RECENT ADVANCES IN INTEGRITY-RELIABILITY-FAILURE

J.F. Silva Gomes, Shaker A. Meguid
Editors

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About the Book

Innovative engineering in mechanics, materials and systems have witnessed the most significant progress in recent years. Important and dramatic improvements in component design will continue to be made by the use of the latest advances in mechanics, materials and manufacturing processes. Different tools are available to optimize any engineering solution, and we must continue our efforts to develop and use superior materials, apply reliable analytical and numerical techniques and validate these with sound experimental methods. During the last few decades the development of computer based techniques, as well as laser-optics methods, nanotechnologies and nanomaterials, among many other technological advances, added new dimension and perspectives to minimize or prevent catastrophic failures of engineering systems, structures and components.

This volume contains the extended Abstracts of the 380 papers accepted for presentation in the IRF2013-4th International Conference on Integrity, Reliability and failure held in Funchal/Portugal, 23-27 June 2013. The book is complemented by an accompanying CD-ROM containing the full length papers.

IRF2013 is part of a prestigious series of conferences that was initiated in 1999, in Porto (Portugal), coordinated by the International Scientific Committee on Mechanics and Materials in Design. The conference attracted over 300 participants with 380 accepted submissions from 45 different countries around the world. These papers were presented in June 23-27, 2013 in the magnificent city of Funchal, Madeira, and the conference themes focused on nanoengineering, computational and structural mechanics, micromechanics, experimental mechanics, advanced materials, thermo-fluid systems and case studies, among other engineering topics.

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EDITORS PREFACE

As the engineering community continues to cross the boundaries of known practices, materials and manufacturing techniques into the frontiers of new functional materials, environments and applications, the opportunities for catastrophic failures will inevitably increase. If our knowledge of how to engineer systems, structures and components to minimize or prevent catastrophic failure is to keep pace with modern manufacturing technologies, the demanding applications, and the intolerance of a safety conscious society, we must continue our efforts to develop and use superior materials, apply reliable analytical techniques and validate these with sound experimental tools. It is with this in mind that this series of conferences was organised.

The objectives of this gathering are to provide a forum for the discussion and dissemination of recent advances in assessing the integrity, reliability and failure of engineering structures, components, and assemblies, foster research in these areas, and promote international co-operation among scientists and engineers in the field. The goal is to enable concerned researchers and scientists from all over the world to exchange ideas on mechanics, materials and design as they relate to system integrity and reliability.

This fourth international conference, which is sponsored by the University of Porto, the University of Toronto and the University of Madeira, is part of a prestigious series of Integrity Reliability and Failure conferences coordinated by the International Scientific Committee on Mechanics and Materials in Design. The conference attracted over 300 participants with 380 accepted submissions from 45 different countries around the world. These papers were presented in June 23-27, 2013 in the magnificent city of Funchal, Madeira. The conference themes which address integrity, reliability and failure focused on Analytical and Numerical tools, Testing and Diagnostics, Surface and Interface Engineering, Sensors and Instrumentation, Tribology, Mechanical Design and Prototyping, Modes of Failure, Composite Materials, Nanotechnologies and Nanomaterials, Biomechanics, Energy and Thermo-Fluid Systems, Impact and Crashworthiness and Case Studies.

We are particularly indebted to the authors and special guests for their plenary lectures and presentations. Each of the more than 380 contributions offered opportunities for thorough discussions with the authors. We acknowledge all of the participants, who contributed with innovations, new research approaches, novel modeling and simulation efforts, and invaluable critical comments. We are also indebted to the outstanding plenary lecturers who highlighted the conference themes with their contributions: Professor Xiong Zhang (Tsinghua University, P. R. China), Professor E.A. Elsayed (Rutgers University, USA) and Professor Noritsugu Umehra (Nagoya University, Japan). We also take this opportunity to thank the members of the International Scientific Committee and reviewers for their time and effort.

Last but by no means least, we offer our sincere gratitude to the symposia organisers for their contribution to the success of the event and the local organising committee for attending to many aspects of the conference demands. For all of them, we are truly very grateful.

Shaker A. Meguid and J.F. Silva Gomes
Funchal / Madeira, June 2013

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APAET-Portuguese Association for Experimental Mechanics
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J.F. Silva Gomes, Shaker A. Meguid (Ed)

Proceedings IRF2013
4th International Conference on Integrity, Reliability and Failure
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SYMPOSIUM_18

Safety of Wooden Structures

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PAPER REF: 4090

THERMAL ANALYSIS OF WOOD-STEEL HYBRID CONSTRUCTION

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ABSTRACT

The main objective of this work is to provide the thermal analysis in wood-steel hybrid elements for building constructions under fire conditions. A transient thermal analysis with nonlinear material behaviour will be solved with ANSYS program. The use of wood-steel hybrid models has major advantages as increased fire resistance, and improved high strength. Wood is a lightweight material, easy to assemble, great architectural features, thermal and acoustic characteristics. However, the high vulnerability of wooden elements under fire, involves evaluating their behaviour accurately. Its physical behaviour is conditioned by the charring layer formation, which may allow the insulation into the structural section. The steel is a current use material allowing high structural strength. However, steel is a non-combustible material, and when compared with wood is a very good conductor of heat. Consequently, the unprotected sections of steel under fire quickly heats, and the fire resistance decreases considerably. The numerical modelling of these hybrid models, providing the analysis at high temperatures, is complicated due to the heat produced, to form a layer of carbonization surrounding the wood, and also the properties of both materials are nonlinear. Using a computer model, it will become possible to calculate the fire resistance of these hybrid elements, an important parameter for safety and design rules.

