

# ECCM 2010

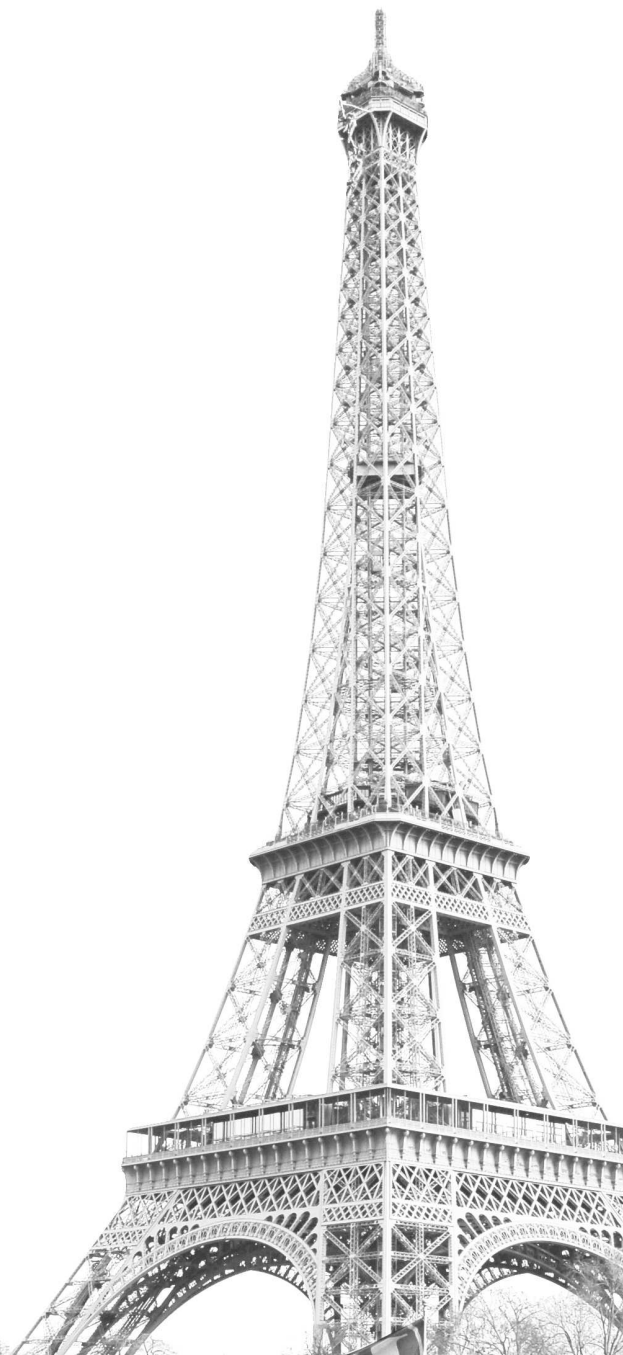
## IV European Conference on Computational Mechanics

Solids, Structures and Coupled Problems  
in Engineering

Palais des Congrès, France  
May 16-21, 2010

### Table of Contents

Conference organization	2
Plenary and semi-plenary lectures	8
Parallel sessions of Monday	10
Parallel sessions of Tuesday	30
Parallel sessions of Wednesday	46
Parallel sessions of Thursday	62
Parallel sessions of Friday	78
Access and conference rooms plans	85
Author index	88



# Conference organization

## Greetings from the co-chairmen of ECCM 2010

Welcome to the Fourth European Conference on Computational Mechanics “Solids, Structures and Coupled problems in Engineering”.

What are the reasons of the tremendous success of this edition of the Conference, with over 2,100 submitted abstracts and about 1,700 papers to be presented? Of course this is the first time this Conference is co-organised under the umbrella of national associations of two countries very active in the field (CSMA in France and GAMM and GACM in Germany). Of course Paris is an attractive city. Nevertheless, the main reason is surely the overwhelming response to the call of mini-symposia and the commitment to all people involved in mini-symposia organization. Clearly the success of the Conference is the success of the entire community!

