New method of increasing building efficiency

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Abstract. Increasing the comfort of a residential building depends a lot on how well the structure of resistance is known and the materials it is made of, but also the possible stages of degradation and the causes that led to them. One of the best performing procedures to determine some of the causes of degradation is thermal imaging known as thermography.The thermography results for the residential building are compared with the legal indices and then the conclusions are drawn, followed by establishing the methods and the techniques of approach for its thermal recovery. Thermography has a very long history, although its use has increased with the commercial and industrial applications of the past forty years.

1 Introduction

With buildings responsible for more than 30 percents of global energy consumption and a quarter of CO2 emissions, there is a huge, under-tapped opportunity to create more sustainable cities through building efficiency. More efficient buildings can generate economic benefits, reduce environmental impacts and improve people's quality of life. [1]

Much progress has been made on improving building energy efficiency over the past decades by focusing on the efficiency of individual building components and, more recently, the efficiency of the building as a whole. As a middle ground between component and whole-building efficiency, a building systems approach considers the interactions of components within and among building systems, as well as interactions among multiple buildings, and between the building and the electric grid. Adopting a systems perspective will become increasingly necessary to achieve meaningful and cost-effective future energy savings within the built environment .[2]

2 Principles of thermography

The energy emitted by a surface of an object whose temperature is above absolute zero as we already know is infrared radiation. This radiation is function of one thing: temperature of the material.

There are three ways by which the radiant energy striking an object may be dissipated: absorption ,transmission and reflection. In order to describe this phenomena we are using three parameters : spectral reflectance ρ_λ ,spectral absorption α_λ and the spectral transmittance τ_λ. These three parameters are wavelength dependent. The sum of these three parameters must be one at any wavelength, as in the following equation: $\alpha_\lambda + \rho_\lambda + \tau_\lambda = 1$ (1). If we discuss about opaque materials, the above equation becomes more simplified. All of the energy is either absorbed or reflected. $\alpha_\lambda + = 1 - \rho_\lambda$ (2).[13]

3 Case study

The objective of this paper is to review the current state and to identify the future challenges regarding the application of thermography in building heat loss calculation . This paper is a result of a study over two buildings , one residential home situated in Constanta and a bloc of apartments from Bucharest. We carried out those two studies at the request of the inhabitants in order to detect why the thermal comfort is so low. All the tests were done using a professional thermal imaging camera, Testo 885-2 .

In both cases a calculation of the heat loss was made first. A calculation of heat inputs for the summer period was also made to see if the insulation is properly dimensioned. We mention that the two buildings have different years of construction, the block is from 1982 and the house is built in 2012, both having a 10 cm extrusion polystyrene insulation applied 8 years and 5 years ago.

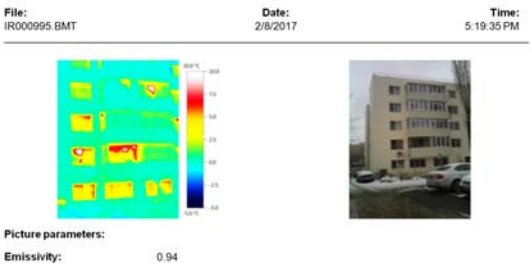

Fig. 1. North side of the building

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As you can see from the pictures, the owner of the house wanted to find out why he has mold and a cold feeling in some parts of the house.

Fig. 2. House – Nord wall

In the following figures, both buildings can be observed from interior and exterior.

In order to be able to present the overall image of the two buildings and to make a fair comparison, I would point out that both buildings are made of BCA and are insulated on the outside with the same type and thickness of polystyrene. The outside temperatures in the two days in which the measurements were made were approximately -4 Celsius

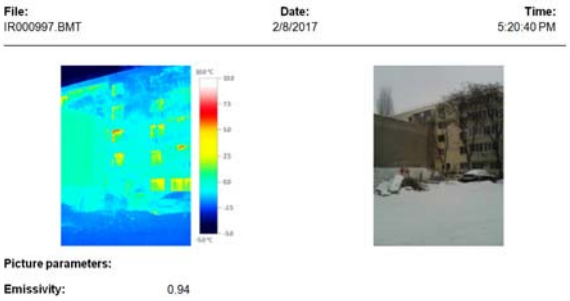

Fig. 3. South side of the building

In both cases, the colour palette of the thermal chamber was set so as to highlight differences of up to 1.5 degrees Celsius. As is shown in figure 3 , the red spots are not thermal bridges but open windows from balconies.

