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SCIENCE DIRECT
Energy and Buildings 36 (2004) 515–523
ENERGY and BUILDINGS
www.elsevier.com/locate/enbuild

Thermographic survey of two rural buildings in Spain

Silvia Martín Ocaña [a,*], Ignacio Cañas Guerrero [a], Ignacio González Requena [b]

[a] *Departamento de Construcción y Vías Rurales, Escuela Técnica Superior de Ingenieros Agrónomos, Universidad Politécnica de Madrid, Avda. Complutense s/n, 28040 Madrid, Spain*

[b] *Departamento de Materiales y Producción Aeroespacial, Escuela Técnica Superior de Ingenieros Aeronáuticos, Universidad Politécnica de Madrid, Madrid, Spain*

Received 24 June 2003; received in revised form 15 December 2003; accepted 23 December 2003

Abstract

Two common housing prototypes of existing buildings in Spanish rural areas were surveyed by infrared inspection. The aim of the study is to assess the usefulness of infrared thermography as a technique for the detection of the thermal performance of rural buildings. For the traditional house the best results were obtained in the thermographic survey carried out in the evening. Contrarily, for the modern house the thermographic survey at daybreak provided more information. Infrared thermography allowed the comparison of the thermal performance of two buildings.

Keywords: Thermography; Thermal performance; Rural housing

1. Introduction

Infrared thermography is being widely employed in some countries to determine the heat losses in urban buildings [1], as well as to predict structural failures [3] and problems relating to humidity [4]. In the present article, the application of thermographic surveys for rural buildings usually found in Spain are analysed, following the suggestions made for old buildings [5,6].

Two common housing prototypes of existing buildings in rural areas of Spain were chosen for the study, both were constructed by different techniques. One building, hereafter called traditional building, was constructed at the end of XIX century with traditional techniques. The other building, hereafter called modern building, was constructed 22 years ago with actual techniques. The aim of the study is to assess the usefulness of infrared thermography as a technique for the detection of the thermal performance of buildings. The surveys were carried out at two times, in the late evening and in the early morning, for avoiding the possible mistakes from direct solar radiation [2,8]. Furthermore, the temperature inside and outside the buildings was measured with the objective of examining in detail the results obtained by the thermographic survey.

2. Theoretic basis

All materials have the capacity of absorbing infrared radiation, increasing its temperature. As well as all materials, whose temperature is above absolute zero emit infrared energy. Human eye is only able to receive the emissions belonging to the visible wavelength. Infrared radiation is located between visible and microwaves regions in the electromagnetic spectrum, comprising the wavelength from 0.75 to 10 μm. Infrared thermography is a technique that turns the emission pattern of an object into a visible image. The thermographic cameras are used to measure the infrared radiation emitted by an object. Really the thermographic camera does not measure the temperature but the radiation of materials, and by means of an interpolation in the Stefan–Boltzmann law (1) it is possible to get the temperature:

$$E = \varepsilon \sigma T^4 \quad (1)$$

where E is the energy of radiation (W/m^2), T is the temperature (K), σ is the Stefan–Boltzmann constant (5.67×10^{-8} W/(m^2 K^4)) and ε is the emissivity (non-dimensional).

The radiation measured by the camera depends on the temperature of the object surface as well as on the emissivity of the material.

There are infrared cameras of short and long wavelength. For the purpose of this investigation, it is necessary to use a long wavelength camera. The advantages of the long wavelength camera are: (1) it goes well at ambient temperatures;

* Corresponding author. Tel.: +34-9133-65767; fax: +34-9133-65625.
E-mail address: smartin@cvr.etsia.upm.es (S. Martín Ocaña).

