ACOME 2017

The 2nd International Conference on Advances in Computational Mechanics

02-04 August 2017 | Phu Quoc Island, Vietnam

ABSTRACT COLLECTION

Hosted by: Vacom – Vietnam Association of Computational Mechanics; HUTECH University

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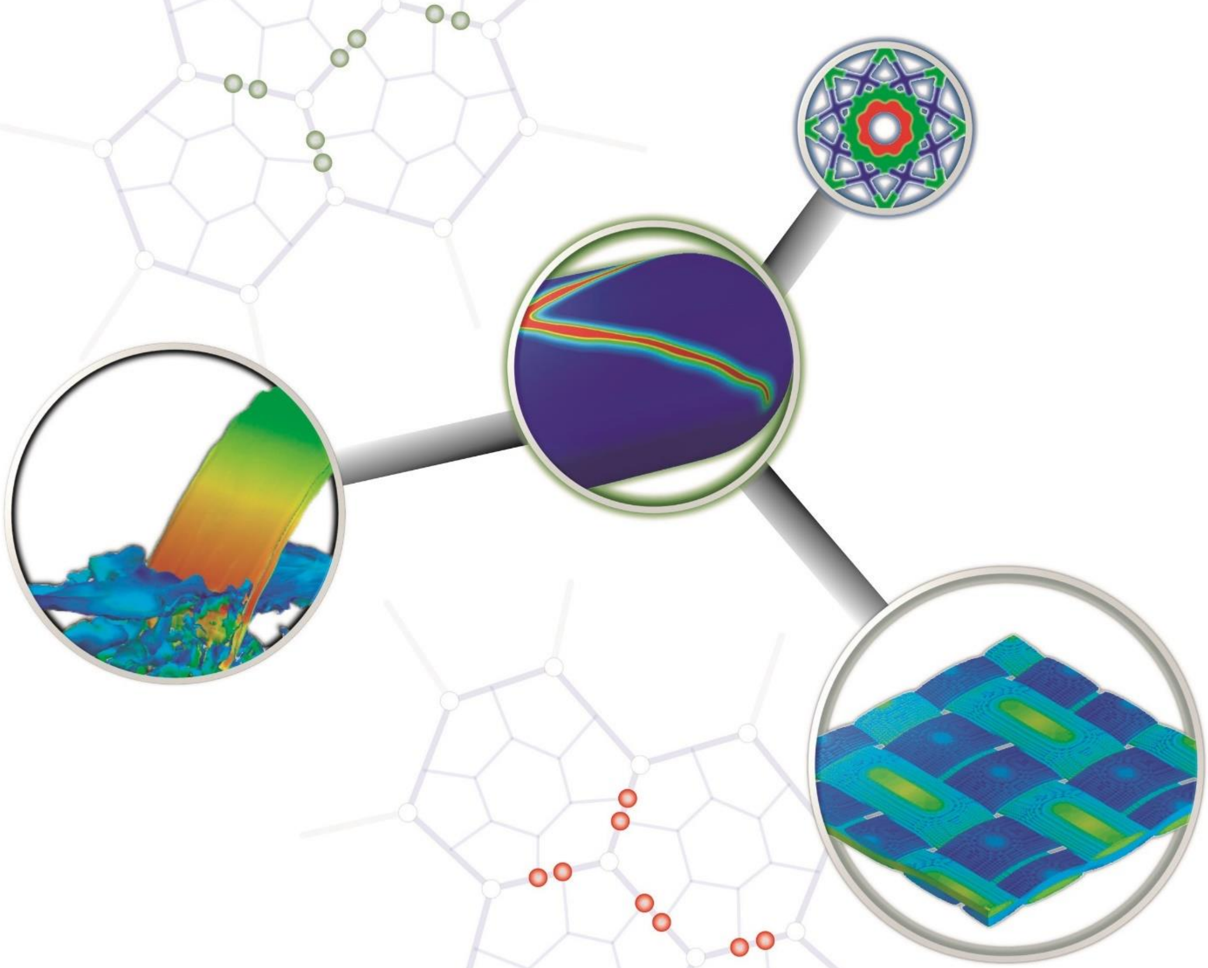

KEYNOTE

LECTURES

COMPUTATIONAL TRANSPORT ONCOPHYSICS

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ABSTRACT

Transport Oncophysics views cancer as a disease of multiscale mass transport deregulation involving biological barriers. According to [1], tissue invasion can be seen as mass transport deregulation at the interface between the cell and the microenvironment; metastasis is a deregulation of local and distant cellular transport at the scale of the organism; tumor-associated angiogenesis completely alters mass and fluid exchange across the microcirculation; alterations in the signaling pathways that accompany the evasion of apoptosis, growth signal dependence and growth inhibitory messages from the immediate environment are also disruptions in molecular transport. Transport aspects control then delivery of therapeutic agents e.g. chemotherapeutics or molecularly targeted therapeutics such as T cells, antibodies for immunotherapy, particles, multistage platforms. Particles and multistage platforms must pass through different and heterogeneous tumor and healthy compartments (e.g. vascular, stroma) with their respective barriers and distinct physical properties. Computational Transport Oncophysics provides the computational tools which, together with imaging, analysis and quantification, will contribute to rationalize the delivery of therapeutic agents and to evaluate their efficiency, forming an oncophysical modeling framework. This framework should comprise a tumor growth model within the local tumor environment, coupled with a patient specific biodistribution model. I concentrate on the tumor growth model and present a very general multiphase flow model in an extracellular matrix (ECM), dealt with as a deforming porous solid which may undergo remodeling; it comprises three fluid phases, i.e. tumor cells (TCs), divided into living and necrotic cells, healthy cells (HCs) and interstitial fluid (IF) [2,3]. The IF transports chemical species such as tumor angiogenic factor (TAF), nutrients and therapeutic agents. Transport of these species within extravascular space takes place by convection and diffusion. Coopted blood vessels are included as line elements with blood flow exchanging nutrients and therapeutic agents with the IF. Angiogenesis is represented by the blood vessel density (density of newly created endothelial cells). The model accounts not only for growth and necrosis but also for migration of cells through the ECM, for different stiffness

of the cell population with respect to the ECM, build-up of cortical tension between healthy and tumor tissues and possible invasion of the tumor tissue by the healthy tissue or vice versa, mediated by these cortical tensions. Further it allows for modeling lysis, adhesion of the cells to their ECMs as well as adhesion among cells and possible detachment. Several examples show the possibilities offered by such a model.

OPTIMIZATION OF FLEXOELETRIC AND PIEZOELECTRIC ENERGY

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ABSTRACT

An algorithm to solve the inverse problem of detecting inclusion interfaces in a piezoelectric structure is proposed. The material interfaces are implicitly represented by level sets which are identified by applying regularization using total variation penalty terms. The inverse problem is solved iteratively and the extended finite element method is used for the analysis of the structure in each iteration.

The formulation is presented for three-dimensional structures and inclusions made of different materials are detected by using multiple level sets. The results obtained prove that the iterative procedure proposed can determine the location and approximate shape of material sub-domains in the presence of higher noise levels.

PIEZOELECTRIC PHONON COUPLING EFFECTS IN 2D MATERIALS

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ABSTRACT

A new continuum theory of acoustic and optical phonons in 2D nanomaterials is derived from first principles, contrary to earlier approaches, by starting with the elastic and electric equations, and taking into account the full crystalline symmetry and piezoelectric couplings when allowed by symmetry. The model solves the full 3D elastic and electric equations accounting appropriately for the boundary conditions in all three dimensions.

Our theory allows determination of both acoustic and optical phonon bandstructures near the zone center and couplings between them in the presence of piezoelectricity.

Graphene (symmetry D_6h) and molybdenum disulphide (MoS2) (symmetry D_3h) are studied as important examples of hexagonal 2D materials with and without piezoelectric coupling, respectively. We predict the nonexistence of confined optical phonon modes for molybdenum disulphide. The present work represents an extension of an acousto-optical phonon model recently derived for 3D zincblende materials [1].

We compute input parameters, i.e., all stiffness tensor coefficients and the frequency-dependent dielectric constants for graphene and molybdenum disulfide using Density Functional Theory calculations.

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TOPOLOGY OPTIMIZATION OF VISCOELASTICALLY DAMPED STRUCTURES UNDER TIME VARYING LOADS

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ABSTRACT

Structures with enhanced damping capabilities are of great interest to various engineering applications. The structures can be excited by transient dynamic loading such as wind, shock and seismic loadings. In these applications, viscoelastically damped structure are often used to attenuate undesired responses. The damping forces in the system depend on the past history of motion via convolution integrals. The viscoelastic damping is modeled by the generalized Maxwell model.

Multi-material topology optimization is presented to design structures involving multi-phase materials. The density approach is applied to obtain the distribution of viscoelastic and structural material simultaneously. The damping is characterized by viscoelastic dissipation energy of the structures under general time-dependent loading.

Both quasi-static and dynamic problems are treated. The design sensitivity analysis method of the system is developed using the adjoint variable method. The discretize-then-differentiate approach is adopted for deriving discrete adjoint equations. Based on the derived sensitivities, topology optimization of damped shells structure is presented. The proposed method can be used to effectively mitigate the dynamic response of the damped structures.

Key words: damping, dissipation energy, multi-material topology optimization, adjoint method

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FLEXIBLE FSI: FROM WIND TURBINES TO AIR BLAST

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ABSTRACT

A flexible Fluid-Structure Interaction (FSI) framework is presented. The framework is derived on the basis of an Augmented Lagrangian formulation for FSI, and is suitable for discretizations using conforming as well as immersed approaches. Isogeometric Analysis (IGA) is an integral part of the FSI framework in that it delivers highly accurate fluid and structural mechanics solutions and provides a natural integration with geometry modeling and computer-aided design. The presentation is infused with a variety of FSI simulations stemming from advanced engineering applications and ranging from floating offshore wind turbines to air-blast-structure interaction.

WHY SMOOTH ELEMENTS?

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ABSTRACT

This talk provides first an overview on meshfree methods based strong, week and weakened weak (W2) formulations, with a focus on the latest W2 formulation that guarantees stable and convergent solutions. We then present a family of W2 models known as the Smoothed Finite Element Method or S-FEM developed in the recent years. The S-FEM family include CS-FEM, ES-FEM, FS-FEM, NS-FEM, and □FEM models, which are created through innovative uses of various types of smoothing domains that are Cell-based, Edge-based, Face-based, Node-based, and combinations of them. Properties of these S-FEM models important for automations in computation will be discussed including, spatial and temporal stability and convergence, softening effects, upper bound properties leading to certified solutions, and insensitivity to the quality of mesh allowing effective uses of triangular/tetrahedral meshes, which are best suited for adaptive analyses. A number of examples will be presented to demonstrate the effectiveness of the S-FEMs.

Key words: FEM, meshfree, S-FEM, S-PIM, GSM, CFD, FSI, numerical methods, modeling and simulation, weakened weak formulation

COMPUTATIONAL MECHANICS AT INTERFACES

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ABSTRACT

We present recent developments of our team for the Modeling and simulation of interfaces. In particular, we show recent developments in well conditioned extended finite element approximations applied to energy minimal three dimensional crack growth and crack detection.

We present in a second part recent results in collocation methods. First we introduce a Meshless point collocation method with implicit boundaries defined from STL or image files. Second we show how isogeometric analysis enables crack propagation and shape optimisation directly from CAD.

We conclude with some open problems and future work directions undertaken in the Legato team and introduce a new Centre for Scientific Computing in Luxembourg.

INTEGRATING GEOMETRIC MODELS WITH NUMERICAL ANALYSIS: A SCALED BOUNDARY FINITE ELEMENT APPROACH

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ABSTRACT

Research on numerical methods has transformed the way engineering analyses and designs are performed in practice. A vital component of the research is the automation of the complete process from geometric modelling of a project to the numerical simulation. In spite of the significant progress researchers have made in this area, the numerical modelling and simulation is too often still a time-consuming and daunting task in engineering. Furthermore, numerical simulations based on digital images and STL models, which are increasingly popular owing to the rapid advance in digital imaging technologies and 3D printing, pose additional challenges.

In this presentation, a technique to fully automate the numerical modelling and simulation process will be presented. The development is underpinned by our recent research on constructing general polytope (polygon in 2D and polyhedron in 3D) elements based on the scaled boundary finite element method. The polytope elements can have any number of faces, edges and vertices and offer a much higher degree of flexibility in mesh generation. This allows the development of a polytope mesh generator based on the simple and efficient quatree/octree algorithm. Geometrical models provided as CAD, STL and digital imaging files can be handled in a unified approach. The whole analysis process is fully automatic. The efficiency, robustness and some salient features of the proposed technique will be demonstrated. Potential research and applications of this novel technique will be discussed.

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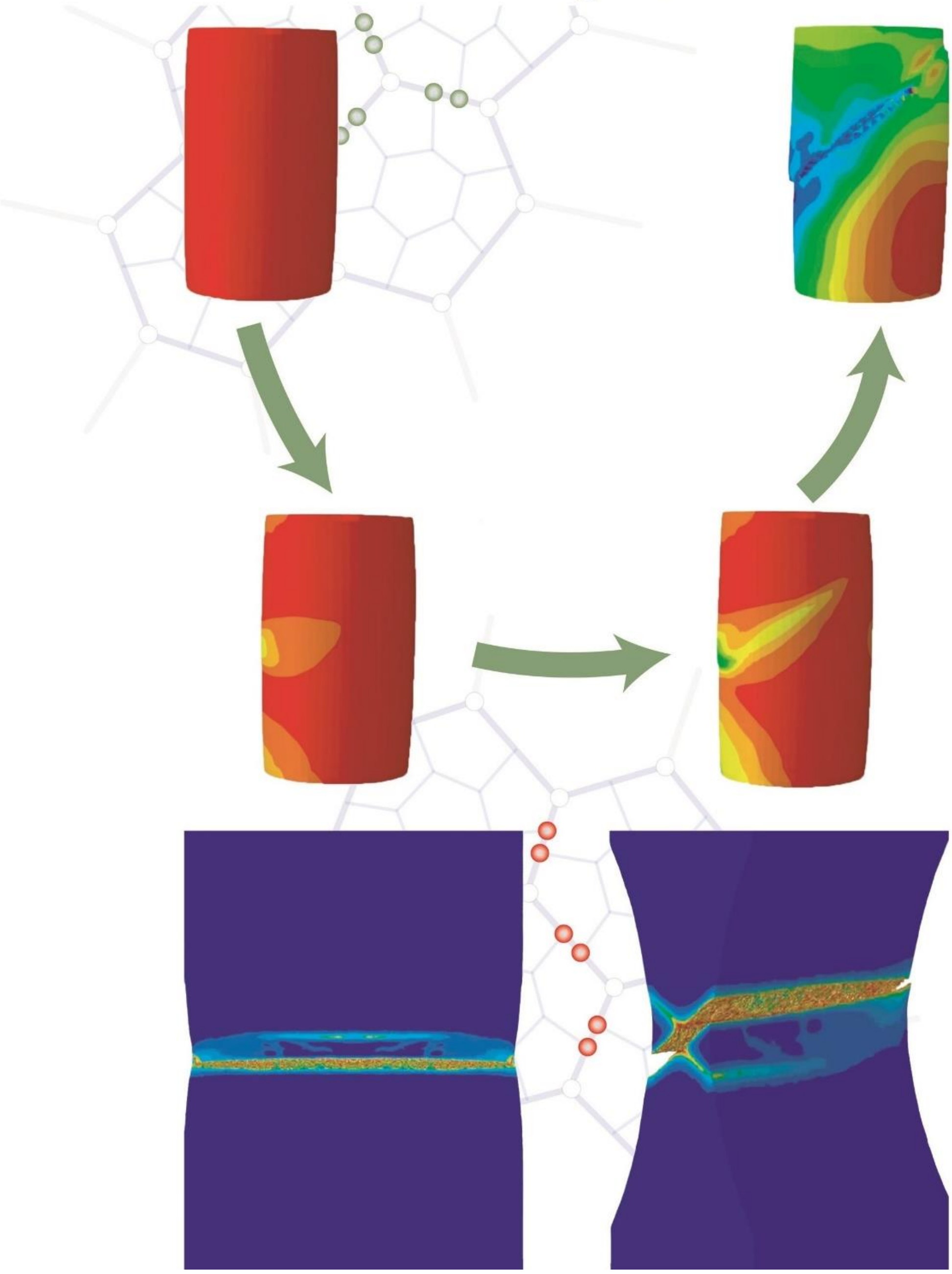

COMPUTATIONAL FRACTURE AND DAMAGE MECHANICS (CFDM)

LINEAR BUCKLING ANALYSIS OF THIN-WALLED STRUCTURES INCLUDING CRACKS AND CUTOUTS

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ABSTRACT

In this study, linear buckling problem of cracked/cutout flat plates is analyzed using a meshfree Repro- ducing Kernel Particle Method [1] on the basis of Mindlin-Reissener shell formulation, which enables transverse shear deformation. There are five degrees of freedom per node including three displacements and two rotations. As for the approximation of both geometry and physical values, the meshfree inter- polation functions are derived from the Reproducing Kernels (RKs). The shear locking problem can be avoided by imposing higher order RK functions. Stabilized Conforming Nodal Integration [2] is adopted to integrate the stiffness matrix, Furthermore, Sub-domain Stabilized Conforming Integration [3] method is utilized to smoothly integrate the stiffness matrix around the crack tip and crack seg- ments. In addition, diffraction method and visibility criterion are employed for modeling of crack tips and crack segment, respectively. When introducing an RK around the crack tip, an enriched basis for representing asymptotic crack tip fields is introduced. A RK function does not itself have Kronecker delta property, thus Singular Kernel [4] functions are adopted so as to impose essential boundary con- ditions. The present method easily could be extended for general curvilinear surfaces (e.g. cylinders, spheres) by introducing convected coordinate system [5, 6].

Buckling analysis of cracked flat plate with different crack lengths and orientation angles are carried out. Buckling loads and modes of flat plates including both circular cutouts and cracks are examined. Obtained results are compared with the available reference solutions as well as finite element analysis results by quadratic elements.

Key Words: Meshfree methods, crack, cutout, linear buckling

FAILURE OF BUILDING STRUCTURES DURING THE COOLING PHASE OF A FIRE

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ABSTRACT

Fires in buildings are characterized by a heating phase followed by a cooling phase, but the effects of the cooling phase on structures are not well covered in the current approaches to structural fire engineering. Indeed, the actual requirement of non-occurrence of structural failure at peak temperature does not guarantee against a delayed failure during or after the cooling phase of a fire, which puts at risk the fire brigades and people proceeding to a building inspection after a fire. Therefore, there is an urgent need to better comprehend and characterize the materials and structures behavior under decreasing temperatures. This work presents an analysis of the behaviour of different structural members under natural fires, with the aim to characterize their sensitivity to the fire cooling phase. Thermo-mechanical numerical simulations based on the non-linear finite element method (SAFIR code) are conducted. Results show that, for all the studied members (column, beam) and materials (reinforced concrete, steel, steel-concrete composite), structural failure during the cooling phase of a fire is a possible event. The major factors that promote delayed structural failure are the thermal inertia and the constituting material of the member. This work enhances the understanding of the structural behaviour under natural fires and has implications for the safety of the fire brigades and people proceeding to a building inspection after a fire.

Key words: Natural Fire, Cooling Phase, Building Structures, Delayed Failure, Performance-Based Design

CALCULATION OF DUCTILE FRACTURE PARAMETERS FOR PUNCHING PROCESSES

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ABSTRACT

Punching processes are useful processes for producing automobile parts, mechanical components, and other parts. In the punching process using a punch and a die, a sheared surface and a fractured surface are usually formed on the cut surface. To produce more accurate parts, it is important to estimate the ratio of the sheared surface to the cut surface before making a punch and a die. Optimal tools and punching conditions such as clearance must be selected within the limits of cost constraints. The finite element method (FEM) has been applied to analyze the ratio of the sheared surface to the fractured surface on cut surfaces. For this purpose, many researchers have used ductile fracture criteria for the fracture initiation of the cut surface. However, it is difficult to determine the fracture criteria on the cut surface by tensile tests or bending tests because the punching process involves many complicated steps. In this study, FEM is applied to calculate the ductile fracture criteria for the punching process proposed by Cockcroft and Latham [1], Oyane [2], and Ayada [3]. The ductile fracture criteria for two materials, such as SPCC and S45C, are compared. The appropriate criteria are mentioned to be predict the boundary for the initiation for fracture in cutting surface.

Key words: Ductile fracture parameters, Punching process, Finite element method

CRACK DETECTION IN A BEAM ON ELASTIC FOUNDATION USING DIFFERENTIAL QUADRATURE METHOD AND THE BEES ALGORITHM OPTIMIZATION

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ABSTRACT

In the present contribution, a practical and non-destructive method for identifying of crack in Beam on Elastic Foundation are presented. Beam modeled by Differential-Quadrature method and location and depth of crack are predicted by bees algorithm. The Crack, which is assumed to be open, is modeled by rotational sprin. Rotational spring divides all-part through cracked beam into two segments. Then the Differential-Quadrature method is applied to the governing differential equations of motion of each segment and the corresponding boundary and continuity conditions. An eigenvalue analysis will be performed on the resulting system of algebraic equations to obtain the natural frequencies of the cracked Beam on Elastic Foundation. Then location and depth of cracks are determined by algorithms such as Bees Algorithm. The equations of Thin- walled beam theory have been used for this research. To insure the integrity and robustness of the presented Algorithm, finite element analysis on the set of cantilever beam, with different crack length and location has been done. The results show that the presented algorithm predicts Location and depth of crack with suitable precision.

Key words: Vibration Analysis, Crack detection, Differential Quadrature Method, Bees Algorithm

CRACK PROPAGATION SIMULATION OF A CURVED CRACK IN A T-SHAPED TUBULAR JOINT EMPLOYING X-FEM

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ABSTRACT

Marine structures such as offshore jacket structures are constructed with many structural members and tubular welded joints. In recent years, requirements of structural durability and safety have been increased. Especially welded joint parts have a risk of damage of fracture. It is important to evaluate the crack propagation behavior after crack initiation as well as avoiding crack generation.

Crack propagation simulation for T-shaped welded tubular joints structures was previously carried out employing conventional FEM [1]. The accuracy of crack propagation analysis before crack penetration by conventional FEM was examined by comparing fatigue experimental results. However, this method can't evaluate crack propagation behavior after crack penetration.

In this work, the propagation of a surface crack in a T-shaped welded tubular structure is studied employ- ing X-FEM [2,3]. X-FEM is well suited for evaluating fatigue strength and behavior of crack growth after crack penetrating. This effective method is adopted to simulate the fracture phenomena, from a small planer surface crack to a curved through-the-thickness crack (through crack). Open-source soft- ware Code Aster is employed to carry out the X-FEM simulation [4]. This software can analyze transi- tion of crack propagation from a curved surface crack to a through crack effectively. The stress intensity factors, trajectory of a curved crack and fatigue cycles are compared with the numerical results of the FEM [1]. The accuracy of crack propagation employing X-FEM is examined by comparing with the experimental results.

Key Words: Fracture Mechanics Analysis, X-FEM, Curved Crack, Crack Propagation

STRESS ANALYSIS OF SILICON-BASED ANODE IN LI-ION BATTERY

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ABSTRACT

We analyze during charging the stress evolution in silicon based anodes of lithium-ion batteries by using an extensive finite element simulation. Effects of charge rates and geometric parameters of the anodes are considered. Results are useful for the design of new architectures of anodes for lithium-ion batteries.

Key words: Diffusion, finite element analysis, Li-ion battery, stress.

USING A NON-LOCAL ELASTIC DAMAGE MODEL TO PREDICT THE FATIGUE LIFE OF ASPHALT PAVEMENT STRUCTURE

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ABSTRACT

Asphalt concrete is a composite material comprising aggregate, sand, mineral filler and bitumen as a binder. Although good compaction is performed during the construction, there is still relative large discontinuity inside the material, and this will favour the appearance of micro-cracks, which decreases the performance of the material. Structural cracking resulted from repeated loading, or fatigue cracking, is a common failure mode of asphalt pavement structure, reducing the serviceability of the pavement. Owing to the present of micro-cracking, the fatigue cracking of asphalt pavement is generally modelled by using damage theory. In this paper, the authors aim to illustrate the application of an isotropic non-local elastic damage model in predicting the fatigue life of a pavement structure. A scalar *D*, called damage variable, is used to define the damage state at a point of the material and the evolution of this variable at a point depends to the historic damage state as well as the present strain tensor at that point. The model parameters are determined on the basis of fatigue test results—namely, 4-point bending test. Numerical examples are presented to illustrate the ability of using damage theory to predict the damage evolution of a pavement structure as well as its service life.

Key words: non-local elastic damage, damage law, fatigue life, pavement structure, finite element method

NUMERICAL STUDY OF GRANULAR SYSTEM WITH THE FRACTURE OF POLYHEDRAL PARTICLES BASED ON DISCRETE ELEMENT METHOD

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ABSTRACT

Dense accumulated granular system is made up of many polyhedral brittle particles. Under the impact load, the partial particles are fracture.

Dense accumulated structure of granular system which is made up of many polyhedral particles only needs the position and angle of the particles. The code of discrete element method which describes granular system made up of the polyhedral particles is optimized. The optimized ways are to use the fast contact detection algorithm and reasonable contact model. Especially, the fast contact detection algorithm is the key technique. And then, the dense accumulated structure of granular system is obtained through using the code.

In order to study the brittle fracture level of single particle, the spring-sphere random fracture model based on discrete element method is reasonably chosen. Combined application between the brittle fracture model and the code of discrete element method which describes granular system made up of the polyhedral particles, the code of granular system with partial polyhedral particles' brittle fracture is written to simulate this problem.

Key words: polyhedral particle, fracture, discrete element method, contact detection algorithm, granular system

NUMERICAL STUDIES ON CONTACT PROBLEM OF INTER-LOCKING CONCRETE BLOCKS FORMING REVETMENT STRUCTURE

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ABSTRACT

The importance of revetment slope (RS) structures for protecting coastal is indisputable. RS structures not only can maintain stability of embankment, but also can reduce sea wave energy by its optimized geometric features. For years, civil engineers have developed numerous solutions of RS structures based on theoretical aspects, experiments and numerical analysis. Due to the lack of analysis criterion, design codes and experimental facilities, numerical analysis methods significantly become of interest. One of the most challenges is that to perform the interactions between concrete blocks, which form RS structure, and water, i.e. dynamic fluid-structure interaction (FSI). Also, interaction between RS structures and embankment or foundation slope stability must be investigated carefully. Analysis of inter-locking blocks interactions is one of our missions in the VLIROUS TEAM 2017 project that we are running. In additions, due to the limitation of existing RS structures, e.g. heavy and dense materials, etc., optimizations of RS structure are concerned. This paper is to overview the development of RS structures and approaches for analyzing contact problems. Theoretical aspects and computational modeling procedures are mentioned. ABAQUS commercial software is adopted. Hence, novel efficient RS structures could be developed and applied in the real world.

