Client Report :

Thermographic Inspection of the Masonry and Hemp Houses – Haverhill, Suffolk

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Executive Summary

J Yong from the Centre for Concrete Construction (CCC) and V Clark from the Centre for Whole Life Costing and Conservation (CWLCC) conducted a thermographic survey of No's 10 and 12 Teasel Close at Haverhill, Suffolk on the 13 and 14 March 2003. The houses were of masonry and hemp construction respectively.

The primary aim of this survey was to capture thermographic images of the front, side and rear elevations of the chosen houses and detect the location of any significant heat losses through the external walls and windows of each property. The data obtained from this survey will be used to provide an indication of the thermal emissivity of the external walls and windows from each selected house.

It was discovered from an examination of the composite images of the front and rear elevations of both houses that there was significant heat loss through the external walls and windows from the traditionally built Masonry House in comparison with the Hemp House.

Contents

1 Introduction

1.1 Background

The Hemp Home Project has been undertaken by the Suffolk Housing Society, of Bury St Edmunds, with support from the Housing Corporation and St Edmundsbury Borough Council. Suffolk Housing Society and St Edmunsbury has engaged the support of the Housing Corporation to fund the Building Research Establishment to carry out extensive research into the project. The purpose of this was to demonstrate that hemp and lime construction is a viable low energy alternative to the more conventional forms of construction based on brick and concrete blocks.

The Hemp Houses and their Masonry constructed neighbours are part of a larger £1.5 million housing development, £675,000 of which was provided in the form of a social housing grant jointly by St Edmundsbury Borough Council and the Housing Corporation. The four properties involved – two hemp and two brick/block – in the research project cost £176,000 to build. The research has cost £75,000 and has been paid for in part by a £60,000 Innovation and Good Practice grant from the Housing Corporation.

J Yong from the Centre for Concrete Construction (CCC) and V Clark from the Centre for Whole Life Costing and Conservation (CWLCC) at the Building Research Establishment (BRE) conducted a thermographic survey on two of the houses, No's 10 and 12 Teasel Close at Haverhill, Suffolk on the 13 and 14 March 2003. The houses were of masonry and hemp construction respectively.

The primary aim of this survey was to capture thermographic images of the front, side and rear elevations of the chosen houses and detect the location of any significant heat losses through the external walls and windows of each property. The data obtained from this survey will be used to provide an indication of the thermal emissivity of the external walls and windows from each selected house.

1.2 Thermography

The use of infrared thermography as a non-destructive evaluation (NDE) technique is primarily aimed at detecting sub-surface features, including defects and anomalies, that can not be detected using standard inspection techniques. The basic principle underpinning many thermographic NDE techniques is that the spatial spread of a heat flux on the surface of a specimen with respect to time depends upon the homogeneity of the specimen, its thermal diffusivity and is influenced by the presence of internal defects. A temperature difference at the surface generated by the differences in thermal conductivity between flaws and the base material/substrate can be detected by an infrared imaging system and thus reveal the presence of defects.

Thermography can be used in either a passive or an active manner but in this investigation, the passive manner was used. The passive thermographic technique relies on natural heat distributions over the surface of a structure and it is usually employed for non-destructive evaluation of buildings, components and processes. Passive thermography in most cases is qualitative and is used to detect anomalies. In some cases, however, with direct thermal modelling it can provide quantitative measurements as well.

In order to obtain satisfactory results which shows the areas of heat loss, it is necessary for the site worker undertaking a thermographic survey to be not only fully conversant with the operation of the equipment but to have a sound knowledge of the materials contained in the structure under investigation and of the ambient conditions required to produce an interpretable thermal image.

2 Description of the project

The basic conditions necessary for a thermographic survey to be carried out are when there is a temperature difference (at least 14^{o}C) between internal and external air temperatures, according to the research carried out by the Energy Efficiency and Renewable Energy Clearinghouse (EREC). Normally, thermographic scans are carried out either in the winter when there is maximum internal central heating of the surveyed house or during warm weather when an air conditioning system has been working.

