



# NONLINEARITY IN STRUCTURAL DYNAMICS

DETECTION, IDENTIFICATION  
AND MODELLING

K WORDEN AND G R TOMLINSON

# Nonlinearity In Engineering Structures Detection Identification And Modelling

**K. Worden, Geoffrey R. Tomlinson**



## **Nonlinearity In Engineering Structures Detection Identification And Modelling:**

**Nonlinearity in Structural Dynamics** K Worden,2019-04-23 Many types of engineering structures exhibit nonlinear behavior under real operating conditions Sometimes the unpredicted nonlinear behavior of a system results in catastrophic failure In civil engineering grandstands at sporting events and concerts may be prone to nonlinear oscillations due to looseness of joints friction and crowd movements

**Nonlinearity in Structural Dynamics** K. Worden,Geoffrey R. Tomlinson,2019 Many types of engineering structures exhibit nonlinear behavior under real operating conditions Sometimes the unpredicted nonlinear behavior of a system results in catastrophic failure In civil engineering grandstands at sporting events and concerts may be prone to nonlinear oscillations due to looseness of joints friction and crowd movements

Structural Dynamics in Engineering Design Nuno M. M. Maia,Dario Di Maio,Alex Carrella,2024-04-24 World class authors describe and illustrate how structural dynamics is applied to the engineering design process Structural Dynamics in Engineering Design covers the fundamentals of structural dynamics and its application to the engineering design process providing all of the necessary information to implement an optimal design process Each of its seven chapters is written by an expert in the field and provides the reader with the structural dynamic theoretical background and its more practical aspects for the implementation of an advanced design capability The first three chapters are dedicated to the underlying theory of the three main processes the fundamentals of vibration theory the basis of experimental dynamics and the main numerical analysis tools including reference to the finite element method Having laid the foundation of the design philosophy the following three chapters present the reader with the three disciplines of identification nonlinear analysis and validation updating The final chapter presents some applications of the approach to real and complex engineering cases Key features Takes a multi disciplinary approach and contains critical information on theory testing and numerical analysis for structural dynamics Includes a chapter on industrial applications including aircraft design and ground vibration testing which illustrates the design process and explains how structural dynamics is applied at different stages The book is a must have for researchers and practitioners in mechanical and aerospace engineering in particular test engineers CAE analysts and structural dynamicists as well as graduate students in mechanical and aerospace engineering departments

**The Bio-Inspired X-Structure/Mechanism Approach for Exploring Nonlinear Benefits in Engineering** Xingjian Jing,2025-07-04 This book presents a unique approach to the design and analysis of beneficial nonlinearity which can take an important and critical role in engineering systems and thus cannot be simply ignored in structural design dynamic response analysis and parameter selection A key issue in the area is thus systematically addressed about how to analyze and design potential nonlinearities introduced to or inherent in a system of under study which is a must do task in many practical applications involving vibration control energy harvesting sensor systems and robots etc This book together with several other books in this book series is to present an up to date summary on the most recent development of a cutting edge method

for nonlinearity manipulation and employment developed in recent several years named as the X shaped structure or mechanism approach The X shaped structure or mechanism is a generic structure or mechanism representing a class of beneficial geometric nonlinearity with realizable and flexible linkage mechanism or structural design of different variants or forms quadrilateral diamond polygon K Z S V shape or others which all share similar geometric nonlinearity and thus similar nonlinear stiffness damping properties flexible in design and easy to implement This book is particularly to present a systematic frequency domain analysis design and optimization method of critical structural or control parameters in nonlinear systems including the X structure mechanism dynamics aiming at better dynamic performance and special nonlinear response as expected in engineering practice Cases studies in vehicle suspension energy harvesting fault detection and fuzzy membership optimization are all showcased The new analysis and design method introduced in this book definitely present a totally new and powerful approach to optimization and understanding of a class of nonlinear systems from a special frequency domain point of view

*Nonlinear Structures & Systems, Volume 1* Matthew R.W. Brake, Ludovic Renson, Robert J. Kuether, Paolo Tiso, 2025-08-07 Nonlinear Structures Systems Volume 1 Proceedings of the 41st IMAC A Conference and Exposition on Structural Dynamics 2023 the first volume of ten from the Conference brings together contributions to this important area of research and engineering The collection presents early findings and case studies on fundamental and applied aspects of Nonlinear Dynamics including papers on Experimental Nonlinear Dynamics Jointed Structures Identification Mechanics Dynamics Nonlinear Damping Nonlinear Modeling and Simulation Nonlinear Reduced Order Modeling Nonlinearity and System Identification

