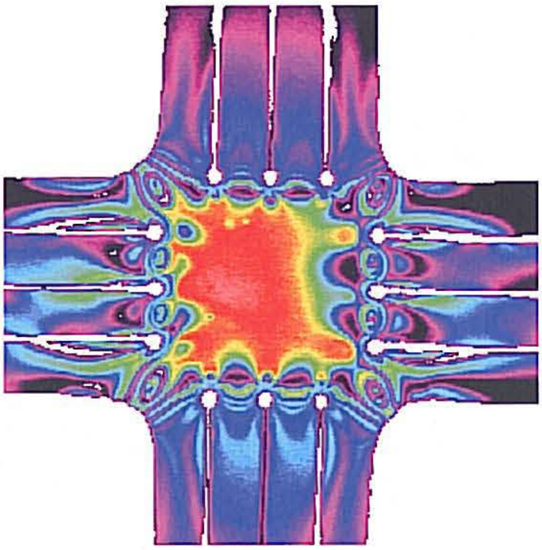
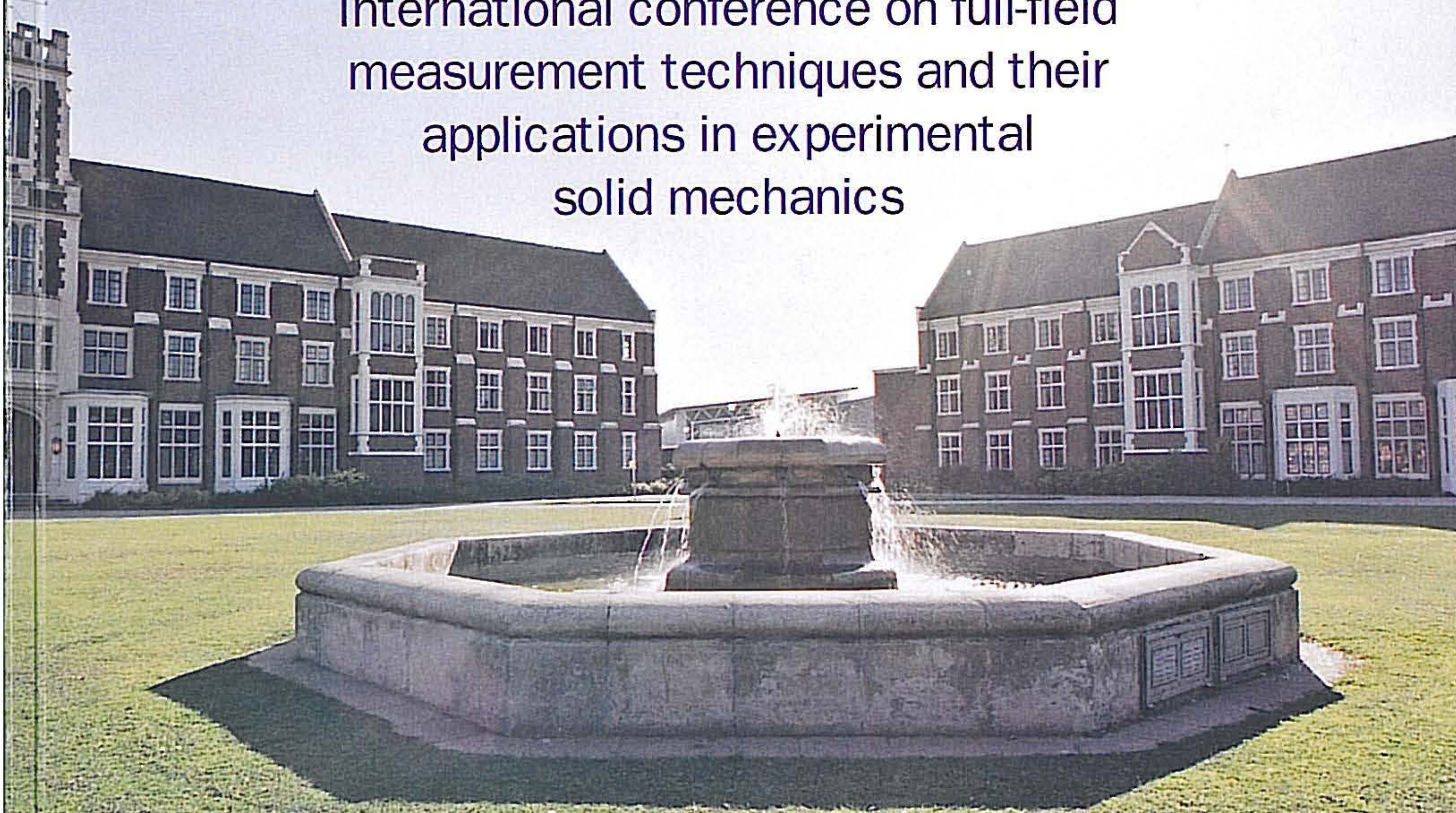


PHOTOMECHANICS 2008

7-9 July 2008
Loughborough, UK

International conference on full-field measurement techniques and their applications in experimental solid mechanics



Book of Abstracts
Edited by Jonathan Huntley and Michel Grédiac

Loughborough University

FOREWORD

We would like to welcome you to Loughborough and the *Photomechanics 2008* conference.

The main objective of this conference is to provide an international forum to promote the new possibilities offered by full-field measurement techniques and to discuss their impact on the mechanical characterization of materials and structures.

Photomechanics 2008 is the second international version of a French series of conferences named *Photomécanique* launched in 1995 by Prof. Berthaud. Based on the increasing success of these national conferences, it was decided in 2004 to launch an international edition, *Photomechanics 2006,* which was held in Clermont-Ferrand, France. *Photomechanics 2008* is the first in this long line of conferences to be held outside France. The 84 abstracts received from 20 different countries clearly indicate the success of this initiative.

