DETERMINATION METHOD OF THERMAL CONDUCTIVITY OF BUILDING PARTS IN SITU THROUGH IR IMAGING BY MINIMIZING THE INFLUENCE OF ENVIRONMENTAL PARAMETERS

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11th International Conference on Environmental Science and Technology
Chania, Crete, Greece, 3 – 5 September 2009

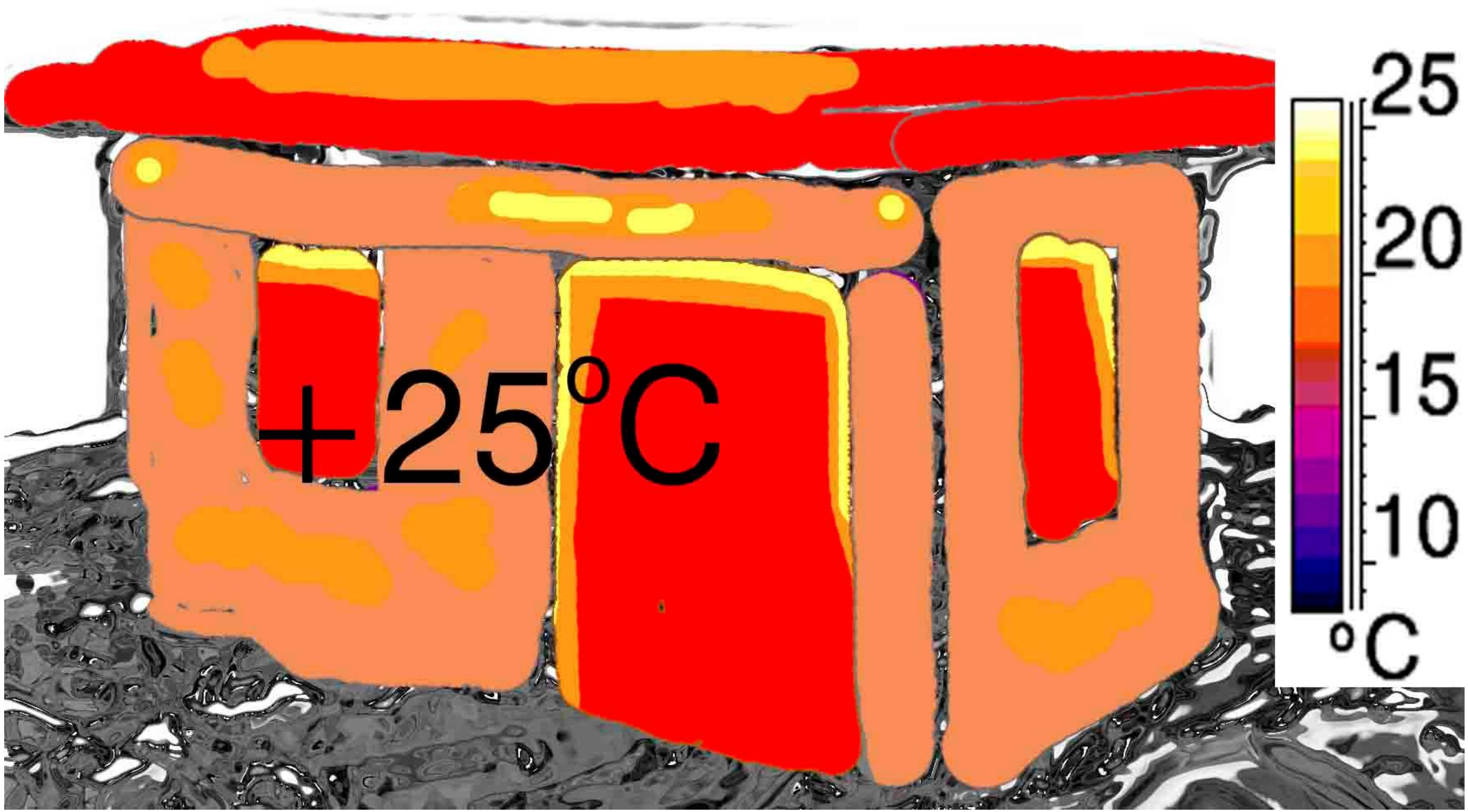
INTRODUCTION

ENGINEER TESTS THE COSNTRUCTION WITH IR IMAGE

IF THE CONSTRUCTION HAS NO THERMAL INSULATION

IR IMAGE IS LIKE THIS:

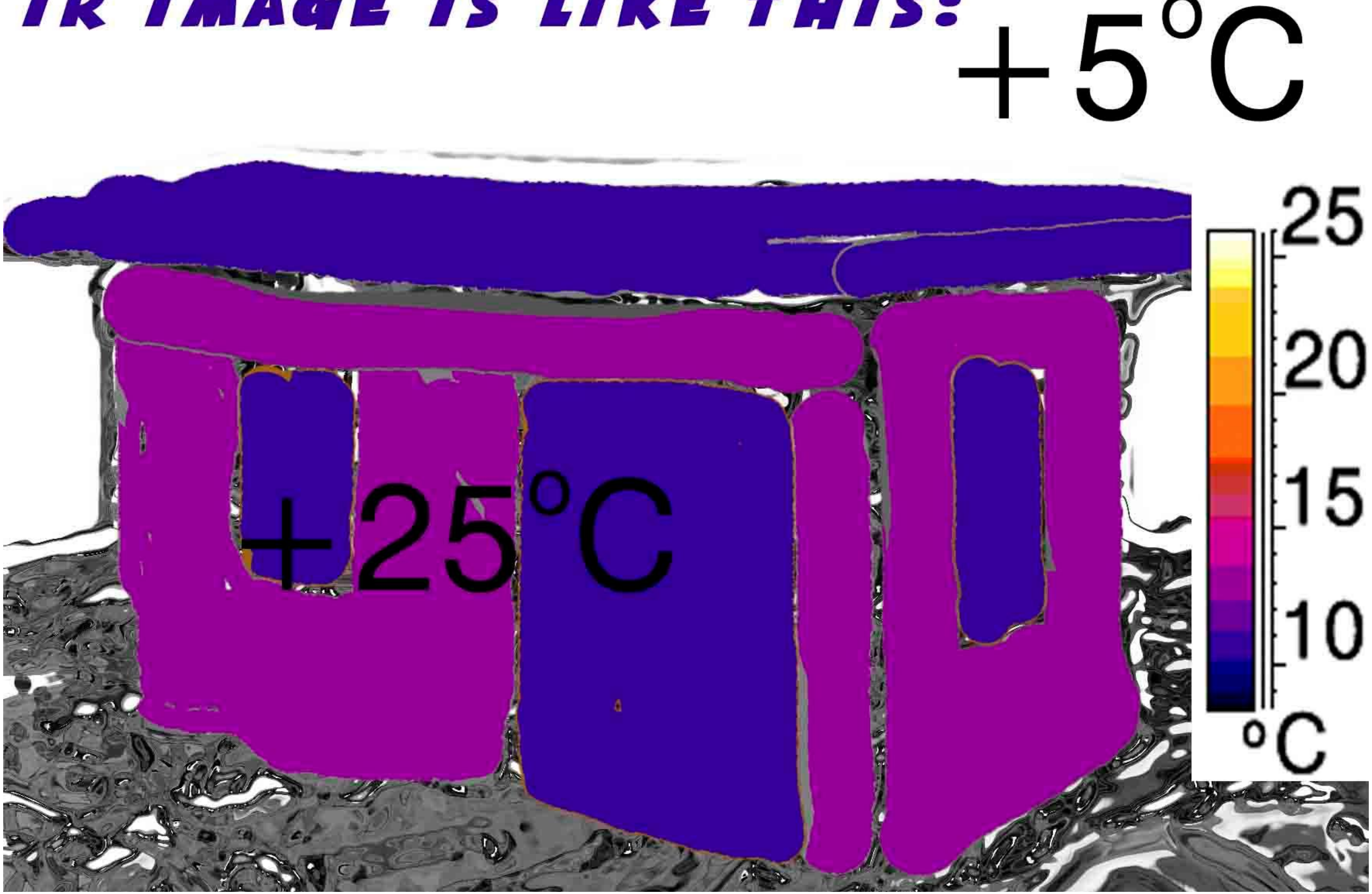
+5°C



INTRODUCTION

IF THE CONSTRUCTION HAS THERMAL INSULATION

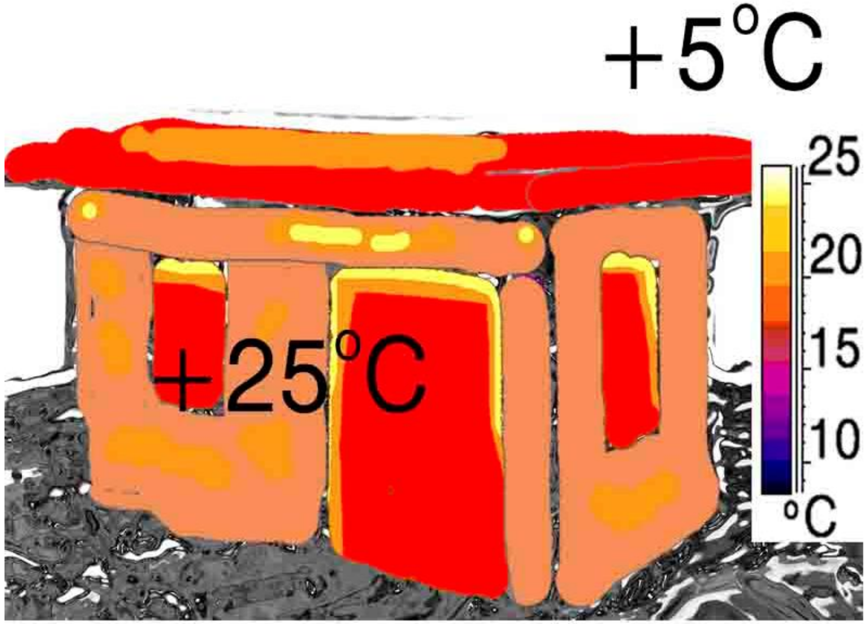
IR IMAGE IS LIKE THIS:

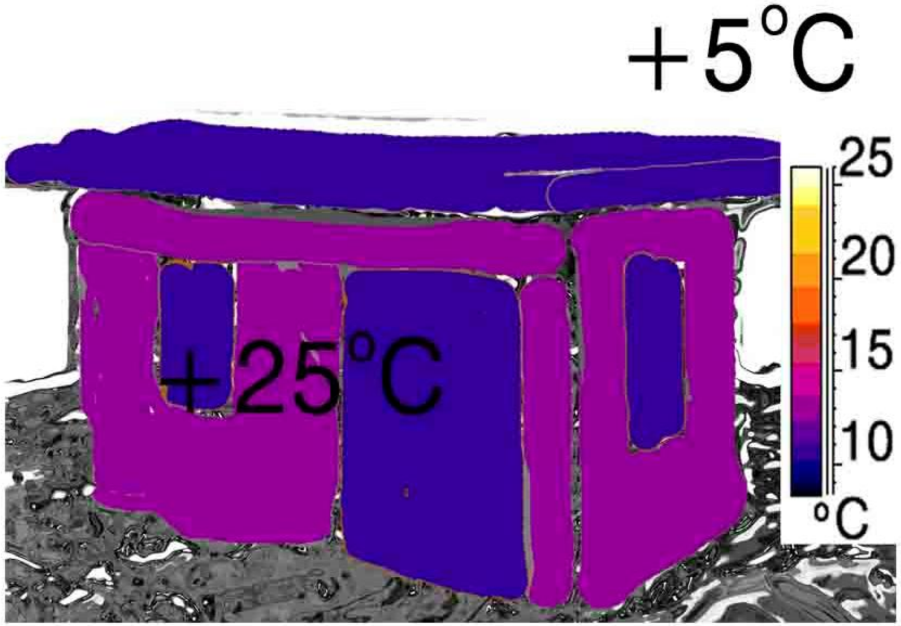


FINALLY THE ENGINEER:

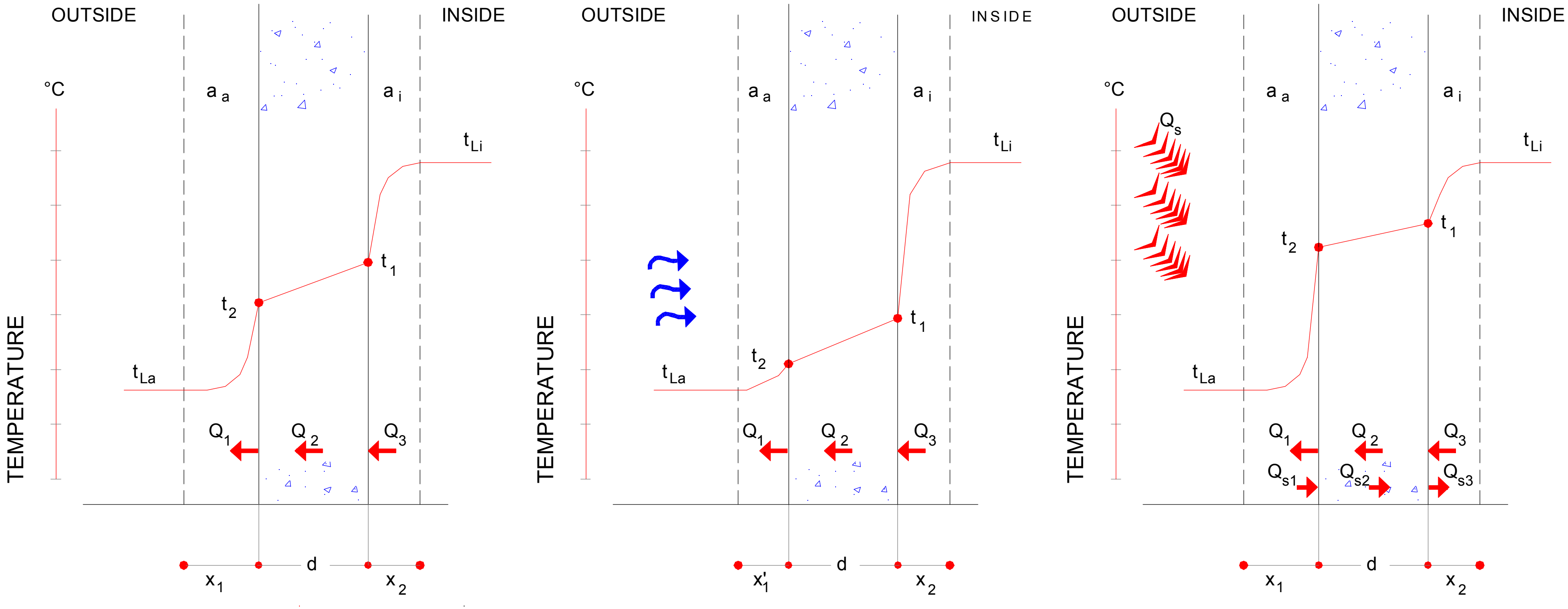
MAKES SUGGESTIONS FOR BETTER THERMAL INSULATION

OR GIVES ENERGY CERTIFICATE





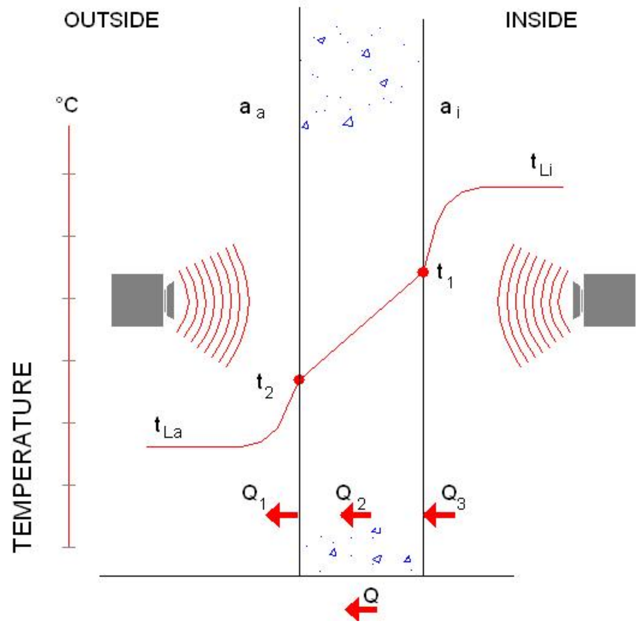
INTRODUCTION

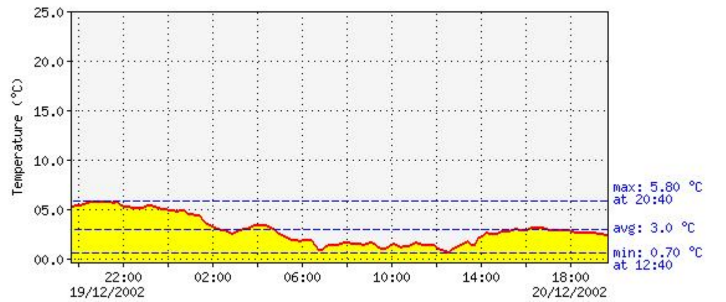


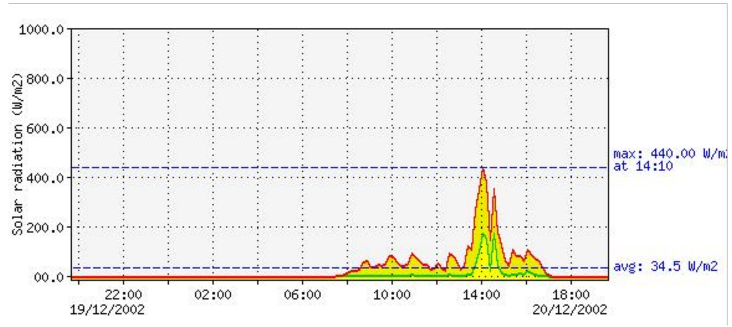
The variation of the surface temperatures in three cases: (a) theoretical, (b) in case of win (blue arrows) and (c) in case of solar radiation (red arrows)