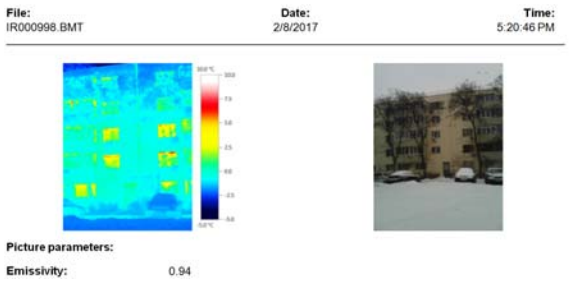

Fig. 4. South side second entrance

Figures 1, 4 and 5 are very conclusive about the way the insulation was made for the apartments bloc. The blue colour from the facades means that the temperature on the exterior surface of the insulation is very close to the exterior temperature leading us to the idea that thickness was well-chosen .

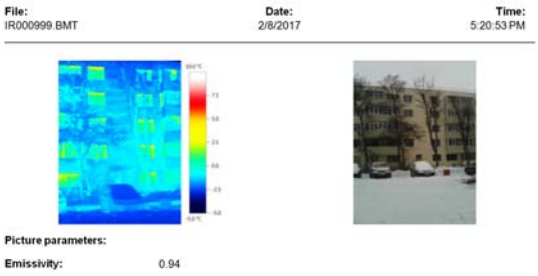

Fig. 5. South side- different angle

At the same time there is no heat loss at the joints of the polystyrene boards, which indicates that the commissioning was done well. One thing notable is the quality of the windows, in both cases studied. These are new generators with at least two sheets of glass. The last image of the building represents the east side of it and we can observe some small differences regarding heat transfer through elements of glass (yellow colour). It is clear that the balconies are not properly heated and the risk of mold to appear at the top of the interior walls high.

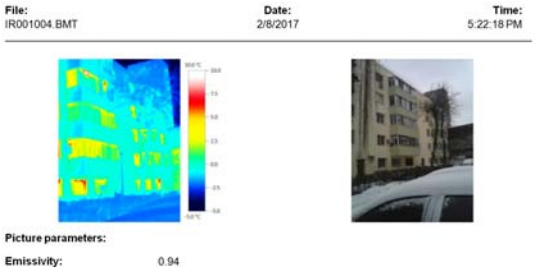

Fig. 6. East side of the building

This method of determining whether there are heat loss issues is non-invasive and has a fairly large scale in recent years. More and more owners want to see the areas with larger losses and also make sure that the insulation works were done properly. This is also the case in Constanta, where the owner has explicitly asked for such a diagnosis, because no matter how much the house was heated, it also had mold in some areas.

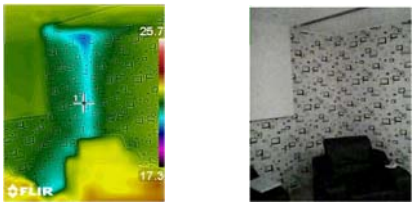

Fig. 7. North corner of the room

From the first thermal camera picture I could notice a fairly high temperature difference between the component elements (walls, beams and poles). It was clear that something had been wrong since the beginning of the construction. In this case, the diagnosis of “sick home” was put in the first moment. I told the owner that

the workers did not isolate the pillars and the beams because the house was built on the border

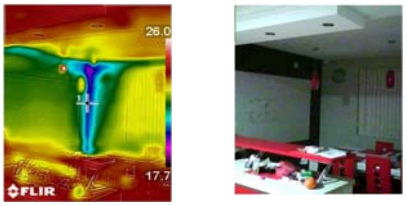

Fig. 8. Ground floor - kitchen

In this case there was no need for a thermography from outside. The solution for stopping the cold sensation was on the first place.

Fig. 9. First floor - bedroom wall

Although this house uses an efficient gas-fired thermal boiler, underfloor heating, and a chiller that serves all the space does not manage to annihilate the discomfort created by cold radiation and mold odor. The picture from figure 9 above shows the wrong way of working, approached by the workers. This not invasive method of thermal vision, corroborated with the calculation of the energy heatloss provides a technical and economical solution, for the problem of thermal discomfort in the building.[3] At the same time, this dynamic method of hot air, but also wet or inadequately insulated parts, can be brought to light.[4]

4 Results

The results of this method are extraordinary from a visual point of view; allowing us to quickly locate the cause of the problem. This diagnosis, made in a relatively short time together with an appropriate heat loss calculation, gives the recipient an overview of the problem. Applied solutions are based on this and can be accomplished much faster. In both cases studied the increase of the thermal efficiency of the respective building was based on this method. The synthesis of the results is presented below :

	Appartment	House
Temp in/ out	20/-4	21/-4
Material	BCA	BCA
Insulation	10 cm	10 cm
Heat loss	89	83
Thermal comfort	ok all the time	ok / cold feeling
Agent provider	Radet	Gas heater

Table 1. Synthesis of the results

Another important result is the difference between anticipated and observed values of temperature.

