Chapter 21

Testing and Calibrating a TAS Model of a Historic Building

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1 Summary

TAS Building Designer is a building simulation tool that simulates the dynamic environmental performance of buildings. The computer model takes into account external weather conditions, building fabric properties, occupancy levels, and ventilation rates (including air infiltration).

It was used to examine the hygrothermal environment inside an old church of heavyweight construction and with extensive mould growth in parts of the interior. Environmental monitoring was undertaken so that real data could be used to validate the predicted results from the simulation modelling.

2 Introduction

St Peter's Church is located in Northampton, England. It is a Norman Church built in approximately 1150. The Tower, along with the Nave and Chancel underwent extensive restoration between the 17th and 19th century. In December 2000, a small damp patch was noticed in the northeast corner of the Chancel. By Spring 2002, the entire north wall of the Nave, and the Tower wall were affected by mould growth.

3 Monitoring

In order to understand the causes of the mould growth and to begin the process of validating the computer model, environmental monitoring was undertaken for a period of one month. Temperature, dew point and relative humidity were monitored and vapour pressure was derived in seven areas of the Church as indicated on the plan.

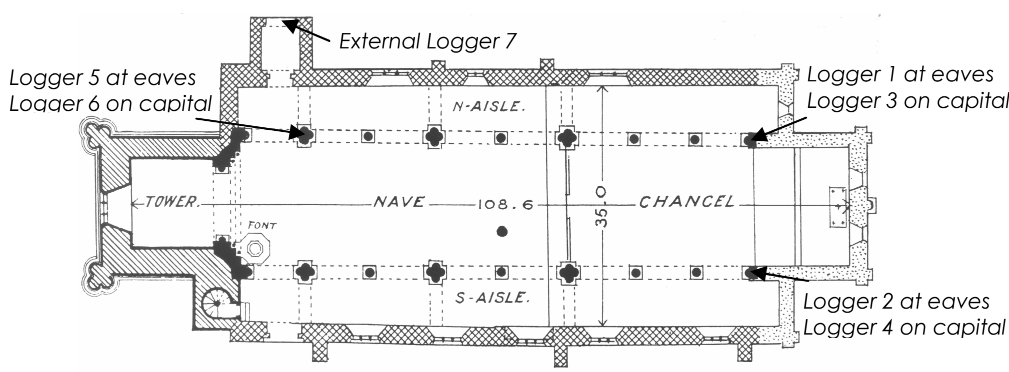

Figure 1: Floor plan with data logger locations

4 Infiltration Rate

To improve the accuracy of the computer simulation modelling the air infiltration rate was measured. Tracer gas provides a cost-effective method of measuring ventilation, infiltration and air change rates (ACR). Sulphur hexafluoride is an inert gas and often used for tracer gas measurements. It is harmless to occupants and causes no damage to the building fabric. During tracer gas measurements a small amount of sulphur hexafluoride is released into the interior of a closed building. A large fan is used to mix thoroughly the sulphur hexafluoride in the air. A multi-gas meter then measures at regular intervals the concentration of sulphur hexafluoride remaining in the air.

If the concentration of the sulphur hexafluoride decreases slowly, it indicates a low air infiltration rate into the building. If the concentration of the sulphur hexafluoride decreases quickly, it indicates a higher air infiltration rate.

Figure 2 illustrates a plot of the natural log of the gas concentration (parts per million) of sulphur hexafluoride against time in St Peters Church. The gradient of the 'line of best fit' equates to the ACR. St Peters Church has an ACR of approximately 0.3, which is average for this type of building.