Key words: revetment slope structure, inter-locking, interactions, finite element method

ATOMISTIC SIMULATION OF BORON NITRIDE NANOTUBES UNDER BENDING

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ABSTRACT

We investigate the bending buckling behavior of boron nitride (BN) nanotubes through molecular dynamics finite element method with Tersoff potential. Effects of the tube length on the critical bending buckling angle and moment are examined for (5, 5) BN armchair and (9, 0) BN zigzag tubes, which exhibit approximately identical diameters. The buckling and fracture mechanism of the tubes under bending are considered and discussed with respect to various tube length-radius ratios *L/D*=10-40. Simulation results will help to design and use BN nanotube-based nanocomposites and nanodevices.

Key words: Atomistic simulation; Bending; Boron nitride nanotube, Buckling.

LIMIT AND SHAKEDOWN ANALYSIS AND DESIGN OF 2D AND 3D FRAME STRUCTURES

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ABSTRACT

After recalling the modern philosophy of ultimate limit state design in civil engineering, the lecture describes the method and performance of the CEPAO software, a tool useful for the analysis and design of civil engineering 2D and 3D frame structures with linear and nonlinear behaviour and fixed or repeated loadings. An algorithm for the computation of the limit states of frameworks with the following problems: Elastic analysis, Limit analysis, Elastic-plastic analysis first-order and second-order (semi-rigid and local buckling, strain hardening effects…), Shakedown analysis, Optimization-Limit, Optimization-Shakedown have been realised in the period 1978-1981 for 2D and extended to 3D in the recent period 2005-2008. All of these calculations are connected with the problem of automatic search of independent mechanism in the sense of kinematical aspect of limit analysis which permits to solve these series of problems in a unified computer program where the number of degree of freedoms and also the time computation is reduced considerably. The elastic and elastic-plastic analysis by equilibrium-stiffness hinge by hinge method are solved and compared to the direct method using linear programming technique performed also by CEPAO. New implementations of special numerical techniques are performed such that large dimension problems are solved without difficulties. Several new numerical results are presented showing the performance of the CEPAO software compared to the recent literature.

Keywords: Limit analysis, Shakedown analysis, Elastic-plastic analysis, Optimization, Semi-rigid connection, Linear programming.

TRUSS DAMAGE DETECTION USING MODIFIED DIFFERENTIAL EVOLUTION ALGORITHM AND VIBRATION DATA

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ABSTRACT

In this paper, an efficient numerical algorithm is developed for the damage detection of planar and space truss structures based on the modified differential evolution algorithm (mDE) [1] and vibration data. For this purpose, the mathematical programming of the finite element based on the force method and the singular value decomposition technique is presented [2]. The general equilibrium equations in which unknown member forces and reaction forces are take into account are formulated. The compatibility equations in terms of forces are explicitly presented by using the singular value decomposition method. The modified differential evolution algorithm (mDE) is used as an optimization algorithm of damage detection. The objective function for damage detection is based on vibration data such as natural fre- quencies and mode shapes [3]. The feasibility and efficiency of the present method are compared with a genetic (GA) algorithm [4] and a particle swarm optimization (PSO) algorithm [5] for examples. The numerical results show that the proposed strategy based on force method using mDE and vibration data can provide a reliable tool on determining the sites and extents of multiple damages of truss structures.

Key Words: Damage detection, Force method, Free vibration analysis, Modified differential evolution algorithm

A NOVEL DIRECT METHOD FOR SHAKEDOWN ANALYSIS: STRESS COMPENSATION METHOD

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ABSTRACT

It's an important task in engineeing design and structural intergrity assessment to determinate the shakedown load or shakedown domain of components under the action of cyclic loadings. In this paper, a novel direct method called the stress compensation method (SCM) for shakedown analysis of engineering structures is presented. Different from the most shakedown analysis method based on the framework of mathematical programming, the SCM is a two-level iterative procedure based on a series of linear finite element solutions. The inner loop of the SCM approximately provides the steady cyclic stress state of an elastoplastic structure under specified loading path, and constructs the static adimissible residual stress field for shakedown analysis based on the Melan's theorem. In outer loop, a sequence of decending load multipliers are updated to approach to the shakedown limit multiplier by using an efficient and robust iteration control technique. Assuming that the material model is elastic-perfectly plastic and obeys the von Mises yield condition, the proposed method is implemented into the commericl finite element software ABAQUS. All the numeical examples confirm the applicability and efficiency of the proposed method for complex 2D and 3D strucutres, with detailed discussions on the convergence and the accuracy. The results are compared to the analytical solutions and those in literatures, as well as to the calculations with the linear matching method (LMM).

Key words: Direct method, Shakedown analysis, Stress compensation method (SCM), Iterative procedure

APPLICATIONS OF CONSERVATION INTEGRALS TO ATOMIC MIXED-MODE FRACTURE OF GRAIN BOUNDARIES IN CRYSTALLINE SOLIDS

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ABSTRACT

Grain boundaries (GBs) of polycrystalline metals can be one of the easiest paths for crack propagations, since atoms at grain boundaries experience less ordered interatomic interactions with neighbouring atoms than those in homogeneous crystalline metals. Each GB of polycrystalline metals has different mechanical properties and failure mechanisms under mixed-mode loadings. Since the fracture toughness depends on the mode mixity in mixed-mode fractures, the stress intensity factors (SIFs) of modes I and II at the crack tip need to be found individually. In this study, we have developed a computational scheme based on atomic-level J-based mutual integral to extract individual SIFs from the molecular dynamics (MD) simulation of the mixed-mode fracture along symmetric-tilt grain boundaries (STGBs) in crystalline solids. For the atomic-level J-based mutual integral, the anisotropic elasticity solution to a semi-infinite crack along a bimaterial interface is used as an auxiliary field. Besides, the atomic-level J and M integrals are also performed to find out the energy release rate and the position of a crack tip under the applied mixed-mode loadings, respectively.

Key words: Mixed-mode fracture; Molecular dynamics; Stress intensity factor; Mutual integral

ELECTRICALLY ASSISTED SPRINGBACK ELIMINATION OF 316L STAINLESS STEEL BY SINGLE PULSE OF ELECTRIC CURRENT PRIOR TO UNLOADING

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ABSTRACT

Various studies [1-3] have reported that the material property of a metal can be altered by applying electric current during deformation without a significant change in temperature. The phenomemen is often called as the electroplasticity. Especially for a sheet metal under tension, a pulsed electric current during deformation generally increases the maximum achievable deformation and results in a very unique ratchet-shape stress-strain curve [4]. It also has been reported that the springback in forming of metals can be reduced or even eliminated by applying a single pulse of electric current at the final moment of deformation before unloading [5, 6].

As an effort to develop a computational simulation model of electrically assisted (EA) stamping of 316L stainless steel (SUS 316L), the effect of a single pulse of electric current on the springback reduction of the selected stainless steel is experimentally investigated. An experimental set-up is established by combining u-bending fixture and an electric current generator. The results show that the springback of the SUS 316L specimen could be nearly eliminated by applying a properly selected electric current density with duration less than 0.3 sec prior to unloading. The result of the present study is implemented to a computational model of EA stamping process of metallic bipolar plates of fuel cell stacks.

Keywords: electrically assisted stamping, springback, 316L stainless steel

PERIDYNAMICS FOR THE MODELLING OF FRACTURES AND FLUID STRUCTURE INTERACTION

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ABSTRACT

In this paper, we propose a nonlocal formulation for both solid and weakly compressible fluid. The nonlocal uid formulation is based on the nonlocal interaction of each material point with its neighbors, which is analogous to the peridynamic theory, a nonlocal formulation for solid. By considering the direction of the interaction, the horizon and dual-horizon are defined and the dual property between horizon and dual-horizon is proved. The nonlocal divergence is introduced, which enables to derive the nonlocal interaction with the local formulation. The formulations allow the varying horizon size and satisfy the conservation of linear momentum, angular momentum and energy at the same time. Two numerical examples are tested to verify the accuracy of the current method.

Key Words: Dual-horizon; nonlocal formulation; weakly compressible fluid; fluid structure interaction.

THERMAL BUCKLING OF CRACKED MINDLIN FGM PLATES BASED ON NEUTRAL SURFACE AND PHASE-FIELD METHOD

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ABSTRACT

A variational phase-field theory is used to study the buckling of cracked FGM plates, unlike existing works of cracked FGM plates, here we focus our attention on the difference between neutral surface and mid-surface. The kinematics of plate is based on the first-order shear deformation plate theory, the Mindlin's theory, the crack is represented by a phase-field parameter. We first study the accuracy of this method by comparing the obtained results of critical buckling temperature rises of cracked FGM plate with reference solutions available in literature. The thermal buckling of cracked FGM plates is then analyzed, considering for two cases: (i) the mid-surface is considered to be identical to the neutral surface; and (ii) the mid-surface is different with the neutral one. Based on the obtained numerical results, it is found that the boundary condition and properties materials have strong effects on thermal buckling of cracked FGM plates. Consequently, the difference between neutral surface and mid-surface is critical in analyzing cracked FGM plates.

Key words: Thermal buckling, Mindlin plates, phase-field method, crack, neutral surface

THE MECHANICAL BEHAVIOR OF 5182 ALUMINUM ALLOY UNDER A PULSED ELECTRIC CURRENT

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ABSTRACT

Using lightweight materials such as aluminum alloys can be an effective way to improve fuel efficiency in automotive industries. However, despite aluminum alloys' high strength-to-weight ratios compared with typical ferrous alloys, the poor formability of alumium alloys at room temperature limits their automotive applications.

Electrically–assisted forming is a promising new forming technique in which the mechanical properties of a metal alloy are altered by simply applying electric current to the metal undner plastic deformation. The reduced flow stress and increased ductility, which are often called the electroplastic effects, are generally observed in electrically-assisted deformation [1-3].

In the present study, the electroplastic tensile behavior of 5182 aluminum alloy under a pulsed electric current is investigated at different strain rates for the development of electrically assisted stamping of the selected aluminum alloy. The experimental result shows a ratchet shape stress–strain curve under a pulsed electric current. The formability of the selected aluminum alloy is significantly improved at near room temperature depending on the electric pulse parameters. A dislocation density based constitutive model [4] is adapted to describe the upper boundary of the ratchet shape stress-strain curve under a pulsed electric current. Thermal and electric current-induced annealing is considered simultaneously in the modified constitutive model. The constitutive model is capable of predicting the experimental results very well.

Key words: Electroplasticity, Aluminum alloy, Electric energy density, Dislocation density based constitutive model.

ACKNOWLEDGEMENT

This work was supported by the National Research Foundation of Korea (NRF) Grant Funded by the Ministry of Science, ICT & Future Planning (MSIP) (NRF-2015R1A5A1037627). This research was supported by a grant (S2317960) from Daewon Kang Up's World Class 300 R&D Supported Project (development of low-cost active suspension adjustment module for 10% enhanced ride comfort/reliability). This work was supported by the Technology Innovation Program (Industrial Strategic technology development program, 10044807, Development of technologies for vehicle body part made from UHSS and Al5000 by electrically assisted manufacturing) funded by the Ministry of Trade, Industry & Energy (MOTIE, Korea).

ANALYSIS OF DYNAMIC FRACTURE PROBLEMS EMPLOYING TWO-DIMENSIONAL ORDINARY STATE-BASED PERIDYNAMICS THEORY

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ABSTRACT

Peridynamics (PD) theory is one of new meshfree methods to analyze fracture problems. The analysis domain is discretized by particles. Attractive pairwise forces interact over the particles are introduced to model a continuum. The fracture modeling can be achieved by splitting the pairwise forces of par- ticles acrossing the crack segment. In the authors' previous study [1], dynamic stress intensity factors (DSIFs) are analyzed based on the ordinary state-based PD (OSPD). An interaction integral method (IIM) is chosen to analyze the DSIFs. Because the OSPD theory cannot treat displacement derivatives directly, moving least square method [2] is adopted to evaluate the displacement derivative in the IIM. In addition, diffraction method [3] is employed to accurately evaluate field variables around the crack tip. In this presentation, several dynamic fracture problems are shown to validate the meshfree modeling and accuracy.

Key Words: Peridynamics, dynamic fracture, meshfree method

AN INVESTIGATION ON TENSILE DEFORMATION BEHAVIOUR OF PRE-CRACKED THIN SPECIMENS MADE OF TRIP STEEL SHEET

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ABSTRACT

Transformation-induced plasticity (TRIP) steel has a metastable austenitic structure. When it is subjected to plastic deformation, the austenite transforms into more stable martensitic phase. This phenomenon is called the strain-induced martensitic transformation (SIMT). TRIP steel in a wide meaning such as type-304 austenitic stainless steel (SUS304) shows excellent mechanical properties such as high toughness and ductility because of SIMT. In addition, TRIP steel might indicate a high energy-absorption characteristic because it could possibly consume impact energy by dissipation processes of both plastic deformation and SIMT during deformation.

Some past studies have focused on the rate sensitivity of energy-absorption characteristic in TRIP steel. Pham and Iwamoto [1] conduct a three-point bending test by using a pre-cracked thick specimen of SUS304. They report positive rate sensitivity of energy-absorption capacity appears. On the other hand, advanced high strength steels including TRIP-assisted steel are provided as thin sheets and their demands are more increasing. At the same time, many industrial members are recently reducing their weight by decreasing thickness. One of the experimental methods to evaluate energy-absorption capacity of thin sheet steels would be small punch (SP) test. Pham and Iwamoto [2] perform a finite element (FE) simulation of the SP test by introducing the Johnson-Cook (JC) damage model [3]. They report the result of SP test with SUS304 indicates the negative rate sensitivity of maximum external force and displacement at a point of fracture.

According to Shindo et. al [4], the results of both test by using the thick specimen and SP test with the thin specimen should be indicated a positive correlation each other, however, actually

negative correlation is pointed out by Pham and Iwamoto [2] due to consideration of the rate sensitivity. They are inconsistent each other. It is predicted different stress state caused by the shape in specimens becomes one of reasons why there is inconsistency. The difference in shape of specimen might induce another mechanism of fracture depending on their thickness. It is important a relationship between the shape of specimens and rate sensitivity should be revealed. However, it is difficult to conduct three-point bending test using thin sheet steels. In addition, in the SP test, the fracture is initiated at the region where tensile deformation is dominant. To solve these problems, another testing method by using thin sheet steels should be established instead of a use of the thick specimen. Furthermore, the damage model considering the stress state caused by the shape of specimen should be formulated because it is essential to express the fracture just after actual deformation for clarifying its mechanism.

In this study, tensile deformation behaviour of pre-cracked specimens by using sheet steel of SUS304 at the various strain rates is simulated by a three-dimensional FEM. The constitutive model with transformation kinetics model and heat conduction equation proposed by Iwamoto et al. [5] which can express deformation behaviour of TRIP steel is applied as well as the JC damage model. The effect of SIMT and damage on the fracture of thin sheet steels is discussed.

Key words: 3D FEM, TRIP steel, sheet steel, pre-cracked specimen, tensile test, damage model

UPPER BOUND LIMIT ANALYSIS OF CIRCULAR TUNNEL IN COHESIVE-FRICTIONAL SOILS USING THE NODE- BASED SMOOTHED FINITE ELEMENT METHOD

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ABSTRACT

The stability of circular tunnel in cohesive-frictional soils subjected to surcharge loading, obeying the Mohr-Coulomb failure criterion, is determined by an upper bound limit analysis procedure using the node-based smoothed finite element method (NS-FEM). Continuous loading is applied to the ground surface, and both smooth and rough interface conditions are modeled. The kinematically admissible velocity fields of the tunnel problems are approximated by NS-FEM using triangular elements. Next, commercial software Mosek is employed to deal with the optmization problems which are formulated as well-known second order cone. Collapse loads as well as failure mechanisms of plane strain tunnels are obtained directly from solving the optmization problems. In this study, the soil internal frictional (ϕ'), material properties of soil ($\gamma D/c'$) and the ratio of tunnel diameter to its depth (H/D) which influence on tunnel stability are also regarded. The results of this study compare reasonable well with the solutions reported in the literature.

Key words: Limit analysis, circular tunnel, stability, SOCP, NS-FEM

NUMERICAL VALIDATION FOR FREE VIBRATION OF CRACKED MINDLIN PLATES USING PHASE-FIELD METHOD

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ABSTRACT

In this work, a variational phase-field model is introduced to investigate free vibration of cracked plates. The kinematics of plate is derived in terms of Reissner-Mindlin plate theory, and the discrete equations derived are then solved by a variational phase field model for fracture. Validation of the numerical simulation for natural frequency of cracked plate is analyzed, taking the same configuration, material property, crack location, and other relevant assumptions. The present results show that the developed phase-field model is accurate and effective in estimation of natural frequency and vibration mode. We further show the applicability of the proposed phase field model by solving examples of cracked plates with complex geometries.

Keywords: Free vibration; Buckling; Reissner-Mindlin Plates; Phase-field method;

PHASE-FIELD BASED SIMULATION OF TRANSVERSE CRACKING IN LAMILATED

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ABSTRACT

Phase-field theory is well-known mathematical model for solving inteface problems, including crack problema in fracture mechanics. In this study, the formula is derived by variational approach based on Reissner-Mindlin plate kinetic theory and phase field theory for simulation of transerve cracking in laminated. Phase-field paramaters are defined independently in different plies of lamilated in order to capturing the crack behavior of each individual plies. Simulation is carried out in order to numerically investigating stiffness reduction and buckling behavior of transverse cracked composite laminate plate. We demonstrated the significant advanced of phase-field approach for composite laminate plates with complex crack geometries.

Key words: Mindlin plates, phase-field method, crack, buckling, crack, composite, phase-field.

NUMERICAL STUDIES OF SOME MODIFIED POLARIZATION SATURATION MODELS IN 2-D SEMIPERMEABLE PIEZOELECTRIC MEDIA USING DISTRIBUTED DISLOCATION METHOD

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ABSTRACT

In this paper, some modified polarization saturation models are proposed and studied numerically in 2-D semipermeable piezoelectric media using distributed dislocation technique (DDT). The polarization saturation (PS) model is modified here by varying the saturated condition imposed on the electrically saturated strip i.e. a constant saturated condition to linear, quadratic and cubic varying electric displacement saturated condition. Numerical studies for these proposed models are simulated by considering their equivalent forms based on the principle of superposition. A centre cracked problem in 2-D semipermeable piezoelectric media under arbitrary poling direction and in-plane electromechanical loadings is considered for these analysis. To validate the developed numerical codes and iterative numerical approach for finding the unknown saturated zone length, the obtained results for PS model are compared with the analytical results available in literature. Thereafter, the results are presented for modified PS models, they show the effect of variation in saturation condition on saturated zone length, critical applied electric displacement loading and crack opening potential (COP) whereas no significant effect has been observed on local intensity factor (LIF) and crack opening displacement (COD). Further, saturated zone length increases with respect to increase in degree of variation of saturation condition i.e. from constant to cubic. Moreover, the variation shows the effect on implication of applied electric loading and defines the critical applied electric loading corresponding to each model. It is observed that the critical value of applied electric loading significantly decreases with the increase in degree of variation of saturation condition. Here, a significant effect of poling direction is also found in all the parameters such as saturated zone length, LIF, COD and COP.

Key words: Distributed dislocation method, local intensity factor, piezoelectric, polarization saturation, semipermeable

FINITE ELEMENT SIMULATION ON SMALL PUNCH TEST FOR AN EVALUATION OF *J*-INTEGRAL FOR TRIP STEEL

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ABSTRACT

The small punch test (SPT) has been recently successfully developed for the purpose of evaluate the fracture toughness in not only brittle but also ductile materials. It is considered that fracture toughness of materials can be estimated by means of the SPT based on the measurement of equivalent fracture strain in the SPT and its correlation with fracture toughness. Moreover, fracture toughness of TRIP (transformation-induced plasticity) steel was evaluated by *J*-integral by using pre-cracked specimen under three-point bending test in the past study. However, the value of *J*-integral is determined at a limited range of deformation rate in three-point bending test. Thus, fracture toughness of TRIP steel need to be evaluated by means of the SPT, especially at a relatively high deformation rate. Additionally, since the effect of strain-induced martensitic transformation during plastic deformation of TRIP steel coupled with a high increase of temperature is quite complicated, a computational work is indispensable. In this study, finite element simulations are performed for the SPT at various deflection rates and different sizes of specimen and puncher by an application of damage model for type-304 austenitic stainless steel, a kind of TRIP steel. The rate-sensitivity of fracture-mechanical characteristics is examined for different sizes of specimen and puncher. Furthermore, a relationship between equivalent fracture strain in the SPT and *J*-integral obtained from three-point bending test is challenged to be correlated.

Key words: TRIP steel, J-integral, small punch test, finite element simulation

ON THE BUCKLING BEHAVIOR OF MULTI-CRACKED FGM PLATES

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ABSTRACT

In this paper, a model of statically stability plate with cracks based finite element analysis will be introduced by numerical simulation computation. The simulation model was built based on Phase-field theory in mechanics of fracture, the case study of plate was significantly computed with the new third-order shear deformation plate theory (TSDT), which is derived from an elasticity formulation, rather by the hypothesis of displacements [1]. Importantly, to verify of reliability of the modeling computation theory, the simulation result was compared to the experiment of Seifi. et al. 2011 [2] to ensure the essential reliability for the paper. After that, the authors also propose and test the effects due to the size, the declination of cracks as well as the thickness of the plate to the stability, additionally, the relation between number of cracks and buckling load involved to un-stability of plate will be discussed. Lastly, visual configurations about forms of un-stability of plate with cracks will be presented.

Key words: Buckling, TSDT, phase-field method, multi-crack.

FRACTURE ANALYSIS OF FUNCTIONALLY GRADED PIEZOELECTRIC MATERIALS USING THE SCALED BOUNDARY FINITE ELEMENT METHOD

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ABSTRACT

Functionally graded piezoelectric material (FGPM) is a type of piezoelectric material in which the electro-elastic properties are considered to vary in space according to a design law. FGPMs are used in many important applications in engineering industries such as aerospace, medical, military, etc., during which cracks can develop under different loading conditions. This emphasizes the importance of frac- ture analysis of FGPMs and to develop an accurate numerical technique to predict the fracture parame- ters of these materials. In present work, the fracture behaviour of FGPM is studied by using the scaled bnoundary finite element method (SBFEM) for the first time to the best of authors' knowledge. The SBFEM is a semi-analytical technique developed by Wolf and Song [1], transforms the conventional Cartesian coordinate system to the scaled boundary coordinate system, viz, circumferential direction and radial direction. The currrent work extends the work of Li *et al.* [2] on modeling piezoelectric ma- terials by using the SBFEM to FGPM. To capture the variation of material properties of piezoelectric material along the domain, the shape functions for *n*-sided polygon developed by Chiong *et al.* [3] is used. These shape functions are linearly complete for uncracked polygons and reproduces singularity at the crack tip for cracked polygons. The displacment field over the domain is expressed as a power series of the radial coordinate. The stiffness matrix in each polygon is derived from the principle of virtual work. The resulting stress distribution along the radial direction is represented analytically and stress intensity factors (SIFs) are evaluated directly from their definition. Numerical examples involving the calculation of SIF for FGPM are choosen from the literature and are solved to validate the present approach.

Key Words: functionally graded piezoelectric materials, fracture, scaled boundary finite element method, princple of virtual work, singularity

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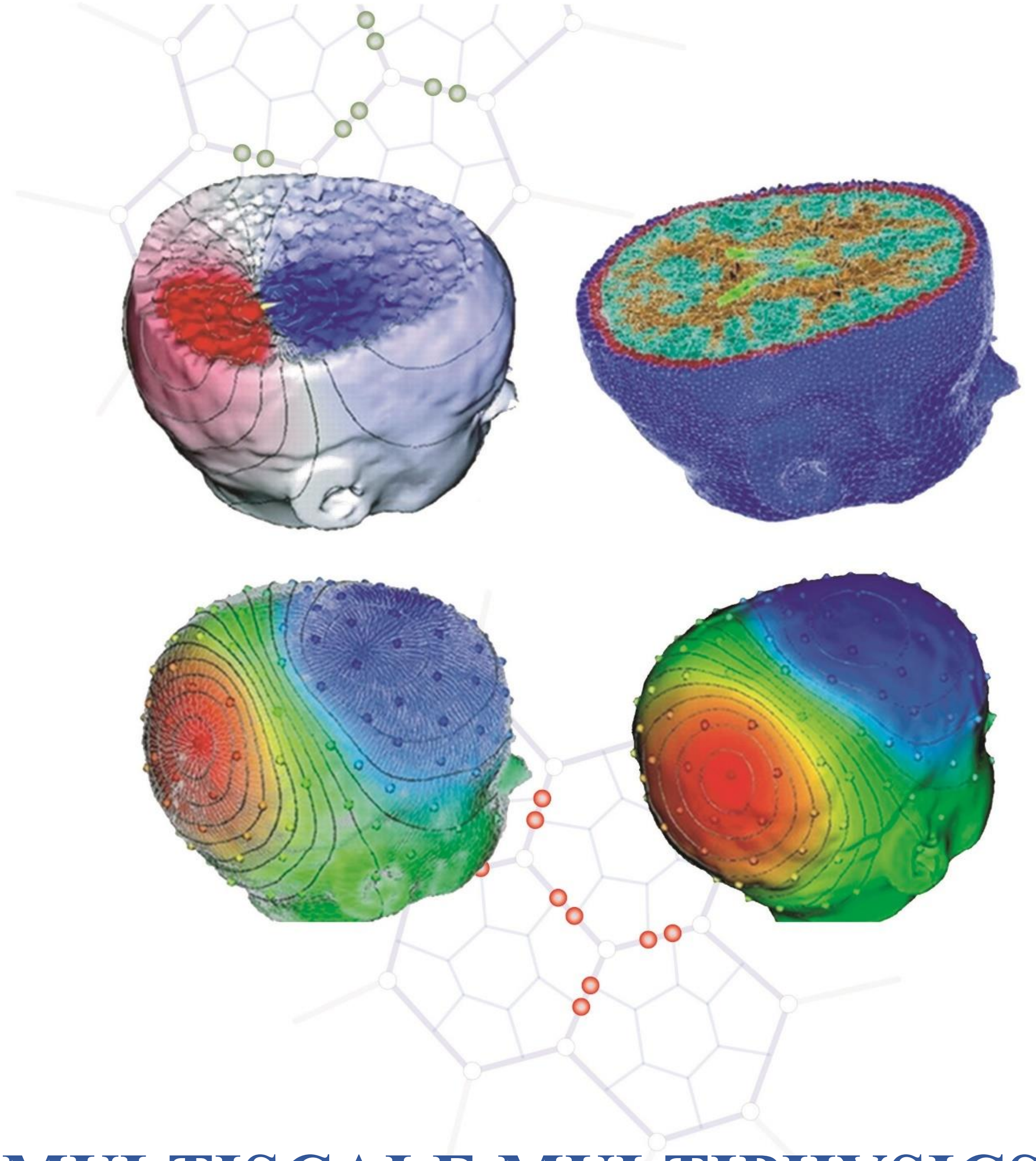

MULTISCALE MULTIPHYSICS PROBLEMS (MMP)

A MICRO-MESO MULTISCALE MODELLING OF IMPACT BEHAVIOR OF WOVEN FABRICS

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ABSTRACT

In this study, a microscopic modeling in the case on an aramid yarn subjected to a ballistic impact was developed in order to reproduce the local deformation and failure mechanism the yarns, and the fabric under an impact ballistic at the fiber scale such as: the sliding and spreading of the fibers in the impact zone, the yarn damage by fibrillation, etc. The notion of an "equivalent fiber" corresponding to about 10 fibers was introduced for a gain of the computation time. In this paper, a total of 42 equivalent fibers is used to model a yarn of 400 fibers. The equivalent fiber is modeled using two element types: shell and solid elements. Indeed, a hybrid meso/micro modeling of the fabric is also carried out. By using this microscopic approach, the ballistic behavior of a yarn and a fabric under a transverse impact using is analyzed in compared with those obtained using the mesoscopic modeling as a reference. The microscopic modeling approach use each type of element (shell and solid) has its advantages of describing the deformation and damage mechanisms of the yarn and the fabric occurred at fibers scale.

