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# Infrared thermography for assessing moisture related phenomena in building components

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## HIGHLIGHTS

- Tracing moisture using non-destructive technics is an advantage in buildings in use.
- IRT accuracy is higher in low reflectance surfaces and during the night.
- IRT detects invisible moisture problems.
- IRT may be used to assess the drying process.
- In quantitative approaches parameters as radiation, wind, T and RH must be included.

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## ABSTRACT

In this work the potential of infrared thermography (IRT) to assess moisture related phenomenon was tested. Initially, several set-ups and boundary conditions were created to compare IRT with other techniques and to understand the ideal conditions for accurate IRT. Afterwards, IRT was used to assess capillary absorption on a full-scale laboratory model and the drying process of two exterior walls. The main conclusions were that smaller differences are obtained for low reflectance surfaces and during the night, IRT can detect invisible moisture problems and can be used to assess the drying process, although the phenomenon complexity raises some difficulties if a quantitative approach is intended.



## 1. Introduction

The problem of moisture in buildings has always aroused great interest, since moisture is one of the main causes of buildings' pathologies. Damage may occur due to the presence of moisture itself or due to its evaporation. Moisture and the drying process may cause degradation of building materials and components, compromising their performance concerning durability, mechanical resistance, waterproofness and appearance. It can also cause unhealthy conditions for users, resulting from biological growth and degradation of materials and building components. Moisture may have different causes that can be divided into 6 groups: built-in moisture; rising damp; infiltrations due to wind-driven rain; surface condensations; moisture due to hygroscopic phenomena; and moisture due to accidental causes.

Moisture content is traditionally assessed using destructive procedures, which require collecting a wall sample to be weighed in laboratory. However, moisture content can also be assessed using non-destructive techniques as moisture detectors. These techniques, although not as accurate as the destructive procedures, are very easy to use and deliver results in real time [1].

Infrared thermography (IRT) is a non-contact and non-destructive testing technology that can be applied to determine the surface temperature of an object. The detectors collect infrared radiation emitted by the surface and convert it into a thermal image with the distribution of the body superficial temperature, the thermograghs. In this process, each pseudo-colour expresses a certain range of temperatures (Fig. 1).

Two approaches can be used to obtain the surface temperature distributions using infrared (IR) cameras: the passive and the active approach [2]. Thermal images can be analysed qualitatively or quantitatively [3] and can be affected by several parameters related to materials properties and to ambient conditions: (a) emissivity, which is crucial if a quantitative analysis is required

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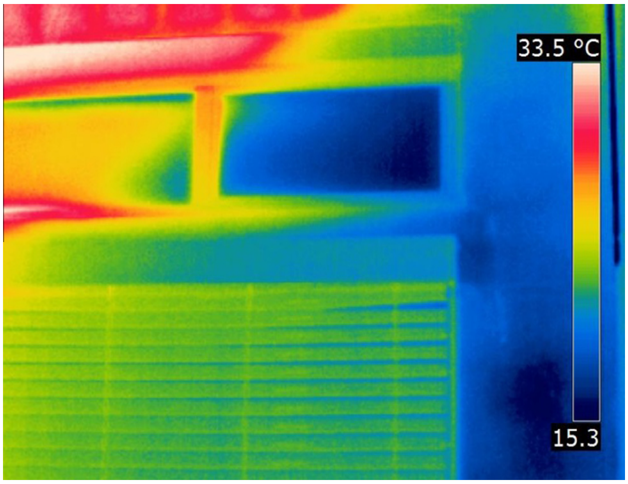


**Fig. 1.** Thermograph of a façade located in Viseu, Portugal.

[4]; (b) surface colour as it can mask defects [5]; (c) reflections on metal and glazed surfaces (surfaces with high reflectance) [5]; (d) meteorological conditions such as air temperature, precipitation, wind speed, cloud cover and direct sunlight [6]; (e) heat sources near the measurement area [3]; (f) period of the day (day or night) and time of year (summer or winter conditions) [6]; (g) distance between camera and target may attenuate thermal radiation and affect images' clarity and precision, for distances over 10 m [6].