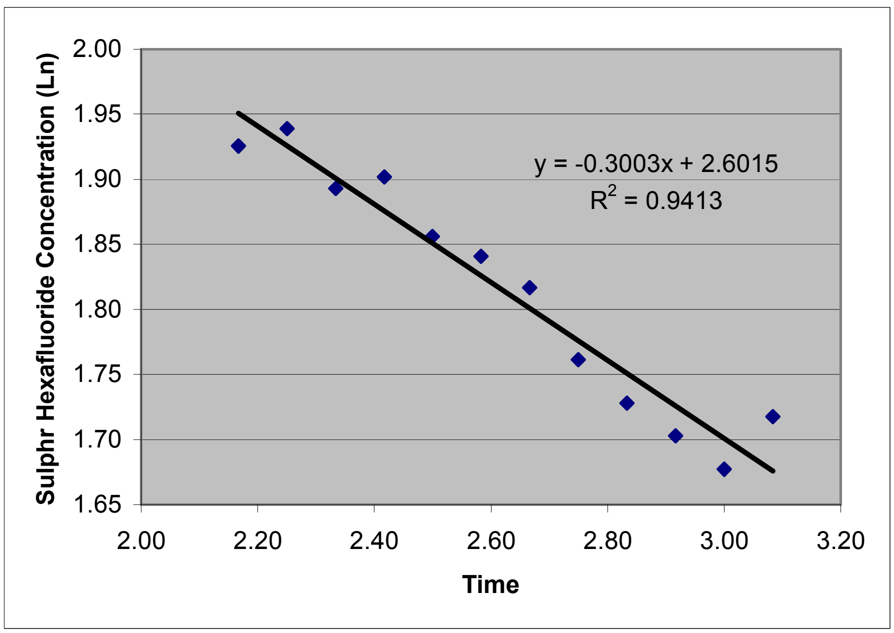

Figure 2: Graph showing air change rate

5 Computer Simulation

The illustrations below show St Peters Church and the three-dimensional TAS model of St Peters Church as observed from the southwest elevation.

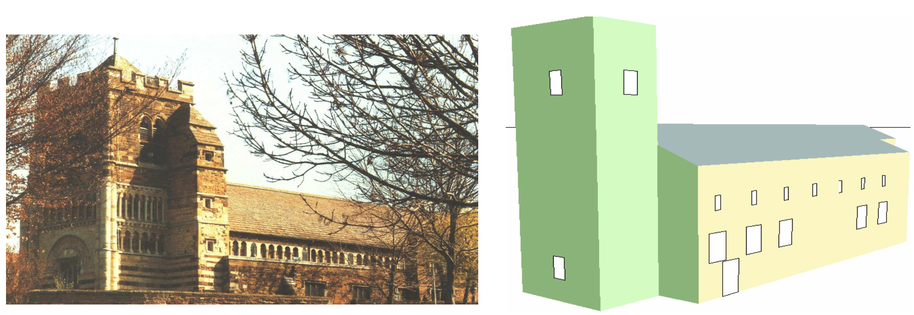

Figure 3: Photograph and TAS model of St Peters Church

6 Comparison between Predicted and Monitored Data

Figure 4 compares the predicted and monitored temperatures for St Peters Church during August 2003. The root-mean-square difference between the predicted and monitored data is 1.0^{o}C. This indicates that there is a strong correlation between both sets of data.

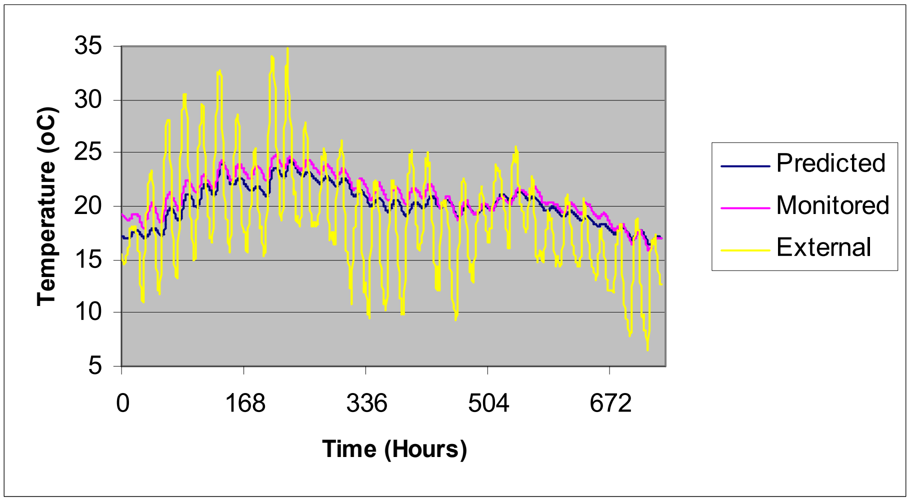

Figure 4: Comparison of predicted and monitored data

Figure 5 compares the predicted and monitored relative humidity for St Peters Church during August 2003. The predicted data follows the monitored data, but shows greater difference. The root-mean-square difference between both sets of data is 7%.

