City University of Hong Kong | Jiang Su Society of Theoretical and Applied Mechanics | Hong Kong Society of Theoretical and Applied Mechanics | The Hong Kong University of Science and Technology

Proceedings of

The 23rd Annual Conference of HKSTAM 2019

The 15th Jiangsu – Hong Kong Forum on Mechanics and Its Application

April 9-14, 2019

Hong Kong

Editors

Paul H. F. LAM, Konstantinos SENETAKIS and Gang WANG

Published by HKSTAM, Hong Kong, China ® 2019

PREFACE

The 23rd Annual Conference of HKSTAM 2019 in conjunction with the 15th Jiangsu–Hong Kong Forum on Mechanics and Its Application is held during April 13, 2019 in Hong Kong University of Science and Technology. This conference is co-organized by the Hong Kong Society of Theoretical and Applied Mechanics (HKSTAM), the Jiang Su Society of Theoretical and Applied Mechanics (JSSTAM), City University of Hong Kong (CityU), and the Hong Kong University of Science and Technology (HKUST). The conference aims to provide a platform for all scientists, engineers, and mathematicians working on mechanics and related areas to share, communicate and exchange ideas, and to enhance co-operations within relevant parties. This proceeding consists of 69 abstracts including 5 Distinguish Lectures by Prof. Christopher K.Y. LEUNG from The Hong Kong University of Science and Technology, Prof. Qingwen REN from Hohai University, Prof. Ben YOUNG from The Hong Kong Polytechnic University, Prof. Dingguo ZHANG from Nanjing University of Science and Technology, and Prof. Johnny C.M. HO from Guangzhou University. The conference also contains 12 parallel sessions with presentations; Twenty-five from members of JSSTAM; Nine from researchers of local universities (e.g., Assistant Professors and Research Assistants); Three from research students of universities in Macau; and Twenty-three from research students of universities in HK.

The Society appreciates all the speakers and contributors for their efforts to make this event a successful one. Special thanks go to Ms. Xuan Wu of JSSTAM for her great help in organizing things in Jiangsu; Mr. Youhua Su and Dr. Jun Hu of City University of Hong Kong for their help in communicating various parties. The Society also wishes to thank the generous support from Institution Members of HKSTAM.

On behalf of and for the Executive Committee

Dr Heung Fai Paul LAM
President of HKSTAM
Associate Professor
Department of Architecture and Civil Engineering
City University of Hong Kong

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Conference Program

April 13, Saturday, Morning

8:30am – 12:00nn	**Registration and reception [Outside Lecture Theater D, Academic Building, HKUST]**
9:00 – 9:15am	**Opening addresses and souvenirs presentations [Lecture Theater D, Academic Building, HKUST]** **Professor Heung-fai Lam (林向暉)** **Professor Ding-guo Zhang (章定国)** **President of HKSTAM** **江苏省力学学会副理事长**
9:15 – 9:45am	**Distinguished Lecture I [Lecture Theater D, Academic Building, HKUST]** **Chair: Professor Ding-guo Zhang (章定国), 江苏省力学学会副理事长** **Professor Christopher K.Y. Leung (梁堅凝)** Professor, Department of Civil and Environmental Engineering, The Hong Kong University of Science and Technology (HKUST) "Micromechanics-Based Design of Strain Hardening Cementitious Composites"
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10:45 – 11:15am	**Distinguished Lecture III [Lecture Theater D, Academic Building, HKUST]** **Chair: Professor Heung-fai Lam, President of HKSTAM** **Professor Ben Young (楊立偉)** Vice-President, The Hong Kong Polytechnic University "Mechanical Properties of High Strength Steel at Elevated Temperatures: Experimental Investigation and Design Recommendations"

11:15 – 11:45am	**Distinguished Lecture IV [Lecture Theater D, Academic Building, HKUST]** **Chair: Professor Heung-fai Lam, President of HKSTAM** **Professor Ding-guo Zhang (章定国)** Vice-President of JSSTAM "Application of the Two-Loop Procedure Numerical Integration Method in Multibody Dynamics (双循环隐式方法在柔性多体系统动力学中的研究与应用)" (in Chinese)
11:45am – 12:15pm	**Distinguished Lecture V [Lecture Theater D, Academic Building, HKUST]** **Chair: Professor Heung-fai Lam, President of HKSTAM** **Professor Johnny C.M. Ho (何正銘)** Professor, Guangzhou University "A Constitutive Model for Predicting the Lateral Strain of Confined Concrete"
12:15 – 2:00pm	**Lunch**

April 13, Saturday, Afternoon (Parallel Sessions A1 to C1)

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2:15 – 2:30pm	Z.Y. Yin#, J. Yang, F. Laouafa and P.Y. Hicher Hydro-mechanical modeling of granular soils considering internal erosion	Y.F. Jin# and Z.Y. Yin An edge-based strain smoothing particle finite element method for large deformation geotechnical problems	马天然#，刘卫群 注气开采诱发断层滑移和可靠性
2:30 – 2:45pm	J.F. Zhou# On flow characteristics of manetorheological fluid through microchannel under alternating gradient magnetic field	H.Y. Zhang Seismic Responses of High-rise Intake Towers Considering Multiple-Support Excitation Effects	S.Q. Wu#, Y.W. Sun and Q.G. Fei A probabilistic framework for the stochastic dynamic load identification on uncertain structures
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2:30 – 2:45pm	J.B. Su#, S.L. Luan, L.M. Zhang, R.H. Zhu and W.G. QIN Partitioned Genetic Algorithm Strategy for Optimal Sensor Placement Based on Structure Features of A High-piled Wharf	Y. Shen#, Y. Kuang, W. Wang and S. Zhang Painlevé paradox during passive dynamic walking of biped robots	Feng Ren# and Hui Tang Elimination of velocity defect in the wake of a circular cylinder using deep reinforcement learning trained active flow control
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3:45 – 4:00pm	W.B. Chen[#] and W.H. Zhou Analysing Two-Dimensional Soil-Structure Interface Shearing Behaviour using Discrete Element Method	Xudong TIAN[#] and Chih-yung WEN Effects of porous walls on the stabilization of the first and second modes in hypersonic boundary layers	Y.J. Wang[#], and Y. Lu Deformation measurement of microlattice structures using digital image correlation (DIC)
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4:30 – 4:45pm	K. Cao[#], H. Yang, Y. Lu *in situ* electro-mechanical study of Ag nanowire/graphene hybrid films	Weitong Lin[#], Da Chen, Chaoqun Dang, Yang Lu, Ji-Jung Kai In situ mechanical characterization of He+ irradiated FeNiCoCr high-entropy alloy	Sufeng Fan[#] and Yang Lu In Situ Micromechanical Characterization of Metallic Glass Microwires under Torsional Loading
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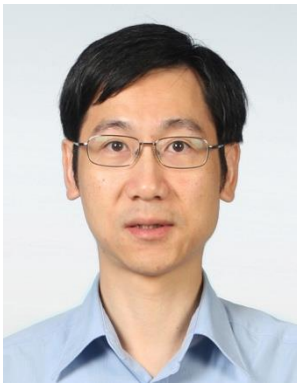
3:45 – 4:00pm	B. Xu[#] and X. Niu Bioinspired design of liquid optical clear adhesive (LOCA) for improving the damage resistance of touchscreen in smartphone	Kewei Feng[#], Gang Wang and Duruo Huang Material point method for large deformation analysis of soil slopes	I.A. Tijani[#], Y.F. Wu and C.W. Lim Modified Plastic-Damage Model for FRP-Repaired Concrete Columns
4:00 – 4:15pm	Zhou Jianfang and Chen Xuehong[#] Study on mechanical properties of plastic fuel tank material after fuel soak	Zhaokun Wang[#], Chenglei Wang, Hui Tang Simulation of fluid-structure interaction during phacoemulsification-based cataract surgery	Chaoqun Dang[#], Yang Lu In situ nanomechanical characterization of ceramic/metal nanocomposites
4:15 – 4:30pm	Z.L. Cheng[#] and W.H. Zhou A Simplified Model for Estimation of Field-Monitored Soil Suction using Genetic Programming	Ran Tao[#], Yakang Jin, Xiang Gao, and Zhigang Li Experimental investigation of flow in converging-diverging microchannels	Ran Xiao[#], Libo Gao1, Xiaobin Feng, Rong Fan, and Yang Lu 3D Printed Gradient Composite Microlattice Mandibular Prosthesis
4:30 – 4:45pm	X.B. Feng[#] and Y. Lu Microstructure and mechanical properties of CoCrFeNiZrx high entropy alloy (HEA) thin films	Z.W. Chen[#], D. Huang, G. Wang and F. Jin Topographic amplification on steep terrain: case study of Tuen Mun valley	F.W. Zhao[#], M. N. Mumtaz Qadri and H. Tang Experimental and theoretical study of a bio-inspired flow energy harvester

April 13, Saturday, Evening

5:00 – 5:15pm	**Closing Ceremony and Award Presentation [LT-D]**
5:15 – 6:15pm	**HKSTAM Annual General Meeting [LT-D]** Attendees: Representatives of all Institution Members and all Full HKSTAM members
6:30 – 8:00pm	**Conference Banquet [南北小廚, G/F, Academic Building]**

~ Closure of the conference ~

Distinguished Lecture I



Prof. Christopher K. Y. Leung (梁堅凝)

Dr. Christopher K. Y. Leung is Professor of Civil and Environmental Engineering at the Hong Kong University of Science and Technology, and was Head of the Department from 2009 to 2015. He received his B.Sc (Hon) from the University of Hong Kong, his M.S from University of California, Berkeley and PhD from MIT. His research interests are in the general area of construction materials, covering fracture mechanics, composite mechanics, fiber optic sensing and the application of composites in civil engineering. Prof. Leung has published over 150 SCI journal papers, and delivered keynote and plenary lectures at various international conferences in the US, Canada, Europe, China and India. He has received a number of research-related awards including the Best Applied Research Paper Award from ASCE Journal of Composites in Construction (2007), the First Class Award in Natural Sciences from the China Ministry of Education (2015) and the Second Class State Natural Science Award from the China State Department (2012). He served as the Honorary President of RILEM (International Union of Laboratories and Experts in Construction Materials, Systems and Structures) in 2011 and is elected Fellow of 6 international institutions/associations, including HKIE, ICE (UK), IStructE (UK), ASCE, RILEM and IA-FraMCoS (International Association for Fracture Mechanics of Concrete and Concrete Structures). He has been a council member of the Hong Kong Construction Industry Council from 2011 to 2017 and is the founding chair of the Committee on Productivity. He has also served as Chairman of the HKIE Materials Division and Chair of the HKAS Working Party on Construction Materials.

Micromechanics-Based Design of Strain Hardening Cementitious Composites

C.K.Y. Leung[*,#,1], **C. Lu**[2] **and J. Yao**[1]

[1]Department of Civil and Environmental Engineering, HKUST, Hong Kong, China

[2]Department of Civil Engineering, Southeast University, Nanjing, China

*Corresponding author: Tel: +852 2358-8183, E-mail: ckleung@ust.hk

[#] Presenter: E-mail: ckleung@ust.hk

Abstract: Strain hardening cementitious composite (SHCC) is a kind of fiber reinforced composites exhibiting tensile strain hardening behaviour up to several percent of strain, accompanied by the formation of multiple cracks with very small opening. In structural members, these properties translate into very high deformation and energy absorption capacities as well as excellent durability (because fine cracks will not facilitate the penetration of water/chemicals to induce degradation of concrete and steel rebar). Also known as Engineered Cementitious Composites (ECC), the design of SHCC is based on principles of mechanics, rather than empirical trial and error. In this presentation, the basic properties and a few practical applications of SHCC will be described first, followed by an explanation of the material design principle. Specifically, the tensile behaviour of the material is governed by the fiber bridging stress vs crack opening ($\sigma-\delta$) relation. This relation is dependent on micro-parameters of the composite, including the properties of fiber, matrix and fiber/matrix interface as well as the fiber volume fraction and geometry. Through the micromechanical modeling of the $\sigma-\delta$ relation and fracture analysis of a crack bridged by the fibers, quantitative criteria for the selection of micro-parameters to achieve strain hardening behaviour can be derived. Following these criteria, SHCC has been made with fiber content as low as 1.5 to 2.0%. However, while it is possible to design composites with hardening behavior, the actual extent of the hardening regime and the crack width vs strain relation (which governs durability) are still hard to predict. Moreover, in the micromechanical model, there is a major empirical parameter which needs to be obtained from tedious experimental testing. Research on these two important issues has recently been carried out at HKUST. The methodologies and major findings of these investigations will be described, and improvements over existing approaches, in both theoretical and practical aspects, will be highlighted.

Acknowledgements

The authors wish to thank the Hong Kong Research Grant Council for the support of their research over the years through a number of GRF grants.

References

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Lu, C. and Leung, C.K.Y. (2016), "A New Model for the Cracking Process and Tensile Ductility of Strain Hardening Cementitious Composites (SHCC)", *Cement and Concrete Research*, **79**, 353-365.

Yao, J. and Leung, C.K.Y. (2019), "A New Physical Model for Empirical Fiber Snubbing Effect in Cementitious Composites Based on Large Deflection Beam Theory", *Cement and Concrete Composites*, **96**, 238-251.

Distinguished Lecture II

Prof. Qing-wen Ren (任青文)

Prof. Qingwen Ren is currently the Deputy director of the Professional Committee of Hydraulic Engineering and Hydropower Buildings, Chinese Society of Hydropower Engineering, a special member of science and technology committee of Sinohydro Corporation and the member of ASCE. He was the president of JSSTAM.

His research interests include hydraulic structure and system safety, failure mechanics, and the theory and application of modern numerical analysis methods. As the first person in charge, he has undertaken one National "973" project, four key projects and four general projects of NSFC, nine National science and technology support projects, and more than 70 provincial and ministerial key projects. He has been carrying out scientific research on the safety of high concrete dam, high slope and underground cavern for the Three Gorges, Xiaowan, Xiangjiaba, Xiluodu, Baihetan, Jinping, South-to-North Water Diversion and other major projects. And he participated in the revision and review of national codes for arch dam, gravity dam, hydraulic tunnel and foundation of hydraulic structures. He has published more than 250 papers and won 1 national science and technology progress award and 7 provincial science and technology progress awards. His research interests include hydraulic structure and system safety, failure mechanics, and the theory and application of modern numerical analysis methods. As the first person in charge, he has undertaken one National "973" project, four key projects and four general projects of NSFC, nine National science and technology support projects, and more than 70 provincial and ministerial key projects. He has been carrying out scientific research on the safety of high concrete dam, high slope and underground cavern for the Three Gorges, Xiaowan, Xiangjiaba, Xiluodu, Baihetan, Jinping, South-to-North Water Diversion and other major projects. And he participated in the revision and review of national codes for arch dam, gravity dam, hydraulic tunnel and foundation of hydraulic structures. He has published more than 250 papers and won 1 national science and technology progress award and 7 provincial science and technology progress awards.

Crack criterion of hydraulic concrete based on structure function

Qingwen Ren[1], Jiafeng Gu[2] and Jiabin Song[1]

[1]Department of Engineering Mechanics, Hohai University, Nanjing, China

[2]Department of Hydraulic Structure, Hohai University, Nanjing, China

[3]Jiangsu Society of Theoretical and Applied Mechanics, Nanjing, China

*Corresponding author: Tel: +85-25-83787781, E-mail: renqw@hhu.edu.cn

[#] Presenter: E-mail: renqw@hhu.edu.cn

Abstract: Hydraulic concrete structures, especially concrete dam, usually have cracks due to various r weasons. Under the highater pressure, the cracks may be further expanded, and even hydraulic fracturing may occur, endangering the safety of the structure. However, most cracking concrete dams are still able to operate safety, which gives rise to the problems of whether or not to allow the appearance of cracks in concrete structures, how wide cracks that won't cause damage, and what a reasonable index can be used to describe and judge the extent of concrete cracking. Concrete dam as a retaining structure, firstly, must has the function of preventing leakage. Thus if the dam cracks are limited in a specified width, which cannot form the flow channels and can ensure the function of preventing leakage, then these cracks can be considered allowable and safe. In this paper the criterion of "allowed cracks" is defined from the angle of ensure the function of preventing leakage. So it must be studied that the value of equivalent plastic strain which corresponds to the "harmful cracks" in numerical simulation. According to the same permeability requirements of the cracked dam with the anti-seepage curtain, the allowable permeability coefficient is found. And based on the test relationship between the tension strain and permeability coefficient for concrete in the related literatures, the value of the relevant tension strain is determined, which is as the cracking criterion of hydraulic concrete. When the tension strain is lower than this value, the distinct flow channels cannot be formed in concrete, and the effect on the behavior of dam is very little. Through the numerical simulation of concrete uniaxial tensile with Concrete Damaged Plastic model (CDP), the parameters of which are determined according to the design code of concrete structures, the relationship among crack width, equivalent plastic strain and principal tensile strain is established. And the equivalent plastic strain criterion and the criterion represented by crack width for concrete cracking are obtained. The application of the research results to the cracking analysis of a concrete dam presents that the relationship between equivalent plastic strain and principal tensile strain is very consistent with the result of numerical simulation of concrete uniaxial tensile, which shows that the relevant conclusions come from the numerical simulation of concrete uniaxial tensile can be applied to the complicated stress states in concrete dam. The above results play an important role in the determination of the cracking region of concrete structure.

Acknowledgements

The authors wish to thank the Support of NFSC.

References

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Distinguished Lecture III

Prof. Ben Young (楊立偉)

Professor Ben Young is currently the Vice President (Student Affairs) of The Hong Kong Polytechnic University. He was Associate Dean of the Graduate School, Associate Dean of the Faculty of Engineering at The University of Hong Kong (HKU). He received BSc, BEng and PhD degrees from The University of Sydney, Australia. Professor Young is the Deputy Chairman of the Structural Division of the Hong Kong Institution of Engineers (HKIE) and also the Vice-President of the Hong Kong Institute of Steel Construction. He is a committee member of the Specification for the "Design of Cold-formed Stainless Steel Structural Members", American Society of Civil Engineers. He is currently a member of the Accreditation Advisory Board under the Innovation and Technology Commission, HKSAR.

His research interests include high strength steel structures, stainless steel structures, aluminium structures and fire resistance of metal structures. Professor Young is currently a Co-Editor-in-Chief of the *Journal of Constructional Steel Research*. He has published over 500 international journal and conference papers, of which over 230 are SCI indexed journal papers. According to the ISI's essential science indicators, Professor Young has been listed for many years in the "Top 1% scholars" for highly cited papers.

Professor Young received the Michael G. Gale Medal for Distinguished Teaching Award in 2004 from The Hong Kong University of Science and Technology. He also received the Outstanding Young Researcher Award in 2006, the Outstanding Teaching Award in 2008, the Outstanding Research Student Supervisor Award in 2015 and the Outstanding Researcher Award in 2017 from HKU. He also received the Best Research Paper Award given by the Journal of Structures, *ELSEVIER* in 2016.

Mechanical properties of high strength steel at elevated temperatures: Experimental investigation and design recommendations

H.T. Li*[1] and B. Young[#2]

[1]School of Civil and Environmental Engineering, Nanyang Technological University, 50 Nanyang Avenue, Singapore (Formerly, Department of Civil Engineering, The University of Hong Kong, Hong Kong, China)

[2]Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University, Hong Kong, China (Formerly, Department of Civil Engineering, The University of Hong Kong, Hong Kong, China)

*Corresponding author: Tel: +65 8311-1643, E-mail: haiting.li@ntu.edu.sg

[#] Presenter: E-mail: ben.young@polyu.edu.hk

Abstract: High strength steel (HSS) sections are being increasingly used in structural applications owing to their superior strength-to-weight ratio, which result in material savings and easier handling in construction. The strength and stiffness of steel structural members may reduce under fire. The mechanical properties at elevated temperatures have a crucial role in fire resistance design of steel structures. A test program has been carried out by Li and Young (2017) to investigate the mechanical properties of cold-formed HSS at elevated temperatures. The coupon specimens were extracted from cold-formed HSS square and rectangular hollow sections with nominal yield stresses of 700 and 900 MPa. The coupon tests were conducted through both steady and transient state test methods for temperatures up to 1000 °C. Mechanical properties including elastic modulus, yield stress, ultimate strength, ultimate strain and strain at fracture were obtained. The test results were compared with the design values in the European, American, Australian and British standards. New design curves to determine the deterioration of mechanical properties of HSS at elevated temperatures have been proposed. It is shown that the proposed design curves are suitable for high strength steel materials with nominal yield stresses ranged from 690 to 960 MPa.