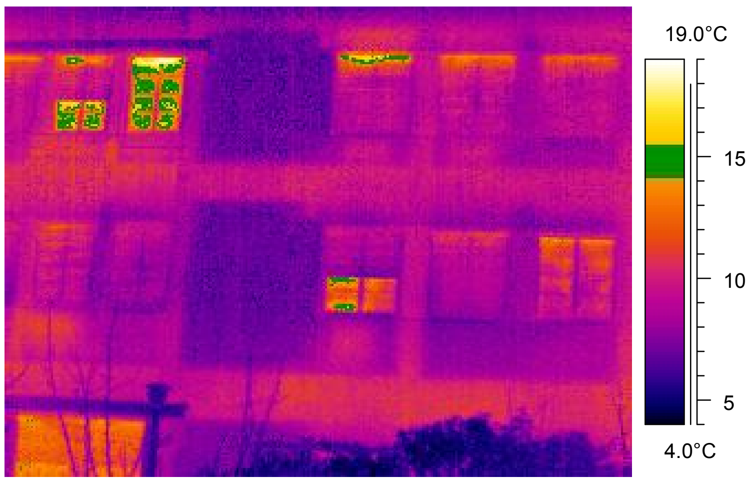
METHOD DESCRIPTION

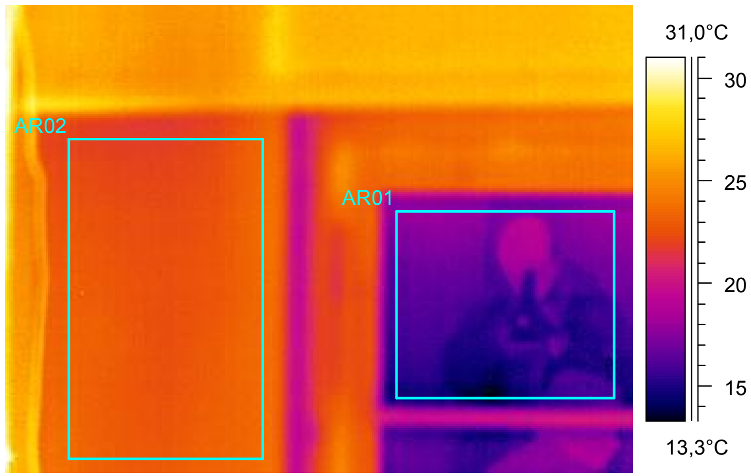
Test example



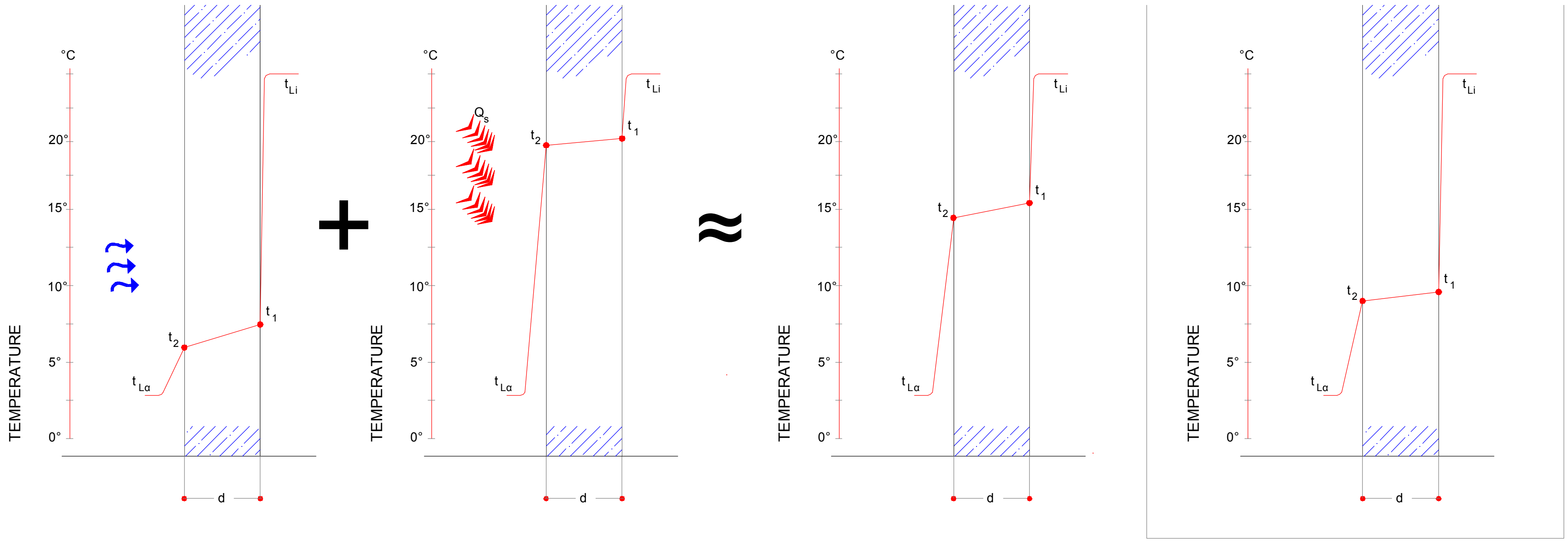








METHOD DESCRIPTION



Environmental aspects of infrared imaging testing

METHOD DESCRIPTION

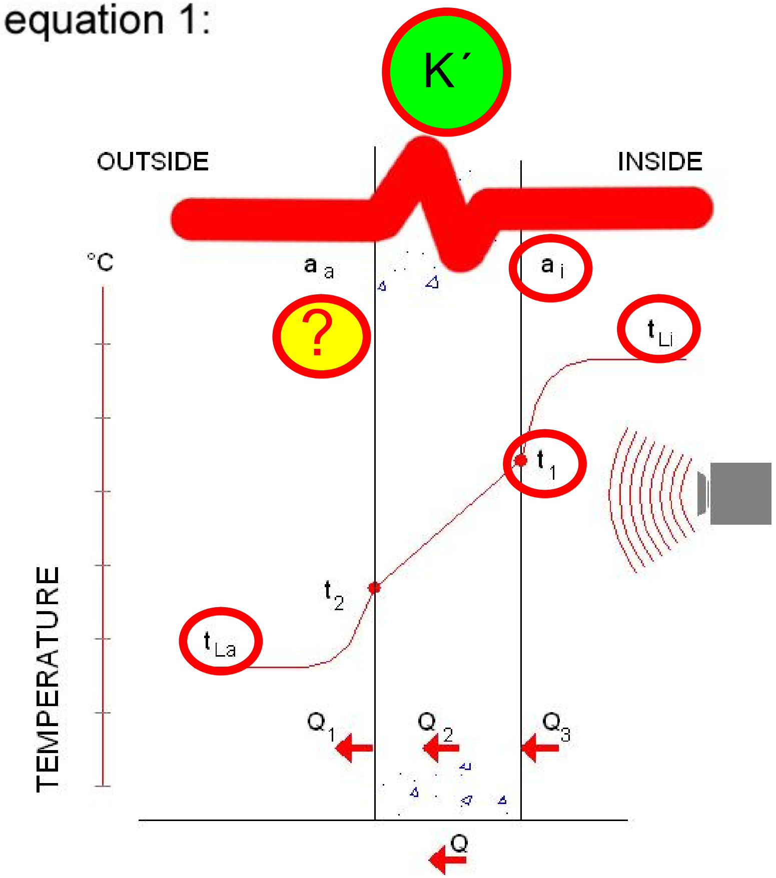
In this method of analysis, the parameters used are:

- t_{La}: outside temperature
- t_{Li}: inside temperature
- t_1 : surface temperature (interior)
- t_2 : surface temperature (exterior)
- a_x : surface conductivity