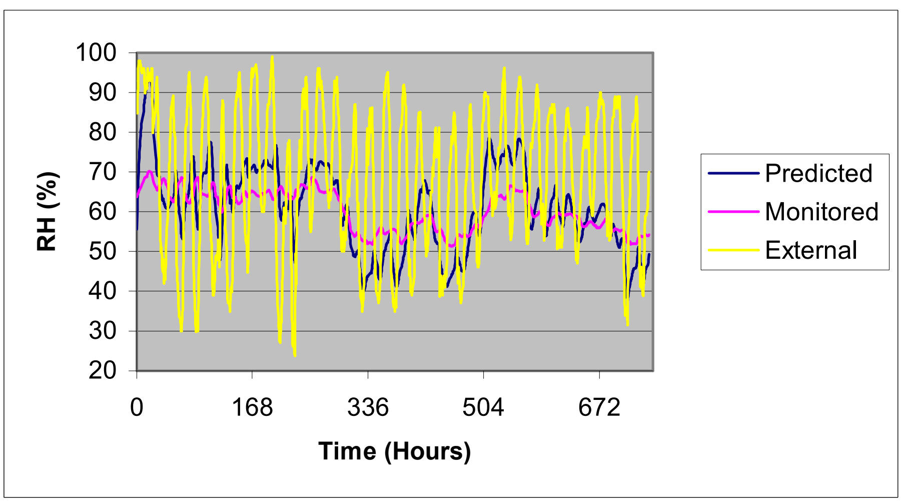

Figure 5: Comparison of predicted and monitored data

The large difference between the predicted and modelled relative humidity is expected as the TAS Building Designer tool does not take into account moisture absorption and release by the building fabric. Normally at times when vapour pressure is high, moisture is absorbed into the building fabric, and at times of low vapour pressure, moisture is released back into the atmosphere. This is demonstrated in figure 6 where the predicted vapour pressure is comparable to the external vapour pressure, and not to the monitored vapour pressure as was the case with temperature.

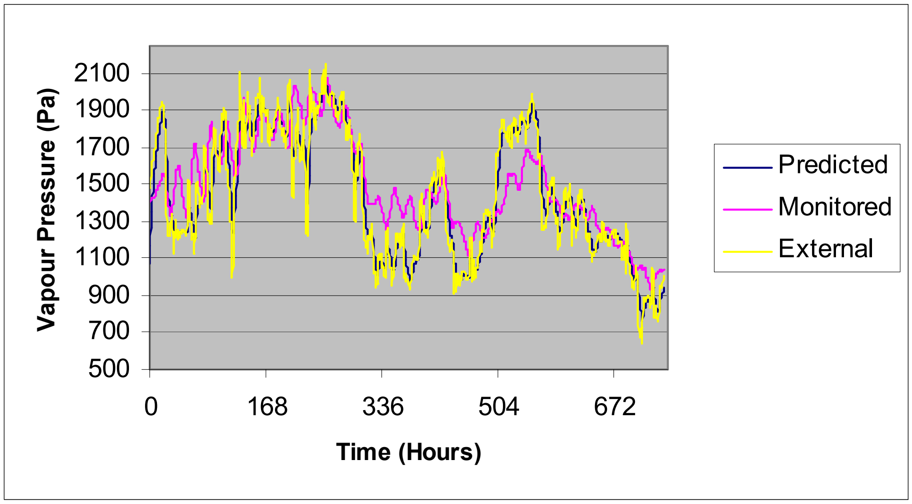

Figure 6: Comparison of predicted and monitored data

7 Conclusions

The combination of real monitoring and computer simulation has proven to be very useful in investigating the hygrothermal environment within St Peters Church. TAS has accurately predicted the temperature inside the Church. The disadvantage of TAS is that it does not take into account moisture absorption and release by the building fabric. This can have significant implications in the final results as moisture storage within the building fabric itself can have a great impact on the internal environment. It is therefore critical that the right model for the task in hand is used. In the case of St. Peter's Church a computer tool which takes into account moisture interaction will be used next.

So future work will include accessing and validating other building simulation tools such as EnergyPlus and WUFI. EnergyPlus allows a model to be constructed that takes into account the moisture buffering capacity of the building fabric. WUFI can model one-dimensional heat and moisture transport in multi-layer building components exposed to the external weather. WUFI will be used to model the hygrothermal behaviour within the building fabric.

Once this work has been completed, a cost effective environmental strategy will be suggested that will minimise the potential danger of further mould growth. Appropriate environmental conditions will also be suggested to decrease the possibility of any future damage to the decorative finishes and building fabric within St Peters Church.

Acknowledgements

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