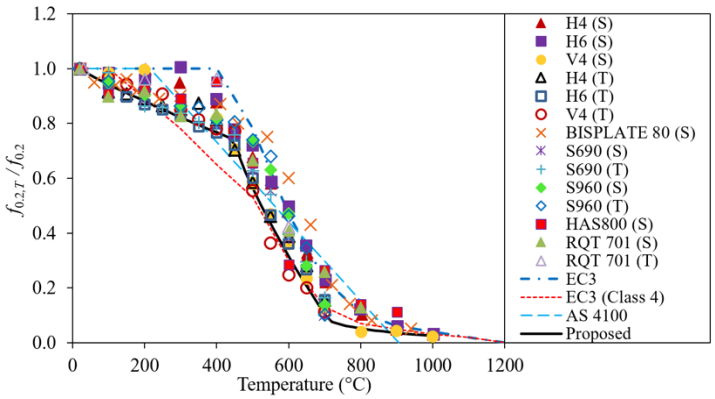

Figure 1. Proposed 0.2% proof stress (yield stress) reduction factors for high strength steel.

Acknowledgement

The authors wish to thank Rautaruukki Corporation for providing the test specimens.

Reference

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Distinguished Lecture IV

Prof. Ding-guo Zhang (章定国)

Dr. Ding-guo Zhang is a professor at the School of Science of Nanjing University of Science and Technology(NJUST). He received the Ph.D. degree in Mechanics from NJUST in 1998. He joined the School of Science of NJUST in Spring 1992, and was appointed the vice dean of the School of Science in Fall 1998. He was a visiting scholar at McGill University from May 2002 to May 2003, and at University of Illinois at Chicago from December 2009 to January 2011, respectively. He is the member of Council of the Chinese Society of Theoretical and Applied Mechanics (CSTAM), and also the vice President of Jiang Su Society of Theoretical and Applied Mechanics (JSSTAM). He has been involved in multibody system dynamics research since 1989, and authored more than 130 journal papers and more than 160 academic conference papers, respectively.

Application of the two-loop procedure numerical integration method in multibody dynamics

D.G. Zhang*#[1] and X. Guo[1]

[1]School of Science, Nanjing University of Science and Technology, Nanjing, Jiangsu, China

*Corresponding author: Tel: +86 8431-5185, E-mail: zhangdg419@mail.njust.edu.cn

Presenter: E-mail: zhangdg419@mail.njust.edu.cn

Abstract: The performance of the two-loop implicit sparse matrix numerical integration (TLISMNI) methods as the numerical solution of index-3 differential algebraic equations (DAEs) of motion arising in stiff multibody dynamics is studied here. The original TLISMNI method which uses the Newmark method as the implicit integration algorithm is proposed by Shabana and Hussein. This integration algorithm considers the accelerations and Lagrange multipliers as basic unknowns and its numerical accuracy is no more than order 2. In order to have a higher integral precision, we propose a series of new two-loop procedures which consider coordinates and velocities as basic unknowns. The whole structure of the proposed method is different from the traditional one due to the different unknowns, and it is suitable for implementation using a broad spectrum of numerical integration methods. Firstly, two numerical examples, a typical four-bar linkage mechanism and the flexible beam modeled by absolute nodal coordinate formulation (ANCF), are presented to demonstrate the efficiency of the proposed TLISMNI method. Results show that the new method is good in generality, and the constraints can be satisfied at position level, velocity level, and acceleration level at the same time. Furthermore, we apply these methods to the contact and constraint problems of flexible multibody dynamics while few studies of TLISMNI methods have been done on these non-smooth problems in order to verify the effect of the proposed algorithms. Finally, the TLISMNI method is used as the numerical solution of the DAEs arising in the control problems. Two simulation examples of inverse dynamics, the rigid chain manipulator and the collision problem related to the capture task by a flexible space robot, are computed to test the applicability of the proposed method.

Acknowledgements

The authors are grateful for the support from the National Natural Science Foundation of China (Grant Numbers 11772158, 11502113), and the Fundamental Research Funds for Central Universities (Grant Number 30917011103).

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Distinguished Lecture V

Prof. Johnny C.M. Ho (何正銘)

Dr Johnny Ching Ming HO is a Professor in the School of Civil Engineering, Guangzhou University, PRC. Before joining the university in 2018, he worked as a Senior Lecturer in the University of Queensland in 2013-2018 and an Assistant Professor in The University of Hong Kong in 2007-2013. Practically, Dr Ho had about 5 years' of experience working in both Hong Kong and Brisbane offices of Arup on some large scale infrastructure projects such as The Stonecutters Bridge in Hong Kong and the Ipswich Motorway Upgrade (Wacol to Darra) in Brisbane. Dr Ho's research interests are on mix design of high-performance concrete with multi-sized fillers, rheology of cement paste and mortar, as well as their application in concrete-filled-steel-tube columns.

A constitutive model for predicting the lateral strain of confined concrete

M.H. Lai and J.C.M. Ho*#

School of Civil Engineering, Guangzhou University, 230 Wai Huan Xi Road, Guangzhou Higher Education Mega Center, Guangzhou 510006, P.R.China

*Corresponding author: E-mail: johnnyho476@gmail.com

Presenter: E-mail: johnnyho0476@gmail.com

Abstract: The confining stress developed in various types of confined concrete is related to the lateral strain of the concrete, of which the inelastic component is up to now very difficult to evaluate. Herein, the lateral strain of confined concrete for the full stress-strain range from pre-crack and elastic state to post-crack and inelastic state is studied based on published experimental results, and a constitutive model for predicting the lateral strain of confined concrete is developed by back calculation. This model is a useful tool for analysing the full range structural behaviour of various kinds of confined concrete columns, e.g. concrete-filled steel tube columns. Later the developed axial-lateral strain model is applied to study the effects of confining stiffness and rupture strain FRP confined concrete. Some of the obtained results will be presented.

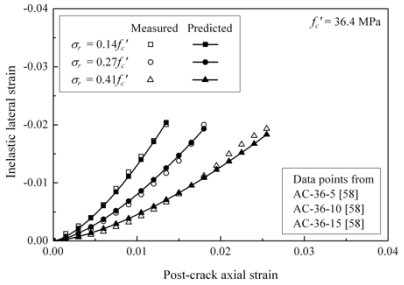

Figure 1 Inelastic lateral strain against post crack axial strain

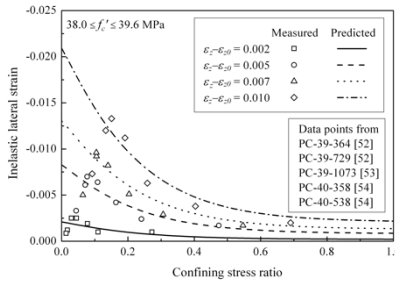

Figure 2 Inelastic lateral strain against confining stress

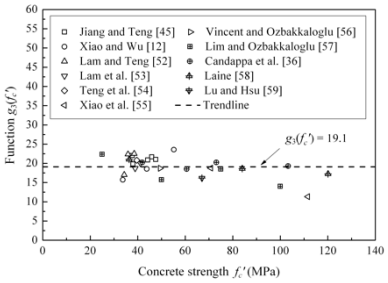

Figure 3 Inelastic lateral strain against concrete strain

Acknowledgements

Research grant provided by the Scientific Research Foundation for the Talents by Guangzhou University, China (Project No. 69-18ZX10363) is gratefully acknowledged.

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薄膜体声波谐振器建模分析的研究进展

Z.H. Qian*#[1], N. Lian[1], Z.N. Zhao[1], F. Zhu[1], B. Wang[1]

[1] State Key Laboratory of Mechanics and Control of Mechanical Structures/College of Aerospace Engineering, Nanjing University of Aeronautics and Astronautics, Nanjing, Jiangsu, China

*Corresponding author: Tel: +86-25-8489-2696, E-mail: qianzh@nuaa.edu.cn

Presenter: E-mail: qianzh@nuaa.edu.cn

Abstract: 薄膜体声波谐振器与传统的基于体声波或表声波的晶体谐振器相比，具有一系列的优点，比如更小的尺寸、更高的 Q 值、更高的工作频率以及与芯片和集成电路技术的相容性等。因此，薄膜体声波谐振器在通信、信号处理、控制、导航和传感等领域具有广泛的应用前景。本文中，我们将介绍几种用于薄膜体声波谐振器结构建模分析的方法，包括无限大板中纯厚度拉伸的一维分析方法，基于 Tiersten-Stevens 标量方程的二维分析方法，以及可以处理模态耦合及面内模态变化的二维板方程方法。

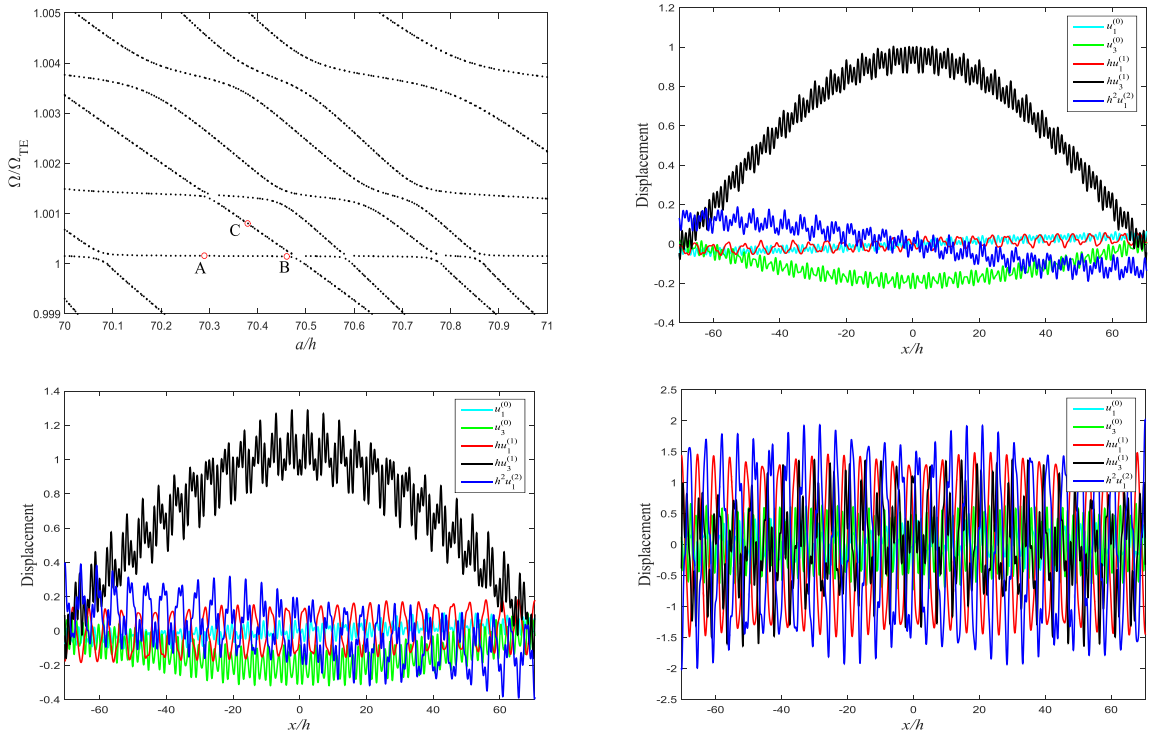

图 1. 薄膜体声波谐振器自由振动的频谱图以及对应 ABC 点处的振动模态分布

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Hydro-mechanical modeling of granular soils considering internal erosion

Z.Y. Yin[1*], J. Yang[2], F. Laouafa[3] and P.Y. Hicher[2]

[1] Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong

[2]Research Institute of Civil Engineering and Mechanics (GeM), UMR CNRS 6183, Ecole Centrale de Nantes, Nantes, France

[3]French National Institute for Industrial Environment and Risks (INERIS), Verneuil en Halatte, France

* Corresponding author: Tel. +852 34008470, E-mail: zhenyu.yin@polyu.edu.hk

[#] Presenter: zhenyu.yin@polyu.edu.hk

Abstract: This paper attempts to formulate a coupled numerical model in the framework of continuum mechanics in order to investigate the phenomenon of internal erosion and its consequences on the mechanical behavior of soils. For this purpose, a four-constituent numerical approach has been developed to describe the internal erosion process. The detachment and transport of the fine particles have been described by a mass exchange formulation between the solid and fluid phases. The stress-strain relationship of the soil is represented by a non-linear incremental model. Based on experimental data, this constitutive model has been enhanced by the introduction of a fines content dependent critical state, which allows accounting for the influence of fines on soil deformation and strength. The applicability of the numerical approach to capture the main features of the internal erosion process and its impact on the mechanical behavior of the eroded soil has been validated by comparing numerical and experimental results of internal erosion tests on HK-CDG mixtures, which demonstrated that the model was able to reproduce with good accuracy the experimental data. Furthermore, the influence of the stress state, the initial soil density, and the initial fraction of fines have been analyzed through numerical simulations.

On flow characteristics of manetorheological fluid through microchannel under alternating gradient magnetic field

J.F. Zhou*#[1]

[1]School of Mechanical and Power Engineering, Nanjing Tech University, Jiangsu, China

*Corresponding author: Tel: +86 25 58139956, E-mail: zhoujianfeng@njtech.edu.cn

Presenter: E-mail: zhoujianfeng@njtech.edu.cn

Abstract: To investigate the flow regularity of manetorheological fluid (MRF) in a mcirochannel flow governed by alternating gradient magnetic field, a 3D numerical simulation method is established based on the lattice Boltzmann method (LBM). Firstly, MRF is treated as a two phase system and the motions of manetic nanoparticles (MPs) are investigated base on the immersed boundary method (IBM). The motions of both a single MP and a short chain of MPs are investigated and each is found to be a superposition of transverse oscillation and longitudinal translation. Secondly, a doubled-population LBM method is developed, where MPs are treated as a quasi fluid. Simulation results show that, affected by the alternating gradient magnetic field, a considerable transverse velocity component occurs in the flow field.

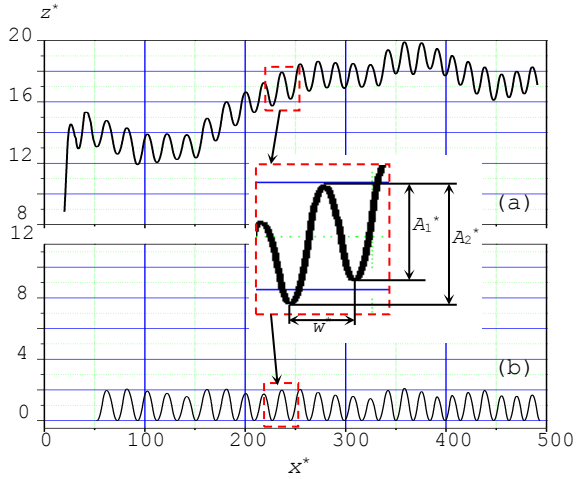

Figure 1. Filtering processing for original trajectory of magnetic particles.

Acknowledgements

This project is supported by National Natural Science Foundation of China (51775262), Natural Science Foundation of Jiangsu Province of China (BK20161546).

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Comparative study on the definitions of non-probabilistic reliability index and reliability

Zhou Jianfang[#1,2], **Gao Ran***[2]

[1]College of Mechanical and Electrical Engineering, Hohai University, Jiangsu, China

[2]College of Mechanicals and Materials, Hohai University, Jiangsu, China

*Corresponding author: Tel: +86 0519-13961401197, E-mail: zhoujf101@163.com

[#] Presenter: E-mail: gaoran-91@163.com

Abstract: In view of the uncertainty problem in practical engineering, the non-probabilistic reliability emerges when the probabilistic reliability theory developed to the bottleneck. The non-probabilistic reliability model can still measure the reliability of the structure in the case of less information, so it has an important position in the practical engineering. Based on the existing research, this paper studies several major non-probabilistic reliability indicator and reliability definitions, and points out that there are non-uniqueness problem in the definition of interval reliability indicators and makes a preliminary analysis. Then the reliability index and reliability of interval and ellipsoid are compared, analyzed and summarized. Finally, the non-probabilistic reliability is compared with the probability reliability obeying the uniform distribution, normal distribution, and the inaccurate probability reliability obeying the triangle distribution, which lays a foundation for the further study of non-probabilistic reliability.

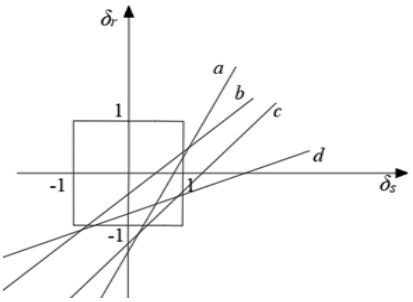

Figure 1. A sample of a figure

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中医的阴阳五行原理与二阶系统理论

N. Chen*[1]

[1]Collage of Mechanical and Electronic Engineering, University of Nanjing Forestry, Jiangsu, China

*Corresponding author: Tel: +86 13851502589, E-mail: chenning@njfu.com.cn

[#] Presenter: E-mail: chenning@njfu.com.cn

Abstract: 中医理论以悠久历史、独特的理论系统和疗效在中国及邻邦的历史中留下不朽功绩。百年来。随着现代医学自西方引入和快速的发展，中医却因理论的科学内涵不明和中药某些成分的毒性备受责疑。因而，揭示中医理论的科学内涵及中西医理论之间相互的关系是振兴中医的至关重要的一步。而其中关键则是作为中医理论哲学指导思想的阴阳五行原理的科学内涵。

本文基于复杂动力学系统的分析方法和数理逻辑，按特征值为实数或复数，将复杂系统的特征系统分为一阶特征系统和二阶特征系统。综合考虑唯象科学的中医理论与基于“双盲实验”的现代医学理论的方法及差异，认为现代医学的研究基于人体的物理系统，主要涉及人体的一阶特征系统。而作为经验科学的中医理论则基于人体表象，涉及的则是人体的二阶系统，这一因素为中医与现代医学理论长期无法融合的主要沟壑。因而，中医的阴阳五行理论与二阶微分系统理论存在着一定的内在联系。主要内容有：

首先，将阴阳变化和五行相生相克关系与线性二阶系统的动力学模型相联系起来，将系统的势能与动能概念与中医的“阴”“阳”相对应，基于系统周期变化中的能量流动和输入输出特性分析，并参考阴阳五行原理在中医临床中运用，定义了二阶系统的“五行”，并分析它们之间的相生和相克关系。

其次，利用二阶系统的能量幅频曲线揭开人体阴阳平衡的科学实质及中医药性等一些受到责疑的中医理论问题。

第三，针对人体脏腑二阶特征系统无法参数建模问题，进一步将中医的辩证论治方法、五行的生克关系和阴阳平衡三者之间的相互关系用数学优化思想进行科学合理的解释，肯定了中医诊治方法的科学性和实用性。

最后，对阴阳五行原理在其它一些周期现象中的运用进行了简单讨论，证实阴阳五行原理是具有普遍性的原理，是我国古代伟大的理论发明。

Acknowledgements

The work thanks the help of Professor J. Liu, Jiangsu Hospital of Traditional Chinese Medicine.

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Thermal effect on dynamics of rotating functionally graded microbeams

Jianshi Fang*[#], Jianping Gu and Xiaopeng Zhang
School of Materials Engineering, Nanjing Institute of Technology, Jiangsu, China
*Corresponding author: Tel: +86 13813925869, E-mail: fangjsh@njit.edu.cn
[#] Presenter

Abstract: Thermal effect on size-dependent free vibration behavior of rotating microbeams (see Figure 1) made of temperature-dependent functionally graded materials (FGMs) is investigated. Material properties of FGMs are assumed to change smoothly along the thickness of the microbeam according to a power-law variation. Considering Euler-Bernoulli beam theory (EBT) and Timoshenko beam theory (TBT), Hamilton's principle is employed to derive the governing equations and associated boundary conditions of rotating microbeams based upon a modified couple stress theory. These equations are numerically solved by using an assumed-mode discretization approach. Several comparative examples are carried out to verify the reliability and accuracy of the present model. The effects of slenderness ratio, FG index, dimensionless angular velocity, dimensionless material length scale parameter and temperature change on the dynamics of rotating FG microbeams are analyzed in detail.

