

# IRF2018

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## Proceedings of the 6<sup>th</sup> International Conference on **INTEGRITY-RELIABILITY-FAILURE**

(Lisbon/Portugal, 22-26 July 2018)

**Editors**

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*J.F. Silva Gomes and Shaker A. Meguid*

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## PREFACE

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IRF2018 is the sixth international gathering of a prestigious series of Integrity-Reliability-Failure conferences coordinated by the International Scientific Committee of Mechanics and Materials in Design. This series of conferences are wholly devoted to advances in mechanics, materials, structural integrity and design. IRF2018 is jointly sponsored by the University of Porto, the University of Toronto and the Portuguese Society for Experimental Mechanics. The conference attracted over 200 participants with 258 accepted submissions involving 702 authors from 42 different countries around the world. The conference themes which address novel and advanced topics on Integrity, Reliability and Failure focused on Automotive, Locomotive, Aerospace, Civil Engineering and Biomechanics, including Computational Mechanics, Experimental Mechanics, Fracture and Fatigue, Composite and Advanced Materials, Tribology and Surface Engineering, Mechanical Design and Prototyping, Biomechanical Applications, Civil Engineering Applications, Energy and Thermo-Fluid Systems, and Industrial Engineering and Management, among other topics.

The conference also included an Open Forum on “*Can Professors Balance Scholarly Work, Teaching and Admin? The Challenges Going Forward*”, where an expert panel with many years of collective and active researchers and educators addressed the issue of balancing the activities of teaching, research and services within the universities.

We believe that the meeting offered our delegates a forum for the discussion and dissemination of their recent work in assessing the integrity, reliability and failure of engineering structures, components and systems, fostered research that integrates mechanics and materials in the design process, and promoted exchange of ideas and international co-operation among scientists and engineers in this important field of engineering.

We are particularly indebted to the authors and special guests for their presentations. Each of the 258 contributions offered opportunities for thorough discussions with the authors. Particularly, we acknowledge the excellent contributions of the participants, their innovative ideas and research directions, the novel modeling and simulation techniques, and the invaluable critical comments. We are also indebted to the outstanding keynote speakers who highlighted the conference themes with their contributions and covered the main topics of the conference. We also take this opportunity to thank the members of the International Scientific Committee and the reviewers for their time and helpful suggestions, the symposia organisers for their efforts and valuable contributions to the success of the event, and the local organising committee for an absolutely superb organization of the meeting in this magnificent city. To all of you, we offer our gratitude.

Given the rapidity with which science is advancing in all areas related to the topics discussed in the present meeting, the next conference in this series (Integrity-Reliability-Failure / IRF2020) will take place in the beautiful city of Funchal/Madeira, in July 2020. Undoubtedly, we expect IRF2020 to be as stimulating and interesting as IRF2018, as evidenced by the excellent contributions offered in this current event. We look forward to seeing all of you in Madeira in July 2020.

*Shaker A. Meguid and J.F. Silva Gomes*  
*Lisbon / Portugal, July 2018*

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*FEUP-Faculdade de Engenharia, Universidade do Porto*

*MADL-Mechanics and Aerospace Design Lab, University of Toronto*

*APAET-Portuguese Society for Experimental Mechanics*

*EURASEM-European Society for Experimental Mechanics*

*SEM-American Society for Experimental Mechanics*

*JSME-Japanese Society of Mechanical Engineering*

*IMEKO-International Measurement Confederation*

*DYMAT-European Association for Dynamics of Materials*

*INEGI-Instituto de Ciência e Inovação em Eng<sup>a</sup>. Mecânica e Eng<sup>a</sup>. Industrial*

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PAPER REF: 7288

## **THERMAL-BRIDGE ASSESSMENT IN GLAZING AND ALUMINIUM FRAMES BY THERMO-IMAGES: A CASE STUDY**

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### **ABSTRACT**

This paper presents the experimental analysis and results of a thermographic inspection performed on aluminum window frames of an instructional facility. The investigation was carried out using thermal images to map the energy loss and gains through aluminum window and door frames on several rooms of the building that houses the School of Technology of the Polytechnic Institute of Bragança in Portugal. The results obtained are discussed in detail and a retrofit strategy is proposed based on the thermal analysis.

