Analysis Of Geometrically Nonlinear Structures

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User's Manual for GAMNAS: Geometric and Material Nonlinear Analysis of Structures Createspace Independent Publishing Platform
The elasto-dynamics of flexible frame structures is of interest in many areas of engineering. In certain structural systems the deflections can be large enough to warrant a nonlinear analysis. For example, offshore structures, long suspension bridges and other relatively slender structures used in space applications require a geometrically nonlinear analysis. In addition, if the structure has deployable elements, as in some space structures, the required analysis becomes even more complex. Typical examples are spacecraft antennae, radio telescopes, solar panels and space-based manipulators with deployable elements. The main objective of the present work is to formulate the problem of sliding beams undergoing large rotations and small strains. Further we aim to develop efficient finite element technique for analysis of such complex systems. Finally we wish to examine the nature of the motion of sliding beams and point out its salient features. We start with two well known approaches in the nonlinear finite element static analysis of highly flexible structures, namely, the updated Lagrangian and the consistent co-rotational methods and extend these techniques to dynamic analysis of geometrically nonlinear beam structures. We analyse several examples by the same methods and compare the performance of each for efficiency and accuracy. Next, using McIver's extension of Hamilton's principle, we formulate the problem of geometrically flexible sliding beams by two different approaches. In the first the beam slides through a fixed rigid channel with a prescribed sliding motion. In this formulation which we refer to as the sliding beam formulation, the material points on the beam slide relative to a fixed channel. In the second formulation the material points on the fixed beam are observed by a moving observer on a sliding channel and the beam is axially at rest. The governing equations of motion for the two formulations describe the same physical problem and by mapping both to a fixed domain, using proper transformations, we show that the two sets of governing equations become identical. It is not, possible to find analytical solutions to our problem and we choose the Galerkin numerical method to obtain the transient response of the problem for the special case axially rigid beam. Next we follow a more elegant approach wherein we use the developed incremental nonlinear finite element approaches (the updated Lagrangian and the consistent co-rotational method) in conjunction with a variable time domain beam finite elements (where the number of elements is fixed and as mass enters the domain of interest, but the sizes of elements change in a prescribed manner in the undeformed configuration). To verify the formulation and its computational implementation we analyse many examples and compare our findings with those reported in the literature when possible. We also use these illustrative examples to identify the importance of various terms such as axial flexibility and foreshortening effects. Finally we look into the problem of parametric resonance for the beam with periodically varying length and we show that the regions of stability obtained in the literature, using a linear analysis, do not hold when a more realistic nonlinear analysis is undertaken.
Analysis of Geometrically Nonlinear Structures AFRICAN SUN MeDIA
This final technical report contains three parts: Part 1 deals with the 2-D shell theory and its element formulation and applications. Part 2 deals with the 3-D degenerated element. These two parts constitute the two major tasks that were completed under the grant. Another related topic that was initiated during the present investigation is the development of a nonlinear material model. This topic is briefly discussed in Part 3. To make each part self-contained, conclusions and references are included in each part. In the interest of brevity, the discussions presented are relatively brief. The details and additional topics are described in the references cited. Reddy, J. N. and Chandrashekhara, K. and Chao, W. C. Unspecified Center ELASTIC PLATES; ELASTIC SHELLS; FINITE ELEMENT METHOD; LAMINATES; NONLINEAR SYSTEMS; SHELL THEORY; BENDING; STRESS-STRAIN RELATIONSHIPS; STRUCTURAL ANALYSIS; STRUCTURAL VIBRATION...
Geometrically Nonlinear Analysis of Inelastic Shell Structures Including Ductile Damage John Wiley & Sons
Beam theories are exploited worldwide to analyze civil, mechanical, automotive, and aerospace structures. Many beam approaches have been proposed during the last centuries by eminent scientists such as Euler, Bernoulli, Navier, Timoshenko, Vlasov, etc. Most of these models are problem dependent: they provide reliable results for a given problem, for instance a given section and cannot be applied to a different one. Beam Structures: Classical and Advanced Theories proposes a new original unified approach to beam theory that includes practically all classical and advanced models for beams and which has become established and recognised globally as the most important contribution to the field in the last quarter of a century. The Carrera Unified Formulation (CUF) has hierarchical properties, that is, the error can be reduced by increasing the number of the unknown variables. This formulation is extremely suitable for computer implementations and can deal with most typical engineering challenges. It overcomes the problem of classical formulae that require different formulas for tension, bending, shear and torsion; it can be applied to any beam geometries and loading conditions, reaching a high level of accuracy with low computational cost, and can tackle problems that in most cases are solved by employing plate/shell and 3D formulations. Key features: compares classical and modern approaches to beam theory, including classical well-known results related to Euler-Bernoulli and Timoshenko beam theories pays particular attention to typical applications related to bridge structures, aircraft wings, helicopters and propeller blades provides a number of numerical examples including typical Aerospace and Civil Engineering problems proposes many benchmark assessments to help the reader implement the CUF if they wish to do so accompanied by a companion website hosting dedicated software MUL2 that is used to obtain the numerical solutions in the book, allowing the reader to reproduce the examples given in the book as well as to solve other problems of their own www.mul2.com Researchers of continuum mechanics of solids and structures and structural analysts in industry will find this book extremely insightful. It will also be of great interest to graduate and postgraduate students of mechanical, civil and aerospace engineering.
Geometric Nonlinear Analysis of Three-dimensional Structures Klaus-Jurgen Bathe
This report describes nonlinear analysis of arbitrary thin shell structures subjected to static loads. The nonlinear analysis includes pre and post-buckling behavior for any degree of nonlinearity due to large displacements and large rotations but small strains. The formulation includes some recent developments of plate and shell theories, automatic solution strategies for the nonlinear equations; all adapted for implementation in mini and micro-computers with virtual memory. Keywords: Finite elements; Numerical analysis; Shell structures; nonlinear algorithms.
Nonlinear Finite Element Analysis of Solids and Structures Analysis of Geometrically Nonlinear Structures
Note: This purchase option should only be used by those who want a print-version of this textbook. An e-version (PDF) is available at no cost at www.mastan2.com DESCRIPTION: The aims of the first edition of Matrix Structural Analysis were to place proper emphasis on the methods of matrix structural analysis used in practice and to lay the groundwork for more advanced subject matter. This extensively revised Second Edition accounts for changes in practice that have taken place in the intervening twenty years. It incorporates advances in the science and art of analysis that are suitable for application now, and will be of increasing importance in the years ahead. It is written to meet the needs of both the present and the coming generation of structural engineers. KEY FEATURES Comprehensive coverage - As in the first edition, the book treats both elementary