Anticipeted temperatures values								
Wals			Windows			Ceiling		
21	21.5	22	19	12	12.5	19.5	19.8	20

Observed temperatures values								
Wals			Windows			Ceiling		
17.5	19	21.5	10	10.45	11	14	18	18.5

Table 2. Temperature results

There are three main temperature stages. If the difference between observed and anticipated temperature from calculations is in interval 1-8 degrees than the problem it is considered minor and can be easily solved. If the difference is between 8-12 the problem becomes more urgent and between 12-15 and above it is critical and immediate intervention is required.

Following the application of this method and related thermal calculations, it was decided to apply the following measures to reduce thermal discomfort as follows: Apartment buildings in Bucharest have been recommended to change the windows somewhat of a high quality and to fill insulation hollows where necessary and reduce heat inputs in summer by fitting drapes. The Constanta house received several recommendations, of which the most urgent is the isolation on the outside of all the pillars and beams. They also have been recommended to mechanically or naturally ventilate the entire space for at least 30 minutes daily to remove moisture and odor. All these recommendations were possible in a relatively short time due to this method of thermal imaging, the method that enhances the efficiency of buildings and spaces by visualizing a few elements of risk.

5 Conclusions

The new concept of sustainable development leads to a different approach than the classic one we are used to when building. Currently, the building is considered to be a continuous development, which has to be treated, rehabilitated and modernized in time to meet the requirements set by the user at a certain stage. Highlights are analyses and interventions related to energy saving under conditions of adequate comfort. This aspect has been called the energy efficiency of the building. Alongside reducing energy needs, two important goals of sustainable development, namely the primary resource economy and the reduction of pollutant emissions in the environment, are achieved.[5]

Increasing energy efficiency can be achieved in a number of ways, from educating building users to the energy economy, interventions that are available to many, and carrying out an expertise and energy audit, where experts recommend a range of technical solutions

modernization. These solutions depend on the type, age and destination of the buildings and constitute what is called the rehabilitation or modernization of the building.[5]

The thermal rehabilitation / modernization of a building is to improve it in order to keep the heat inside. This involves adding thermal insulation, sealing, improving or even replacing windows and doors, as well as improving the equipment and facilities with which the building is fitted. Thermal rehabilitation also means the implementation of energy efficiency measures in all renovation and repair activities of the building.[5]

Energy efficiency of buildings is a top priority, given the poor quality of most existing buildings, whether old or cheap. On the other hand, the costs related to the thermal rehabilitation of a building are lower than the costs of installing additional heating capacity for heating. In Romania, energy consumption for the population sector is at the level of 40% of the total energy consumption of the country, and this share has been found more or less all over the world.[5]

This method of thermal imaging , is one of the best non-destructive and non-invasive methods, making it useful in the following situations:

- determining areas with heat loss of buildings, identifying deficiencies of thermal insulation;
- identification of excessive air infiltration;
- determining the areas where condensation and mold are likely to occur;
- identifying clogged pipes;
- determining constructive issues [3]

Improved building efficiency can reduce costs, improve productivity and help create jobs for people in cities. Increasing efficiency in buildings is one of the most cost-effective ways to improve cities – every $1 invested saves $2 in new electricity generation and distribution costs. [1]

References

1. https://www.wri.org/publication/accelerating-building-efficiency-actions-city-leaders
2. http://buildingefficiency.net/
3. Andrei Preda, *Thermographic inspection for building diagnosis* (Eenviro 2018 conference, Cluj, 2018)
4. D Deleanu, GM Dumitrașcu, *Cinematica: culegere de probleme* 1999 – Printech.
5. http://www.ipconsult.ro/Indrumar%20de%20Eficienta%20Energetica%20pentru%20Cladiri%20I.htm - *Indrumar de eficienta energetica pentru cladiri – I*
6. Commission of the European Communities. Green Paper: A European Strategy for Sustainable, Competitive and Secure Energy; COM (2006) 105 Final; European Commission: Brussels, Belgium, 2006.
7. Flir., "Thermal Imaging guidebook for buildings and renewable energy applications " www.flir.com M. Ben Rabha, M.F. Boujmil, M. Saadoun, B. Bessaïs, Eur. Phys. J. Appl. Phys. (to be published)
8. Barreira ,E; Almeida ,R; Infrared Thermography for Building Moisture Inspection, 2018
9. Barreira ,E; De Freitas V. P.; Evaluation of building materials using infrared thermography, Elsevier, 2007
10. Barreira ,E; De Freitas V. P.; Thermography Applications in the Study of Buildings Hygrothermal Behaviour, www.intechopen.com March 2014
11. https://www.certificatulmeu.ro/termografie-in-constructii/
12. http://certificat-energetic24h.eu/termografia-in-constructii-termoviziune-sau-termografie-cladiri.html.
13. Usamentiaga, R; Molleda, J; Bulnes,G,F ; "Infrared thermography for temperature mesuremnts and non-destructive testing" , Sensors 2014 14, 12305-12348; doi:10.3390/s140712305