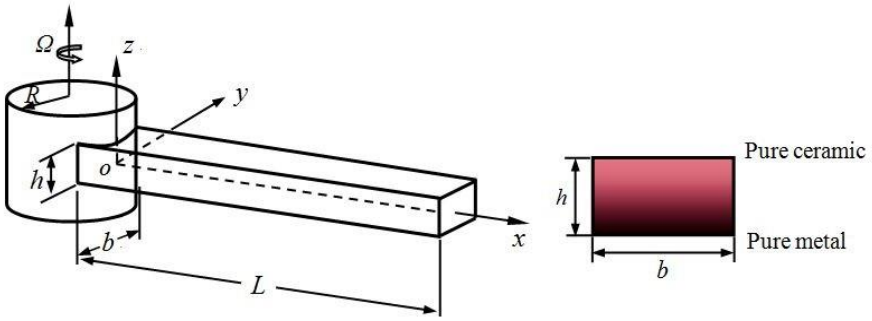

Figure 1. The three-dimensional configuration of a rotating hub-FG microbeam system.

Acknowledgements

The authors wish to thank the financial support from NSFC (Grant No. 11872031 and 11302096) and the Natural Science Foundation of NJIT (Grant No. ZKJ201701).

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An edge-based strain smoothing particle finite element method for large deformation geotechnical problems

Y-F JIN[1#] and Z-Y YIN[1*]

[1] Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong

* Corresponding author: Tel. +852 34008470, E-mail: zhenyu.yin@polyu.edu.hk

[#] Presenter: E-mail: yinfu.jin@polyu.edu.hk

Abstract: To solve large deformation geotechnical problems, a novel strain-smoothed particle finite element method (SPFEM) is proposed that incorporates a simple and effective edge-based strain smoothing method within the framework of the original PFEM. The advantage of the novel method is to use very simple lower-order triangular element without suffering from volumetric locking via the strain smoothing method, instead of the higher-order triangular element/mixed stabilised formulation in the original PFEM, while preserving the same calculation accuracy with reducing calculation time. To guarantee the computational stability, the proposed SPFEM uses an explicit time integration scheme, and adopts an adaptive updating time step and artificial bulk viscosity of numerical damping. Performance of the proposed SPFEM for geotechnical problems is examined by four benchmark numerical examples: (1) bar vibrations, (2) settlement of strip footing, (3) collapse of aluminium bars column and (4) failure of a homogeneous soil slope. All results demonstrate that the novel SPFEM is a powerful and easily extensible numerical tool for simulating large deformation geotechnical problems.

Seismic Responses of High-rise Intake Towers Considering Multiple-Support Excitation Effects

H.Y. Zhang*[1]

[1] College of Water Conservancy and Hydropower Engineering, Hohai University, Nanjing, Jiangsu, China

*Corresponding author: Tel: +86 13770957562, E-mail: zhanghanyun@hhu.edu.cn

Abstract: The seismic safety and proper functioning of intake towers in a major earthquake are very crucial to the whole hydraulic project, since the controlled release of the reservoir could help to prevent catastrophic failure of a dam after an earthquake by reducing the water pressure. The dynamic response of high-rise intake towers during earthquakes may present quite complex characteristics due to many factors. The complexity of the analysis is increased by important soil-structure interaction effects. A free-standing intake tower usually exhibits an access bridge that connects the top of the tower to the dam or abutment. Therefore, the intake-outlet tower and bridge system has two well-separated supports. Different local soil conditions, traveling wave effects, phase difference in the seismic motions, and other factors can cause a spatial variability of the ground motion at the supports. These multiple-support excitation effects can be important in the calculation of the seismic response of the system. Therefore, and because of the lack of previous investigations dealing with these effects, this paper is aimed to study in more detail their influence on the dynamic response of the high-rise intake tower. The multiple-support ground motion excitation method will be proposed. The dynamic interaction between the tower and the access bridge will be investigated.

Acknowledgements

The author wishes to thank financial supports provided by the National Natural Science Foundation of China (No. 51709090) and the Natural Science Foundation of Jiangsu Province (No. BK20170884).

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Fundamental material research on high-entropy alloy (HEA) microlattices

Wenzhao Zhou[#1,2], **Libo Gao**[2,3], **Yang Lu***[1,2]

[1] Nano-Manufacturing Laboratory (NML), Shenzhen Research Institute, City University of Hong Kong, Shenzhen, China

[2] CityU-Xidian Joint Laboratory of Micro/Nano-Manufacturing, Shenzhen 518057, China

[3] School of Mechano-Electronic Engineering, Xidian University, Xian 710071, China

*Corresponding author: E-mail: yanglu@cityu.edu.hk

[#] Presenter: E-mail: zhouwzmse@163.com

Abstract: Microlattice structure, especially the metal microlattice attracts more attention due to its excellent mechanical properties such as high strength, lightweight. Recently, our team together with some other scientists in the material field fabricate the microlattice structure by coating the high entropy alloy (HEA) thin film to the substrate. By the combination of microlattice structure enhancement effect, mechanical properties and the size effect of the HEA thin film, it was found that the lightweight nanocrystalline HEA microlattice not only exhibits high compressive strength but also has great compression ductility.

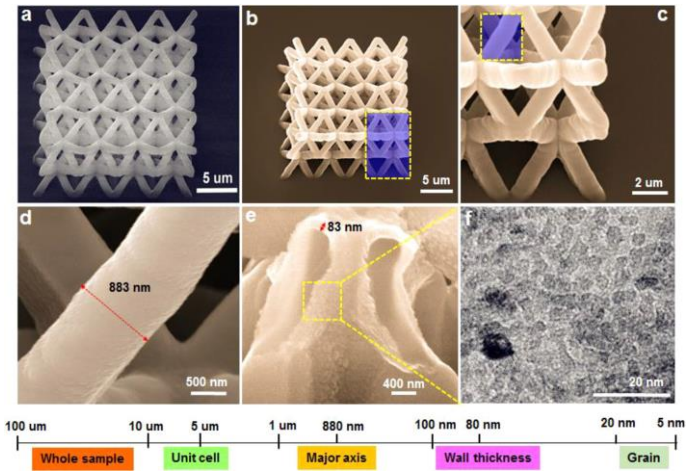

Figure 1. Multiple size figures of the nanocrystalline HEA thin film coated microlattice structure.

Acknowledgements

The authors gratefully thanked the funding supports from Shenzhen Science and Technology Innovation Committee under the grants JCYJ20170413141157573. Part of this project was supported by City University of Hong Kong (Project Nos. 9667164 and 9667153).

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Experimental and numerical investigation on the ballistic performance of metallic sandwich plates for marine applications

A.L. Tian[1], J.W[1], R. C. Ye[1]

[1] School of Naval Architecture and Ocean Engineering, Jiangsu University of Science and Technology,Zhenjiang 212003, China

*Corresponding author: Tel: 13852944955, E-mail:tianali@just.edu.cn

[#] Presenter: E-mail: tianali@just.edu.cn

Abstract: To predict the performance of protective structures of marine applications, the ballistic performance of sandwich plates with steel skins and aluminum foam core, the quasi-static compressive experimental of four types aluminum foam with different density are carried out. The failure mechanism, mechanic parameters and modified constitutive model are obtained. The tests using numerical simulation method by using finite element code LS-DYNA were conducted with different impact velocities based on quasi-static experimental parameters. Effect of projectile shape, skins thickness, core thickness and core densities on the residual velocity, plastic deformation and energy absorption ability of sandwich plates are discussed, while typical penetration failure modes and deformation mechanism are presented and analyzed. It was shown that mechanics properties of aluminum foam with different density can be described accurately by modified constitutive model. The failure modes of sandwich plates are different for hemisphere-nosed and blunted-nosed projectile and the projectile shape effect is significant for ballistic performance when the impact velocity approaches ballistic limit. The ballistic limit increases with the increase of thickness of skins or core, core density which shows an approximate linear relationship.

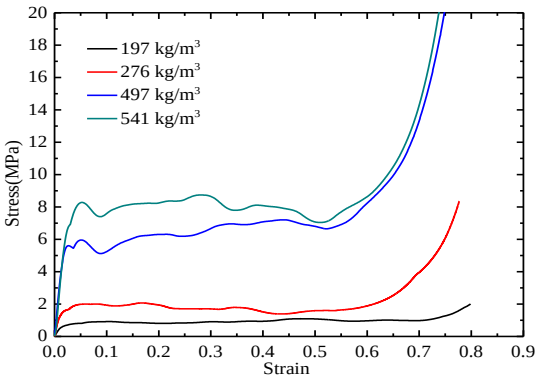

Fig.1 Compression stress-strain curve

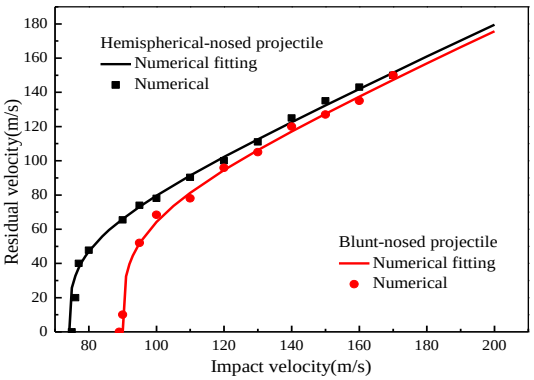

Fig.2 Residual velocity of aluminum foam sandwich plate

Acknowledgements

The authors wish to thank the financial support from the National Natural Science Foundation for Young Scholars of China under Grant Numbers E091002/51109101 and E091002/51509115, A Plan for Supporting the Deep Blue Talents of School of Naval Architecture and Ocean Engineering.

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Aspect ratio effect on performance of H-rotor vertical axis wind turbines in turbulent flows via wind tunnel testing

H.Y. PENG[#1], H.F. Lam[2] and H.J. Liu*[1]

[1]School of Civil and Environmental Engineering, Harbin Institute of Technology, Shenzhen, China

[2]Department of Architecture and Civil Engineering, City University of Hong Kong, Hong Kong, China

*Corresponding author: Tel: +86 755 2603-3805, E-mail: liuhongjun@hit.edu.cn

[#]Presenter: E-mail: penghuayi@hit.edu.cn

Abstract: In this work, the power performance of H-rotor VAWTs was examined experimentally in turbulence of various length scales. A range of turbulence integral length scales were produced by wooden grids with different mesh sizes. The power coefficients, C_P, of VAWTs were measured by applying resistance in the rotor circuit. Measurement uncertainty was carried out. The experimental results evidently proved that turbulence enhanced the power performance of VAWTs. Moreover, the rated C_P was found to be inversely proportional to the integral length scale, whereas it increased with the turbine aspect ratio. The underline reasons for the phenomena were addressed. This work serves the interest of the design and application of VAWTs in urban areas.

Figure 1. Wind turbine installed in the wind tunnel.

Acknowledgements

The work was supported by Youth Science Funding of National Natural Science Foundation of China (NSFC) (Project No. 51808174), Science & Technology Program of Shenzhen, China (Project No. JCYJ20170413105418298), and Science & Technology Program of Shenzhen, China (Project No. JCYJ20170811153857358).

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注气开采诱发断层滑移和可靠性

马天然 [1#], 刘卫群*[1]

[1] 力学与土木工程学院, 中国矿业大学, 江苏, 中国

*Corresponding author: Tel: +86-13003514091, E-mail: weiqun_liu@126.com

[#] Presenter: E-mail: matianran@cumt.edu.cn

Abstract: 注气开采过程中，大量 CO_2 的注入以及煤层气的开采将会引起深部煤层应力状态的改变。煤层的应力扰动将会诱发断层活化和引发裂隙扩展（或者闭合），导致气体逃逸，地下水污染和流失以及地震活动。针对煤储层均质区、损伤区和断层内核区区域不同的岩石属性，本文利用不同渗透率模型描述其流固模拟耦合行为。然后，利用 TOUGH-FLAC 模拟分析 CO_2 -ECBM 注气开采过程中地质断层的影响和注气开采诱发断层活化行为。模拟结果表明：断层活化和微震频率与断层角度、渗透率密切相关，倾角越大、渗透率越小的断层越容易活化。目前参数条件下，注气 250 天有诱发断层滑移和微震的可能性，滑移量 0.35 m、震级 3.4 左右。

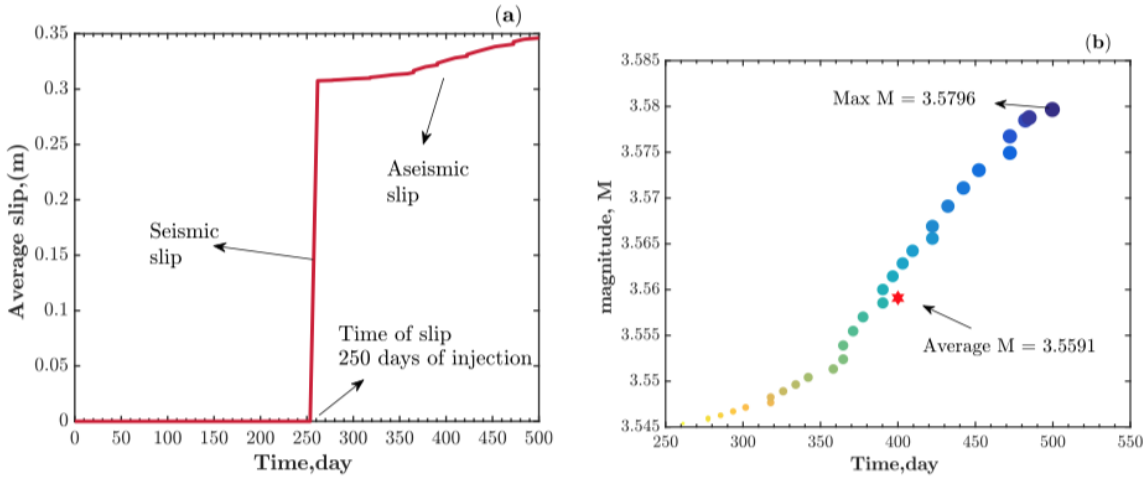

Figure 1. 断层平均滑移和微震级数随时间的变化曲线

Acknowledgements

Tianran Ma would like to thank Jonny Rutqvist and Hao Xu for their helpful discussions on the simulation. This study was supported by Special Subject Grant of National “973” Basic Research Program of China (No. 2015CB251602) and Jiangsu Natural Science Foundation (No. BK20141125).

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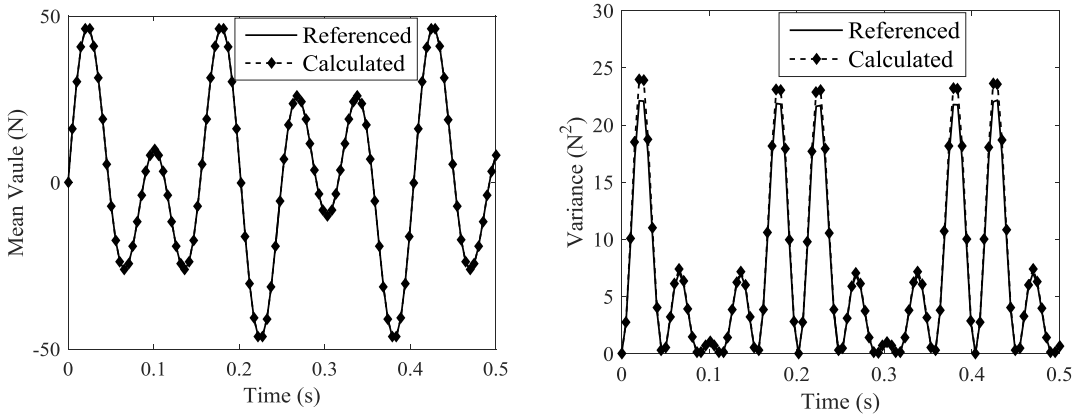
A probabilistic framework for the stochastic dynamic load identification on uncertain structures

S.Q. Wu*#[1,3], Y.W. Sun[2.3] and Q.G. Fei[3]

[1]Department of Engineering Mechanics, Southeast University, Jiangsu, China
[2]School of Mechanical Engineering, Southeast University, Jiangsu, China
[3]Institute of Aerospace Machinery and Dynamics, Southeast University, Jiangsu, China
*Corresponding author: Tel: +86 5209xxxx, E-mail: cesqwu@seu.edu.cn
Presenter: E-mail: cesqwu@seu.edu.cn

Abstract: A stochastic dynamic load identification algorithm is proposed on an uncertain dynamical system in which the random system parameters are represented by correlated Gaussian random fields. A unified probabilistic framework based on Polynomial Chaos Expansion (PCE) for the stochastic dynamical problem is formulated. With the orthogonality of PCE, the stochastic load identification problem on an uncertain dynamical system is transformed to a problem of stochastic load identification on an equivalent deterministic system. Numerical simulations and experimental studies on a cantilever beam under a concentrate stochastic force are conducted to estimate the statistical characteristics of the stochastic load from the stochastic structural response samples.



(a) mean value (b) variance

Figure 1. Comparison of the identified and referenced statistics of the stochastic dynamic force

Acknowledgements

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Incipient Damage Identification in Composite Laminates Using Multi-resolution Modal Teager-Kaiser Energy

W. Xu[#1,2], Z. Su[2] and M. Cao*[1]

[1]Department of Engineering Mechanics, Hohai University, Nanjing, China

[2]Department of Mechanical Engineering, Hong Kong Polytechnic University, Hong Kong, China

*Corresponding author: Tel: +86 15251841008, E-mail: cmszhy@hhu.edu.cn

[#] Presenter: E-mail: wxu@hhu.edu.cn; weixu@polyu.edu.hk

Abstract: Incipient damage in composite laminates, like delamination and crack, can occur during the process of manufacturing and operating. Incipient damage can accumulate and develop, and gradually impair the integrity and safety of laminated composite structures. Hence, methods for identifying incipient damage in composite laminates at the early stage are of significance. For damage identification relying on mode shapes, high spatial sampling resolution is required for precise location of incipient damage. However, noise components contaminated in such densely-sampled mode shapes can easily cause intense noise interference that likely masks actual damage features. Hence, methods for incipient damage identification are required to be sensitive to damage and robust against noise interference. This study proposes a concept of multi-resolution modal Teager-Kaiser energy that is formulated from a mode shape using the Teager-Kaiser energy operator and the wavelet transform, based on which methods are developed for designating the presence and location of incipient damage in composite laminates under noisy environments [1-3]. The proposed damage identification methods are experimentally validated on CFRP laminates with incipient crack and delamination, whose mode shapes are precisely acquired via the non-contact measurement using a scanning laser vibrometer. The results show that the methods relying on the multi-resolution modal Teager-Kaiser energy can effectively identify incipient damage in composite laminates under noisy environments.

Acknowledgements

This work is supported by the National Natural Science Foundation of China (Nos. 51708173, 11772115, 51635008, and 51875492). Dr. Xu is particularly grateful to the Hong Kong Scholars Program (No. XJ2018042). The authors are also grateful to the support in the experiment provided by the Institute of Fluid-Flow Machinery at the Polish Academy of Sciences.

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A unified constitutive model for confined concrete

M.H. LAI
School of Civil Engineering, Guangzhou University, Guangdong, China

Abstract: A theoretical stress-strain model for confined concrete is proposed in this paper. This model is obtained through a four-step procedure. As the first crucial step, a new and accurate hoop strain equation is proposed and verified based on experimental results. Having validated the assumption of stress path independence of confined concrete under monotonic uni-axial compression, an actively confined concrete model is adopted. Next, the stress-state of confining material, such as steel tube, CFRP wrap or GFRP tube is accurately modelled. Lastly, by using the newly proposed hoop strain equation together with the interaction models between core concrete and confining material, the behaviour of confined concrete can be predicted. The validity of this model is subsequently verified with the published experimental results of concrete-filled-steel-tube, FRP-confined concrete or GFRP tube confined concrete columns.