concepts and relativity advanced material. Nonlinear frame analysis - An introduction to nonlinear analysis is presented in four chapters: a general introduction, geometric nonlinearity, material nonlinearity, and solution of nonlinear equilibrium equations. Interactive computer graphics program - Packaged with the text is MASTAN2, a MATLAB based program that provides for graphically interactive structure definition, linear and nonlinear analysis, and display of results. Examples - The book contains approximately 150 illustrative examples in which all developments of consequence in the text are applied and discussed.

Geometrical Methods of Nonlinear Analysis John Wiley & Sons

A gain-scheduling approach for the control of geometrically nonlinear structures is developed. The objective is to improve performance over current linear design techniques that are applied to the same control problem. The approach is applicable to a variety of structures that have complex dynamics with slow variations such as flexible robotic arms and space structures with gimballing solar arrays. The modeling approach is motivated by the lack of in situ test data available for design of 0-g controllers. A Linear Fractional form allows the nonlinear and uncertain aspects of the structure to be modeled independently. The geometric nonlinearity is modeled using a feedback description of structural coupling. The uncertainty model is based on a physical parameter description, so that an experimentally identified 1-g parametric uncertainty model can be extrapolated to 0-g. The control approach is motivated by the success of linear control design synthesis and analysis techniques for space structures. Graphical heuristics for linear control design using Linear Quadratic Gaussian (LQG) and Sensitivity Weighted LQG techniques are introduced. A procedure to realize reduced-order gain-scheduled controllers from a family of linear state-space controllers is developed. A nonlinear analysis framework suitable for the slow variations of geometrically nonlinear structures is also presented. The realization procedure and nonlinear analysis is combined with the graphical linear design heuristics to form an iterative gain scheduled design process. The complete gain scheduling approach is applied to the MIT/MACE-II experiment flown on the International Space Station. Gain scheduled controller designs are shown to provide improved performance and robustness over a Multiple Model linear controllerdesign.

Proceedings of the 39th IMAC, A Conference and Exposition on Structural Dynamics 2021 Springer Nature

This book focuses on nonlinear finite element analysis of thin-walled smart structures integrated with piezoelectric materials. Two types of nonlinear phenomena are presented in the book, namely geometrical nonlinearity and material nonlinearity. Geometrical nonlinearity mainly results from large deformations and large rotations of structures. The book discusses various geometrically nonlinear theories including von Kármán type nonlinear theory, moderate rotation nonlinear theory, fully geometrically nonlinear theory with moderate rotations and large rotation nonlinear theory. The material nonlinearity mainly considered in this book is electroelastic coupled nonlinearity resulting from large driving electric field. This book will be a good reference for students and researchers in the field of structural mechanics.

