

APPLICATION OF NONLINEAR STOCHASTIC MECHANICS IN OFFSHORE ENGINEERING

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ABSTRACT

Nonlinear stochastic mechanics are widely used in the field of offshore engineering. In this paper we survey four applications: nonlinear collapse and fatigue analysis of jacket structures, dynamic analysis of jack-up structures, springing and slow-drift response of a tension leg platform, and hysteretic foundation behavior of a concrete gravity platform.

1. INTRODUCTION

Offshore engineering poses many challenges for structural and soil engineers, oceanographers, and hydrodynamicists. In particular, as current offshore oil reserves become depleted, oil exploration and production is moving into increasing water depths and offshore platforms are installed at water depths of several hundred meters. For example, fixed offshore structures exist at water depth exceeding 300 meters.

Nonlinear phenomena are present in both the loading process, the structural behavior and, for fixed platforms, in the soil mechanics. Nonlinearities in the loading arise from nonlinear waves (non-Gaussian sea surface elevation) and nonlinearities in force mechanisms, as given for example by the Morison equation or second-order diffraction theory. The structure itself may exhibit various nonlinearities. This is the case for example for fixed, dynamically sensitive jack-up and deep-water jacket structures, tethered tension leg platforms, and moored semi-submersible platforms. Depending on soil conditions, nonlinear soil effects may influence both fixed structures—either gravity-based or on piles—and temporarily installed jack-up structures with footings at the sea bed.

Extensive analysis of the behavior and strength of offshore structures takes place throughout the life cycle of the structure, i.e. in concept evaluation, design, construction and operation. In operation, analyses are performed because of damage caused by dropped objects, platform/ship collisions, and explosion damages. Furthermore, a need for substantial re-design of the (deck) structure often arises.

Nonlinear Stochastic Mechanics

Arturo Cuomo



Nonlinear Stochastic Mechanics:

IUTAM Symposium on Advances in Nonlinear Stochastic Mechanics A. Naess, S. Krenk, 2012-12-06 The IUTAM Symposium on Advances in Nonlinear Stochastic Mechanics held in Trondheim July 3-7 1995 was the eighth of a series of IUTAM sponsored symposia which focus on the application of stochastic methods in mechanics. The previous meetings took place in Coventry UK 1972, Southampton UK 1976, Frankfurt/Oder Germany 1982, Stockholm Sweden 1984, Innsbruck/Austria 1987, Turin Italy 1991, and San Antonio Texas 1993. The symposium provided an extraordinary opportunity for scholars to meet and discuss recent advances in stochastic mechanics. The participants represented a wide range of expertise from pure theoreticians to people primarily oriented toward applications. A significant achievement of the symposium was the very extensive discussions taking place over the whole range from highly theoretical questions to practical engineering applications. Several presentations also clearly demonstrated the substantial progress that has been achieved in recent years in terms of developing and implementing stochastic analysis techniques for mechanical engineering systems. This aspect was further underpinned by specially invited extended lectures on computational stochastic mechanics, engineering applications of stochastic mechanics, and nonlinear active control. The symposium also reflected the very active and high quality research taking place in the field of stochastic stability. Ten presentations were given on this topic out of a total of 47 papers. A main conclusion that can be drawn from the proceedings of this symposium is that stochastic mechanics as a subject has reached great depth and width in both methodology and applicability.

Nonlinear Dynamics and Stochastic Mechanics

Wolfgang Kliemann, S. Namachchivaya, 1995-04-18 Engineering systems have played a crucial role in stimulating many of the modern developments in nonlinear and stochastic dynamics. After 20 years of rapid progress in these areas, this book provides an overview of the current state of nonlinear modeling and analysis for mechanical and structural systems. This volume is a coherent compendium written by leading experts from the United States, Canada, Western and Eastern Europe, and Australia. The 22 articles describe the background, recent developments, applications, and future directions in bifurcation theory, chaos, perturbation methods, stochastic stability, stochastic flows, random vibrations, reliability, disordered systems, earthquake engineering, and numerics. The book gives readers a sophisticated toolbox that will allow them to tackle modeling problems in mechanical systems that use stochastic and nonlinear dynamics ideas. An extensive bibliography and index ensure this volume will remain a reference standard for years to come.

