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Nguyen Xuan Hung
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MESSAGE FROM THE CONFERENCE CHAIR

It is my pleasure to welcome you to the International Conference on Advances in Computational Mechanics, ACOME 2012. On behalf of the Organizing Committee, I would like to thank all of you for your participations and hope that you will enjoy the presentations and the discussions as well as the networking opportunities at this Conference.

This Conference is hosted by Ton Duc Thang University in Ho Chi Minh City, and sponsored by Ton Duc Thang University, the National Foundation for Science and Technology Development (NAFOSTED), International University of Vietnam National University in Ho Chi Minh City.

This is the first time we have more than 80 researchers and scientists from all over the world gathering in Vietnam to exchange knowledge and expertise in the development and innovative applications of computational mechanics. Many of them are distinguished researchers and scientists in computational mechanics. A majority of them come from universities and research institutes of 14 overseas countries: Australia, Belgium, England, France, Germany, Indonesia, Italia, Japan, Korea, Russia, Singapore, Spain, Thailand and USA. There are 78 papers of the following major topics in the proceedings:

- Computational Solids and Structural Mechanics
- Computational Mechanics of Materials and Structures
- Computational Fracture and Damage Mechanics
- Computational Fluid Mechanics
- Computational Solids and Fluid Mechanics
- Computational Structural and Fluid Mechanics
- Computational Dynamics
- Computational Dynamics and Controls
- Isogeometric Analysis
- Limit and Shakedown Analysis - Theory and Computation
- Optimization and Inversed Problems
- Numerical and Experimental Modeling of Concrete Structures
- Computational Civil Engineering

The main tasks of preparing the proceedings and organizing the Conference were carried out by a group of the enthusiastic young researchers; many of them are former students of the EMMC (European Master in Mechanics of Constructions) and MCMC (European Master in Computational Mechanics of Continuum) programs.

In the last decade, there have been a growing number of young Vietnamese researchers in the field of computational mechanics; most of them are former EMMC and MCMC students. Professor Nguyen Dang Hung is the main organizer of these successful EMMC and MCMC programs.

So that on this occasion, the organizers would like to honour Professor Nguyen Dang Hung for his distinguished contribution to the development of the computational mechanics community in Vietnam.

After this first International Conference on Advances in Computational Mechanics, I hope that similar conferences of these topics will be organized in Vietnam on a regular basis in the future.

Professor Nguyen Thien Tong
Conference Chair
ACOME 2012

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CONTENTS

Numerical and Experimental Modeling of Concrete Structures

Computational Civil Engineering

THE INTERNATIONAL CONFERENCE ON ADVANCES IN COMPUTATIONAL MECHANICS
ACOME 2012 August 14-16, Ho Chi Minh City, Vietnam

MECHANICAL CHARACTERIZATION OF MATERIALS AND DIAGNOSIS OF STRUCTURES BY INVERSE ANALYSES: SOME INNOVATIVE PROCEDURES AND APPLICATIONS

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ABSTRACT

A survey is presented herein of some recent research contributions to the methodology of inverse structural analysis based on statical tests for diagnosis of possibly damaged structures and for mechanical characterization of materials in diverse industrial environments. The following issues are briefly considered: identifications of parameters in material models and of residual stresses on the basis of indentation experiments; mechanical characterization of free-foils and laminates by cruciform and compression tests and digital image correlation measurements; diagnosis, both superficially and in depth, of concrete dams, possibly affected by alkali-silica-reaction or otherwise damaged.

Key words: *Inverse analysis, Parameter identification, Digital image correlation, Proper orthogonal decomposition, Trust region algorithm, Artificial neural networks*

ARCHETYPE-BLENDING CONTINUUM (ABC) THEORY

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ABSTRACT

This research presents a new formulation of the archetype-blending continuum theory that is able to introduce detailed mesostructural characteristics in all classes of heterogeneous and multicomponent materials by connecting generalized continuum theory, microstructural imaging, statistical and micromechanical methods in a single theoretical-cum-computational framework. The aim is designing macroscale engineering systems from the science deriving at the processing level of material constituents (archetypes) with compatible simulation techniques. We enumerate the core focus of the proposed theory.

- Modular and bottom-up constitutive modeling strategy that enables modelers to separately focus on the multiscale modeling strategy of sub-structured material heterogeneities (sub-morphisms).
- Blending algorithms that combine constitutive modules in a multi-component constitutive law, incorporating detailed mesostructural imaging, statistical quantification and micromechanical analyses (i.e. conformational complexity, or meso-morphism).
- Unification, and mesostructural foundation, of the three field effects characterizing generalized continua: *Sub-morphism*, *Conformational Complexity*, *Nonlocality*, thus tracking the distribution of energy across each blend represented by a point in the dynamically equivalent simple body.

Such an aim—predicting complex engineering system behavior via compatible simulations—is the foundation of multiscale and multicomponent modeling within computational engineering and science so that complex system behavior may be reliably predicted across a spectrum of length and time scales.

Key words: *Computational plasticity, FEM, Meshfree methods, Multi-scale modelling*

ON DUALITY, SYMMETRY AND SYMMETRY LOST IN SOLID MECHANICS

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ABSTRACT

The paper recalls the concept of duality in Mathematics and extends it to Solid Mechanics. One important application of duality is to restore some symmetry between current fields and their adjoint ones. This leads to many alternative schemes for numerical analyses, different from the classical one as used in classical formulation of boundary value problems (Finite Element Method).

Usually, Conservation laws in Fracture Mechanics make use of the current fields, displacement and stress. Many conservation laws of this type are not free of the source term. Consequently, one cannot derive path-independent integrals for use in Fracture Mechanics.

The introduction of variables and dual or adjoint variables leads to true path-independent integrals. Duality also introduces some anti-symmetry in current fields and adjoint ones for some boundary value problems. The symmetry is lost between fields and adjoint fields. The last notion enables us to derive new variational formulation on dual subspaces and to exactly solve inverse problems for detecting cracks and volume defects.

Key words: *Duality, Symmetry lost, Inverse problems*

S-FEM FOR FRACTURE PROBLEMS, THEORY, FORMULATION AND APPLICATION

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ABSTRACT

This paper briefs some of recent works on applications of the smoothed finite element method (SFEM) to fracture problems. In the SFEM formulation for simulating the singular filed near the crack-tip, it is known that one can directly enrich the filed by adding in proper terms needed to simulate the singularity, which can be done in a number of ways (see the SFEM book). In this work a generalized technique called the "enriched linear PIM" for constructing shape functions is used to formulate a special "five-node (T5) singular crack-tip element" that can produce a proper order of stress singularity near the crack-tip. One layer of T5 crack-tip singular elements are used in a basic mesh of linear elements leading to a very simple model that can be crated automatically for complicated geometry. Because SFEM uses weakened weak formulation, such a simple model does not require transition elements and the compatibility is ensured. In addition, the singular terms of functions as well as mapping procedures are no longer necessary to compute the stiffness matrix. Thus, the singular SFEM method is straightforward and can be easily implemented in the existing codes. The stress intensity factors of mix-modes can also be easily evaluated by an appropriate treatment during the domain form of the interaction integral, due to the use of simple triangular mesh. The effectiveness of the present singular T5 element is demonstrated via benchmark example.

Key words: *Numerical method, Meshless, Smoothed FEM, S-FEM, Strain smoothing, Singular element, J-integral, Stress intensity factor*

ANALYTICAL EXPRESSIONS OF BUCKLING LOADS FOR TWO-LAYER TIMOSHENKO MEMBERS WITH INTERLAYER SLIPS

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ABSTRACT

This paper deals with a linear bifurcation buckling analysis of shear-deformable two layer beams/column in partial interaction. The effect of transverse shear deformation of two layers is taken into account by assuming that each layer behaves as a Timoshenko beam element. Therefore, the layers have independent shear trains that depend indeed on their own shear modulus. The two layers are connected continuously and the partial interaction is modeled by assuming a respective continuous relationship between the interface shear flow and the corresponding slip. A set of differential equations is derived from a general 3D bifurcation analysis. An original closed-form solution of these equations is developed from which the analytical expression of critical buckling loads of the two-layer composite beams under axial compression is derived for various boundary conditions. The expression of the critical loads is shown to be consistent with the one obtained with different kinematic assumptions such as Euler-Bernoulli beam kinematic and Timoshenko beam kinematic with one rotation field. More precisely, the latter can be deduced from former by setting the limiting cases of the transverse shear stiffnesses. Finally, numerical 2D finite element computations are performed in order to validate the analytical results and show the importance of transverse shear deformation and partial interaction in such a buckling analysis.

Key words: *Layered beam, Partial interaction, Shear flexibility, Bifurcation analysis, Buckling*

DIAGNOSIS OF BEAM-DAMAGE LOCATION USING NEURAL NETWORKS AND WAVELET ANALYSIS

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ABSTRACT

This paper presents a beam-damage-locating algorithm (BDLA) which is built based on an artificial neural network (ANN) and a new solution to wavelet analysis. The proposed algorithm uses ANN for remembering undamaged-beam dynamic properties and uses an average quantity of wavelet transform coefficient (AQWTC) of the beam vibration signal to find out damaged locations. Firstly, the beam is discretized into elements and then excited to vibrate. Vibrating signal, which is displacement in this work, at each element is measured and transformed into wavelet signal with a used-scale-sheet to calculate the corresponding difference of AQWTC between two cases: undamaged status and the status at the checking time. Database about this difference is then used for finding out the elements exhibiting strange features in wavelet quantitative analysis, which are considered as beam-damaged signs. The effectiveness of the proposed method is evaluated by experiments.

Key words: *Damage location, Damage diagnosis, Structure manage, Structure health monitor*

LARGE DEFLECTION ANALYSIS OF FUNCTIONALLY GRADED EULER-BERNOULLI BEAMS WITH VARIABLE CROSS SECTION

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ABSTRACT

A finite element procedure for large deflection analysis of functionally graded Bernoulli beams with variable cross section is described. The material property of the beams is assumed to be varied continuously in the thickness direction by the power law. A nonlinear beam element taking the effects of material inhomogeneity, nonuniform cross section and the shift in neutral axis from the midplane into account is formulated in the context of the co-rotational formulation. The numerical examples show that the formulated element is capable of giving accurate results by using a small number of elements. The influence of the material inhomogeneity and variation of cross section on the large defection behaviour of the beams is investigated and highlighted.

