GADeS 2016

V Riunione del
Gruppo AIMETA di
Dinamica & Stabilità

Brescia, 15–16 settembre 2016

BOOK OF ABSTRACTS

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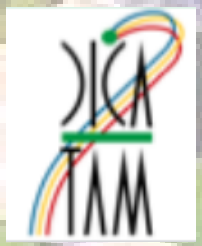

Dipartimento di Ingegneria Civile,
Architettura, Territorio,
Ambiente e di Matematica

Contents

Foreword

Aim and scope

The aim of GADeS is to promote the scientific interaction between researchers operating in the fields of Solid and Structural Dynamics, Machine Dynamics and Dynamical Systems, as well as the opportunity for improving cooperation with researchers working on Identification and Control problems, independently from the scientific sector, thus in coherence with the AIMETA's statutory spirit. Indeed, the integration of researchers, who are studying particular and/or complementary problems, appears very important since it can enlarge the range of interests of the Group. Therefore, the AIMETA GADeS Group is specifically aimed at sharing knowledge from different sectors, through the organization of workshop, mini-symposia, special sessions in AIMETA's conferences and, last but not least, the coordinated participation to Italian and European research project.

Topics of the Workshop

The topics of the Workshop are:

- materials with memory and hysteresis: analytical problems, thermodynamics and phase transitions;
- shape memory alloys;
- binary fluid and solid mixtures;
- viscoelasticity and thermo-viscoelasticity;
- evolution and control problems in advanced materials and complex structures;
- dynamics of multibody systems;
- stability problems;
- piezo-electro-mechanical systems;
- aeroelastic instability;
- singular perturbations;
- mathematical models of liquid crystals.

Venue

- The Conference will take place in
  Sala Consiliare, Via Branze 38, Brescia (Italy).

Organizing Committee

Claudio Giorgi (Università degli Studi di Brescia, Italy)
Maria Grazia Naso (Università degli Studi di Brescia, Italy)
Elena Vuk (Università degli Studi di Brescia, Italy)

Conference

September 15–16, 2016

Sala Consiliare, Ingegneria, Via Branze 38, Brescia

Ivana Bochicchio

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Modeling and steady states of a linear suspension bridge model

In this work we deduce the dimensionless model for the bending of a linear string-beam system. A careful analysis of the resulting steady states is performed. We infer that every solution can be written as linear combination of at most two distinct eigenvectors of a suitable operator.

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Phase transitions models for shape memory materials

We propose a refined and general three-dimensional phenomenological constitutive model for shape memory alloys (SMAs). Such an improved model takes into account several physical phenomena, as martensite reorientation and different kinetics between forward/reverse phase transformations, including also smooth thermo-mechanical response, low-stress phase transformations as well as transformation-dependent elastic properties. Hence, we extend our analysis to a class of polymers, exhibiting shape memory effects. On the basis of an experimental campaign on semi-crystalline shape memory polymers, we develop a new one-dimensional phenomenological constitutive model, based on the phase transition approach and formulated in a finite strain framework, in order to reproduce experimental observations.

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Alcune considerazioni sulla stabilità dinamica

Joint work with
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Questa presentazione riferisce di un lavoro presentato al convegno internazionale SEMC2016.

Sono presentati alcuni casi particolari, relativi a travi piane in presenza di un'unica massa concentrata, soggette anche a carico di tipo follower. Si trascura lo smorzamento e la deformabilità assiale. Si assume che gli spostamenti siano piccoli e quindi si adotta la teoria al second'ordine. Le ipotesi semplificative adottate fan sì che i sistemi siano ad una sola coordinata lagrangiana; di conseguenza l'analisi di stabilità dinamica può dar luogo a

divergenza o divergenza all'infinito. In un esempio che in un caso particolare coincide con l'esempio classico, cioè la mensola incastrata alla base, con una massa concentrata alla sommità, soggetta ad un carico concentrato follower di compressione, studiato, fra gli altri, da (Panovko & Gubanova 1967), si ottiene un comportamento paradossale. Come noto, il carico critico nell'esempio classico sopracitato coincide con quello della trave incastro-appoggio soggetta a carico conservativo. Si propone a questo proposito una congettura che trova riscontro in un altro esempio. Infine si presentano due esempi in cui la teoria al secondo ordine individua instabilità a trazione.