*Experimental Vibration Analysis for Civil Engineering Structures* Álvaro Cunha, Elsa Caetano, 2025-09-23 This volume presents peer reviewed contributions from the 11th International Conference on Experimental Vibration Analysis for Civil Engineering Structures EVACES held in Porto Portugal on July 2 4 2025 The event brought together engineers scientists researchers and practitioners providing a forum for discussing and disseminating the latest developments and achievements in all major aspects of dynamic testing for civil engineering structures including instrumentation sources of excitation data analysis system identification monitoring and condition assessment in situ and laboratory experiments codes and standards and vibration mitigation The topics included but were not limited to damage identification and structural health monitoring testing sensing and modeling vibration isolation and control system and model identification coupled dynamical systems including human structure vehicle structure and soil structure interaction and application of advanced techniques involving the Internet of Things robot UAV big data and artificial intelligence

**Strong Motion Instrumentation for Civil Engineering Structures** Mustafa Özder Erdik, Mehmet Çelebi, Vladimir Mihailov, Nurdan Apaydin, 2012-12-06 Most of the existing strong motion instrumentation on civil engineering structures is installed and operated as federal state university industry or private applications in many cases operated as a closed system This hampers co operation and data exchange hampering the acquisition of strong motion and structural data sometimes

even within a single country There is a powerful need to inform engineers of existing strong motion data and to improve the accessibility of data worldwide This book will play a role in fulfilling such a need by disseminating state of the art information technology and developments in the strong motion instrumentation of civil engineering structures The subject has direct implications for the earthquake response of structures improvements in design for earthquake resistance and hazard mitigation Readership Researchers in earthquake engineering engineers designing earthquake resistant structures and producers of strong motion recording equipment

**Handbook of Applications of Chaos Theory** Christos H.

Skiadas,Charilaos Skiadas,2017-12-19 In addition to explaining and modeling unexplored phenomena in nature and society chaos uses vital parts of nonlinear dynamical systems theory and established chaotic theory to open new frontiers and fields of study Handbook of Applications of Chaos Theory covers the main parts of chaos theory along with various applications to diverse areas Expert contributors from around the world show how chaos theory is used to model unexplored cases and stimulate new applications Accessible to scientists engineers and practitioners in a variety of fields the book discusses the intermittency route to chaos evolutionary dynamics and deterministic chaos and the transition to phase synchronization chaos It presents important contributions on strange attractors self exciting and hidden attractors stability theory Lyapunov exponents and chaotic analysis It explores the state of the art of chaos in plasma physics plasma harmonics and overtone coupling It also describes flows and turbulence chaotic interference versus decoherence and an application of microwave networks to the simulation of quantum graphs The book proceeds to give a detailed presentation of the chaotic rogue and noisy optical dissipative solitons parhelic like circle and chaotic light scattering and interesting forms of the hyperbolic prism the Poincar disc and foams It also covers numerous application areas from the analysis of blood pressure data and clinical digital pathology to chaotic pattern recognition to economics to musical arts and research

**Resilience, Earthquake Engineering and Structural Health Monitoring** Gian Paolo Cimellaro,Ying Zhou,Alessandro Cardoni,Farhad Ansari,2025-11-30 This volume gathers the proceedings of the 3rd International Conference on Resilience Earthquake Engineering and Structural Health Monitoring ICONREM held in Turin Italy on June 24 28 2024 The conference fostered new paradigms in the interface of critical infrastructures and the economic and social impact of resilience The volume covers highly diverse topics including algorithms for structural health monitoring bridge dynamics constitutive modelling under earthquake loading dynamics of concrete steel and masonry structures geotechnical earthquake engineering optimum design control in structural dynamics and earthquake engineering performance based earthquake engineering reliability of dynamic systems repair retrofit of structures resilience assessment seismic isolation seismic risk and reliability analysis The contributions which are published after a rigorous international peer review process highlight numerous exciting ideas that will spur novel research directions and foster multidisciplinary collaboration among different specialists