Before the thermographic survey, site orientation was conducted to ensure familiarity of the site workers with the area being investigated. In this case, the thermographic survey was carried out at the front and rear of both the houses in the evening between 8.30pm – 10.30pm. The house owners were requested to switch on the heating to 20^{o}C from 5pm onwards to allow approximately 3 hours of heating before the thermographic survey was conducted. In order to compare the temperature both inside and outside the houses, measurements were taken using a thermometer. The indoor temperature was monitored in each home using temperature and humidity loggers by the CWLCC.

The temperature scale of the infrared (IR) camera was set to be consistent between -3.0^{o}C to 7.3^{o}C representing a temperature differential of 10.3^{o}C. All the thermographic images were taken using the same temperature scale throughout the survey process to aid comparison between the two houses. The distance between the tripod and the inspected houses was obtained using a Laser Disto 'Classic' measuring instrument.

The order in which the survey was carried out is shown in Table 1. Due to the presence of bushes it was not possible to capture the entire front elevation of either the Hemp or Masonry House with a single image. Similarly, problems were encountered at the rear of the houses due to the location of the back gate and fence. Consequently, several thermal images for each elevation were assembled together to form a complete image of the front and rear elevation for the respective houses.

3 Findings

The details and timings relevant to the thermographic survey of the Masonry and Hemp Houses are shown in Table 1 below:

Type of Houses	Masonry House (Front)	Hemp House (Front)	Masonry House (Rear)	Hemp House (Rear)
Time taken at the start of the thermographic survey (24 hours)	20:50	21:15	21:34	21:43
Distance between the tripod and the inspected surfaces (m)	9.52	9.58	9.18	6.76
Outdoor temperature (^{o}C)	2	1	1	1

Table 1: Details of the thermographic survey.

According to the data collected, approximately 30 minutes were required to obtain the thermal images for each elevation surveyed. As a consequence, it took approximately 2 hours to complete the thermographic survey of both houses. Images taken as part of the survey have been presented as Figures 1 to 11 of Appendix A. Figures 12-14 are graphs of the temperatures monitored in the house over the winter and particularly on the evening of the thermographic survey.

3.1 Masonry House

The Masonry House is understood to be off traditional cavity wall construction with a tiled timber roof.

The digital photo and thermographic image of the front elevation of the Masonry House are shown as Figures 1 and 2 respectively. Figure 2 is compiled from six separate thermal images. The digital photo and thermographic image of the rear elevation of the Masonry House are shown as Figures 3 and 4 respectively. Figure 4 is again compiled from six separate thermal images.

3.2 Hemp House

The Hemp House is founded on a limecrete foundation and brick plinth. The walls are of a timber “balloon” type structural frame and these were shuttered and cast using a hemp/sand/lime matrix (in small lifts). The ground floor is a hemp / lime / sand slab topped with a sand / lime screed. The upper floor is of tongued and grooved boarding on timber joists . The roof is of trussed rafters and is covered with concrete tiles. Heating pipes and conduits for the electrical services are cast into the wall matrix.

The digital photo and thermographic image of the front elevation of the Hemp House are shown as Figures 5 and 6 respectively. Figure 6 is compiled from six separate thermal images. The digital photo and thermographic image of the rear elevation of the Hemp House are shown as Figures 7a, 7b and 8 respectively. Figure 8 is compiled from nine separate thermal images.

3.3 Comparison of the Masonry and the Hemp Houses

The results of the thermographic survey conducted by BRE indicated that there was a significant amount of heat loss through the external walls and windows to the Masonry House in comparison with that occurring in the Hemp House (Figures 11a, 11b, 11c and 11d). Unfortunately, a problem was encountered during the assembly of the thermographic images resulting in a slight distortion of the images of the houses. However, the completed images of the front and rear elevations to both houses clearly reveal a contrast in the thermal losses occurring in each of the two houses.