A rate-dependent failure criterion based on distortion strain energy density

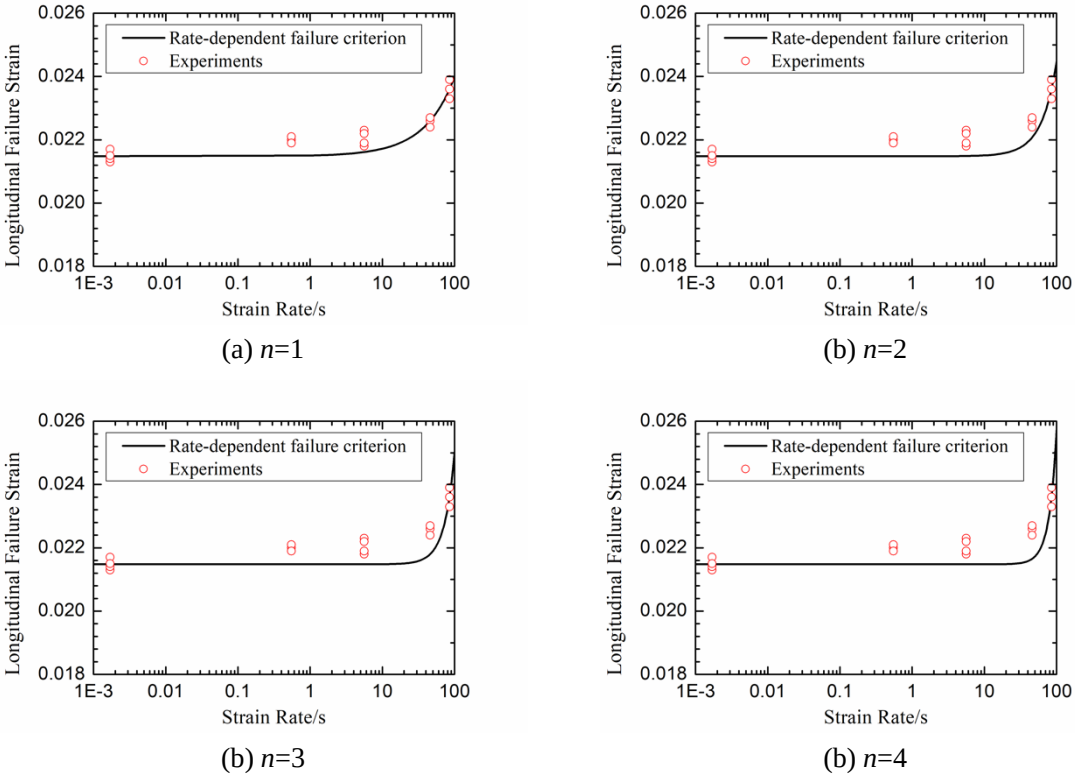
P.W. Zhang*[#1], J.W. Yu[2] and Q.G. Fei[#2]

[1]Jiangsu Key Laboratory of Engineering Mechanics, Department of Engineering Mechanics, Southeast University, Nanjing, Jiangsu, China

[2]Department of Mechanical Engineering, Southeast University, Nanjing, Jiangsu, China

*Corresponding author: Tel: +86 15366122369, E-mail: zhangpeiwei@seu.edu.cn

Abstract: A strain-rate dependent failure criterion is proposed for composites based on rate-dependent constitutive model and the concept of distortion strain energy density. In a linear elastic orthotropic constitutive model, stresses are decoupled into two parts, static stress and dynamic stress in which a strain rate is introduced in a form of power function. By subtracting volumetric strain energy density from total strain energy density, the so-called dynamic distortion strain energy density is then derived rigidly to establish strain-rate dependent failure criterion. According to published test data, parameters in the failure criterion established are fitted, and dynamic failure strain and stress are depicted versus strain rate and parameters. Some common sense about strain rate effect is explained quantitatively.



(a) n=1 (b) n=2

(b) n=3 (b) n=4

Figure 1. Effect of strain rates on longitudinal tension failure strain.

Acknowledgements

The authors are grateful to the supports of the National Natural Science Foundation of China (11572086,11202050).

Distinct Relaxation Timescales of Neurites Revealed by Indentation under Different Loading Modes

Z. Gong[1,2,‡], C. Fang[1,‡,#], R. You[3], X. Shao[1], X. Wei[1], R.C.C Chang[3,4], Y. Lin[1,*]

[1] Department of Mechanical Engineering, University of Hong Kong, Hong Kong, China

[2] Department of Materials Science and Engineering, University of Pennsylvania, Philadelphia, Pennsylvania, USA

[3] Laboratory of Neurodegenerative Diseases, School of Biomedical Sciences, LKS Faculty of Medicine, University of Hong Kong, Hong Kong, China

[4]State Key Laboratory of Brain and Cognitive Sciences, Hong Kong, China

* Corresponding author: ylin@hku.hk

Presenter: fangchao@hku.hk

Abstract: It is commonly believed that the dynamic response of neurites plays a key role in the behaviours and functioning of primary neurons. However, the physical properties of such finger-like structure remain poorly characterized. Here, using AFM indentation, we systematically examined the mechanical response of neurite under three different (i.e. step, oscillating and ramp) loading modes. To extract intrinsic material properties from the data, FEM simulations were also conducted where the neurite was treated as a viscoelastic solid consisting of multiple characteristic relaxation times. Interestingly, the initial and long-term elastic moduli of neurite were found to be around 800 and 80 Pa. In addition, a minimum of three relaxation timescales, i.e. ~0.01, 0.1 and 1 seconds, were needed in order to explain different experimental data. We further demonstrated that these characteristic times should originate from thermal fluctuations of the microtubule, membrane relaxation and cytosol viscosity, respectively.

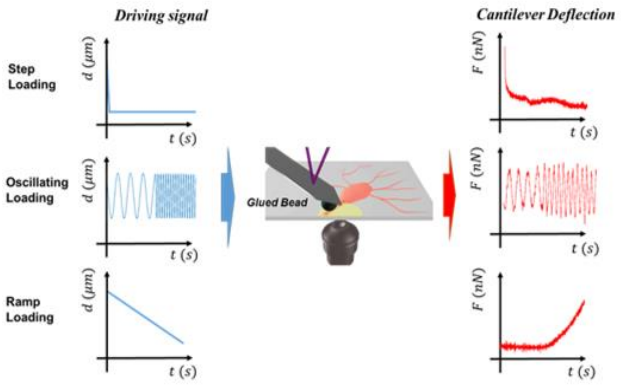


Figure 1. Schematic plot of AFM indentation tests on neurites with three different loading modes.

Acknowledgements

The authors wish to thank the grants from the Research Grants Council (Project Nos. HKU 17205114, HKU 17211215, HKU 17257016) of the Hong Kong Special Administration Region and the National Natural Science Foundation of China (Project No. 11572273).

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Partitioned Genetic Algorithm Strategy for Optimal Sensor Placement Based on Structure Features of A High-piled Wharf

J.B. Su[#1], S.L. Luan[1], L.M. Zhang*[2], R.H. Zhu[1] and W.G. QIN[3]

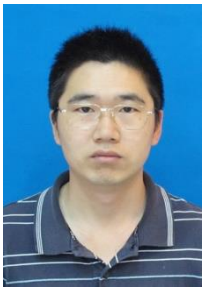
[1]Coastal and Offshore Engineering, Hohai University, Jiangsu, China

[2]Department of Civil and Environmental Engineering, The Hong Kong University of Science and Technology, Hong Kong, China

[3]China Design Group Co., Ltd., Jiangsu, China

*Corresponding author: Tel: +852 2358-8720, E-mail: cezhangl@ust.hk

[#] Presenter: E-mail: jbsu@hhu.edu.cn



Abstract: Health monitoring, detection, and safety assessment of high-piled wharf structures are key problems to be solved urgently in the field of maritime transport engineering. An optimal method for placing accelerometers for monitoring a high-piled wharf structure is presented in this paper. In this method, a partitioned genetic algorithm strategy is proposed based on the frequency and vibration modes of the high-piled wharf obtained by a modal analysis using the finite element method. The modal assurance criterion (MAC) matrix is used as an evaluation index of sensor placement results. Subsequently, the sensor placement scheme obtained by the proposed method is applied to a reduced-scale model of a high-piled wharf to validate the method. The results demonstrate that the proposed sensor optimal placement method reduces the number of accelerometers and improves the calculation efficiency by ensuring relatively complete information on the high-piled wharf structure.

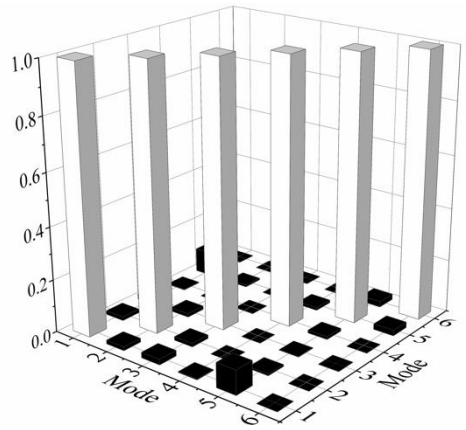


Figure 1. MAC matrix of the 12 measurement points

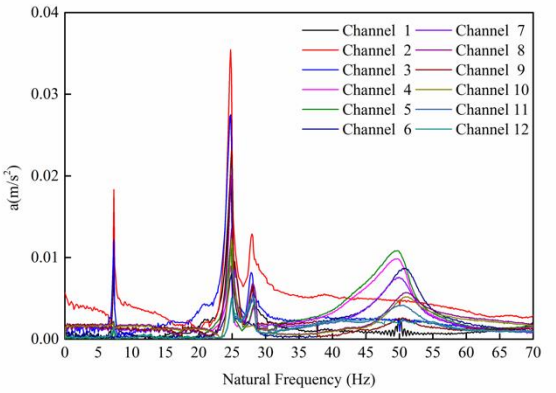


Figure 2. Frequency spectrum curve of high-pile wharf model

Acknowledgements

The authors wish to thank the National Natural Science Foundation of China (Grants No. 51679081 and No. 51709093).

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A meshfree method for dynamic analysis of rotating Mindlin plates

C.F. Du [#1], **D.G. Zhang*** [2], **J.S. Zhang** [2], **J.H. Fan** [3]

[1] College of Civil Science and Engineering, Yangzhou University, Yangzhou 225127, China

[2] School of Sciences, Nanjing University of Science and Technology, Nanjing 210094, China

*Corresponding author: zhangdg419@mail.njust.edu.cn

[#] Presenter: E-mail: duchaofan1987@163.com

Abstract: The radial point interpolation method (RPIM) is proposed for dynamic analysis of rotating Mindlin plates. Considering the non-linear coupling deformation which means the in-plane longitudinal shortening terms caused by transverse deformation, the first-order approximation coupled (FOAC) dynamic model is established via employing Lagrange's equations of the second kind. The effectiveness of RPIM is first demonstrated in some static cases and then extended for dynamic analysis of a rectangular plate undergoing large overall motion. The simulation results are compared with those obtained by using zero-order approximation coupled (ZOAC) dynamic model, which shows the results using FOAC are more accurate, especially in the situation of high rotating speed. Meanwhile, the influence of the radial basis shape parameters is discussed and the optimal parameters for plates are recommended. In addition, the method to overcome the shear locking issue is also provided.

Acknowledgements

The authors wish to thank the support from the National Natural Science Foundation of China (Grant Nos. 11272155, 11132007, 11802263, 11502098), the 333 Project of Jiangsu Province, China (Grant No. BRA2011172), the Fundamental Research Funds for the Central Universities of China (Grant No. 30920130112009), the Natural Science Foundation of the Jiangsu Province of China (Grant No. BK20180895).

Experimental investigation on the energy evolution for rocks during rock deformation and failure

Y. Xing[#1], F. Gao*[2] and Zhizhen Zhang[1]

[1]School of Mechanics and Civil Engineering, China University of Mining and Technology, Jiangsu, China

[2]State Key laboratory for Geomechanics & Deep Underground Engineering, China University of Mining and Technology, Jiangsu, China

*Corresponding author: Tel: +86 13805207152, E-mail: fgao@cumt.edu.cn

[#] Presenter: E-mail: yanx@cumt.edu.cn

Abstract: In recent years, progressive attention has been paid on the study of strain energy of rocks during rock deformation and failure. This study investigated the failure and energy characteristics of sandstone and coal through uniaxial cyclic loading and unloading tests. Monotonic loading tests were firstly carried out to determine the physical and mechanical properties of the rocks. Results show that both elastic and dissipated strain energies increase quadratically with strain, until the stage of unstable crack growth; after that, fluctuations were observed, and mostly in the dissipated energy. In addition, coal exhibited greater fluctuations than sandstone. The brittleness of the rocks was determined based on the ratio of reversible energy to irreversible energy, and the result agrees with that from the available method in literature. Through the analysis of evolution of energy rates, the processes of energy build-up and energy release, due to local crack interaction and crack coalescence, were identified; the crack initiation and crack damage thresholds are subsequently estimated. It was found that the energy values and energy rates of sandstone were higher than those of coal. From the stage of crack initiation up to the stable crack growth stage, the energy dissipation is distinct for sandstone, accompanied by cyclic energy build-up and energy release. The dissipation process is, however, insignificant for coal; instead, the crack coalescence takes place more abruptly near the failure point. This study presents a detailed procedure to investigate the evolution of strain energies of the rock under compression, which provides insightful findings on the mechanisms of rock deformation and failure.

Acknowledgements

This research was funded by Jiangsu Natural Science Foundation (BK20180653).

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Control of period-doubling in varying compliance resonances for a ball bearing

Z.Y. Zhang*[#1,2], X.T. Rui[2] and Y.S. Chen[3]

[1]School of Science, Nanjing University of Science and Technology, Jiangsu, China

[2]Institute of Launch Dynamics, Nanjing University of Science and Technology, Jiangsu, China

[3]School of Astronautics, Harbin Institute of Technology, Heilongjiang, China

*Corresponding author: Tel: +86 15996496915, E-mail: zhiyzhang@njust.edu.cn

[#] Presenter

Abstract: Varying compliance (VC) is an inevitable parametrical excitation to rolling bearing systems due to time-varying stiffness from rolling element revolution. Period doubling instability in the VC primary resonances of ball bearing is presented in many studies. However, few studies have directly attempted to suppress this bifurcating instability. On this basis, a dynamic stiffness evaluating method is presented for assessing the threshold of the period doubling and complex motions in VC primary resonances of ball bearing, where the elaborate evolution of the bifurcating process is obtained by harmonic balance and alternating frequency/time domain (HB-AFT) method and using Floquet theory. Our analysis indicates that by introducing certain additional stiffness, the period doubling and corresponding subharmonic internal resonance can be suppressed.

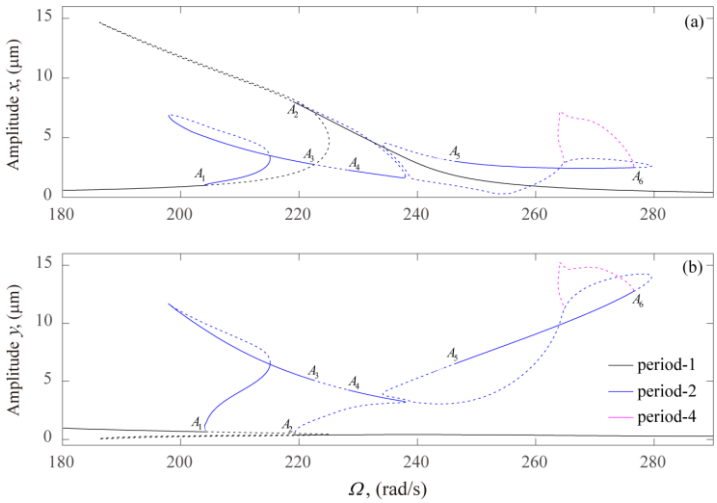

Figure 1 Stable (solid line) and unstable (dashed line) Peak–Peak (P-P) frequency–response curves of the periodic branch

Acknowledgements

The authors wish to thank financial supports from National Natural Science Foundation of China (11602108) and Natural Science Foundation of Jiangsu Province (BK20160820)

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Enhancement of the mechanical properties of the auxetic cellular materials

X. Li[#1], Y. Lu*[1, 2, 3]

[1]Nanomanufacturing Laboratory (NML), Shenzhen Research Institute, City University of Hong Kong, Shenzhen 518057, China

[2]Department of Mechanical Engineering, City University of Hong Kong, Kowloon, Hong Kong, China

[3]CityU-Xidian Joint Laboratory of Micro/Nano-Manufacturing, Shenzhen 518057, China

*Corresponding author: E-mail: yanglu@cityu.edu.hk

[#] Presenter: E-mail: xiangl2225-x@my.cityu.edu.hk

Abstract: Auxetic cellular materials shown many great mechanical properties, however, the stiffness of the auxetic materials are relatively low. Recently, efforts were gradually focused on the enhancement of the mechanical performance of the auxetic cellular materials. However, enhanced mechanical properties generally lead to the decrease of the negative Poisson's ratio. It is of great significance to propose novel auxetic structures with enhanced mechanical properties and non-reduced negative Poisson's ratio. Here, we like to introduce a novel auxetic cellular structure which could have high Young's modulus and yield strength on one principle direction and not reduce its negative Poisson's ratio.

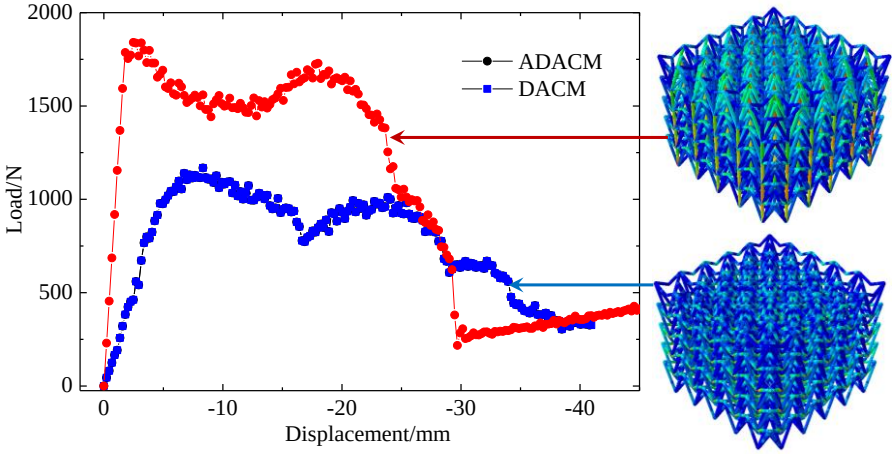

Figure 1. Compression results of the novel auxetic cellular materials.

Acknowledgements

The authors gratefully thanked the funding supports from Shenzhen Science and Technology Innovation Committee under the grants JCYJ20170413141157573 and JCYJ20170818103206501. Part of this project was supported by City University of Hong Kong (Project Nos. 9667164 and 9667153).

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Painlevé paradox during passive dynamic walking of biped robots

Y. Shen*#[1], Y. Kuang[1], W. Wang[1] and S. Zhang[1]

[1]Department of Mechanics and Engineering Science, Nanjing University of Science and Technology, Jiangsu, China

*Corresponding author: Tel: +86-25-84315590, E-mail: yunianshen@njust.edu.cn

Presenter: E-mail: yunianshen@njust.edu.cn

Abstract: The walking stability problem and Painlevé paradox during the passive walking of bipedal robots are studied by both completely rigid body model (CRBM) and completely flexible body model (CFBM). The whole walking process can be seen as the repetition of the four states, i.e. left single-leg support state, double-legs support state, right single-leg support state and double-legs support state. Based on the multiple states, a CRBM is established. The contact constraint is treated by completely inelastic collision hypothesis; the initial conditions is calculated by conservation of angular momentum. Dynamic equations for the four system states are derived by using Lagrange equation. The relationship between the ratio f_t/f_n and time t under initial condition of the stable walking is obtained, and by using this relationship, region of friction coefficient for the stable walking state is obtained. The possible singular phenomenon- Painlevé paradox problem is analysed. The critical value of the coefficient of friction for Painlevé paradox is specified. In addition, the analytical results of robot's dynamic responses are compared with the finite element numerical simulation. It shows that the results from CFBM are totally different from solutions calculated by the rigid body model. The critical value of coefficient of friction is smaller than those of CRBM.