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Alcuni aspetti del monitoraggio e del controllo della tensione nei cavi in ponti strallati

In questo contributo, si analizzano casi di studio esistenti in cui i classici metodi per il controllo e monitoraggio delle vibrazioni di cavi non sono praticabili ed è necessario ricorrere a soluzioni alternative di semplice implementazione. Tali soluzioni richiedono comunque di tenere esplicitamente conto delle non-linearità insite nel comportamento dinamico del tipo di strutture flessibili in esame. A tale scopo, si persegue lo sviluppo di un modello numerico della struttura convalidato dall'evidenza sperimentale, con particolare attenzione posta sulle condizioni iniziali di tensione nei cavi. Si procede poi a variare le condizioni iniziali e ad analizzare il legame tra l'evoluzione della tensione nei cavi ed i parametri della risposta strutturale. La conoscenza sia pur numerica di questo legame è utilizzabile, sia in forma diretta che in forma inversa, nei problemi di controllo off-line della tensione nei cavi e nei problemi di monitoraggio dei cambiamenti di tensione a partire dalle registrazioni della risposta strutturale

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An experimental survey of pedestrian-induced vibrations on Michelangelo's David

Joint work with
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Every year about a million and a half of tourists visit Michelangelo's David in the Accademia Gallery in Florence (Italy). Such a big number, about four thousand people every opening day, has motivated in the last few years several concerns regarding the effects of the visitors footfall induced vibrations on the statue's stability. The problem, in principle, may be of concern taking into account the well-known system of historic visible cracks

affecting the statue: a first system in the tree trunk that supports the right leg, and a second one in the lower part of the left leg [1]. To assess the effect of the pedestrian-induced vibrations in the two days of Monday, 27 and Tuesday, 28, July 2015, measurements of dynamic movements of Michelangelo's David by using an interferometric radar were made. The first day (Monday) correspond to the closure day of the Accademia Gallery, the second measurement day (Tuesday) is the day that, statistically, correspond to the peak daily visitors. The monitoring was carried out by a no-contact technique using a interferometric high sensitivity radar, which effectiveness in measuring the resonant frequencies of structures and historic monuments has been proven through numerous monitoring activities over the last years [2]. Because the measurement system (radar and tripod) has its own dynamic behaviour, on the radar head an accelerometer has been installed in order to purge the displacement measurement of David from the component due to the movement of the measuring instrument. Measures were carried out in the presence and in the absence of the visitors, in order to assess their influence on the dynamic behaviour of the statue. A numerical model of the statue was eventually employed to evaluate the experimental results.

Keywords: Dynamic measurements; Interferometric radar; Human-induced vibrations; Modal identification; Statue.

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Weakly nonlinear dynamics of taut strings travelled by a single moving force

Si analizza il comportamento dinamico in ambito non-lineare di una stringa tesa soggetta al transito di una forza mobile. La risposta del sistema viene determinata, in modo perturbativo, attraverso il Metodo delle Scale Multiple (MSM) ed il Metodo della Straightforward Expansion (SE). Infine, i risultati asintotici vengono confrontati con quelli numerici ottenuti attraverso una discretizzazione alla Galerkin.

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Caratteristiche di uno smorzatore dinamico non-lineare

Al fine di migliorare le prestazioni di uno smorzatore dinamico, può essere utilizzato un elemento a rigidezza non-lineare avente caratteristica di tipo cubico. Il presente lavoro illustra il comportamento dinamico di un assorbitore di vibrazione non-lineare quando è collegato ad un oscillatore lineare di tipo massa-molla-smorzatore, eccitato da una forzante armonica. Gli effetti di non-linearità, rapporto di massa e rapporto di frequenza sulla risposta dinamica del sistema a due gradi di libertà sono studiati mediante una formulazione analitica approssimata. I grafici delle curve di risposta in frequenza sono utilizzati per confrontare il caso non-lineare con quello lineare corrispondente.

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On the nonlinear effects of the damping destabilization paradox

Si analizza il paradosso di destabilizzazione in regime non-lineare. Attraverso il Metodo delle Scale Multiple (MSM) si determinano le equazioni di biforcazione e si discute lo scenario post-critico. Alcune simulazioni numeriche concludono il lavoro.