Key words: *Functionally graded beam, Variable cross section, Neutral axis, Large deflection analysis, Co-rotational formulation*

A DOUBLE-CHANNEL VERTICAL SOLAR CHIMNEY

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ABSTRACT

Solar chimney is a device which absorbs solar heat and, based on stack effects, induces air flow through it to ventilate interior space of connected buildings. A typical chimney consists of an air channel with an absorber surface on one side and a glazing glass plate on the other side. We propose a new type of chimney with the absorber surface placed on the central plane of the channel. This new configuration is expected to enhance heat transfer between the absorber surface and the airflow, and to ease insulation requirement between the absorber surface and the wall of the building.

Computational method is used to examine ventilation performance of the new chimney. First, the computations are validated by the experimental data by Mathur *et al.* (2006). Comparisons to a typical chimney are also conducted. Second, effects of the chimney dimensions (inlet height, air gap width, ratio of left gap width and right gap width, and absorber height) and heat flux from the absorber surface on the induced ventilation rate are also examined. The results show that a chimney with 2.4m height, 0.1m air gap width, and at the heat flux of 500W/m^2 from the absorber surface can offer a ventilation flowrate of 234m^3/h which is sufficient to ventilate a residential room of 78 m^3.

Key words: *Solar chimney, Ventilation flowrate, Solar flux*

MODELING OF THE MECHANICAL BEHAVIOR OF MSWI BOTTOM ASH WITH THE MOHR-COULOMB MODEL: USING THE FINITE ELEMENT SOFTWARE CESAR-LCPC

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ABSTRACT

Bottom ash from Municipal Solid Waste Incineration (MSWI) can be viewed as a typical granular material because they result from the incineration of various domestic wastes. They are mainly used in road engineering in substitution of the traditional natural aggregates. As the characterization of their mechanical behavior is essential in order to use them, many studies have been led in the Civil Engineering department of the Ecole des Mines de Douai (France) in the past few years. This presented article addressed the mechanical behavior of bottom ash with triaxial tests. After, the simulation of triaxial tests is carried out by using software CESAR-LCPC. The Mohr-Coulomb model was chosen to characterizing the evolution of material “bottom ash” under the influence of external mechanical actions. The modelling results are very promising.

Key words: *Bottom ash, Triaxial test, Mechanical behavior, Simulation, Mohr-Coulomb model*

DYNAMIC RESPONSE OF CABLE STAYED BRIDGES UNDER VEHICLES CONSIDERING THE MOVING MASSES

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ABSTRACT

This paper presents the dynamic response of two-dimensional cable stayed bridges under vehicles considering the moving masses. The action of vehicles is idealized as moving load and masses of suspension and tire with constant velocity at the same time. The simple cable stayed bridge is discreted by finite element method with 2D frame and cable elements. The governing equation of motion can be derived by D'Alembert principle and solved by step by step Newmark method. A computer program based on MATLAB language is developed and verified by comparing analysis results with those found from SAP2000 software to predict the dynamic behavior of the structure. From the numerical study, it is concluded that the moving masses have influence on the dynamic response and should be considered.

Key words: *Cable stayed bridge, Moving masses, Dynamic Amplification Factor DAF*

SIMULATION OF THERMAL FIELDS OF HIGH VOLTAGE UNDERGROUND CABLES USING THE ADAPTIVE *hp* - FINITE ELEMENT METHOD

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ABSTRACT

In this study, we present the application of the adaptive higher-order finite element method (*hp*-FEM) to the steady-state two-dimensional (2-D) heat transfer problems. The *hp*-FEM uses both the adaptive Delaunay mesh and the higher-order interpolation polynomial to create the adaptive mesh refinement and to increase the accuracy of solution, respectively. In order to evaluate the accuracy of our new approach, we apply the proposed methods to a 2-D benchmark heat transfer problem. The obtained results have been shown that the *hp*-FEM solutions are more accurate than those of the lowest-order FEM, the finite difference method (FDM), and the RBF meshfree method. In addition, we also apply the *hp*-FEM to the temperature distribution and current-carrying capacity of the single- and double-circuit high-voltage underground cable systems buried in the homogeneous and multi-layer soils. Our numerical results demonstrate that the proposed methods compare favorably to the boundary element method (BEM), the FDM, COMSOL 3.5 finite element analysis software and the data of cable manufactory.

Key words: *hp-FEM, Temperature, Ampacity, Underground cable*

LIMIT LOAD COMPUTATION OF MINDLIN-REISSNER PLATES USING THE ES-DSG METHOD AND SECOND-ORDER CONE PROGRAMMING

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ABSTRACT

This paper presents a novel formulation for computation of collapse load of Mindli-Reissner plates, that uses a stabilized discrete shear gap finite element in combination with second-order cone programming. Displacement fields are approximated using the discrete shear gap, ensuring that shear locking problem can be avoided. Moreover, a stabilized strain smoothing technique is applied to enhance the accuracy of solutions. Another significant contribution of this paper is to formulate the underlying optimization problem in the form of a standard second-order cone programming, so that it can be solved using highly efficient primal-dual interior point algorithm. Various plates with arbitrary geometries and boundary conditions are examined to illustrate the performance of the proposed procedure.

Key words: *Computational plasticity, ES-FEM, DSG, Mindlin plate, SOCP*

AN EFFECTIVE ADAPTIVE LIMIT ANALYSIS OF SOIL USING FEM AND SECOND-ORDER CONE PROGRAMMING

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ABSTRACT

The main objective of this paper is to propose an effective adaptive mesh refinement strategy for the upper bound limit analysis of soil using the finite element method (FEM) and the second-order cone programming (SOCP). The values of plastic dissipation of triangular elements obtained from SOCP are used directly as the "error indicators" for adaptive mesh refinement strategy, and hence the algorithm is very straightforward, simple and no any post-process for the error indicators is required. A simple refinement strategy using the newest node bisection is used and briefly presented. The numerical results of some benchmark problems show that the present adaptive procedure can accurately catch the appearance of slip surfaces in the collapse mechanism and give the fast convergence of the bearing capacity factors.

Key words: *Limit analysis, Adaptive finite element method, Soil mechanics, Second-order cone programming (SOCP)*

LIMIT ANALYSIS OF CRACKED STRUCTURES USING XFEM AND SECOND-ORDER CONE PROGRAMMING

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ABSTRACT

This paper presents a numerical procedure for limit analysis of cracked structures using extended finite element method (XFEM) in combination with second-order cone programming (SOCP). The cracked structures are easily modelled and simulated using XFEM because it allows discontinuties across elements, and these discontinuties are recognized by means of level set method. The obtained discretization formulation is then cast in a form which involves second-order cone constraints, ensuring that the underlying optimization problem can be solved by highly efficient primal-dual interior point algorithm. The efficiency of the present approach is illustrated by examing several numerical examples.

Key words: *Limit analysis (LA), Extend finite element method (XFEM), Second-order cone programming (SOCP)*

AN IMPROVEMENT IN IMPLEMENTATION OF THE MESHLESS METHOD RBIEM

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ABSTRACT

This work proposes an efficient implementation scheme of the RBIEM named as the m-RBIEM. The m-RBIEM evaluates the boundary integral of a circular sub-domain directly by using polar coordinate system which does not require boundary dicretization process that the RBIEM does. It is shown in this work that the m-RBIEM is more accurate than the old version RBIEM and requires less computational time used to evaluate coefficients of global matrix. Moreover, the m-RBIEM is easier to implement due to the simpler analytical formula of the integral in the polar variables. The efficiency of the m-RBIEM is verified by solving the Poisson and the diffusion-convection problems.

Key words: *Meshless method, Integral equations, Circular sub-domains, Radial basis functions*

ANALYSIS OF SHELL STRUCTURES VIA A SMOOTHED FOUR-NODE FLAT ELEMENT

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ABSTRACT

This study reports the development of an efficient 4-node flat shell element with six degrees of freedom per node for the analysis of arbitrary shell structures. The element is developed by incorporating a strain smoothing technique into a flat shell finite element approach. The membrane part is formulated by applying the smoothing operation on a quadrilateral membrane element using Allman-type interpolation functions with in-plane rotations. The plate-bending component is established by a combination of the smoothed curvature and the substitute shear strain fields. As a result, the evaluation of membrane, bending and geometric stiffness matrices are based on integration along the boundary of smoothing elements, which leads to accurate numerical solutions even with badly-shaped elements. Numerical examples and comparison with other existing solutions show that the present element is efficient, accurate and free of locking.

Key words: *Flat shell, Strain smoothing method, Locking free, Drilling degrees of freedom, First-order shear deformation theory*

GEOMETRICALLY NONLINEAR RESPONSES OF A FUNCTIONALLY GRADED BEAM ON WINKLER FOUNDATION UNDER A MOVING HARMONIC LOAD

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ABSTRACT

The non linear responses of the functionally graded (FG) beam on Winkler's elastic foundation under a moving harmonic load are presented in this paper. The analytical model of the beam is described by using the first order shear deformation theory and Von-Karman relationships for material behavior. The material properties of the beam are assumed to follow simple power law form. The governing equation of motion of the beam is derived based on Hamilton principle expressed as Lagrange's equations with specific boundary conditions satisfied with Lagrange's multipliers. The Newmark - β method is used for integrating of the equation of motion. The effects of large deformation, material distribution, velocity of moving load, excitation frequency, Winkler foundation factor on displacements and internal forces of the beam have been examined thoroughly to draw some useful conclusions.

Key words: *Nonlinear analysis, Functionally graded beam, Moving harmonic load, Winkler foundation*

COMPUTATIONAL HOMOGENIZATION FOR MULTISCALE CRACK MODELLING

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ABSTRACT

The concept of the RVE for quasi-brittle softening materials is revisited in which we developed a new averaging technique coined the failure zone averaging scheme. The basic idea of the scheme is to do the averaging over a propagating damaged zone, rather than over the entire fine scale domain. By doing so, we obtained homogenized initially rigid cohesive laws which are independent of fine scale model size which allows us to state that an RVE exists for softening materials when averaging towards a coarse scale cohesive law. From this result, we develop a computational homogenization based multiscale crack framework. The basic ingredients of the method are as follows. The coarse scale model is a homogeneous elastic solid (with effective properties) containing a cohesive crack (modelled by XFEM). The behavior of that cohesive crack is coming from FE computations performed on a fine scale model. In the fine scale model, all heterogeneities are explicitly meshed and failure of microstructural constituents is modelled by a non-local continuum damage model. The coarse-fine scale coupling is done in the spirit of the multilevel FE framework which is better known as FE^2 methods. The method is objective with respect to coarse/fine scale discretizations and to the size of the fine scale sample. Numerical examples are given to demonstrate the performance of the method.