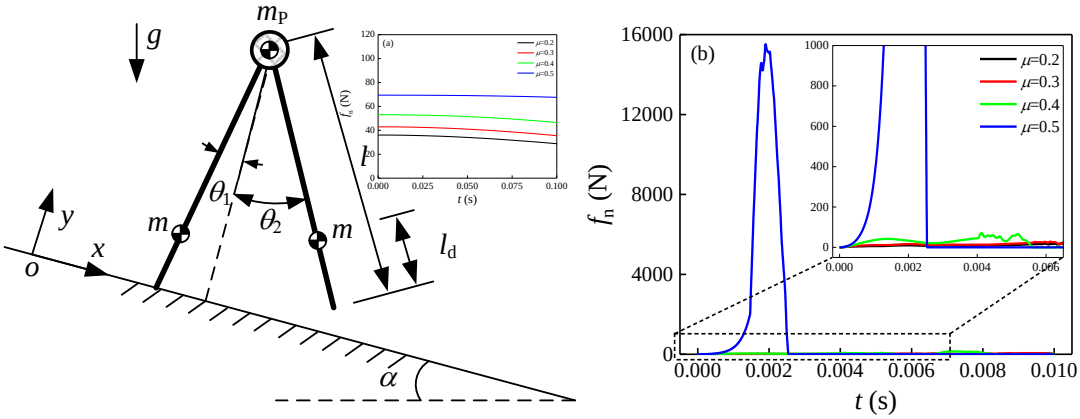

Figure 1. f_n with different μ during passive walking of bipedal robots: (a) CRBM solutions; (b) CFBM solutions.

Acknowledgements

The authors wish to thank Robotics and Intelligent Machine Lab, NUST. This research was supported by National Natural Science Foundations of China (Grant No. 11572157).

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Diffraction of a Weakly Unstable Gaseous Detonation

L.S. Shi[#], C.K. Uy and C.Y. Wen*

Department of Mechanical Engineering

The Hong Kong Polytechnic University, Kowloon, Hong Kong

*Corresponding author: Tel: +852 27666644, E-mail: cywen@polyu.edu.hk

[#]Presenter: E-mail: ls.m.shi@polyu.edu.hk

Abstract: Numerical simulations are performed to investigate the re-initiation mechanism of a diffracted detonation wave near the critical channel width for a weakly unstable gas ($\gamma = 1.2, Q = 50, Ea = 24$). The authors extend the work by Arienti and Shepherd (2005) to compare differences in diffractions of a planar detonation wave and a cellular detonation wave. The results reveal that the critical channel width predicted using a cellular detonation wave is smaller compared to that predicted using a planar detonation wave. For planar detonation diffraction, due to the large gradient of induction time of the shocked but unreacted gas, a bulge of flame is observed at the top right portion (Figure 1). The re-initiation occurs through the interactions between the flame bulge and the leading shock wave. For cellular detonation diffraction, the continuous collisions of transverse waves (Figure 2) which generate local explosion sites, sustain the detonation wave to propagation. The calculation in this work suggests that the transverse waves can facilitate the successful transmission.

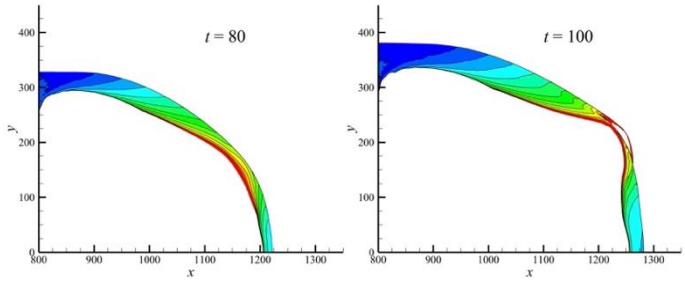

Figure 1. Induction time of the shocked-unreacted gas for planar detonation diffraction. Red indicates short timescale, and blue for long timescale.

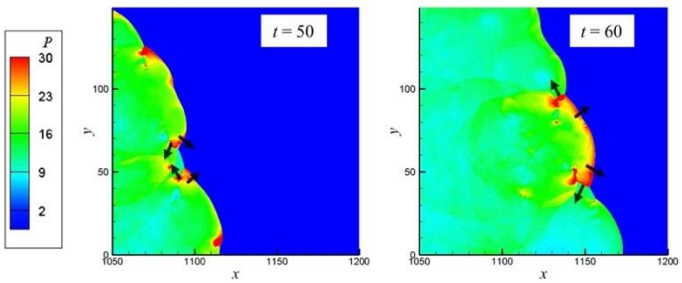

Figure 2. Formation of local over-driven detonation for cellular detonation diffraction.

Acknowledgements

The authors wish to thank the support by the State Key Laboratory of Explosion Science and Technology, Beijing Institute of Technology (Grant No. KFJJ18-12M) and the National Natural Science Foundation of China (Grant No. 11772284).

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螺度“紧固”气体/Helicity ‘fastens’ a gas

J. Peng[1,2], Y. Yang[1,2], J.-X. Xu[3] and 朱建州/J.-Z. Zhu*[#2]

[1] 中国科学院力学研究所高温气体实验室，北京

[2] 南京市高淳区速诚基础与交叉科学研究中心，江苏/Su-Cheng Centre for Fundamental and Interdisciplinary Sciences, Jiangsu, Gaochun, China

[3] 江南计算技术研究所，无锡，江苏

*Corresponding author: Tel: +86 25 5734-2286

[#] Presenter: E-mail: jz@sccfis.org

Abstract: 对于“紧固”固态物体，螺钉比无螺的钉子更好，非平凡的缠绕绳结比简单的好。气体和液体比固态物质更难以驾驭。但是，流动中就有这么一个度量流线螺紧性和涡绳纽结度的物理量。它是速度与其旋度（涡量）的内积的空间平均，叫螺度。三维均匀各向同性湍流直接数值模拟结果显示，有螺度的这种“拓扑经典物态”压制了压缩模，具有更多的涡模态能量配分（相比于其它与压缩模相关的模态）。这不仅验证了之前绝热正压低马赫数的理论计算分析中的螺度降低湍流噪声的预测（朱建州，2016），而且发现适用范围更广。同时，在这一思想指导下，由于（非线性）薛定谔方程可通过 Madelung 变换转化为流体方程，我们分析最近的一个 Gross-Pitaevskii 模型数值模拟数据（Clark di Leoni, P.，2016），认为我们的结果同样适用于波色-爱因斯坦凝聚的波色气体的拓扑量子物态。这些结果对于等离子体物理也有直接或间接的启示。

A screw works better than a nail, or a well-knotted rope better than a naive one, in fastening solid matter. A gas or a liquid is more tameless. However, a flow itself has a physical quantity, the helicity, measuring the screwing strength of the velocity field and the degree of the knottedness (or linkage) of the vorticity rope(s). It is shown, in three-dimensional direct numerical simulations of isotropic turbulence, that, the topological states of such (classical) matter with helicity depress the compressive modes or favor the partition of energy to the vortical modes (Zhu, 2016), compared to other the compressive relevant modes, such as the dilatation and pressure modes, of turbulence; that is, helicity stiffens the flow, with immediate implications for aerodynamics (such as aeroacoustics), conducting and quantum fluids, supportive evidence for the latter topological quantum state is found from numerical results (Clark di Leoni, P., 2016) of the Gross-Pitaevskii model for the Bose-Einstein condensate of Bose gas.

Acknowledgements

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Biomechanical Study on Patient-Specific Silicon Airway Stents

Z.G. Zhang*#[1]

[1]College of Mechanical and Electrical Engineering, Hohai University, Jiangsu, China

*Corresponding author: Tel: +86 152 5191 9961, E-mail: zhangzg@hhu.edu.cn

Presenter: E-mail: zhangzg@hhu.edu.cn

Abstract: Dumon stents have been used in the treatment of airway stenosis for almost 30 years in foreign countries [1]. However, airway restenoses or even obstruction caused by excessive proliferation of granulation tissue at both ends occurs frequently after stenting. This might be due to the individual differences in the anatomic morphology of patients' airway stenosis, which might result in the non-fully fitting between Dumon stent and patient's airway wall, hence the local stress concentration. To verify this hypothesis, we designed and manufactured a series of patient-specific silicone airway stents through 3D printing technology. Results of animal experiments (canine) demonstrate that compared with commercial Dumon stents, patient-specific silicone airway stents can effectively suppress the proliferation of granulation tissue and reduce the incidence of airway restenosis, as shown in Figure 1. In general, 3D printing technology has the advantages of patient-specific, low cost and quick production. We believe that the customizing of individualized implantable medical devices through 3D printing technology would become a research hot spot in the future.

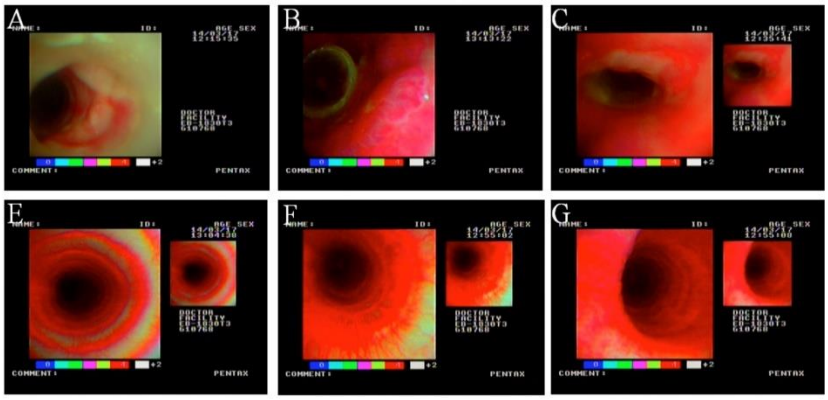

Figure 1. Bronchoscopy results (8 weeks after stenting): A-C refer to Dumon Stents; E-G refer to patient-specific silicone airway stents.

Acknowledgements

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Non-equilibrium Stokes-Einstein relation via active microrheology of hydrodynamically interacting colloidal dispersions

H. C. W. Chu[*#1] and R. N. Zia[2]

[1]Department of Chemical Engineering, Carnegie Mellon University, USA

[2]Department of Chemical Engineering, Stanford University, USA

* Corresponding author: hcwchu@cmu.edu

Presenter: hcwchu@cmu.edu

Abstract: We derive a theoretical model for the nonequilibrium stress in a flowing suspension by tracking the motion of a single embedded probe. While Stokes-Einstein relations connect passive, observable diffusion of a colloidal particle to properties of the suspending medium, they are limited to linear response. Active forcing a probe through a suspension produces nonequilibrium stress that at steady state can be related directly to observable probe motion utilizing an equation of motion rather than an equation of state, giving a nonequilibrium Stokes-Einstein relation (NESER). Here that freely-draining theory is expanded to account for hydrodynamic interactions. To do so, we construct an effective hydrodynamic resistance tensor, through which the particle flux is projected to give the advective and diffusive components of a Cauchy momentum balance. The resultant phenomenological relation between suspension stress, viscosity and diffusivity is a generalized NESER. The phenomenological model is compared with the statistical mechanics theory for dilute suspensions as well as dynamic simulation at finite concentration which show good agreement, indicating that the suspension stress, viscosity, and force-induced diffusion in a flowing colloidal dispersion can be obtained simply by tracking the motion of a single Brownian probe.

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Elimination of velocity defect in the wake of a circular cylinder using deep reinforcement learning trained active flow control

Feng Ren[#], Hui Tang*

Department of Mechanical Engineering, The Hong Kong Polytechnic University, Hong Kong, China

*Corresponding author: Tel: +852 2766-7815, E-mail: h.tang@polyu.edu.hk

[#]Presenter: E-mail: feng.ren@polyu.edu.hk

Abstract: Velocity defect occurs in the wake of a blunt body, which is usually employed to calculate drag in wind/water tunnel experiments. In this study, we present an active strategy through deep reinforcement learning for eliminating the velocity defect in the wake of a circular cylinder. The flow system is shown in Fig. 1. A group of blowing/suction actuators are adopted on the leeside of the cylinder. Their individual forcing strength is automatically tuned by the reinforcement learning agent through feedback signals from a downstream hot-wire rake. The simulation is conducted with a GPU-accelerated flow solver that is based on the lattice Boltzmann method (LBM) with multi-block grid partition. From the control-theory perspective, the multi-input and multi-output feature of this problem makes it challenging to obtain an optimum explicit control law or to explore the parameter space. By adopting two sets of deep neural network, the reinforcement learning agent can learn from the time sequences of the sensors, actuators and a specified reward function through trials and errors, and finally converge and become capable of determining the optimal control policy[1]. The current study offers an innovative view that could potentially help underwater vehicles achieve low detectability.

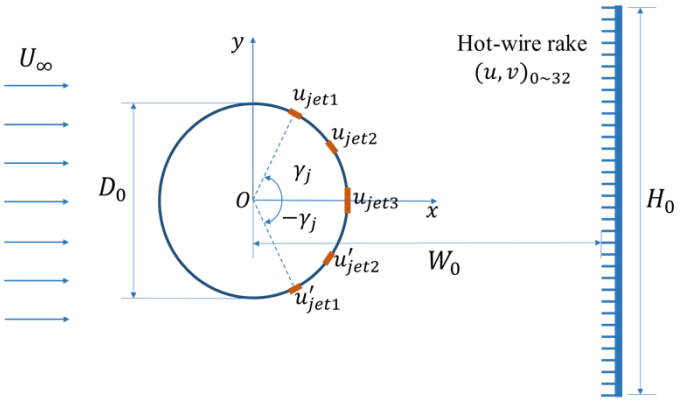

Figure 1. Schematic of the flow system

Acknowledgements

We gratefully acknowledge the financial support from the RGC of Hong Kong under GRF (Project No. 15214418) and The Hong Kong Polytechnic University (Project No. G-YBXQ).

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Dynamic Testing and Analysis of a Large Space Flexible Structure

G.L. Wang[1], D.D. He*[#1]

[1]Department of Engineering Mechanics, Southeast University, Jiangsu, China

*Corresponding author: Tel: +86 13913995727, E-mail: he_0314@seu.edu.cn

[#] Presenter: E-mail: he_0314@seu.edu.cn

Abstract: The experimental modal analysis of a large space truss was conducted using the hammering method. The modal parameters were obtained based on the test results and verified by The MAC (Modal Assurance Criterion). The influence of suspension condition and response test point position on the experimental results of the truss structure were analysed. The results show that (i) modal coupling can be avoided by decrease added stiffness of suspension; (ii) the repeatability of the modal test is improved by uniform distribution of suspension points; (iii) the energy loss of the excitation can be reduced by placing accelerometer near the centre of the structure, which can significantly ensure the completeness of the test results; (v) the influence of suspension effect on low order modes can be reduced by increasing the length of suspension. The results are beneficial to operating ground modal test of large flexible hinged structure.

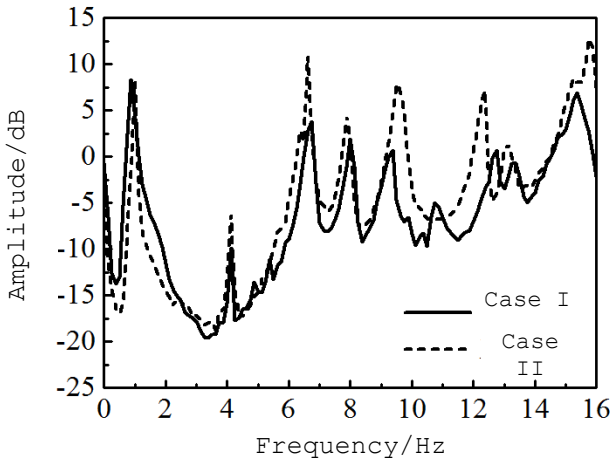

Figure 1. Comparison of frequency response functions between Case I (spring suspension) and Case II (elastic rope suspension)

Acknowledgements

This paper is supported by the National Natural Science Foundation Project (Grant No. 11602112 and 11572086).

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Decay mechanisms of red sandstone rocks in heating-cooling cycles

Luo Ning[1,*], Liu Weidong[2]

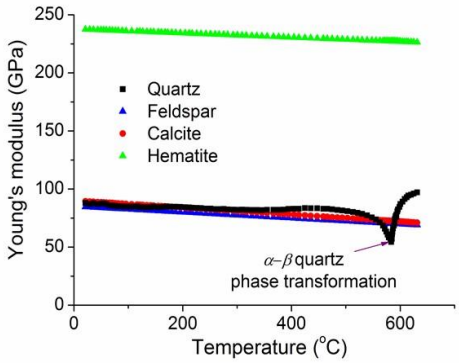
[1] State Key Laboratory for Geo-mechanics and Deep Underground Engineering, School of Mechanics and Civil Engineering, China University of Mining and Technology, Xuzhou 221116, China

[2] Laboratory for Precision and Nano Processing Technologies, School of Mechanical and Manufacturing Engineering, University of New South Wales, Sydney, NSW 2052, Australia

*Corresponding author: Tel: +86-18305201191, E-mail: nluo@cumt.edu.cn

Abstract:

Rocks decay significantly during or after heating/cooling cycles, which can in turn lead to hazards such as mountain landslide and stone building collapse. Here we successfully traced the decay process of red sandstones during heating/cooling cycles by monitoring the evolution of their Young's moduli. We found that rock decay can take place in both heating and cooling processes in several stages, and that the decay is mainly attributed to the opening and growth of internal cracks, induced by inhomogeneous thermal expansion/shrinkage of mineral grains and the α-β phase transition of quartz.



The changes of Young's modulus of minerals with temperature

Acknowledgements

This research was financially supported by the National Natural Science Foundation of China (No.11502282 and 51734009), the independent Innovation Project for Double First-level Construction of CUMT (2018ZZCX04).

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DEM modelling of Toyoura sand considering real particle shapes

B. Srinivas Vivek[#1] and G. Wang*[2]

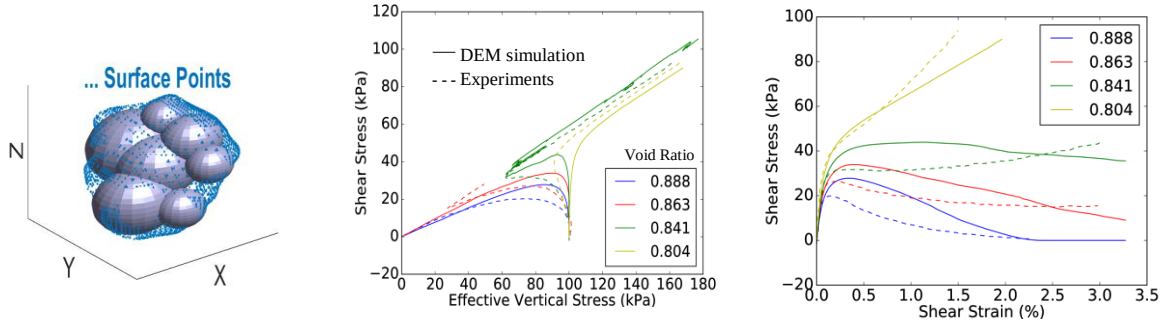
[1]Department of Civil and Environmental Engineering, HKUST, Hong Kong, China

[2]Department of Civil and Environmental Engineering, HKUST, Hong Kong, China

*Corresponding author: Tel: +852 2358-7161, E-mail: gwang@ust.hk

[#] Presenter: E-mail: svbokkisa@connect.ust.hk

Abstract: Recently, Discrete Element Method (DEM) has becoming a powerful tool to simulate complex behaviour of granular soils (e.g. Wang and Wei 2016). Yet, traditional DEM often ignores the effect of realistic particle shapes, which might significantly influence the density, stiffness and strength of granular packing. To overcome this drawback, "clumped" particles are used in DEM modelling. As shown in Fig. 1(a), 10 spheres are rigidly bonded to approximate the realistic shape of a single sand particle. A Representative Volume Element (RVE) consisting of 2940 clumps is generated based on X-ray CT scan of Toyoura sand (Katagiri *et al.* 2010). RVEs of different void ratios are tested to simulate monotonic undrained simple shear behaviour, which agrees well with experimental data (Yoshimine et al. 1998), shown in Fig. 1(b)(c). We further investigated the effects of model parameters for inter-particle contact (Young's modulus E, Poisson's ratio v) and inter-particle friction angle (ϕ) on the macroscopic response of an RVE. It is found that E and ϕ have significant effect on soil behaviour whereas v has little or no effect. Work is under way to investigate liquefaction phenomenon (e.g. Ye and Wang 2016) of Toyoura sand using DEM considering realistic particle shapes.