**Keywords:** thermal bridges, thermography, thermal insulation.

### **INTRODUCTION**

Construction of modern buildings presents a great challenge towards the improvement in building energy efficiency and the implementation sustainable building policies and legislation to achieve the so-called near zero-energy buildings (NZEB). Although near zero-energy design of new buildings is a positive step, the main problem is related with energy demand reduction in a high number of energy-inefficient existing buildings making more critical to incentive the refurbishment of existing buildings rather than to demolish and replace them with new constructions.

It is well-known that thermal heat losses and gains through the building envelope are mainly due to energy transfer through the glazing and window frames. Energy can also be lost by infiltration around the window frame, conduction through a frame as well as by radiation through the glazing surface (also a small amount of energy is also lost through convection within the glazing cavity). Although metal frame design have been enhanced considerably over the last decades, early metal frames with simple sections and without thermal breaks are present in most existing buildings becoming the main weak spot in improving the energy performance of such buildings. Evaluating thermal heat losses and gains in these construction components can be helpful to determine the best retrofit strategy to increase energy efficiency while ensure optimal thermal comfort based on cost-benefit analysis.

Non-destructive testing methods and non-contact measurement devices such as infrared thermography (IRT) cameras provide powerful tools for quickly and accurate data visualization and analysis of temperature distribution of entire surfaces. Thermal imaging have evolved significantly to the point that affordable and compact medium resolution thermal imaging cameras are now available for building applications. Usually, energy auditors and maintenance technicians use thermography to locate overheating points to identify faulty devices, machinery components or electrical equipment damage, but also to locate leakages, moisture detection and to inspect buildings.

In this regard, the aim of this study is to identify thermal losses and how they are distributed in glazing and aluminum frames of an existing building using an infrared scanning inspection. An affordable FLIR camera is used to record daily temperature distribution measurements of glazing and frames over a period of several months in selected rooms of the building that houses the School of Technology of the Polytechnic Institute of Bragança in Portugal. In this case, original windows/doors feature single-glazed units with simple aluminum frame.

## RESULTS AND CONCLUSIONS

The thermal information is used to evaluate the heat losses and gains through window and door glazing and frames. Climatic data from a local weather station is used to validate the outdoor temperature and the thermal measurements. The results based on the analysis of the thermal images captured on the surface of the window/door are used to characterize the performance of the glazing and surrounding frame. Temperature variation throughout the day was recorded and analyzed (Figure 1).

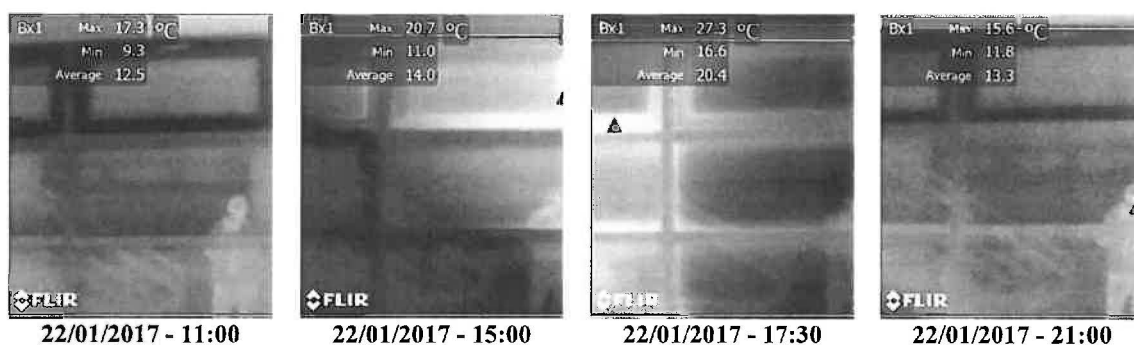


Fig. 1 - Thermal images for heat losses and gains glazing analysis.

A thermal bridge analysis was carried out to identify critical heat loss points allowing cost-effective retrofit measures to be defined in order to improve the performance of the glazing and window frames and increment the energy efficiency of the building envelope.

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