- K: thermal conductivity of part of the building's envelope
- R: thermal resistance of part of the building's envelope =1/K

$^1/_\Lambda$: thermal resistance of the material

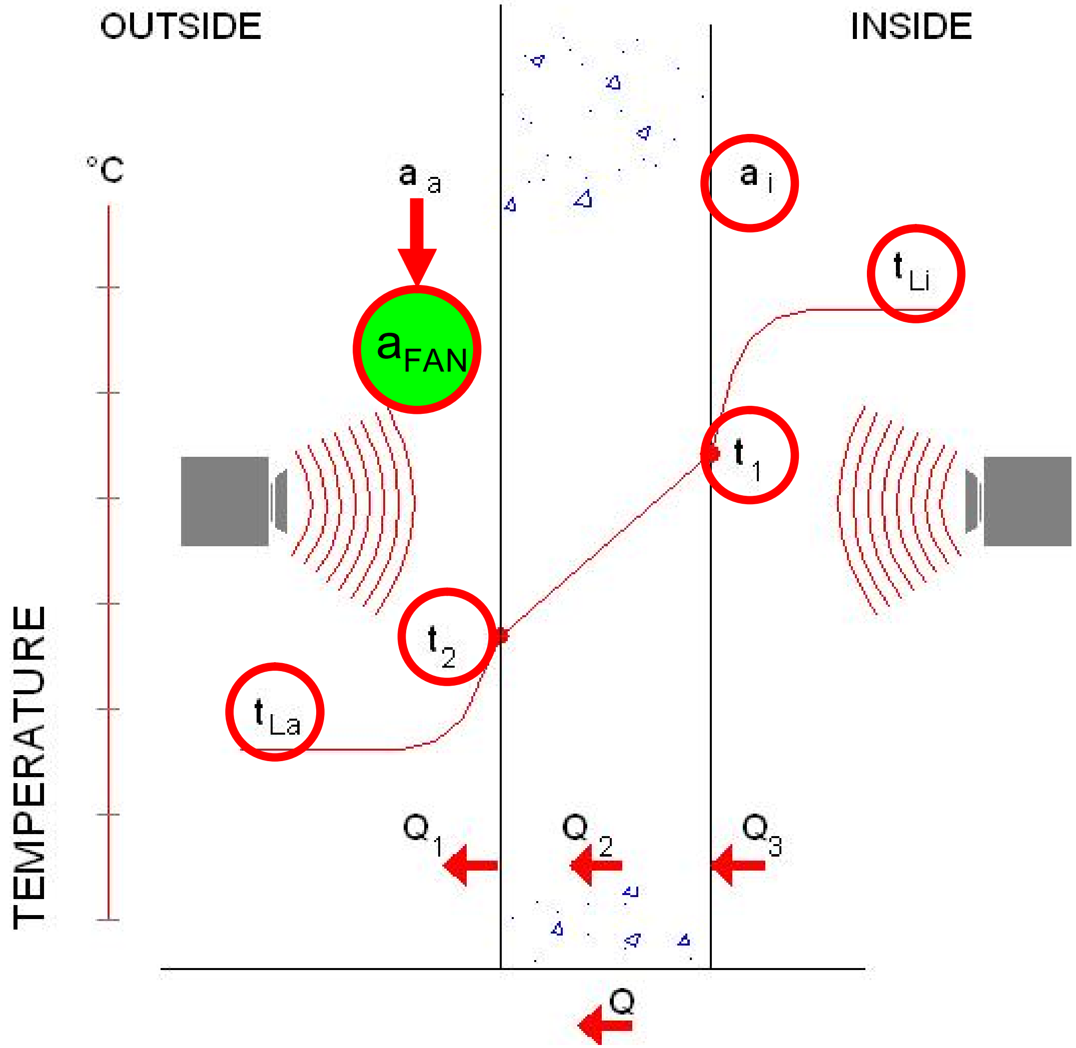
A first approach of the thermal conductivity from the interior temperature and the surface conductivity a_i of the interior of the building can be found in equation 1:

$$K' * (t_{Li} - t_{La}) = a_i * (t_{Li} - t_1) \rightarrow K' = \frac{a_i (t_{Li} - t_1)}{(t_{Li} - t_{La})}$$