(a) (b) (c)

Figure 1. (a) Clumped model for a sand particle; (b)(c) Undrained simple shear tests by DEM vs experiments

Acknowledgements

The authors acknowledge support from Hong Kong Research Grants Council Theme-based Research T22-603/15N, and GRF grant no. 16204618

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Analysing Two-Dimensional Soil-Structure Interface Shearing Behaviour using Discrete Element Method

W.B. Chen[#1] and W.H. Zhou*[1]

[1]Department of Civil and Environmental Engineering, University of Macau, Macau, China

*Corresponding author: Tel: +853 6296-7996, E-mail: hannahzhou@um.edu.mo

[#] Presenter: E-mail: yb77415@um.edu.mo

Abstract: This study aims to investigate the two-dimensional shear stress of an interface shearing caused by different shear orientations. The shear orientation was defined to be an angle θ between the shear direction and the texture line of the directional rough surface. Discrete element method simulations have been successfully applied to a range of problems encountered with interface shear tests (Zhu et al. 2017; Jing et al. 2018). Using the discrete element method, 3D numerical interface shear tests, under the seven shear orientations ($\theta = 0°, 10°, 30°, 45°, 60°, 75°$ *and* $90°$) were conducted. The analysis of shear-induced contact force changes on the lateral boundaries of shear box indicates the 2D shear stress exists in the interface. The analysis of displacement movement patterns and normal contact distributions were further presented to explain why the normal contact force change on the lateral boundaries.

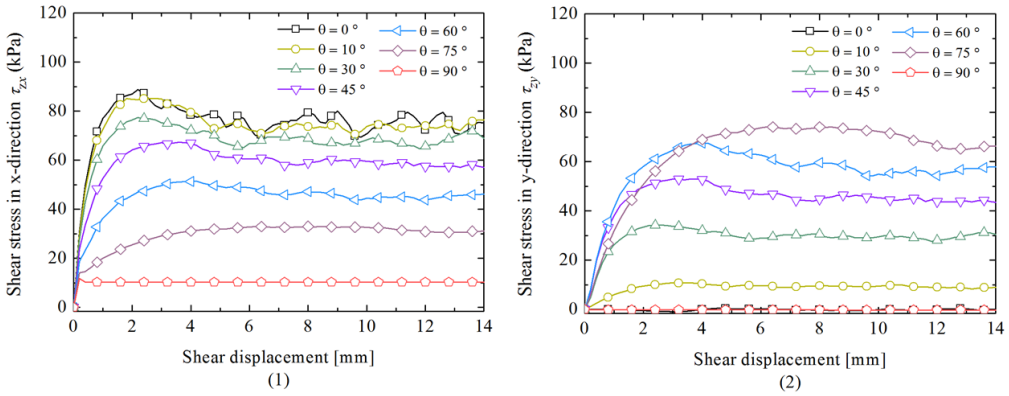

Figure 1. Stress ratio with respect to shear displacement d_x for seven specimens under normal stresses σ_{zz}= 150 kPa: (1) τ_{zx}/σ_{zz} and (2) τ_{zy}/σ_{zz}

Acknowledgements

The authors wish to thank the financial support from the Macau Science and Technology Development Fund (FDCT) (125/2014/A3), the University of Macau Research Fund (MYRG2017-00198-FST, MYRG2015-00112-FST).

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Ballistic testing and numerical simulation analysis of aeroengine laminated casing

Fan Zhang[#1], Zhenzhong Cao[1], Dingguo Zhang[*1] and Liang Li[1,2]

[1] School of Science, Nanjing University of Science and Technology, Jiangsu, China

[2] Department of Mechanical and Automation Engineering, The Chinese University of Hong Kong, Hong Kong, China

*Corresponding author: Tel: +025 8431-5185, E-mail: zhangdg419@mail.njust.edu.cn

[#] Presenter: E-mail: 952054222@qq.com

Abstract: To study the containment of the outer metal structure case of aeroengine lined reinforced composite material under the impact of blade-shaped projectiles, a smoothbore cannon test system was used to test the target penetration process of laminated aramid fiber composite laminates (Facing surface) and Ti-6Al-4V(TC4) metal laminates. The process of blade penetration into the target plate was recorded by a high-speed camera system in order to study the anti-penetration performance and failure modes of different composite laminated targets. It is found that the impact resistance of composite target increases with the increase of the thickness of inner composite material, and the impact resistance of composite target with inner composite material is stronger than that of double TC4 metal target with the same mass. The numerical simulation results of ballistic testing are in good agreement with those of commercial finite element software ANSYS/LS-DYNA. In this paper, an analytical method is proposed to simulate the different damage modes and energy absorption mechanisms of composite laminates and composite-metal laminated target plates impacted by blade projectiles. The energy transfer of blade impacting target plate is described by the theory of stress wave propagation. Considering that the kinetic energy of the blade will be absorbed or dissipated by the conical body formed in the process of impacting, the tensile fracture of primary yarns, the deformation of secondary yarns, shear plugging, matrix cracking and delamination. Ballistic limit velocity, penetration time and energy of each part can be obtained by energy conservation:

$$E_0^{\mathrm{KP}} = E_i^{\mathrm{KP}} + E_i^{\mathrm{KC}} + E_{i-1}^{\mathrm{PY}} + E_{i-1}^{\mathrm{SY}} + E_{i-1}^{\mathrm{SP}} + E_{i-1}^{\mathrm{DL}} + E_{i-1}^{\mathrm{MC}}, (i = 1, ..., I)$$

The analytical data is in good agreement with the experimental and commercial software numerical simulation results, which verifies the universality and correctness of the analysis model.

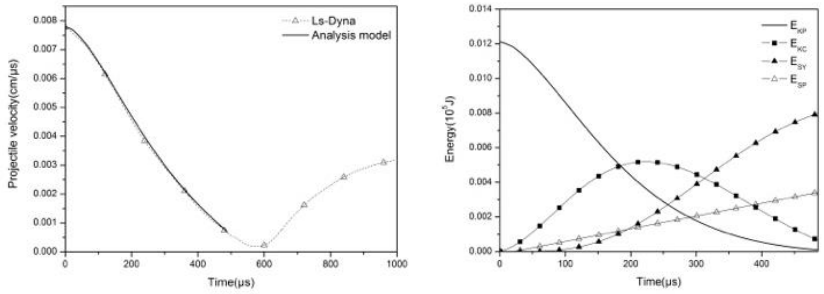

Figure 1. Comparisons between analytical model results and Ls-dyna results and energy changes of each part

Acknowledgements

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Mechanical characterization of metal-coated polymer microfibers

Wenqiang Zhang [#1], Xiaobin Feng[1], Sufeng Fan[1], Lu Yang[*1,2,3]

[1]Department of Mechanical Engineering, City University of Hong Kong, Hong Kong, China

[2] Nano-Manufacturing Laboratory (NML), Shenzhen Research Institute of City University of Hong Kong, Shenzhen 518057, China

[3] CityU-Xidian Joint Laboratory of Micro/Nano-Manufacturing, Shenzhen 518057, China

*Corresponding author: Tel: +852 3442-4061, E-mail: yanglu@cityu.edu.hk

[#] Presenter: E-mail: wqzhang8-c@my.cityu.edu.hk

Abstract: Polymer-metal composite, combining the high stiffness of polymer and high strength of metal materials, has a wide application in flexible electronic device, micro lattice metamaterials, and biomedical structure. Generally, the polymer-metal composite is composed by the polymer subtract and metal film as basic structure. As a result, the mechanical properties of the polymer subtract and metal film play a key role in performance and service life polymer-metal composite. In this work, we employed metal-coated polymer microfibers to simulate the polymer subtract and metal film structure. The polymer microfibres were manufactured by Projection Micro-Stereolithography which enable us to precisely control the fibre size at microscale, while the metal film was deposited by magnetron sputtering. Basically, the mechanical properties of the metal-coated polymer microfibers were evaluated by tensile test. Moreover, the influence of different sizes of polymer microfiber and different thicknesses of metal film on the mechanical properties was investigated. Additionally, the fracture mechanism of the metal-coated polymer microfibers was investigated to explore the strengthening mechanism of the metal on polymer.

Acknowledgements

The authors gratefully thank the funding supports from Shenzhen Science and Technology Innovation Committee under the grant JCYJ20170818103206501 and Hong Kong RGC under the grant CityU 11216515. Part of this work was supported by City University of Hong Kong (Project Nos. 7005070 and 9667153).

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in situ electro-mechanical study of Ag nanowire/graphene hybrid films

K. Cao[#1], H. Yang, Y. Lu*[1]

[1]Department of Mechanical Engineering, City University of Hong Kong, Hong Kong, China

[#] Presenter: E-mail: kecao3-c@my.cityu.edu.hk

*Corresponding author: Tel: +852 3442-2385, E-mail: yanglu@cityu.edu.hk

Abstract: The fast-growing field of flexible electronics create the demand for transparent conducting films (TCFs) with good flexibility, which should maintain good performance under mechanical deformations. Nanowires have been demonstrated with many intriguing properties which are different from their bulk counterparts, such as high strength and large elasticity approaching their theoretical limit. Ag nanowires with high conductivity hold great potential for the application in flexible electronics. Ag nanowire films can have sheet resistance comparable with the commercialized indium tin oxide (ITO) films at the same optical transmittance. However, metal nanowire films have low oxidation resistance, poor adhesion to the substrate, and low stability in harsh environments. Owing to the extraordinary mechanical, electrical and optical properties, graphene can be introduced as an oxidation-resistant layer. In this work, Ag nanowire/graphene hybrid films were fabricated. Compared to Ag nanowires films or graphene, the Ag nanowire/graphene hybrid films have improved electrical conductivity and mechanical stability through *in situ* bending tests at macro scale. *In situ* transmission electron microscope (TEM) tensile tests also show the hybrid film with increased mechanical properties. Our work provides some new insights on the design and the mechanical behaviour of hybrid films for flexible electronics.

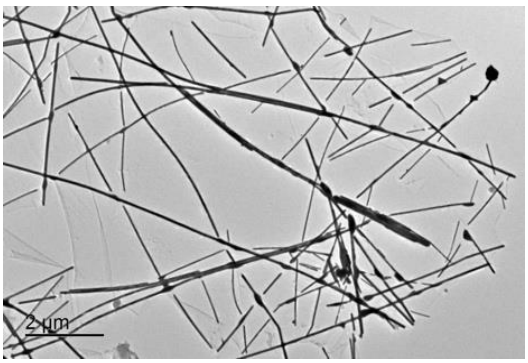

Figure 1. The fabricated Ag nanowire/graphene hybrid films

Acknowledgements

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On the work-hardening capacity of micro-alloyed Ag microwires

Xiaocui Li[#1], Haokun Yang[1,2], Yang Lu*[1,2]

[1]Department of Mechanical Engineering, City University of Hong Kong, Hong Kong, China

[2]Hong Kong Branch of National Precious Metals Material Engineering Research Center, City University of Hong Kong, Hong Kong, China

*Corresponding author: Tel: +852 3442-4061, E-mail: yanglu@cityu.edu.hk

Presenter: E-mail: xiaocuili2-c@my.cityu.edu.hk

Abstract: In this study, the work-hardening behavior of micro-alloyed Ag microwires with different grain sizes has been investigated. Meanwhile, the microstructure evolutions of them have been observed and compared by backscattered electron (BSE), electron backscattered diffraction (EBSD) and transmission microscope (TEM) before and after tensile tests. The result illustrated that the work-hardening rates did not change apparently for the samples with different grain sizes, meaning that the work-hardening capacity did not weaken with increasing grain size. As a typical low stacking faults energy (SFE) material, the abundant stacking faults and twins in Ag were observed and confirmed to play the role of the work-hardening mechanism. This current study provides the instructive suggestion for Ag microwires fabrication and bonding process.

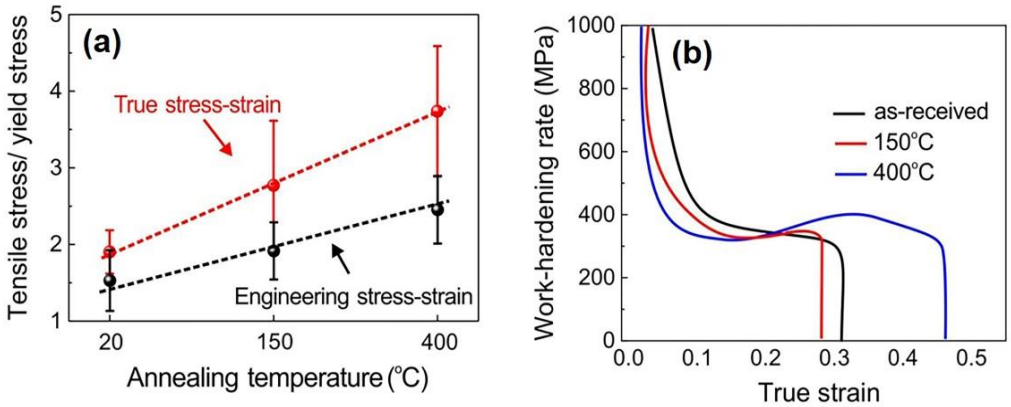

Figure 1. The mechanical properties of as-received, 150℃ annealed and 400℃ annealed samples. (a) The ration of tensile stress/yield stress versus annealing temperature; (b) the work hardening rates versus true strain.

Acknowledgements

The authors wish to thank the financially support from Hong Kong Branch of National Precious Metals Material Engineering Research Center at City University of Hong Kong, the National Key R&D Program of China [2017YFA0204403], and the Shenzhen Virtual University Park [R-IND1710].

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The failure mechanisms and prediction model of fasteners under multi-axial loading

Zhenzhong Cao[#1], Matthew Brake[2], Fan Zhang[1], Dingguo Zhang*[1] and Liang Li[1,3]

[1]School of Science, Nanjing University of Science and Technology, Jiangsu, China

[2]William Marsh Rice University, Houston, TX, USA

[3] Department of Mechanical and Automation Engineering, The Chinese University of Hong Kong, Hong Kong, China

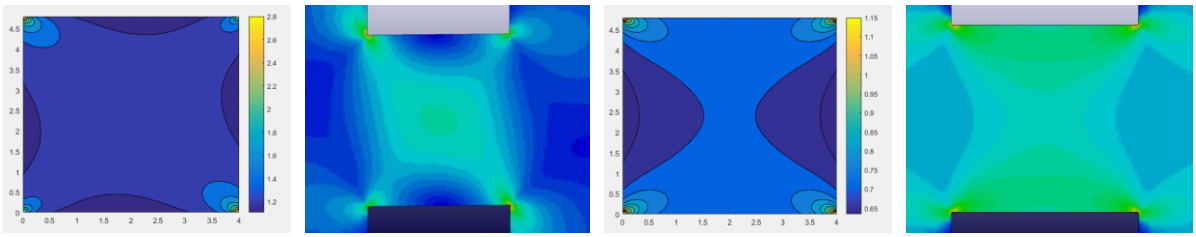
*Corresponding author: Tel: +025 8431-5185, E-mail: zhangdg419@mail.njust.edu.cn

[#] Presenter: E-mail: caozhenzhong@njust.edu.cn

Abstract: This study investigates the failure mechanisms that control the loading angle and fixture effects on the mechanical response of fasteners by using a simple finite element bolt model without threads which had been validated by comparing it with experiment results, and uses the semi-infinite notch theory to obtain a prediction model for the onset of failure of fasteners under various loading angles. The investigation reveals that the loading angle and fixture effects on fasteners' mechanical response are attributed to the change of stress concentrations at the contact tips, and verifies that a reduced model of a fastener can be used to predict its constitutive behaviour accurately. Basing on the conclusion that the contact tips are most notable, Williams' solution:

$$\sigma_{ij}(r,\theta) = K_I r^{\lambda_I - 1} f_{ij}^{I}(\theta) + K_{II} r^{\lambda_{II} - 1} f_{ij}^{II}(\theta)$$

is used to obtain the stress field near the intersection of the bolt and the fixture, and superposition is used to add the solutions for the four stress concentrations of the contact tips together. Figure 1 presents that the stress distribution results of this analytical model are in good agreement with the numerical results. A quick way for failure onset prediction of fasteners under different loading angles is obtained by using this analytical model.



Analytical Numerical Analytical Numerical

(a) Shear loading condition (b) Shear loading condition

Figure 1. Stress distribution comparisons of shear and tension loading conditions.

Acknowledgements

The authors wish to thank the support from the National Science Foundation of China (Grant Numbers 11772158, 11502113), and the Fundamental Research Funds for Central Universities (Grant Number 30917011103).

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Effects of porous walls on the stabilization of the first and second modes in hypersonic boundary layers

Xudong TIAN[#1] and Chih-yung WEN[*1]

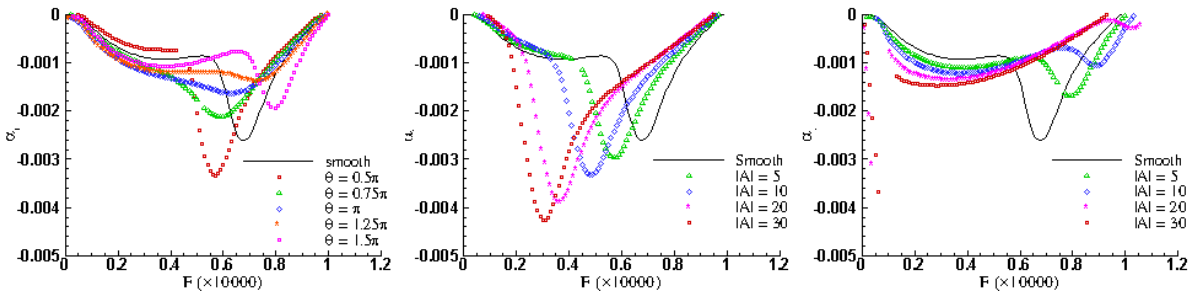
[1]Department of Mechanical Engineering, The Hong Kong Polytechnic University, Hong Kong, China

[*]Corresponding author: Tel: +852 2766644, E-mail: cywen@polyu.edu.hk

[#]Presenter: E-mail: xudong.tian@connect.polyu.hk

Abstract:

Hypersonic boundary layers transition is a very crucial issue for the development of aerospace vehicles. For low forcing environmental disturbances, laminar-to-turbulent transition is ruled by eigenmode growth, including the first and second modes, crossflow instability and Görtler vortices [1]. Shaping can eliminate the perturbations induced by crossflow instability and Görtler vortices but cannot stabilize the first and second modes. For high Mach number, the second mode commonly dominates the boundary layer instabilities, which, however, may be changed by wall temperature, because hot wall can stabilize the second mode and destabilize the first mode. In term of the high frequency of the second mode (on the order of 100kHz), the porous surface of thermal protection system (TPS) is suggested to absorb the disturbances, which has been confirmed experimentally [2]. This work will study the effects of the admittances of porous walls ($A = |A|e^{i\theta}$) on the stabilization of the first and second modes in a flat-plane boundary layer at Mach 6. As shown in Fig. 1, the admittance magnitude $|A|$ and phase θ have effects on the growth rate $-a_i$ and frequency F of the first and second modes.



a) b) c)

Fig.1 Variation of a_i under different cases: a) |A|=5, b) $\theta = 0.55\pi$, c) $\theta = 1.45\pi$

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Effect of Nanoscale Zero-Valent Iron (nZVI) on Deformation Behaviour of Lead-Contaminated Soil

Y.Z. Chen[#1], W.H Zhou*[1], F.M. Liu[1,2] and S. Yi[2]

[1]Department of Civil and Environmental Engineering, University of Macau, Macau, China

[2]School of Environmental Science and Engineering, Southern University of Science and Technology, Shenzhen, China

*Corresponding author: Tel: +853 8822-4469, E-mail: Hannahzhou@um.edu.mo

[#] Presenter: E-mail: carloschen801@gmail.com

Abstract: The contaminated sediment in the river and coastal have complex contaminants, high initial water content, high compressibility, and low shear strength, and is considered to be potentially problematic. An effective approach for the treatment and increasing the strength is to incorporate high-performance nanomaterials - Nanoscale Zero-Valent Iron (nZVI). In the previous researches, it is founded that the mechanical behaviour of soils, such as strength and stiffness, was improved with the addition of nZVI through the effect of soil fabric and interparticle bonding (Chen et al. 2019; Zhou et al. 2019). However, limited attempts have been made to investigate the deformation behaviour of nanomaterials treated soils. In this presentation, it is to identify the deformation behaviour of nZVI treated soils and to explore the mechanism by several microstructure analysis.