We would like to express our gratitude to all the sponsors for their strong support of the conference and its main subject “Computational Mechanics”. We also wish to thank Professor Oñate and Cristina Forace from CIMNE for their help in the dissemination of the information, and Professor Mota-Soares who, as organizer of ECCM 2006, helped us in launching this Conference. Also very helpful was the support of Professors Schrefler and Perego, who generously shared their experience as organizers of WCCM 2008 in Venice. This conference could not have been organized without the incredible commitment of the CEA and especially of Thierry Charras (General Secretary) and Antoine Letellier (Web site). Finally, the active involvement of Marc Bonnet and Hachmi Ben Dhia in the scientific management, and of David Néron in the programme edition, were also essential.

We hope this Conference will meet your expectations, both scientifically and socially, and we are very proud to be able to welcome all of you in Paris.

O. Allix and P. Wriggers  
Chairmen of the Conference

## Greetings from the President of ECCOMAS

On behalf of the European Community on Computational Methods in Applied Sciences (ECCOMAS) it is a great pleasure for me to welcome you to the IV European Conference on Computational Mechanics in Solids, Structures and Coupled Problems in Engineering (ECCM 2010) here in Paris. The ECCM Conference, together with the ECCOMAS congress and the European Conference on Computational Fluid Dynamics (CFD), constitute the three main scientific events of ECCOMAS organized every four years. ECCOMAS is a scientific organization grouping European associations with interests in the development and applications of computational methods in science and technology. The mission of ECCOMAS is to promote joint efforts of European universities, research institutes and industries which are active in the broader field of numerical methods and computer simulation in Engineering and Applied Sciences, to address critical societal and technological problems with particular emphasis on multidisciplinary applications. In addition to these three large-scale European events, ECCOMAS supports regional conferences, endorses thematic conferences and workshops, promotes young investigators conferences and courses and encourages the organization of open industrial days within its fields.

The main objective of the ECCM Conference series is to provide a forum for presentation and discussion of state-of-the-art advances in scientific computing applied to solids, structures and coupled problems in engineering, including basic methodologies, scientific developments and industrial applications, and to serve as a platform for establishing links between research groups of academia and industry with common as well as complementary activities. The previous ECCM Conferences were held in Munich in 1999, Cracow in 2001 and Lisbon in 2006. The ECCM 2010 Conference inaugurates the awarding of the Euler Medal for outstanding and sustained contribution to the area of computational solids and structural mechanics and coupled problems in engineering. This Medal, together with the O.C. Zienkiewicz Award for young scientists in the field of computational engineering sciences, is awarded biannually at the ECCOMAS Congresses and the ECCM Conferences.

I would like to take this opportunity to thank the Chairmen of the ECCM 2010 Conference, Professors Oliver Allix and Peter Wriggers and their teams for the excellent organization and for the impressive number of participants, reaching almost 2,000, which is a landmark in the history of the ECCM Conferences and to extend my best wishes to all the participants for an enjoyable and fruitful experience, both from the scientific and cultural points of view.

M. Papadrakakis  
President of ECCOMAS

## Organizing institutions

- ECCOMAS<sup>12</sup> European Community on Computational Methods in Applied Sciences
- IACM International Association for Computational Mechanics
- ECCSM<sup>3</sup> Computational, Solid and Structural Mechanics Committee
- CSMA French Computational Structural Mechanics Association
- GACM German Association for Computational Mechanics
- GAMM Gesellschaft für Angewandte Mathematik und Mechanik
- CEA
- ENS Cachan
- Ecole Polytechnique
- Ecole Centrale Paris

## Organizing committee

- O. Allix (Conference Chairman), ENS Cachan, France
- P. Wriggers (Conference Chairman), Leibniz Universität Hannover, Germany
- T. Charras (General Secretary), CEA, France
- H. Ben Dhia, Ecole Centrale Paris, France
- M. Bonnet, Ecole Polytechnique, France
- D. Néron, ENS Cachan, France
- A. Letellier, CEA, France

