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, 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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PAPER REF: 4692

A DISPLACEMENT FORMULATION FOR CYLINDRICAL SHELLS UNDER RADIAL LOADS

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ABSTRACT

A displacement formulation for cylindrical shells subjected to radial loads is presented. Static loads are applied to straight thin pipes using a variational method and results are compared both to finite element analysis and a shell element from Ansys program. The formulation includes a combination of trigonometric functions in two variables, longitudinal and circumferential direction. Then a system of differential equations is solved for two different load cases and the vertical displacement is obtained in the points where the load is applied.

Keywords: cylindrical shell, trigonometric functions, point load.

INTRODUCTION

The basic assumptions in the present analysis of the deformation of straight pipes are that the shell is thin and the transversal section is inextensible, not including pressure effects.

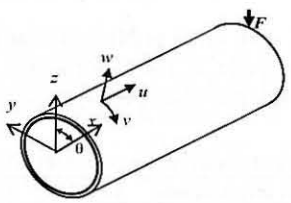

Fig. 1 - Shell displacements

Considering the parameter x as longitudinal and θ as circumferential, u the longitudinal displacement, v the circumferential displacement and w the transversal displacement, kinematics expressions relating the mid-surface strains to the displacements are:

$$\varepsilon_{xx} = \frac{\partial u}{\partial x} = 0$$

$$\varepsilon_{\theta\theta} = \frac{1}{r}\left(\frac{\partial v}{\partial \theta} + w\right) = 0 \qquad (1)$$

$$\gamma_{x\theta} = \frac{1}{r}\frac{\partial u}{\partial \theta} + \frac{\partial v}{\partial x} = 0$$

while the curvatures and twist are expressed by:

$$\chi_{\theta\theta} = \frac{1}{r^2}\left(-\frac{\partial v}{\partial \theta} + \frac{\partial^2 w}{\partial \theta^2}\right)$$

$$\chi_{x\theta} = \frac{2}{r}\left(-\frac{\partial v}{\partial x} + \frac{\partial^2 w}{\partial x \partial \theta}\right) \quad (2)$$

The total energy is defined by the following expression:

$$\frac{1}{2}\int_0^{2\pi}\int_0^{L} Dk^2_{\theta\theta} + \frac{D(1-\nu)}{2}k^2_{x\theta}\, r dx d\theta \quad (3)$$

The displacement is formulated using odd functions in θ combined with different functions in x. Several cases for x-functions are considered. The geometric parameters are the pipe length L, the thickness h and the radius r. The material is steel and load cases are:

Case 1: a point load in the pipe end,

Case 2: pinched forces applied in the middle of the pipe.

RESULTS AND CONCLUSIONS

A total of 2 different approaches were tested for both load cases. The pipe dimensions are represented in table 1.

Table 1 - Pipe dimensions

Length, m	Radius, m	Thickness, m
0.40	0.159945	0.00335
0.2		0.00396
		0.00457

The results show good agreement with other published solutions using multi-nodal or finite element analysis, as represented in table 2. The deformation is larger when the pipe length increases and the ring defection is smaller when the pipe thickness increases.

Table 2 - Vertical displacement for h=0.00335m (Case 2)

Different formulations	L=0.2m	L=0.4m
Finite element	0.0151	0.0242
Multi-nodal	0.0140	0.0230
Variational	0.0142	0.0233

This study shows that the functional approach with minimization of the total energy leads to the same results as compared with finite elements, as published by (Fonseca et al, 2011).

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[1]-Fonseca E.M.M., Madureira Luísa, Melo F.J.Q. A multi-nodal ring finite element for analysis of pipe deflection. International J of Manufacturing Science and Engineering, 2011, Vol2, N2, pp. 109-114.