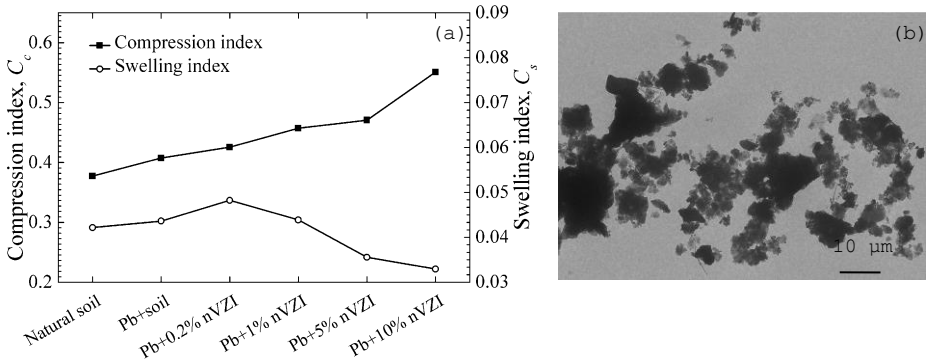

Figure 1. Variation of (a) the compression index and swelling index for soils under different treated conditions and (b) the TEM image of Pb+10% nZVI.

Acknowledgements

The authors wish to thank the financial support from the Macau Science and Technology Development Fund (FDCT) (125/2014/A3, 193/2017/A3), the University of Macau Research Fund (MYRG2015-00112-FST, MYRG2017-00198-FST).

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Mechanical properties of freestanding monolayer MoS_2

Ying Han[#1], Ke Cao[1] and Yang Lu*[1]

[1]Department of Mechanical Engineering, City University of Hong Kong, Hong Kong, China

*Corresponding author: Tel: +852 3442-4061, E-mail: yanglu@cityu.edu.hk

[#] Presenter: E-mail: yinghan9-c@my.cityu.edu.hk

Abstract: The outstanding properties of graphene have captured researchers' attention in two-dimensional (2D) materials with remarkable electrical, mechanical and optical attributes. However, without band-gap, graphene can't satisfy the real application even it possesses high carrier mobilities. Moreover, other 2D materials especially transition metal dichalcogenides (TMDs) have emerged with different band-gaps. As a representative of TMDs, monolayer MoS_2 possesses direct band-gap of 1.8 eV which opens the possibility of many optoelectronic applications. As the most important properties, mechanical properties play an important role in practical applications. However, experimental research about mechanical properties of MoS_2 is limited. Here, we developed an *in situ* platform to investigate mechanical properties of freestanding monolayer MoS_2. By applying a uniaxial load, the in situ tensile tests were carried by our platform. The elastic properties and failure mechanisms of MoS_2 were investigated. Our platform is also applicable to other 2D materials to explore their mechanical properties.

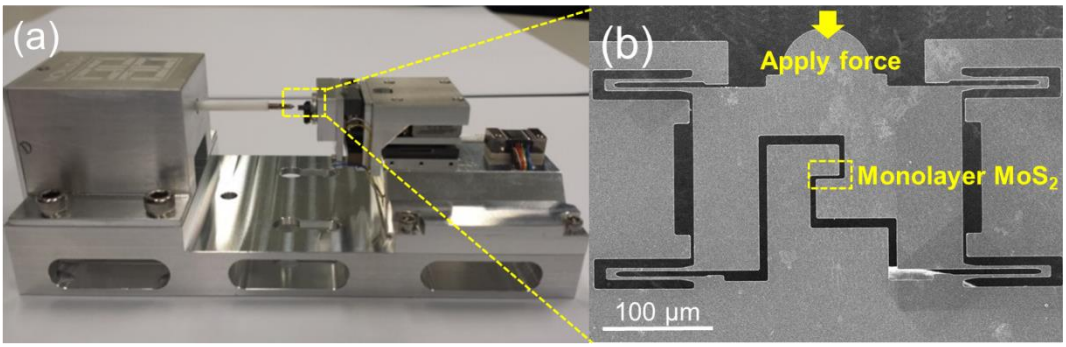

Figure 1. The platform of *in situ* tensile tests

Acknowledgments

The authors gratefully thank the funding supports from the City University of Hong Kong under SRG 7005070.

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In situ mechanical characterization of He^+ irradiated FeNiCoCr high-entropy alloy

Weitong Lin[#1], Da Chen[1], Chaoqun Dang[1], Yang Lu[1,2]*, Ji-Jung Kai[1]*

[1]Department of Mechanical Engineering, City University of Hong Kong, Hong Kong, PR China

[2]Centre for Advanced Structural Materials, Shenzhen Research Institute, City University of Hong Kong, Shenzhen, PR China

*Corresponding author: Tel: +852 3442-4061, E-mail: yanglu@cityu.edu.hk (Y. Lu)

Tel: +852 3442-8071, E-mail: jijkai@cityu.edu.hk (J.J. Kai)

[#] Presenter: E-mail: wtlin9-c@my.cityu.edu.hk

Abstract: FeNiCoCr high-entropy alloy (HEA), as one of the emerging structural alloys for next-generation nuclear reactors, has shown the enhanced radiation tolerance under heavy ion bombardment. However, the effects of helium accumulation, a product of nuclear fission reaction, on the mechanical behavior of FeNiCoCr HEA have not been studied. Here, deformation mechanisms, crack behavior and strain-stress relationship of He^+ irradiated FeNiCoCr HEA (Chen et al. 2018) were systematically studied by *in situ* TEM tensile and compression testing (Ding et al. 2016; Zhang et al. 2016). The results demonstrate that helium nanobubbles alter the stacking fault formation and substantially enhance the strength of FeNiCoCr HEA. We believe that this work could not only improve our understanding of He^+ irradiated HEAs, but also provide a promising way to reveal the mechanical behavior of nuclear materials.

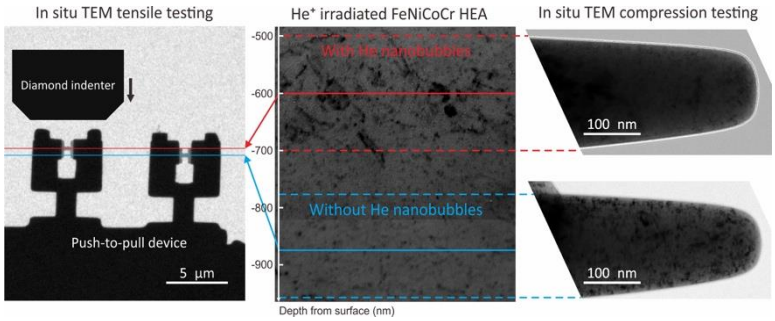

Figure 1. In situ TEM tensile and compression testing of FeNiCoCr HEAs with and without He^+ irradiation.

Acknowledgements

The authors wish to thank Hong Kong Research Grant Council (No. CityU 11212915 and CityU 11205018), City University of Hong Kong (No. 9680108) and Shenzhen Science and Technology Innovation Committee (Grant Number: JCYJ20170413141157573).

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On the effects of modelling errors and uncertainties in structural damage identification

M.O. Adeagbo*#[1] and H.F. Lam[1]

[1] Department of Architecture and Civil Engineering, City University of Hong Kong, Hong Kong, China

*Corresponding author and #Presenter: +852 5603-7832, moadeagbo2-c@my.cityu.edu.hk

Abstract: For structural response prediction, structural health monitoring and structural control, identification of an accurate and representative model of the target structural system is essential. Modelling errors and uncertainties resulting from the simplification of complex structures, discretization of structural systems, inadequate theories for certain structural behaviours and inaccurate assignment of model parameters are inevitable. To address these issues, structural model identification and updating techniques based on measured system data have been developed. When several classes of models are available to represent structural behaviours, making a technical and appropriate choice is nontrivial. In this research, an MCMCS-based Bayesian probabilistic technique is employed to fully consider the uncertainties in updating model parameters, and to select the most plausible model class from available ones using the Bayesian model class selection. Detection of ballast damage of an in-situ sleeper is employed to demonstrate the proposed methodology. Impact hammer test was carried out on a sleeper of an indoor track panel, with damage simulated in the ballast at the right two-third section to obtain in-situ vibration measurement. The proposed damage identification methodology is then applied to predict the location and severity of the ballast damage. Since ballast has been proven to possess non-linear stress-strain characteristics, the effects of modelling errors and uncertainties on the predicted structural response and identification accuracy is then demonstrated by modelling the ballast using three different classes of models: (1) the linear elastic model, (2) the non-linear modified Ludwik's model, and (3) the non-linear Prager model. Finally, the Bayesian model class selection is used to identify the optimal ballast model.

Acknowledgements

The work described in this paper was supported by a grant from the Research Grants Council of the Hong Kong Special Administrative Region, China (Project No. CityU 11242716 (GRF 9042336)).

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Deformation measurement of microlattice structures using digital image correlation (DIC)

Y.J. Wang[#1,2,3] and Y. Lu[*1,2,3]

[1]Department of MNE, City University of Hong Kong, Hong Kong, China

[2]CityU-Xidian Joint Laboratory of Micro/Nano-Manufacturing, Shenzhen, China

[3]Nano-Manufacturing Laboratory (NML), Shenzhen Research Institute of City University of Hong Kong, Shenzhen, China

*Corresponding author: Tel: +852 3442-2385, E-mail: yanglu@cityu.edu.hk

[#] Presenter: E-mail: yuejiwang4@my.cityu.edu.hk

Abstract: This work is to develop a novel method for the heterogeneous strain measurement of micro- and nanolattices in uniaxial compression tests. Based on scanning electron microscopy (SEM) images or images obtained by optical imaging systems, digital image correlation (DIC) is carried out to determine strain distribution of these structures by measuring the deformation of structs on the outer surface of the lattices. The results facilitate further investigation of the deformation and failure mechanism of various micro- and nanolattices under compression. Besides, the overall axial and lateral strain are measured to decide the Young's modulus, Poisson's ratio, elastic recoverability, and energy absorption capability of these structures.

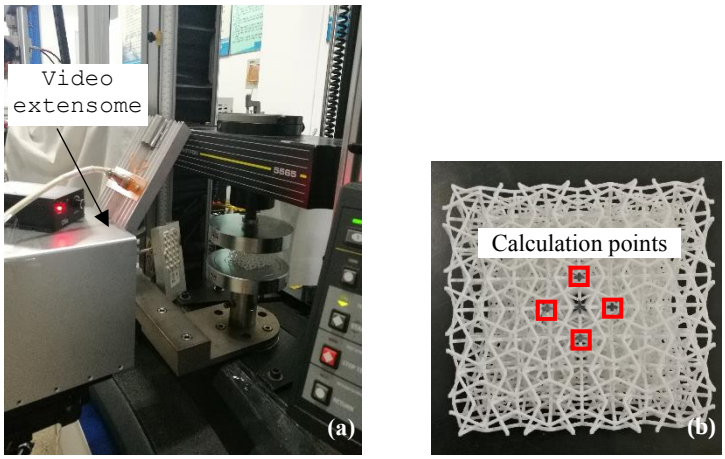

Figure 1. (a) Experimental setup for the determination of elastic properties of three novel auxetic 3D cellular structures; (b) Marked surface of the auxetic 3D cellular structure for DIC calculation.

Acknowledgements

The authors gratefully thanked the funding supports from Shenzhen Science and Technology Innovation Committee under the grants JCYJ20170413141157573 and JCYJ20170818103206501. Part of this project was supported by City University of Hong Kong (Project No. 9667153).

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‘Super Bamboo’ – a new sustainable structural material

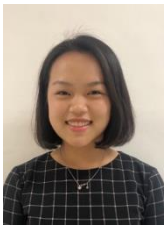
S.J. Chen[#1,2], R. Fan[1,2], and Y. Lu*[1,2]

[1]Department of Mechanical Engineering, City University of Hong Kong, Hong Kong

[2]Nanomanufacturing Laboratory (NML), Shenzhen Research Institute, City University of Hong Kong, Shenzhen 518057, China

*Corresponding author: Tel: +852 3442-4061, E-mail: yanglu@cityu.edu.hk

[#] Presenter: E-mail: sijiechen3-c@my.cityu.edu.hk



Abstract: We have developed a novel bamboo-based structural material which is made of 100% bamboo and is eco-friendly, lightweight, and high-strength. Two steps for making “Super bamboo” starts with the partial removal of lignin and hemicellulose via a boiling process in alkaline chemical treatment, and then hot compression until its hierarchical structure is fully compressed. The resulted “super bamboo” has much higher Young’s modulus, tensile strength, and compressive strength compared to nature bamboo. Its strength-weight ratio can be above 5 times of that of low carbon steel. The new ‘super bamboo’ materials have good durable because parenchymal cells and vessels inside are full compressed. The process is expected to reduce the cost of the bamboo-based material by 35% as compared to using existing bamboo process methods. The cost-effectiveness, together with its remarkable mechanical properties and sustainability, make the “super bamboo” competitive alternatives of conventional concrete, composites, and metals for certain applications.

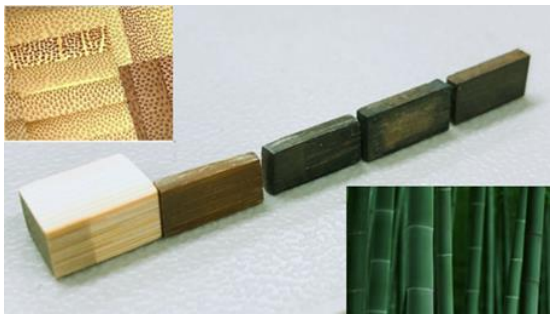


Figure 1. Schematic of natural bamboo and ‘super bamboo’ under different treatments

Acknowledgements

The authors gratefully thanked the funding supports from Shenzhen Science and Technology Innovation Committee under the grants JCYJ20170818103206501. Part of this project was supported by City University of Hong Kong (Project Nos. 6000604, 9667164 and 9667153).

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Dynamic modelling and vibration analysis of rotating beams with active constrained layer damping treatment in temperature field

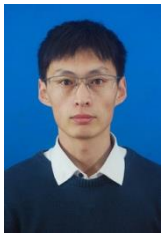
Y.B Guo[#1], L. Li[1,2] and D.G. Zhang*[1]

[1] School of Science, Nanjing University of Science and Technology, Jiangsu, China

[2] Department of Mechanical and Automation Engineering, The Chinese University of Hong Kong, Hong Kong, China

*Corresponding author: Tel: +86 8431-5185, E-mail: zhangdg419@mail.njust.edu.cn

[#] Presenter: E-mail: gyb_mechanics825@163.com



Abstract: A new rigid-flexible-thermal coupled dynamic model is developed for rotating beams with active constrained layer damping (ACLD) treatment in closed-loop and open-loop cases. By solving the corresponding linearized vibration equations of the smart system, the thermal vibration characteristics of the system in the two cases are analyzed. Influences of parameters such as the angular velocity, the temperature, the gains of PD control on the frequencies and damping ratios of the smart beam are discussed. Simulation results show that the variation of temperature can strongly affect the frequencies and damping performance of the ACLD beam, and there are critical temperatures that can change the damping performance of the ACLD beam in both open-loop and closed-loop cases. Research in this paper will be helpful for the dynamics of high speed rotating blades operating under thermal environment.

Acknowledgements

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In Situ Micromechanical Characterization of Metallic Glass Microwires under Torsional Loading

Sufeng Fan[#1] and **Yang Lu***[1,2]

[1]Department of Mechanical Engineering, City University of Hong Kong, Kowloon, Hong Kong SAR, China

[2]Hong Kong Branch of National Precious Metals Material Engineering Research Center (NPMM), 83 Tat Chee Avenue, Kowloon, Hong Kong, China

*Corresponding author: Tel: +852 3442-4061, E-mail: yanglu@cityu.edu.hk

[#] Presenter: E-mail: sffan2-c@my.cityu.edu.hk

Abstract: Small-scale metallic glasses have many applications in microelectromechanical systems (MEMS) and sensors which require good mechanical properties. In this work, by developing a micro robotic system, we investigated the torsional behaviour of Fe-Co based metallic glass microwires inside a SEM. Benefiting from the *in-situ* SEM imaging capability, the fracture behaviour of metallic glass microwire has been uncovered clearly. Plastic deformation of the microwires include both homogenous and inhomogeneous plastic strain, which began with the liquid-like region, then a crack formed because of shear bands and propagated along the spiral direction. Moreover, we found an inverse relationship between the plastic strain and the loading rate.

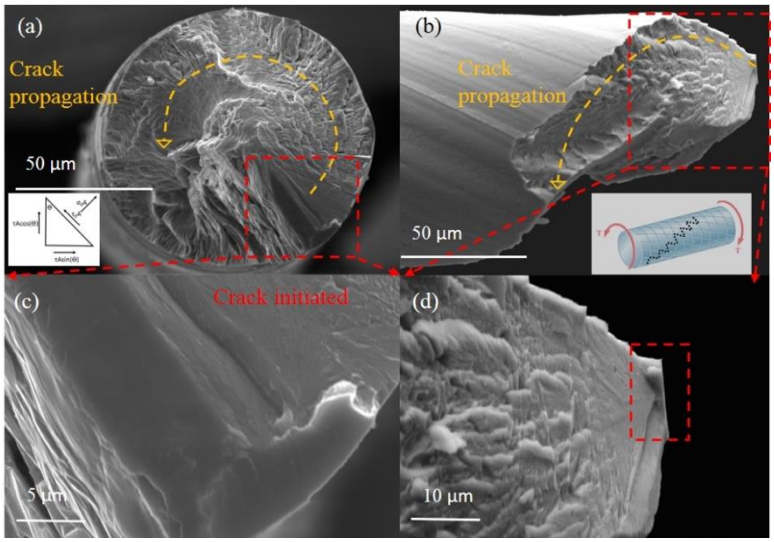

Figure 1. Microstructure of the fracture surface. [2]

Acknowledgements

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Unified theory of structures based on micropolar elasticity

R. Augello[1], **E. Carrera**[1] **and A. Pagani**[1]

[1]Department of Mechanical and Aerospace Engineering, Politecnico di Torino, Torino, Italy

*Corresponding author: Tel: +852 5527 1128, E-mail: riccardo.augello@polito.it

[#] Presenter: riccardo.augello@polito.it

Abstract: In engineering and scientific applications, the classical continuum mechanics represents the most adopted tool to analyse structural problems. The Classical Elasticity (CE) theory assumes that the rotations within the continuum are a direct consequence of displacements and the interaction between adjacent points occur only by means of translational forces. However, in many cases, it may no longer represent an appropriate and reliable mathematical model to describe the physical phenomena that happen within the structure. When the size of the analysed structure is comparable to the microstructural scale, the body behaves quite differently from the prediction that CE could lead to. In these cases, the microstructure of the material must be considered and several generalized continua models have been developed in the history. Among the generalized continuum theories, there is the Micropolar Elasticity (ME). At the end of the 19th century, the main ideas leading to the micropolar continuum, were discussed by many authors. One of the most important work is the one made by Voigt [1], who suggested that the interaction of two parts of the body is transmitted not only through the force vector but also through a moment vector. Thus, besides a force stress vector, an independent couple stress vector has also been defined. The complete theory of asymmetric elasticity was further developed by the brothers Francois and Eugène Cosserat [2], who introduced the asymmetry of the force-based stress tensor and deformations tensor. This work intends to establish a unified theory of structure based on the Micropolar Elasticity. The solution proposed is developed in the domain of the Carrera Unified Formulation (CUF) [3], according to which theories of structures can degenerate into generalized kinematics that makes use of an arbitrary expansion of the generalized variables. Different types of structures have been analysed, and the results are compared and validated with examples found in the literature. The effects of the new material parameters are addressed too, along with the capability of the proposed model to deal with size-effects. Finally, stress analysis is given to highlight the difference between the ME and the Classical Elasticity (CE).

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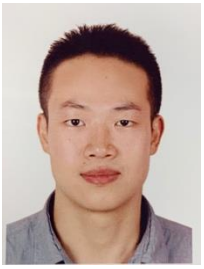
Bioinspired design of liquid optical clear adhesive (LOCA) for improving the damage resistance of touchscreen in smartphone



B. Xu[#] and X. Niu[*]

Department of Mechanical Engineering, City University of Hong Kong, Hong Kong, China

*Corresponding author: Tel: +852 3442-8432, E-mail: xinrui.niu@cityu.edu.hk

[#] Presenter: E-mail: boxu32-c@my.cityu.edu.hk

Abstract: Nowadays, smartphones are an indispensable part of people's daily life. Touchscreens in smartphones are getting larger and larger to meet the demand of dissipating the heat generated by smartphone components as well as improving users experience when they surf the web or play mobile games with smartphones. Meanwhile, increased size of the touchscreen induces problems. One of the most significant problems is that the glass layer of the larger and thinner touchscreens are easier to be cracked or shattered than before, which lessens the overall damage resistance of the touchscreen. In order to tackle this problem, chemical or physical methods have been developed to strengthen the glass layer of touchscreens. However, these methods are expensive and energy consuming because high temperature and precision machining technology are required.