The thermographic image shown in Figure 6 indicated that in comparison to the remaining areas of walling there was significant heat loss through the section of the foundation wall below damp proof course (dpc) level immediately adjacent the right front corner of the property. It is understood that the foundation wall consists of a brick plinth built in steps and staggers with frost resistant bricks below ground. This area is not insulated. It should be noted that the ground level adjacent the wall to the left hand side of the front door shown in Figures 5 and 6, was coincident with the dpc level and not below it as on the right hand side of the door. Hence there was no indication of excessive heat loss on the left hand side of the front door shown in Figure 6 as this area of walling was hidden from the camera. Furthermore, from the thermographic image taken of the upper left hand first floor window to the rear elevation of the house, there was heat loss due to the trickle ventilation (shown in Figures 9 and 10).

In comparing the results obtained from the survey of the Masonry and the Hemp Houses (refer Figures 11b and 11d), it appears that the temperature of the external walls to the Masonry House is slightly higher by approximately 4^{o}C to 6^{o}C than the walls to the Hemp House. It is assumed that the temperature of the “Balanced flue vent to the central heating boilers” in the two houses is similar and therefore can be used as a reference temperature scale for the background temperature of the two houses.

From figures 12 and 13, the record of the temperature on the night of the survey, it is possible to see that the difference between the external temperature and internal temperatures of the houses was more than 14 ^{o}C in accordance with the necessary conditions of the test. From the graphs of figure 14 it is evident that the temperatures throughout the winter remained steady and similar in both houses therefore the heating system in the masonry house would have to work harder if the heat loss through the walls was greater than in the hemp house. The gas and electricity consumption was measured independently of BRE and this showed that the masonry house did use more energy throughout the winter than the hemp house.

4 Conclusion

Based on the thermographic survey carried out, the following conclusions can be drawn:

- The temperature monitored in both the houses during the test shows it was a steady 14 ^oC more than the external temperature as the test required and the heating system was capable of maintaining the internal temperature at the requested level.
- Data obtained using the IR camera shows the Hemp House was cooler than the Masonry House by approximately 4^oC to 6^oC (as shown in the temperature scale of the IR camera).
- Given that the internal temperature of both houses was similar on the night of the test we can conclude that the external walls of the Hemp House appear to retain more heat than those of the traditionally built Masonry House.

5 References

1. *Consumer Energy Information: EREC Brief about Thermography*
   http://www.eere.energy.gov/consumerinfo/refbriefs/cb3.html
   [Accessed: 26 March 2003]

2. Yates T. Final Report on the Construction of the Hemp Houses at Haverhill, Suffolk. Client report number 209-717 Rev.1, August 2002.

Appendix

Figure 1: Front elevation of the Masonry House at No.10 Teasel Close, Haverhill, Suffolk.

Figure 2: Thermographic image which represents the front elevation of the Masonry House as shown in Figure 1: Colour graduation represents temperature scale of -3^{o}C to 7.3^{o}C.

Figure 3: Rear elevation of the Masonry House at No.10 Teasel Close, Haverhill, Suffolk.

