RECENT ADVANCES IN
INTEGRITY-RELIABILITY-FAILURE

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

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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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TRACKS / MAIN TOPICS:

Topic_A: Analytical and Numerical tools
Topic_B: Testing and Diagnostics
Topic_C: Surface and Interface Engineering
Topic_D: Civil Engineering Applications
Topic_E: Sensors and Instrumentation
Topic_F: Tribology, Gears and Transmissions
Topic_G: Mechanical Design and Prototyping
Topic_H: Modes of Failure
Topic_I: Composite Materials
Topic_J: Nanotechnologies and Nanomaterials
Topic_K: Biomechanical Applications
Topic_L: Energy and Thermo-Fluid Systems
Topic_M: Impact and Crashworthiness
Topic_N: Case Studies

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Coordinators: Álvaro Cunha (U.Porto), Elsa Caetano (U.Porto)

Symp_15: Behaviour Characterization of Constructions for Earthquake Demands
Coordinators: Humberto Varum (U.Aveiro), Hugo Rodrigues (U.Aveiro)

Symp_17: Concrete Material Performance
Coordinators: Nuno Dourado (UTAD), Marcelo Moura (U.Porto)

Symp_18: Safety of Wooden Structures
Coordinators: Elza Fonseca (IPB), Débora Ferreira (IPB)

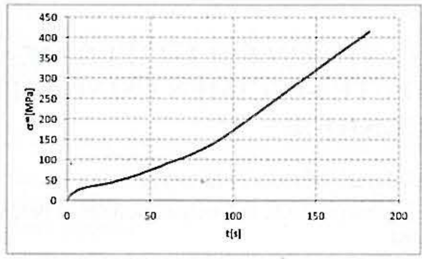
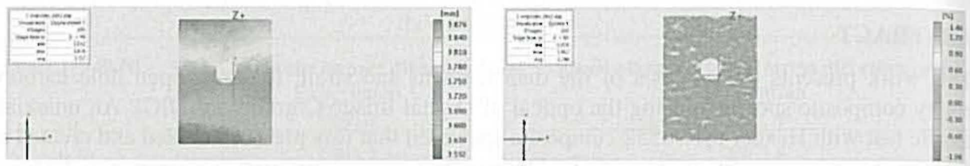


Fig. 1 - Remote stress versus time.



(a) (b)

Fig. 2 - Displacement (a) and strain (b) fields for the 90^{th} second in y direction.

The comparative analysis shows that there is a good agreement between the measure displacements field and the numerical simulation at the hole edge. The experimental results show that Digital Image Correlation is a suitable full-field experimental technique for the measurement of the displacement field in composite materials, especially for large deformations. However, presents low sensitivity for the measurement of strain field, as result, shows a low signal-to-noise ratio, making difficult the analysis of strain field, even at the edge of the hole.

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PAPER REF: 4634

DISPLACEMENT AND STRAIN FIELDS ASSESSMENT OF PDMS USING DIGITAL IMAGE CORRELATION

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ABSTRACT

The main goal of this work is the characterization of the hyper-elastic mechanical behaviour of PDMS. The special specimens of PDMS (Sylgard® 184) were tested in a bi-axial tensile machine. During the tensile test was used a commercial digital image correlation system (ARAMIS of GOM) to obtain de displacement and strain fields. These measurements are compared with numerical simulations which use the most popular algorithms of constitutive models.

Keywords: polydimethylsiloxane, hyper-elastic, digital image correlation, finite element method.

INTRODUCTION

The polydimethylsiloxane (PDMS) is an elastomer with properties that make it a very attractive polymer for various applications in different fields, like biomedical engineering (Yabuta, 2003) and electronics (Andersson, 2003). In last years, this have been used in the development of micro and nanodevices (Mata, 2005), optical MEMs (Schneider, 2009), among others. These news applications demand a better understanding of PDMS mechanical behavior, which only could be achieved using new experimental and numerical approaches. Until now, most of experimental works are based on tensile tests which give average values of mechanical properties. However, the new applications of PDMS material demand a more detail characterization of their mechanical behavior, being the optical experimental techniques more suitable to supply this information. These materials present a hyper-elastic behavior and high deformations levels, which can only be measured with a few optical techniques. In this work is used the Digital Image Correlation (DIC) optical technique to measure the displacement and strain fields of a specimen during a bi-axial tensile test.