Such a large number is mainly due to the patronage of different international associations and to the support of various institutions and companies. We would like to thank all of them for their effective advertising of the conference and for their much appreciated financial contributions.

The authors of some abstracts were invited to contribute full-length papers to *Strain, an International Journal for Experimental Mechanics* edited by the *European Association of Experimental Mechanics*. We would like to take this opportunity to thank Emmanuel Gdoutos and Bob Mines for their confidence in the scientific level of the conference.

We are also very grateful to the 34 members of the scientific committee who reviewed the abstracts received and to the 6 members of the local organizing committee for their tireless work. The conference could not have been organized without their contributions.

Finally, we hope you will enjoy your stay in Loughborough!

Jonathan Huntley and Michel Grédiac
Co-Chairmen of *Photomechanics 2008*

PHOTOMECHANICS 2008

Loughborough, United Kingdom

7^{th} – 9^{th} July 2008

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STRAIN FIELDS ADJACENT TO BONE-IMPLANT INTERFACES: STRAIN FIELD ANALYSIS USING DIGITAL IMAGE CORRELATION TECHNIQUES

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ABSTRACT: When using conventional surface strain measurement techniques (e.g. strain gauges, dial gauges), the measurement of deformations within cancellous bone is frequently hampered by the material's highly porous structure and poor mechanical properties. Although detailed strain maps derived from actual experimental data have the potential to resolve many questions concerning the mechanics of cancellous bone [1], the traditional method of producing maps through measurements with optical techniques has been applied infrequently in its study of this material [1-4].

Previous works have focused on the suitability of the non-invasive technique of speckle interferometry (ESPI) to measure the displacement fields in the surroundings of a bone-implant interface replicate [5-7]. Speckle techniques have been widely applied in the assessment of deformation patterns, which are obtained in the form of fringe patterns, each fringe corresponding to points having the same displacement in the direction of the sensitivity vector. Although ESPI has proven very powerful in monitoring displacement fields in many applications, digital image correlation (DIC) has proven to be a good alternative [8].

Digital Image Correlation (DIC), which is a refinement of the basic marker technique, is a simple non-invasive and non-destructive technique that can be easily automated to provide full-field displacements and strains with a wide range of measurement sensitivity and resolution [9]. Fundamentally, this technique compares pixels from different images and tries to match them. Template matching involves taking a given pattern in one image and shifting a template containing the same pattern in another image [10]. A digital camera can be used without special light conditions to capture the surface intensity pattern in each instant. If several images are taken during a test loading, the displacement field can be followed and subsequently the strain can be obtained by spatial differentiation. Unlike ESPI, the DIC technique maintains the simplicity of conventional measurement methods, without challenging sample preparation or expensive setup.

Normalized cross-correlation (NCC) methods are very efficient tools in template matching, presenting significant advantage over standard cross-correlation techniques, since they are quite robust to different lightning conditions, less sensitive to noise and can be normalized to allow pattern matching regardless of scale and images' offset [11]. The normalized cross-correlation between two images of intensity *f(x,y)* and *f*(x,y)* can be stated as [12-13]:

$$C(u,v)=\frac{\int\left[f(x,y)-\overline{f}(u,v)\right]\cdot\left[f^{*}(x-u,y-v)-f^{*}_{u,v}\right]dA}{\int\left[f(x,y)-\overline{f}(u,v)\right]^{2}\cdot\left[f^{*}(x-u,y-v)-f^{*}_{u,v}\right]^{2}dA} \tag{1}$$

The values of displacement *u* and *v* are computed by maximizing Equation (1) for each subset of images. The smooth and continuous displacement fields can be obtained by least-squares spline approximation of the measured displacements [14] and the template is shifted pixel-by-pixel across the image, forming a correlation plane [11].

A duplication of the experimental jig previously designed and manufactured by Simões et al. [5] will be used to measure the in-plane displacements in the bone-implant interface. The cancellous bone of the proximal femur is idealized as a simple foam cube (commercial polyurethane HEREX® C 70.40) whereas the implant is represented by a prismatic metal tapered rod, centrally inserted in the foam cube (Fig.1).

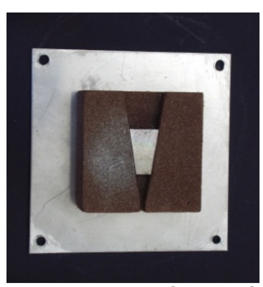

Figure 1- Experimental apparatus to measure the strains in the bone-implant interface.

The model, sectioned longitudinally to expose the interface, will be loaded in compression during image acquisition. Finally, the displacement and strain fields measured through digital image correlation technique will be compared with previous results obtained from both speckle interferometry (Fig. 2a) and finite element analysis (Fig.2b) [5-7].

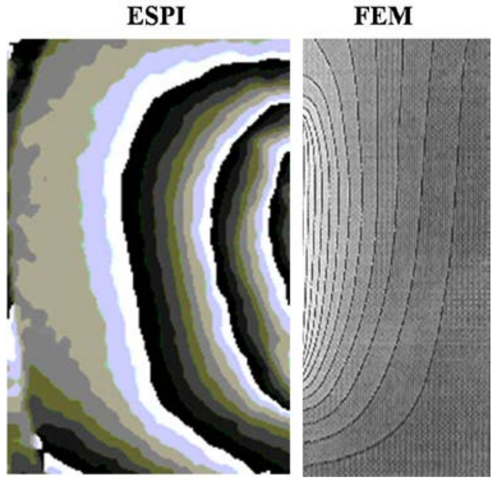

Figure 2- (a) Fringe pattern of the axial displacements and (b) FEM axial displacement field [7].

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