Key words: *Fully coupled multiscale, Computational homogenization, FE^2, Multiscale cohesive law, Representative volume element (RVE), Random heterogeneous quasi-brittle materials*

PLASTIC COLLAPSE MECHANISMS IN THIN DISKS SUBJECT TO THERMO-MECHANICAL LOADING

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ABSTRACT

A new solution for plastic collapse of a thin annular disk subject to thermo-mechanical loading is presented. It is assumed that plastic yielding is controlled by Hill's quadratic orthotropic yield criterion. A distinguished feature of the boundary value problem considered is that there are two loading parameters. One of these parameters is temperature and the other is pressure over the inner radius of the disk. The general qualitative structure of the solution at plastic collapse is discussed in detail. It is shown that two different plastic collapse mechanisms are possible. One of these mechanisms is characterized by strain localization at the inner radius of the disk. The entire disk becomes plastic according to the other collapse mechanism. In addition, two special regimes of plastic collapse are identified. According to one of these regimes, plastic collapse occurs when the entire disk is elastic except its inner radius. According to the other regime, the entire disk becomes plastic at the same values of the loading parameters at which plastic yielding starts to develop.

Key words: *Thin disks, Plastic collapse, Plastic anisotropy, Thermo-mechanical loading, Qualitative features of solution*

HOMOGENIZATION TOWARDS A GRADIENT PLASTICITY MODEL – FROM MESO TO MACRO

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ABSTRACT

The macroscopic inelastic response of polycrystalline materials is strongly influenced by heterogeneities in the microscopic plastic slip. A well-known phenomenon is the Hall-Petch effect where the yield stress is dependent on the grain size. A second type of size effect is dependent on the specimen size which is caused by the gradients of the plastic strain at the structural scale. Our work aims to study how the size dependent behaviour propagates into the macro level. In the interest of transparency, we limit ourselves to a simple laminar grain structure with symmetric double slip subjected to plane bending. At the fine-scale, we adopt the single crystal plasticity model in [1]. A homogenization theory is proposed to translate this mesoscopic crystal plasticity formulation to a macroscopic one in a thermodynamically consistent manner. In additional to the standard equilibrium condition, a homogenized micro-force balance is obtained. The plane bending problem is solved with the homogenized model where the solutions are shown to match closely with the fine-scale analyses.

Key words: *Homogenization, Gradient plasticity*

A GRADIENT-DAMAGE MODEL FOR VISCOPLASTIC PLATES UNDER IMPULSIVE LOADINGS: EXPERIMENTAL AND COMPUTATIONAL ASPECTS

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ABSTRACT

In this paper, vibrations of viscoplastic plates under impulsive loadings are investigated both experimentally and numerically. Firstly, techniques for short-time measurements, which are applied to shock tubes to record rapid loading processes and plate deformations, are presented. A gradient-damage model for dynamic finite element computation is then proposed and validated by using the global displacement-force curves obtained from the shock-tube tests on plate specimens. To take void nucleation and growth into account, the gradient regularization and the difference between non-local and local damage fields are considered by enhancing the free energy function, which includes a non-local damage variable and its gradients on the mid surface of shell structures. The performance of the proposed model is demonstrated through numerical results, which match well with experimental ones.

Key words: *Gradient-enhanced, Damage, Viscoplasticity, Shells, Shock-waves*

MULTI-SCALE MODEL TO PREDICT THE BALLISTIC IMPACT BEHAVIOUR OF MULTI-LAYER PLAIN-WOVEN FABRICS

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ABSTRACT

This paper presents a multi-scale model that can predict the ballistic impact behaviour of multi-layer plain-woven fabrics using the finite element method. Multi-layer fabrics of 30.5×30.5 cm, woven by high performance yarns Kevlar® 29 3000 denier, are impacted by a 0.3 FSP projectile (Fragment Simulating Projectile). Using a multi-scale approach, behavior of multi-layer fabrics subjected to different impact velocities is numerically analyzed. Ballistic limit of the fabric can also be predicted. The multi-scale model shows an effective gain of computation time in comparison with current mesoscopic ones. Computational results show a good agreement with experimental data.

Key words: *FEM, Multi-scale modelling, Impact behaviour, Textile fabric, Failure, Boundary conditions*

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RICH TOMOGRAPHY TECHNIQUES FOR THE ANALYSIS OF MICROSTRUCTURE AND DEFORMATION

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ABSTRACT

Until very recently, the three-dimensionality of the material world presented numerous challenges in terms of characterisation, data handling, visualisation, and modelling. For this reason, 2D representation of sections, projections or surfaces remained the mainstay of most popular imaging techniques, such as optical and electron microscopy, and X-ray radiography. However, the advent of faster computers with greater memory capacity ensured that large 3D matrices can now not only be stored and manipulated efficiently, but also that advanced algorithms such as Algebraic Reconstruction Techniques (ART) can be used to interpret redundant datasets containing multiple projections or averages across the object obtained by some suitable analytical measurement technique. These tools open up unprecedented opportunities for numerical simulation. Model formulation can be accomplished semi-automatically on the basis of microstructurally-informed 3D imaging, while model validation can be achieved by direct comparison of 3D maps of complex quantities, such as displacement vectors or strain tensor components. In this paper we review several modalities of what can be referred to as “rich” tomography: strain tomography in the bulk of a load bearing structural component; Laue orientation tomography for non-destructive mapping of grain orientation within a polycrystal, and the use of sequences of tomographic reconstructions for Digital Volume Correlation (DVC) analysis of *in situ* deformation.

Key words: *Rich tomography, Laue orientation tomography, Strain tomography, Digital Volume Correlation*

PHENOMENOLOGICAL AND MICROMECHANICAL MODELS FOR HIGH TEMPERATURE CREEP OF SINGLE CRYSTAL SUPERALLOYS

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ABSTRACT

This work presents two finite element models for high temperature creep of single crystal superalloys. Firstly, a nonlocal damage-viscoplastic model, which is based on a variational formulation consisting of free energy and dissipation potentials for plasticity and damage, is developed. From the minimum principle for dissipation potentials [1, 2], evolution equations for internal variables are derived to characterize phenomenologically three stages of creep. Furthermore, experimental observations indicate that the microstructure being composed of gamma and gamma prime phases evolves during high temperature creep. Therefore, the microstructure evolution is included in the second model by adding a diffusive dissipation potential to the variational formulation. Herein, microstructure of two phases can be treated as rank-two laminates. Both models are capable of describing different creep regimes in a unified way and will allow prediction on dislocation motion. Some numerical examples are compared with experimental data to illustrate the performance of both models.

Key words: *Creep, Dissipation, Damage, Nonlocal, Viscoplasticity, Coarsening*

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FROM DIFFUSE TO LOCALISED DAMAGE: THE ROLE OF FRICTION

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ABSTRACT

The importance of accounting for all major dissipative mechanisms in modelling failure process of quasi-brittle materials is addressed in this paper. This macro scale process may consist of several different underlying dissipative mechanisms at lower scales, the dominant of which is the creation of surface areas, followed by frictional loss between the new surfaces. Of particular interest in this paper is how the choice of constitutive models, all possessing same macro stress-strain response but having different contributions from different dissipative mechanisms, can affect the transition from diffuse to localised damage. For this purpose, we develop a model featuring coupling between two major failure mechanisms in quasi-brittle failure: the creation of new surface areas (e.g. micro-cracking), and frictional loss (e.g. friction between crack surfaces). Analysis of experimental measurement by Bažant shows that, the latter, even in mode I fracture, seems to be the dominant dissipative mechanism and can be evidenced at the structural scales through the experimentally observed residual deformations. Our model possesses a novel link between the observable partition of fracture energy and the parameter that controls the coupling between damage (representing micro-cracking) and plasticity (representing friction). Therefore the frictional contribution to the failure process can be varied, while keeping the macroscopic stress-strain response unchanged. On this basis, a series of parametric studies is carried out to explore the effects of friction on the transition from diffuse to localised damage. It is found that neglecting frictional dissipation leads to the over-prediction of both the magnitude and the spreading of damage, which could impact the simulation of other processes (e.g. fluid transport) directly affected by the mechanical failure process.

Key words: *Fracture energy, Frictional loss, Damage, Plasticity, Constitutive modelling*

A STUDY ON STRESS CONCENTRATION EFFECT IN RAPID EVALUATION OF FATIGUE LIMIT BY NUMERICAL ANALYSIS

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ABSTRACT

The technique for rapid evaluation of fatigue limit using infrared thermography has been developed and paid much attention recently. However, the enhancement of reliability of this technique is demanded for practical application in industries. This study is conducted to verify the effect of stress concentration on fatigue limit evaluation through numerical simulation. Temperature evolutions of stainless steel specimens with different notches are simulated by 3D elasto-plastic finite element analysis. It has been shown that the fatigue limit evaluation based on the temperature evolution is essentially explained by plastic energy dissipation, and that the temperature evolution should be measured after a sufficiently large number of cycles so that plastic shakedown is achieved. It has been remarked that the fatigue limit is overestimated if the spatial resolution of infrared thermography is not fine enough to measure the temperature evolution at the stress concentration site.

Key words: *Fatigue limit, Energy dissipation, Stress concentration, Infrared thermography, Finite element analysis*

REPRESENTATIVE VOLUME ELEMENT FOR PLATES WITH RANDOM MICROSTRUCTURES

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ABSTRACT

Using the Green's operator for a periodic medium with fraction-free boundary conditions proposed by authors (see [1,2]), this paper aims to estimate the minimum size of the Representative Volume Element (REV) for a random plate. The microstructure of the plate is randomly generated first with identical hexagons. The Monte-Carlo method is then introduced to estimate the ensemble average of the effective properties of the plate for many independent realizations on each volume size. The minimum size of the representative volume element will finally be derived from a required precision on the mean value and variance of the homogenized stiffnesses of the plate.

