Earth Structures, Renders & Plasters:
Experiments in Historical Techniques & Weathering

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Introduction

This paper presents the findings of an experimental research programme to test the performance of earth building materials, which was carried out by Historic Scotland between 1996 and 2004.

A wide-ranging programme of more than two hundred and thirty tests, carried out over seven years, has explored and assessed the traditional Scottish techniques of building with earth, gaining a better understanding of historic construction techniques, the processes of decay that effect surviving earth structures and the appropriate use and specification of materials for repairs and new work.

The programme was initiated following a renewed awareness of the importance of earth materials in traditional construction, as described in TAN 6: Earth Structures and Construction in Scotland (1996). It was a specific response to the recognition that the complete cessation of the traditional use of earth materials in Scotland by the early C20 had left a knowledge and skills gap that limited the technical understanding of surviving earth structures and hindered the development and implementation of appropriate conservation practice.

The Programme

A wide programme of field tests was established to replicate traditional construction techniques using a representative range of bioregional materials. These included:

- twenty-nine internal test walls of panel construction, comprising a range of earth daub on timber armature and rope techniques
- seventy-eight internal tests of coatings, comprising a range of earth and lime techniques
- thirty internal tests of washes, comprising a range of lime, oil, dung, tallow and other materials
- twenty-four external test walls of monolithic construction, comprising a range of mudwall, rammed earth and claywall techniques
- thirteen external test walls of masonry construction, comprising a range of stone with earth mortar, earth brick with earth mortar and turf block techniques
- fourteen external test walls of panel construction, comprising a range of earth daub on stake and rice, horizontal rails and ropes and kebber and motte techniques
- twenty-nine external tests of applied coatings, comprising a range of clay renders, lime renders, harls and stuccos
- eleven external tests of washes, comprising a range of lime, oil and dung materials

Materials tested included earth, straw, flax, hay, hair, dung, manure, lime, wood shavings, seaweed, ash, oil, tallow, whey, lanolin, urine and blood.

The tests comprised small sample walls and panels and all the tests were monitored and assessed for their performance during construction and initial durability. The external tests were monitored and assessed for their durability over a period of up to seven years. These tests were carried out at three external sites, chosen to represent a typical range of climatic conditions.

Findings

Perhaps unsurprisingly, the techniques that performed best were the ones that are found most frequently in traditional Scottish construction. The characteristics of these successful techniques are that they:

- require a low level of processing of typical Scottish sub-soils and associated materials (taking into account that traditionally soils and materials were often sourced in a different way from contemporary practice
- do not require specialist equipment
- can be accomplished with a variable quality of locally sourced materials
- are reasonably tolerant of inclement working conditions
- can achieve a durable construction, requiring minimal maintenance in Scottish climatic conditions.

Regional techniques, using particular local materials, required specialist skills, which would historically have existed locally. Techniques from outside the tradition were generally inappropriate to climatic conditions or required significantly more effort.

A range of subsoils were demonstrated to be successful as the basis for construction materials, with grading proving the most important factor in their selection. Well-graded materials can be remarkably durable, while poorly graded mixes will never perform well. The second important criterion is compatibility of materials. This affects additives, facing materials, coatings and finishes. The programme produced unexpectedly good and bad results in a number of tests and these indicated that some of the interactions between materials are complex and not fully understood.

Six distinct decay mechanisms were observed, including shrinkage, surface erosion, sacrificial erosion, freeze/thaw cycles and delamination. The first year, when the material is drying, is a period of particular vulnerability to decay. Expansive clay content was not demonstrated to effect durability.

When other materials were combined with earth, their degree of compatibility had a significant effect on durability. Constructions which had a mixed surface of earth and other, denser, materials, proved to be vulnerable to progressive decay at the interface of these materials. The earth would decay sacrificially with the result that the wall as a whole was less durable than well made monolithic earth walls. Lime coatings were demonstrated to have fundamentally different properties from earth backgrounds, raising questions over current practice.

Successful earth construction was demonstrated to require skill and experience in the selection, preparation and application of materials. While a wide range of materials can potentially be used successfully in earth construction and the basic principles are simple, the best quality work can only be achieved within quite narrow parameters of materials specification and construction technique.

Earth construction is a field with considerable potential for development in conservation knowledge and practical applications. Earth materials have the potential to be durable and compatible repair and conservation materials. This potential extends beyond applications to existing earth structures. Their malleability, reversibility and hygroscopic interaction with water vapour, make them appropriate for work to other materials and structures.

The programme highlighted areas that would merit further technical research, including:

- The tests indicated that earth renders may have significant potential as a technically appropriate coating material, though the complex factors influencing a successful render are poorly understood and merit further research.

- The tests indicated that lime renders can have significant technical deficiencies as coatings for earth materials. These are currently widely used in such circumstances and further research would help to develop appropriate best practice guidance.

This report, associated Inspection Reports, photographic archives and the test walls that are still standing, are a valuable information resource of long-term relevance to practical conservation projects and future research. The published Final Report will be available from Historic Scotland (TCRE Department, Historic Scotland, Longmore House, Salisbury Place, Edinburgh EH9 1AL, Tel: +44 131 668 8600, www.historic-scotland.gov.uk).

We are currently considering new research into soft toppings, the use earth and/or vegetation to form protective coverings, and would welcome contact from others concerned with this field.