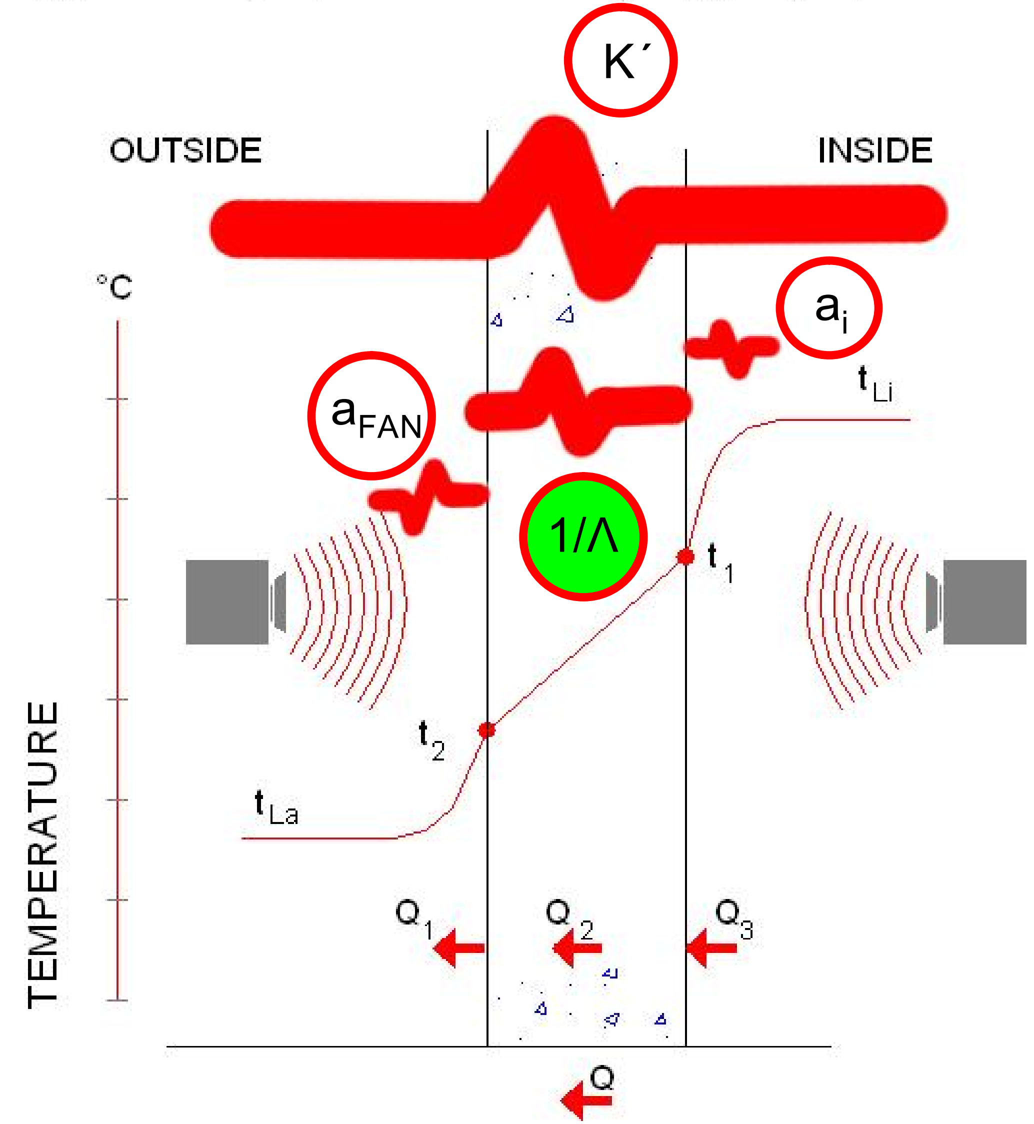
The outdoor surface conductivity a_{FAN} is determined in equation 2:

$$a_{FAN} * (t_2 - t_{La}) = a_i * (t_{Li} - t_1) \rightarrow a_{FAN} = \frac{a_i (t_{Li} - t_1)}{(t_2 - t_{La})} \quad (2)$$