Key words: *Representative volume element, Homogenization, Heterogeneous plates*

ULTIMATE STRENGTH ANALYSIS OF STEEL PLATES USING ISO/DIS 1872-2 AND ULSAP

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ABSTRACT

Ultimate limit states (or ultimate strength) have been assessed that is the much better basis than the allowable working stresses. Today, we design and strength assessment the structural types such as aerospace structures, offshore platforms, ships and land-based structures following the ISO STANDARD.

Aim of this paper is to perform benchmark calculation in order to validating formulas of ISO Standard [1]. An effective approach for plate, using the ISO/DIS 1872-2 standard [1] and ULSAP (Mestro software) [2], are calculated in the current research for studying the ultimate strength problems of plates with six load cases: longitudinal compression, transverse compression, biaxial compression with/without lateral pressure.

The trends of ISO Standard results in some cases agree well to the Maestro results. Other cases are not similar. The values of ISO results were found smaller than Maestro results. For this reason, the ISO results are not more conservative than ULSAP results.

Key words: *Ultimate limit states (ULS), Ultimate strength, Plate structures, Combined biaxial compression and lateral, Pressure loads*

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MATCHING ASYMPTOTIC METHOD AND NUCLEATION OF A DEFECT AT A NOTCH

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ABSTRACT

In the present study, we use matching asymptotic expansion to treat the elastic problem associated with a small defect located at the tip of a notch. The use of such asymptotic methods is necessary because the presence both of small parameters and singularities leads to inaccurate computations by classical finite element methods. The method is applied here in an antiplane setting.

Key words: *Brittle fracture*, *Cohesive model*, *Asymptotic methods*, *Singularities*

NEW METHODS IN FATIGUE OF STRUCTURES

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ABSTRACT

Combining the application of the shakedown theory and a multiscale approach to analysis of fatigue allows interpreting all types of fatigue problems in an efficient manner. The description of the stabilized mechanical state after shakedown at the engineering macroscopic scale and at the mesoscopic scale of grains gives access to the engineering values which will drive the fatigue damage of the structure. The evolution of stress and strain tensors thus obtained for a cycle of fatigue allows predicting the fatigue strength of structures. At high cycle fatigue, when elastic shakedown takes place, the fatigue strength can be described by a simple combination of mesoscopic shear amplitude and hydrostatic tension at any point of the calculated structure, irrespective of the complexity of the structure and the loading. Two new developments incorporating spectral or modal approaches allow analyzing the fatigue resistance of structures undergoing vibrations in a very efficient manner. At low cycle fatigue, from the stabilized state of stress and strain, the fatigue strength is derived from a combination of the inelastic strain energy and the hydrostatic pressure. Numerous examples of fatigue analysis are presented.

Key words: *Multiaxial fatigue, Shakedown, Multiscale approach, High cycle fatigue, Vibratory fatigue, Spectral approach, Modal approach, Fatigue of welded structures, Thermomechanical fatigue, Low cycle fatigue*

ON THE RATE BOUNDARY VALUE PROBLEM FOR DAMAGE MODELIZATION BY THICK LEVEL-SET

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ABSTRACT

In total damage the rupture occurs on a moving surface along which strong discontinuities of displacement gradient are localized. A damage modelisation is proposed based on a continuous transition from undamaged to damaged material. In this new framework, the evolution of damage is associated with a moving layer of finite length l_c. With this description, initiation and propagation of damage can be unified in the same constitutive law. Using a normality law based on the driving force associated with the motion of the layer, the solution of the rate boundary value problem of propagation and displacement satisfies a variational inequality. Characterization of uniqueness is then given.

Key words: *Damage, Level-set, Moving surface, Moving layer, XFEM*

EVALUATION OF STRAIN ENERGY BASED DAMAGE INDICES FOR FLEXURAL CRACK DETECTION OF RC BEAMS

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ABSTRACT

Vibration Based Damage Identification Techniques which use modal data or their functions, have received significant research interest in recent years due to their ability to detect damage in structures and hence contribute towards the safety of the structures. In this context, Strain Energy based Damage Indices (SEDIs), based on modal strain energy, have been successful in localising damage in structures made of homogeneous materials such as steel. However, their application to reinforced concrete (RC) structures needs further investigation due to the significant difference in the prominent damage type, the flexural crack. The work reported in this paper is an integral part of a comprehensive research program to develop and apply effective strain energy based damage indices to assess damage in reinforced concrete flexural members. This research program established (i) a suitable flexural crack simulation technique, (ii) four improved SEDIs and (iii) programmable sequential steps to minimise effects of noise. This paper evaluates and ranks the four newly developed SEDIs and existing seven SEDIs for their ability to detect and localise flexural cracks in RC beams. Based on the results of the evaluations, it recommends the SEDIs for use with single and multiple vibration modes.

Key words: *Strain energy, Damage index, Damage localization, Flexural cracks, RC beam, False alarms*

A RECENT EULERIAN-LAGRANGIAN CFD METHODOLOGY FOR MODELLING DIRECT INJECTION DIESEL SPRAYS

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ABSTRACT

The global objective of this work is to show the capabilities of the Eulerian-Lagrangian Spray Atomization (ELSA) model for the simulation of Diesel sprays in cold starting conditions. Our main topic is to focus in the analysis of spray formation and its evolution at low temperature 255K (-18°C) and non-evaporative conditions. Spray behaviour and several macroscopic properties, included the liquid spray penetration, and cone angle are also characterized. This study has been carried out using different ambient temperature and chamber pressure conditions. Additionally, the variations of several technical quantities, as the area coefficient and effective diameter are also studied. The results are compared with the latest experimental results in this field obtained in our institute. In the meantime, we also compare with the normal ambient temperature at 298 K (25°C) where the numerical validation of the model has shown a good agreement.

Key words: *CFD, ELSA, Eulerian, Lagrangian, Diesel spray, Non-evaporating, Atomization.*

EFFECTS OF SEDIMENTS AND ICEBERGS ON TSUNAMIS

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ABSTRACT

The effects of oceanic sediments and iceberg or ice water on tsunamis have been investigated by using the recently developed expressions of the dynamic water mass and dynamic water height. Oceanic sediments and icebergs tend to increase the vertical tsunami waves compared to that of the normal sea water without sediments or icebergs. Other effects of many different soil or rock layers, air bubbles, solids and frequency on tsunamis are also considered in the analyses. Dynamic equivalent factors are proposed and defined as the ratio the dynamic soil or rock thickness to the dynamic water height, also between the dynamic rock height and dynamic soil height; based on the dynamic soil mass, dynamic rock mass and dynamic water mass. Particular attention is given to the analysis of the 2004 Indian Ocean Tsunami.

Key words: *Tsunami, Sediment, Iceberg, Frequency, Bulk modulus, Mass density, Dynamic water mass, Poisson's ratio*

CFD AERODYNAMIC ANALYSIS OF 5MW WIND TURBINE CONSIDERING WIND SHEAR AND YAW ERROR

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ABSTRACT

The power curve of a wind turbine depends upon a large number of meteorological parameters such as wind shear, turbulence and inclined airflow. Because of inclined airflow, the flowfield around the rotor blade of a 5MW horizontal axis wind turbine (HAWT) becomes more complex than axial flow conditions as a consequence of the azimuthal variation in the relative velocity between the blade section and fluid. The skewed wake generated from blade tips leads to instability inflow through the rotor and interaction between the blade and wake appears under certain condition. This causes strong turbulence and unsteady interactions in the flow past the rotor and tends to decrease the power curve. The present study deals with the aerodynamic performance of a large utility-scale NREL 5MW horizontal axis wind turbine considering the wind shear profile and yaw error. The Reynolds Average Navier-Stokes equation with shear-stress transport (SST) k-ω turbulence model was used to simulate the aerodynamic performance of this wind turbine. The results presented herein show good agreement with previous computations results. Additionally, it is clearly seen that the inclined in-flow has a significant effect on the aerodynamic performance of huge wind turbine.

Key words: *NREL 5MW wind turbine, CFD, Wind shear effect, Yaw angle*

CALCULATION OF LONGSHORE SEDIMENT TRANSPORT IN THE SWASH ZONE WITH APPLICATION TO SHORELINE CHANGE MODELING

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ABSTRACT

A modified formula for the longshore sediment transport (LST) rate in the swash zone was proposed based on the sediment transport equation developed by Watanabe et al. (1991). The new formula was validated against experimental data carried out in the Large-scale Sediment Transport Facility. This formula was then included in the one-line model of shoreline change to describe the total LST rate, including the swash zone and surf zone. The model simulations were validated against annual net longshore transport rates reported in the literature and measured shorelines at Long Island coast, United States. Overall, the model simulations were in good agreement with the measurements.

Key words: *Swash zone, Wave runup, Sediment transport, Numerical model, Longshore transport, Shoreline change*

BLAST LOADED STIFFENED ORTHOTROPIC CONCRETE PLATES

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ABSTRACT

This study is concerned with the numerical study of a semi rigid orthotropic stiffened concrete plate subjected to a localized blast load. The aim of this research is to determine the dynamic response of the orthotropic plate with different stiffeners configurations, thickness of the plate, and time duration of the blast load. Numerical solutions for the natural frequencies and mode shapes are obtained by using the Modified Bolotin Method (MBM). Number of modes of the orthotropic plate are real numbers and solved from transcendental equations. Special emphasis is focused on the dynamic deflection of mid-point displacements. The results obtained give an insight into the effect of the stiffeners configurations and the time duration of the blast load on the dynamic response of the orthotropic plate and indicate that stiffeners configurations and time duration affect their overall behaviour.

