Stone Consolidants
Inorganic treatments

John Fidler *Conservation Director*

New research on inorganic solvents offers improved techniques for masonry conservation.

The history of conserving historic building materials could be written around our attitudes towards building materials. Stone masonry, of course, takes pride of place as the most popular and revered natural construction material because of its prominence, beauty, antiquity and resilience through the ages. It is one of the most common building materials in England and the most studied: vast libraries of books and papers bear witness to its appeal and to the study of its preservation.

If you look through any Internet search engine for lists of 'conservation' and 'preservation', a host of sites will appear on studies of stone consolidants, the impregnating chemicals that strengthen the surface or sub-surface of decaying stones, and protect against moisture and pollution.

Organic consolidants in England

In England, we have a long track record of experimentation with so-called 'preservatives'. William Lethaby, for example, cited the medieval practice of using linseed oil to protect stonework, and Professor Robert Baker revived limewatering and lime shelter coats at Wells Cathedral (Fidler 2002). After the fiasco of the serious stone decay of A W N Pugin's facades at the Palace of Westminster within 30 years of building, the report of the public inquiry in 1861 included investigations of solutions such as Sylvester's treatment (1846), a water repellent based on soap and alum. Most of the consolidating materials used unsuccessfully in the second half of the 19th century included potassium or, even worse, sodium silicate ('waterglass') such as Kuhlmann's patent of 1852 and Szerelmey's of 1857.

At Westminster Abbey in the 1860s, Sir George Gilbert Scott used a solution of shellac in 'spirits of wine' (ethanol) on the interior of Westminster Abbey, squirted into the stone. Scott observed that it was not effective on the exterior in areas of driving rain, and he and subsequent surveyors used waxes on the interior instead. He also permitted a Professor Church to experiment with wall paintings and Reigate stone conservation at Westminster Abbey Chapter House by using 'baryta water', an early experiment with barium hydroxide solution.

In the 20th century, a great deal of international effort, time and money was spent on testing and failing to find successful outcomes with epoxide and polyvinyl fluoride (PVF) materials. More promise was shown by research into acrylics, alkoxysilanes and mixtures of the two materials. English Heritage's own experimental field work with the Building Research Establishment on Brethane (Martin 2002) shows the scope and limits of these organic compounds. The most widely used of the silanes is ethyl silicate, as conservators consider it safe, straightforward and controllable. These organic materials, however, all have limitations, and there has been concern about compatibility with calcareous materials such as marbles, limestones and calcareous sandstone masonry.

Inorganic consolidants

In response to the disadvantages of organic consolidants, English Heritage and the Getty Conservation Institute, Los Angeles, California, convened an international colloquium at the Society of Antiquaries, London, in December 2000. Specialists in conservation science and practice from the USA, UK, Spain and Italy discussed the use of alternative methods based on inorganic materials, potentially of benefit to decaying marbles, limestones and plasters. These include:

- limewatering (calcium hydroxide in solution): a revived yet scientifically unproven craft process
- barium hydroxide (a complicated variation

on limewatering with higher risks): successfully used on certain frescoes and plasters in Italy
- biological deposition of calcium carbonate: a new pioneering technique using a variety of pathways from calcite precipitation through bacteria, to precipitation enhancement due to proteins from seashells
- the creation of a protective layer of artificial calcium oxalate by limestone exposure to ammonium oxalate
- the part conversion of calcareous surfaces by exposure to heavily buffered tartaric acid to enable them to be chemically sensitised to silane-based consolidants, especially ethyl silicate.

The findings of the colloquium, which included 14 participants and 12 authors, have now been published by the International Institute for Conservation, in its series of *Reviews in Conservation*.

The report (Hansen 2003) reviews key literature, identifies questions and promotes discussion of a range of issues, including application techniques, performance, compatibility and retreatability. While many of these issues have been discussed in publications before, Hanson identifies significant areas for new research.

It is important to distinguish between consolidating properties (either at the stone surface or at depth) and other properties such as protective water repellency (oxalate patinas) and sacrificial coatings (lime shelter coats). Claims made by advocates for some of these systems do not appear to stand close scrutiny (Woolfit 2002), but Hanson concludes that quantitative data to evaluate the success or failure of inorganic consolidants has rarely been collected, or analysed and published. For usable conclusions, however, data should be collected on the following aspects: consolidating or strengthening value; depth of penetration; effect on appearance; compatibility with substrate; durability of treatment; effect on porosity and permeability; biological resistance; ease of application; and health and safety impacts.