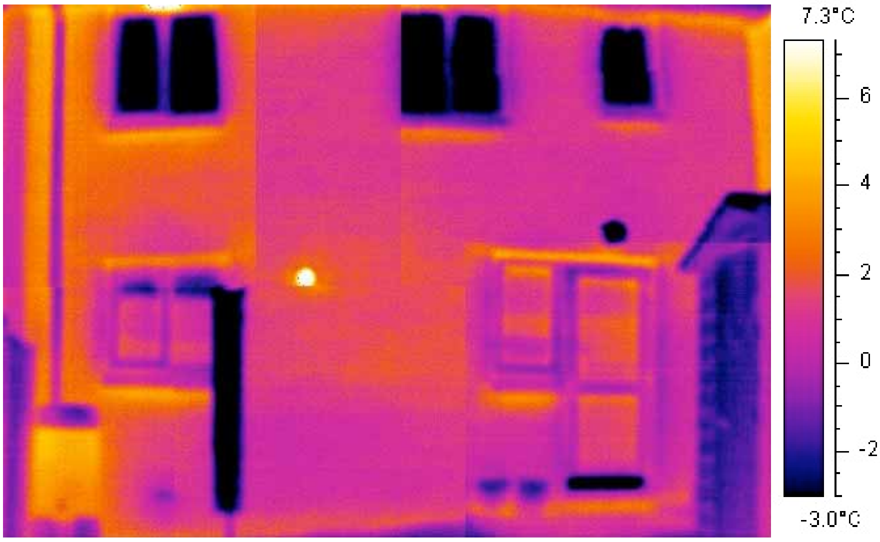

Figure 4: Thermographic image which represents the rear of Masonry House as shown in Figure 3: Colour graduation represents temperature scale of -3°C to 7.3°C.

This area was made of Masonry

Figure 5: Front elevation of the Hemp House at No.12 Teasel Close, Haverhill, Suffolk.

This area was made of Masonry

Figure 6: Thermographic image which represents the front elevation of the Hemp House as shown in Figure 5: Colour graduation represents temperature scale of -3°C to 7.3°C.

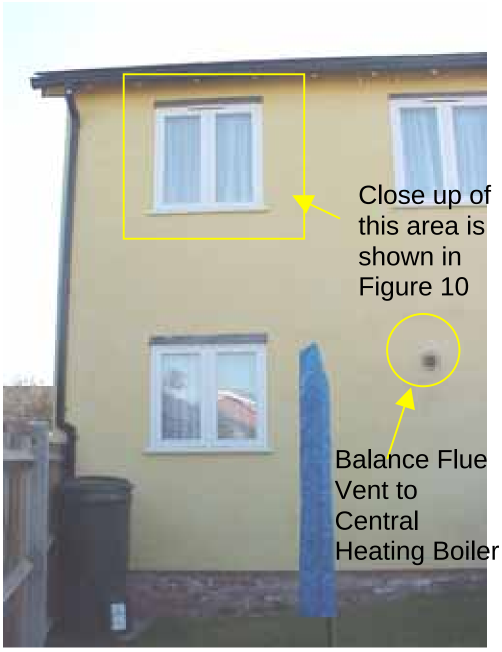

Figure 7a **Figure 7b**

Figures 7a and 7b: Rear elevation of the Hemp House at No.12 Teasel Close, Haverhill, Suffolk. It was impossible to capture the whole back elevation due to the location of the back gate therefore two separate digital images had to be obtained.