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Interferenza tra vibrazioni indotte da distacco di vortici e instabilità di galoppo trasversale: sperimentazione in galleria del vento e modellazione analitica per un prisma a sezione rettangolare

Il fenomeno dell'interferenza tra vibrazioni indotte dal distacco di vortici (VIV) e instabilità di galoppo trasversale costituisce un interessante problema fisico con importanti risvolti ingegneristici per strutture snelle soggette all'azione del vento. Tale fenomeno è stato studiato nel dettaglio in galleria del vento del CRIACIV nel caso di un prisma allungato con sezione rettangolare caratterizzata da un rapporto fra i lati pari a 1.5 (con il lato corto perpendicolare al flusso), variando progressivamente lo smorzamento del sistema mediante smorzatori magnetici. Il fenomeno è stato poi affrontato per via analitica tramite due oscillatori non lineari accoppiati, quello corrispondente al corpo e quello relativo alla scia, pensata come una lamina equivalente alla Birkhoff. Le forze quasi-stazionarie dovute al moto del prisma e alle conseguenti ondulazioni della scia sono state sovrapposte linearmente a quelle non stazionarie dovute al distacco di vortici. Rispetto al passato, il

parametro di accoppiamento fra i due oscillatori è stato modificato in maniera sostanziale, ottenendo risultati molto promettenti se confrontati con quelli delle prove sperimentali. Infatti, Il modello analitico, nonostante la sua semplicità, sembra essere capace di riprodurre in maniera soddisfacente il comportamento del sistema e le caratteristiche di fondo del fenomeno di interferenza, spiegando quindi il meccanismo che ne sta alla base.

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Complex dynamics of circular cylindrical shells

Complex dynamics of circular cylindrical shells subjected to inertial axial loads are investigated. The shell is vertically mounted on a shaker, i.e. its base is clamped to the shaker fixture, which induces a vertical motion along the shell axis. On the top of the shell a rigid disk is mounted, the vertical motion induced by the shaker induces huge inertial forces due to the rigid body motion. A complicating effect is due to the base actuator, which is an electro- -dynamic shaking table; the interaction between the shell and shaker dynamics changes dramatically the system behaviour. The non-linear Sanders-Koiter theory is considered for the structural dynamics: the resulting set of non-linear partial differential equations is coupled with the linear ordinary differential equations that govern the shaker dynamics. A deep analysis of the non-stationary response of the shell is carried out in order to clarify the transition from stationary to non-stationary response. The model is validated by means of experimental results.

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Aeroelastic instabilities in equivalent nonlinear beams

Joint work with
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Galloping and vortex-induced vibrations (VIV) are the most popular aeroelastic phenomena together with flutter, this latter mainly related to elongated and bridge-deck sections in unsteady flow conditions (Paidoussis et al., 2011). They are usually addressed using simple linear mechanical models, focusing on a suitable description of aeroelastic forces. However, there are cases where this approach is not possible or leads to great approximations. This happens in both galloping oscillations (for instance concerning

suspended cables, e.g. Luongo and Piccardo, 2008) and crossflow VIV (for instance related to flexible circular cylinders, e.g. Srinil and Zanganeh 2012). The development of non-linear mechanical models also allows to better approximate the VIV experimental response of suspension bridge decks (e.g. Diana et al., 2006). Concerning shear-type buildings Piccardo et al. (2014, 2015, 2016a, 2016b) have recently proposed a continuous non- linear equivalent beam model. The instability analysis has been carried out specifying the aerodynamic forces as self-excited aeroelastic actions deduced by the quasi-steady approach (in the case of galloping oscillations) or introducing a generalized van der Pol-Duffing model (in the case of VIV). This presentation briefly outlines the results obtained illustrating the possible prospects of this research field.

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Comportamento post-critico di sistemi a due gradi di libertà per oscillazioni da flutter

La risposta di un sistema a due gradi di libertà, oscillante in direzione trasversale al flusso e in rotazione a seguito del fenomeno aeroelastico del flutter, non è ancora ben compresa in campo post-critico. Per contro, moti auto-eccitati e con grandi ampiezze sono richiesti per lo sviluppo di applicazioni efficienti di estrazione di energia. Quindi, la ricerca è rivolta all'analisi dei parametri governanti del problema di flutter e dei loro effetti sulla risposta dinamica del sistema. Test in galleria del vento sono stati condotti su un modello sezione di piastra sottile installato in un setup elastico specifico per grandi ampiezze di oscillazione, affiancando anche analisi lineari parametriche. Inoltre, lo studio dell'influenza dello smorzamento in traslazione diventa fondamentale, simulando l'effetto sul sistema meccanico dell'apparto di conversione.

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Response robustness and safety against jump to contact in AFMs controlled via different techniques

Joint work with
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Analyzing the nonlinear dynamical behavior of a mechanical system usually entails the investigation of the stability of its response under variation of some (characterizing and/or controllable) parameter. However, beside these analyses, possible changes in the system initial conditions due to imperfections have to be taken into account, since it is nowadays ascertained that the safe operation of a nonlinear system depends not only on the local stability of its solutions but also on the global dynamics associated with the uncorrupted basin surrounding each solution. This is certainly true for the currently very popular micro/nano mechanical systems, for which slight changes of the initial position and/or velocity at the nanoscale level can produce dramatic modifications of the overall dynamics. Among them, Atomic Force Microscopes (AFMs) working in noncontact mode can undergo the unwanted "jump-to-contact" phenomenon, or escape (in dynamical systems terms), due to the atomic attraction between the cantilever tip and the sample to be scanned which can become stronger than the beam restoring elastic force making the equilibrium configuration unstable and producing contacts between tip and sample responsible for errors in the topography process.