Keywords: wood-steel, hybrid construction, fire, numerical model.

INTRODUCTION

The use of hybrid materials could increase the structural integrity of the construction elements. Steel material has many advantages over wood elements, strength, stability, resistance to woodworm, among others. Steel is incombustible and most of the times it can full recover strength after fire but, steel material conducts heat extremely well, (Jan et al, 2002), (Barbosa et al, 2012). Wood is a renewable resource, recently attracted by public attention. Wood is a natural material with good structural characteristics. The wood when exposed to accidental actions, such as fire conditions, has a surrounding charring depth. However, this layer can delay the heating process to the core section, acting as an insulating.

In this work wood-steel hybrid profiles subjected to fire are presented to verify the best solution used in design construction. The complexity of this analysis needs some numerical techniques with high performance, which is the case of the finite element analysis.

RESULTS AND CONCLUSIONS

The thermal properties of steel and wood are function of the temperature and should be determined from the Eurocode 3 (CEN 1995) and Eurocode 5 (CEN 2004), as represented in figure 1.

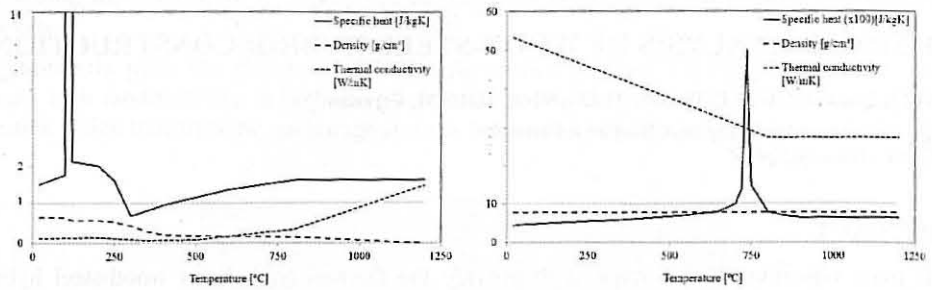

Fig. 1 - Steel and wood thermal properties.

Conclusions are presented and discussed about the importance of the temperature field obtained in wood-steel hybrid sections using a finite element modelling.

According to the results, wood elements present lower temperatures than steel, and the maximum temperature is always inside the char layer. The wood-steel hybrid profile can to perform well under fire conditions. Regarding the design construction (outside wood of the steel profile), it is concluded that it has a good fire resistance, even for the three sides fire exposure, showing the ability of wood to protect the steel, as shown in figure 2.

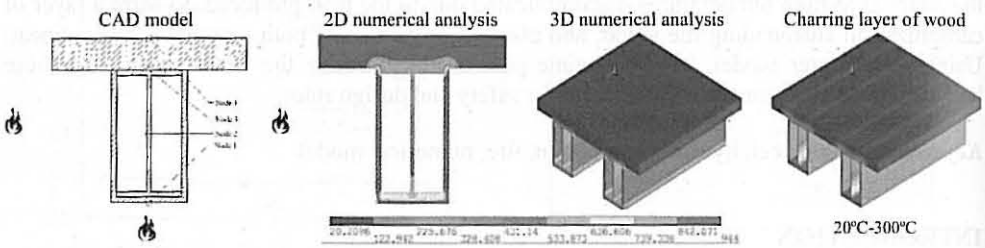

Fig. 2 - Temperatures in wood-steel hybrid profile at the end of 3600s.

REFERENCES

[1]-Jan, K., Phil, C., Making Steel Framing as Thermally Efficient as Wood Most Current Developments from ORNL, Proceedings of the Thirteenth Symposium on Improving Building Systems in Hot and Humid Climates, Houston, TX, ESL-HH-02-05-40, 2002.

[2]-Barbosa, L.F.M.; Almeida, P.M.L.; Fonseca, E.M.M.; Barreira, L.M.S.; Coelho, D.C.S.; Hybrid wood/steel elements under fire, International Congress Fire Computer Modeling, Universidad de Cantabria, pp. 407-420, ISBN 978-84-86116-69-9, 2012.

[3]-EN 1993-1-2:1995. Eurocode 3: Design of Structures - Part 1-2: General Rules - Structural Fire Design, CEN, 1995.

[4]-EN 1995-1-2:2004. Eurocode 5: Design of timber structures, Part 1-2: General-Structural fire design, CEN, 2004.