Nonlinear Analysis of Structures (1997) John Wiley & Sons

A comprehensive book focusing on the Force Analogy Method, a novel method for nonlinear dynamic analysis and simulation This book focusses on the Force Analogy Method, a novel method for nonlinear dynamic analysis and simulation. A review of the current nonlinear analysis method for earthquake engineering will be summarized and explained. Additionally, how the force analogy method can be used in nonlinear static analysis will be discussed through several nonlinear static examples. The emphasis of this book is to extend and develop the force analogy method to performing dynamic analysis on structures under earthquake excitations, where the force analogy method is incorporated in the flexural element, axial element, shearing element and so on will be exhibited. Moreover, the geometric nonlinearity into nonlinear dynamic analysis algorithm based on the force analogy method is included. The application of the force analogy method in seismic design for buildings and structural control area is discussed and combined with practical engineering.

Theory of Nonlinear Structural Analysis Springer

Geometrical (in particular, topological) methods in nonlinear analysis were originally invented by Banach, Birkhoff, Kellogg, Schauder, Leray, and others in existence proofs. Since about the fifties, these methods turned out to be essentially the sole approach to a variety of new problems: the investigation of iteration processes and other procedures in numerical analysis, in bifur cation problems and branching of solutions, estimates on the number of solutions and criteria for the existence of nonzero solutions, the analysis of the structure of the solution set, etc. These methods have been widely applied to the theory of forced vibrations and auto-oscillations, to various problems in the theory of elasticity and fluid. mechanics, to control theory, theoretical physics, and various parts of mathematics. At present, nonlinear analysis along with its geometrical, topological, analytical, variational, and other methods is developing tremendously thanks to research work in many countries. Totally new ideas have been advanced, difficult problems have been solved, and new applications have been indicated. To enumerate the publications of the last few years one would need dozens of pages. On the other hand, many problems of non linear analysis are still far from a solution (problems arising from the internal development of mathematics and, in particular, problems arising in the process of interpreting new problems in the natural sciences). We hope that the English edition of our book will contribute to the further propagation of the ideas of nonlinear analysis.

Geometrically nonlinear analysis of inelastic shell structures including ductile damage Springer Nature

Analysis of Geometrically Nonlinear StructuresSpringer Science & Business Media

Geometrically Nonlinear Analysis of Laminated Elastic Structures John Wiley & Sons

Nonlinear Analysis of Structures presents a complete evaluation of the nonlinear static and dynamic behavior of beams, rods, plates, trusses, frames, mechanisms, stiffened structures, sandwich plates, and shells. These elements are important components in a wide variety of structures and vehicles such as spacecraft and missiles, underwater vessels and structures, and modern housing. Today's engineers and designers must understand these elements and their behavior when they are subjected to various types of loads. Coverage includes the various types of nonlinearities, stress-strain relations and the development of nonlinear governing equations derived from nonlinear elastic theory. This complete guide includes both mathematical treatment and real-world applications, with a wealth of problems and examples to support the text. Special topics include a useful and informative chapter on nonlinear analysis of composite structures, and another on recent developments in symbolic computation. Designed for both self-study and classroom instruction, Nonlinear Analysis of Structures is also an authoritative reference for practicing engineers and scientists. One of the world's leaders in the study of nonlinear structural analysis, Professor Sathyamoorthy has made significant research contributions to the field of nonlinear mechanics for twenty-seven years. His foremost contribution to date has been the development of a unique transverse shear deformation theory for plates undergoing large amplitude vibrations and the examination of multiple mode solutions for plates. In addition to his notable research, Professor Sathyamoorthy has also developed and taught courses in the field at universities in India, Canada, and the United States.

Analysis of Geometrically Nonlinear Frames by the Displacement Method Springer Science & Business Media

This book presents a systematic and unified study of geometric nonlinear functional analysis. This area has its classical roots in the beginning of the twentieth century and is now a very active research area, having close connections to geometric measure theory, probability, classical analysis, combinatorics, and Banach space theory. The main theme of the book is the study of uniformly continuous and Lipschitz functions between Banach spaces (e.g., differentiability, stability, approximation, existence of extensions, fixed points, etc.). This study leads naturally also to the classification of Banach spaces and of their important subsets (mainly spheres) in the uniform and Lipschitz categories. Many recent rather deep theorems and delicate examples are included with complete and detailed proofs. Challenging open problems are described and explained, and promising new research directions are indicated.

