Hot Articles

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Science & Technology

Title: Model Reduction for Flow Analysis and Control

Author: Clarence W. Rowley and Scott T.M. Dawson

Journal: Annual Review of Fluid Mechanics

Volume: 49 **Issue:** - **Page:** 387-417

Doi: 10.1146/annurev-fluid-010816-060042

Abstract

Advances in experimental techniques and the ever-increasing fidelity of numerical simulations have led to an abundance of data describing fluid flows. This review discusses a range of techniques for analyzing such data, with the aim of extracting simplified models that capture the essential features of these flows, in order to gain insight into the flow physics, and potentially identify mechanisms for controlling these flows. We review well-developed techniques, such as proper orthogonal decomposition and Galerkin projection, and discuss more recent techniques developed for linear systems, such as balanced truncation and dynamic mode decomposition (DMD). We then discuss some of the methods available for nonlinear systems, with particular attention to the Koopman operator, an infinite-dimensional linear operator that completely characterizes the dynamics of a nonlinear system and provides an extension of DMD to nonlinear systems.

Database

Annual Reviews

Title: Flow Structure and Turbulence in Wind Farms

Author: Richard J.A.M. Stevens and Charles Meneveau

Journal: Annual Review of Fluid Mechanics

Volume: 49 **Issue:** - **Page:** 311-339

Doi: 10.1146/annurev-fluid-010816-060206

Abstract

Similar to other renewable energy sources, wind energy is characterized by a low power density. Hence, for wind energy to make considerable contributions to the world's overall energy supply, large wind farms (on- and offshore) consisting of arrays of ever larger wind turbines are being envisioned and built. From a fluid mechanics perspective, wind farms encompass turbulent flow phenomena occurring at many spatial and temporal scales. Of particular interest to understanding mean power extraction and fluctuations in wind farms are the scales ranging from 1 to 10 m that comprise the wakes behind individual wind turbines, to motions reaching 100 m to kilometers in scale, inherently associated with the atmospheric boundary layer. In this review, we summarize current understanding of these flow phenomena (particularly mean and second-order statistics) through field studies, wind tunnel experiments, large-eddy simulations, and analytical modeling, emphasizing the most relevant features for wind farm design and operation.

Database

Annual Reviews

Title: Vapor Bubbles

Author: Andrea Prosperetti

Journal: Annual Review of Fluid Mechanics

Volume: 49 Issue: - Page: 221-248

Doi: 10.1146/annurev-fluid-010816-060221

Abstract

This article reviews the fundamental physics of vapor bubbles in liquids. Work on bubble growth and condensation for stationary and translating bubbles is summarized and the differences with bubbles containing a permanent gas stressed. In particular, it is shown that the natural frequency of a vapor bubble is proportional not to the inverse radius, as for a gas bubble, but to the inverse radius raised to the power 2/3. Permanent gas dissolved in the liquid diffuses into the bubble with strong effects on its dynamics. The effects of the diffusion of heat and mass on the propagation of pressure waves in a vaporous bubbly liquid are discussed. Other topics briefly touched on include thermocapillary flow, plasmonic nanobubbles, and vapor bubbles in an immiscible liquid.

Database

Annual Reviews

Title: Nanoporous materials with a general isotropic plastic matrix: Exact limit state under isotropic loadings

Author: Stella Brach, Luc Dormieux, Djimédo Kondo, Giuseppe Vairo

Journal: International Journal of Plasticity

Volume: 89 **Issue:** - **Page:** 1–28

Doi: 10.1016/j.ijplas.2016.10.007

Abstract

In this paper, hydrostatic strength properties of nanoporous materials are investigated by addressing the limit state of a hollow sphere undergoing isotropic loading conditions. Void-size effects are modelled by treating the cavity boundary as a coherent-imperfect homogeneous interface. The hollow sphere is assumed to be comprised of a rigid-ideal-plastic material obeying to a general isotropic yield criterion. The latter is defined by considering a simplified form of the yield function proposed by Bigoni and Piccolroaz in [Int J Solids Struct; 41: 2855–2878], resulting able to account for a broad class of pressure-sensitive materials whose plastic response is also affected by the stress Lode angle. The corresponding support function is consistently derived and discussed. The exact solution of the limit-state problem is fully determined, providing a closed-form description of stress, strain-rate and velocity fields, as well as the macroscopic hydrostatic strength of nanoporous media. Proposed approach allows to consistently generalise available analytical solutions for porous and nanoporous materials, by accounting for a general plastic response of the solid matrix and for void-size effects. Finally, present exact solution, as well as the identification of the support function for the adopted general strength criterion, open towards novel kinematic limit-analysis approaches for describing macroscale strength properties of nanoporous materials under arbitrary triaxial loadings.