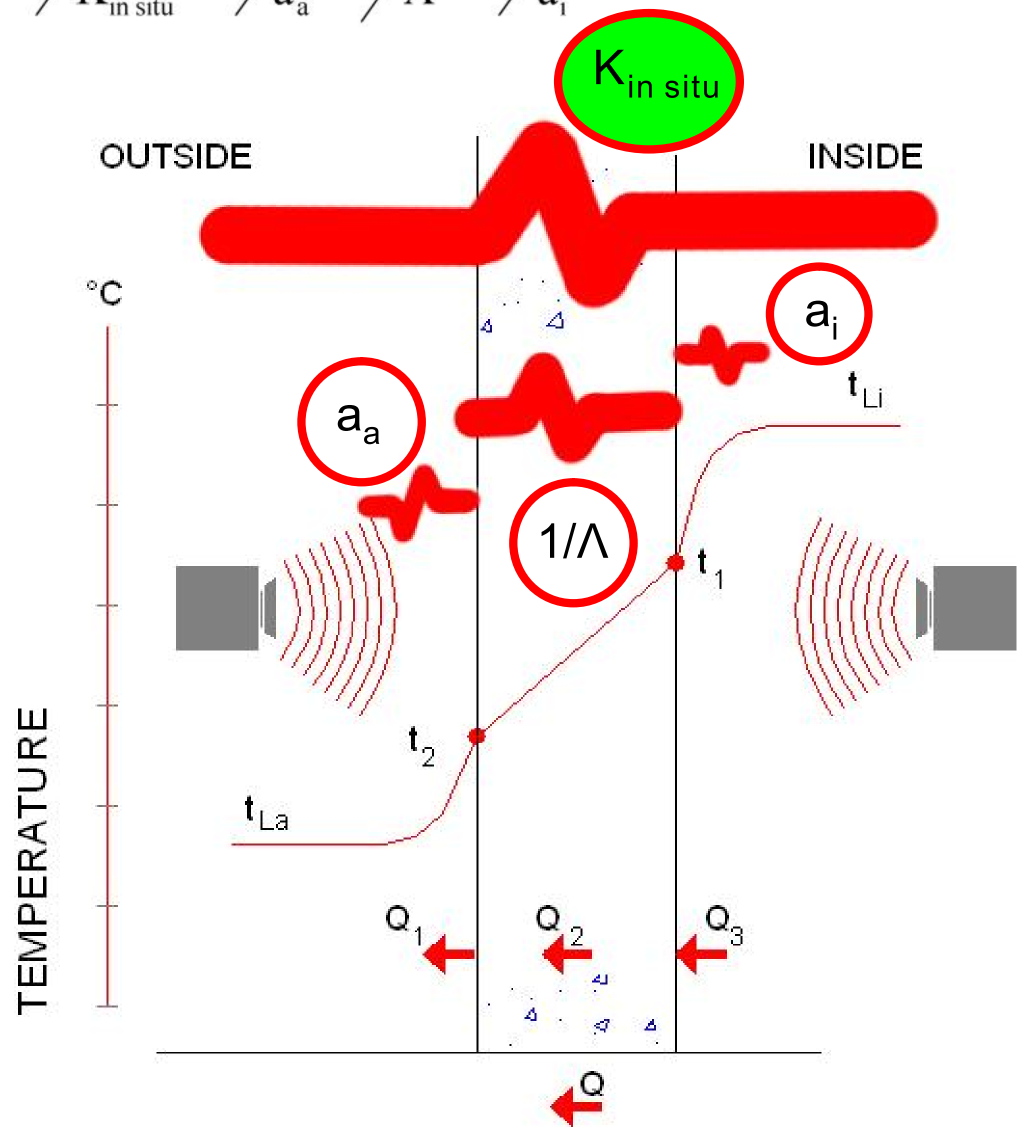
The thermal resistance of the materials $1/\Lambda$ according to previous data is calculated in equation 3:

$$R' = 1/K' = 1/a_{FAN} + 1/\Lambda + 1/a_i \rightarrow 1/\Lambda = 1/K' - 1/a_{FAN} - 1/a_i \qquad (3)$$



The thermal resistance of a building's envelope according to the Greek Standards for the thermal insulation of buildings is given in equation 4:

$$R_{\text{in situ}} = \frac{1}{K_{\text{in situ}}} = \frac{1}{a_a} + \frac{1}{\Lambda} + \frac{1}{a_i} \quad (4)$$

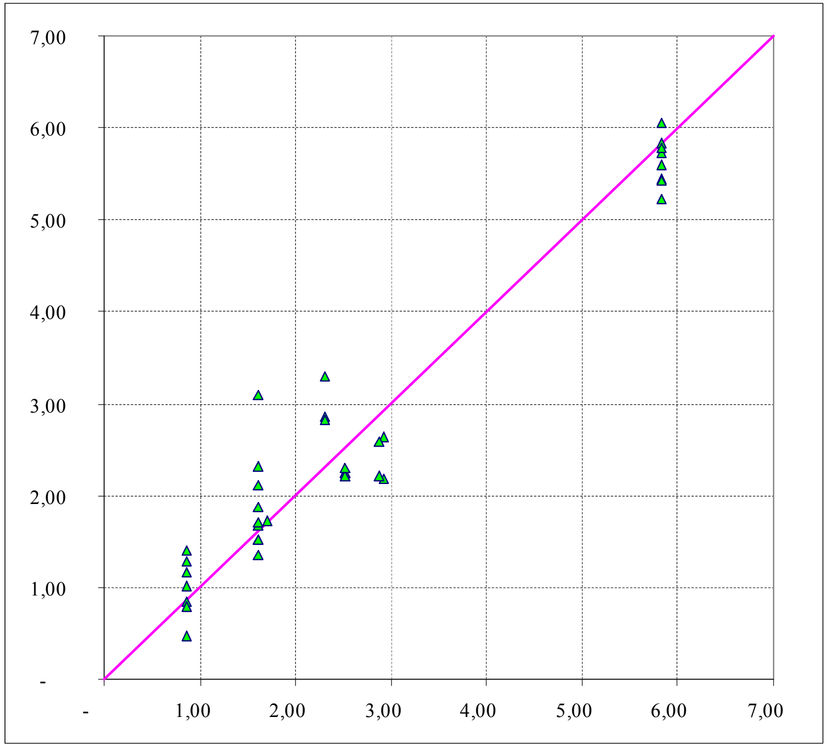


$K_{in\ situ}$

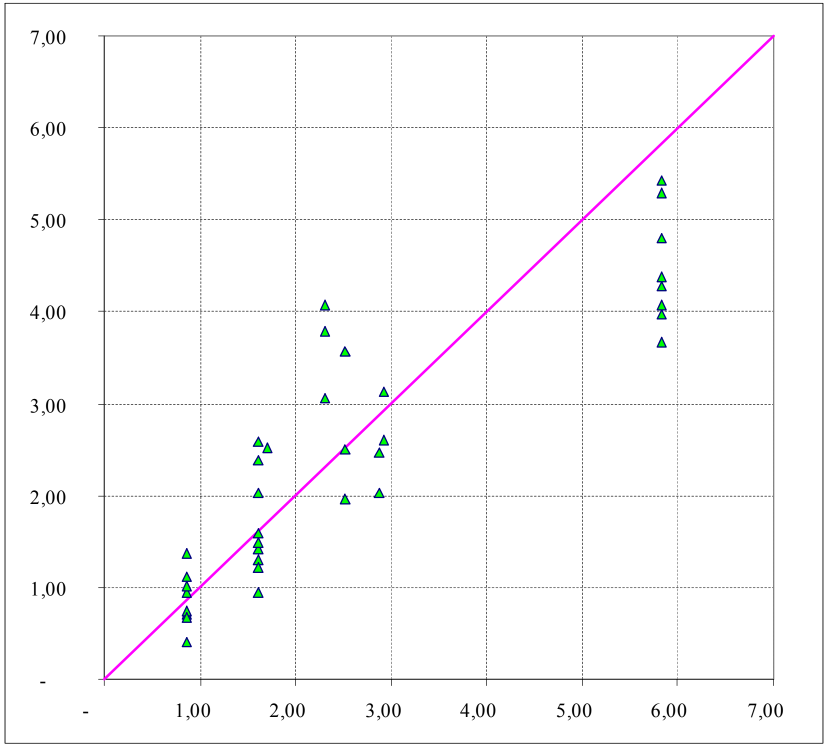
Absence of solar influence

efficiency factor:

K´



94%



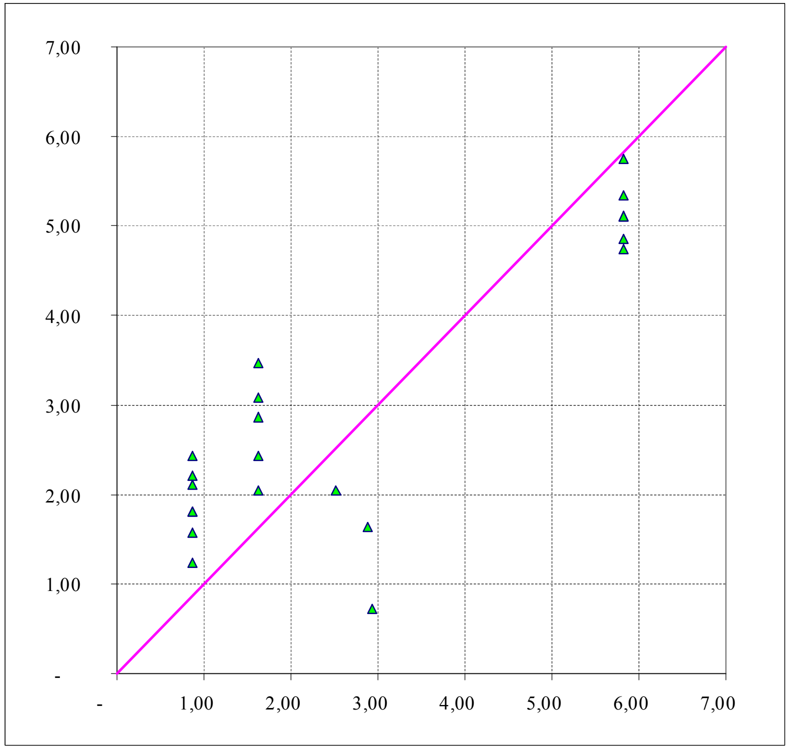
74%

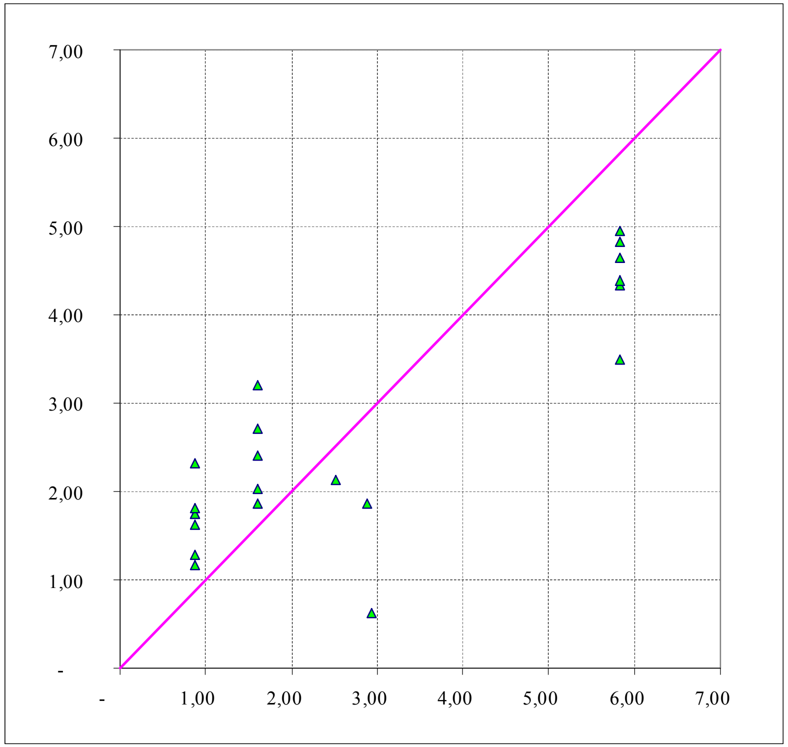
$K_{in\ situ}$

Presence of solar influence

K'

efficiency factor:





70%

67%

DISCUSSION

Difficulties in applying the method in specific type of materials with high thermal storage capacity, such as stone.

Experimental data show that for the application of the method for the calculation of the thermal conductivity in this type of materials, the following conditions should apply:

- Elimination of environmental interruption (solar energy, wind)
- Maximization of the temperature difference (indoor - outdoor)
- Stable thermal flow for more than three hours

Therefore, the optimal measurement is taken during cold winter nights, and at the same time when inside temperature of the building is the highest possible.

So the method is defined to provide results for the thermal behaviour of different parts of a building with precision of more than 80% if the following conditions apply:

- Stable thermal flow between indoor and outdoor system for more than 1 hour
- Minimum variation of the outdoor temperature
- Difference between indoor and outdoor temperatures superior to 15°C
- No measurements are taken while there is solar radiation on the building.

CONCLUSIONS

Through this method, infrared imaging, mostly used as an approach for qualitative analysis in buildings, becomes a quantitative analysis tool for improving the accuracy of the in situ determination of the thermal conductivity of buildings' materials.

Based on this method, existing buildings' parts can be evaluated quantitatively with regard to their thermal conductivity, which is related to the buildings' energy requirements. In addition, failures in buildings' envelopes, such as thermal bridges, can be detected and analysed quantitatively, while also measures for improving the insulation of buildings can be evaluated through quantitative and accurate data.