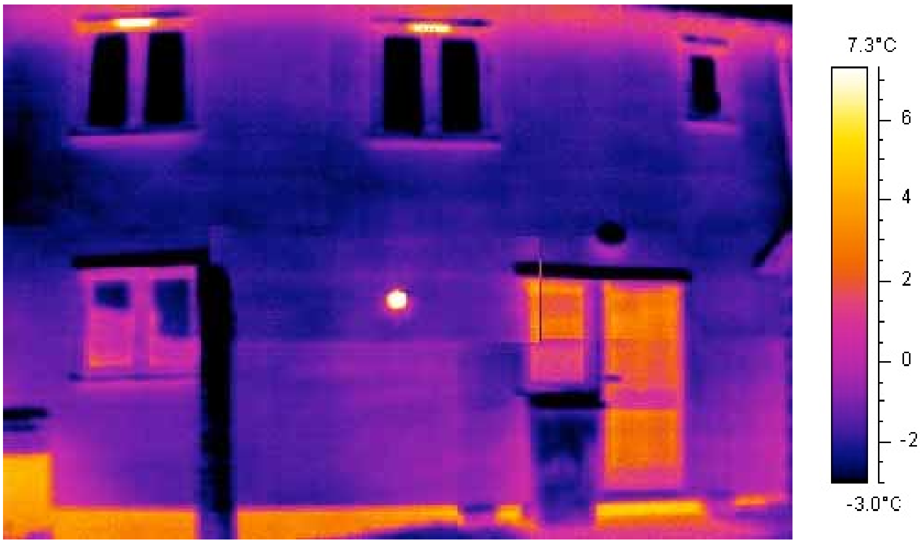

Figure 8: Thermographic image which represents the rear of Hemp House as shown in Figure 7a and 7b: Colour graduation represents temperature scale of -3^{o}C to 7.3^{o}C.

Figure 9: This photo showed the area where there was heat loss from the trickle ventilation (at the back window of the Hemp House).

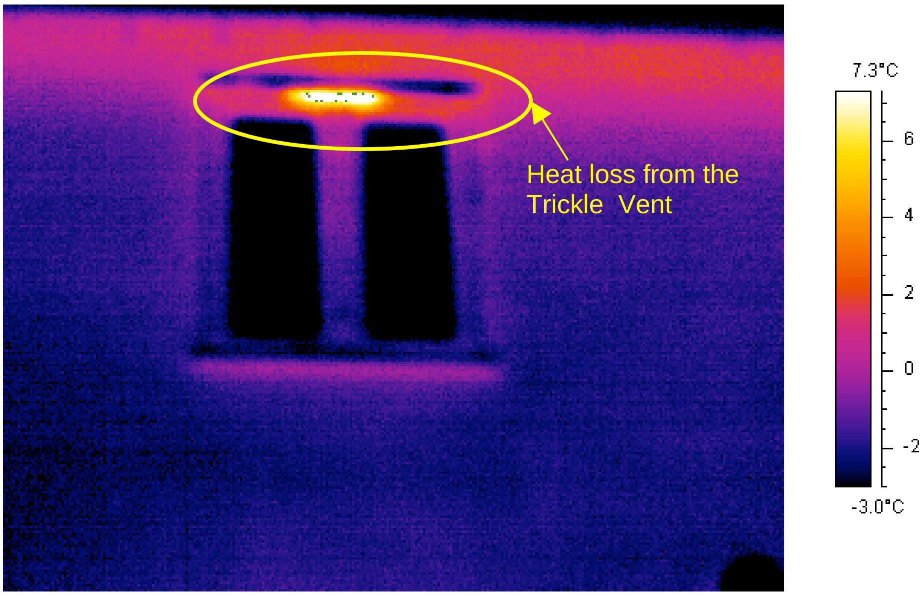

Figure 10: Thermographic image showing the area where the heat losses took place.

Figure 11a: Thermographic image of the front of the Masonry House.

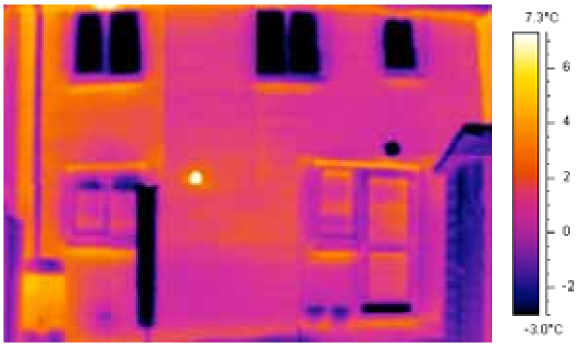

Figure 11b: Thermographic image of the rear of Masonry House

Figure 11c: Thermographic image of the front of Hemp House.

Figure 11d: Thermographic image of the rear of the Hemp House.