RESULTS AND CONCLUSIONS

The load curves of the bi-axial tensile test are shown in Fig. 1. By observing the load-displacement curve it is possible to verify a typical behaviour of hyper-elastic materials, with two different regions, where the first region is nonlinear and the second is approximately linear.

During the bi-axial tensile test sequences of images of the specimen faces are digital recorded by CCD in order to posterior extract the displacement and strain fields. To achieved this objective, a random speckle pattern were previous created in the specimen surface by spraying white and black ink.

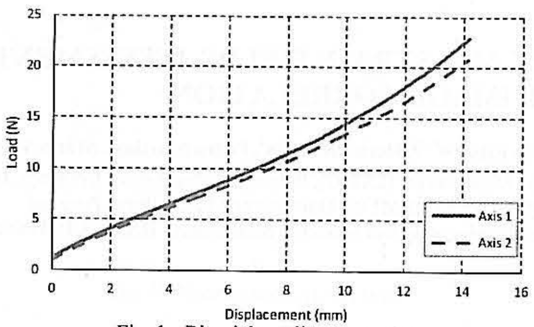
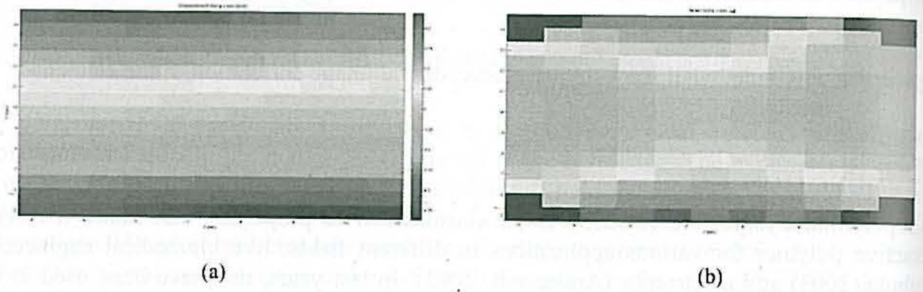


Fig. 1 - Bi-axial tensile test results

In the Fig. 2 are shown the displacement and strain fields for a load case of 7 N for the vertical direction.



(a) (b)

Fig. 2 - Displacement (a) and strain (b) field for a load of 7 N in axis 2 direction obtained by DIC.

The optical technique of Digital Image Correlation proved to be suited for the measurement of displacements and strain fields of hyper-elastic materials. The results show that this technique correlates well in the displacements when high spatial resolution is used, allowing to extract the information for large deformation amplitudes.

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PAPER REF: 4627

HOLOGRAPHIC TECHNIQUES APPLIED IN DENTISTRY STUDIES

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ABSTRACT

In this work we present de development and implementation of two experimental devices based in holographic techniques for the measurement of surface deformation applied to dentistry studies. The proposed systems, an ESPI (Electronic Speckle Pattern Interferometry) system and a DH (Digital Holography) system, both present all the advantages associated with these techniques such as: high resolution, full field, non contact and the possibility of post processing the obtained numerical data. However when compared to each other they present advantages and disadvantages.

The two techniques were applied in some studies in the orofacial biomechanics and material characterization. The advantages and disadvantages in their use are discussed. The potential development of each these techniques are also discussed.

Keywords: holographic, ESPI, digital holography, dentistry.

INTRODUCTION

Holographic techniques are nowadays well established with proven results in different areas. They present several advantages when compared with conventional ones, since they are full field, high resolution and non contact techniques. Electronic Speckle Pattern Interferometry (ESPI) and Digital Holohgraphy (DH) use the same principle, but in DH no lens or other imaging device is used between the object and the video sensor. In DH holograms are digitally sampled, information of optically interfering waves is stored in the form of matrices. Numerical processing is used to simulate the optical processes of interferometry, spatial filtering, etc. This way is possible to calculate the interference phase directly from the holograms, without generation of an interference pattern. In ESPI the results are obtained in real time but in DH due to the numerical reconstruction of the holograms all the process is slower and the results are not obtained in real time.

The application of these techniques to dentistry studies has been done during the last years in the characterization of the mechanical behaviour of dental structures. Currently dentists have available an extensive set of methodologies, components and materials to perform dental rehabilitation. The application of new materials in dentistry like composites, adhesives and ceramics, used in association with metallic implants has increased in the last years. To improve the clinics it is important to understand the limitations of the materials and techniques used because the success of most procedures is highly dependent on the understanding of the Biomechanics associated. Holographic techniques are well adapted for this purpose due to their high resolution field measurements which can be performed with no