Key words: *Blast load, Stiffener configuration, Modified Bolotin Method, Transcendental equations*

FINITE ELEMENT MODELING OF A MAGNETORHEOLOGICAL BRAKE CONSIDERING HYSTERESIS

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ABSTRACT

This paper proposes an approach to modelling a magneto-rheological (MR) brake considering hysteresis with the aid of finite element method (FEM). In order to obtain the braking torque, which depends on the yield stress of MR fluid, a magnetic intensity, which affects to the variation of this yield stress, needs to be obtained. Subsequently, the governing equation for magnetic potential is developed from which the solution of magnetic intensity can be determined. This equation is a Poisson type and unlikely solved by analytical methods due to the complexity of the geometry of the MR brake. Therefore, FEM is used to solve it numerically. Moreover, in discretized magnetic elements, the effect of hysteresis and nonlinearity of materials composing the device is considered. In order to capture this hysteresis, a classical Prandtl-Ishlinskii (PI) model is adopted. Simulation result is then demonstrated and compared with the one obtained from commercial software to show the effectiveness of the proposed approach.

Key words: *FEM, MR fluid, MR brake, Hysteresis, Classical Prandtl-Ishlinskii, Hysteresis model*

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DESIGN OF A FLOW-MODE MAGNETO-RHEOLOGICAL SUSPENSION SYSTEM FOR WASHING MACHINES

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ABSTRACT

This research work focuses on optimal design of a flow-mode magneto-rheological (MR) damper that can replace the conventional passive damper for a washing machine. Firstly, rigid mode vibration of the washing machine due to an unbalanced mass is analyzed and an optimal positioning of the suppression system for the washing machine is considered. An MR damper configuration for the washer is then proposed considering available space for the system.

Damping force of the MR damper is derived based on Bingham rheological behavior of the MR fluid. An optimal design problem for the proposed MR brake is then constructed. The optimization is to minimize the damping coefficient of MR damper while the maximum value of damping force is kept being greater than a required value. An optimization procedure based on finite element analysis integrated with an optimization tool is employed to obtain optimal geometric dimensions of the MR damper. Optimal solution of the MR damper is then presented with remarkable discussions.

Key words: *Magneto-rheological, MR damper, Washing machine, Vibration control*

A STATIC CONDENSATION REDUCED BASIS ELEMENT APPROXIMATION: APPLICATION TO THREE-DIMENSIONAL ACOUSTIC MUFFLER ANALYSIS

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ABSTRACT

We apply the static condensation reduced basis element (scRBE) method to treat the class of parametrized complex Helmholtz partial differential equation. We construct a set of components of interoperable parametrized reference components in a Library to model a family of target models relevant to acoustic devices. The components in the Library are built upon the scRBE method by using RB formulation, and are compatible to each other by a set of common interfaces, or port. We apply an Offline-Online computational strategy to achieve rapid and accurate prediction of any parametric systems formed from a set of components in a Library. We demonstrate that the approach can handle large scale models with many parameters and/or topology variations efficiency in several numerical examples. We show that significant computational savings can be obtained by the scRBE method.

Key words: *Reduced basis element, A Posteriori error estimation, Acoustics, Domain decomposition*

VERTICAL AND HORIZONTAL DYNAMIC ATTENUATION COEFFICIENTS IN OCEAN WAVES BY DYNAMIC WATER HEIGHTS

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ABSTRACT

Vertical and horizontal dynamic attenuation coefficients in oceans based on dynamic water heights increase with the increase in frequency of wave propagation and the square root of mass density of solid-air-water (SAW) mixture, and with the decrease in the square root of bulk modulus of the solid-air-water (SAW) mixture. The ratio of the vertical and horizontal attenuation coefficients only depends on the Poisson's ratio of the solid-air-water mixture.

The percentage of air bubbles in the solid-air-water (SAW) mixtures could substantially affect dynamic attenuation coefficients through many parameters, such as the bulk modulus, mass density and Poisson's ratio of the solid-air-water (SAW) mixtures. Especially, the increase in the percentage of air bubbles could tremendously reduce tsunami heights in the low ranges of the percentage of air bubbles of the solid-air-water (SAW) mixtures. Parametric studies of the effects of some parameters on the dynamic attenuation coefficients are also carried out.

The comparison between the dynamic attenuation coefficients for oceans and those for soils, which are derived from the dynamic soil masses and from other findings, are considered in detail. In general, the dynamic attenuation coefficients for soils caused by any kind of vibrations or earthquakes normally depend on the frequency, shear modulus, mass density and Poisson's ratio of soils.

Key words: *Attenuation coefficient, Ocean wave, Frequency, Bulk modulus, Mass density, Dynamic water height, Dynamic soil mass*

COMPUTATIONS OF COMPOUND CAPILLARY JETS

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ABSTRACT

In this paper, we present numerical calculations of formation and breakup of an axisymmetric, laminar compound jet in a co-flowing outer fluid. We use a front-tracking/finite difference method to track the unsteady motion of the compound jet and its breakup. We focus here on the breakup modes of the compound jet, dripping and jetting, in response to the velocity ratios, U_{21} and U_{31}, and the interfacial tension ratio. Dripping produces drops close to the nozzle exit whereas jetting pushes the breakup point to a position far downstream. Increasing U_{21} results in thinning the inner jet and strengthening the outer jet, and thus promotes jetting. In contrast, increasing U_{31} thins the outer jet, and thus, when the inner jet is dripping, the outer jet can break up into drops in two modes: jetting for forming simple drops and dripping for forming compound drops. Continuously increasing U_{31} results in thinning both inner and outer jets, and thus produces small compound drops in the jetting mode. In addition, starting from dripping, a decrease in the interfacial tension ratio of the outer to inner interfaces results in the mixed dripping-jetting and jetting modes.

Key words: *Compound jet, Compound drop, Breakup mode, Front-tracking*

COUPLED ATOMISTIC-CONTINUUM SIMULATION OF LATTICE DYNAMIC FRACTURE BASED ON EXTENDED SPACE-TIME FEM

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ABSTRACT

A space-time finite element method employing discontinuous Galerkin approach for the simulations of dynamic lattice fracture is presented. The developed approach is motivated by the needs to understand the mechanics and physics that are governed by mechanisms that take place over multiple spatial and temporal scales. The space-time weak form is first developed for atomistic system with a coarse-grained material model. The regular space-time shape function basis is augmented with enrichment function based on the problem physics by exploiting the concept of partition of unity. With the proper selection of the enrichment function, fine scale physics such as phonons and fractures can be represented in the much coarser continuum simulation in both the spatial and temporal scales. The fine and coarse scale simulations can employ different time steps; the unconditional stability of the method makes selection of a large time step possible. Coupling between the fine and coarse scale simulation is achieved with the introduction of a projection operator and bridging scale treatment [1-2]. After an outline of the framework, we show that the proposed method not only leads to a reflectionless boundary condition at the continuum/atomistic interface but also results in accurate representations of momentum and energy [3-4] in the simulation of lattice fracture.

Key words: *Lattice Fracture, Continuum/Atomistic Interface, Enrichment, Space-time FEM*

DYNAMIC WATER STIFFNESS, DYNAMIC WATER DAMPING AND DYNAMIC WATER MASS FOR SHIP-WATER-INTERACTION ANALYSES

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ABSTRACT

Expressions of the dynamic water stiffness, dynamic water damping and dynamic water mass, which have been theoretically developed for vertical, horizontal, rocking and torsional vibrations based on the recent developments of expressions of new dynamic soil stiffness, dynamic soil damping, and dynamic soil mass, depends on the frequency of ship vibration, bulk modulus and mass density of ocean water. Total dynamic mass of the ship-water system for ship-water-interaction analyses is equal to the ship mass minus the sum of the buoyant mass and dynamic water mass. Dynamic water stiffness increases with the increase in the frequency of the ship vibration, while the dynamic water damping decreases with the increase in the frequency of ship vibration, as expected; and the vertical and horizontal water-spring constants have also been developed.

Expressions of the amplitude magnification of the ship during vibration and the maximum magnitudes of vibration for vertical and horizontal vibrations are also discussed in detail.

Key words: *Dynamic Stiffness, Damping, Water mass, Ship, Magnification, Frequency, Bulk modulus, Mass density, Embedment.*

MODEL ORDER REDUCTION FOR BAYESIAN APPROACH TO INVERSE PROBLEMS

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ABSTRACT

This work presents an approach to solve inverse problems in the application of water quality management in reservoir systems. These applications such as contaminant cleanup etc. are challenging because they require large computational efforts and storage requirements for identifying the contaminant location and its distribution. In addition, the real-time systems may contain some uncertain parameters such as wind velocity and these uncertainties must be accounted for in the inverse problems. The approach is developed that uses the combination of a reduced-order model and a Bayesian inference approach to rapidly determine contaminant locations given sparse measurements of contaminant concentration. The system is modelled by the coupling of Navier-Stokes equations and convection-diffusion transport equations. The Galerkin finite element method provides an approximate numerical solution – the "full model" which cannot be solved in real-time. The proper orthogonal decomposition (POD) and Galerkin projection technique are applied to obtain a reduced-order model that approximates the full model. Bayesian formulation of the inverse problem is solved using Markov chain Monte Carlo (MCMC) method for a variety of source locations in the domain. Numerical results show that Bayesian formulation of the inverse problem provides the realization of probability density of source location. Applying the reduced model to the inverse source problem yields a speed-up in computational time with a factor of about 32 with acceptable accuracy in comparison with the full model. Application of the inverse problems strategy shows the potential effectiveness of this computational modeling approach for managing water quality.

Key words: *Bayesian, Convection-diffusion equation, Navier-Stokes equations, MCMC, Inverse problem, POD, Reduced-order model*

ESTABLISHMENT OF METHODOLOGY FOR DETERMINATION OF THE STRENGTH CONDITION OF FIXED OFFSHORE JACKET STRUCTURES IN DEEPWATER BASING ON PROBABILISTIC MODEL AND RELIABILITY THEORY, AND ITS APPLICATION IN VIETNAMESE SEA CONDITION

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ABSTRACT

Exploitation of oil and gas fields in deepwater is being tendency worldwide. It requires to install production platforms with high safety in the most unfavorable conditions. This has encouraged a new approach describing the environmental actions by statistical modelling, then establishment of the appropriate methods for structural analysis and design of deepwater platforms, from fixed jacket to anchored floating platforms.

In the framework of this paper, authors present the methodology expressing the strength condition by a probabilistic model for estimate of the safety based on reliability theory, in order to analyse fixed platform jacket structure in deepwater aimed to be apply in Vietnam sea conditions from 200 to 400 m depth.

