these limiting factors result in the need to compromise our ideal solution, but it is important that the reasons leading to the compromise solution are clearly documented and that those involved in the decisions are informed of the reasons and any implications for the building or structure.

The next section provides three brief case studies which examine different approaches to the selection of stone for conservation projects – in the first the requirement is to locate the original source of the stone; in the second the need to identify a more durable stone; and in the third example a suitable stone is required.

CASE STUDIES

Vimy Ridge Monument, France - Looking for the original stone

The Vimy Ridge Monument in Northern France commemorates the action on 9 April 1917 when 100,000 soldiers of the Canadian Corps attacked Vimy Ridge. In 1922 the government of France gave 100 hectares of Vimy Ridge to Canada to be used as a memorial park to remember those who fought in the attack and those other Canadians who were lost in action in the First World War. In 1926 work began on the monument which had been designed by the Canadian architect Walter Allward.

The twin 'pylons', each 67 metres in height, represent the countries of Canada and France (Fig. 1). Twenty sculptured figures on the monument and the names of 11,285 Canadians missing in France are carved on the walls. The monument took ten years to build and was unveiled on 29 July 1936.

Fig. 1. *The Vimy Ridge Memorial*

The original 'Trau' stone from the 'Dalmatian Coast' in what is now Croatia was selected with great care as it was intended that it should last for many years. However, the first problems were noted within 30 years and by the late 1990s there were plans for a major restoration to funded by Canadian Heritage to restore the plinth and the stone panels containing the names of those killed or missing from the Canadian forces. The preparation work for this project was undertaken between 2000 and 2002 as a joint project by Canada, UK and Serbia.

The key part of the project was the selection of a replacement stone, preferably from the original quarry provided that its durability could be established through a pro-

Fig. 2. *Matching the stone at Vimy*

gramme of testing and assessment. e testing programme was developed using failure mode and e ect analysis where the likely modes of failure and their consequences are evaluated. e main causes of failure were determined as being related to di erential movement between the stone and the sub-structure, which was resulting in stresses within the stone. As a result, it was agreed that physical properties (strength, water absorption and thermal movement) and appearance (colour and texture) needed to be included in the testing programme. A good understanding of the causes of failure was considered essential if future risks of failure were to be minimised.

Once the testing programme was in place it was necessary to identify currently available stones. e only stone known to be in commercial production was 'Veselje Unito' from the island of Brac, just o the Croatian coast. However, this stone had been used in some earlier restoration work, with disappointing results. e di culty with nding the original quarry was that its location had not been recorded at the time of the original construction probably in part

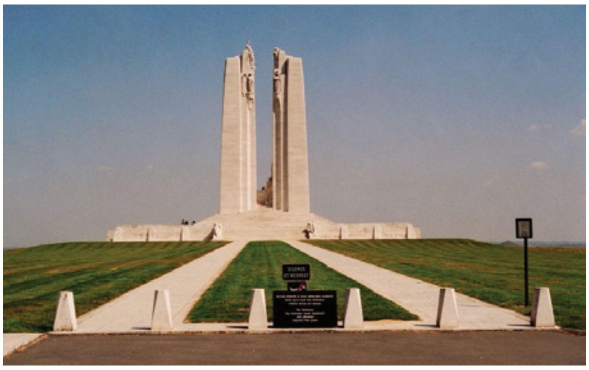

Fig. 3. *The Vimy Ridge Memorial restored*

because the stone was quarried in Croatia, processed in Italy by an English mason, to designs by a Canadian architect! However, through a process of visiting possible sites identi- ed by a geologist in Zagreb and researching through local archives the original site was identi ed in Seget, Trogir, Croatia.

Samples of the stone were collected and tested, and proved to be a very good match and to be su ciently durable to be a good choice for the restoration (Fig. 2). Despite the success in sourcing the stone, di culties were encountered in actually obtaining stone for the restoration project due to arguments over the ownership of the quarry and the availability of the stone, which resulted in long delays in the actual restoration work. However, it is now complete and the site was re-dedicated in April 2007 on the 90th anniversary of the assault on the Ridge (Fig. 3).

Albany Cathedral, New York State – Looking for a 'better' stone

e Cathedral of the Immaculate Conception, Albany, New York State (USA) was initially constructed between 1848 and 1852 (Fig. 4). e design was by Patrick Charles Keeley and was inspired by Cologne Cathedral. e north spire was constructed in 1862 and the south spire in 1887.

e cathedral was completed in 1892 with the construction of the sanctuary and sacristies at the west end. e cathedral is now part of a major urban area and the stonework has decayed – particularly the more exposed stonework in the spires and the clerestory – and by 2000 it was in need of replacement.

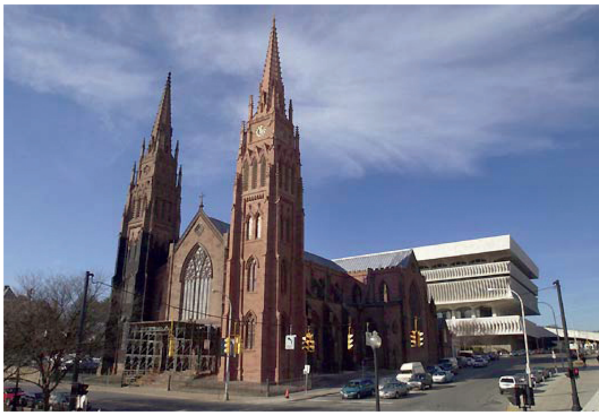

Fig. 4. *Albany Cathedral, New York*

e original source of the Portland brownstone was known to be from the Connecticut River Valley, and it was also known that it was some of the rst stone quarried in that area. e Brownstone Industry was very active in the nineteenth century and supplied stone for many buildings in the north-eastern states. It began to decline at the time of the economic depression in the late 1920s – early 1930s, and a series of devastating oods in 1936 lead to a complete closure of the quarries. Since 1993 there had been a limited working of quarries but production was still small.