## International programme committee

- E. Oñate (President of IACM), Polytechnic University of Catalunya, Spain
- H. Mang (Vice-President of ECCOMAS), Technical University of Vienna, Austria
- M. Papadrakakis (President of ECCOMAS), National Technical University of Athens, Greece
- O. Allix (Conference Chairman), ENS Cachan, France
- P. Beckers, University of Liège, Belgium
- A. I. Borovkov, Polytechnical University of Saint Petersburg, Russia
- R. de Borst, Technische Universiteit Eindhoven, The Netherlands
- T. Burczynski, Silesian University of Technology, Poland
- D. Givoli, Israel Institute of Technology, Israel
- M. Kleiber, Polish Academy of Science, Poland
- P. Ladevèze, ENS Cachan, France
- C. A. Mota Soares, Technical University of Lisbon, Portugal
- R. Ohayon, CNAM Paris, France
- D.R.J. Owen, University of Wales, United Kingdom
- E. Ramm, University of Stuttgart, Germany
- B. Schrefler, University of Padua, Italy
- E. Stein, University of Hannover, Germany
- N.E. Wiberg, Chalmers University, Sweden
- P. Wriggers (Vice Chairman), IKM/LUH, Germany

## Local programme committee

- O. Allix, LMT, ENS Cachan, France
- H. Ben Dhia, LMSS-MAT, Ecole Centrale Paris, France
- M. Bischoff, Universität Stuttgart, Germany
- M. Bonnet, LMS, Ecole Polytechnique, France
- P. Cartraud, GeM, Ecole Centrale Nantes, France
- P. Chabrand, LMA, Université de la Méditerranée, France
- A. Combescure, LaMCoS, INSA Lyon, France
- F. Feyel, ONERA Châtillon, France
- S. Reese, Ruhr-Universität Bochum, Germany
- J. Schröder, Universität Stuttgart, Germany
- P. Verpeaux, CEA Saclay, France
- W. Wall, Universität Munich, Germany
- P. Wriggers, IKM, Leibniz Universität Hannover, Germany

## International advisory board

- P. Alart, France
- D. Aubry, France
- T. Belytschko, USA
- M. Bendsoe, Denmark
- P. Bergan, Norway
- D. Beskos, Greece
- N. Bicanic, United Kingdom
- M.H. Bodoruglu, Turkey
- S. Cescotto, Belgium
- J-L Chenot, France
- P. Chinesta, France
- C. Comi, Italy
- A. Corigliano, Italy
- E. De Arantes e Oliveira, Portugal
- P. Díez, Spain
- J.C. De Sá, Portugal
- A. Eriksson, Sweden
- C. Farhat, USA
- Z. Gaspar, Hungary
- M. Geers, Netherlands
- M. Geradin, Italy
- E. Van der Giessen, Netherlands
- P. Hansbo, Sweden
- G. Holzapfel, Austria
- A. Huerta, Spain
- T.J.R. Hughes, USA
- A. Ibrahimbegovic, France
- S. R. Idelsohn, Argentina
- J. Korelc, Slovenia
- W.K. Liu, USA
- T. Lodygowski, Poland
- E. Lund, Denmark
- P. Martins, Portugal
- K.M. Mathisen, Norway
- H. Matthies, Germany
- C. Miehe, Germany
- N. Moes, France
- P. Neittaanmäki, Finland
- J.T. Oden, USA
- N. Olhoff, Denmark
- X. Oliver, Spain
- U. Perego, Italy
- D. Peric, United Kingdom
- P. Pimenta, Brazil
- F.G. Rammerstorfer, Austria
- E. Rank, Germany
- B.D. Reddy, South Africa
- K. Runesson, Sweden
- E. Sacco, Italy
- G.I. Schueller, Austria
- O. Sigmund, Denmark
- S. Sloan, Australia
- J. Soric, Croatia
- R. Stenberg, Finland
- S. Stupkiewicz, Poland
- W. Wagner, Germany
- Z. Waszczyszyn, Poland
- N.E. Wiberg, Sweden
- G. Zavarise, Italy
- T.I. Zohdi, USA