Key words: Computational mechanics, multiphysics, optimization, finite element

ATOMISTIC SIMULATION OF BORON NITRIDE NANOTUBES UNDER BENDING

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ABSTRACT

We investigate the bending buckling behavior of boron nitride (BN) nanotubes through molecular dynamics finite element method with Tersoff potential. Effects of the tube length on the critical bending buckling angle and moment are examined for (5, 5) BN armchair and (9, 0) BN zigzag tubes, which exhibit approximately identical diameters. The buckling and fracture mechanism of the tubes under bending are considered and discussed with respect to various tube length-radius ratios *L/D*=10-40. Simulation results will help to design and use BN nanotube-based nanocomposites and nanodevices.

Key words: Atomistic simulation; Bending; Boron nitride nanotube, Buckling.

MULTISCALE PERIDYNAMIC MODEL FOR ANALYSIS OF MASS DIFFUSION IN CONCRETE INCORPORATING ITZS

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ABSTRACT

Interfacial transition zone (ITZ) in concrete is a thin layer with thickness less than 50 μm between coarse aggregate and cement-paste. High porosity and diffusivity of ITZs significantly affect mass diffusion in concrete. Suitable numerical model for analysis of mass diffusion in concrete should contain the microstructures of ITZs. In this study, a multiscale peridymanic model of concrete was proposed to conduct analysis of mass diffusion. Firstly, coarse peridynamics model of concrete was established with uniform mesh frame. Approach for generating random aggregate structures was adopted to separate the elements with mechanical properties of aggregates or of cement pastes. The statistical volume elements crossing with the boundaries of aggregate structures were selected as potential elements of ITZs. Secondly, adaptive remeshing process was implemented on the selected elements, and the refined elements could be efficiently assigned isolated properties. With the proposed method, a numerical model of concrete incorporating ITZs with practical thickness could be obtained. Consequently, multiscale peridynamic model of concrete with hierarchical element size was constructed. Total number of elements in multiscale model is decreased significantly comparing with the ones in common model using uniform element size. Corresponding algorithm and computing program of the proposed method was implemented in MATLAB. A few benchmark numerical examples were performed to verify both the accuracy and efficiency of the developed model in analyzing mass diffusion in concrete. These examples clearly demonstrate that high diffusivity of ITZs tends to accelerate mass migration along concentration gradient, and thickness of ITZs is a pivotal factor to affect the mass diffusion in concrete.

Key words: Multiscale peridynamics model, Mass diffusion, ITZ, Adaptive meshing method, Concrete

ORIENTATION-DEPENDENT RESPONSE OF PURE ZINC GRAINS UNDER INSTRUMENTED INDENTATION: MICROMECHANICAL MODELLING

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ABSTRACT

This paper concerns the micromechanical behaviour modelling of a pure zinc polycrystal. An inverse optimization strategy was developed to determine plastic deformation properties from instrumented indentation tests performed on individual grains of cold-rolled polycrystalline sheets. Nanoindentation tests have been performed on grains using a spherical-conical diamond indenter, providing load-penetration depth curves. The crystalline orientation of those grains has been determined using an EBSD analysis. Furthermore, a crystal plasticity model has been implemented in the finite element code Abaqus using a user material subroutine. To identify the constitutive model parameters, the inverse identification problem has been solved using the MOGA-II genetic algorithm coupled with a finite element analysis of the nanoindentation test. In a first approach, the identification procedure used the load-displacement curves issued from the indentation performed on a grain of given crystalline orientation. A good agreement is achieved between experimental and numerical results. This constitutive model has been validated by simulating the indentation response of grains of distinct crystalline orientations, involving different slip systems activity rates.

Key words: HCP, Crystal plasticity, inverse identification, nanoindentation, finite element analysis

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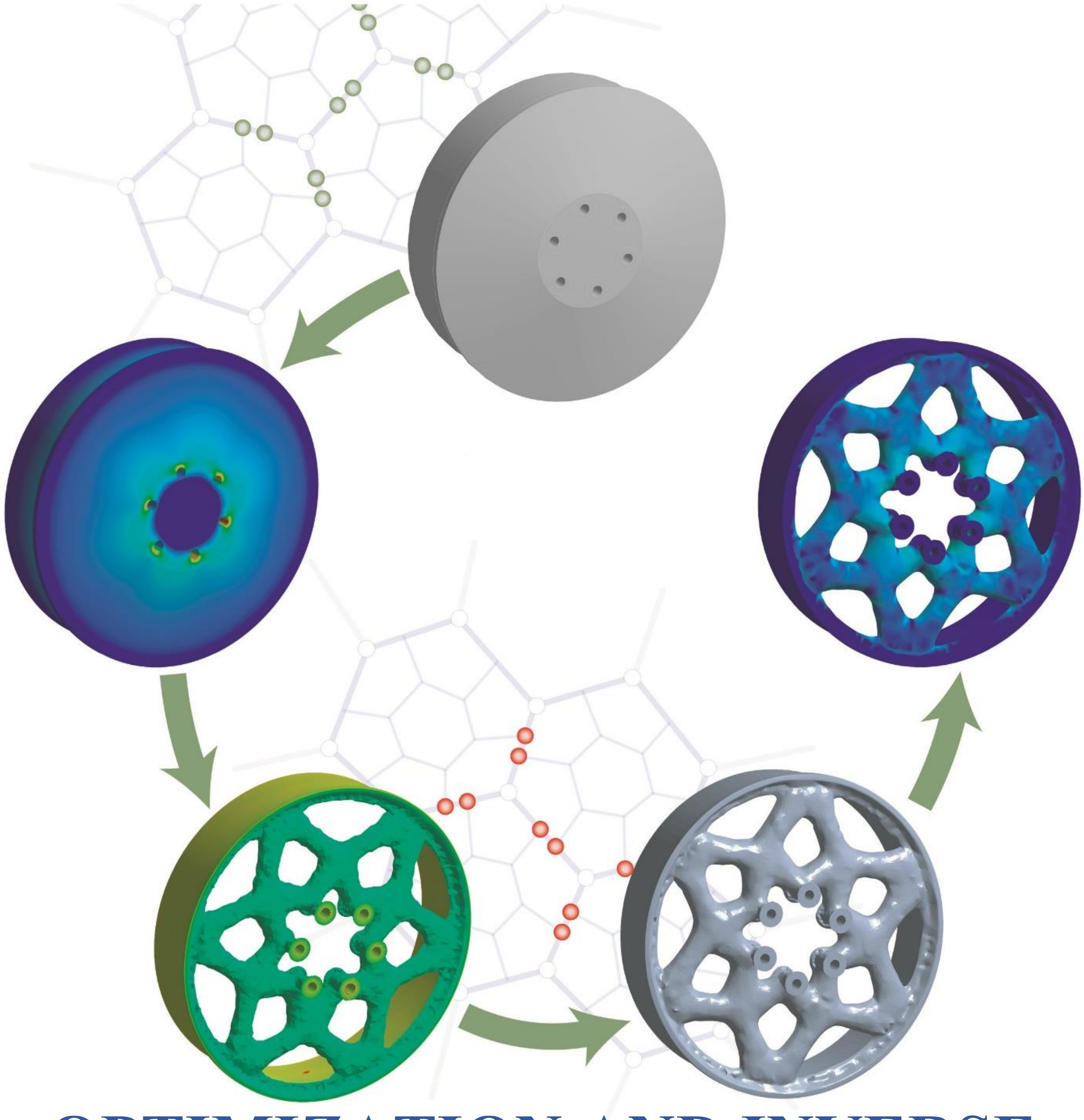

OPTIMIZATION AND INVERSE PROBLEMS

(OIP)

OPTIMIZATION OF THE LONGITUDINAL COOLING FIN BY LEVENBERG-MARQUARDT METHOD

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ABSTRACT

The optimization of longitudinal cooling fin by using Levenberg-Marquardt method is present in this paper. The shape of the fin is constructed by B-spline curve in which the control points of the B-spline are regarded as optimization variables. Furthermore, a mechanism “volume updating” is introduced in to the Levenberg-Marquardt to minimize the volume of the optimal fin. To demonstrate the proposed method, the optimal fin of the proposed method will be compared with Schmidt’s optimal fin. From the obtained results, it can be declared that the proposed method is an efficient and accurate method in optimizing the volume of the longitudinal cooling fin.

Key words: Shape Optimization, Modified Newton Raphson, Rectangular fin, Triangular fin.

OPTIMIZATION OF TRUSS STRUCTURES USING A NEW ADJUSTED DIFFERENTIAL EVOLUTION ALGORITHM COMBINED WITH ARTIFICIAL NEURAL NETWORK

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ABSTRACT

In this paper, a new technique combing an improved version of the Differential Evolution (DE) algorithm with Artifical Neural Network (ANN) is introduced for finding the optimal mass of truss structures. The improved version of DE algorithm is obtained by modifying two steps of the original DE: mutation and selection. In the mutation phase, an adaptive scheme using multi-mutation operators is adopted for selecting target vectors in population. In the selection phase, an elitist selection technique is applied to build up the population for the next generation. In the constrained handling step of the optimization process, the ANN is used to quickly compute the respond of the structure. This helps to increase the speed of finding the solution and so, decrease the cost. The results are compared with the ones of other references and prove the effectiveness of the proposed method.

Key words: Differential Evolution (DE), Adaptive Elitist differential evolution (aeDE), Artificial Neural Network, optimization algorithm, design of truss structures.

OPTIMIZING STEEL FRAMES USING PRACTICAL ADVANCED ANALYSIS AND MICRO-GENETIC ALGORITHM

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ABSTRACT

This paper presents an effective and accurate method for optimizing space steel frames using practical advanced analysis (PAA) and micro-genetic algorithm (µGA). The practical advanced analysis using the beam-column approach is applied for predicting both the second-order effects and the inelastic behavior of structures to save computational time of the nonlinear inelastic analysis. µGA is utilized for finding the global optimal solution, and OpenMP is employed to perform parallel computing in order to reduce efficiently computational time. Some numerical examples are shown to demonstrate the accuracy and computational efficiency of the proposed method.

Key words: Micro-genetic algorithm, structural optimization , practical advanced analysis, parallel computing, steel frames.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the financial support provided by the Scientific Research Fund of Ho Chi Minh City Open University of Vietnam (No. E2017.4.13.1). This work was also supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP) (No. 2015R1A2A2A01007339).

AN ARTIFICIAL NEURAL NETWORK-BASED OPTIMIZATION OF STIFFENED COMPOSITE PLATE USING A NEW ADJUSTED DIFFERENTIAL EVOLUTION ALGORITHM

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ABSTRACT

Stiffened composite plates has been widely used in many engineering area including: construction, ship buidling, aircraft, etc. And so, the demand of optimizing the design of stiffened composite plate has also been rising. In this paper, a so-called ABDE (ANN-Based Differential Evolution) algorithm is introduced to search for the optimal design of stiffened composite plates. The new algorithm is the combination of the Artifical Neural Network (ANN) and an improved Differential Evolution (DE) algorithm in solving optimization problems. In this technique, the ANN helps to quickly compute the respond of the structure which is used in constraint handling step or finding the objective function of DE algorithm. This helps to decrease the cost and increase the speed of convergence effectively.

Key words: Differential Evolution (DE), Artificial Neural Network (ANN), optimization algorithm, stiffened composite plate, composite structures

A QUICK COMPUTATIONAL METHOD FOR IMPROVING AERODYNAMIC SHAPE OF UAV WING

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ABSTRACT

To obtain optimal aerodynamic 3D shape of small-sized UAV wing at small flight speed and high lift coefficient, the optimization problem is set to minimize drag coefficient with fixed plane form and constant lift coefficient. The thickness chordwise function is assumed to be given. The direct optimization problem must to be solved by CFD methods with viscosity consideration in 3D flow that involves a great volume of computations which is feasible only on super computers [1,6]. The paper presents a combined direct – inverse method that makes the optimization problem be feasible on ordinary PC.

Key words: Computational mechanics, wing shape optimization, CFD, vortex lattice method.

A POLYTREE-BASED ADAPTIVE POLYGONAL FINITE ELEMENT METHOD FOR MULTI-MATERIAL TOPOLOGY OPTIMIZATION

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Key words: Polytree, topology optimization, multi-material, optimality criteria method, adaptive filter, alternating active phase.

ABSTRACT

This paper presents a novel adaptive methodology for multi-material topology optimization problem. Polytree data structure is introduced as a general recursive multi-level mesh that automatically refined in processing based on error analysis. In order to resolve hanging nodes in element edges, the Wachspress coordinate is employed on a reference element before using a mapping scheme to obtain shape functions and their derivatives for any polygons. A new way in definition of filter radius is also introduced to improve the efficiency of filters and optimal results. The combination of poly-tree meshes and adaptive filters do not only clarify the interfaces between material phases (including void phase), but also decrease the computing time of overall process in comparison by using the regular fine meshes. Several benchmark and practical problems are considered to illustrate the advantage of the proposed method.

ENGINEERING OPTIMIZATION USING AN IMPROVED EPSILON DIFFERENTIAL EVOLUTION WITH DIRECTIONAL MUTATION AND NEAREST NEIGHBOR COMPARISON

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ABSTRACT

In this paper, an efficient differential evolution (DE) algorithm is presented to solve constrained optimization problem. To skip unnecessary function evaluations, a simple mechanism called nearest neighbor comparison (NNC) is applied. The NNC is a method to prejudge a solution by its nearest point in the search population, so that unpromising solution will be skipped without evaluation. The NNC has been proposed to reduce the number of function evaluations effectively in unconstrained optimization. In this study, the NNC method is proposed for constrained optimization by combining with the ε constrained method. Moreover, a simple directional mutation rule is introduced to increase the possibility of creating improved solutions. Both the NNC method and the directional mutation rule do not require additional control parameter for DE, as often found in several modified DE variants. The effectiveness of the proposed constrained DE algorithm, named as εDEdn, is illustrated by solving five benchmark engineering design problems. The results show that the NNC combined with the ε constrained method can omit up to fifty percents function evaluations. It is also shown that the direction mutation can increases the convergence rate of the optimization. Comparing with other state-of-the-art DE variants reported in the literatures, the proposed DE often gives equal or better results with considerably smaller number of function calls.

Key words: Engineering optimization, differential evolution, directional mutation, nearest neighbor comparison, epsilon constrained method

NONDESTRUCTIVE VIBRATIONAL TESTS AND ANALYTICAL SOLUTIONS TO DETERMINE THE YOUNG'S MODULUS OF RAMMED EARTH MATERIAL

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ABSTRACT

Rammed-earth (RE) is a construction material which is manufactured from the soil. The soil is dynamically compacted at its optimum water content, inside a formwork to build a monolithic wall. The RE wall is composed of several layers, about 10-12 cm thick. In the last decades, RE material has been the focus of numerous scientific researches because of sustainable properties of this material: low embodied energy, positive hygro-thermal behaviour and a particular esthetic aspect. In several situations, nondestructive methods are needed to assess the mechanical characteristics of RE material, for both old and new RE constructions. This paper presents how in-situ vibrational measurements can be used to identify the dynamic behavior of RE walls and to determine the Young's modulus of the RE walls measured.

To determine Young's modulus from the dynamic characteristics, an analytical model based on Timoshenko's beam theory is presented, both for flexural and torsional modes. Then, the proposed analytical model is verified with measurements on several walls having different cross-section forms: rectangle and L-shape. The walls' natural frequencies were identified from the dynamic measurements by using the Frequency Domain Decomposition method. In parallel, for the comparison, the Young's modulus of the RE material studied were also determined by classical static measurements (on the walls, prismatic and cylindrical specimens). The displacements were measured by using the Image Correlation technique. The comparisons showed that the results from the proposed analytical method provided high accuracies and better than that obtained by measurements on the usual specimens (prismatic and cylindrical).

Key words: rammed earth, natural frequencies, Young's modulus, nondestructive testing, sustainable development

A SEQUENTIAL METHOD IN ESTIMATING LASER HEAT FLUX ON THREE-DIMENSIONAL CONDUCTION MODEL

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ABSTRACT

Estimation of laser heat flux in three-dimensional conduction model by using a sequential method is presented in this paper. The advantages of this method are that no preselected functional form for the unknown absorption coefficient is necessary and non-linear least-squares is needed in the algorithm. Two examples have been fulfilled to demonstrate the proposed method. The obtained results can be concluded that the proposed method is an accurate, robust, and stable method to inversely determine the laser heat flux in three-dimensional conduction model.

Keywords: Laser heating, Inverse Problem, Laser heat flux, Parameter estimation

AERODYNAMIC OPTIMAL DESIGN FOR WIND TURBINE AIRFOIL USING INTEGRATED OPTIMIZATION METHOD

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ABSTRACT

In this work, a new approach for aerodynamic optimization of wind turbine airfoil is presented. This technique combines commercial computational fluid dynamics (CFD) codes with differential evolution (DE), a reliable gradient-free global optimization method. During the optimization process, commercial CFD codes are used to evaluate aerodynamic characteristics of wind turbine airfoil and an improved DE algorithm is utilized to find the optimal airfoil design. The objective of this research is to maximize the aerodynamic coefficients of wind turbine airfoil at the design angle of attack (AOA) with specific ambient environment. The airfoil shape is modelled by control points which their coordinates are design variables. The reliability of CFD codes is validated by comparing the analytical results of a typical wind turbine airfoil with its experimental data. Finally, the optimal design of wind turbine airfoil is evaluated about aerodynamic performance in comparison with existing airfoils and some discussions are performed.

Key words: design wind turbine airfoil, differential evolution, computational fluid dynamics, integrated optimization

GRAPH REPRESENTATION FOR STRUCTURAL TOPOLOGY OPTIMIZATION USING MODIFIED DIFFERENTIAL EVOLUTION ALGORITHM

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ABSTRACT

This paper present a graph representation based on B-spline curves and differential evolution (DE) al- gorithm to define optimal topologies of structures. In which, a simple graph is predetermined by the user but it is not easy for each different object. Therefore, a new technique based on an automati- cally connected graph representation which requires the number of vertices is proposed to increase the flexibility and effectiveness in search process as well. In this method, a graph for structure is de- fined by coefficients of connected matrix determined based on the number of vertices. Each edge of the graph is a cubic B-spline curve divided into many segments corresponding to different values of thickness. Topology optimization using graph representation overcomes drawbacks such as gray scale and checkerboard. Moreover, a modified differential evolution (mDE) is used to reduce computational cost but mDE still ensures the ability to find the global solution. In optimization problems, compliance considered as objective function is minimized and subject to constraint and design variable vector con- sists of both continuous and discrete variables. Finally, several structures are investigated to verify the effectiveness of the proposed method by comparing gained results with those from the previous method in the literature.

Key Words: Topology optimization, Graph representation, B-spline curve, Differential evolution (DE), Modified diferential evolution (mDE)

MULTI-MATERIAL TOPOLOGY OPTIMIZATION OF NON-UNIFORM THICKNESS THIN PLATE

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ABSTRACT

The study contributes to evaluate multiphase topology optimization design of non-uniform thickness thin plate by using Kirchhoff plate theory. By ignoring the van der Waals interaction between two adjacent plates, non-uniform thickness thin plates are described as a single-layer sheet. Stiffness and adjoint sensitivity formulations linked to non-uniform thickness plate potential energy are proposed in terms of multiphase design variables. The mathematical formulations of complaint sensitivity with respect to variable thickness and multi-material densities are derived and their sensitivities are investigated. Multiphase optimization problem is solved through alternative active-phase algorithm with Gauss-Seidel version as an optimization model of optimality criteria. In the present study, compliance of multiple material non-uniform thickness thin plate with variable thickness is minimized. Numerical examples demonstrate interactions between linearly or non-linearly non-uniform thickness and multiple materials to thin mid-plates with the same amount volume fraction and total structural volume.

Key Words: multiple materials, topology optimization, linearly and non-linearly non-uniform thickness, Kirchhoff plate, finite element method

OPTIMAL TOPOLOGY DESIGN OF MULTI-MATERIAL STRUCTURES UNDER STIFFNESS AND STRUCTURAL BUCKLING CONSTRAINTS

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ABSTRACT

This study contributes to analyzing continuum structures under buckling and volume constraints based on multi-material topology optimization. The solutions for spurious buckling mode which occurs within multi-material topology optimization process are given and discussed. Moreover, the changing optimal topologies of single material structure and multi-material structure corresponding to different buckling constraints are presented. An investigation of buckling constraint parameter is described and it allows single-objective minimum compliance topology optimization to obtain two objectives of maximizing both structure stiffness and first buckling load factor. A Jacobi active-phase algorithm is used to generate the multi-phase topology optimization. It provides a rational solution appropriated to topology optimizer, Method of Moving Asymptotes (MMA) due to confliction in updating design variables. Density distributions of multiple materials determined by topology optimization are based on Solid Isotropic Material with Penalization (SIMP) approach and two-dimensional finite element formulation. Numerical examples of compressed structures considering structural instability are performed to use both single material and multiple materials and verify efficiency and superiority of the present method. In addition, the effectiveness of multi-material structures in stability improvement is verified.

Key Words: multi-material, topology optimization, buckling constraints, Jacobi active-phase algorithm, spurious buckling mode, structural stability

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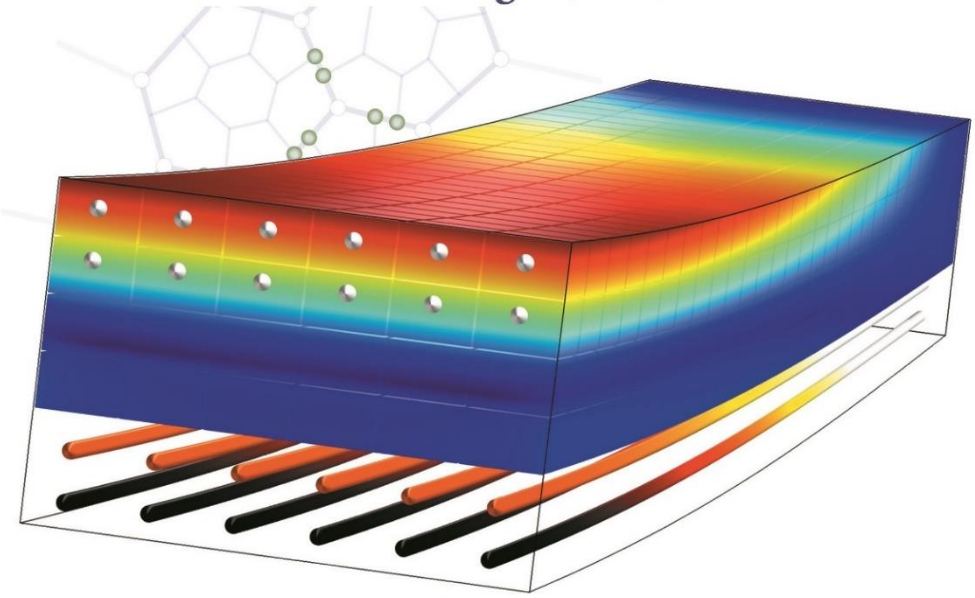

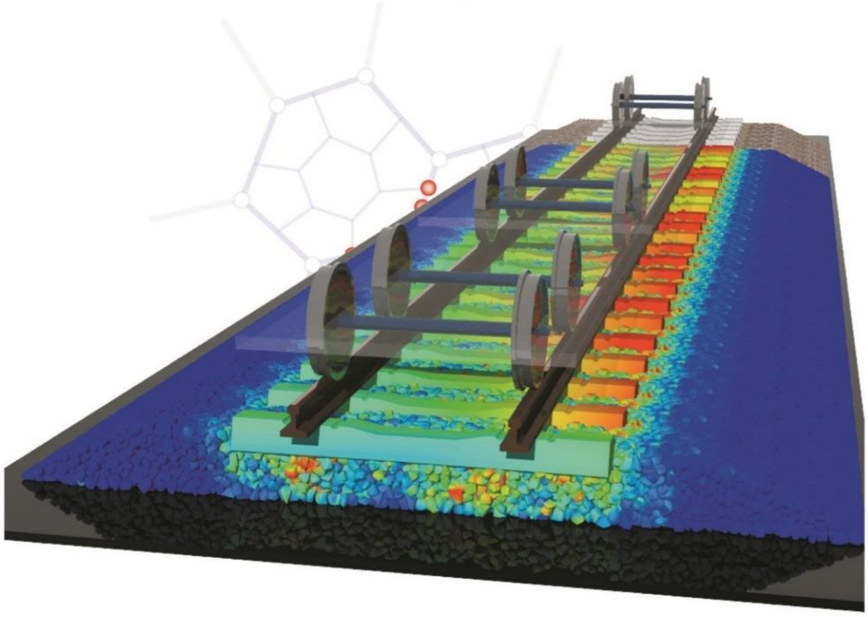

REINFORCED CONCRETE, STEEL AND STEEL-CONCRETE COMPOSITE STRUCTURES (RCSS)

SHEAR CAPACITY OF PARTIALLY UNBONDED POST-TENSIONED CONCRETE T-BEAMS STRENGTHENED WITH CFRP AND GFRP JACKETS

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ABSTRACT

Existing codes and design guidelines have not mentioned a procedure to calculate the shear resistance of partially unbonded post-tensioned reinforced concrete (RC) beams strengthened with fiber reinforced polymer (FRP) sheets. Up to date, the number of studies about the shear behaviour of post-tensioned RC beams strengthened with FRP in shear is very limited, particularly for partially unbonded post-tensioned RC beams. The effect of many factors on the shear resistance of such the beams has not been well investigated, for example, fiber factors (the type of fiber, the strengthening scheme, and the number of layers), the concrete strength, and the ratio of the shear span to the effective depth (a/d_e). This study investigates the shear behaviour of partially unbonded post-tensioned RC beams strengthened with U-shaped FRP strips. The experiment consists of 22 partially post-tensioned RC beams with T section and unbonded tendons. The variables include three concrete strengths (38 MPa, 55 MPa, and 73 MPa), two numbers of FRP layers (1 and 2 layers), U-shaped FRP strips (continuous and spaced), two types of FRP (CFRP and GFRP), and varied the ratio a/d_e. The testing results have shown that the FRP shear strengthening is more effective with higher concrete strength. The number of FRP layers, strengthening schemes, and type of FRP have a slight influence on the shear resistance of the beams but they significantly affect the ultimate deformation of the FRP jackets. The efficiency of using U-shaped FRP strips considerably reduces with a reduction of the ratio a/d_e. As a result, the existing design guides may not yield reliable predictions since they have not considered this ratio. Particularly, the effect of the ratio a/d_e becomes more prominent when it is small, which can lead to a huge variation between the predicted strength and its actual value.