Nonlinear Stochastic Mechanics Nicola Bellomo, Fabio Casciati, 2012-12-06 The Symposium held in Torino/Italy Villa Gualino July 1-5 1991 is the sixth of a series of IUTAM Symposia on the application of stochastic analysis to continuum and discrete mechanics. The previous one held in Innsbruck 1987 was mainly concentrated on qualitative and quantitative analysis of stochastic dynamical systems as well as on bifurcation and transition to chaos of deterministic systems. This Symposium concentrated on fundamental aspects: stochastic analysis and mathematical methods on specific applications in various branches of mechanics, engineering, and applied sciences as well as

on related fields as analysis of large systems system identification earthquake prediction Numerical methods suitable to provide quantitative results say stochastic finite elements approximation of probability distribution and direct integration of differential equations have also been the object of interesting presentations Specific topics of the sessions have been Engineering Applications Equivalent Linearization of Discrete Stochastic Systems Fatigue and Life Estimation Fluid Dynamics Numerical Methods Random Vibration Reliability Analysis Stochastic Differential Equations System Identification Stochastic Control We are indebted to the IUTAM Bureau for having promoted and sponsored this Symposium and the Scientific Committee for having collaborated to the selection of participants and lecturers as well as to a prompt reviewing of the papers submitted for publication into these proceedings A special thank is due to Frank Kozin the organization of this meeting was for him very important he missed the meeting but his organizer ability was present

Nonlinear Stochastic Mechanics Nicola Bellomo, Fabio Casciati, 1992-08-06 The Symposium held in Torino ISI Villa Gualino July 1 5 1991 is the sixth of a series of IUTAM Symposia on the application of stochastic analysis to continuum and discrete mechanics The previous one held in Innsbruck 1987 was mainly concentrated on qualitative and quantitative analysis of stochastic dynamical systems as well as on bifurcation and transition to chaos of deterministic systems This Symposium concentrated on fundamental aspects stochastic analysis and mathematical methods on specific applications in various branches of mechanics engineering and applied sciences as well as on related fields as analysis of large systems system identification earthquake prediction Numerical methods suitable to provide quantitative results say stochastic finite elements approximation of probability distribution and direct integration of differential equations have also been the object of interesting presentations Specific topics of the sessions have been Engineering Applications Equivalent Linearization of Discrete Stochastic Systems Fatigue and Life Estimation Fluid Dynamics Numerical Methods Random Vibration Reliability Analysis Stochastic Differential Equations System Identification Stochastic Control We are indebted to the IUTAM Bureau for having promoted and sponsored this Symposium and the Scientific Committee for having collaborated to the selection of participants and lecturers as well as to a prompt reviewing of the papers submitted for publication into these proceedings A special thank is due to Frank Kozin the organization of this meeting was for him very important he missed the meeting but his organizer ability was present

Nonlinear Stochastic Systems in Physics and Mechanics N. Bellomo, Riccardo Riganti, 1987 This book presents the conceptional line which goes from the observation of physical systems to their modeling and analysis by ordinary differential nonlinear stochastic equations First the problems of the mathematical modeling of physical systems are developed These mathematical models are then classified in terms of ordinary differential stochastic equations from which both qualitative and quantitative results are developed Each one of the various subjects are methods dealt with ends with an application in mathematical physics or in nonlinear mechanics

IUTAM Symposium on Advances in Nonlinear Stochastic Mechanics A. Naess, S. Krenk, 2011-12-06 The IUTAM Symposium on Advances in Nonlinear Stochastic Mechanics

held in Trondheim July 3-7 1995 was the eighth of a series of IUTAM sponsored symposia which focus on the application of stochastic methods in mechanics. The previous meetings took place in Coventry UK 1972, Southampton UK 1976, Frankfurt/Oder Germany 1982, Stockholm Sweden 1984, Innsbruck/Austria 1987, Turin Italy 1991, and San Antonio Texas 1993. The symposium provided an extraordinary opportunity for scholars to meet and discuss recent advances in stochastic mechanics. The participants represented a wide range of expertise from pure theoreticians to people primarily oriented toward applications. A significant achievement of the symposium was the very extensive discussions taking place over the whole range from highly theoretical questions to practical engineering applications. Several presentations also clearly demonstrated the substantial progress that has been achieved in recent years in terms of developing and implementing stochastic analysis techniques for mechanical engineering systems. This aspect was further underpinned by specially invited extended lectures on computational stochastic mechanics, engineering applications of stochastic mechanics, and nonlinear active control. The symposium also reflected the very active and high quality research taking place in the field of stochastic stability. Ten presentations were given on this topic of a total of 47 papers. A main conclusion that can be drawn from the proceedings of this symposium is that stochastic mechanics as a subject has reached great depth and width in both methodology and applicability.