<sup>1</sup>Meeting of the Managing Board of ECCOMAS on Sunday, 14:00

<sup>2</sup>Meeting of the General Assembly of ECCOMAS on Wednesday, 18:30

<sup>3</sup>Meeting of the ECCSM Committee on Wednesday, 12:40 to 14:00

## Out of Plane Bending in Curved Pipes

L. Madureira<sup>1</sup>, E. Fonseca<sup>2</sup>, F. Q. Melo<sup>3</sup>

<sup>1</sup> Faculdade de Engenharia, Universidade do Porto, Portugal, luisa.madureira@fe.up.pt

<sup>2</sup> Instituto Politécnico de Bragança, Portugal, efonseca@ipb.pt

<sup>3</sup> Universidade de Aveiro, Portugal, francisco@ua.pt

Piping structures have large application in power generation and chemical plants. Given their complexity and construction safety standards, the development of accurate numerical methods has been analyzed by several authors [1,2,3] with trigonometric solutions. Also pipe finite elements, with a considerable amount and complexity of work, has been used to define accurate models for numerical approach of the stress field [4,5,6,7].

In this work both analytical and numerical approaches are presented. A mathematical analytical solution is derived using a mixed formulation where unknown functions are combined with Fourier series [8]. Using a minimization criterion for the total energy involved in the process a system of second order ordinary differential equations is obtained and then solved using the MAPLE<sup>®</sup> mathematical package. Numerical simulation was performed using the Finite Element Method for the same steel pipe under out-of-plane bending and results are compared showing that good agreement can be reached if more terms are included in the Fourier expansion. In this example four terms were considered.

The shell is considered thin and inextensible in longitudinal direction and the Kirchoff model is used. The curvature radius  $R$  is much larger than  $r$ , the section radius, as depicted in Figure 1. The solution for the three dimensional out-of-plane bending uses a set of trigonometric functions that is complementary of the in-plane case

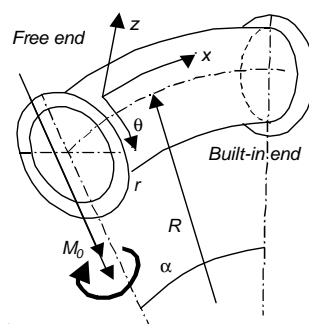


Fig. 1 -Out-of-Plane bending moment  $M_0$  in a rigid flanged curved pipe

The results of the example studied here with both analytical and finite element techniques are shown in Figures 2 and 3 where a comparison with experimental results obtained by Smith and Ford [9] is included.

An out-of-plane bending moment in a rigid flanged curved pipe was performed (with two diametrically opposed forces) using Ansys<sup>®</sup> program. The finite element used was the SHELL93. This

type of element is particularly well suited to model curved shells. The element has six degrees of freedom at each node: translations in the nodal x, y, and z directions and rotations about the nodal x, y, and z-axes. The deformation shapes are quadratic in both in-plane directions. The element has plasticity, stress stiffening, large deflection, and large strain capabilities.