Key words: concrete strength; shear span to effective depth ratio; fabric thickness; fabric-epoxy U-wraps; carbon fabric; glass fabric; partially unbonded post-tensioned concrete beam; shear capacity.

ACKNOWLEDGMENTS

This research was funded by Vietnamese Foundation for Science & Technology Development (NAFOSTED) under Grant No. 107.99-2015.30.

IMPLEMENTATION OF MULTISURFACE CRYSTAL PLASTICITY FOR MICRO CUTTING SIMULATIONS

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ABSTRACT

The finite element (FE) simulation of micro machining processes of commercially pure-titanium involves several challenges, for example the contact between tool and chip, the material separation, the large deformation and the complicated nonlinear behaviour of the material.

In order to obtain a stable FE implementation, a robust formulation of the material model is required. In contrast to machining processes on the macroscale, the crystallographic hexagonal-closed-packed structure of cp-titanium has to be taken into account for micro machining processes. The elastic material behaviour is described by a hyperelastic, compressible Neo-Hookean material law. The plastic part involves the plastic crystallographic slip, quantified by plastic coefficients, satisfying the Karush-Kuhn-Tucker (KKT) conditions [1,2]. It is crucial to determine the plastic coefficients with a robust predictor-corrector algorithm. In contrast to single slip crystal plasticity, the set of active slip systems in multisurface crystal plasticity with more than one active slip system is not necessarily unique. Therefore, the active set cannot be determined solely by the predictor, and the algorithm has to be extended by additional criteria. However, there are critical deformation states, where no valid active set, satisfying the KKT conditions, can be found by the active set search based on the elastic predictors, resulting in an unstable algorithm [1,3]. In order to obtain a robust active set search implementation, the KKT conditions can be replaced by an equivalent system of Fischer-Burmeister (FB) complementary functions. If plastic slip occurs, indicated through the elastic predictor of one of the slip systems, the system of FB-functions is solved for all slip systems. The active set is determined implicitly by solving the system [3]. Comparative simulations with both algorithms show the robustness of the implicit active set search.

An example of 3D micro cutting simulation with the implicit active set search is given with the aim to investigate the influence of the crystal orientation on the cutting forces and the surface morphology.

Key words: crystal plasticity, large deformation, Fischer-Burmeister function, finite element method

EXPERIMENTAL AND NUMERICAL RESEARCH ON THE FIRE BEHAVIOR OF STEEL COLUMN PROTECTED BY GYPSUM PLASTERBOARD UNDER FIRE CONDITION

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ABSTRACT

In Vietnam, the fire problem in steel structures is relativity much, thus the study of fire protection solutions for the load-bearing steel structures (beams, columns) is very important in the building. One of solution is the use of gypsum plasterboard. This paper presents firstly an experimental identification of the thermal conductivity of gypsum plasterboard used in Vietnam, and then a full-scale experimental investigation relative to the fire resistance of steel column protected by gypsum plasterboard. In parallel, a numerical model is also developed in order to simulate the thermal transfer and mechanical behaviour of steel column protected by gypsum plasterboard under fire conditions. This model is used to compare with the experimental results and to analyses the influence of different parameters on the fire behaviour of steel column protected by gypsum plasterboard in Vietnam conditions.

Key words: Steel column, fire resistance, gypsum plasterboard, fire test, numerical model

NUMERICAL STUDY ON A NEW THROUGH-COLUMN-TYPE JOINT FOR RCS FRAME

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ABSTRACT

Hybrid RCS frames consisting of reinforced concrete (RC) column and steel (S) are used frequently in practice for mid- to high-rise buildings. RCS frames possess several advantages from structural, economical and construction view points compared to either traditional RC or steel frames. One of the key elements in RCS frames is the beam-column joints. This paper deals with numerical study on static response of a new Reinforce Concrete-Steel (RCS) exterior beam-column joint. The studied beam-column joint detail is a through-column type in which an H steel profile totally embedded inside RC column is directly welded to the steel beam. The H steel profile was covered by two supplementary plates in the joint area. This detail provides two main advantages: the column is continuous and no the stirrups in the joint area are needed. The nonlinear behavior of the new joint is studied numerically and showed that this proposed joint is suitable as a special moment connection. In addition, the parametric studies are carried out to investigate the influences of the stirrups, the encased profile length and supplementary plate length on the behaviour of the joint.

Keywords: Beam-column connection, RCS joint, FE modeling.

A PHASE FIELD MODEL TO STUDY THE INFLUENCE OF TEMPERATURE ON MARTENSITIC TRANSFORMATIONS

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ABSTRACT

Iron, as an allotrope, exhibits different solid phases on the microstructure featuring different crystal configuration variants with varying material properties. A martensitic phase is usually desired near the surface, rendering the workpiece more resistant to e.g. mechanical wear. A transformation might be induced either by cooling, or by applying pressure. A process, which aims at machining the final form as well as achieving surface hardening simultaneously, rather than subsequently, is cryogenic turning. During the process a locally and temporally dependent temperature field and mechanical loading arises, motivating our here presented finite element study [1].

We study the martensitic transformation (MT) by means of a phase field model. In this work, two allotropes of iron are of interest: an austenitic (fcc) parent phase and the martensitic (bcc) phases, extending the model proposed in [2]. Order parameters are used to scale between the parent phase and the martensitic phases. Molecular dynamic simulations suggest that the Nishiyama-Wasserman (NW) path of the martensitic transformation is more favourable than the Bain path [3]. However, as considering the NW path would require to take 12 transformation paths into account, we choose the Bain orientation relationship, accounting only for three paths.

Temperature dependency of the phase separation potential is assumed. For the sake of interchangeabil- ity, we use hyper-dual numbers to calculate numerically exact first and second order derivatives [4]. The model is implemented in the finite element code FEAP, with the order parameters and the displacements as degrees of freedom. Numerical examples are given to illustrate the features of this model.

Key Words: phase field model, martensitic transformation, finite element

NUMERICAL ANALYSIS THE BEHAVIORS OF END-PLATE BEAM-TO-COLUMN STEEL JOINTS UNDER CYCLIC LOADING

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ABSTRACT

This article presents implementation and calibration of Modified Richard-Abbott model for cyclic response of a partial-strength composite joint. The joints parameters are found and the comparison between the analytical hysteretic results and the experimental hysteretic results is made as well as the hysteretic energy dissipated evaluated for each cycle and obtained for both type of analyses. The behavior of the partial-strength composite joint is analyzed under several cyclic loading. The accumulated dissipated energy and the dissipated energy in a load cycle are discussed related to the degradation of a steel-concrete composite joint.

Key words: Dissipated energy, the steel-concrete composite joints, the hysteretic moment-rotation curve, partial-strength composite joint, the rigidity degradation of the joint

FLEXURAL BEHAVIOR OF UNBONDED POST-TENSIONED CONCRETE T-BEAMS EXTERNALLY BONDED WITH CFRP SHEETS UNDER STATIC LOADING.

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ABSTRACT

This paper presents a study on flexural behavior of post-tensioned prestressed concrete (PC) T-beams externally strengthened by CFRP sheets under static loading with or without the presence of U-strip CFRP anchorage systems. A total of nine post-tensioned concrete T-beams in large size including one control unstrengthened beam and eight beams externally bonded with 2, 4 and 6 CFRP reinforcing plies were tested under static four-point loading. Two types of transverse CFRP U-strip anchorage system were also retrofitted in the shear span. The results showed that CFRP reinforcing sheet significantly increased the flexural capacity of PC T-beams (up to 37%), lessened displacement, improved ductility, reduced crack width (up to 48%), and this reduction level declined with the increase in the number of CFRP reinforcing plies. The maximum strain in CFRP sheets in strengthened PC T-beams ranged from 38.7% to 69.3% of the ultimate elongation and tended to decline with a large number of CFRP reinforcing plies. Deformation in tendons of strengthened beams was significantly affected by the CFRP reinforcing sheet and transverse U-strip anchorage system. A formulae to determine stress in unbonded tendons in CFRP-strengthened post-tensioned PC beams at ultimate limit state was proposed for flexural capacity design. The calculation results show that the proposed formula produces consistent agreement with experimental results (Mean = 0.94) and the small variation coefficient (COV= 0.14) confirms the stability of this formula.

Key words: CFRP sheet; flexural strengthening; number of CFRP layer; U-strip CFRP anchorage; post-tensioned concrete T-beams; cracking behavior; flexural capacity; formula

THEORICAL AND EXPERIMENTAL STUDIES ON HYBRID STEEL-RC WALLS

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ABSTRACT

Hybrid RCS frames consisting of reinforced concrete (RC) column and steel (S) are used frequently in practice for mid- to high-rise buildings. RCS frames possess several advantages from structural, economical and construction view points compared to either traditional RC or steel frames. One of the key elements in RCS frames is the composite shear wall consisting of several steel sections encased in reinforced concrete. Regarding the RC walls reinforced by more than one steel profile, namely hybrid steel-RC wall, although a number of researchers have focused on its various aspects, they are currently not covered by standards because they are neither reinforced concrete structures in the sense of Eurocode 2 or ACI318, nor composite steel-concrete structures in the sense of Eurocode 4 or AISC 2010. This paper deals with theoretical and experimental study on hybrid walls with several embedded steel profiles. The first part of this paper is dedicated to present a tentative design model for hybrid elements (walls and columns) subjected to combined axial force, bending and shear. Particular attention will be paid to shear (longitudinal and transversal) resistances because preventing shear failure is one of the major concerns when designing a composite structural member. Next, an experimental study on the static behavior of hybrid walls subjected to combined shear and bending is presented. Six hybrid walls with different types of the structural steel-concrete connection and reinforcement detailing are tested. The specimens exhibited ductility behavior. The specimens with shear connectors (i.e. headed studs, stiffeners) were more ductile in terms of displacement ductility than the ones without connectors. Finally, to assess the validity of the developed design model a comparison between the experimental results and design predictions is presented.

Keywords: Steel-concrete hybrid shear walls, shear connection, design method, static test

AN INVESTIGATION ON LONGITUDINAL RESIDUAL STRAINS DISTRIBUTION OF THIN-WALLED PRESS-BRAKED COLD FORMED STEEL SECTIONS USING 3D FEM TECHNIQUE

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ABSTRACT

Cold formed steel sections are typically produced by cold work manufacturing processes. The amount of cold work to form the sections may induce residual stresses in the section, especially in the area of bending. Studies by previous researchers of the effects of local buckling on the failure mechanics of thin-walled compression members have shown that ultimate failure will occur when the yielding has reached most of the middle surface in the corner region of the sections. Hence, these cold work processes may have significant effects on the section behaviour and load-bearing capacity. In addition, another factor may play significant role in formed section's load-bearing capacity is the longitudinal residual strain. The longitudinal residual strain raised during forming process is one of the most important indicators that can be used to determine the geometric behaviour of the formed section and in relation to occurrence of defects such as local buckling. Since, residual stresses distribution is not uniform (Along member length). Therefore, the main motivation of this research paper is performing 3D-FE to investigate peak longitudinal residual strains of thin-walled steel plate with large bending angle along member length. A 3D finite element simulation in ABAQUS has been employed to simulate this forming process. The study concluded that, longitudinal residual strain at the section corner edge higher than rest of the corner region. These strains at the edge, are higher than the yield strain ($\boldsymbol{\varepsilon_y}$) of the formed section which occurred due to lack of transverse restraint. This lead to plate edge tend to bend toward the normal direction when it's under a high transverse bending. These cause a significant difference in longitudinal strain at plate edge.

Key words: Residual Strain, Longitudinal residual strain, finite element, 3D-FE

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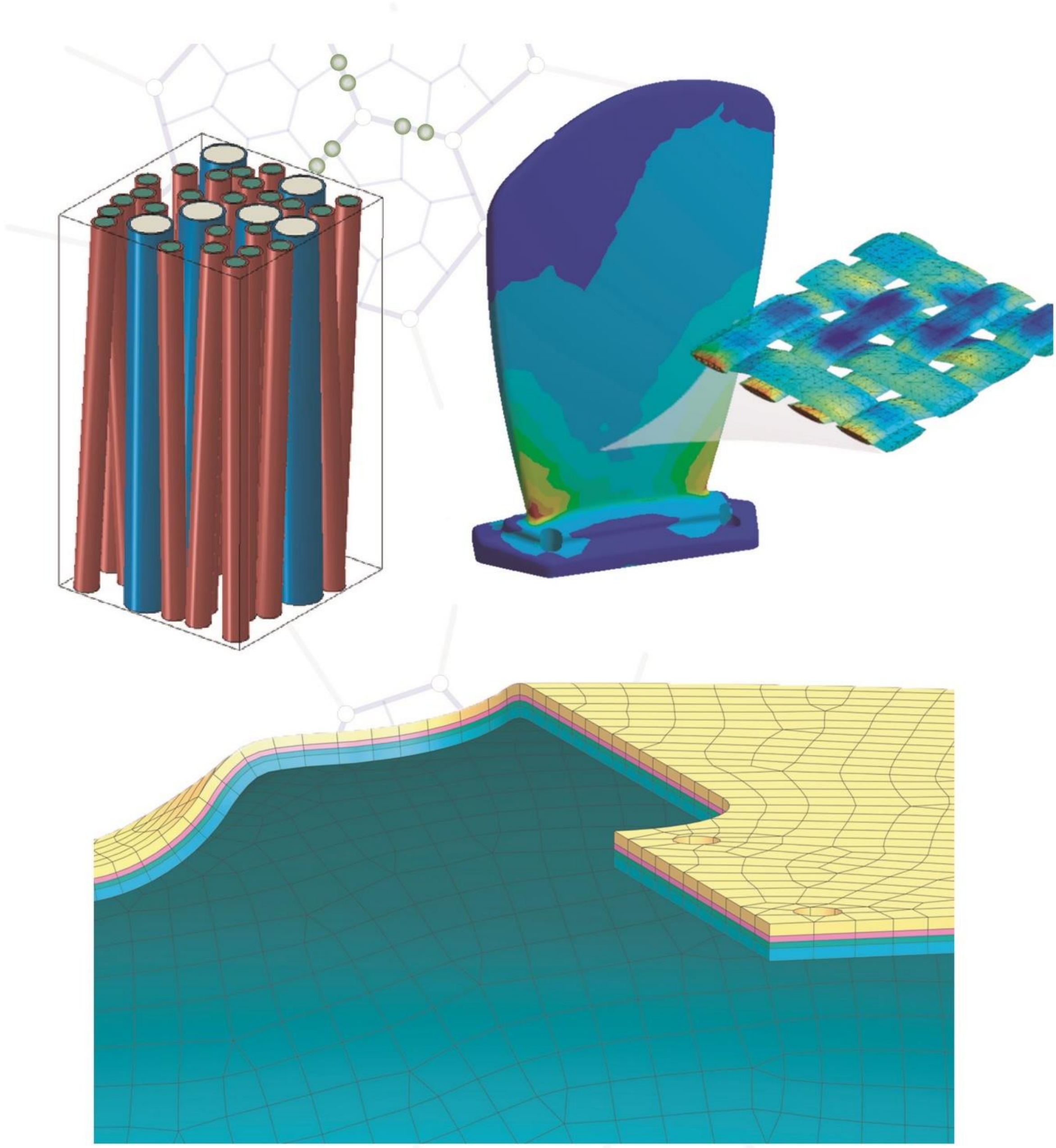

COMPOSITES AND HYBRID STRUCTURES

(CHS)

FLEXURAL STRENGTHENING OF REINFORCED CONCRETE FRAMES USING FRP

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ABSTRACT

Fibre reinforced polymer (FRP) with its distinct characteristics has become the material of choice in strengthening applications of existing reinforced concrete (RC) structures. Flexural strengthening using FRP can significantly improve the seismic resistance and thus reduce the potential damage of retrofitted RC structures in comparison to the original ones if subjected to similar seismic intensities. The current study targets on quantifying the potential damage reduction of a flexural strengthened RC frame subjected to different seismic levels based on current seismic design codes. The reduced damage indices and the positive changes on the damage of the FRP retrofitted frame are presented in this paper. Limitations of this study is also stated.

Keywords: FRP; Flexural strengthening; RC frame; Seismic load

STATIC RESPONSE AND FREE VIBRATION ANALYSIS OF FUNCTIONALLY GRADED SHELLS USING A CELL-BASED SMOOTHED DISCRETE SHEAR GAP METHOD AND THREE-NODE TRIANGULAR ELEMENTS

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ABSTRACT

A cell-based smoothed discrete shear gap method (CS-DSG3) using three-node triangular elements was recently proposed to improve the effective of the discrete shear gap method (DSG3) for static and vibration analyses of isotropic Mindlin plates and shells. In this study, the CS-DSG3 is further extended for static and free vibration responses of functionally graded shells. In the present method, the first-order shear deformation theory is used in the formulation owing to the simplicity and computational efficiency. The accuracy and reliability of proposed method is verified by comparing its numerical solution with those of others available numerical results.

Key words: cell-based smoothed discrete shear gap method (CS-DSG3), functionally graded shell, first-order shear deformation theory (FSDT).

COMPARISON BETWEEN NUMERICAL AND EXPERIMENTAL RESULTS OF THE HYBRID WALLS SUBJECTED TO BENDING AND SHEAR

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ABSTRACT

This paper presents experimental and numerical results of the hybrid walls with several encased steel profiles subjected to bending and shear. These results are compared with each other on the load bearing capacity, the strain distribution, the stress distribution, the slip distribution, the crack pattern, the failure modes... These steel-concrete composite structural elements belong to the so-called “hybrid” structures which are neither reinforced concrete structure in the sense of Eurocode 2, nor steel-concrete composite structures in the sense of Eurocode 4. Currently, there is no design calculation guide of the resistance for this type of structure in international standards. Therefore, the comparison between numerical and experimental results is performed to point out the mechanism of the load transfer and failure taking place within the hybrid walls subjected to bending and shear. It is the basis for developing a tentative design method for hybrid walls reinforced by several steel profiles. The six hybrid wall specimens were prepared and tested at the Structures Laboratory of INSA Rennes, France. The structural response of all hybrid walls specimens were simulated by a full 3D finite element model using the Abaqus software.

Keywords: Numerical simulation, experimental results, hybrid wall, static test, 3D FE model

BENDING ANALYSIS OF LAMINATED COMPOSITE BEAMS USING HYBRID SHAPE FUNCTIONS

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ABSTRACT

Bending behaviours of laminated composite beams are presented in this study. The present theory accounts for a higher-order variation of axial displacement. The governing equations are derived from Lagrange's equations. Ritz method is developed in which new hybrid shape functions are proposed for analysis of laminated composite beams with various boundary conditions. Numerical results are presented and compared with those from earlier works to validate the accuracy of the proposed solutions and to investigate effects of the span-to-height ratio, boundary conditions, fibre orientation and material anisotropy on the displacement and stresses.

Keywords: Composite beams; Ritz method; Shape function; Bending.

ACKNOWLEDGEMENTS

This research is funded by Vietnam National Foundation for Science and Technology Development (NAFOSTED) under Grant No. 107.02-2015.07.

DAMAGE-BASED SEISMIC DESIGN METHOD OF REINFORCED CONCRETE STRUCTURES

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ABSTRACT

Damage often occurs in reinforced concrete (RC) structures subjected to earthquakes. Different criteria such as stress, force, displacement and so on have been used to control the damage level in seismic design of RC structures. However, these criteria may indirectly relate to the damage of structures. The collapse and severe damage of buildings in the past earthquake events has raised doubts to these criteria and new design methods should be invented. In this paper, a seismic design method with damage control is proposed. To control the damage of structures, the damage index, which varies from 0 (no damage) to 1 (collapse), is used to quantify the damage levels. A procedure of the proposed seismic design method and its application for a case study are presented. The proposed design method shows its advantages as the damage of structures is controlled by the damage index and the distribution of damage in structures is evaluated.

Keywords: Seismic design; RC structure; Damage index

AN IN-SITU COMPRESSION TEST AND MESOSCALE MODELLING OF LIGHTWEIGHT CELLULAR CONCRETE USING X-RAY COMPUTED TOMOGRAPHY (XCT)

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ABSTRACT

In this research, the mesoscale simulation of lightweight cellular concrete (LCC) material with an in-situ compression test is presented. The LCC contains a cement binder and high ratio of random air-voids. The development of new lightweight concrete material poses new challenges to design and modelling. Using X-Ray Computed Tomography (XCT) and image-processing techniques, the microstructure of LCC can be precisely characterized and directly transferred to finite element modeling. The process of applying load is interrupted by the scanning steps to observe the response of LCC sample during the in-situ compresion test. The quasi-static simulation is performed in Abaqus software using the coupled damage plasticity mode with is able to integrate both the degradation of stiffness and plastic deformation. The numerical simulation is verified and compared with the in-situ compression test for both a stress-strain curve and cracks/damages developments. It is found that the local failure at the thin walls between pores of LCC sample govern the failure mechanism. The modelling strategy provides an effective technique to quantify and understand the underlying failure mechanism of LCC material.

Key words: Lightweight cellular concrete, XCT scan, mesoscale modeling, mesh generation, polygonal finite element method.

AN ES-FEM FOR FREE VIBRATION ANALYSIS OF FG-CNTRC PLATES

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ABSTRACT

An edge-based smoothed finite element method is extended to free vibration analysis of FG-CNTRC plates based on C0-type higher order shear deformation theory (C0-HSDT). The gradient smoothing technique based on smoothing domains associated with edges of the element is used to smooth displacement field. This gradient smoothing technique can provide proper softening effect and thus improve significantly the accuracy of solution of the FG-CNTRC plates. The material properties of FG-CNTRCs are assumed to be graded through the thickness direction according to four distributions of the volume fraction of carbon nanotubes. Some numerical examples are presented to illustrate the effectiveness of the ES-FEM compared with some existing methods for the FG-CNTRC plates.

Key words: free vibration analysis, FG-CNTRC, smoothed finite element method, carbon nanotubes (CNTs), higher-order shear deformation theory (HSDT).

ANALYTICAL BEHAVIOUR OF RECTANGULAR PLATES UNDER IN-PLANE AND LATERAL DYNAMIC LOADS

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ABSTRACT

A modified Bolotin method for the determination of the natural frequencies and mode shapes of orthotropic rectangular plates with semi rigid boundary condition is described in this paper. The presentation of the semi rigid orthotropic plate's frequency in a form analogous to the corresponding frequency of a simply supported plate is postulated, considering the wave numbers as unknown quantities. These two equations are determined from a system of two transcendental equations, obtained from the solution of two auxiliary Levy's type problems. The method was shown to be remarkably accurate when used to determine the natural frequencies of plates with non-simply supported boundary conditions. A natural extension of this research is related to the buckling and lateral vibration of orthotropic plates subjected to in-plane forces which are time invariant and constant over the area of the plate, with their principal directions parallel to the plate edges and the dynamic lateral force. It is the purpose of this paper to illustrate this extension and to demonstrate its applicability by the presentation of numerical results for a particular plate.

Key words: Modified Bolotin method, transcendental equation, auxiliary, in-plane forces, lateral force.

EQUIVALENT INCLUSION APPROACH AND APPROXIMATIONS FOR THERMAL CONDUCTIVITY OF COMPOSITES WITH FIBROUS FILLERS

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ABSTRACT

Based on the polarization approximations, the thermal conductivity of composites with randomly oriented inclusions of fiber forms is firstly derived. Equivalent inclusion approach is then developed to account for possible diversions such as non-idealistic geometric forms of the inhomogeneities using reference conductivity data. Applications involving experimental data from the literature show the usefulness of the approach.

KeyWords: Effective conductivity, polarization approximations, fibrous fillers

NONLINEAR STATIC BENDING ANALYSIS OF FUNCTIONALLY GRADED PLATES USING MISQ24 ELEMENTS WITH DRILLING ROTATIONS

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ABSTRACT

This paper develops a computational model for nonlinear static bending analysis of functionally graded (FG) plates using a smoothed four-node quadrilateral element MISQ24 [1,2] within the context of the first order shear deformation theory (FSDT). In particular, the construction of the nonlinear geometric equations is based on Total Lagrangian approach in which motion at the present state compared with the initial state is considered large. Small strain-large displacement theory of von Kármán will be used in nonlinear formulations of the smoothed quadrilateral element MISQ24 with drilling rotations. The solution of the nonlinear equilibrium equations is obtained by the iterative method of Newton-Raphson with the appropriate convergence criteria. The present numerical results are compared with the other numerical results available in the literature in order to demonstrate the effectiveness of the developed element. These results also contribute a better knowledge and understanding of nonlinear bending behaviors of these structures.

Key words: Functionally graded plates, nonlinear static bending analysis, first-order shear deformation theory (FSDT), drilling rotations

A NODE-BASED MITC3 ELEMENT FOR STATIC ANALYSES OF LAMINATED COMPOSITE PLATES USING THE HIGHER-ORDER SHEAR DEFORMATION THEORY

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ABSTRACT

In this paper, the node-based smoothed finite element method is developed for three-node triangular plate elements using the mixed interpolation of tensorial components (MITC) technique to remove the shear locking. The C^0-type continuous plate elements represent the higher-order shear deformation theory of laminated composite plates by adding two degree of freedoms related to derivatives of deflection. Based on the MITC3 technique for three-node triangular degenerated shell elements, an explicit formulation of gradients of the transverse shear strains is derived. The constant strain fields within the C^0-type continuous plate elements are averaged over node-based domains defined by connecting the centroids and edges' middle points of elements having common nodes. The proposed elements, namely NS-MITC3, show good accuracy and convergence as compared to other plate elements when employed to the static analysis of laminated composite plates.

Key words: Node-based smoothed finite element method (NS-FEM), mixed interpolation of tensorial components (MITC), higher-order shear deformation theory (HSDT), laminated composite plates

OPTIMISATION OF FOAM-FILLED AUXETIC UNIT CELLS UNDER EXTREME LOADING

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ABSTRACT

The design of structures against extreme loading events such as blast and impact requires an increase in performance for a low weight structure. Lightweight sandwich panels offer increased performance compared to an equivalent mass monolithic panel under these such events. The core of the sandwich panel is of interest in their design, for which auxetics will be further investigated in this research. Auxetics are materials and structures with a negative Poisson's ratio, meaning they will contract laterally under an axial compressive load and vice versa. This will bring more material to the point of impact, offering increased energy absorption, toughness, and indentation resistance, ultimately making them desirable as protective structures. Due to the auxetic phenomenon in the sandwich panel's core, greater densification will also occur under loading, utilising more of the core material. Studies into the performance of auxetic structures under extreme loading is still limited, and a greater understanding of their response with infill materials is a focus in this research.

The core itself is made of a repeated foam-filled auxetic unit cell, which has been optimised under a compressive displacement. Several unit cell geometries were considered, with one such unit cell being the 2D re-entrant honeycomb. Optimisation was performed in Abaqus for the unit cell's design parameters including: wall thickness, bottom length, and depth of the re-entrant section, keeping the mass constant. This was then assessed against two criteria, maximising the energy absorption and minimising the peak reaction force generated during loading. Metamodelling was used to generate the data for the creation of a Response Surface based on Latin Hypercube Design. The cubic polynomial approximation provides the best fit for the data, from which the optimal parameters have been obtained for the maximum amount of energy absorbed and a constrained peak reaction force. Additionally, the importance of the infill material is seen in comparisons to the hollow unit cells. Validation of the model based on experimental data will still need to be performed. Using this optimisation method the design of the core can be streamlined, as only a single unit cell is modelled as opposed to the whole core, with extra simulations of the whole panel necessary to confirm the optimised design is true for the larger model.