Nonlinear Dynamics and Stochastic Mechanics Navaratnam Sri Namachchivaya, 1996. This volume contains the proceedings of the International Symposium on Nonlinear Dynamics and Stochastic Mechanics held at the Fields Institute for Research in Mathematical Sciences from August-September 1993 as part of the 1992-93 Program Year on Dynamical Systems and Bifurcation Theory. In recent years, mathematicians and applied scientists have made significant progress in understanding and have developed powerful tools for the analysis of the complex behaviour of deterministic and stochastic dynamical systems. By moving beyond classical perturbation methods to more general geometrical, computational, and analytical methods, this book is at the forefront in transferring these new mathematical ideas into engineering practice. This work presents the solutions of some specific problems in engineering structures and mechanics and demonstrates by explicit example these new methods of solution.

Nonlinear Stochastic Systems in Physics and Mechanics Nicola Bellomo, 1987.

Nonlocal Quantum Field Theory and Stochastic Quantum Mechanics K.H. Namsrai, 1986. Over this stochastic space-time leads to the non-local fields considered by G.V. Efimov. In other words, stochasticity of space-time after being averaged on a large scale as a self-memory makes the theory nonlocal. This allows one to consider in a unified way the effect of stochasticity or nonlocality in all physical processes. Moreover, the universal character of this hypothesis of space-time at small distances enables us to re-interpret the dynamics of stochastic particles and to study some important problems of the theory of stochastic processes such as the relativistic description of diffusion-Feynman type processes and the problem of the origin of self-turbulence in the motion of free particles within nonlinear stochastic mechanics. In this direction, our approach Part II may be useful in recent developments of the stochastic interpretation of quantum mechanics and fields due

to E Nelson D Kershaw I Fenyes F Guerra de la Pena Auerbach J P Vigier M Davidson and others In particular as shown by N Cufaro Petroni and J P Vigier within the discussed approach a causal action at distance interpretation of a series of experiments by A Aspect and his co workers indicating a possible non locality property of quantum mechanics may also be obtained Aspect s results have recently inspired a great interest in different nonlocal theories and models devoted to an understanding of the implications of this nonlocality This book consists of two parts

Computational Stochastic Mechanics P.D. Spanos, 1999-11-09 Proceedings of the June 1998 conference Seventy contributions discuss Monte Carlo and signal processing methods random vibrations safety and reliability control optimization and modeling of nonlinearity earthquake engineering random processes and fields damage fatigue materials applied prob

Nonlinear Stochastic Systems in Physics and Mechanics Nicola Bellomo, Riccardo Riganti, 1978

Nonlinear Stochastic Dynamic Engineering Systems Franz Ziegler, Gerhard I. Schueller, 2012-12-06 This symposium held at Innsbruck Igls on June 21 26 1987 is the fifth in a series of IUTAM Symposia on the application of stochastic methods in mechanics The first two meetings in Warwick 1972 and Southampton 1976 concentrated on the stability of stochastic dynamical systems and stochastic methods in dynamics respectively The third meeting in Frankfurt Oder 1982 added aspects of reliability while the fourth symposium in Stockholm 1984 dealt mainly with fatigue and fracture problems The general theme of the present symposium is devoted to nonlinear stochastic dynamics of engineering systems which is believed of great importance for providing the tools for basic development and progress in various fields of mechanical structural and aeronautical engineering particularly in the areas of vehicle dynamics multi storey structural dynamics systems identification offshore structural dynamics nuclear structures under various stochastic loading conditions i e wind earthquake parametric excitations etc The contributions collected in this volume cover a wide spectrum of topics ranging from more theoretical analytical and numerical treatment to practical application in various fields The truly international character of the meeting is accomplished by 42 contributions and 86 participants from as many as 19 countries and hence contributed to the original idea of IUTAM which is to foster international cooperation It should be recalled that for getting this cooperation started again after the First World War Theodore von Kármán and Tullio Levi Civita called the world s first international IUTAM conference on hydro and aeromechanics in 1922 in Innsbruck Austria

