RECENT ADVANCES IN INTEGRITY-RELIABILITY-FAILURE

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

Proceedings of the 4th International Conference on Integrity, Reliability and Failure, Funchal, Portugal, 23-27 June 2013

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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, Madera, 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 Umehara (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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PAPER REF: 4041

FIRE BEHAVIOUR OF COMPOSITE STEEL TRUSS AND CONCRETE BEAM

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ABSTRACT

This work compares the thermal behaviour on four different Composite Steel Truss and Concrete Beam (CSTCB), when submitted to two fire conditions (one side and four sides). This analysis aims to be a preliminary assessment of a series of experimental tests. CSTCB with pre-cast plate delay temperature evolution on the steel truss and reinforcement, increasing fire resistance.

Keywords: fire, numerical analysis, composite beam, steel truss and concrete.

INTRODUCTION

The prefabricated concrete trussed beams (CSTCB) are composite elements designed to resist to bending, consisting of a steel truss encased in concrete, casted in place, with different typologies and a steel base plate or pre-casted concrete plate, encased partially or totally in casted concrete. These beam elements present a wide variety of building solutions, being characterized by two constructive stages. The first stage considers the element made only by the self-supported steel truss, assuming the beam as simple supported. This structure is able to support its own weight and the weight of the slabs without any provisional supports. The design should follow the general rules for steel structures (CEN a, 2005). In the second stage, truss is encased by concrete and behaves similarly to a reinforced concrete (RC) beam (Quaranta et al., 2011).

Longitudinal reinforcement at the bottom and at the upper side depends in the chosen configuration. Usually two upper bars require one plane steel truss, while three or four upper rebars require two or three plane steel truss, respectively (Quaranta et al., 2011), see Figure 1.

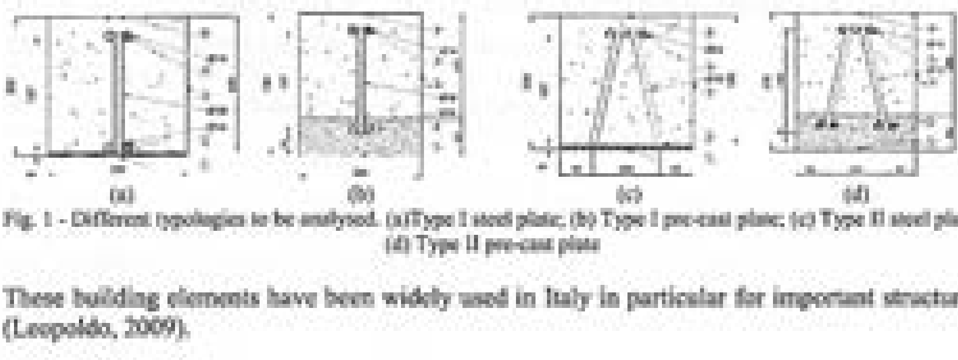

Fig. 1 - Different typologies to be analysed. (a)Type I steel plate; (b) Type I pre-cast plate; (c) Type II steel plate; (d) Type II pre-cast plate

These building elements have been widely used in Italy in particular for important structures (Leopoldo, 2009).

RESULTS AND CONCLUSIONS

A three-dimensional model was defined with unsteady nonlinear material thermal analysis to evaluate temperature on the CSTCB. The standard fire curve ISO 834 was applied in one side and in four sides, using the traditional convection and radiation parameters. The material behaviour was defined according to the European standards (CEN b, 2005; CEN, 2004).

Figure 2 represents a numerical comparison between the cross section type I (a) and type I (b) with fire from one side (bottom). There is a substantial difference between the temperature values of the bottom cord for the longitudinal reinforcement (see point 2 in Figure 1).

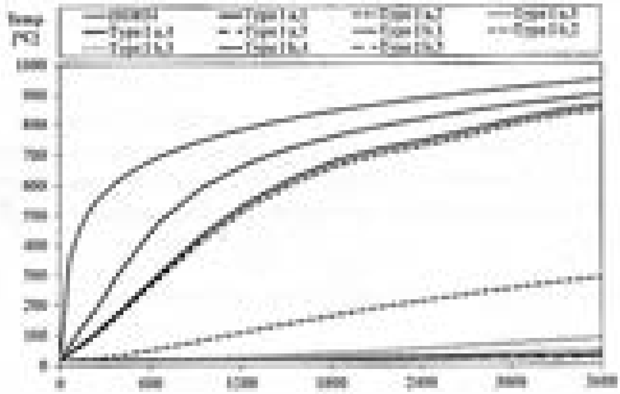

Fig. 2 - Numerical results for cross section Type I (a and b)

REFERENCES

[1]-CEN a, EN1993-1-1, "Design of steel structures - Part 1-1: General rules and rules for buildings", May 2005.

[2]-CEN b; EN 1993-1-2; Eurocode 3, Design of steel structures - Part 1-2: General rules - Structural fire design, April 2005.

[3]-CEN; EN 1992-1-2, "Eurocode 2: Design of concrete structures - Part 1-2: General rules - Structural fire design"; December 2004.

[4]-G. Quaranta, F. Petrone, G.C. Marano, F. Trentadue and G. Monti; "Structural design of composite concrete-steel beams with spatial truss reinforcement elements", Asian journal of civil engineering (building and housing), vol. 12, pp. 155-178, no. 2, 2011.

[5]-Leopoldo Tesser, "Composite steel truss and concrete beams and beam-column joints for seismic resistant frames Modelling, numerical analysis and experimental verifications"; PhD thesis, Department of Construction and Transport, University of Padova, Italy, February 2009.