Key words: Auxetic, negative Poisson’s ratio, optimisation, impact

STATIC ANALYSIS OF FG-CNTRC PLATES USING HIGHER-ORDER SHEAR DEFORMATION THEORY

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ABSTRACT

This paper presents a simple formulation based on HSDT to study the static analysis of functionally graded carbon nano-reinforced composite (FG-CNTRC) plates. The material properties of FG-CNTRCs are assumed to be graded through the thickness direction according to four distributions of the volume fraction of carbon nanotubes. The governing equation is approximated according to the HSDT model using the edge-based smoothed finite element method (ES-FEM). This hence does not require shear correction factors and improves significantly the accuracy of transverse shear stresses. The stiffness formulation of the ES-FEM is performed by using the strain smoothing technique over the smoothing domains associated with edges of elements. The accuracy and reliability of the proposed method are confirmed in several numerical examples.

Key words: FG-CNTRC, carbon nanotubes (CNTs), higher-order shear deformation theory (HSDT), static analysis.

A PULL-OUT TEST TO CHARACTERIZE THE FIBRE/MATRIX INTERFACES AGEING OF HEMP FIBRE REINFORCED POLYPROPYLENE COMPOSITES

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ABSTRACT

The fiber/matrix interface of natural fibers reinforced polymer composites is the weak zone that limits their use in some applications. The exist methods of fibre/matrix interface characterization are usually expensive and complexes. Also, the 'real' properties of the interface have not been well taken in the Interfacial Shear Strength (IFSS) calculation. Therefore, a pull-out test has been developed recently in our laboratory to limit these shortcomings. Moreover, the interface ageing by environmental factors like relative humidity (RH) is still not clearly characterized. The developed method was then applied to investigate the interface deteriorations of the hemp fibres reinforced polypropylene composites due to moisture accelerated ageing. By this way, fifty single fibre micro-composite specimens were tested after one week. The pull-out test was realized using an in-situ micro tensile machine. The IFSS was then determined considering the non-regular geometry and the non-constant of the fiber cross section. The results show that the humidity exposition weakens severely the fiber-matrix adhesion, and then the fibers were pulled out effortlessly from the matrix. Furthermore, qualitative deteriorations of the fibre and the interface were noted by optical observations. The IFSS was also severely reduced to 42:97% after 1 week. The qualitative deteriorations and the reduction of the mechanical properties of the interface were explicated by the occurrence of several of phisico-chimical phenomena during the ageing.

KeyWords: Hemp, polypropylene, interface characterization, pull-out test, moisture aging

FINITE ELEMENT SIMULATION OF THE STRENGTH OF CORRUGATED BOARD BOXES UNDER IMPACT DYNAMICS

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ABSTRACT

In this study, we propose a model based on the finite element method to study the behavior of corrugated cardboard boxes subjected to shocks. To reduce the preparation of the CAD model and the computational times, we have developed an elastoplastic homogenization model for the corrugated cardboard. The homogenization consists in representing a corrugated cardboard panel by a homogeneous plate. A through thickness integration on a representative volume element (RVE) containing a flute and two flat linerboards is proposed. Each constituent is considered as an orthotropic elastoplastic material with specific hypotheses for the corrugated medium. The model was implemented in the finite element software ABAQUS. Damage boundary curve (DBC) for corrugated cardboard boxes are defined by experimental testing and finite element simulations using the proposed model. The numerical results obtained are in good agreement with the experimental results.

Key words: Corrugated cardboard, finite element, homogenization, impact dynamics

A MOVING ELEMENT METHOD FOR THE DYNAMIC ANALYSIS OF COMPOSITE PLATE RESTING ON A PASTERNAK FOUNDATION SUBJECTED TO A MOVING LOAD

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ABSTRACT

The paper proposes a new computational approach using the moving element method (MEM) for simulated dynamic responses of composite plate resting on a Pasternak foundation subjected to a moving load based on the first-order shear deformation theory (FSDT). The dissipation mechanisms are derived in establishment the governing equation of the composite plate resting on a Pasternak foundation. The governing equations as well as the plate element mass, damping and stiffness matrices are formulated in a convected coordinate in which the origin is attached to the applied point of the moving load. Thus, the proposed method simply treats the moving load as 'stationary' at the node of the plate to avoid updating the locations of the moving load due to the change of the contact points on the plate. To verify the accuracy of the proposed method, the dynamic response of composite plate without foundation subjected to a moving load is first investigated. The results obtained in this study are compared with other published results in the literature. Next, a parametric study is performed to examine the effects of the Pasternak foundation, dissipation mechanisms, load's velocity, the material properties of the composite plate on the dynamic response.

Key words: Moving element method, composite plate, Pasternak foundation, dissipation mechanisms, moving load.

OPTIMAL VOLUME FRACTION OF FUNCTIONALLY GRADED BEAMS WITH VARIOUS SHEAR DEFORMATION THEORIES

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ABSTRACT

In this paper, the volume fraction optimization of functionally graded beams for maximizing the first natural frequency is investigated. Different formulations using three, four and five parameters are used to describe volume fraction. Navier's solutions based on various shear deformation theories are developed to compute the natural frequencies. A new meta-heuristic algorithm called Social Group Optimization (SGO) is proposed for the first time to solve the functionally graded beam optimization problem. Optimal volume fractions for beams with different ratios of material properties are then obtained. It is found that, the five parameter distribution gives the highest first natural frequency for all cases. Moreover, the results show consistency of the optimal volume fractions obtained by different shear deformation theories. It is also confirmed that SGO is an efficient tool for this complicated optimization problem.

Key words: Functionally graded beam, shear deformation theory, volume fraction, free vibration, social group optimization

RELATIONSHIP BETWEEN DENSITY AND COMPRESSIVE STRENGTH OF FLY ASH BASED GEOPOLYMER FOAM CONCRETE: EXPERIMENTAL AND NUMERICAL APPROACH

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Key words: Discrete Element Method (DEM), foam concrete, air-void, strength-density.

ABSTRACT

This paper investigates the effects of material density and air-void contents on the compressive behaviour of a fly ash based geopolymer foam concretes (FGFC) using experiment and the discrete element method (DEM). By comparing DEM with experiment, this work demonstrates the capability of DEM in modelling the complicated behaviour of FGFC, which feature high porosity, complicated internal structure and complex fragmentation process. The validated DEM model is then used to systematically study the effects of particle size, air-void features and material density on the compressive strength of FGFC. A non-linear relationship between the compressive strength and density of the foamed concrete is found from DEM simulations, which are consistent with our experimental findings. Furthermore, it is found that the air-void distribution has a significant influence on the compressive strength of FGFC, while the mortar particle size in DEM seems to have less influence on the material loading bearing capacity if their size is small and uniform enough. To this end, this paper suggests that DEM could be considered as an alternative tool, besides laboratory tests that usually require significant resources, for characterising the mechanical behaviour of FGFC.

A MODIFIED MOVING KRIGING INTERPOLATION-BASED MESHFREE METHOD WITH REFINED SINUSOIDAL SHEAR DEFORMATION THEORY FOR ANALYSIS OF FUNCTIONALLY GRADED PLATES

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ABSTRACT

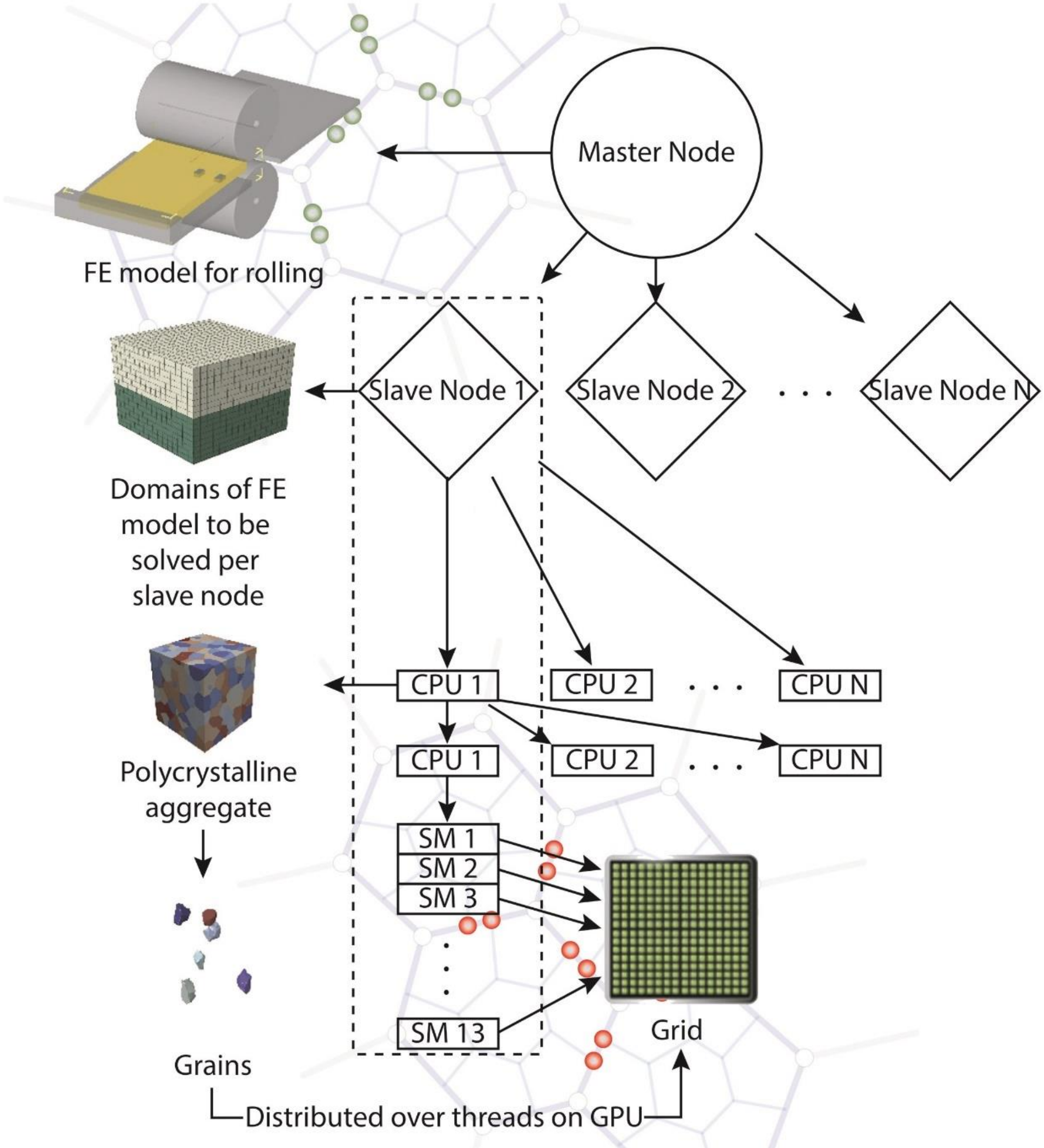
This paper presents a new numerical approach based on a modified Moving Kriging–interpolation meshfree method integrated with the refined sinusoidal shear deformation plate theory to analyze static bending and free vibration of functionally graded plates. Unlike traditional higher order shear deformation plate theories, this theory presented retains only four governing equations, accounts for a sinusoidal distribution of the transverse shear strains through the thickness of the plate, and satisfies the zero traction boundary conditions on the top and bottom surfaces of the plate without using shear correction factor. A new modified Gaussian correlation function to construct MK interpolation shape functions is presented. We first propose the formulation and then provide comparison studies via numerical examples, which are performed to confirm the accuracy and reliability of the proposed method.

Key words: Functionally graded material, meshfree methods, Sinusoidal shear deformation theory, Moving Kriging interpolation

ACOME 2017

Phu Quoc Island, Vietnam

2 - 4 August, 2017



NUMERICAL METHODS AND HIGH PERFORMANCE COMPUTING (NMHPC)

EFFICIENT IMPLEMENTATION OF COMPLEX ELASTO-PLASTIC MODELS IN HIGH PERFORMANCE COMPUTING SYSTEMS

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ABSTRACT

New energy production technologies like fracking and enhanced geothermal systems, requires simulation of rock fracturing and fractures evolution. These simulations are computationally challenging, primarily due to different space and time scales of the processes involved and complex geometries of the physical domains under study. In particular, the dynamic solution of the equations related to rock deformation requires very short time steps and introduces different competing deformation modes that translate into program branching. This is the most computing intensive part in field scales thermo-hydro-mechanical (THM) modeling. It represents around 90% of the total computational time.

This computational cost problem could be tackle using next generation computing clusters that have heterogeneous architecture nodes, in which very dense computations are off-loaded to one or more co-processors. These co-processors are single instruction, multiple data (SIMD) highly parallel computing devices like Graphical Processor Units (GPU) or Intel Many Integrated Core (MIC) architecture.

Our work focuses in efficient 2D simulation of THM models in multi-GPU clusters, particularly the mechanical part using explicit finite differences approximation. This involve the implementation of brittle-elasto-plastic models that must be solved efficiently, accounting for the different deformation modes and consequent programming branching.

Normally, program branching imposes a high efficiency penalty when SIMD devices are used. We present different optimization techniques to handle it and to enhance the performance in High Performance Computing systems (HPC). These strategies could be applied to different mechanical models for a variety of problems.

Key words: High Performance Computing, elasto-plastic models, GPU clusters**,** heterogeneus programming

ESTIMATING THE INTERNAL FORCES OF RAFT IN PILED RAFT FOUNDATION FOR NORMAL AND GROUNDWATER PUMPING CONDITIONS

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ABSTRACT

Today, piled raft foundations are widely used in design of structures, especially for projects with several basements. The raft can be used as the basement and used to share the load of foundation. In this paper, Poulos method in which the raft was cut into many piled strips was used as an analytical method. The study also used Plaxis 2D and SAP 2000 to calculate internal forces for the raft in piled raft foundation. A case of Vietcombank building with 10 floors and 1 basement, constructed on soil profile of Soc Trang province, was considered. The piled raft with a 35m×19m×1m (length×width×thickness) raft and 28 piles were used for the analysis. Normal and groundwater pumping conditions were applied for the soils. The results showed that maximum moment and shear force occurred in the raft were affected when groundwater pumping condition was applied to the model. The internal forces of raft in piled raft foundation for different conditions were captured and some discussion were presented in this paper.

Key words: Piled raft foundations, PDR (Poulos, David and Randolph) method, internal forces of raft, soil profile in Soc Trang province, groundwater pumping.

ESTABLISHMENT OF ARTIFICIAL ACCELEROGRAM FOR SHAKING TABLE TEST

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ABSTRACT

In order to evaluate behavior of building and other structures under seismic action, one of the methods is testing specimen on the shaking table. This paper presents the establishment of artificial accelerogram for testing of semi-precast specimen on shaking table by using similitude theory to convert the artificial accelerogram of the prototype building to artificial accelerogram of the small scale specimen and compare the test result and analysis result.

Keywords: testing specimen, artificial accelerogram, shaking table test.

ANALYTICAL STUDY ON IN-PLANE AND OUT-OF-PLANE RESPONSES OF A CURVED FLOATING BRIDGE

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ABSTRACT

The in-plane and out-of-plane responses of a curved floating bridge that is vertically supported by pontoons and laterally held by shore abutments at two ends are studied analytically. The in-plane solution is derived based on strain compatibility. A Euler curved beam model is used to develop the solution to the out-of-plane response of the bridge. Trigonometric trial functions are adopted to approximate the vertical displacement and the torsional rotation of the curved beam. Both solutions are verified against FE analysis results and good agreement is found between the results. The studies will focus on the effect of end support stiffness on the in-plane response of the bridge and the out-of-plane response of the bridge subject to tidal variation.

Key words: Floating Bridge, pontoon bridge, curved bridge, strain compatibility, Euler beam

ACKNOWLEDGEMENT

This material is based on research/work supported by the Singapore Ministry of National Development, National Research Foundation and JTC Corporation under L2 NIC Award No. L2NICTDF1-2015-2.

NUMERICAL ANALYSIS OF HYBRID WALLS USING FEM

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ABSTRACT

The article presents the numerical study dealing with the behavior and the real load bearing capacity of hybrid walls by Abaqus software. Especially identify the bearing capacity behavior of the composite steel-concrete walls with several fully encased steel profiles (hybrid walls) while the materials were yielded until failure. Structural hybrid steel-concrete walls, material constitutive law for steel and concrete, load schematic, element types, numerical solution controls, interactions, steel-concrete bond, composite behavior and mechanical contact,... will be described in detail. It is expected that nonlinear FEM analysis can give more details on behavior as well as on shear and bending resistance mechanisms until failure of the hybrid walls. The nonlinear FEM analysis will be able to predict specimen strength, maximum displacement, strains and stress distribution, crack pattern and failure modes. The reliability of this method was evaluated by comparing the analysis results with a part of the experimental results.

Keywords: Numerical analysis, hybrid wall, profile, connection, simple bending, plastic, failure.

A NEW BEAM THEORY CONSIDERING HORIZONTAL SHEAR STRAIN

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ABSTRACT

Methods of setting up and solving problems of flexural members, considering the horizontal shear strain, have been studied since the 1970s but there has not been any complete theory. When considering the influence of horizontal shear strain, with the horizontal shear strain approaching zero (when shear elastic modulus $G \to \infty$ or the ratio *h/l* is very small), the presented solutions do not converge to the case of zero horizontal shear strain, due to the *shear locking* phenomenon. Many authors have conducted studies to overcome this problem. Although they have achieved acceptable solutions, theoretical mistakes are unavoidable. In this article, the author will present a new method, in which the displacement and shear force functions are considered as functions that need to be determined to set up a new Beam Theory Considering Horizontal Shear Strain. To develop beam problems based on the Method of Gauss's Principle of Least Constraint, the author uses the calculus of variations and partial integral to establish two differential equations to determine two unknown functions and beams' boundary conditions. The beam theory (not considering the horizontal shear strain) is a separated condition of this theory. Using this theory in calculating beams and frames does not encounter *shear locking* phenomenon. The author will present equations of elastic line; analytic formulas determining deflection, angle of rotation, moment and shear force of beams, with different supports and static loads. When considering horizontal shear strain, changes occur in both the displacement and internal forces of beams and frames. However, while the displacement increases considerably, the redistribution of internal forces is quite insignificant.

Key words: Shear strain, Timoshenko beam, shear locking, Gauss's princple of least constraint, variationnal calculus.

INVESTIGATION OF A5052 ALUMINUM ALLOY TO SS400 STEEL BY MIG WELDING PROCESS

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ABSTRACT

This paper aims to investigate the simulation and experiment of the welding of butt-joint 5052 aluminum alloy to SS400 steel by Sysweld software and Metal Inert Gas (MIG) welding process with AR4043 welding wire. Welding seams were evaluated by mechanical testing and metallurgical analysis, surface morphology welding seam and other welding defects were investigated. The microstructure of intermetallic layer has been observed using microhardness testing and scanning electron microscopy (SEM). A without intermetallic layer and intermetallic layer joint between welding seam and SS400 steel at fusion area appeared after the welding process. To improve the quality of welds, the best thickness of the intermetallic layer (IMCs) was from 3 µm ÷ 7 µm. The fracture tensile inspection results of welding seam achieved at 230 MPa and the fracture occurred at the IMCs layer, the average microstructure hardness of IMCs layer zone is 346.3 HV and without IMC layer zone is 117.85 HV. The intermetallic layer was at the minimum to improve the quality of welds.

Key words: MIG welding process, But-joint, IMCs layer, A5052 alloys, SS400 steel, SYSWELD software

BEHAVIOUR OF TWO-CHAMBER ALUMINIUM PROFILES UNDER AXIAL CRUSHING: AN EXPERIMENTAL AND NUMERICAL STUDY

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ABSTRACT:

The present study investigated the capacity of the finite element models for predicting the behaviour of a two chamber extruded profiles in AA6060-T7 alloy subjected to axial crushing under quasi-static loading conditions. Experimental tests were performed (including uniaxial tests, in-plane shear test and plane strain tension tests) to characterize the elastic-plastic, anisotropy and fracture behaviour of the investigated material. The material under investigation exhibited anisotropic properties and isotropic yield models such as von-Mises was not able to predict correctly the shear and plane strain test behaviour. It depicted that the advanced material model with anisotropic Yld2004-18p yield function and ECL criterion were necessary to predict the material tests results (UT, ISS and PST) both in terms of force-displacement curves and ductile fracture. Axial crushing tests were also conducted to investigate the energy absorption capacity of two chamber profiles made of this alloy. A solid element based numerical model of these component tests was established in the commercial finite element code LS-DYNA, and simulations were run with the calibrated material models and fracture criterion. The predicted force–displacement curves, the energy absorption and fracture was in an good agreement with the experimental results. These results demonstrate that it is now possible to use numerical models as a design tool for optimizing aluminium profiles for automotive applications.

Keywords: Simulations, testing, two chamber profiles, aluminium, fracture

DOF CONDENSATION OF THICK CURVED BEAM ELEMENT FORMULATED BY ISOGEOMETRIC APPROACH

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ABSTRACT

The study of a thick in-plane curved beam is more complex than that of the straight beam because the structural deformations of the curved beam depend not only on the rotation and transverse displacement but also on the coupled tangential displacement caused by the curvature of the structure. The Isogeometric approach is a computational geometry based on a series of polynomial functions (Non-Uniform Rational B-Spline, NURBS) used to represent the exact geometry. In the Isogeometric Approach, the free curvature geometry of the beam element can be represented exactly. A thick two-node curved beam element can be developed by using the Isogeometric Approach based on Timoshenko beam theory, which allows the transverse shear deformation and rotatory inertia effects. The natural shape of the beam curvature and the shape functions formulation of the element can be formulated by using the Isogeometric Approach. However, in the Isogeometric Approach, the number of equations will increase according to the number of degree of the polynomial and its control points. For saving computation cost, a new condensation method is applied to reduce the number of equations of the degree of freedoms (DOF) at control points so that it is equal to the standard two-node six-DOF beam element. This paper highlights the application of the NURBS for a curved Timoshenko beam element in the context of finite element analysis and proposes a new condensation method to eliminate the drawbacks raised from the Isogeometric Approach. Examples are given to verify the effectiveness of the condensation method in static and free vibration problems.

Key words: Thick curved beam, Isogeometric approach, condensation, finite element analysis

EFFECT OF HYPER-PARAMETERS ON DEEP LEARNINGNETWORKS IN STRUCTURAL ENGINEERING

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ABSTRACT

Since the first journal article on structural engineering applications of neural networks (NN) was published, a large number of articles about structural engineering have been published on these fields. However, over the last decade, researchers who attempt to apply the neural network concept to structural analysis problems have reduced significantly because of a fundamental limitation. At the beginning of the new millennium, in a deep learning field, newer methods have been proposed by using new activation functions, loss functions, alleviating overfitting methods with hyper-parameters, and other effective methods. Recent advances in deep learning techniques can provide a more suitable solution to the problem. The aim of our study is to show effects and differences of newer deep learning techniques on neural networks of structural analysis topics. A well-known ten bar truss example is presented to show condition for neural networks, and role of hyper-parameters in the structures.

Keywords: Deep learning, Structural analysis, Feedforward neural network, Hyper-parameter

FUZZY TIME- HISTORY ANALYSIS OF 2D-BRACED STEEL FRAME WITH FUZZY FIXITY FACTORS

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ABSTRACT

This paper studies the application of the fuzzy finite element procedure for dynamic analysis of the planar braced steel frame structures with fuzzy input parameters. The fixity factors of beam – column and column – base connections, loads, mass per unit volume and damping ratio are modeled as triangular fuzzy numbers. The Newmark-β numerical integration method is applied to determine the displacement of the linear dynamic equilibrium equation system. The α – level optimization using the Differential Evolution (DE) integrated with finite element method is proposed to apply in the fuzzy structural dynamic analysis. The efficiency of proposed methodology is demonstrated through the example problem relating to the twenty-five – story, three – bay concentrically braced frame.

Key words: braced steel frame, fuzzy connection, fuzzy structural dynamic, differential evolution algorithm

OPTIMAL AIRPLANES' PATHS FOR MINIMIZING AIRLINE COMPANY'S COST SUBJECTED TO PASSENGERS' DEMAND: FORMULATION AND VERIFICATION

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ABSTRACT

A new formulation which addresses a new/specific/practical problem facing the airline industry, such as "Optimal Airplanes' Paths For Minimizing Airline Company's Cost Subjected to Passengers' Demand", is presented in this paper. If the flying paths are explicitly used as unknown variables, then one has to deal with a very large number of unknown variables. To avoid such bottlenecks, our proposed approach consists of finding which city-pair flight legs are flown, and how many times the optimum flight paths will use these flight legs. With this obtained information, the optimum flight paths can be obtained by a post-processing phase! The mentioned "Optimal Airplanes' Paths" problem can be formulated as a **N**on-**L**inear **I**nteger **P**rogramming (**NLIP**) problem. Numerical results are also included in this paper to validate the proposed NLIP formulation.

Keywords: Optimal Airplanes' Paths, Non-Linear Integer Programming (NLIP), Formulation, Passengers' Demands, Minimizing Airline Company's Cost

GEOMETRY INDEPENDENT FIELD APPROXIMATION (GIFT): PAIRING CAD GEOMETRY WITH PHT-SPLINES FIELD

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ABSTRACT

In this work, we show some applications of the method, proposed by the authors in [1]. The main idea of the method consists in generalizing the isogeometric analysis by keeping the original CAD geometry, given by NURBS, but pairing it with a solution spline space which is more suitable for adaptive analysis. One of such choices is PHT-splines, which allow local refinement, and therefore, can accurately approximate solutions with high gradients. The approach is tested on a number of benchmark problems in elasticity, and is shown to yield accurate results with significant computational savings in comparison with standard IGA.

A NATURALLY STABILIZED NODAL INTEGRATION MESHFREE FORMULATION FOR THERMO-MECHANICAL ANALYSIS OF FUNCTIONALLY GRADED MATERIAL PLATES

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ABSTRACT

This paper presents naturally stabilized nodal integration (NSNI) meshfree formulations for thermo-mechanical analysis of functionally graded material (FGM) plates. The effective material properties of FGM plates are homogenized by a rule of mixture. Gradient strains from the present approach are directly compute at nodes the same as the direct nodal integration (DNI). The current approach is to alleviate instability solutions in the DNI and to decrease significantly computational cost when compared to the high-order Gauss quadrature scheme. Enforcing essential boundary conditions is completely similar to the finite element method (FEM) due to satisfying the Kronecker delta function property of moving Kriging integration shape functions. Numerical validations are given to show the efficiency of the present approach.

Key words: Naturally stabilized nodal integration, moving Kriging interpolation, meshfree method, functionally graded material.