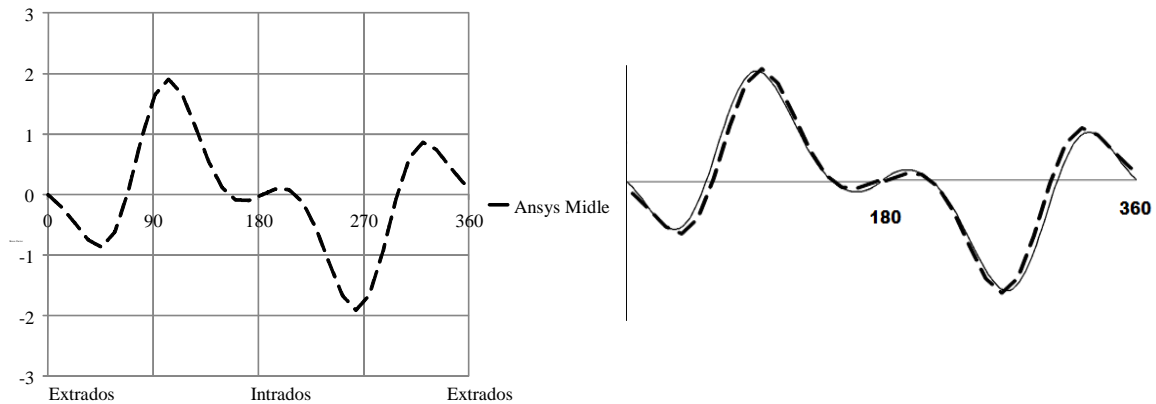


Fig.2 Axial stress distribution for out-of-plane loading (---ANSYS and —Fourier expansion)

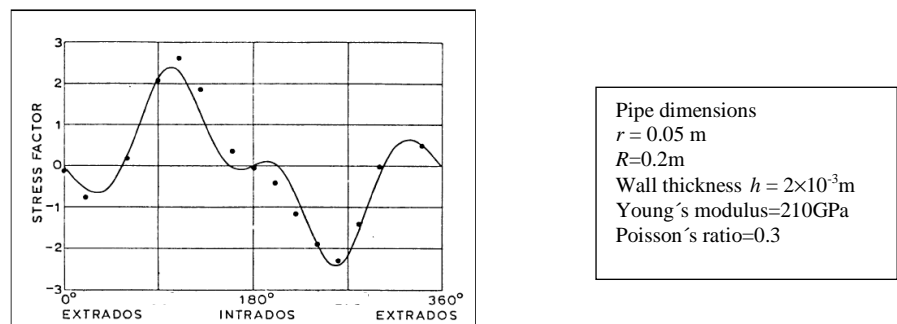


Fig.3 Axial stress distribution for out-of-plane loading compared to Smith and Ford [9]

These results show that a good accuracy is obtained when compared both with finite element methods and experimental results published in the literature.

## References

- [1] Thomson G., *Stress Analysis in Smooth Bend Pipes*, PhD Thesis, University of Strathclyde, Scotland, 1980.
- [2] Bathe K-J and Almeida C, "A simple and effective pipe elbow element - linear analysis", *Transn. ASME, Journal of Applied Mechanics*, (1980) Vol 47, pp.93-100
- [3] Bathe K-J and Almeida C, "A simple and effective pipe elbow element - pressure stiffening effects", *Transn. ASME, Journal of Applied Mechanics*, (1982) Vol 49, pp. 914-916
- [4] Melo F and Castro P, "The linear elastic stress analysis of curved pipes under generalized loads using a reduced integration finite ring element", *Journ. of Strain Analysis*, (1997) Vol 32, N 1.
- [5] Othsubo H and Watanabe O, "Stress Analysis of Pipe Bends by Ring Elements", *Transn. ASME, Journal of Applied Mechanics*, (1978) Vol 100, pp.112-121
- [6] Wilczek E, *Statische Berechnung eines Rohrkrümmers mit Realen Randbedingungen (Static analysis of curved pipes with realistic boundary conditions)* PhD thesis (in German), Technischen Hochschule Aachen, Aachen. 1984
- [7] Kitching R, *Smooth and Mitred Pipe Bends*, Chap. 7 in "The Stress Analysis of Pressure Vessels & Pressure Vessels Components" Ed. by S. S. Gill, Pergamon Press 1970
- [8] Madureira L and Melo F, "Stress analysis of curved pipes with hybrid formulation". *Pressure Vessels & Piping* Vol 81 N3, 2004, pp 243-249
- [9] Smith R and Ford H, "Experiments on Pipe Lines and Pipe Bends Subjected to Three-Dimensional Loading" *Journal of Mechanical Engineering Science*, 1967, 9:2, pp 124-137.