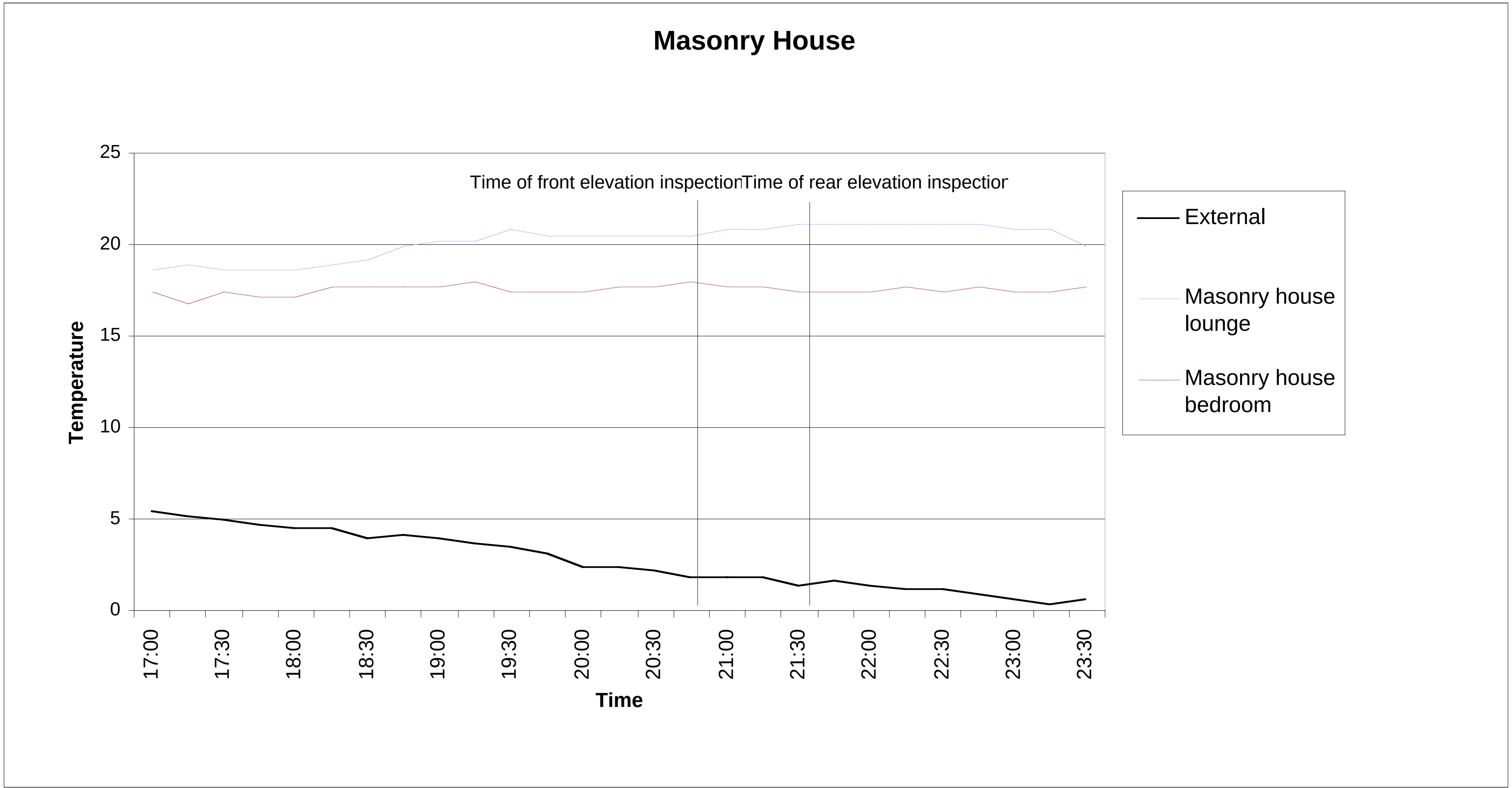

Figure 12 Temperature inside the masonry house on the evening of the thermographic survey