DISPLACEMENT BASED FORMULATION OVER ARBITRARY CONVEX POLYHEDRA: STRAIN SMOOTHING AND SCALED BOUNDARY FINITE ELEMENT METHOD

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ABSTRACT

This talk will focus on two different displacement based finite element formulations over arbitrary convex polyhedra: (a) based on strain smoothing technique and (b) scaled boundary finite element method (SBFEM). With the strain smoothing technique, a new smoothed derivative is written as a weighted average of the compatible strain field. This eliminates the need to know the explicit form of the shape functions and also requires fewer integration points to compute the terms in the stiffness matrix. On another front, the SBFEM is a semi-analytical technique that shares the advantages of the FEM and the BEM. Analytical solutions are sought within the polyhedra whilst finite element discretisation is employed on the surface of the polyhedra. The robustness, the convenience and the accuracy properties will be discussed with a few benchmark problems in linear elastostatics.

Key Words: scaled boundary finite element method, strain smoothing, numerical integration

AN EFFECTIVE TWO-POINT TIME DISCRETISATION SCHEME USING INTERGRATED RADIAL BASIS FUNCTIONS

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ABSTRACT

This paper proposes an effective numerical procedure which is based on integrated radial basis functions (IRBF) for solving time-dependent problems on rectangular and non rectangular domains. For time discretisation, a two-point IRBF time scheme is proposed, where the time derivative is expressed in terms of not only nodal function values at the current and previous time level but also nodal derivative value at the previous time level. This allows for functions other than a linear one on a time step to also be captured. For space discretisation, both five-point finite difference and compact five-point IRBF stencils [Mai-Duy and Tran-Cong (2013)] are utilised. Numerical results show that for a given spatial approximation, the proposed two-point time discretisation scheme produces more accurate results than the conventional time scheme (i.e. first-order finite difference).

Key words: Time discretisation; integrated radial basis functions; time-dependent differential problems.

PRE-POST SOFTWARE FOR ADVANCED ANALYSIS OF STEEL FRAMES

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ABSTRACT

This paper presents a pre-post software package and a solver for advanced analysis of steel frames. The pre-post software package is coded in the programming language of Visual C++ while the solver is coded in the FORTRAN programming language. An user-friendly graphic interface of the pre-post software is developed to facilitate the modeling process and result interpretation of the problem. The solver employs the stability functions for capturing the second-order effects of framed members to minimize modeling and computational time. The plastic hinge beam-column element and the distributed plasticity beam-column element are available in the proposed software. The generalized displacement control method is employed to solve the nonlinear static equilibrium equations. The present software is verified for the accuracy and computational efficiency through a numerical example of an Orbison six-story space steel frame.

Key words: Advanced analysis, geometric nonlinearity, nonlinear analysis algorithm, steel frames, Visual C++, FORTRAN

A COUPLING BETWEEN ISOGEOMETRIC ANALYSIS (IGA) AND PROPER GENERALIZED DECOMPOSITION (PGD) FOR PROBLEMS WITH COMPLEX PARAMETRIZED GEOMETRY

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ABSTRACT

The paper focuses on the geometrical optimization of complex shapes by coupling Isogeometric Anal- ysis (IGA) and Proper Generalized Decomposition (PGD). It is well-known that IGA enables us to represent the exact geometry of mechanical problems based on basis functions generated from Non-uniform Rational B-Splines (NURBS). Considering geometry as a new coordinate of the model, the problem can be solved only once for any value of the geometry parameters by the PGD method.

In IGA, the shape of the problem is defined by changing the coordinates of control points, and the new control points are generated automatically under any level of refinement process without changing the geometry. In addition, the geometry parameters are determined in the function of control points at the coarsest mesh level. Therefore, this feature allows us to obtain simply the information of the offline phase of PGD procedure which describes geometry transformation from the physical domain to the parametric domain at the beginning step. In Finite Element Method (FEM) with 3 node trian- gle elements, some research shows that the transformation depends on only the geometry parameters. However, space function still exist inside the geometry transformation as IGA uses NURBS as the basis with higher order. It is needed to employ Singular Value Decomposition (SVD) or High Order Singular Value Decomposition (HOSVD) to separate the transformation.

Two numerical problems are performed: a linear elasticity problem of a plate with the centered hole with various radius, and an NACA airfoil 4 digits under torsion. The examples are typical linear engineering problem with the smooth curve boundary which IGA was proven to be more advanced to FEM. The final results and the error estimation show the potential power mastering the numerical method of coupling IGA and PGD model reduction for geometry parameterization of complex shapes. The problems will also be extended to damage of plate with the hole or achieved torsion stiffness of airfoil as a quantity of interest for goal-oriented error assessment.

Key Words: Computational mechanics, Proper Generalised decomposition (PGD), a posteriori error estimation

SMOOTHED FINITE ELEMENT METHOD FOR REDUCED SHAKEDOWN KINEMATIC FORMULATION

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ABSTRACT

A solution strategy for a kinematic shakedown analysis formulation based on S-FEM (ES-FEM and NS-FEM) has been described. S-FEM used in combination with second-order cone programming in the frame work of the reduced shakedown kinematic formulation. Results in a comparative advantage that are the size of optimization problem is reduced and that accurate solutions can be obtained with minimal computational effort.

Key words: Shakedown, reduced kinematic formulation, second-order cone programming, S-Fem

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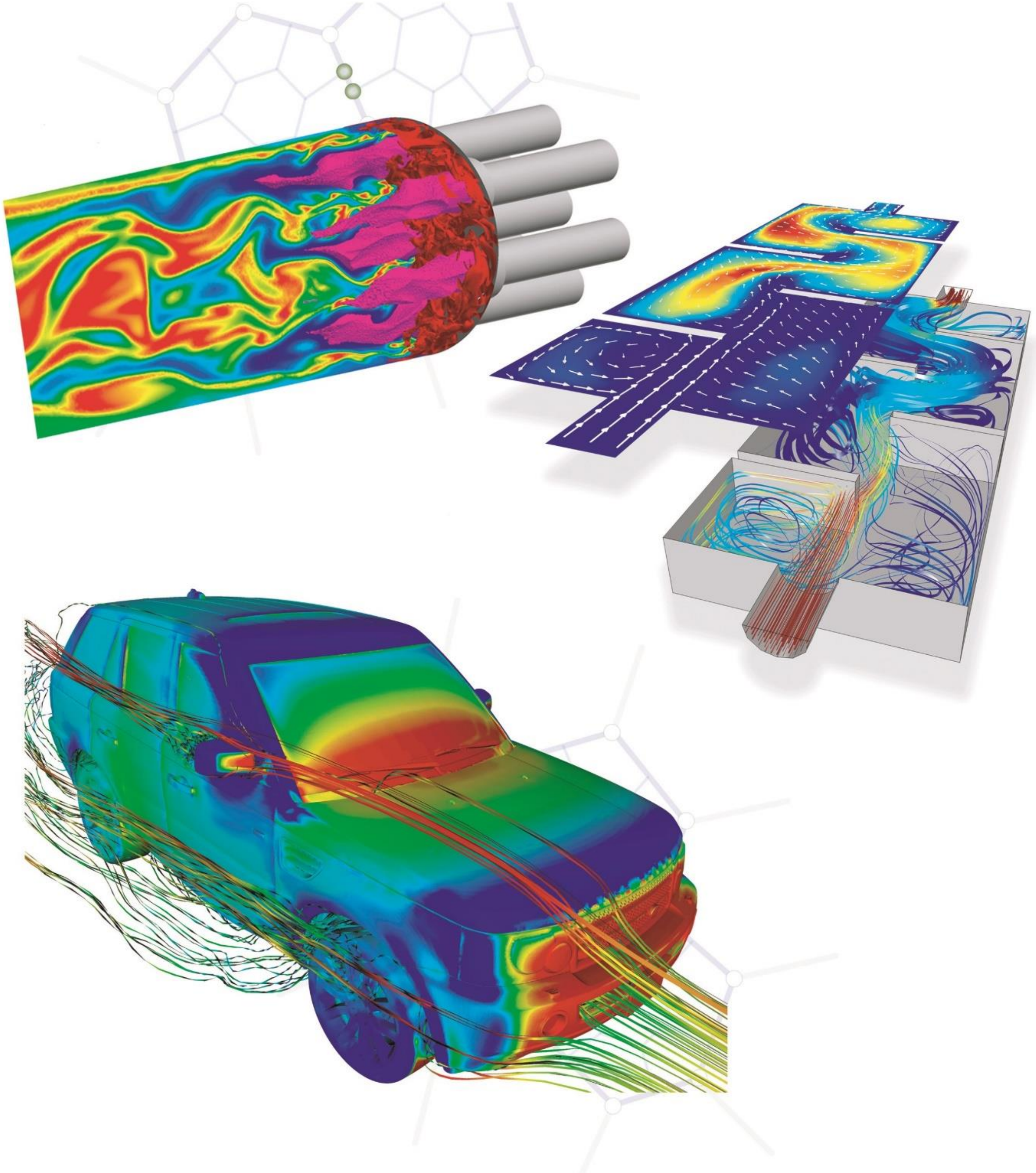

FLOW PROBLEMS

(FP)

BINARY GAS MIXTURE IN A HIGH-SPEED CHANNEL

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ABSTRACT

The viscous, compressible flow in a 2D wall-bounded channel, with bottom wall moving in positive x- direction, simulated using the direct simulation Monte Carlo (DSMC) method *[1, 2, 3, 4, 5, 6, 7, 8, 9, 10]*, has been used as a test bed for examining different aspects of flow phenomenon and separation performance of a binary gas mixture at Mach number $Ma = U_w / \sqrt{\gamma\ k_B\ T_w / m}$ in the range $0.1 < Ma < 30$, and Knudsen number $Kn = (1/(\sqrt{2}\, \pi\, d^2\, n_d\, H)$ in the range $0.1 < Kn < 10$. Here, H is the channel width, U_w is the wall velocity, T_w is the wall temperature, m, and d are the molecular mass and molecular diameter, n_d is the number density, and k_B is the Boltzmann constant. The generalized analytical model is formulated which includes the fifth order differential equation for the boundary layer at the channel wall in terms of master potential (χ), which is derived from the equations of motion in a rectangular $(x-y)$ *plane*. The starting point of the analytical model is the Navier-Stokes, mass, momentum and energy conservation equations in the rectangular $(x-y)$ coordinate, where x and y are the streamwise and wall-normal coordinates. The linearization approximation is used, where the equations of motion are truncated at linear order in the velocity and pressure disturbances to the base flow, which is an isothermal compressible Couette flow. Additional assumptions in the analytical model include high aspect ratio (length of the channel L is large compared to the height H), constant temperature in the base state (isothermal condition), and low Reynolds number (laminar flow). In this limit, the gas flow is restricted to a boundary layer of thickness $(Re^{-1/2} H)$ at the wall of the channel. The solutions of the generalized analytical model in a high-speed channel are compared with direct simulation Monte Carlo (DSMC) simulations. The comparison reveals that the boundary conditions in the simulations and analysis have to be compared with care. The commonly used 'diffuse reflection' boundary conditions at solid walls in DSMC simulations result in a non-zero slip velocity as well as a 'temperature slip' (gas temperature at the wall is different from wall temperature). These have to be incorporated in the analysis in order to make quantitative predictions. When these precautions are taken, there is excellent agreement between analysis and simulations, to within 10%.

Key words: High-speed channel flow, DSMC Simulations, Rarefied gas flow.

ANALYSIS AND EVALUATION OF THE GROUND WAVE PROPAGATION DUE TO BLASTING ACTIVITIES OF ROAD CONSTRUCTION BY NUMERICAL MODELS AND EXPERIMENTS

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ABSTRACT

Blasting activities in road construction work cause the ground wave propagation that can cause damage to the neighboring buildings. This paper focused on analyzing the numeric models of blasting in tunnel construction using FEM software name MIDAS GTS NX with reference to empirical measurements. From the results of analysis allows us to identify relationships wave propagation speed in the ground and the radius from the point of considering to the source of vibration. Based on the results of this analysis to assess the potential damage to neighboring buildings as well as measures designed to limit the impact of wave propagation to neighboring buildings for similar projects.

Key words: Finite element (FEM), the ground wave propagation, peak particle velocity (PPV), vibration sources, radius, vibration limit velocity.

STUDY THE HULL FORM AND PROPELLER-RUDDER SYSTEM OF THE FISHING VESSEL FOR VIETNAM

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ABSTRACT

Currently, the construction of steel fishing vessels in Vietnam is extremely important. For the traditional fishing vessels were built in Vietnam, the characteristic form of the contours corresponding to low-speed running and block coefficient is increased. The transition to a new level of construction and operation of fishing vessels requires a thorough and detailed analysis of the hull form and the characteristics of propeller-rudder system, as well as their interaction in the process of fishing operations. In this paper discusses studying the characteristics of the hull form and propeller-rudder system (propeller in the nozzle) of the fishing vessel (project 70133), intended for the manufacture and operation in Vietnam by using Computational Fluid Dynamics.

Key words: Fishing vessel, propeller-rudder system, resistance of ship.

FLUID-STRUCTURE INTERACTION ANALYSIS OF REVETMENT STRUCTURES – AN OVERVIEW

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ABSTRACT

The strong development of numerical models, especially, *computational fluid dynamic* (CFD, i.e. the using of computational software to visualize how liquid affects objects as it flows past), and *fluid-structure interaction* (FSI, i.e. the coupling applications of fluid and structural mechanics disciplines) brought engineers more good measures to investigate the interaction problems. Meanwhile, the understanding gap of interaction between fluid and revetment structure (RS, i.e. a special structure lean on the slope of dikes to keep the safe of slope and core from erosion due to current and wave) is one of the biggest interests. Hence, the priority aim of this study is to develop computer simulations, which will be used as the tools during the construction of RS that will better protect the coasts from flood and erosion.

Key words: Revetment, fluid-structure interaction (FSI), monolithic approach, partitioned approach, conforming mesh, non-conforming mesh.

STUDYING CONVECTIVE FLOW IN A VERTICAL SOLAR CHIMNEY AT LOW RAYLEIGH NUMBER BY LATTICE BOLTZMANN METHOD: A SIMPLE METHOD TO SUPPRESS THE REVERSE FLOW AT OUTLET

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ABSTRACT

Solar chimneys absorb solar radiation heat and induce natural convective air flow for natural ventilation of buildings. In this study, we simulate induced airflow in a two-dimensional vertical solar chimney by Lattice Boltzmann Method (LBM) and focus on laminar flow region at low Rayleigh (Ra) number. Standard D2Q9 and D2Q4 models with single relaxation time are used for flow and temperature fields, respectively. Air flow and air temperature distributions inside the chimney are investigated under effects of main parameters of solar chimneys: heat flux, chimney height H and chimney width b. Typical characteristics of a solar chimney were well reproduced in our simulations. Particularly, we analyze flow reversal region near the outlet of the chimney. The flow separation regions were observed at low ratio of H/b at a given Ra number or at high Ra number at a given H/b ratio and significantly reduced the induced flowrate. To suppress the flow reversal, we propose a simple method of rearranging the heat transfer surface on the opposite side in the upper and lower halves of the chimney. The results show that this method can eliminate the separation region and increases the induced flowrate at low ratio of H/b at a given Ra number.

Key words: Lattice Boltzmann Method, solar chimney, convective flow, natural ventilation, reverse flow

INFLUENCE OF SWELLING PRESSURE ON PORE WATER IN EMBANKMENT CORE WITH SWELLING CLAY SOIL

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ABSTRACT

In the construction of dams, the construction of water reservoirs for agriculture and hydroelectricity usually uses clay soils that expand the core inside the dam to protect it. In open clay soil, the swelling pressure occurs when the soil begins to soak up from the reservoir and the swelling state is expansive with pressure from the soil pressure of the embankment. The swelling process corresponds to the water absorption of clay that is swollen. At the end of the absorption of lightning, the expansiveness begins to end. Clay blocks in the core have pressure of the dam body cover and the soil mass is kept from changing the volume when the soil expands the pore volume in the soil mass and the water pressure in the pore will change during this process, The saturation curve of the water rises due to the permeability coefficient and the stability of the embankment. At the end of the expansion process, the expansion pressure decreases to 0. At this point the pore water pressure is unchanged and the ground is stable. Applying this research for the construction of structures on swell clay floors will be safe.

Key words: expansive clay soil; Pore water pressure; Swelling pressure; expansive clay soil; Pore water pressure; Swelling pressure; Swelling pressure resistance; no swelling clays; earth; earth dam stability

THE DECK OVERLAP STRENGTH RESEARCH OF THE FISHING VESSEL FOR VIETNAM

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ABSTRACT

SolidWorks Simulation allows to analyze the local strength of hull construction, determine the strength characteristics of structural elements and equipment. It is possible to assess the strength of a structure or assembly as a whole, to determine which structural elements or parts of the assembly will reduce the product's operational reliability and make changes to obtain an equivalent construction or assembly. The purpose of the study is researching the strength of the fishing vessel deck overlap by using SolidWorks Simulation.

Key words: Fishing vessel, strength, deck overlap.

SEDIMENT DISTURBANCE AND SEDIMENT DISPERSION FROM TECHNICAL ACTIVITIES AT DEEP SEAFLOOR

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ABSTRACT

Polymetallic nodules containing up to 33% manganese are found in abundance in cartain parts of the Pacific and Indian Ocean. Collection of the nodules is likely to disturb a large amount of seabed sediment (possibly up to 50 tons/day), and hence the need to assess on how far and how long the sediment spreads and stays in the ocean. The sediment transport process consists of two physical processes, the sediment disturbance by the technical activities and the sediment dispersion by underlined ocean currents. The sediment disturbance occurs at a length and a time scale of the technical activities, while the sediment dispersion occurs in ocean scale and continually even after the technical activities cease. In this study, the sediment disturbance and the sediment dispersion are simulated using smoothed particle hydrodynamics (SPH) method. Sediment disturbance simulations are validated with lab-scale experiments on equipment/sediment interaction. Our motivations are to figure out possible correlations between the sediment re-suspension rate and the sediment spreading speed and the sediment deposition rate.

Key words: Sedimentation, sediment transport, smoothed particle hydrodynamics, two-phase flows, mixture model

MODELLING OF POLLUTANT DIFFUSION IN UNSATURATED DOUBLE-POROSITY MEDIUM BY A MULTISCALE METHOD

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ABSTRACT

Modelling of solute transport is of great interest for civil and environmental engineering (soil/groundwater decontamination, concrete structure anti-degradation from salt ingress, for example). One of solute transport processes is the diffusion mechanism that has received much attention in different domains, especially in waste containment applications [1,2]. There exists a difficulty for this mechanism study residing in the heterogeneity of geo-materials. The diffusion of a substance in a homogeneous porous medium is traditionally modeled by Fick's law, but the classic models could not capture mass transport behaviours in heterogeneous media [3,4]. A class of such media can be modeled by the double-porosity medium consisting of two porous geo-materials with micro- and macro-porosity, respectively, like fractured rocks or aggregated soils [5,6].

In this paper, the development of a macroscopic model for the pollutant diffusion in unsaturated double-porosity medium is presented, applying the homogenization technique – a multiscale method. The resulting model consists of coupled two equations for diffusion in the macro- and micro-porosity regions. The effective diffusion tensor representing for the double-porosity medium is also obtained. The developed model is verified by comparing with the reference solution of the fine scale model through a numerical example of geotechnical problem.

Key words: diffusion, mass transport, double-porosity medium, multiscale method, homogenization

BUILDING THE EMPIRICAL FORMULA DEFINING PARAMETERS OF BLAST WAVE IN CORAL ENVIRONMENT

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ABSTRACT

The article presents the empirical method to determine the characteristics of coral material and coral foundation serving for computation and design of defense security works on islands. The authors built the empirical formula to define the parameters of blast wave in coral medium and compared the computation results using AUTODYN software, and then drew the conclusion as the basis for application in reality.

Key Words: Blast loading, blast wave propagation, soil

DEVELOPMENT OF A 3-DOF HAPTIC TELE-MANIPULATOR SYSTEM USING NEW MAGNETORHEOLOGICAL BRAKES

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ABSTRACT

In this work, a tele-manipulator system with force feedback (Haptic tele-manipulator) is designed and manufactured. The haptic tele-manipulator system in this study consists of two main parts: slave and master manipulator. The slave manipulator is a three 3-rotary degrees of freedom (DOF) manipulator and driven by AC servo motors. At the end effector of the slave manipulator a 3D force sensor is mounted to measure impact force from the environment. The master manipulator is used to control the slave manipulator; it has a structure and shape similar to the slave manipulator. At the joints of the master manipulator, magneto-rheological brakes (MRBs) are installed. They are meant to create the variable braking torque. Then the braking torque corresponds to the torque made by the force measured values from sensors mounted on the slave manipulator. In this way, the operator of the master manipulator can feel the force at the end effector of the slave during its operation.

Keywords: magneto-rheological brake, optimal design, haptic system, haptic tele-manipulator

EFFECT OF LOW FREQUENCY FLOW ON CABLE DRY-STATE GALLOPING

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ABSTRACT

Cable-stayed bridge has widely been applied for medium to very long span. Thanks to advanced construction technology and structural materials, its span length is being broken time by time. Due to the increase of main span, cable length becomes longer and more vulnerable to wind excitation. In this scenario, it has been pointed out that a stay cable could gallop under wind actions. Common large amplitude vibration types are rain-wind-induced vibration (RWIV) and dry-state galloping (DG). Therefore, countermeasure for DG and RWIV is one of the key design factors of cable-stayed bridges. Many studies on its mechanism and countermeasures have been conducted in which its causes and mechanism were explained to some extent. It is typically explained that an axial flow behind the cable and flow fields around the cable at the critical Reynolds number regime suppress Karman vortex shedding and then low-frequency vortices related to latent Strouhal frequencies become stronger, which causes dry galloping at high reduced wind speeds [1-3]. Though the complete explanation for the mechanism has not been given. In this study, using a spiral protuberance cable, which was developed as an aerodynamic countermeasure stay cable [4], and a circular cable, wake flow behind the cable as well as wind-induced dynamic response were captured by wind tunnel test. Comparing power spectral densities and coherence along the cable axis of the wake flow between spiral cables and circular cables at different wind speeds, the role of low-frequency vortices/flow on dry galloping and the suppression mechanism of the spiral protuberance were clarified.

Key words: dry-state galloping, spiral protuberances, wake flow, low frequency flow, excitation mode

EVALUATE THE CHANGE OF VISCOUS PROPERTY OF DAMPERS TO VIBRATION OF A HORIZONTAL-AXIS WASHING MACHINE

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ABSTRACT

This article focuses on the effect of viscous characteristics of dampers to vibration of a horizontal washing machine. The prototype model is a LG horizontal washer (WD-8990TDS), that is the drum unit and cabinet are connected by a suspension system composed of three friction dampers and two springs. A dynamical model with 5-DOF of the washing machine is established by using Lagrange method combined with experiments to determine parameters of the model. Matlab /Simulink® software is used to simulate. The suitability of the model was determined by comparing between simulation results and experimental results. The results will be used to test solution to improve suspension design to reduce vibrations in washing machines.

Key words: dynamic modeling, washing machine, friction damper, vibration

CFD SIMULATIONS OF NATURAL CAVITATING FLOW AROUND HIGH SPEED BODIES

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ABSTRACT

The movement of a high-speed body underwater is highly complicated due to the following facts:

- In the first stage when the body's velocity is high enough, due to a significant pressure drop around the body, there exists cavitating flow which is characterized by a vapor pocket that fully or partially encloses the body. The skin friction is minimized because the body little comes in contact with the liquid phase. Naturally, this stage is highly desirable in the design of underwater bodies.

- In the next stage (the second one), when the body's speed decreases, the vapor pocket becomes smaller. The frictional drag increases dramatically. In both the first and second stages, there might be also complicated interaction between the body and the surrounding liquid.

- In the final stage (the third one), the body largely comes into contact with the liquid phase. Its speed decreases quickly and its movement almost comes to stop soon after that.

A proper design of underwater bodies must produce a stable motion with a straight trajectory, on one hand, and must maximize the travel distance of the body, on the other hand. To this end, both physical experiment and CFD simulation can be exploited to investigate the behaviors of a body. A number of previous studies have been carried out (e.g. see [1]). However, little specific data regarding the body design have been documented in the published literature so far. On the experimental side, transient physical experiments are highly difficult. That is typically due to the fact that high velocity and two-phase cavitating flow are involved.

This study investigates numerically a number of varied designs of high-speed underwater body. The designs are different in the body's typical parameters which include the nose shape and length. Both steady state simulations of single/two-phase cavitating flow around bodies have been carried out by CFD method. The well-known two-phase mixture model and the turbulence k-epsilon model are exploited. For model validation, comparisons with some published experimental and numerical data [2] have been carried out. The behaviors of the different bodies are obtained and reported.

Key words: Computational fluid dynamics, cavitation, two-phase flow, underwater, high-speed

ANALYSIS OF FLUID-STRUCTURES INTERACTION PROBLEM OF REVETMENT SLOPE THIN-WALLED STRUCTURE USING ABAQUS

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ABSTRACT

This paper aims to analyze fluid-structure interaction (FSI) problems of revetment slope thin-walled structures using ABAQUS software. The method is based on a combination of Computation Fluid Dynamics (CFD) for fluids and Finite Element Method (FEM) for structures. During the simulation process, the required data is exchanged by the subsystems. Based on the co-simulation FSI, behaviors of solid structure under impact of flow are examined. The purpose of the co-simulation is to reduce costs and time consumed in manufacturing revetment slope (RS) structures. The expected results help improve geometry of blocks. Geometry dimensions of blocks of revetment slope thin-walled structure are supported by Busadco Company (Ba Ria Vung Tau Urban Sewerage and Development One Member Limited Company). In this article, an overview of computational aspect of FSI is presented. We expect to provide application of simulation technology to deal with such RS structures.

Key words: Co-simulation, Fluid Structure Interaction (FSI), ABAQUS software, revetment slope structure, thin-walled structure.

A DISSIPATIVE PARTICLE DYNAMICS MODEL FOR BINGHAM-TYPE TWO-PHASE FLOWS

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ABSTRACT

Yield stress fluids are widely utilized in many applications relevant to engineering sciences as well as daily life. Notwithstanding numerical simulations have provided a more detailed view of properties of yield stress fluids, there are still many challenges in numerical simulation by virtue of the complex of such fluids. In this paper, simulation of monodisperse colloidal suspension is studied in the context of Dissipative Particle Dynamics (DPD) method [1] to model a Bingham-type two-phase fluid flow, where the spring model [2,3,4] is further developed to represent the solid/suspended phase, and the discussion is focussed on the effects of the exclusion zones/sizes of the solvent and colloidal particles on its rheological properties.

Key Words: Dissipative particle dynamics, Spring model, Bingham-type fluid, Colloidal suspension

EXTRUSION FLOW MODELING OF CONCENTRATED MINERAL SUSPENSIONS

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ABSTRACT

This study deals with the stability of the flow of cementitious materials induced by the extrusion forming process. Recently, such process has gained much interest because of its involvement in 3D printing process. For this kind of concentrated suspensions, during the extrusion process, the load distribution induces a differential repartition of the stresses between the solid part and the fluid part of the material. The fluid pressure gradient induced by the solicitation leads to a fluid filtration through the granular squeleton, leading to local variations of the porosity of the material along the extruder. However, the evolution of the porosity changes the behaviour of the material from an entirely plastic (undrained) to fully frictional behaviour (drained) [1-2].

