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Experimental Mechanics of Solids

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Cesar A. Sciammarella and Federico M. Sciammarella
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Experimental solid mechanics is the study of materials to determine their physical properties. This study might include performing a stress analysis or measuring the extent of displacement, shape, strain and stress which a material suffers under controlled conditions. In the last few years there have been remarkable developments in experimental techniques that measure shape, displacement and strains and these sorts of experiments are increasingly conducted using computational techniques.

Experimental Mechanics of Solids is a comprehensive introduction to the topics, technologies and methods of experimental mechanics of solids. It begins by establishing the fundamentals of continuum mechanics, explaining key areas such as the equations used, stresses and strains, and two and three dimensional problems. Having laid down the foundations of the topic, the book then moves on to look at specific techniques and technologies with emphasis on the most recent developments such as optics and image processing. Most of the current computational methods, as well as practical ones, are included to ensure that the book provides information essential to the reader in practical or research applications.

Key features:

- Presents widely used and accepted methodologies that are based on research and development work of the lead author
- Systematically works through the topics and theories of experimental mechanics including detailed treatments of the Moire, Speckle and holographic optical methods
- Includes illustrations and diagrams to illuminate the topic clearly for the reader
- Provides a comprehensive introduction to the topic, and also acts as a quick reference guide
- Accompanied by a website www.wiley.com/go/sciammarella hosting problems and solutions.

This comprehensive book forms an invaluable resource for graduate students and is also a point of reference for researchers and practitioners in structural and materials engineering.

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EXPERIMENTAL MECHANICS OF SOLIDS

This book is dedicated to:
Esther & Stephanie our loving wives and great supporters
Eduardo a great son and older brother
Sasha and Lhasa – faithful companions

About the Authors

Cesar A. Sciammarella was Director of the world renowned Experimental Mechanics Laboratory at the Illinois Institute of Technology for more than 30 years. Over that time he made pioneering developments in applying moiré, holography, and speckle interferometry methodologies as an experimental tool to solve industrial problems around the world. He recently completed a five year project funded by the Italian government to help the Politecnico of Bari develop its experimental mechanics lab and increase its future talent. Currently he is Research Professor at Northern Illinois University where he is working on various industrial projects involving optical contouring and experimental mechanics down at the nanometric level. This effort has taken him beyond the Rayleigh limit that traditionally was considered as the maximum resolution that could be obtained in optics in far field observations. His recent work has yielded measurements in the far field of nanocrystals and nanospheres with accuracies on the order of ± 3.3 nm. His recent discoveries will no doubt lead this field as he has done in the past. He has been an active member in the Society of Experimental Mechanics where he has received almost every honor possible.

Federico M. Sciammarella joined the College of Engineering and Engineering Technology at Northern Illinois University in 2007 and is an assistant professor in the Mechanical Engineering Department. His two research areas are laser materials processing and experimental mechanics. One of several projects involves laser assisted machining (LAM) of ceramics through NIU's Rapid Optimization of Commercial Knowledge (ROCK) Project. The ROCK project enhances the capabilities of small companies by working through supply chains and with experts to improve their productivities and process. He has now spent some time using a novel optical method developed with his father and colleague Dr. Lamberti, Advanced Digital Moiré Contouring to measure surface roughness of the ceramic bars after the LAM process. Through its mission, the ROCK project, working with local companies, strive to develop niche technologies that will directly benefit the U.S. and by providing higher quality parts at reduced costs, improving supply logistics, and creating new manufacturing tools and methods that are critical to the continued growth of this nation.

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Preface

The aim of this book, *Experimental Mechanics of Solids*, is to provide a comprehensive and in depth look at the various approaches possible to analyze systems and materials via experimental mechanics. This field has grown mostly through ideas, chance and pure intuition. This field is now mature enough that a comprehensive analysis on the nature of material properties is possible. Often we do things without too much thought and experimental mechanics is no exception.

The approach of this book is to break down each chapter into specific categories and provide some historical context so that the reader can understand how we have reached a certain level in the respective fields. The first two chapters provide some insight into the fundamental issues with regards to continuum mechanics and stress analysis that must be clear to the reader so that they may then make the appropriate decisions when performing field measurements. The next three chapters deal with the use and application of strain gages. There has been a lot of work done in this field so the aim was to provide some basic and practical information for the reader to be able to make sound choices with regards to a selection of gage and understanding the conditions for measurements. The remaining chapters deal with optical methods. Here for the first time ever the reader will see the unifying nature behind all these methods and should walk away with a more complete understanding of the various optical techniques. Most importantly, all the various examples that we have done over our careers are shared so that the reader can understand the advantages of one method over another in a given application.

Ultimately this book should serve as both a learning tool and a resource for industry when faced with difficult problems that only experimental mechanics can help solve. It is our hope that the students who read this book will understand what it takes to perform research in this field and provide inspiration for the future generations of experimentalists.

Our thanks go to Kristina Young M.S. who kindly rendered our illustrations.

Foreword

It is a great honor for me to write the foreword of *Experimental Mechanics of Solids* authored by Prof. Cesar A. Sciammarella and Dr. Federico M. Sciammarella. I have been involved with the authors for the past 10 years. Professor C.A. Sciammarella has taught me optics and made me familiar with the use of optics in that wonderful field called Experimental Solid Mechanics. Dr. F.M. Sciammarella, my friend, was a PhD student when I visited Prof. C.A. Sciammarella's lab at the Illinois Institute of Technology. We took the class on Experimental Solid Mechanics taught by Prof. C.A. Sciammarella. Since then Fred and I collaborated on many pioneering studies carried out by the Professor.

I always asked Prof. Sciammarella to write a book with the purpose to disclose his enormous knowledge to young "fellows" who are interested in Experimental Solid Mechanics. In his five years at the Politecnico in Bari, the Professor was very busy carrying out frontier research and organizing international conferences that brought world renowned scientists to Bari. In spite of all of this hard work, Prof. Sciammarella found the time for conceiving the general organization of his book. In October 2008, when Prof. Sciammarella moved back to US we promised to continue working together. I am glad to say that Prof. Sciammarella, Dr. Sciammarella and myself still work together and will work together in the future, always investigating new exciting topics.

I have seen this book being developed day by day, chapter by chapter. Prof. Sciammarella and Dr. Sciammarella have shown me several chapters of their work. I remember the discussions we had in Chicago. There is no doubt that the quality of the book is outstanding. Apart from the technical content that is excellent in view of the high scientific reputation of the two authors, what has impressed me at the first reading is the clarity of the presentation which has plenty of useful examples. At the second reading, one realizes that the clarity is the obvious result of a total knowledge of the subject presented in the book. I now teach experimental mechanics and I am eager to suggest this new book to my students.

Thank you very much Professor and Fred for having given this book to us!

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BARI, ITALY

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