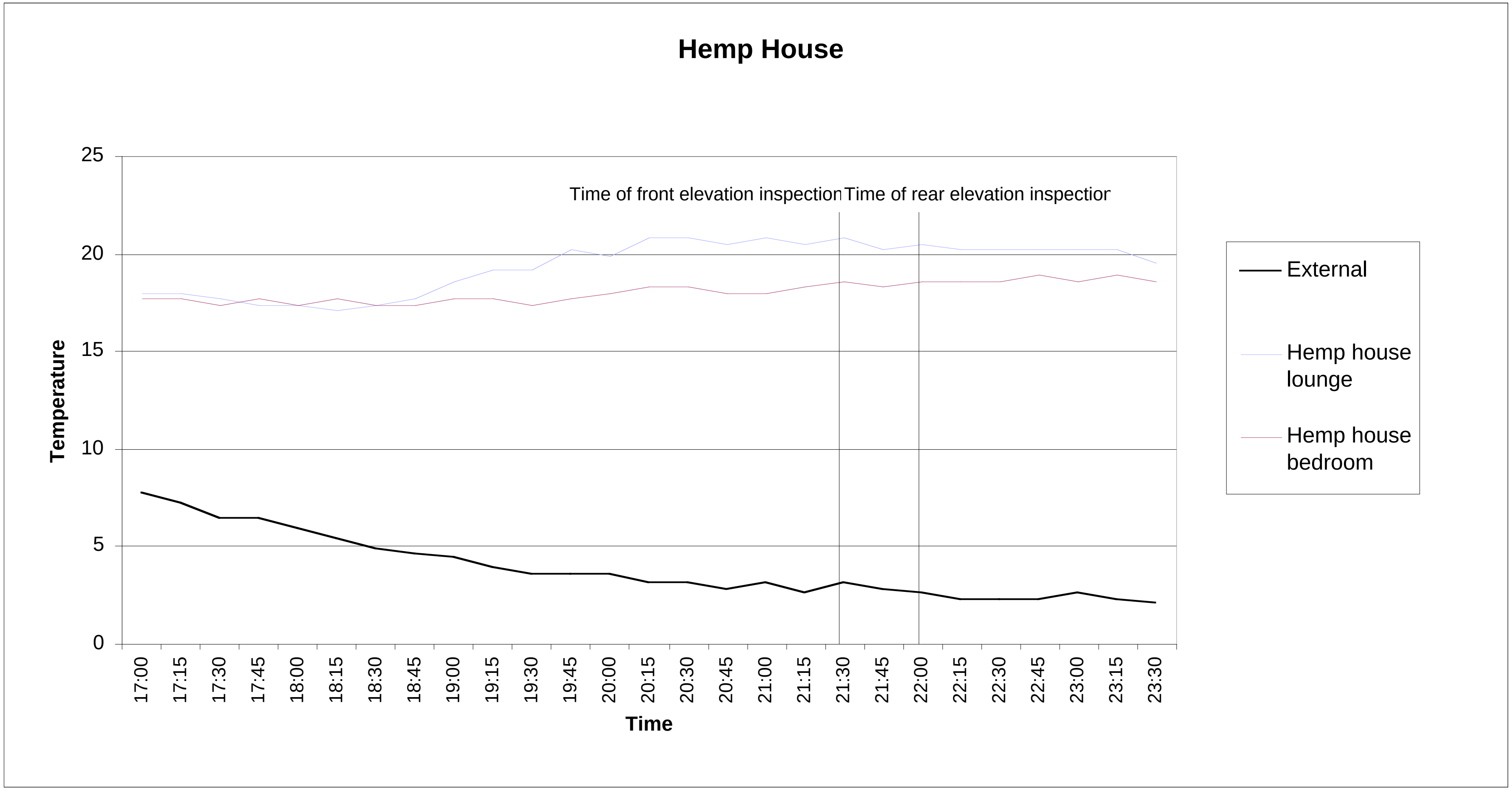

Figure 13 Temperature inside the hemp house on the evening of the thermographic survey