The paper content is developed from authors' research results in the National research Project KC.09.15/06-10.

Key words: *Strength condition, Fixed offshore jacket structures, Deepwater, Probabilistic model*

ANALYSIS OF SHELL STRUCTURES BY A CELL-BASED SMOOTHED DISCRETE SHEAR GAP METHOD USING TRIANGULAR ELEMENTS

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ABSTRACT

The cell-based strain smoothing technique is combined with the discrete shear gap method (DSG3) using three-node triangular elements to give a so-called cell-based smoothed discrete shear gap method (CS-DSG3) for static and free vibration analyses of Reissner-Mindlin shells. In the process of formulating the system stiffness matrix of the CS-DSG3, each triangular element will be divided into three sub-triangles, and in each sub-triangle, the stabilized DSG3 is used to compute the strains and to avoid the transverse shear locking. Then the strain smoothing technique on whole the triangular element is used to smooth the strains on these three sub-triangles. The CS-DSG3 hence not only overcomes the drawback of the DSG3 which depends on the sequence of node numbers of elements, but also improve the accuracy as well as the stability of the DSG3. The numerical examples demonstrated that the CS-DSG3 is free of shear locking and achieves the high accuracy compared to others existing shell elements.

Key words: *Reissner-Mindlin shell, Shear locking, Cell-based smoothed discrete shear gap technique (CS-DSG3), Smoothed finite element method, Strain smoothing technique*

AN ANALYSIS OF ECCENTRICALLY STIFFENED PLATES BY CS-DSG3 USING TRIANGULAR ELEMENTS

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ABSTRACT

The paper presents the numerical analyses of eccentrically stiffened plates by the cell-based smoothed discrete shear gap method (CS-DSG3) using triangular elements. In this method, the original plate element CS-DSG3 is combined with a membrane element and stiffened by a thick beam element. The eccentricity between the plate and the beam is included in the formulation of the beam. Some numerical examples are provided to validate the reliability of the present method.

Key words: *Eccentrically stiffened plate, Finite element method (FEM), Cell-based smoothed discrete shear gap method (CS-DSG3)*

ANALYSIS OF HIGH-SPEED RAIL ACCOUNTING FOR JUMPING WHEEL PHENOMENON

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ABSTRACT

In this paper, a computational study using the moving element method (MEM) was carried out to investigate the dynamic response of a high-speed train-track system. The effect of the 'jumping wheel' phenomenon, which occurs when there is a momentary loss of contact between the wheel and track, will be investigated. The dynamic response of a train travelling across a transition region where there is a sudden change in foundation stiffness and its effect on the jumping wheel phenomenon are also investigated. Parametric study is performed to understand the effect of various factors on the response of the train-track system such as the degree of change of foundation stiffness, travelling velocity of the train and the severity of railhead roughness.

Key words: *Moving element method, Track transition, Wheel-rail interaction, Track irregularity*

HYBRID FREQUENCY-TIME DOMAIN MODEL FOR COUPLED SLOSHING-FLOATING TANK MOTION PROBLEM

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ABSTRACT

A hybrid frequency-time domain simulation scheme is used to analyze the dynamic response of sea-wave-induced fully non-linear sloshing fluid in a floating tank. During simulation time, the sloshing model is coupled with the floating tank model so that the interaction between the non-linear sloshing fluid and floating rectangular tank motions arising from wave-induced forces is considered. The tank is assumed to be a rigid body floating on the sea and a time domain model based on frequency domain data is built upon the Cummins equation [1]. State-space models are proposed as approximate representations of the convolutions in this equation. Navier-Stokes equations are applied to model the nonlinear fluid sloshing in the tank and are solved using the finite difference method (FDM). The generalized Newton's method is used to compute the fluid pressures iteratively and the volume of fluid method is used to track the non-linear free surface. DIFFRACT [2] is employed as the radiation/diffraction panel program to evaluate hydrodynamic coefficients and incident wave forces. The parametric study is also investigated with different filling levels of the sloshing fluid. The coupling effects of three degree of freedom motion of the tank and fluid oscillation inside the tank are found to be significant and should be included in analysis and design processes of floating tanks. The numerical model presented in this paper is expected to be useful for further studies in investigating coupled sloshing-ship motion problems.

Key words: *Liquid sloshing, Floating tank, Navier–Stokes equations, VOF method, Finite Difference, Cummins equation, State-space model, Time-domain model*

NUMERICAL SIMULATION OF FULLY NONLINEAR WAVE RADIATION BY SUBMERGED OSCILLATING VERTICAL CYLINDERS

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ABSTRACT

In the numerical model of present analysis, the higher-order boundary element method is used to solve the mixed boundary value problem based on an Eulerian description at each time step. The 4th order Runge–Kutta scheme is adopted to update the free water surface boundary conditions expressed in a Lagrangian formulation. Following completion of the numerical model, the problems of radiation (heave) of water waves by a submerged sphere in finite depth are simulated and the computed results are verified against published numerical results in order to ensure the effectiveness of the model. The validated numerical model is then used to simulate the nonlinear wave radiation by a fully submerged vertical circular cylinder undergoing various forced sinusoidal motion in otherwise still condition. Numerical results are obtained for a series of wave radiation problems; the completely submerged cylinder is placed in surge, heave and combined surge-heave motion with different drafts, amplitudes and frequencies. The corresponding numerical results of cylinder motions, wave profiles, and hydrodynamic forces are then compared and explained for all the cases.

Key words: *Fully nonlinear, Wave radiation, Boundary element method, Oscillating cylinder, Hydrodynamic force*

PREDICTION OF COLUMN AND COREWALL SHORTENINGS IN HIGH-RISE BUILDINGS USING CEB-FIP90

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ABSTRACT

In high-rise buildings, deformations of key structural members (columns, corewalls…) under the effects of loads, environments, material properties… are significant to the structural performances during and after construction stages. These deformations include elastic strain and inelastic strain (creep and shrinkage). The differential shortening between columns and corewalls can cause distortion of floor flatness, increasing the deformation of beams, claddings, partitions, tubes, operation of the lifts… In addition, it will cause additional bending moments in beams connected columns and adjacent corewalls. For the proper design, these deformations of column and shear wall in high-rise buildings need to be calculated exactly considering aforementioned effects. In this paper, the CEB-FIP90 standard is introduced to study and analysis the elastic and inelastic strain of vertical members in high-rise buildings. The considered factors include: humidity, temperature, time dependent non-linear properties of materials and the construction sequence of the building. The obtained results can be a useful reference document in the design, construction and management of high-rise building project.

Key words: *Elastic & Inelastic Strain, Creep & Shrinkage, Humidity, Temperature, Construction Sequence*

SUGGESTION ON THE CONDITIONS TO ACTIVATE THE CATENARY ACTION IN THE BUILDING FRAMES FURTHER TO AN IMPACT LEADING TO THE LOSS OF A COLUMN

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ABSTRACT

This investigation is done in order to understand the influence of damage to the building structures in some accidental situation or exceptional events, such as the attacks or structural failures. It is dedicated to the investigation of the global behavior of a frame further to the lost of a column, taking account of the redistribution of the internal forces. The answer will show the possibility of finding a way to design the constructions with appropriate robustness, so the structure could keep stable for the rescue or evacuate activities in accidents. The meaning of building robustness is defined by the activation the alternative load paths.

To simulate the exceptional event, the loading sequence is applied to a specific point on the frame to represent its behavior in a given one. In particular, the loading sequence is divided in order to highlight the major response of the frame along the exceptional event. Thus, the development of the alternative load paths within the damaged structure after the event of the loss of a column is investigated.

Based on these results, structural elements, which transfer the load to the foundation, are isolated as key elements of building robustness. These elements reform the alternative load paths. Two possible load paths in the investigated event are described. After that, the influence of the structure's properties on the activation of the catenary actions will also be studied. The quick calculation method is developed to predict the response of the frame after the lost of a column is presented. The method is validated by compare to the numerical simulation results.

Key words: *Progressive collapse, Robustness, Multi-storey building, Loading sequence, Alternative load path, Key elements, Critical conditions, Catenary action*

AEROELASTICITY STABILITY OF A LONG-SPAN SUSPENSION BRIDGE BY MECHANICALLY DRIVEN FLAP

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ABSTRACT

The alternative solution for flutter and buffeting stability of a long suspension bridge will be a passive control using flaps. This method not only enables a lightweight economic stiffening girder without an additional stiffness for aerodynamic stability but also avoid the problems from the malfunctions of control systems and energy supply system of an active control by winglets and flaps. A mechanically control using flaps for increasing flutter speed and decreasing buffeting response of a suspension bridge is numerically studied through a three dimensional bridge model. The result shows that the flutter speed is increased and the buffeting response is decreased through the mechanical drive of the flaps.

Key words: *Flutter, Buffeting, Flap, Passive control, Flutter speed*

MONITORING OF CABLES TENSION USING TWO DIMENSIONAL VIBRATORY ORBITS

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ABSTRACT

Monitoring of cable tension using eigenfrequencies is a common practice. The underlying idea is to use the taut string theory which gives the frequencies of a cable as a function of the tension, the length, and the mass per unit length. In real cables however, the frequencies of the odd modes in the plane of gravity are increased due to the sag. This effect is usually significant only for the first mode. In this paper, after reviewing the effect of sag on the first frequency of a cable, we propose to use two dimensional vibratory orbits as a feature to monitor the tension in the cables. The technique relies on the frequency difference between the first in-plane and the first out-of-plane mode of the cable due to the sag. A software is developed in Matlab-Simulink to model cable non-linear behaviour (such as small sag) couple to other linear structure. The results are compared to Simulink model and a very good agreement is obtained.