Geometrically Nonlinear Analysis of Discretized Structures by the Group Theoretic Approach CRC Press

The availability of computers has, in real terms, moved forward the practice of structural engineering. Where it was once enough to have any analysis given a complex configuration, the profession today is much more demanding. How engineers should be more demanding is the subject of this book. In terms of the theory of structures, the importance of geometric nonlinearities is explained by the theorem which states that "In the presence of prestress, geometric nonlinearities are of the same order of magnitude as linear elastic effects in structures. " This theorem implies that in most cases (in all cases of incremental analysis) geometric nonlinearities should be considered. And it is well known that problems of buckling, cable nets, fabric structures, ... REQUIRE the inclusion of geometric nonlinearities. What is offered in the book which follows is a unified approach (for both discrete and continuous systems) to geometric nonlinearities which incidentally does not require a discussion of large strain. What makes this all work is perturbation theory. Let the equations of equilibrium for a system be written as where P represents the applied loads, F represents the member forces or stresses, and N represents the operator which describes system equilibrium.

Analysis of Geometrically Nonlinear and Softening Response of Thin Structures by a New Facet Shell Element American Mathematical Soc.

The basic structure of the Hessian and Jacobian matrices for geometrically nonlinear behavior of truss structures is given and numerical results are presented for a series of large problems using both dense and sparse projected Lagrangian methods."

Geometrically Nonlinear Analysis of Laminated Elastic Structures Createspace Independent Publishing Platform

* Explains the physical meaning of linear and nonlinear structural mechanics. * Shows how to perform nonlinear structural analysis. * Points out important nonlinear structural dynamics behaviors. * Provides ready-to-use governing equations.

Matrix Structural Analysis

Built upon the two original books by Mike Crisfield and theirown lecture notes, renowned scientist René de Borst and histeam offer a thoroughly updated yet condensed edition that retainsand builds upon the excellent reputation and appeal amongststudents and engineers alike for which Crisfield's first edition isacclaimed. Together with numerous additions and updates, the new authorshave retained the core content of the original publication, whilebringing an improved focus on new developments and ideas. Thisedition offers the latest insights in non-linear finite elementtechnology, including non-linear solution strategies, computationalplasticity, damage mechanics, time-dependent effects,hyperelasticity and large-strain elasto-plasticity. The authors' integrated and consistent style and unrivalledengineering approach assures this book's unique position within thecomputational mechanics literature. Key features: Combines the two previous volumes into one heavily revised textwith obsolete material removed, an improved layout and updatedreferences and notations Extensive new material on more recent developments incomputational mechanics Easily readable, engineering oriented, with no more details inthe main text than necessary to understand the concepts. Pseudo-code throughout makes the link between theory andalgorithms, and the actual implementation. Accompanied by a website (www.wiley.com/go/deborst) with aPython code, based on the pseudo-code within the book and suitablefor solving small-size problems. Non-linear Finite Element Analysis of Solids and Structures, 2ndEdition is an essential reference for practising engineers andresearchers that can also be used as a text for undergraduate andgraduate students within computational mechanics.

Elastic Stability and Geometrically Nonlinear Analysis of Frame Structures

This book is an outcome of academic cooperation between the Volgograd State University of Architecture and Civil Engineering in Russia, Stellenbosch University in South Africa and the Technische Universit„t Berlin in Germany. The authors performed coordinated and cooperative research on nonlinear structural analysis and on computer-supported civil engineering over a period of several years. Many of the innovative aspects of this book were invented and developed in the course of the research effort.

Linear and Geometrically Nonlinear Analysis of Shell Structures by a Shear Flexible Finite Element Shell Formulation

A method was developed for the geometrically nonlinear analysis of the static response of thin-walled stiffened composite structures loaded in uniaxial or biaxial compression. The method is applicable to arbitrary prismatic configurations composed of linked plate strips, such as stiffened panels and thin-walled columns. The longitudinal ends of the structure are assumed to be simply supported, and geometric shape imperfections can be modeled. The method can predict the nonlinear phenomena of postbuckling strength and imperfection sensitivity which are exhibited by some buckling-dominated structures. The method is computer-based and is semi-analytic in nature, making it computationally economical in comparison to finite element methods. The method uses a perturbation approach based on the use of a series of buckling mode shapes to represent displacement contributions associated with nonlinear response. Displacement contributions which are of second order in the model amplitudes are incorported in addition to the buckling mode shapes. The principle of virtual work is applied using a finite basis of buckling modes, and terms through the third order in the model amplitudes are retained. A set of cubic nonlinear algebraic equations are obtained, from which approximate equilibrium solutions are determined. Buckling mode shapes for the general class of structure are obtained using the VIPASA analysis code within the PASCO stiffened-panel design code. Thus, subject to some additional restrictions in loading and plate anisotropy, structures which can be modeled with respect to buckling behavior by VIPASA can be analyzed with respect to nonlinear response using the new method. Results obtained using the method are compared with both experimental and analytical results in the literature. The configurations investigated include several different unstiffened and blade-stiffening panel configurations, featuring both homogeneous, isotropic materials, and laminated composite materi...

Geometrically Nonlinear Analysis of Discretized Structures by the Group Theoretic Approach

Nonlinear Structures & Systems, Volume 1