0378-7788/$ – see front matter
doi:10.1016/j.enbuild.2003.12.012

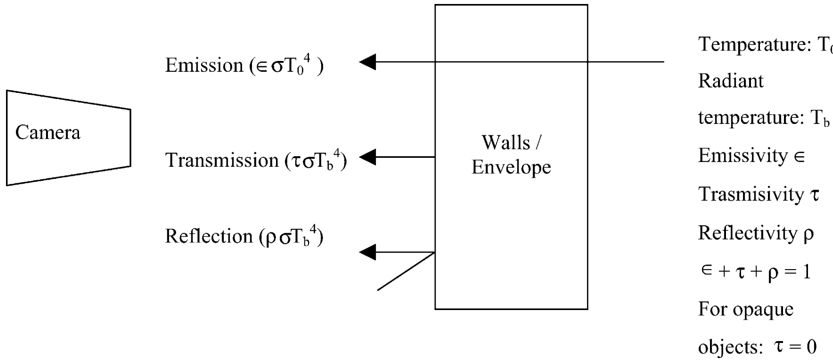

Fig. 1. Components of radiation measured by thermographic camera.

(2) it is able to detect small temperature differences; and (3) it is less affected by solar reflection.

An object can reflect, transmit, and emit radiation. These three components of radiation are detected by infrared camera (see Fig. 1).

Most of the construction materials have emissivity values from 0.9 to 0.95, these high figures make it possible to get an accurate value of temperature. However, there are some materials with lower values of emissivity (metallic materials and materials with brilliant surface). These materials perform badly with the measurement of temperature by thermographic surveys and usually the thermography gives values of temperature lower than the real ones. In addition, due to their high reflectance, when solar rays fall upon them, points with higher temperature appear on the thermographic image. For the detection of this type of mistakes, it is recommended to make the survey from different locations and at different times.

3. Characteristics of the camera

The infrared camera used in this research is a ThermaCAM SC 2000 from FLIR SYSTEMS, and the software is ThermaCAM Researcher 2001 (from FLIR). The camera has the ability to make both thermal and visual images, with real-time 14-bit digital output and auto focus. The ThermaCAM SC 2000's system automatic calibration uses four internal temperature references, automatic lens identification, and mathematical algorithms to ensure industry leading measurement performance. The technical specifications of the camera are:

- Field of view/minimum focus distance: $24^\circ \times 18^\circ/0.3$ m;
- Thermal sensitivity: $0.07\,^\circ$C at $30\,^\circ$C;
- Spatial resolution (IFOV): 1.3 mrad.

4. The assessed buildings

The thermal performance of buildings was analysed by the thermographic survey of two different buildings located in Castillejo de Robledo, a small village of the province of Soria, characterised by its cold winters (see Fig. 2).

4.1. The traditional building

This building was constructed at the end of XIX century, it maintains its original exterior walls. Some alterations have been made but they are related only with the interior parts of the building (flooring, painting, interior divisions, and stair; see Fig. 3).

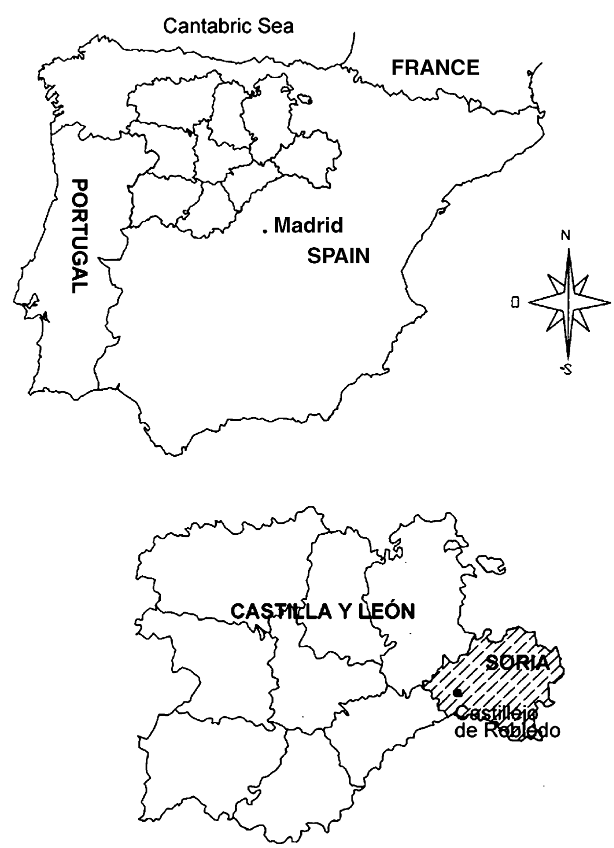

Fig. 2. Map of location of Castillejo de Robledo.