IUTAM Symposium on Nonlinear Stochastic Dynamics N. Sri Namachchivaya, Y.K. Lin, 2003-11-30 Non linear stochastic systems are at the center of many engineering disciplines and progress in theoretical research had led to a better understanding of non linear phenomena This book provides information on new fundamental results and their applications which are beginning to appear across the entire spectrum of mechanics The outstanding points of these proceedings are Coherent compendium of the current state of modelling and analysis of non linear stochastic systems from engineering applied mathematics and physics point of view Subject areas include Multiscale phenomena stability and bifurcations control and estimation computational methods and modelling For the Engineering and

Physics communities this book will provide first hand information on recent mathematical developments The applied mathematics community will benefit from the modelling and information on various possible applications

Nonlinear Dynamics Stochastic Mechanics W.-C. Xie,N. Sri Namachchivaya,2002 *Journal of Research of the National Institute of Standards and Technology* ,1994 *Nonlinear Dynamics and Stochastic Mechanics* Wei-Chau Xie,Navaratnam Sri Namachchivaya,Balakumar Balachandran,2000 Thirteen papers from a November 2000 meeting examine central topics in theory and applications of nonlinear dynamics stochastic mechanics and dynamics and control of nonlinear mechanical and structural systems Papers address topics related to fundamental applied analytical computational and e

Structural Safety and Reliability Naruhito Shiraishi,Masanobu Shinozuka,Yi-Kwei Wen,1998 *Engineering Structures Under Extreme Conditions* Adnan Ibrahimbegović,Boštjan Brank,2005 *Mechanical Vibration: Where Do We Stand?* Isaac Elishakoff,2007-12-12 There is always a delightful sense of movement vibration and life Theodore Robinson 1852 1896 have never solved a major mechanical or interpretive problem at the keyboard I have always solved it in my mind Jorge Bolet 1914 1990 The idea of this book stems from the realization that scientists not unlike laymen should occasionally interrupt their regular work and reflect on the past to see both the accomplishments and the drawbacks so as to be able to plan for future research in the proper perspective But an inquisitive reader may ask Can one really document in any field let alone mechanical vibrations whose very name signifies change where do we stand Did not a Greek philosopher famously claim that one cannot enter a river twice Another on an even more sophisticated note added that actually it is impossible to enter a river even once For in the process of entering both entrant and river change Likewise one can argue that it is nearly impossible to answer the question posed in the title of this volume But experience shows despite the sage observations of the philosophers that one does enter a river lake sea or ocean Likewise scientists do stop if not for a minute for a conference to reflect on the past and if not in its detail then at least in big strokes on various topics presented by the participants questions by the listeners often change the research direction of the presenter

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Table of Contents Nonlinear Stochastic Mechanics

1. Understanding the eBook Nonlinear Stochastic Mechanics
 - The Rise of Digital Reading Nonlinear Stochastic Mechanics
 - Advantages of eBooks Over Traditional Books
2. Identifying Nonlinear Stochastic Mechanics
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Nonlinear Stochastic Mechanics
 - User-Friendly Interface
4. Exploring eBook Recommendations from Nonlinear Stochastic Mechanics
 - Personalized Recommendations

- Nonlinear Stochastic Mechanics User Reviews and Ratings
- Nonlinear Stochastic Mechanics and Bestseller Lists
- 5. Accessing Nonlinear Stochastic Mechanics Free and Paid eBooks
 - Nonlinear Stochastic Mechanics Public Domain eBooks
 - Nonlinear Stochastic Mechanics eBook Subscription Services
 - Nonlinear Stochastic Mechanics Budget-Friendly Options
- 6. Navigating Nonlinear Stochastic Mechanics eBook Formats
 - ePub, PDF, MOBI, and More
 - Nonlinear Stochastic Mechanics Compatibility with Devices
 - Nonlinear Stochastic Mechanics Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Nonlinear Stochastic Mechanics
 - Highlighting and Note-Taking Nonlinear Stochastic Mechanics
 - Interactive Elements Nonlinear Stochastic Mechanics
- 8. Staying Engaged with Nonlinear Stochastic Mechanics
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Nonlinear Stochastic Mechanics
- 9. Balancing eBooks and Physical Books Nonlinear Stochastic Mechanics
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Nonlinear Stochastic Mechanics
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Nonlinear Stochastic Mechanics
 - Setting Reading Goals Nonlinear Stochastic Mechanics
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Nonlinear Stochastic Mechanics
 - Fact-Checking eBook Content of Nonlinear Stochastic Mechanics

- Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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