Database

ScienceDirect

Title: A micromechanical-based constitutive model for fibrous fine-grained composite soils

Author: Hesam Dejaloud, Yaser Jafarian

Journal: International Journal of Plasticity

Volume: 89 **Issue:** - **Page:** 150–172

Doi: 10.1016/j.ijplas.2016.11.008

Abstract

Composite soils such as municipal solid wastes (MSWs), peats, and reinforced soils are generally composed of multiple phases with different properties. Numerical modeling of these soils which takes the individual constituents into account might be impractical as it requires great computational efforts. Hence, geotechnical practitioners may prefer to treat a representative material which accounts for the whole mechanical aspects of the composite soil. In the current study, a constitutive model has been developed which treats the fine-grained composite soils in two general phases: matrix (paste) and fiber. To represent the behavior of these phases, two distinct constitutive models are used: (1) an anisotropic critical state-based constitutive model for matrix phase and (2) a Von-Mises type model for fiber phase. In order to consider the composite soil as a single phase homogeneous material, a volumetric homogenization procedure is used based on the micromechanical theories. Accordingly, strain concentration tensor is developed which determines the equivalent stiffness tensor for the homogenized soil. Based on the hypotheses derived from the experimental observations, the basic model is gradually enhanced in order to account for some important aspects of composite matters including fibers orientation, fibers discontinuity, and slippage-mobilization of fibers within the matrix phase. The effect of these aspects on the overall response of soil under monotonic loading is studied. Reasonable performance of the proposed model is demonstrated by the results of triaxial compression tests on reinforced clay with nylon and palm fibers.

Database

ScienceDirect

Title: A physically based model of stress softening and hysteresis of filled rubber including rate- and temperature dependency

Author: J. Plagge, M. Klüppel

Journal: International Journal of Plasticity

Volume: 89 **Issue:** - **Page:** 173–196

Doi:

Abstract

A novel physically based material model is presented that describes the complex stress-strain behavior of filled rubbers under arbitrary deformation histories in a constitutive manner. The polymer response is considered by the extended non-affine tube model. Stress softening is taken into account via the breakdown of highly stressed polymer-filler domains under load and homogenization of the medium. Set stress and hysteresis are introduced via a continuous reformation mechanism, characterized by a single critical stress parameter. The latter is predicted to be dependent on temperature and deformation rate by means of Kramers escape rate. This is confirmed for a wide range of temperatures and speeds by fitting to multihysteresis measurements carried out in a heat chamber. Fitting parameters reveal that the mechanism responsible for hysteresis and set stress takes place on the nanometer scale with energies of roughly 100 kJ/mol. The behavior of the fitting parameters is analyzed for varying filler loadings and crosslinker concentrations in EPDM. Simulations of the stress-strain response for several deformation modes are in good agreement with experiments and its mathematical simplicity makes it very promising for applications with Finite Element Methods (FEM).

Database

ScienceDirect

Title: Nonlinear vibration energy harvesting with adjustable stiffness, damping and inertia

Author: Chunchuan Liu, Xingjian Jing

Journal: Nonlinear Dynamics

Volume: 88 **Issue:** - **Page:** 79–95

Doi: 10.1007/s11071-016-3231-1

Abstract

A novel nonlinear structure with adjustable stiffness, damping and inertia is proposed and studied for vibration energy harvesting. The system consists of an adjustable-inertia system and X-shaped supporting structures. The novelty of the adjustable-inertia design is to enhance the mode coupling property between two orthogonal motion directions, i.e., the translational and rotational directions, which is very helpful for the improvement of the vibration energy harvesting performance. Weakly nonlinear stiffness and damping characteristics can be introduced by the X-shaped supporting structures. Combining the mode coupling effect above and the nonlinear stiffness and damping characteristics of the X-shaped structures, the vibration energy harvesting performance can be significantly enhanced, in both the low frequency range and broadband spectrum. The proposed 2-DOF nonlinear vibration energy harvesting structure can outperform the corresponding 2-DOF linear system and the existing nonlinear harvesting systems. The results in this study provide a novel and effective method for passive structure design of vibration energy harvesting systems to improve efficiency in the low frequency range.