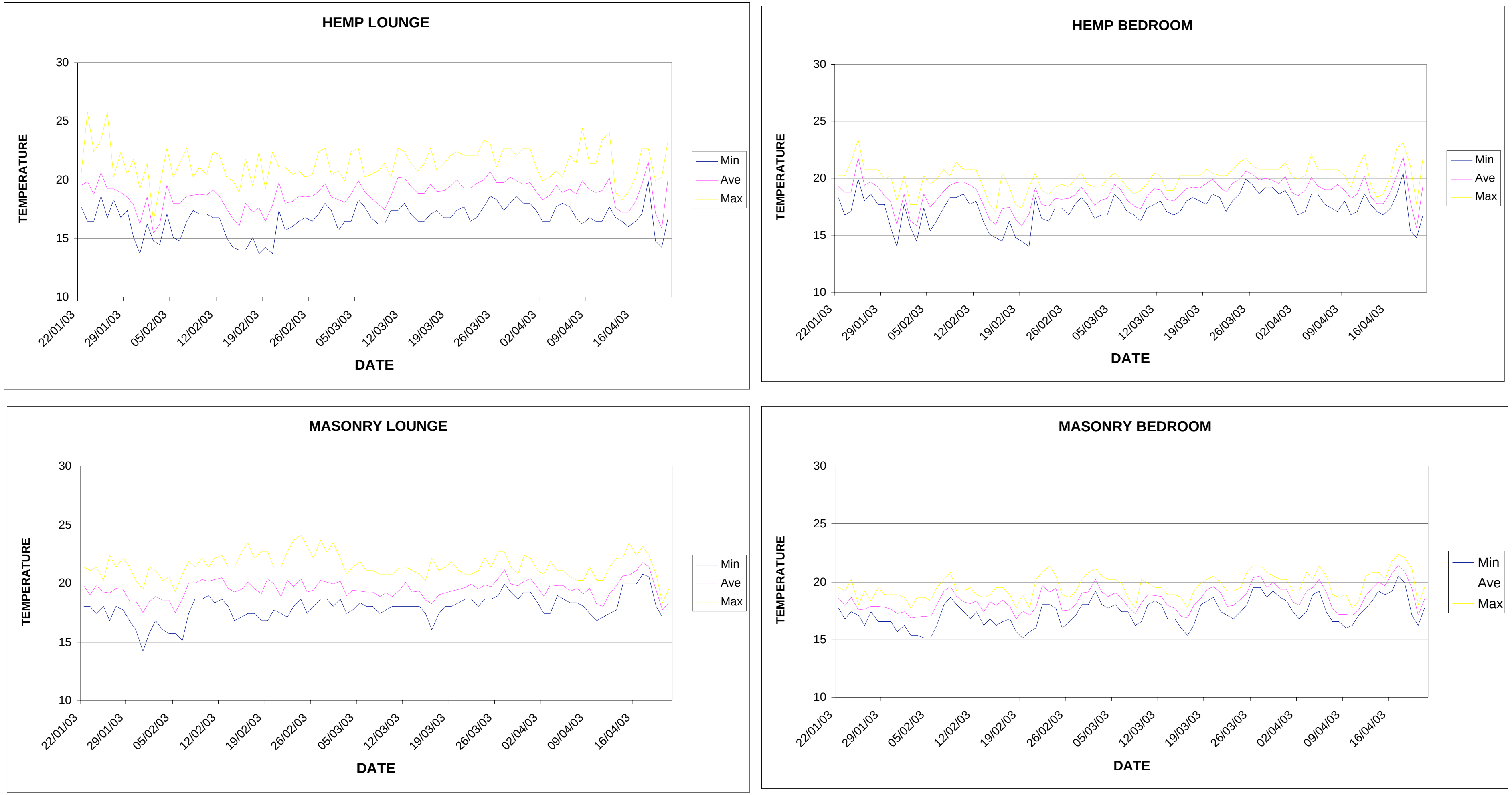

Figure 14 Temperatures in the two houses during the monitoring period