**System Identification and Damage Detection of Nonlinear Structures** Ye Xia,2012-04 Many civil and mechanical engineering

structures exhibit nonlinear hysteretic behavior when subject to dynamic loads The modeling and identification of non linear hysteretic systems is a practical but challenging problem encountered in the engineering field To overcome such a challenge this book proposes the application of a reduced order finite element model in conjunction with a recently proposed damage detection technique referred to as the adaptive quadratic sum square error with unknown inputs AQSSE UI The identification process is divided into two steps 1 static condensation technique is used to reduce the order of the equations of motion of the finite element model 2 AQSSE UI is used for the on line system identification and damage detection of the reduced order system The proposed approach is capable of identifying time varying parameters of linear or nonlinear hysteresis structures The capability of the proposed damage detection technique is demonstrated by shake table test on three large scale structures at NCREE Taiwan Health Monitoring of Structural and Biological Systems 2007 Tribikram Kundu,2007 Proceedings of SPIE present the original research papers presented at SPIE conferences and other high quality conferences in the broad ranging fields of optics and photonics These books provide prompt access to the latest innovations in research and technology in their respective fields Proceedings of SPIE are among the most cited references in patent literature Advanced Manufacturing and Industrial Engineering Xianghua Liu,2014-08-13 Selected peer reviewed papers from the 4th International Conference on Advanced Engineering Materials and Technology AEMT 2014 June 14 15 2014 Xiamen China **Journal of Chemical Engineering of Japan** ,2001 Includes abstracts of Kagaku k gaku v 31 Health Monitoring and Smart Nondestructive Evaluation of Structural and Biological Systems III Tribikram Kundu,2004 Proceedings of SPIE present the original research papers presented at SPIE conferences and other high quality conferences in the broad ranging fields of optics and photonics These books provide prompt access to the latest innovations in research and technology in their respective fields Proceedings of SPIE are among the most cited references in patent literature *Proceedings of the 1st International Operational Modal Analysis Conference* Rune Brincher,Nis Møller,2005 System Identification and Damage Detection of Nonlinear Structures Ye Xia,2011 Many civil and mechanical engineering structures exhibit nonlinear hysteretic behavior when subject to dynamic loads The modeling and identification of non linear hysteretic systems with stiffness and strength degradations is a practical but challenging problem encountered in the engineering field Time domain analysis techniques including the least square estimation LSE and the extended Kalman filter EKF have been used for the identification of structural parameters However the LSE approach may require the displacement measurements which are usually not measured in practice With only the measurements of acceleration responses the on line system identification and damage detection is possible based on the EKF approach However for the EKF approach the solutions may easily become unstable and may not converge Furthermore system identification approaches such as LSE and EKF approaches are usually more suitable for simple structures For the finite element model FEM of a complex structure with a large number of degree of freedom DOFs it may require a large number of sensors and involve a heavy computational effort for the identification of

structural damages To overcome such a challenge we propose the application of a reduced order finite element model in conjunction with a recently proposed damage detection technique referred to as the adaptive quadratic sum square error with unknown inputs AQSSE UI The identification process is divided into two steps In the first step static condensation technique is used to reduce the order of the equations of motion of the finite element model In the second step the adaptive quadratic sum square error with unknown inputs AQSSE UI is used for the on line system identification and damage detection of the reduced order system The proposed approach is capable of identifying time varying parameters of linear or nonlinear hysteresis structures The capability of the proposed damage detection technique is demonstrated by shake table test data using large scale structures A 1/3 scaled 6 story steel frame a 1/3 scaled 2 story RC frame and a 1/2 scaled one story two bay RC frame have been tested experimentally on the shake table at NCREE The National Center for Research on Earthquake Engineering Taiwan For the 1/3 scaled 6 story steel frame structure the damages of the joints were simulated by loosening the connection bolts The 1/3 scaled 2 story RC frame was subject to a sequence of earthquake excitations back to back Both RC frames are modeled by a series of finite elements and plastic hinges following the generalized Bouc Wen model Experimental results demonstrate that the proposed damage detection technique is quite accurate and effective for the tracking of i the stiffness degradation of linear structures and ii the non linear hysteretic parameters with stiffness and strength degradations

*AIAA Journal* American Institute of Aeronautics and Astronautics,2008      **Smart Structures and Materials** ,1996      **Critical Reviews in Biomedical Engineering** ,1998      *Proceedings of the ASME Applied Mechanics Division* ,2004

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