The occurrence of the relative filtration of the fluid through the solid part of the material is governed by a competition between the permeability of the granular skeleton and the velocity of the extrusion process. A modelling of the extrusion flow of concentrated suspensions, taking into account the filtration of the fluid phase based on soil mechanics theory, is developed.

After a complete experimental hydro-mechanical characterisation [3], extrusions of two mineral suspensions, a cement based material and a kaolin paste, are performed at different velocities in order to obtain the total range of behaviour of the tested materials, from fully undrained to fully drained.

The experimental results are then compared with the model prediction of the extrusion tests.

Key words: extrusion test, fluid filtration, friction

NUMERICAL EXPERIMENT OF SUBCOOLED POOL BOILING BY USING CFD SIMULATION

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ABSTRACT

Subcooled pool boiling is a fundamental boiling mechanism in which detached vapor bubbles from heated surface(s) rise and condense in a liquid which is below saturation and has zero net flow rate. It is of immense importance in many industrial and engineering systems, such as heat transfer/heat exchanger/cooling systems. That is because of its great heat transfer coefficient in comparison with other heat transfer mechanisms. However, it is one of the most complicated two-phase phenomenon due to, for example, the simultaneous liquid /vapor motion at the same time with heat and mass transfer across the phase interface. Moreover, the phase interface geometry is typically highly distorted and deformable with complicated bubble breakup/coalescence mechanisms. As a consequence, both experimental and numerical studies of subcooled boiling still rely on various simplifications and assumptions.

As the capability of the CFD codes to simulate accurately two-phase flows has been gradually improved, high resolution numerical simulation of the subcooled boiling phenomenon now becomes increased popularity in the study of the most complicated two-phase flow phenomena, i.e. the subcooled boiling. The numerical results are supported by those of a number of physical experiments. As a result, numerical experiments can be an adequate mean for the study of subcooled boiling.

The objective of this study is to accurately numerically simulate the subcooled pool boiling in a vertical pipe by using CFD approach. The physical experimental model has been developed in our previous study. For the numerical simulation, the extended RPI boiling model is exploited in the framework of the two-fluid approach. The accuracy of the calculated results are evaluated. Based on the use of the available correlations of the interfacial terms (e.g. the source/sink of the heat/mass transfer at the interface), the applicability of the numerical experimental setup to the study of the highly complicated behaviors of subcooled boiling is initially evaluated.

Key words: Subcooled boiling, two-phase flow, bubbly flow, CFD simulation, two-fluid approach, wall boiling, heat mass transfer

INVESTIGATION ON TURBULENCE EFFECTS ON FLUTTER DERIVATIVES OF SUSPENDED TRUSS BRIDGE SECTION

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ABSTRACT

This paper presents the flutter derivatives extracted from a stochastic state space system identification method under difference turbulent flows. The aim of the study is to clarify the effects of oncoming turbulence on the flutter of suspended long span bridges by using section model wind tunnel test. Several wind tunnel tests on a trussed deck section have been carried out with different oncoming turbulent properties involving turbulence intensities and turbulent scales. The analysis includes the investigation on: the transient response data from wind tunnel test have been analyzed by the system identification technique in extracting flutter derivatives (FDs) and the difficulties involved in this method are discussed. The time domain analysis stochastic system identification is proposed to extract simultaneously all FDs from two degree of freedom systems. Finally, the results under different condition was discussed and concluded.

Key words: Flutter derivative, stochastic system identification, wind turbulence, flutter critical velocity

STRUCTURAL KINEMATIC MODEL OF COHESIVE SEDIMENT SUSPENSIONS

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ABSTRACT

The aim of this work is to investigate the rheological properties of cohesive sediment suspensions which contains a large fraction of clays (e.g., bentonite clay). The rheological properties of such mixtures are of great importance for the prediction of submarine sediment flows as well as the estimation of forces acting on subsea infrastructure. It is evident from the experimental data that cohesive sediment mixtures are not a simple yield stress fluid. Because of the inter-particle interactions, there exists a network microstructure which may break up by large enough applied stresses and then recovers at a low stress level [1]. The apparent viscosity is thus a functional of the microstructure. This property is called Thixotropy and typically modelled by a kinematic equation with a structural parameter [1, 2]. The rheological data obtained from an HAAKE-MARS rotational rheometer are used to formulate this constitutive equation. The structural kinematics concept has been incorporated in a Smooth Particle Hydrodynamics (SPH) discretisation [3] of the flow equations. With this methodology, we study how cohesive sediment - modelled as a thixotropic liquid - is liquefied when interacting with a pipeline - modelled by a cylinder, and the hydrodynamic forces experienced by that pipe are also estimated.

Keywords: Structural kinematic model, Numerical simulation, Rheology, SPH, Fluid Structure Interaction

OPTIMIZATION OF PRECISION DIE DESIGN ON HIGH PRESSURE DIE CASTING OF ALSI9CU3 USING TAGUCHI METHOD

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ABSTRACT

Precision high-pressure die casting (HPDC) for non-ferrous casting applications is increasingly used in the foundries. For die design of HPDC, it needs well-design of gating, runner system, die cavity. This paper focuses on the following issues: filling simulation, defect analysis by computer aided simulation, finally the use of the Taguchi analysis to find out optimal parameters and factors to increase the aluminum AlSi9Cu3 die-casting quality and efficiency. After analysis the results of optimum are: gate area of 40 mm2, group 2 location of gate, gate velocity 50 m/s, liquid alloy temperature 640°C. Based on the results of calculation parameters, we conducted design die by computer aided with the main objective is to optimize the die design parameters. The use of this integrated solution can shorten the cycle of die design and manufacture, and result in the production of high quality die castings in the shortest time with the biggest profit.

Key words: die design, Taguchi method, die-casting, shrinkage porosity, AlSi9Cu3 aluminum.

FLOW AND PERFORMANCE ANALYSIS OF A VALVELESS MICROPUMP

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ABSTRACT

The flow behaviour and performance parameters of a diffuser-nozzle element of a valveless micropump have been investigated for different geometric and flow properties. When a fluctuating pressure is imposed on the inlet boundary of a diffuser-nozzle element, there is a net flow in diffuser direction due to the dynamic effect. The variation of this net flow along with rectification capacity, and diffuser efficiency has been investigated for different inlet-outlet length combination and frequencies of driving pressure. Flow behaviour and recirculation region due to dynamic effect have been studied as qualitative study. Pressure and velocity have been analyzed for quantitative analysis and for validation with results found in literature. 2-D geometry has been used in the present study. 3-D geometry has been modeled to justify the results obtained from 2-D analysis. Different inlet-outlet length combination ranging from 0.2 mm to 1 mm has been used. Five different pressure frequencies ranging from 5 kHz to 50 kHz have been used to investigate their effects on the performance of diffuser-nozzle element in high frequency ranges. The net flow and performance of the nozzle-diffuser element are found to be less dependent on outlet length, while more dependent on inlet length and decreasing with the increase of frequency.

Key words: Diffuser-Nozzle Element, micropump, pressure frequency, dynamic effect, recirculation

AEROELASTICITY ANALYSIS ON WING STRUCTURE USING IBM METHOD

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ABSTRACT

Flutter of airplane wings is a critical issue determining the reliability of the aircraft. The Flutter phenomenon is the results of the fluid-structural interaction and is usually involved with complicated phenomena such as the shock wave/boundary layer interaction, flow separation, non-linear limited cycle oscillation, etc. Accurate prediction of the Flutter is very challenging due to the perplexing physical phenomena and the required large amount of computation. In this paper, a developed code based on Immersed Boundary Method (IBM) was realized to predict aeroelasticity response and characteristic parameters of wing structure. There were two rectangular and two trapezoid 3D-shape of wing; each 3D-shape of wing had NACA65A004 and supercritical airfoil respectively. Results from IBM method were first analyzed to carry out behaviors of flow on and around airplane wings and then were compared with experimental results at low speed.

Key words: Aeroelasticity, Flutter, FSI, IBM.

NUMERICAL MODELLING THE AEROELASTIC RESPONSE OF IRREGULAR SLENDER STRUCTURES

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ABSTRACT

This paper presents a general framework for evaluation of the aeroelastic response of complex slender structure with generic cross sections. First, the Rayleigh-Ritz approach and the Lagrange equation are employed to describe the vibrations of a continuous coupled structure though a system of ordinary differential equations in a way more familiar with structural analysts. Then the general framework for instability analysis will be presented. Finally, the theory is then applied to a real telecommunication pole with irregular shape. The numerical results show different aspects from traditional findings, emphasising the structural irregularity.

Key words: Numerical modelling, aeroelasticity, wind-structure interaction, irregular structure, eccentricity.

EVALUATING THE SALTWATER INTRUSION TO AQUIFER MIDDLE-UPPER PLEISTOCENE (QP2-3) IN COASTAL AREA OF TRA VINH PROVINCE DUE TO GROUNDWATER EXPLOITATION

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ABSTRACT

Today, one of the most serious problems in Tra Vinh as other coastal provinces in Mekong Delta is the exploitation of groundwater for different purposes. In many cases, the aquifers are pumped or withdraw with greater discharge to its natural ability, thus causing seawater is drawn into the system [4]. This paper aims at evaluating the saltwater intrusion into aquifer middle-upper pleistocene in Tra Vinh province area due to groundwater extraction. The calculating area include 2.176 nodes, 2.079 elements and grid step $\Delta x=\Delta y=1.000$m. The program is set up to determine the interface between freshwater and saltwater which move from the sea into the mainland of middle-upper pleistocene aquifer. Calculation result show that, at the initial point when pumping with outflow Q=29.987 m3/day the toe interface in position of 2.019m from the sea, then with the time exploitation t=150.000 days the interface move into in the mainland about 21.000÷24.000m. The calculation results are useful for managers and abstraction units to launche reasonable exploitation plan by knowing the proress of salt line dependent on time.

Keywords: saltwater intrusion, middle-upper pleistocene aquifer, interface depth, coastal, Tra Vinh.

MODELLING OF 3D INFLATABLE LARGE DEFORMATION AIR PLUG IN CONTACT WITH CONCRETE LINING

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ABSTRACT

Resilient tunnel plug is a recently developed technique for the block of flood in tunnel by using an inflatable cylindrical airbag with air concealed. The plug, i.e. air bag surface, itself is made of textile composite with high strength, lightweight and easily foldable. The air plug can be inflated in a short amount of time and aligns with the internal surface of the tunnel tightly so that the fluid will be stopped at the required position. The use of air plug provides new solutions to the response of emergencies and accidents in tunnel operation such as the screening of smoke from fire and flood from precipitation. Recently, the possibility of using the air plug for the rescue of accidents in tunneling construction is being exploited. In this paper, we will investigate the feasibility of utilizing air plug to screen the soil and water flow in case of boring face failure. Air element and thin shell element will be used to model the air inside the plug and the plug shell. The contact element is used to model the frictional contact between the tunnel lining and the air plug surface. It is revealed that the air plug can provide sufficient friction to resist the flow of water and soil. However, the careful choice of the pressure is important to avoid excessive deformation of the tunnel lining.

Key Words: Large deformation; Thin shell; Air element; Contact; Air plug; Tunnel

A NON-LOCAL FORMULATION FOR WEAKLY COMPRESSIBLE FLUID

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ABSTRACT

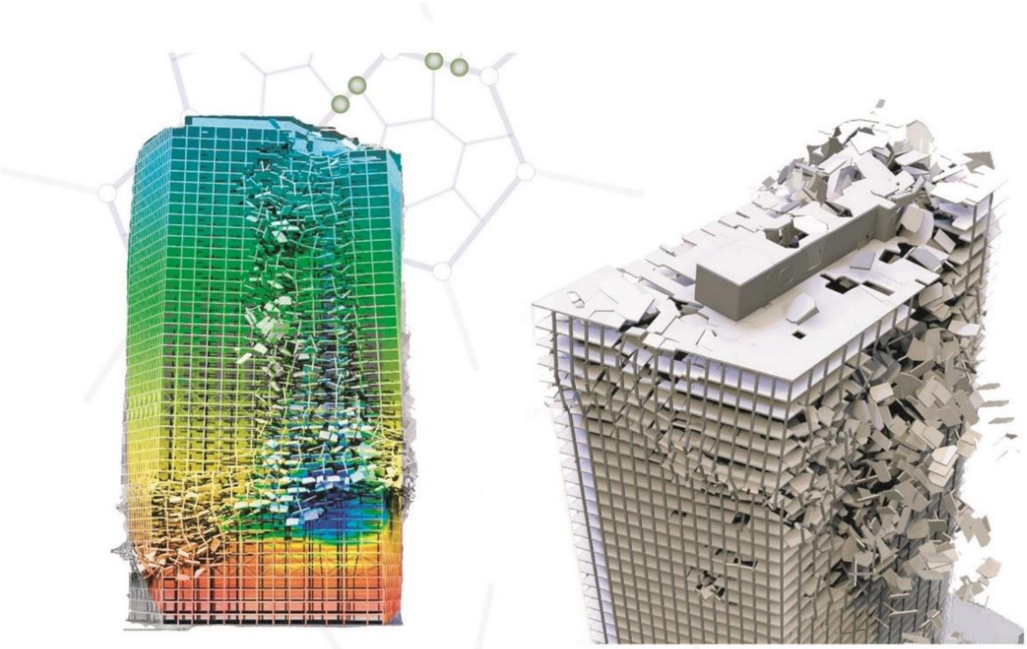
In this paper, we propose a nonlocal formulation for both solid and weakly compressible fluid. The nonlocal fluid formulation is based on the nonlocal interaction of each material point with its neighbors, which is analogous to the peridynamic theory, a nonlocal formulation for solid. By considering the direction of the interaction, the horizon and dual-horizon are defined and the dual property between horizon and dual-horizon is proved. The nonlocal divergence is introduced, which enables to derive the nonlocal interaction with the local formulation. The formulations allow the varying horizon size and satisfy the conservation of linear momentum, angular momentum and energy at the same time. Two numerical examples are tested to verify the accuracy of the current method.

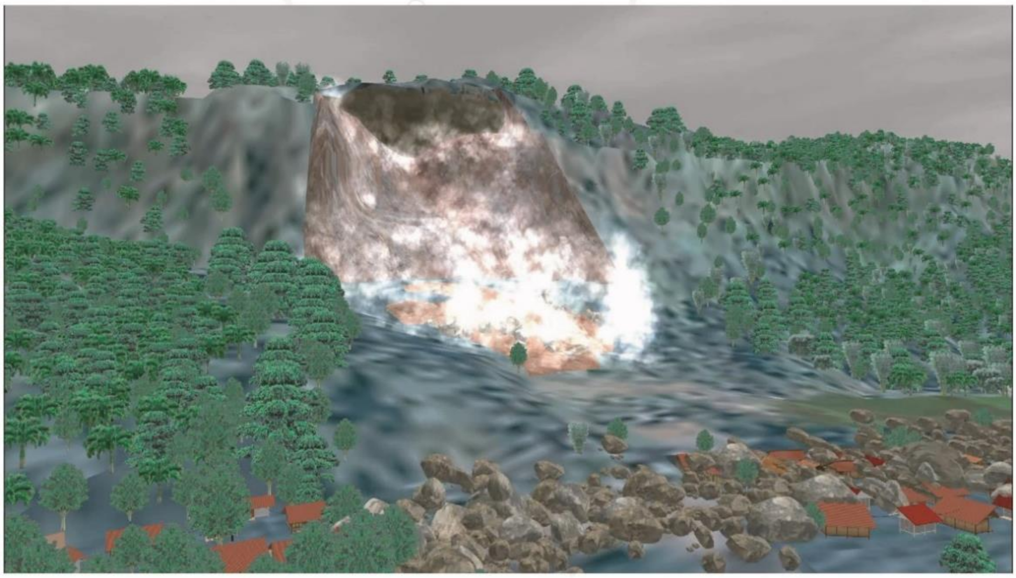
Key Words: Dual-horizon, nonlocal formulation, weakly compressible fluid

ACOME 2017

Phu Quoc Island, Vietnam

2 - 4 August, 2017





CATASTROPHIC DESTRUCTION MECHANICS AND NUMERICAL MODELLING (CDMNM)

V-NOTCH FRACTURE ANALYSIS USING XFEM AND STRAIN ENERGY APPROACH

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ABSTRACT

A new effective approach based on strain energy method incorporating with extended finite element method (XFEM) is proposed to evaluate the stress intensity factors (SIFs) of sharp V-notched structures. This approach takes advantages of both enrichments and the strain energy method. While enrichments allow the representation of notch-faces independent of the mesh, the strain energy approach is however used for the evaluation of fracture parameters as its formulation is simple and easy to implement. In this work, a jump enrichment function is taken for describing the intersection of notch-faces, whereas eight branch functions are employed for capturing nodes surrounding the notch-tip. Furthermore, high accurate results can be obtained by only using the first term of asymptotic stress field. Our results also show the SIFs calculated by the present method are independent of integral paths. Several V-notched numerical examples are analyzed to demonstrate the accuracy of the developed method.

Key words: V-notch, stress intensity factors, XFEM, strain energy approach

ENERGY CHANGE AND ITS CRITERION DURING THE STRENTH REDUCTION PROCESS OF GRAVITY DAM

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ABSTRACT

This paper investigates the elastic strain energy variation of guo-zhang model in concrete standard (GB 50010-2002), and proposes the Maximum elastic strain energy principle. With this principle, a numerical model is set up, and the inner link of local dangerous parts and its elastic strain energy change is analyzed. The corresponding safety factor is compared with the result of present commonly used criterion. The results showed that, the stability safety factor against sliding based on the Maximum elastic strain energy principle is close to results of the classical methods, and the proposed method also has the advantage that other method does not have, it can be used as a powerful instability criterion of the strength reduction method for gravity dam.

Key words: Srength reduction method, instability criterion, Maximum elastic strain energy principle, safety factor.

CONCRETE MESOSCOPIC MODEL BASED ON QUADTREE MESH REFINEMENT TECHNOLOGY

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ABSTRACT

At mesoscopic level, the concrete is considered as a three-phase composite material of aggregate, mortar and the interfacial transition zone（ITZ）between them. The first appearance of the ITZ of concrete crack is formed in the edge of the aggregate. The performance of concrete is relative to the geometry and physical properties of the ITZ in the very great degree. The ITZ, as the weak part of the concrete, has an essential influence on the macroscopic properties of concrete. How to reasonably reflect the ITZ to the mesoscopic numerical simulation of concrete materials is worth further study.

Based on the background mesh method commonly proposed to obtain the concrete mesoscopic model, the mesh refinement technology of balanced quadtree is used to refine the local meshes of the ITZ. The concrete mesoscopic mesh model which is more reasonable for reflecting the constituent of the ITZ is given, and the programmed implementation scheme of mesh refinement is studied.

The proposed concrete mesoscopic model can directly assign corresponding material parameters to the ITZ, and improve the serrated imperfection of meshes of the ITZ in the background mesh method. Accordingly, the geometrical morphology and material property of the ITZ are simulated better well and more truly. At the same time, more elaborate description of the transition zone near the ITZ is carried out based on the encrypted model. The change of the stress and strain field near the ITZ can be captured more accurately. Numerical examples are presented to demonstrate the rationality and effectiveness of the proposed method.

Key words: concrete, mesoscopic mode, quadtree structure, mesh refinement

MULTI-SCALE ANALYSIS OF FATIGUE PERFORMANCE FOR LONG-SPAN BRIDGE CONSIDERING VEHICLE-BRIDGE COUPLED DYNAMIC CHARACTERISTICS

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ABSTRACT

A multi-scale finite element model, including all structure members, local critical component, welding details and cracks, was established to assess the fatigue performance of long-span bridge. Vehicle-bridge coupling model was constructed to consider the dynamic interactions of the vehicle and bridge. The vibration response of bridge was analyzed by iteratively solving the dynamic equation of vehicle-bridge system. The time histories of dynamic stresses were obtained, and fatigue life of the bridge was predicted. The results show that the established multi-scale model can effectively simulate the fatigue cracking process in bridge and accurately predict the residual service life of the bridge. Compared with the static analysis of influence line under traffic loadings, the proposed multi-scale modeling method could efficiently consider the vehicle-bridge coupled dynamic interaction. The influences of vehicle speed, bridge lateral vibration and the excitation of pavement roughness could be simultanously taken into account to accurately compute the dynamic stress responses in critical location of bridge.

Key words: Multi-scale analysis, long-span bridge, vehicle-bridge coupled, fatigue performance

CRACKING BEHAVIOR OF A CONCRETE ARCH DAM WITH WEAK UPPER ABUTMENT

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ABSTRACT

The cracking behavior and failure mode of a 78-m-high concrete double-curvature arch dam with weak upper abutment are investigated through performing cracking analysis. The mechanical behavior of concrete is simulated using a smeared crack model, in which a combination of the compression yield surface and the crack detection surface with a damaged elasticity concept is employed to describe the failure of concrete. The arch dam with practical mechanical properties of the upper and lower abutments is firstly studied with emphasis on its cracking behavior during overloading. Then, a comprehensive sensitivity analysis is carried out to investigate the influence of the ratio of the mechanical properties of upper abutment to those of lower abutment on dam failure with prime attention placed on the failure mode. Simulation results indicate the adopted smeared crack model is well-suited to the crack analysis of concrete arch dam. It is shown that cracking is localized around the interface between upper and lower abutments, which leads to a fast crack growth in the through-thickness direction of dam and finally causes the dam failure. Furthermore, the sensitivity analysis presents three types of failure modes corresponding to different raito value, wherein Modes II and III should be avoided since the weak upper abutment plays a predominant role in the cracking and failure of concrete arch dam.

Key Words: Arch dam, cracking behavior, failure mode, smeared crack model, weak dam abutment

A COUPLING THREE-DIMENSIONAL FINITE ELEMENT METHOD AND DISCONTINUOUS DEFORMATION ANALYSIS BASED ON COMPLEMENTARY THEORY

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ABSTRACT

The continuous and discontinuous deformation analysis is essential for the stability analysis of the anchor bar-surrounding rock masses system. To eliminate the open-close iteration and the penalty factor of the 3D-DDA, the CDDA is proposed to extend into the three dimensional block system. Then a novel simulation approach, the coupling method of 3D CDDA-FEM, is demonstrated, which combines the specific benefits of two numerical methods: The contacts between blocks are described by 3D-CDDA while the displacement field inside block are described by FEM. Two numerical examples verify that the new coupling method is feasible and the displacement solution is more accurate. Taking different initial stress conditions of anchor bars into account, the stability analysis of anchor bar-surrounding rock masses system demonstrate that the appropriate installation and the optimal initial stress of anchor bar efficiently improve the stability of surrounding rock masses system of underground chamber.

Key words: Complementary discontinuous deformation analysis (CDDA), finite element method (FEM), Stability analysis, prestressed anchor bar, surrounding rock masses system

MULTISCALE ANALYSIS OF CONCRETE DAMAGE AND CRACK PROPAGATION UNDER HIGH CYCLE LOADING

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ABSTRACT

Concrete is a typical multiphase composite material in which the initiation and propagation of cracks under fatigue loading are mainly determined by its mesoscopic structure.

In this paper, a multiphase mesoscopic model of concrete is proposed to simulate real ITZ structure and its variation of thickness by the integrated scripting method. The model better reflects the stochastic characteristics of the mesoscopic structure of concrete. According to the fatigue crack propagation characteristics of different stages, the interactive micro and macro models are established and the internal joint-boundaries of two models during the analysis is reasonably divided to targeted analyze the whole process of fatigue crack initiation, propagation and failure of concrete specimen. Based on the technique of cyclic block, concurrent simulation of the damage and crack propagation of concrete under high cycle fatigue loading is realized.

The analysis results show that the fatigue cracks in concrete mainly born near the ITZ and gradually enter into the cement mortar matrix to formulate the cracks which have a certain size. The cracks influence each other until the crack of dominant position appears, which will insatiably propagate and result in the failure of specimen.

Key words: concrete, fatigue fracture, mesoscopic model, numerical simulation, multiscale analysis, high cycle loading

APPLICATION OF ENERGY-BASED DAMAGE INDEXES FOR SEISMIC ANALYSIS OF CONCRETE DAM

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ABSTRACT

The objective of this paper is to evaluate the applicability of the energy-based damage index in seismic analysis of concrete dam. First, a complete comparison is performed between two common energy-based damage models for seismic analysis of steel and reinforced concrete structure. Parameter sensibility is analysed for these two models respectively and the damage evolution features under different ground motions is discussed. Next, a hysteretic model for concrete materials is applied in the energy-based damage models for the seismic damage analysis of concrete dam from the energy concept and the applicability is discussed based on a SDOF system. Furthermore, a numerical model of concrete gravity dam is established and the seismic nonlinear history analysis is carried out in the framework of finite element method. The damage evolution and distribution from the energy-based damage model is evaluated by comparison with the results from other damage indexes. It is concluded that the energy-based damage index can be used effectively to estimate the damage evolution of concrete dam under a given ground motion.