Key words: *Cable tension, Vibratory orbit, Eigenfrequencies, Monitoring, Cable sag, Cable-stayed bridge*

STRUCTURAL CONTROL OF BENCHMARK BUILDINGS EQUIPPED WITH VARIABLE STIFFNESS DEVICES AND VISCOUS FLUID DAMPERS

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ABSTRACT

This paper presents benchmark structural control problems for seismically excited nonlinear buildings. Focusing on three typical steel structures, 3-, 9- and 20-story buildings designed for the SAC project for Los Angeles, California, the goal of this study is to evaluate the efficiency of a model building configured with semi-active controlled stiffness devices (S-CSD) and enhanced by passive viscous fluid dampers (P-VFD). Evaluation criteria, control constrains, and control algorithms of variable stiffness devices (including Riccati Optimal Active Control Algorithm - ROAC, Pole Placement Algorithm, Instantaneous Control with Displacement and Velocity Feedback - ICDVF, and Instantaneous Optimal Active Closed-Loop Control Algorithm - IOAC) are presented in this paper for design problems. Control strategies may be either passive, semi-active, or combination thereof (hybrid) to reduce the seismic response of the buildings. A simulation program has been built up (by using MATLAB) and made available to facilitate comparison of the efficiency and merits of the various control strategies. The structural control theory is applied to the benchmark problems to illustrate some of the design challenges in numerical samples.

Key words: *Benchmark problems, Structural control, Semi-active control, Hybrid control*

STOCHASTIC ANALYSIS OF CORIOLIS DYNAMIC VIBRATION ABSORBER BY KARHUNEN LOEVE EXPANSION AND PARTIAL LINEARIZATION TECHNIQUE

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ABSTRACT

Coriolis dynamic vibration absorber is a device working in nonlinear zone. In stochastic analysis of this device, the problem is that the Monte Carlo simulation requires large computation time, while the full equivalent linearization technique is inaccurate to describe the nonlinear behaviour. We present a combination of Karhunen Loeve expansion and partial linearization technique to overcome the disadvantages of two mentioned methods. The numerical demonstration of a ropeway gondola induced by wind load is presented.

Keywords: *Karhunen Loeve expansion, Stochastic linearization, Dynamic vibration absorber*

IMPROVING LONG-SPAN SUSPENSION BRIDGE WIND STABILITY WITH ACTIVE CONTROL WINGLETS

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ABSTRACT

The alternative solution for flutter and buffeting stability of a long suspension bridge will be an active control using winglets. This method enables a lightweight economic stiffening girder without an additional stiffness for aerodynamic stability. A feedback control using winglets for increasing flutter speed and decreasing buffeting response of a suspension bridge is studied numerically through a two dimensional bridge deck model. The result shows that the flutter speed is increased and buffeting response is decreased through the adequate control motions of the winglets. In addition, numerical study is carried out on a 3000m span suspension bridge. The effect for flutter speed increasing is obtained by the control with partially installed winglet.

Key words: *Flutter, Buffeting, Winglet, Active control, Suspension bridge*

A NEW MEASURE OF SIMILARITY BETWEEN TWO TIME DATA IN THE FREQUENCY DOMAIN

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ABSTRACT

As a measure of similarity between two signals, the correlation coefficient and the coherence function are most frequently used. The correlation coefficient is a time domain method and the coherence function is a frequency domain method. The former is easy to calculate, but its accuracy is influenced by many factors such as the signal-to-noise ratio, the length of data and the frequency bandwidth of the data, etc. The latter is less influenced by these factors, but it cannot be used if only a pair of signal is available because the coherence function requires averaging.

To overcome these disadvantages, a new frequency domain measure of similarity is proposed. The method utilises the group delay between two signals and does not require averaging. It also shows better accuracy than the conventional correlation method using a relatively short data, which may well be suitable for a practical application such as a large human-computer interactive touch-screen board.

In this paper, the principle of the proposed method is described analytically and also verified experimentally. The experimental results are very promising that it is not only an alternative measure but may be used as a new standard technique.

Key words: *Correlation coefficient, Group delay, LTM (Location Template Matching), Cross-correlation, Cross-spectral density function, Measure of similarity*

ISOGEOMETRIC ANALYSIS BASED HETEROGENEOUS MULTISCALE METHOD

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ABSTRACT

An efficient approach based on the framework of isogeometric analysis for elliptic homogenization problems is proposed. These problems possess highly oscillating coefficients leading to the extremely expensive cost while using traditional finite element methods. The isogeometric analysis heterogeneous multiscale method (IGA-HMM) investigated in this paper is regarded as a potential candidate for solving such problems. The method utilizes non-uniform rational B-splines (NURBS) as basis functions for both exact geometric representation and analysis. It tremendously facilitates high-order macroscopic discretizations thanks to the flexibility of refinement and degree elevation with an arbitrary continuity level provided by NURBS basis functions. Numerical results show the reliability and efficiency of the proposed method.

Key words: *Isogeometric analysis, NURBS, Multiscale methods, Heterogeneous, Homogenization*

AN APPLICATION OF CONCENTRATION OF LOADS ON A SHIP STRUCTURE USING IN ISOGEOMETRIC ANALYSIS

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ABSTRACT

In ship-design processes, ship modeling needs to be as accurate as possible for the effectiveness in numerical analysis of the performance. The ship modeling is constructed from non-uniform rational B-spline (NURBS) technique with high accuracy of geometry. Recently, the concept of isogeometric analysis (IGA) is approached to integrate the computer aided design (CAD) and finite element analysis. NURBS elements can be translated into many finite element (FEM) packages, which facilitate the numerical analysis across the different design stages. The problem for the concentrated load on a ship structure of NURBS surface is needed to be solved in IGA. The primary objective of our study is to fit the new control points of NURBS surface and the concentrated load from the physical coordinates while ensuring the accuracy of initial geometry.

Key words: *NURBS, Isogeometric analysis, Concentrated load, Initial geometry*

A MIXED NURBS-BASED ISOGEOMETRIC APPROACH FOR INCOMPRESSIBLE MEDIA PROBLEMS

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ABSTRACT

In this paper, we study **u**-*p* mixed formulation relied on NURBS-based Isogeometric approach (IgA) for analysis of some incompressible problems. In mixed method, displacement (velocity) field is approximated using NURBS basis functions with one order higher than that of pressure one. Being different from standard FEM, the IgA allows to increase (or decrease) easily the order and continuous derivative of interpolated functions. As a result, a family of NURBS elements which satisfy the inf-sup condition is presented. Two benchmark problems are provided to validate the excellent performance of the method.

Key words: *NURBS, Isogeometric, Inf-sup, Volumetric locking, Mixed formulation*

ISOGEOMETRIC LIMIT ANALYSIS FOR PLANE STRESS PROBLEMS

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ABSTRACT

In this paper, a novel numerical procedure based on the framework of IsoGeometric Analysis (IGA) in combination with second-order cone programming for limit analysis is presented. The method is based on an upper bound limit with rigid-perfectly plastic material model. In calculation, the high order elements are built from Non-Uniform Rational B-splines (NURBS) for both geometry and field approximation. The discretization problem is transformed into the form of a second-order cone programming problem which can be solved using highly efficient interior-point solvers. Numerical results show the excellent performance of the present method compared with other available methods.

Key words: *Isogeometric analysis, NURBS, Limit analysis, Second-order cone programming*

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LIMIT AND SHAKEDOWN ANALYSIS UNDER UNCERTAINTY

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ABSTRACT

Structural reliability analysis is based on the concept of a limit state function separating failure from safe states of a structure. Upper and lower bound theorems of limit and shakedown analysis are used for a direct definition of the limit state function for failure by plastic collapse or by inadaptation. Shakedown describes an asymptotic and therefore time invariant structural behavior under time variant loading. The limit state function and its gradient are obtained from a mathematical optimization problem. The method is implemented into a general purpose FEM code. Combined with FORM/SORM robust and precise analyses can be performed for structures with high reliability. This approach is particularly effective because the sensitivities which are needed by FORM/SORM are derived from the solution of the deterministic problem.

Key words: *Shakedown, Direct plasticity, FEM, Mathematical programming, Structural reliability, FORM/SORM*

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REDUCED SHAKEDOWN FORMULATION IN PLANE STRESS PROBLEMS

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ABSTRACT

Shakedown theory determines the load limits for structures under variable loads. Our recently-constructed reduced shakedown kinematic formulations are re-examined, with particular expressions constructed for plane stress problems in both cases of Mises and Tresca materials. While the possibilities for numerical implementations of the reduced forms are to be explored, we illustrate the applications of the forms to estimate the nonshakedown loads for a circular hollow disk under variable pressure and temperature fields.

Key words: *Shakedown, Reduced kinematic approach*

FEM BASED SHAKEDOWN ANALYSIS OF HARDENING STRUCTURES

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ABSTRACT

This paper develops a new FEM based upper bound algorithm for limit and shakedown analysis of hardening structures by a direct plastic method. The hardening model is a simple two-surface model of plasticity with a fixed bounding surface. The initial yield surface can translate inside the bounding surface, and it is bounded by one of the two equivalent conditions: (1) it always stays inside the bounding surface, or (2) its centre cannot move outside the back-stress surface.

The algorithm gives an effective tool to analyze the problems with a very high number of degrees of freedom. Our numerical results are very close to the analytical solutions and numerical solutions in literature.

Key words: *Ratchetting, Kinematic hardening, Two-surface plasticity, Shakedown, FEM*

PILE FOUNDATION LAYOUT DESIGN BY USING GA

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ABSTRACT

In pile foundation design problem, the placing of piles under the footing is usually based on experiences and heuristic judgments of practitioners. Frequently, piles are placed at locations such as: corner; intersection; end-way; under a column or wall; and/or predetermined location on a continuous footing layout. The "equal" and "balance" of intervals between piles on the continuous footing layout are intuitively experiences based factors which need to be considered by the designers in placing the piles. These heuristic judgments for piles placing are intended to avoid excessive bending moments acting to the footing of the foundation against vertical loadings from the upper structure. In addition, there is another design factor that also necessary to be considered, i.e. positioning of the centre of gravity of the upper structure and shear centre of the pile foundation. These both centres have to be located as close as possible to reduce the torsional effect under the horizontal loadings during the occurrence of earthquakes. The centre of gravity can be calculated from distribution of the vertical loadings which are transferred from the upper structure to the footing through columns and/or shear walls. Besides, the shear centre can be calculated from the arrangement of piles on the continuous footing layout. In this study, a genetic algorithm (GA) is proposed as a tool for designing layout of piles on a continuous footing of residential house.

