# PETERBOROUGH CATHEDRAL

## ENVIRONMENTAL MONITORING DATA

## 10th JANUARY TO 4th APRIL 1995.

ENGLISH HERITAGE

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Monitoring has been undertaken to establish the environmental conditions within the cathedral so that an assessment can be made as to whether the medieval painted ceiling is being adversely affected by the heating system.

Heating is provided by gas fired Gurney stoves, these were installed in the late 19th century and were originally coal burning. They were converted to oil firing in the 1960's and subsequently refurbished and converted to use gas approximately 4-5 years ago. Since modification, they are reported to have an increased heat output, internal air temperatures, which are recorded by the Vergers, have risen by around 5°C. The relative humidity would consequently have reduced by around 20%. As this type of heater produces radiant and convected heat and the products of combustion are vented directly to the atmosphere, they will not add moisture to the internal space. The heaters are run 24 hours/day with a night set back during the heating season and should therefore have a stabilising effect on the internal relative humidity.

Temperature and humidity probes, plus surface temperature sensors, have been installed in the main body of the cathedral and in various voids above the painted ceiling (see drawings showing sensor positions). Conditions are also being monitored externally to enable an estimate to be made whether extremes of temperature affect the internal readings.

## EXTERNAL CONDITIONS.

During the first monitoring period external temperatures varied between -2°C and 20°C, the relative humidity ranged from 100% to 43%. For the majority of the time the mean figure for the relative humidity was 85% with daily variations of up to 30%. The average temperature was 6·5°C, graph 1 clearly shows the daily variations of temperature and humidity and indicates a general rise in temperature towards the end of the period.

## INTERNAL CONDITIONS.

### Main Body of Building.

Temperature and humidity sensors were installed at three levels in the nave to determine the degree of "layering" of the heated air. Additional sensors were fixed to the underside of the painted ceiling to measure surface and air temperatures and relative humidity.

SENSORS 155, 158 and 157.

These sensors are positioned in a vertical stack adjacent to the Pulpit, the readings from the sensors were very close, only 1·5°C and 2·5% RH separated the means of the three results.

This indicates an almost total absence of a temperature gradient and shows that the heating is very effective in operation.

The maximum relative humidity is between 55 and 62% with corresponding minimum figures of 33.5% and 37% depending on the sensor. This figure is low for a building of this type when compared with similar monitoring studies. It is probable that this will have contributed to the drying out and subsequent shrinkage of the ceiling. Graph 2 shows the temperature and humidity readings from the upper two sensors. It can be seen how close the two sets of readings are, indicating the lack of temperature gradient.

SENSORS 159 and SUR2.

Sensor SUR2 is attached directly to the surface of the painted ceiling, sensor 159 measures the temperature and relative humidity of the air adjacent to the ceiling. The profile of the temperature graphs was identical, the surface readings being on average 1° lower than the air temperatures. This is probably due to the lower temperature on the opposite side of the ceiling transmitting through the fabric and affecting the temperature of the timber panel.

<u>Roof Voids.</u>

SENSORS 156 and SUR1.

Sensor SUR1 is attached directly to the roof void side of the painted ceiling and gave consistently lower readings than SUR2 which is on the inside of the building. Both temperature sensors followed the same pattern as the external readings, see graph 3. The two internal temperature readings are separated by between 2° and 4°, the surface being the higher. As mentioned previously, this is due to heat passing through the wooden ceiling and hence directly influencing the sensor readings.

Graph 4 shows a selection of readings taken from the sensor 156 and the external sensor at the end of January. This clearly demonstrates that there is a "buffering" effect given by the building fabric. The internal relative humidity is generally within a desired range of between 45 and 70%.

## CONCLUSIONS.

Comparing the data obtained from the external sensor with that recorded within the roof space, it is unlikely that a situation would arise where condensation will form on the wooden ceiling. This has been confirmed by use of a diagnostic computer programme which confirms that the ceiling temperature is always several degrees above the point where interstitial condensation will occur. A print from the programme (Graph 5) shows the predicted temperature profile using the existing roof construction of tiles, bitumen felt and wooden boards. As the roof is in good repair, these results would tend to disprove any theories that the damage was caused by water ingress in the recent past.

It is probable that the shrinkage of the painted ceiling coincided with the conversion of the

Gurney stoves to gas firing. The relative humidity is likely to have been reduced with the increase of temperature thus altering the equilibrium moisture content of the wood. This would have caused some degree of shrinkage of the wood resulting in conditions where it became possible for the fastenings to become dislodged. Visual inspection of the ceiling should continue to check whether the condition of the wooden panels has stabilised or if the fastenings are continuing to become dislodged.

Additional sensors were installed in April and these should give information which will make a more detailed analysis possible.

K Waterman
25/5/95

**SITE: PETERBOROUGH CATHEDRAL**
**MONITORING DATES: 10th JANUARY TO 4th APRIL 1995 (Period 1)**

(E denotes 'Expanded Graph' Included)

| SENSOR POSITION | | TEMPERATURE | | | | RELATIVE HUMIDITY % | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | MAX | MIN | MEAN | STD DEV | MAX | MIN | MEAN | STD DEV |
| External Sensor Located on the North Wall | | 19.76 | -2.32 | 6.54 | 3.46 | 100 | 43 | 85.31 | 11.33 |
| S155 PULPIT GROUND LEVEL | | 20.72 | 12.8 | 16.51 | 1.31 | 62 | 37 | 50.68 | 4.78 |
| S158 FIRST LEVEL ABOVE PULPIT | E | 20.96 | 14.48 | 16.93 | 1.37 | 61 | 36.5 | 50.05 | 4.69 |
| S157 SECOND LEVEL ABOVE PULPIT | E | 20.96 | 14.48 | 17.12 | 1.34 | 59.5 | 35 | 48.13 | 4.82 |
| SUR2 SURFACE TEMPERATURE ON PAINTED CEILING | E | 19.52 | -6.64 | 15.81 | 1.88 | | | | |
| S159 ADJACENT PAINTED CEILING | | 20.96 | 14.48 | 17.36 | 1.38 | 55 | 33.5 | 46.95 | 3.65 |
| SUR1 SURFACE TEMPERATURE ROOF SPACE NORTH SIDE | | 20.96 | 7.76 | 13.44 | 1.97 | | | | |
| S156 ROOF SPACE NORTH SIDE LOW LEVEL | | 20.72 | 5.6 | 11.16 | 2.37 | 87.5 | 35 | 61.2 | 8.01 |