Database

SpringerLink

Title: A validated model for a pin-slot clearance joint

Author: Luka Skrinjar, Janko Slavič, Miha Boltežar

Journal: Nonlinear Dynamics

Volume: 88 **Issue:** - **Page:** 131-143

Doi: 10.1007/s11071-016-3234-y

Abstract

The numerical modeling of joints with a certain amount of clearance and a subsequent validation of the model are important for accurate multibody simulations. For such validated modeling, not only the kinematic constraints, but also the contact models, are important. If a joint has no clearance, it is assumed to be ideal. However, in real applications, there is frequently some clearance in the joints. Adding clearance and kinematic conditions to a pin-slot joint significantly increases the number of kinematic and contact parameters. Consequently, the resulting kinematics and the contact forces can vary significantly with regard to the selection of those parameters. This research covers the development of a validated model for a pin-slot clearance joint. Different kinematic constraints and contact models are discussed. The presented model is an experimentally validated one for a pin-slot clearance joint that is commonly used in safety-critical applications like electrical circuit breakers. Special attention is given to the Hertz, Kelvin–Voigt, Johnson, and Lankarani–Nikravesh contact models. When comparing different contact models within numerical approaches and comparing the results with experimental data, significant differences in the results were observed. With a validated model of a pin-slot clearance joint, a physically consistent numerical simulation was obtained.

Database

SpringerLink

[Science & Technology]

Title: Ship generated mini-tsunamis

Author: John Grue

Journal: Journal of Fluid Mechanics

Volume: 816 **Issue:** - **Page:** 142-166

Doi: 10.1017/jfm.2017.67

Abstract

Very long waves are generated when a ship moves across an appreciable depth change Δh comparable to the average and relatively shallow water depth h at the location, with Δh/h≃1. The phenomenon is new and the waves were recently observed in the Oslofjord in Norway. The 0.5–1 km long waves, extending across the 2–3 km wide fjord, are observed as run-ups and run-downs along the shore, with periods of 30–60 s, where a wave height up to 1.4 m has been measured. The waves travelling with the shallow water speed, found ahead of the ships moving at subcritical depth Froude number, behave like a mini-tsunami. A qualitative explanation of the linear generation mechanism is provided by an asymptotic analysis, valid for Δh/h≪1 and long waves, expressing the generation in terms of a pressure impulse at the depth change. Complementary fully dispersive calculations for Δh/h≃1 document symmetries of the waves at positive or negative Δh. The wave height grows with the ship speed U according to Un with n in the range 3–4, for Δh/h≃1, while the growth in U is only very weak for Δh/h≪1 (the asymptotics). Calculations show good agreement with observations.

Database

Cambridge Journals Online

Title: Gyrotactic swimmer dispersion in pipe flow: testing the theory

Author: Ottavio A. Croze, Rachel N. Bearon, Martin A. Bees

Journal: Journal of Fluid Mechanics

Volume: 816 **Issue:** - **Page:** 481-506

Doi: 10.1017/jfm.2017.90

Abstract

Suspensions of microswimmers are a rich source of fascinating new fluid mechanics. Recently we predicted the active pipe flow dispersion of gyrotactic microalgae, whose orientation is biased by gravity and flow shear. Analytical theory predicts that these active swimmers disperse in a markedly distinct manner from passive tracers (Taylor dispersion). Dispersing swimmers display non-zero drift and effective diffusivity that is non-monotonic with Péclet number. Such predictions agree with numerical simulations, but hitherto have not been tested experimentally. Here, to facilitate comparison, we obtain new solutions of the axial dispersion theory accounting both for swimmer negative buoyancy and a local nonlinear response of swimmers to shear, provided by two alternative microscopic stochastic descriptions. We obtain new predictions for suspensions of the model swimming alga Dunaliella salina, whose motility and buoyant mass we parametrise using tracking video microscopy. We then present a new experimental method to measure gyrotactic dispersion using fluorescently stained D. salina and provide a preliminary comparison with predictions of a non-zero drift above the mean flow for each microscopic stochastic description. Finally, we propose further experiments for a full experimental characterisation of gyrotactic dispersion measures and discuss the implications of our results for algal dispersion in industrial photobioreactors.

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