Key words: *Pile, Foundation, Layout design, Genetic Algorithm*

MULTIDISCIPLINARY DESIGN OPTIMIZATION OF HELICOPTER ROTOR BLADES

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ABSTRACT

This study developed an integrated framework for aerodynamic, structural design optimization of helicopter rotor blades with consideration of manufacturing cost. A number of codes were developed to perform estimation of helicopter configuration from customer requirements, performance analysis, trim analysis, rotor blades configuration representation. These codes are then integrated with two-dimensional airfoil analysis tool to fully design rotor blades configuration including rotor planform and airfoil shape. A modular structural design methodology was developed for composites rotor blades with sophisticate geometric cross-section. A D-spar cross-sectional structure was chosen as a baseline. All inner configuration including thickness of D-spar, skin, web, number and ply angles of layers of each composite part, materials are parameterized. A parametric CAD model was created in order to transfer configuration data from sizing to manufacturing cost analysis. The integration of three modules constructed a framework where the size of helicopter, aerodynamic performance analysis, structure analysis, and manufacturing cost estimation could be quickly investigated. Sensitive analysis of configuration parameters including outer shape (rotor blades planform, airfoil shape) and inner structure (D-spar, web, skin) specified smooth working of the framework. Therefore, an integrated aerodynamics and structure design optimization of helicopter rotor blades design with consideration of manufacturing factor could be performed at early state of the design. Both outer shape and inner structure of rotor blades could be considered at the same time for optimization purpose.

Key words: *Helicopter design, Rotor blade design, Integration*

FINITE ELEMENT ANALYSIS ON TEMPERATURE DISTRIBUTION OF ETHANE STORAGE TANK CONCRETE FOUNDATION - A CASE STUDY

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ABSTRACT

T-4801 Ethane Storage Tank is one of the large petroleum liquid storage tank located in Maptaphut, Rayong province in Thailand. In December 2010, field inspection of T-4801 Tank has reported that icing and bubbling were observed for the tank and after three weeks, icing was disappeared and bubbling rate was become smaller. The dew condensation was observed at some part of the welding joint between the outer shell wall plate and bottom plate. As for the bottom of the foundation, dewfall was also observed in all peripheral around annular space. Consequently, it is reasonably considered that some low temperature liquid remains in the tank bottom and accordingly the dewfall has been presented at 80 cm thick reinforced concrete foundation which is induced by thermal conduction. This paper presents finite element analysis on the temperature distribution of the Ethane Storage Tank RC foundation as a case study using two commercial finite element packages. Numerical results showed that predicted temperature gradient agreed well with the field measurements. Findings from this study are also highlighted and commented upon.

Key words: *Heat transfer analysis, Finite Element Analysis, FEA, Thermal conductivity*

FIRE RESISTANCE ESTIMATION OF AN EXISTING PRE-STRESSED COMPOSITE FLOOR

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ABSTRACT

This paper presents a performance based approach method to estimate the fire resistance of an existing floor. The slab of an old school (in France) is under investigation for fire resistance according to the new requirement of French standard. Due to the lack of experimental information, this fire-resistance is investigated by numerical simulation. Obtained result is approved by the Center of Science and Technical for Building (CSTB, France) for practice on the construction site.

Key words: *Fire resistance, Fired-clay, Pre-stressed concrete beam, Slab, Gypsum, Mortar coating*

RESEARCH ON SOLUTION TO STRENGTHEN CONCRETE T BEAMS REINFORCED WITH CARBON FIBER REINFORCED POLYMER COMPOSITES

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ABSTRACT

Currently, a number of bridges after a long time to use to put degraded or need to increase bearing capacity. In this paper a solution strengthening resistance of the T-section reinforced concrete beams using carbon fiber reinforced polymer (CFRP). Theoretical model calculations were applied to calculate the enhanced resistance to bending and shearing of the Thua Luu Bridge Hue city and Hoa Xuan Bridge Da Nang city. Results calculated on the actual work has shown a significant increase beam bearing capacity than the previous structure solution using reinforced glued layers by fiber reinforced polymer (FRP).

Key words: *Increase bearing capacity, Enhanced resistance, Bending, Shearing, Layers*

SIMULATION OF SPALLING BEHAVIOUR OF CONCRETE DUE TO REBAR CORROSION USING RBSM

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ABSTRACT

This paper aims to present an application of one of the discrete methods, Rigid-Body-Spring-Model (RBSM), in the structural analysis of concrete structure. The analytical model based on RBSM method, which was developed by the authors, is applied to simulate one of the problems of the durability of concrete structure. The simulation evaluates damage of concrete due to rebar corrosion, which is spalling behavior of the concrete surface of the expressway due to rebar corrosion. The simulation results are compared with the survey data obtained from the maintenance process of the expressway structure. An analytical study is conducted to investigate some factors affecting the spalling behavior of concrete due to rebar corrosion. As a result, the spalling behavior and effects on the spalling of concrete due to rebar corrosion can be understood.

Key words: *Rigid-body-spring-model, Rebar corrosion, Concrete, Spalling, Crack*

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A COMPUTATIONAL METHOD FOR NONLINEAR ANALYSIS OF REINFORCED CONCRETE FRAME ELEMENTS

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ABSTRACT

Reinforced concrete structures exhibit in general a nonlinear behaviour due to the inherent mechanical characteristics of concrete and reinforcement as well as the bond between them. For reinforced concrete frames, the challenge of performing a more realistic analysis increases due to the geometrical nonlinearity including large displacements. This paper introduces a computational method for analysis of such structures focusing on frame elements. The method is a combination of the displacement method, the transfer matrix method and a cross section analysis algorithm. A new numerical model for reinforced concrete structures under repeated loading is also presented.

Key words: *Nonlinear behaviour, Tension stiffening effect, Iterative method, Transfer matrix method, Repeated loading*

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A SIMPLIFIED MODEL TO SIMULATE THE NON LINEAR BEHAVIOUR OF REINFORCED CONCRETE COLUMN

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ABSTRACT

In this paper, a simplified modelling strategy to simulate the non linear behaviour of reinforced concrete structure is presented. The structure is modelled using multifibre beam elements and so the number of degrees of freedom of the problem is reduced. The equations of a multifibre Euler-Bernoulli beam element and its use for modelling the non linear behaviour of reinforced concrete structures are detailed. Comparison with experimental results of a reinforced concrete column submitted to cyclic loading shows the performance of the approach.

Key words: *Damage mechanics, Multifibre beam element, Non linear, Simplified model*

DESIGN OF A PERMANENT STRUCTURAL HEALTH MONITORING SYSTEM ON THE GUADALQUIVIR RAIL BRIDGE BASED ON BASELINE AMBIENT VIBRATION TESTING AND OPTIMAL SENSOR PLACEMENT

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ABSTRACT

Nowadays for important civil structures, a permanent structural health monitoring system is often embedded during or after construction stage. The proper design of such system for existing structures is largely dependent on prior experience. This paper proposes an approach for such a problem by using the results of a preceding dynamic measurement test. This test is carried out in ambient conditions and the modal parameters are identified by the versatile reference-based stochastic subspace system identification method. These results are utilized (i) as baseline data for future monitoring and (ii) to design an efficient monitoring system by an optimal sensor location methodology. The strategy is applied to the Guadalquivir rail bridge in Andalusia, Spain. This study shows that by using identified modal parameters, a realistic sensor location design can be achieved and it immediately reveals the inadequacy if otherwise we were relying on analytical modelling or intuition. This method is very simple to implement and can be applied at a wide scale, e.g. to all existing constructed facilities in a highway section.

Key words: *Ambient vibration test, Optimal sensor, Stochastic subspace identification, Structural health monitoring, Guadalquivir rail bridge*

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HEAT TRANSFER AND STRUCTURAL RESPONSE MODELLING OF CONCRETE FILLED STEEL HOLLOW SECTION COLUMNS

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ABSTRACT

Numerical modelling is a very useful tool to predict the fire resistance of a structure, or to reproduce artificially what has happened during a real fire. SAFIR, a non linear computer code developed at the university of Liege-Belgium, is specifically written for modeling the behavior of structures subjected to fire. It allows a determination of the temperatures in the structure resulting from the fire and, in a subsequent analysis, determination of the successive positions of equilibrium of the structure until collapse. Ten steel hollow section columns filled with self-compacting concrete embedding another steel profile have been tested in the Fire Engineering Laboratory of the University of Liege - Belgium. SAFIR code has been used to simulate the thermal and structural behavior under fire conditions. A good agreement between numerical and experimental results has been obtained. This shows that SAFIR code can predict well the behavior of CFSHS columns subjected to fire.

Keywords: *Numerical modelling, Fire conditions, Steel, Concrete, Composite*

A SIMPLE MODEL FOR CALCULATION OF SUPERSTRUCTURE - SOIL INTERACTION

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ABSTRACT

In this work, a simple model is proposed in order to deal with the interaction between building superstructure and soil via the foundation. Kinematic limit conditions in the vertical direction will be replaced by normal contact conditions between foundations and soil. Differently from classical calculation, internal forces calculated in the superstructure are compatible with soil deformations. The formulation is nonlinear due to nonlinearity of contact condition and of soil characteristics itself. The discrete equilibrium equation is therefore nonlinear which can be solved by Newton-Raphson method.

Keywords: *Contact, Superstructure, Soil, Interaction, Nonlinear*

CRACK IDENTIFICATION IN FUNCTIONALLY GRADED MATERIAL PLATE BY WAVELET ANALYSIS OF VIBRATION MODE

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ABSTRACT

In fracture mechanics, crack identification is an important issue but relatively hard to carry out. When a structure has a crack, the dynamic characteristics of the structure, such as natural frequencies and mode shapes, will be changed. An analysis of these changes will enable to identify the crack. In this paper, a method based on the wavelet analysis of modal vibration data is introduced to detect the cracks in the functionally graded material (FGM) plate. In practice, the modal vibration data which include the natural frequencies and mode shapes of cracked plate are usually defined by measured equipments. However, due to the unavailability of experimental data, numerical analysis with noisy modal data is used for simulation instead. The modal vibration data, which are the free flexural vibrations of cracked FGM plate in this paper, are then used as signal for wavelet analysis to determine the position of the crack. In this research, the two-dimensional wavelet transform is employed in analysis. The numerical results show that the proposed method is not only accurate but also relatively visual.

Key words: *Wavelet analysis, Crack identification, Detection of crack, Functionally graded material (FGM) plate, Vibration mode, XFEM*

AUTHOR INDEX