This technology has been applied to buildings for a couple of decades to evaluate their performance [3]. It has been used to assess the floor covering comfort [5], detect insulation defects [3], air leaks [7], thermal bridges [8] and to inspect construction details [6,9]. IRT has also been used as a conservation evaluation tool for historic buildings treatments [10], to detect defects in façades [11,12] and as inspection technique for frescoes assessment [13,14]. The use of IRT in inspection procedures is well defined in standards such as ASTM C 1060-90, ISO 6781 and EN 13187 [15–17].

Nevertheless, the procedures to detect moisture in building components using IRT are still under development [12,18–21] as it is still not clear if it can be used to detect moisture before any visible marks occur, such as efflorescence, biological growth, detachments or material's degradation, avoiding severe degradation, and to trace a water leak through the building's elements. However, changes in moisture content are related to changes in surface temperature and can, therefore, be detected by IRT, due to three physical phenomena:

- Evaporative cooling at the moist area: the evaporation at the surface is an endothermic reaction, which induces a decrease on the surface temperature [5,17,19,22–28];
- Reduced thermal resistance: the heat flow through wet materials is higher than through dry materials, which creates a heterogeneous thermal pattern as the surface temperature over the wet material is higher, if the inspection is made from the outside during the colder season. This effect is pushed to extremes when the wetting occurs in thermal insulation materials [17,29,30];
- Increased heat storage capacity of the moist material: the surface temperature over a wet area responds more slowly to a change in the air temperature than the surface temperature over a dry area. Thus, when the whole surface is cooling, wet areas will cool more slowly. During the course of a sunlit day, wet areas will store more solar energy than dry areas, thus, they will cool more slowly during the evening [17,18,30,31].

From the above references, only Grinzato et al. [24,25], Lerma et al. [31] and Edis et al. [30] were able to establish a criterion for a quantitative assessment of the problem. In those studies moisture content was assessed using different physical principles (evaporative cooling of the surface and increased heat storage capacity).

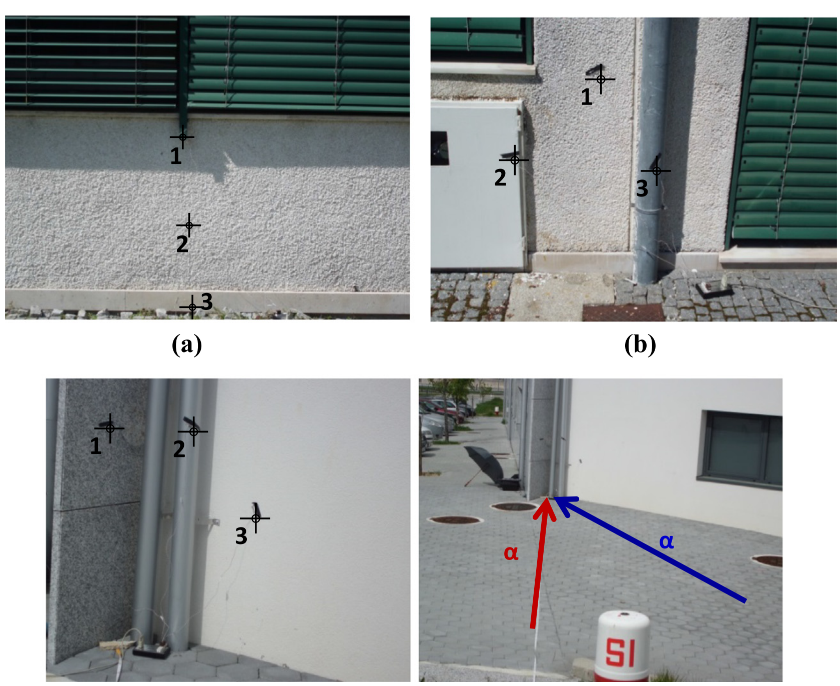


**Fig. 2.** Assemblies and surfaces under study for T.II: (a) Assembly A; (b) Assembly B; (c) Assembly C.