Key words: Seismic analysis, energy-based damage index, concrete dam, finite element

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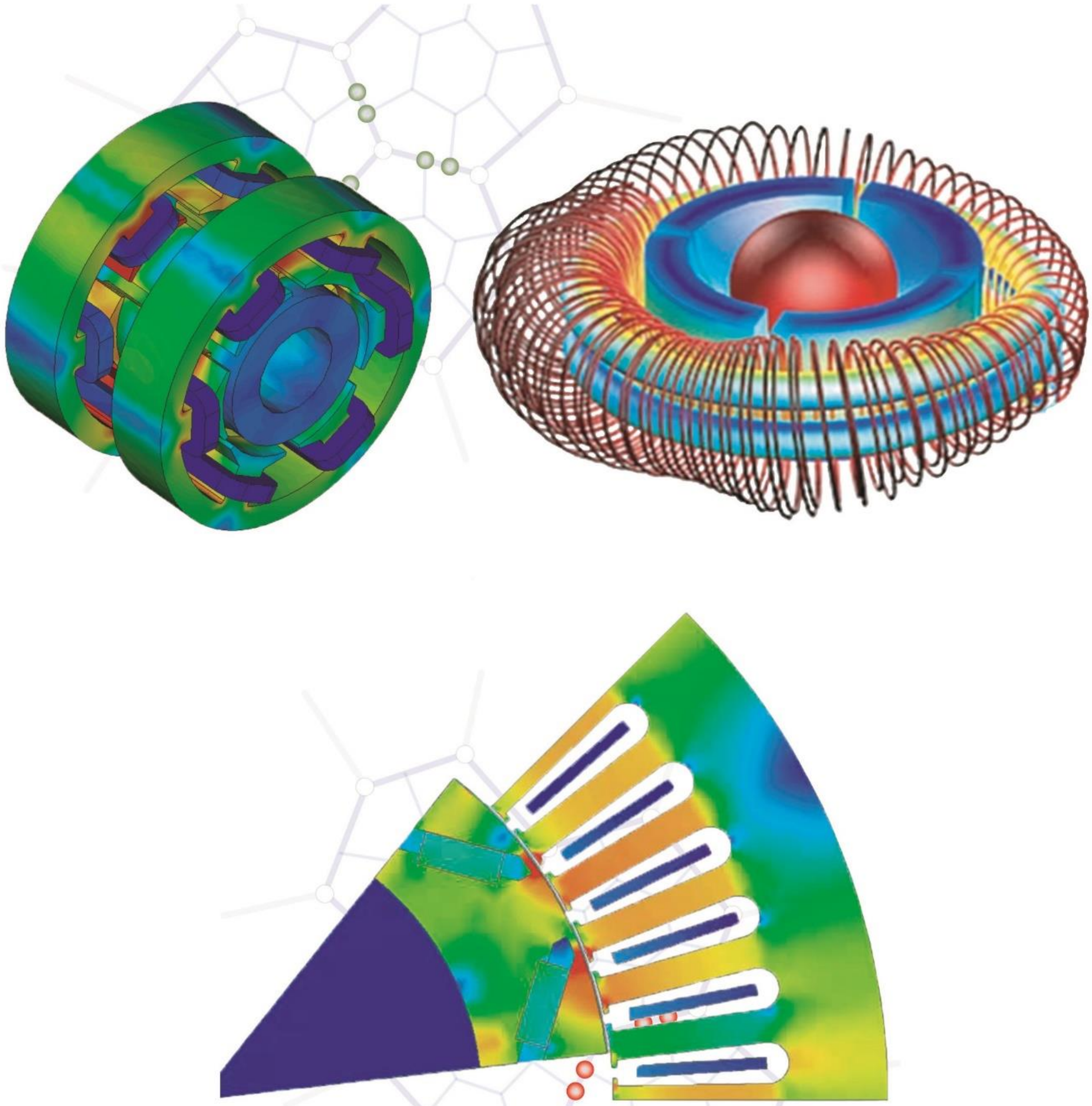

COMPUTATIONAL MECHATRONICS (CM)

CASCADE TRAINING MULTILAYER FUZZY MODEL FOR IDENTIFYING NONLINEAR MIMO SYSTEM

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ABSTRACT

In this paper, a new cascade training multilayer fuzzy logic is proposed for identifying forward model of double coupled tank system based on experiment. The multilayer fuzzy model consists of multiple MISO model, for each MISO model, it consists of multiple single Fuzzy T-S model. The cascade training optimized with DE algorithm sequentially trained Multilayer fuzzy model one by one. All parameters of the model are optimally trained with differential evolution (DE) algorithm. The experimental results show that proposed method give better performance than the normal training. This proposed method can be used for optimal multilayer fuzzy logic that efficiently applied for identifying nonlinear MISO and MIMO systems. The experimental cascade training tests are presented. It proves a more accuracy and takes less time to compute than the normal training method and demonstrates promisingly scalable and simple method as to successfully identify nonlinear uncertain MIMO system.

Key words: identification of nonlinear MIMO mechanical system, cascade training multilayer fuzzy model, multiple single Fuzzy T-S model, differential evolution (DE) optimization algorithm, double coupled tank system.

PERFORMANCE EVALUATION OF A 2D HAPTIC JOYSTICK FEATURING BIDIRECTIONAL MAGNETO-RHEOLOGICAL ACTUATORS

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ABSTRACT

In this research, a new 2D haptic joystick featuring a 2D-gimbal mechanism and two bidirectional magneto-rheological actuators (BMRA) is designed, manufactured and experimentally tested. Firstly, a new configuration of proposed 2D-haptic joystick is introduced, then the BMRAs for force feedback of the haptic joystick are proposed, optimally designed and experimentally evaluated. The BMRA has two discs rotating in opposite directions at the same speed. The two discs are placed inside a housing which is connected to the gimbal mechanism. The BMRA has two coils placed directly on each side of the housing. A proptotype of the whole haptic joystick are then manufactured, and a controller is designed to feedback a required force to the operator. Force feedback performance of the haptic joystick are then experimentally investigated and compared with simulated one.

Keywords: MR fluid, bidirectional magneto-rheological actuator, joystick, haptic

ENHANCED ADAPTIVE FUZZY SLIDING MODE CONTROL FOR NONLINEAR UNCERTAIN SERIAL PNEUMATIC-ARTIFICIAL-MUSCLE (PAM) ROBOT SYSTEM

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ABSTRACT

This paper proposes a new enhanced adaptive fuzzy sliding mode controller (EAFSMC) with its perfect suitability for use in the control of a highly nonlinear and uncertain serial pneumatic artificial muscle (PAM) robot. The critical proof of the stability and the convergence of the overall system is presented using Lyapunov stability principle. Simulation results of the proposed EAFSMC control, applied to a two degree of freedom nonlinear serial PAM robot, are implemented and we have evaluated their efficacy in maintaining Lyapunov stability and their good performance.

Keywords: Enhanced adaptive fuzzy sliding mode control (EAFSMC), Adaptive Takagi-Sugeno (T-S) fuzzy rules, Pneumatic-Artificial-Muscle (PAM), 2-DOF serial PAM robot, Lyapunov stability principle.

DESIGN AND EVALUATION OF A SHEAR-MODE MR DAMPER FOR SUSPENSION SYSTEM OF FRONT-LOADED WASHING MACHINES

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ABSTRACT

In this research, a low damping force shear-mode magneto-rheological (MR) damper that can replace conventional passive damper of a front-loaded washing machine is designed and experimentally evaluated. In the design of the MR damper, required damping force, off-state friction force, size and low cost of the MR damper are taken into account. Firstly, a suppression system for washing machines featuring MR dampers is proposed considering required damping force, available space and cost of the system. Optimization of the proposed MR suspension system is then performed considering required damping force, off-state friction force, size, power consumption and low cost of the MR damper. From the optimal results, simulated performance of the optimized MR damper is obtained and presented with discussions. A detailed design of the MR damper is then conducted and a prototype MR damper is manufactured. In addition, experimental results on the prototype MR damper are obtained and compared with simulated ones. Finally, discussions on performance and application of the MR suspension system for front-loaded washing machines are given.

Keywords: Front-loaded washing machine, MR damper, Suspension system, Optimal design

DEVELOPMENT OF A 3-DOF HAPTIC TELE-MANIPULATOR SYSTEM USING NEW MAGNETORHEOLOGICAL BRAKES

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ABSTRACT

In this work, a tele-manipulator system with force feedback (Haptic tele-manipulator) is designed and manufactured. The haptic tele-manipulator system in this study consists of two main parts: slave and master manipulator. The slave manipulator is a three 3-rotary degrees of freedom (DOF) manipulator and driven by AC servo motors. At the end effector of the slave manipulator a 3D force sensor is mounted to measure impact force from the environment. The master manipulator is used to control the slave manipulator; it has a structure and shape similar to the slave manipulator. At the joints of the master manipulator, magneto-rheological brakes (MRBs) are installed. They are meant to create the variable braking torque. Then the braking torque corresponds to the torque made by the force measured values from sensors mounted on the slave manipulator. In this way, the operator of the master manipulator can feel the force at the end effector of the slave during its operation.

Keywords: magneto-rheological brake, optimal design, haptic system, haptic tele-manipulator

DYNAMIC ANALYSIS OF HYDRAULIC –MECHANICAL SYSTEM USING PROPORTIONAL VALVE

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ABSTRACT

Power hydraulic systems are used very often in industry. Usually, the stroke of piston - a hydraulic actuator is controlled in on-off manner using traditional valves and start/stop switches on the moving way. Another characteristic of traditional hydraulic system is suitable with static load. For applying dynamic load, the behavior of system is not properly good. Nowadays, hydraulic systems with proportional valve are used commonly. Proportional valve allows controlling for a variable stroke of piston. It also allows the system work with variable load. This paper presents the dynamic analysis of a mechanical - hydraulic system using proportional directional valve. The system dynamics is evaluated when the load changes in linear manner. A mathematical model is established to serve for determining dynamic characteristics of the system. PID control is also used in the simulation to enhance the integrity of the system.

Key words: Dynamics, hydraulic system, proportional valve.

ANALYSIS AND SUMMARIZATION OF A MECHANISM FEATURING VARIABLE STIFFNESS

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ABSTRACT

This study presents the analysis of a novel mechanism based on the summarization of conventional models and gyroscope. The theoretical mechanism employs a nonlinear spring and a cantilever beam. This system has only one fixed support for the spring, and one non-contacted support to prevent the impact of friction in operation for cantilever beam. Exciting forces applies to the structure include vertical and horizontal forces, and a moment. The cantilever beam is symbolized as an Euler-Bernoulli beam which has nonlinear property. After formulating, detections along the 2D coordinate are pointed out by using a nonlinear approximate method as adomian decomposition method. The results of this method are compared with the numerical method. It is shown that the values of analysis and the numerical simulation are consistent with small errors. In addition, vibrations of the tip-mass which is attached at the end of the beam are derived and simulated. Results of the tip-mass vibrations are harmonic responses which proves that vibrations of any system always remain under harmonic conditions. This finding and the mentioned results are the base for the development of the new mechanism for both sensors and energy harvesting devices.

Key words: Adomian decomposition method, Euler-Bernoulli beam, Tip-mass vibrations , Flexible beam, energy harvesting device.

A TOOH PROFILE DESIGN FOR ROOTS ROTORS OF VACUUM PUMP

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ABSTRACT

In traditional tooth designs of the vacuum pump, the circular, cycloidal curves and their combination are usually used for generating the tooth profiles of roots rotor. However, to increase efficiency and reduce vibration and noise for the pump, a novel tooth profile for the roots rotor of a vacuum pump is proposed. Which are comprised by five different segments that are generated by the curves in order: circular arc, extended epicycloid, involute, extended hypocycloidal and conjugated circular arc. A numeral example is presented to evaluate and compare the performance (volumetric efficiency and seal line length) for the proposed tooth profile and a traditional tooth design of the vacuum pump (cycloidal-cycloidal tooth profile) with considering to the number of rotor lobes. It reveals that the proposed tooth profile provides a much advantage than the traditional tooth profile.

Key words: tooth profile; volumetric efficiency; seal line length; roots rotor; vacuum pump

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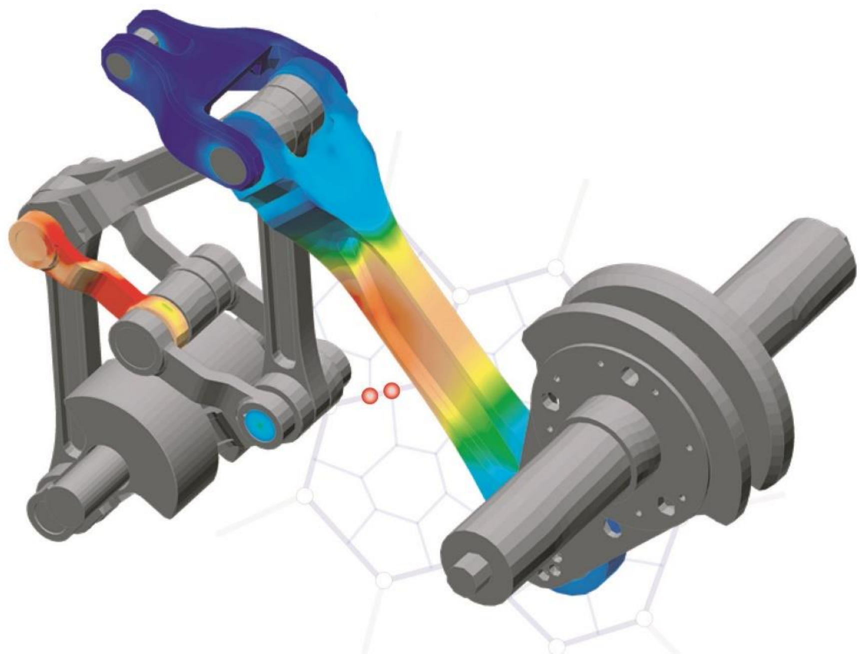

COMPUTATIONAL DYNAMICS

(CD)

ANALYSIS OF DYNAMIC IMPACT FACTORS OF BRIDGE DUE TO MOVING VEHICLES USING FINITE ELEMENT METHOD

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ABSTRACT

This article presents analysis of dynamic impact factors for displacement, bending moment and shear force of bridge under moving vehicles by finite element method. Vehicle is a dumper truck with three axles. Each axle of vehicle is idealised as two mass dynamic system, in which a mass is supported by a spring and a dashpot. The structural bridges are simulated as bending girder elements. The finite element method is applied to establish the overall model of vehicle-bridge interaction. Galerkin method and Green theory are used to discrete the motion equation of vehicle-bridge system in space domain. Solutions of the motion equations are solved by Runge-Kutta-Mersion method (RKM) in time domain. The numerical results are in good agreement with full-scale dynamic testing under controlled traffic condition of the super T concrete girder at Nguyen-Tri-Phuong bridge in Danang city, Vietnam. Numerical results show that there are significantly difference between dynamic factors for displacement, bending moment and shear force. Therefore, the common use of only one of dynamic impact factor for both displacement and internal forces of stuctures in the bridge design code are needed additional consideration. Also, the study results are references to help engineers to have more information for safety design requirements and suitability with the actual operation of bridges.

Key words: Dynamic impact factor for displacement, dynamic impact factor for bending moment, dynamic impact factor for shear force, moving vehicle, finite element method, vehicle-bridge interaction.

ESTIMATING MODAL PARAMETERS OF STRUCTURES USING ARDUINO PLATFORM

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ABSTRACT

This paper presents the identification of the modal parameters as frequencies, damping coefficients and mode shapes based on using Arduino platform to measure oscillation signals of structure in time domain. The use Arduino platform aims to reduce costs in the experimental field. Experiments are carried out on a cantilever beam; the measurement process collects input/output or only output signal. MATLAB software is also used for the computing and data processing, these signals are transformed from time domain to frequency domain by Fast Fourier Transform (FFT). Modal parameters are estimated in the frequency domain. Comparing obtained modal parameter from experimental method with analysis method. Results are found to be in agreement with the theory.

Key words: Modal parameters, frequencies, damps, mode shapes, Arduino, sensors

DYNAMIC ANALYSIS OF BEAMS ON TWO PARAMETERS VISCOELASTIC PASTERNAK FOUNDATION SUBJECTED TO THE MOVING LOAD AND CONSIDERING EFFECTS OF BEAM ROUGHNESS

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ABSTRACT

In this paper, Improved Moving Element Method(IMEM) is developed to analyze the dynamic response of the beam resting on the two parametersviscoelastic Pasternak foundation subjected to the moving load and considering effects of beam roughness. Beams are modeled by moving elements while the load is fixed. The motion differential equation of the structural system is established based on the principle of virtual public balance and solved by means of numerical integration based on the Newmark algorithm. The characteristic parameters of the foundation and load are investigated in order to analyze the dynamic response of the beamsuch as: the second parameter of foundation, the roughness of beam, the velocity and acceleration of moving load.

Keywords: Beams resting on the two parametersviscoelastic Pasternak foundation, Moving Element Method, roughness of beam, moving load.

THE EFFECTS OF BOUNDARY CONDITIONS ON THE DYNAMIC RESPONSE OF FLOATING STRUCTURES SUBJECTED TO A MOVING FORCE BY USING A HYBRID BEM-FEM METHOD

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ABSTRACT

In this paper, the flexural responses of a floating flexible plate subjected to a moving force in the still water are computed by using a hybrid method combining both the boundary element method (BEM) and finite element method (FEM). By using this method, the structure is discretized into a number of finite elements according to FEM. Moreover, the potential flow theory is used to define the surrounding fluid of structure that divided into number of constant boundary elements. The transient responses of floating structure caused by the moving force with various speeds on two types of boundary conditions including simply supports and cantilever are investigated. The paper represents the peak vertical displacements at points along the longitudinal centreline of the structure, together with the ratio between the maximum absolute displacement which floating plate obtains in case of static load and those due to moving load at various speeds for each of boundary conditions. Moreover, the curve of contact force's displacement is also investigated.

Keywords: The finite element method (FEM); The boundary element method (BEM); Hydroelastic; VLFS, Moving load.

STATIONARY RANDOM VIBRATION ANALYSIS OF DYNAMIC VEHICLE-BRIDGE INTERACTION DUE TO ROAD UNEVENNESS

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ABSTRACT

This article presents stationary random vibration analysis of dynamic vehicle-bridge interaction due to road unevenness based on the Finite element method and Monte-Carlo simulation method. The road unevenness is described by a zero-mean stationary Gaussian random process. The vehicle is a dumper truck with three axles. Each axle of vehicle is idealised as two mass dynamic system, in which a mass is supported by a spring and a dashpot. The structural bridges are simulated as bending beam elements. The finite element method is applied to established the overall model of vehicle-bridge interaction. Galerkin method and Green theory are used to discrete the motion equation of vehicle-bridge system in space domain. Solutions of the motion equations are solved by Runge-Kutta-Mersion method (RKM) in time domain. The numerical results are in good agreement field test results of the prestressed beam-slab at Nguyen-Tri-Phuong bridge, Danang city, Vietnam. Also, the effects of road surface condition on dynamic impact factor of bridge are investigated detail. The numerical results show that dynamic impact factor of bridge has increased significantly when road unevenness have changed from Grade A-road to Grade E-road according to ISO 8608:1995 [1]“Mechanical vibration - Road surface profiles – Reporting of measured data”.

Key words: Monte-Carlo simulation method, finite element method, road unevenness, moving vehicles, vehicle-bridge interaction.

TRANSIENT RESPONSE OF LAMINATED COMPOSITE SPHERICAL SHELLS USING AN EDGE-BASED SMOOTHED FINITE ELEMENT METHOD COMBINING WITH MITC3

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ABSTRACT

An edge-based smoothed finite element method (ES-FEM) was recently proposed to significantly improve the accuracy and convergence rate of classic finite element method for static and force vibration analyses plates and shells. In this paper, the ES-FEM is further extended for transient analysis of laminated composite shells subjected to the step and blast loading. In the present method, the mixed interpolation of tensorial components for triangular element (MITC3) technique without shear locking is combined into the edge-based smoothed finite element method to give so-called edge-based smoothed mixed interpolation of tensorial components for triangular element (ES-MITC3). The accuracy and reliability of proposed method is verified by comparing its numerical solutions with those of others available numerical results.

Key words: an edge-based smoothed mix interpolation of tensorial components (ES-MITC), laminated composite shells, the first order shear deformation theory.

ACOME 2017

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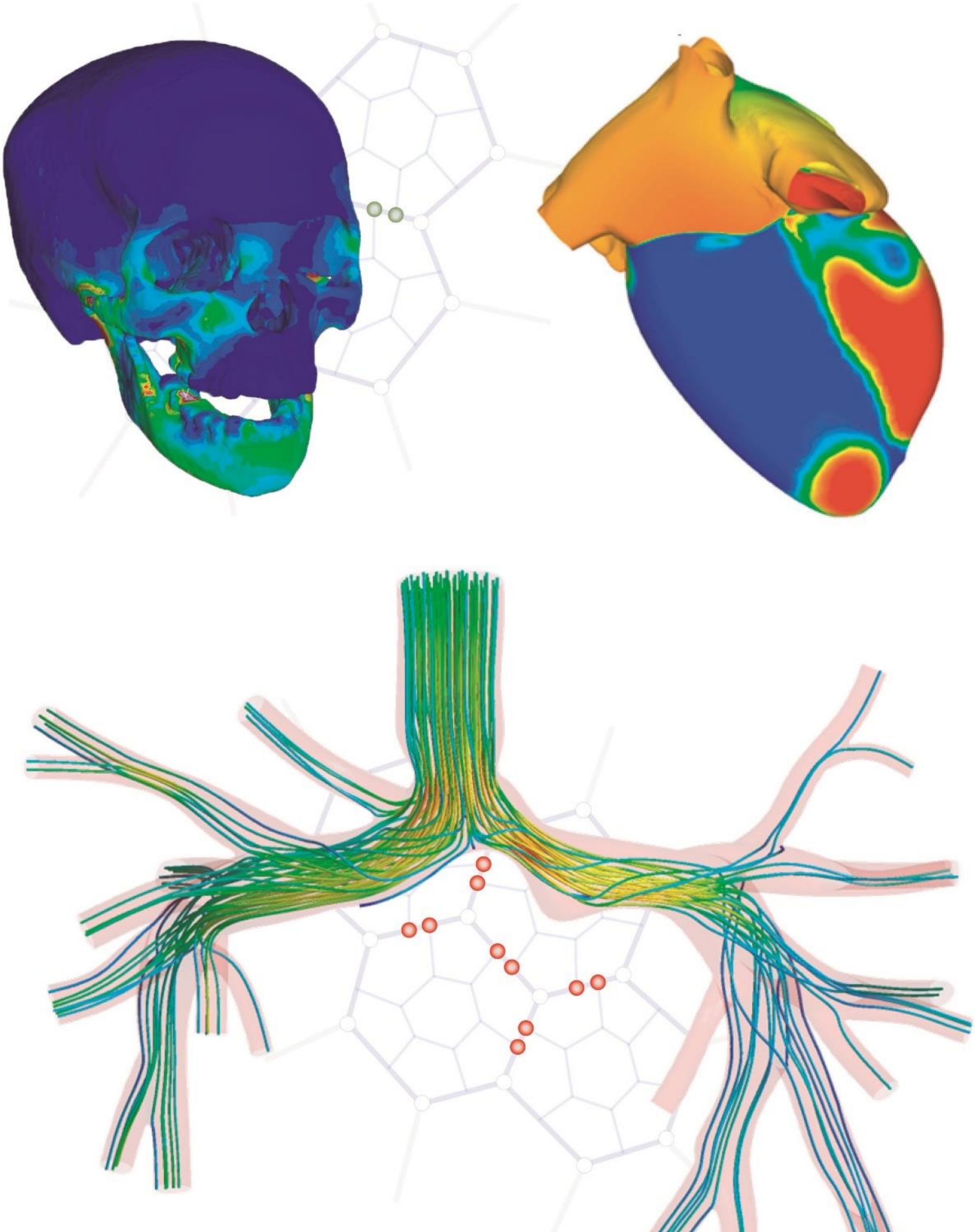

BIOLOGICAL SYSTEMS

(BS)

QUANTITATIVE ULTRASOUND IN CANCELLOUS BONE USING THE ECHOGRAPHIC RESPONSE OF A METALLIC PIN: A NUMERICAL STUDY

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ABSTRACT

Degenerative discopathy is a common pathology, which may require surgical intervention. Bone quality is an important parameter but it remains difficult to be assessed clinically. In a previous work [1], an ultrasonic pulse echo technique has been shown to be feasible to retrieve bone mechanical properties by taking advantage of the presence of a metallic pin, which is inserted into the vertebral body to maintain soft tissues during spine surgery.

In this work, we developed a numerical model that uses the three-dimensional finite difference time domain (FDTD) method to simulate the ultrasonic wave propagation occurring in cancellous bone samples in which a metallic has been inserted [2]. In order to describe interaction between bone tissue and ultrasound, the cancellous bone samples were described by using high-resolution 3-D images obtained from microcomputed tomography (μCT). The numerical model aims at taking into account the ultrasonic propagation in cancellous bone as well as the reflection of the ultrasonic wave on the pin (whose axis is perpendicular to the direction of propagation). More specifically, we aim at i) validating the numerical model by comparing the QUS parameters (SOS (Speed of Sound) and Broadband ultrasound attenuation (BUA)) obtained experimentally and numerically, ii) assessing the effect of variation of bone volume fraction (BV/TV) on the QUS parameters obtained in this given configuration and iii) assessing the effects of changes of the relative orientation of the pin and of the sensor axis on the QUS parameters.

The results show that the correlation coefficient between experimental and simulated SOS (respectively BUA) was equal to 0.90 (respectively 0.55). A significant correlation of SOS with BV/TV (R = 0.82) was obtained, while BUA values exhibit a non-linear behavior versus BV/TV. The orientation of the pin should be controlled with an accuracy of around 1° in order to obtain accurate results. The results indicate that using the ultrasonic wave reflected by a pin has a potential to estimate the bone density. SOS is more reliable than BUA due its lower sensitivity to the tilt angle.

Key words: Quantitative Ultrasound, cancellous bone, FDTD, µ-CT image

A POLYGONAL USER DEFINED FINITE ELEMENT FOR EFFICIENTLY MODELLING COMPLEX BIOLOGICAL STRUCTURES

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ABSTRACT

Biological structures exhibit complex hierarchical architectures over several length scales, which facilitate superior energy dissipating mechanisms against extreme loads. For example, nacre, the inner irridescent layer of mollusc shells has a polygonal brick wall-like structure in which the bricks are bonded together by a complex biopolymer, and stacked together over several hundred staggered layers. This type of structure is well approximated by a voronoi diagram [1], which is a region of interconnected convex polygons. In modelling the behaviour of nacre-like voronoi structures under extreme loads, it has been found that the microstructural toughening features, such as crack bridging, play a significant role in improving the energy dissipation of the system [2] but not to the extent observed at the micro-scale in nacre [3]. However, the restrictions in computational costs were a significant barrier to this study, in that many hexahedral and triangular prismatic elements were used to simulate one voronoi layer, which restricted the simulation to a maximum of ten nacreous layers.

Recently, polygonal finite elements have been employed as a computational mechanics modelling tool, which has been shown to decrease computational costs significantly as opposed to traditional isoparametric finite elements [3]. They have significant potential in facilitating the simulation of the voronoi bricks found in nacre because one polygonal element can represent one brick. Although these elements are well-suited for modelling many complex structures, they are not employed in finite element codes such as ABAQUS.

In this work, a user element subroutine will be developed to implement polygonal finite elements into ABAQUS. The user element can access existing material models by calling a built-in subroutine. This element will, in effect, enable the modelling of complex biological structures that can utilise existing material models to mimic the composite structure found in nacre with significantly less computational effort.

Key words: Computational mechanics, biological structures, polygonal finite element, Abaqus subroutine

THE PREVENTION OF PRESSURE ULCERS: BIOMECHANICAL MODELIZATION AND SIMULATION OF HUMAN SEAT CUSHION CONTRIBUTIONS

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ABSTRACT

The main cause of pressure ulcers (PUs) is high pressure on the surface of buttock-tissue and support cushion as well as the area inside the bones and muscle tissue. There are also many other factors, including shear stress, friction, temperature and moisture. So far, many studies have used numerical simulations and experimental to find the influence of the stresses and strains, the surface pressures on the formation and development of pressure ulcers. This paper presents a biomechanical modelization and simulation of the interactions between wheelchair seat cushion and human buttock tissue (HBT) aiming to prevent ulcers. In this paper, we used three-dimensional (3D) finite element model (FEM) of a HBT in contact with a honeycomb seat cushion (HSC) in a sitting position. This cushion is made from thermoplastic polyurethane (TPU) for disabled people who use wheelchairs. Mechanical simulation performed to find the pressure distribution, the stress and the deformation. Thermal simulation permits to identify the temperature distribution on the surface of HBT and HSC that are the factors can cause PUs. Our results showed that the highest distribution pressure, the von-Mises stress respectively found corresponds to 175.8 kPa and 36.45 kPa. The highest temperatures obtained in the zone of interaction between buttock-tissue and HSC corresponds to 33.74°C after 35 min seating. Our study proposes a new methodology for the improvement and validation of FEM to identify the risk of PUs. The results will permit to improve cushion by collaboration with the manufacturer (optimization of shapes and materials) to create the own cushion model for each patient increasing his daily life.

Key words: Thermal-mechanical, buttock-tissue, pressure ulcers (PUs), wheelchair, seat-cushion, honeycomb, thermoplastic polyurethane (TPU), finite element