All the inorganic treatments evaluated rely on reaction chemistry, that is, where material is precipitated from solution, some chemicals are dissolved and others are precipitated in their place. The chemicals tend to be environmentally friendly, water- rather than organic solvent-based. Importantly, some of the treatments assumed by practitioners to be simple folk remedies embody complex preparation and treatment methods where the application technique is as critical as the materials used or the degree of decay.

Ways have been found to remedy some effects in traditional practice. For example, in the application of lime watering (using calcium hydroxide), the amount of material in solution can be increased by increasing the use of sugars, by limiting sedimentation with ethanol or by using dispersed lime (micro-particles). Also, for statuary, a new approach is to apply the solution in a 100% carbon dioxide environment.

Hansen concludes that these methods are all developmental work in progress: 'Problems in evaluating the consolidation and protective treatments fall into two categories: the lack of knowledge of specifics in reaction chemistry and application procedures; and the lack of sufficient experimentation and testing methods necessary to quantify the required strength of consolidation, compatibility and long-term effects.'

Wells Cathedral, Somerset, where extensive consolidation with calcium hydroxide has been carried out.

Advice to the practitioner

The use of any type of masonry consolidant should be an action of last resort for conservators, and English Heritage has provided guidance on the matter (Ashurst & Ashurst 1988; Martin 1996). Some unproven remedies, cloaked by their advocates in the mantle of craft tradition, are based on complex inorganic chemistry and crystallography, about which little is understood. Importantly for the practitioner, some inorganic consolidating treatments have little effect or wear away so rapidly as to be uneconomic (Fidler 2002). There is plenty of scope for further research. □

Howden Minster, Goole, North Humberside. Deterioration of decorative tracery in an external arcade built of magnesium limestone, which is particularly difficult to consolidate.

REFERENCES

Ashurst, J and Ashurst, N 1988 'Stone Masonry', in *Practical Building Conservation*, English Heritage Technical Handbook (Series 1). Aldershot: Gower Technical Press, 87–91

Fidler, J 2002 'Lime treatments: an overview of lime watering and shelter coating of friable historic limestone masonry' in Fidler, J (ed) *Stone: stone building materials, construction, and associated component systems – their decay and treatment*, English Heritage Research Transactions series (Vol 2). London: James and James (Science Publishers) Ltd, 19–28

H M Government 1861 'Report of the Committee appointed by the First Commissioner of Public Works and Buildings on 23 March 1861 to inquire into the decay of the stone of the New Palace of Westminster and into the best means of preserving the stone from further injury', London: Command Paper

Hansen, E *et al* 2003 'A review of selected inorganic consolidants and protective treatments for porous calcareous materials', in Streeton, N (ed) *Reviews in Conservation*, **4**. London: The International Institute for Conservation of Historic and Artistic Works (IIC), 13–25

Martin, B 1996 'Stone consolidants – a review', in *A Future for the Past: strategic technical research in the cathedrals grants programme. Proceedings of a joint conference of English Heritage and the Cathedral Architects Association held in London 25 & 26 March 1994*. London: James & James (Science Publishers) Ltd, 30–50

Martin, B *et al* 2002 'Stone Consolidants: Brethane – a report of an 18-year review of Brethane-treated sites', in Fidler, J (ed) *Stone: stone building materials, construction, and associated component systems – their decay and treatment*, English Heritage Research Transactions series (Vol 2). London: James and James (Science Publishers) Ltd, 3–18

Papworth, W 1888 *Joseph Gwilt's Encyclopaedia of Architecture Historical, Theoretical and Practical*, London: Longmans (paragraphs 1640–48, and 1667, 478–80)

Woolfit, C *et al* 2002 'Lime method evaluation: a survey of sites where lime-based conservation techniques have been employed to treat decaying limestone', in Fidler, J (ed) *Stone: stone building materials, construction, and associated component systems – their decay and treatment*, English Heritage Research Transactions series (Vol 2). London: James and James (Science) Publishers, 29–44