Whilst acknowledging that the stone had lasted for more than 100 years, the cathedral authorities decided at an early stage to look for a 'more durable stone' for the restoration project. e architects drew up a short list of possible stones that could provide a range of alternatives:

1. Brownstone (US)
2. Red St Bees (UK)
3. Red Wilderness (UK)
4. Röttbacher (FRG)
5. Weserhartsandsteine (FRG)

A programme of physical testing was developed that covered a range of properties but with an emphasis on durability, which was the prime concern of the architect and the

Bishop. Samples of the current production of Brownstone were included for comparison. Past test data was reviewed for each stone and then new samples, representative of production at that time, were subjected to the following tests:

1. Petrography / mineralogy BSEN12407
2. Sodium sulphate crystallisation test BSEN12372
3. Freeze/Thaw resistance BS EN 12371
4. Acid Immersion test (BRE In-house method based on Ross & Butlin 1989)

In order to provide an objective method of choosing the replacement stone a 'scoring system' based on the performance requirements was used to provide a ranking of the di erent stones. e nal choice of stone was made on the basis of cost from all of those that met the requirements, as there was a limited budget for the project.

Red St Bees sandstone was chosen and then a programme to assess the quarry and the stone reserves was carried out, because of the long period over which stone was to be extracted. Finally, a programme of production control testing was put in place in order to maintain 'agreed quality', manage any risks, and maximise the future service life of the stone.

Gloucester Cathedral – Looking for a 'suitable' stone

e Cathedral Church of St. Peter and the Holy and Indivisible Trinity, Gloucester, UK has a long history. e building of the Abbey Church started in 1089, and there were extensive additions between 1373 and 1470. ere are records of major repairs and alterations to the cathedral in the period from 1735 to 1752 and again in 1847–73 when F.S. Waller and Sir Gilbert Scott were the architects. In1953 there was a major appeal for the restoration of the Cathedral and the appeal was renewed in 1989. At present there is a continuing restoration programme for various areas of fourteenth and eenth century stonework, as well as the replacement of some of the previous repairs. As a result of the long history of the building and the many phases of repair there are many di erent stones in the building. Consequently, choosing a stone for repair and replacement is complex – do you try to identify the original stone, the last replacement (even though it may have failed) or a new and suitable one?

In the case of Gloucester the original quarries were known but long since closed, and so the possibility of re-opening an abandoned quarry needed to be considered. is involved considering:

1. Why was it closed?
2. Were there any workable reserves?
3. What were the additional costs associated with re-opening a quarry, particularly in an area of outstanding natural beauty.

Given the location of the original quarries and the problems with some the stone extracted from the in the nineteenth century the decision was taken to select a close 'match' on the basis of mineralogy, colour, and physical properties. At rst it appeared that the limited number of active quarries in the area would preclude the nding of suitable stone acceptable to all parties but a review of records at BRE and the British Geological Survey (BGS) () combined with a programme of testing and evaluation did identify stones for the masonry and for the more exposed weathering details.

But which stones are required and which are available? All of the case studies raise the question of which stones are currently available and which will be needed in the future. In response to this question English Heritage, with support from ODPM Minerals Planning and English Nature set up a Pilot Project for a Strategic Stone Study for England.

e project team was drawn from the British Geological Survey and the Building Research Establishment Ltd supported by Terry Hughes, David Je erson, and English Heritage Architectural Conservation Sta . e project aims were to:

1. Identify which stones were used in the construction of vernacular and historic buildings in a trial area - the white sandstones of the West Midlands
2. Determine which stones are most 'important'
3. Consider which sources are suitable or future repair work.

e pilot studies emphasised the need for background research preferably supported by local knowledge. In the case of the North Shropshire studies the extensive information in the publications of David ompson was a very valuable resource. Some of the work can be carried out via the internet but the nature of the information means that a lot is still to be found in local archives and libraries. As so o en, time spent in preparation will reduce the time needed on site and in all probability provide a more reliable and representative data set as it would allow the work to focus on the most likely buildings and areas.

Good preparation work should allow a three-stage process for each eldwork area:

1. Carry out a desk study to identify listed buildings and structures plus other heritage buildings and structures of importance
2. If possible support the desk study by reference to local groups (RIGS, local history groups, amenity societies, etc)
3. Survey the buildings identified – either surveying all or a sample. Verify that the sample is representative by a visual survey of the remaining buildings or by selecting a second sample.

is pilot study has shown that su cient data is available for the proposed methodology to produce reliable and consistent information which can used to populate a national database of stone resources required to sustain the built heritage. e next step should be to establish a team to oversee the application of the methodology across the country.

It would be desirable to have the recording forms available as downloadable les from a web site with some compulsory elds and some free text. Ultimately an 'upload system' for completed forms should be set up as this will allow a central quality control system and a centralised database to be maintained.

FINAL THOUGHTS

A number of points should be born in mind in the identi-cation of appropriate stone:

1. Assess the problems and potential problems of finding a stone. Determine what the main controlling parameters will be.
2. Gather information on the original stone and those available
3. Communicate with all those involved and make sure that there are good lines of communication.
4. Plan ahead and never underestimate how long decisions might take.

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