From a global dynamics perspective, it is thus of interest to clearly detect in the state plane the basins of attraction (i.e. the union of all possible initial conditions) of the periodic (acceptable) solutions and that of the (undesirable) unbounded responses compromising the device operation. Furthermore, the relevant erosion process due to variations of some system parameter (usually the excitation amplitude) can be followed and quantified by means of the realization of the so-called erosion profiles. As a practical consequence of such analyses, belonging to the field of dynamical integrity, the sensitivity of a dynamical system to variations of both operational parameters and initial conditions are discussed, and some hints useful to define thresholds able to ensure acceptable safety targets are achieved.

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Internal resonances and nonlinear energy exchange of Single-Walled Carbon Nanotubes

In this work, the nonlinear vibrations and energy exchange of Single-Walled Carbon Nanotubes (SWNTs) are investigated. The Sanders-Koiter theory is applied to model the nonlinear dynamics of the system in the case of finite amplitude of vibration. The SWNT deformation is described in terms of longitudinal, circumferential and radial displacement fields. Simply supported boundary conditions are considered. The circumferential flexural modes (CFMs), radial breathing modes (RBMs) and beam-like modes (BLMs) are studied. A numerical model of the SWNT dynamics is proposed. The three displacement fields are expanded in the nonlinear field by using approximate linear eigenfunctions. An energy method based on the Lagrange equations is used to reduce the nonlinear partial differential equations of motion to a set of nonlinear ordinary differential equations, which is solved using the implicit Runge-Kutta numerical method. The nonlinear energy exchange along the SWNT axis is analysed for different initial excitation amplitudes. The internal resonances between CFMs, RBMs and BLMs are investigated. The transition from energy beating to energy localization in the nonlinear field is studied.

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Recent Studies on Serviceability Analysis of Footbridges

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Modern footbridges are very slender structures, with low damping characteristics and often characterized by natural frequencies falling within the range of typical human step frequencies. Thus, they could be very sensitive to human-induced vibrations and their serviceability assessment is becoming a central step in their design. Serviceability assessment should be carried out for the different traffic conditions expected during the footbridge working life, and the randomness of walking parameters should be taken into account. Recent guidelines and research papers [1] provide simplified procedures to carry out their serviceability analyses.

An interesting alternative to simplified procedures is the introduction of an Equivalent Spectral Model of pedestrian excitation [2], that provides results in accordance with experimental observations [3] for unrestricted pedestrian traffic conditions. The Equivalent Spectral Model can be applied at the design stage to assess the footbridge vibrations sensitivity in the spirit of recent guidelines. It provides a closed-form estimate of both the standard deviation and the mean value of the maximum dynamic response. Differently from recent guidelines, which are based on specific values of the random parameters involved (in particular mean value and coefficient of variation of the step frequency), the Equivalent Spectral Model allows to take into account the intrinsic randomness of the walking parameters.

The central aim of this presentation is to show the results of Monte Carlo simulations of walking-induced forces, carried out starting from a full probabilistic model of the walking parameters. In this way the influence of the statistical distribution of walking speed, dynamic load factor, pedestrian weight and step frequency on the maximum dynamic response is fully analyzed. Furthermore, the numerically obtained dynamic response (in terms of standard deviation, peak factor and maximum value) is compared with the one provided by guidelines and by the Equivalent Spectral Model [4]. Based on these parametric analyses, the recommended values of the statistical parameters are defined as functions of the footbridge natural frequency. Furthermore, a direct and simple graphical evaluation of footbridge maximum acceleration is proposed.

Finally, a generalization of the Equivalent Spectral Model to crowded conditions [5] is presented , based both on experimental relationships among pedestrian density, step velocity and step frequency taken from the literature, and on a physically-based expression for the coherence function.

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Instability phenomena in homogeneous models of multilayer tubular beams

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A direct nonlinear 1-dimensional model of elastic, multilayer, planar beam is formulated. The model also accounts for changes in shape of the cross-section: the ovalization (or flattening), typical in tubular beams, as well as warping. Instability phenomena can occur due to coupling between bending and ovalization (Brazier Effect), possibly causing the collapse of the structure even in the elastic phase.

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