millenium

*Millenium, 2*(Edição Especial Nº14)

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# O QUE ESCONDEM OS EDIFÍCIOS?
# WHAT DO BUILDINGS HIDE?
# ¿QUÉ ESCONDEN LOS EDIFICIOS?

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RECEIVED: 25th January, 2024
ACCEPTED: 25th January, 2024
PUBLISHED: 15th February, 2024

**DOI:** https://doi.org/10.29352/mill0214e.34406

**EDITORIAL**

## WHAT DO BUILDINGS HIDE?

This was the base question for a project of innovative pedagogical practices in the field of Civil Engineering. The idea is to ensure a more active role for students in the teaching and learning process, using experimental setups and diagnostic equipment, which allow them to work in a living laboratory, applying innovative diagnostic tools to see what is "hidden" by the most superficial layers of buildings.

However, the question "What do buildings hide?" is pertinent, not only from a pedagogical point of view, but also from a professional point of view, both for those who work in the construction and rehabilitation of buildings sector and for those who carry out research in this area. Indeed, buildings are very complex systems, made up by several overlapping layers, of which only the outermost ones being directly observable. However, it is often the inner layers that most influence the performance of buildings and that make it possible to guarantee the fundamental and indispensable requirements for them to be used with quality.

This aspect is even more relevant when we talk about building rehabilitation. According to the dictionary, the word "rehabilitate" means to regenerate or recover, on its whole or just partly. Although this concept emerged in other scientific and social fields, it was quickly adopted with great success in the construction sector, especially buildings.

In fact, the building can and should be seen as a living system, which interacts with its occupants and the environment. Thus, it is necessary to take care of it and allow it to adapt effectively to new realities and demands, facilitating its regeneration or recovery, on its whole or partly, for a better interaction with a society and an external environment in continuous change. But this will only be possible if we know in detail and in depth what is hidden in its various layers and systems.

Truth is, in a rehabilitation process it is very important to assess the real state of conservation of the buildings before starting any intervention, because only in this way will be possible to define suitable solutions that allow the expected performance after rehabilitation to be achieved. Thus, since each building is unique, when rehabilitating there are no pre-defined strategies, therefore being essential to use appropriate and effective survey and diagnosis techniques, which guarantee reliable and really useful results. These techniques can be either traditional or more innovative, have different levels of destruction, can be used in situ or in the laboratory, and have different operating principles. One of the most innovative diagnostic techniques that have been applied to the study of buildings is infrared thermography (IRT). This non-destructive testing technology measures surface temperatures without contact, displaying them as 2D images, providing real-time results without significantly disturbing the building's occupants. Measurements can be performed using a passive approach, which is used when the damaged zone is naturally at a higher or lower temperature than the undamaged areas, or using an active approach, when an energy source is used to produce thermal contrast between the area without problems and the ones with anomalies, which, being naturally in thermal equilibrium, is not possible to observe without this technology.

The analysis of the results of IRT tests can be carried out in two different ways: qualitatively or quantitatively. In qualitative analysis, only thermal patterns are identified and compared. Therefore, it is a more superficial approach, easy and relatively fast to implement, that can be adopted in situ. In quantitative analysis, the goal is to determine either the actual temperature or the temperature differences between hot and cold spots, so it requires more detail and a greater number of measurement parameters must be considered. It is, therefore, more time-consuming, having to include some office work.

IRT measurements are affected by a number of parameters, which can be related to material properties, test conditions, boundary conditions or the equipment itself. These factors lead to distortions in surface temperature that can be mistaken for defects. In other words, some thermal anomalies that are observed may not correspond to actual defects in the building. It is, therefore, essential that the measurements are carried out by qualified technicians, who know the fundamentals that are the basis of this technology.

With IRT it is possible to study moisture-related problems, weather infiltrations or rising damp. This is possible because evaporation of liquid water at the surface is an endothermic phenomenon, which consumes energy, causing the surface temperature to decrease in relation to the dry zone, thus allowing this thermal anomaly to be detected by the infrared camera. The greater the amount of water, the more intense this phenomenon is and the better moisture presence is detected. However, the main advantage of using IRT for moisture detection is that, in addition to the visually detected zone, it allows to observe intermediate zones, which correspond to transition areas between the wet area, with liquid water on the surface, and the dry area, where evaporation and diffusion phenomena occur in more internal layers. On the other hand, it is also known that there is a correlation between the temperature difference between the wet and dry zone of the material and its moisture content, although the robustness of this correlation depends on the type of material and the environmental conditions.

IRT also allows detachments of the coatings, which are not observed with the naked eye, to be detected. In this case, and unlike moisture, it is necessary to use a heat source, which can be solar radiation, in elements that are directly exposed to the sun, or an infrared lamp, if the problem is inside the building. Due to the heat source, there is a higher increase in the surface temperature in the detachment area, mainly because of the existence of an air layer between the cladding and the support, which introduces an additional thermal resistance to the heat flow, which occurs from the outside to the inside of the construction element,

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increasing the temperature in the defect zone. Currently, there is already the possibility of detecting these detachments automatically, using artificial intelligence, however, an experienced operator will always be necessary, as these problems are complex, and an automatic analysis can indicate thermal anomalies that do not correspond to real defects.

The identification of air leakage points in the connections between construction elements, namely in the openings, and the quantification of their impact, is also possible through IRT. This technology does not allow the visualization of the air passing through the leakage or the measurement of the temperature of the air, but it does allow the evaluation of the temperature difference that the air flow causes on a nearby surface, either because the temperature of the outdoor air is lower than that of the surface under study, or because the movement of the air causes the surface temperature to decrease due to convection. To enhance the visualization of these leakage points, it is necessary to depressurize the space or carry out the test on days of greater wind intensity, however, it is not necessary to have a very high pressure difference for highlighting the phenomenon. The temperature difference observed in thermal images depends not only on the nature and size of the leakage point but also on the pressure difference to which the component is subjected and the temperature difference inside and outside.

Another example of the application of this technology is the detection of thermal bridges. In this case, it is necessary that the test is carried out in winter, with the heating system on, to ensure temperature differences between inside and outside of more than 10ºC for at least 24 hours. However, in unheated spaces IRT can also be applied, as long as an artificial heat source is used during the tests. In either situation, the thermal bridge is detected because the heat transfer in the thermal bridge is more higher, causing temperature differences that are detected by the infrared camera.

With the examples of application of IRT presented above, it is intended to demonstrate its potential as a diagnostic technique applied to the study of buildings. But that is not all. It is also intended to highlight, through these examples, that only the use of appropriate and effective survey and diagnostic techniques, whether IRT or any other, whose operating principles are perfectly known by those who use them, allows to answer the initial question: "What do buildings hide?".