

Investigations into the Causes of Stone Deterioration and Approach to Long-Term Preservation in the Chapter House.

Since 1991, work has been carried out to investigate the causes and rates of deterioration and long-term care of the carved decoration in the Chapter House. Such a detailed appraisal has never been undertaken before in an English Cathedral and over the following 9 years, the various stages of investigation, practical treatment, etc., have led to a deep understanding of the factors affecting this part of the building. This evaluative approach has been subsequently adopted at other Cathedrals and English Heritage sites, to assess complex problems affecting stonework. Joint funding was secured from the English Heritage Cathedral Grant Scheme and the Getty Grant Program to include:

- A complete photogrammetric and photographic survey.
- Detailed structural survey and geotechnical investigation of the sub-soil conditions.
- Visual recording of the condition of the carved stonework using a specially devised colour-coded system to assess alterations in physical condition.
- Petrological analysis to establish the specific characteristics and internal composition of the White Mansfield stone type.
- Salt analysis to determine the nature, concentrations and salt profiles in the walls.
- Periods of continuous environmental monitoring to evaluate variations in temperature and relative humidity and surface temperature and moisture measurements.
- Historical research to evaluate rates of progressive deterioration.
- Assessing the impact of visitors.
- Evaluating materials and suitable methodologies for practical treatment.

The results of these investigations showed small areas of lost detail on the arcading's over a long period, with physical rather than chemical breakdown being the main cause of deterioration. Gypsum within the pores of the stone in combination with sources of atmospheric and liquid moisture was exploiting the natural weaknesses and laminations in the stone (exacerbated by face-bedding on the tympana during the original construction). Periodic salt activity observed during re-inspections may also have been affected by a combination of moisture movements in the walls and random variations in temperature and relative humidity.

Practical treatment carried out between 1997-98 involved:

- Careful removal of previous hard cement mortar pointing and repairs.
- Grouting behind detaching surface layers.
- Inserting refined lime mortar repairs to fill blisters, gaps cavities, cracks and laminations, and acrylic resin/stone dust fillings in finer cracks.
- Securing detaching areas of foliated carving by discreet (1.6mm diameter) drilling through non-decorated surfaces and inserting small stainless steel pins/cramps.
- Dry salt removal and desalination on the ashlar stonework of the walls to reduce surface salt levels with acid-free blotting paper/de-ionised water poultices.

Removal of old repairs, grouting, filling and removal of surface salt deposits on foliated carving beneath the vault on the west and southwest elevations were also carried out during 2000. The heating system has been improved and a humidistat was fitted to maintain a relative humidity of 60% by controlling the supply of heat from the boiler.

This long-term project, completed in December 2000, has demonstrated an inter-disciplinary approach, which apart from the benefits to this important building, has also contributed to the wider understanding of stone conservation. The project has been short-listed for a prestigious national conservation award and articles on this project are currently in preparation for publication in conservation journals later this year.