This talk will present a novel method to enhance damage resistance of the touchscreen of smartphone. Instead of strengthening glass layer of the touchscreen, the adhesive layer which bonds the touchscreen glass and phone body, is structurally modified. A multilayer beam structure which can mimic the mechanical behaviour of a smartphone was designed with the aid of finite element (FE) simulation and validated by comparing with the experimental results. A novel liquid optical clear adhesive (LOCA) was fabricated based on a bio-inspired structure developed by Niu et al. (2009) and utilized to construct the multilayer beam structure. Three-point bending tests were performed to obtain the strength of the multilayer structure. Experimental results showed that, compared to commercially available LOCA, the bio-inspired LOCA was able to enhance damage resistance of the multilayer structure for 30%. FE analysis was performed to study the strengthening mechanism of bio-inspired LOCA. This work invented a new material and a novel method to improve damage resistance of touchscreens of smartphones. Compared to the conventional methods, the new method is more economic friendly and convenient. The research and design philosophy can be easily extended to the damage-resistant design of other electronic devices with large screens such as tablet, laptop, television, etc.

Acknowledgements

This work is supported by CityU College Seed Grant for Collaboration with BIEL Crystal 9610374. This work utilized the High Performance Computer Cluster managed by the College of Science and Engineering of City University of Hong Kong.

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Study on mechanical properties of plastic fuel tank material after fuel soak

Zhou Jianfang[1], Chen Xuehong*#1

[1] College of Mechanics and Materials, Hohai University, Jiangsu, China

*Corresponding author: Tel: +86-13585245726, E-mail: chenxuehong1983@163.com

Presenter: E-mail: chenxuehong1983@163.com

Abstract: In order to further study the mechanical properties change of high density polyethylene (HDPE) soaked in fuel, the tensile test and impact test of HDPE soaked in diesel, B30 (30% v/v biodiesel, 70% v/v diesel), gasoline, M15 (15% v/v methanol, 70% v/v gasoline) and E30 (30% v/v bioethanol, 70% v/v gasoline) was carried out. In order to represent real situation of fuel soaked plastic fuel tank, all test specimens were directly cut from real plastic fuel tank, manufactured using the HDPE pellets through the hollow blow molding process and soaked in all test fuels. The effects of fuel soaking on different mechanical properties, the change trend of mechanical properties with increasing soaking time and the effects of different fuels were discussed. By comparing the test results between wet specimens and dry specimens, the mechanism of mechanical degradation of HDPE soaked in fuels was discussed. Finally, based on the results of tensile and impact tests, the reasons for the increase of impact strength was discussed.

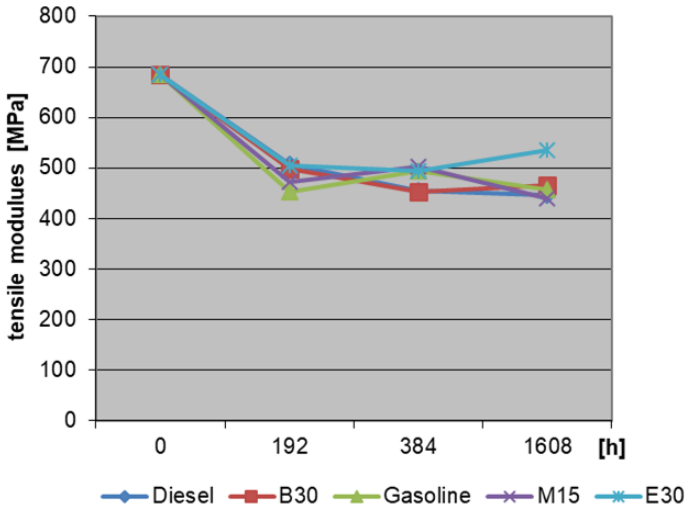

Figure 1. Change of tensile modulus of HDPE with soaking time of dry specimens.

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A Simplified Model for Estimation of Field-Monitored Soil Suction using Genetic Programming

Z.L. Cheng[#1] and W.H. Zhou*[1]

[1]Department of Civil and Environmental Engineering, University of Macau, Macau, China

*Corresponding author: Tel: +853 8822 4469, E-mail: hannahzhou@um.edu.mo

[#] Presenter: E-mail: yb77414@um.edu.mo

Abstract: In shallow soil layers of urban landscape, soil suction is greatly affected by vegetation and atmosphere. In this study, a field monitoring was conducted for recording variations of soil suction, air relative humidity and air temperature at different distances from a tree and at a constant depth under natural environmental conditions. A computational model is built using the genetic programming (GP) method for describing the functional relationship between soil suction and the four input variables. Based on the performance analysis, the efficiency and reliability of the developed computational model are validated. It can be concluded that the proposed computational model based on the artificial intelligence can sufficiently describe the relationship between the soil suction as a crucial parameter in geotechnical engineering and four input variables with acceptable errors.

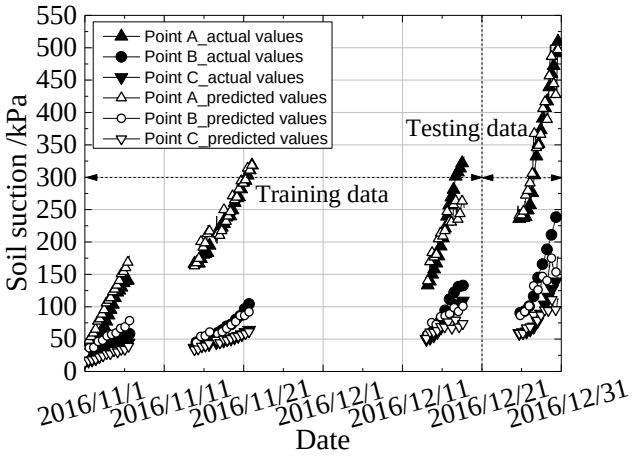

Figure 1. The comparison between actual and predicted values of soil suction at three monitoring points.

Acknowledgements

The authors wish to thank the financial supports from the Macau Science and Technology Development Fund (FDCT) (125/2014/A3) and University of Macau Research Fund (MYRG2015-00112-FST).

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Microstructure and mechanical properties of $CoCrFeNiZr_x$ high entropy alloy (HEA) thin films

X.B. Feng[#] and Y. Lu*

Department of Mechanical Engineering, City University of Hong Kong, Kowloon, Hong Kong SAR, China

*Corresponding author: E-mail: yanglu@cityu.edu.hk

[#] Presenter: E-mail: xbfeng2-c@my.cityu.edu.hk

Abstract: In this work, we systematically investigated the relationship between microstructure and mechanical properties of CoCrFeNiZrx (x= 0, 0.3, 0.5, 1) high entropy thin films. A transition from single phase crystal to amorphous structure was observed with increasing Zr concentration from 0 at.% to 25 at.%. In the intermediate Zr concentration-range spanning from 7.0 at.% to 12 at.%, Zr addition renders a peak hardness of 6.8 GPa with a crystal-amorphous dual phase structure. In the meantime, we provide reasonable insights into understanding behaviors above. These findings will convey the valuable information for designing ultrastrong high entropy alloys for practical applications.

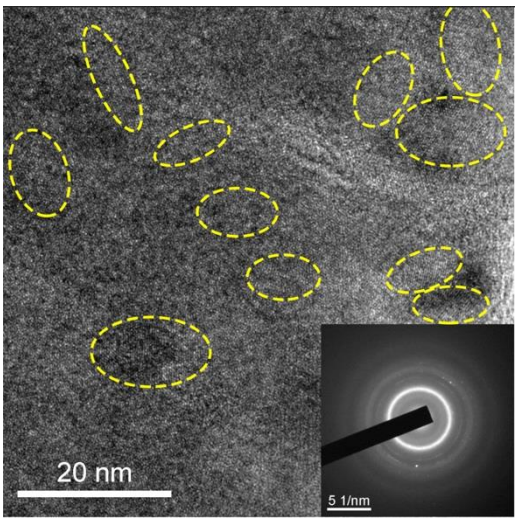

Figure 1. Representative cross-sectional HRTEM image of dual phase CoCrFeNiZr0.3 high entropy alloy thin film. Inserts are the corresponding selected area diffraction pattern (SADP).

Acknowledgements

The authors gratefully thanked the funding supports from Shenzhen Science and Technology Innovation Committee under the grants JCYJ20170413141157573. Part of this project was supported by City University of Hong Kong (Project 9680108).

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A new two-loop procedure numerical integration method for index-3 DAE of multibody dynamic problems

X. Guo[#1] and D.G. Zhang*[1]

[1] School of Science, Nanjing University of Science and Technology, Jiangsu, China

*Corresponding author: Tel: +86 8431-5185, E-mail: zhangdg419@mail.njust.edu.cn

[#] Presenter: E-mail: guoxian88617@163.com

Abstract: The performance of the two-loop implicit sparse matrix numerical integration (TLISMNI) methods as the numerical solution of index-3 differential algebraic equations (DAEs) of motion arising in flexible multibody dynamics is studied here. The iteration from the implicit integration algorithm and the iteration from the nonlinear algebraic constraint equations construct their own loop independently. The TLISMNI method, as a state-space-based method, has notable features: no use of numerical force differentiation, friendliness of sparse matrix techniques and the satisfaction of constraints at position, velocity and acceleration levels. The original TLISMNI method was proposed for the first time by Shabana and Hussein uses the Newmark method as the implicit integration algorithm. This integration algorithm considers the accelerations and Lagrange multipliers as basic unknowns and its numerical accuracy is no more than order 2. In order to have a higher integral precision, we use the extended backward differentiation formula (EBDF) scheme as the integration algorithm used in the TLISMNI method (TLISMNI/EBDF method), which consider coordinates and velocities as basic unknowns. The whole structure of the proposed method is different from the traditional one due to the different unknowns. In order to test the applicability of the proposed method, four kinds of simulation examples solved by the new two-loop method are presented here. Results show that the TLISMNI/EBDF method can increase the order of the original TLISMNI method and improve the convergence characteristics. Furthermore, the proposed method only needs to perform less iterations to satisfy the same tolerance of error than the traditional TLISMNI method does. Increasing the number of iterations can increase the calculation amount and round-off errors with the growth of the problem size.

Acknowledgements

The authors are grateful for the support from the National Natural Science Foundation of China (Grant Numbers 11772158, 11502113), and the Fundamental Research Funds for Central Universities (Grant Number 30917011103).

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Material point method for large deformation analysis of soil slopes

Kewei Feng[#1], Gang Wang*[1] and Duruo Huang[1]

[1]Department of Civil and Environmental Engineering, The Hong Kong University of Science and Technology, Hong Kong, China

*Corresponding author: gwang@ust.hk

[#] Presenter: kfeng@ust.hk

Abstract: Realistic prediction of landslides is critical for the design of key infrastructure in seismically active regions. However, present slope stability analysis generally focuses on landslide triggering, and limited information is provided on large deformation and post-failure behaviour. In the study, the dynamic behaviour of soil slopes is simulated using Material Point Method (Sulsky *et al.* 1995), which models the materials as Lagrangian particles moving through a background Eulerian mesh. A Mohr-Coulomb model with strain softening behaviour is developed for describing the soil behaviour at large deformation. The influence of soil properties on the triggering of instability and downward sliding of the soil mass is evaluated in a parametric study by varying peak and residual strengths. Progressive deformation in the soil mass may cause shear strength reduction, and topographic amplification of waves is observed along the slope surface (e.g. Wang *et al.* 2018). All these factors determine the acceleration of the sliding mass and its travelling distance. In the end, simple Newmark sliding block analysis (e.g., Du and Wang 2016) was used to compare with the numerical simulation. The method will be further developed for regional scale seismic landslide analysis (Huang and Wang 2015).

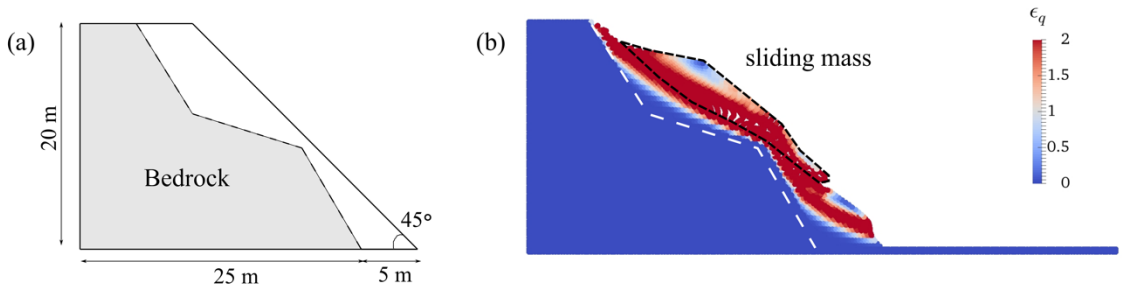

Figure 1. (a) Initial slope geometry; (b) Distribution of deviatoric strain on sliding mass under dynamic load

Acknowledgements

The authors acknowledge support from Hong Kong Research Grants Council theme-based research funding No. T22-603/15N and GRF grant No. 16214118.

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Simulation of fluid-structure interaction during phacoemulsification-based cataract surgery

Zhaokun Wang*#, Chenglei Wang, Hui Tang

Department of Mechanical Engineering, The Hong Kong Polytechnic University, Hong Kong, China

*#Corresponding author and presenter: zhaokun.wang@connect.polyu.hk

Abstract: Cataract is the leading cause of blindness, responsible for 33% of visual impairment worldwide. The most effective treatment for cataracts is phacoemulsification-based cataract surgery, which has become nowadays the standard method to remove cataract[1]. Investigating the interaction between intraocular flow and iris during phacoemulsification-based cataract surgery is important to understand the occurrence of intraoperative floppy iris syndrome (IFIS), which always degrades the surgery outcome. Addressing this problem typically requires the analysis coupling both fluid dynamics and structural mechanics[2]. In the work, we study the dynamics of a simplified iris with the intraocular flow in cataract surgery using a newly developed fluid-structure interaction (FSI) simulation framework, as sketched in Fig. 1. The lattice Boltzmann method (LBM) is used to simulate the intraocular flow driven by a simplified phaco probe. The iris structure with large deformation is solved using the finite element method (FEM) based on the co-rotational formulation method. The immersed boundary (IB) method is used to deal with the fluid-iris interaction. The dynamics of the fluid-iris system is studied in details. Different iris deformation states are identified. In addition, the effects of the iris bending stiffness, mass ratio and phaco probe position and vibration frequency on these states are examined. The simulation results reveal some physical insights into the dynamics of this intraocular fluid-iris system, which can provide reasonable guidance to clinicians.

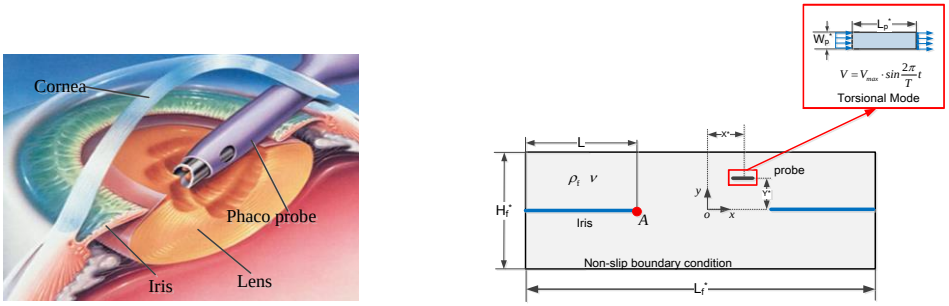

Fig.1. Schematics of (a) cataract surgery (adapted from: http://www.drray.co.uk/cataract-surgery-diagram/) and (b) FSI simulation settings.

Acknowledgements

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Experimental investigation of flow in converging-diverging microchannels

Ran Tao[#1], Yakang Jin[1], Xiang Gao[1], and Zhigang Li*[1]

[1]Department of Mechanical and Aerospace Engineering, The Hong Kong University of Science, Hong Kong, China

*Corresponding author: Tel: +852 2358-7186, E-mail: mezli@ust.hk

[#] Presenter: E-mail: rtaoaa@connect.ust.hk

Abstract: Experiments are conducted to investigate fluid flows in converging-diverging microchannels (CDMCs). A new dimensionless number related to channel geometry, Gm, is introduced to combine with the Reynolds number, Re, to characterize the flows. It is found that the new dimensionless number, $\mathrm{Re_G} = \mathrm{Re}\cdot\mathrm{Gm}$, is more appropriate than Re for flow characterization in CDMCs. Flows are laminar for $\mathrm{Re_G} < 40$ regardless of the geometry of CDMCs. For laminar flows, the flow resistance model developed in the literature works well. For transitional and turbulent flows, a general scaling law for the flow resistance is developed, which suggests a polynomial dependence of pressure drop on the flow rate. Numerical simulations have also been performed to confirm experimental results.

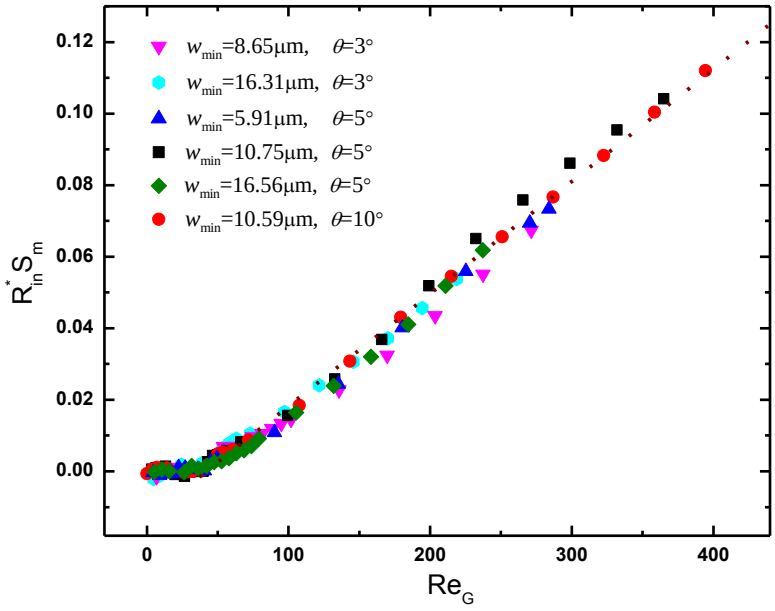

Figure 1. Variation of $R^*_{in}S_m$ as a function of $\mathrm{Re_G}$

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Topographic amplification on steep terrain: case study of Tuen Mun valley

Z.W. Chen[#1], D. Huang[2] , G. Wang[*1] and F. Jin[2]

[1]Department of Civil and Environmental Engineering, The Hong Kong University of Science and Technology, Hong Kong, China

[2]Department of Hydraulic Engineering, Tsinghua University, Beijing, China

*Corresponding author: Tel: +852 9811 2496, E-mail: gwang@ust.hk

[#] Presenter: E-mail: zchendq@connect.ust.hk

Abstract: In this study, a regional-scale 3D Spectral Element analysis is conducted to study topographic amplification of earthquake ground motions on steep terrain using Tuen Mun area in Hong Kong as a testbed. It is found that ground motion amplification is frequency dependent, which can be well correlated with topographic features such as curvatures smoothed over a characteristic length (Wang et al. 2018). To quantify the notable difference in ground-motion amplification along different directions, a combination of smoothed curvatures along and perpendicular to the shaking direction is proposed. The "polarized" smoothed curvature has strong correlation with the polarized amplification pattern, as shown in Fig. 1. Moreover, it is found that oblique incidence of waves reduces amplification on ridges along the wave propagation direction; opposite trend of variation in amplification presents on two sides of the ridges perpendicular to the wave propagation direction. Further studies are under way to quantify the effect of wave incidence angles, as well as spatial correlation of ground motions via time-frequency domain analysis (Huang and Wang 2015).

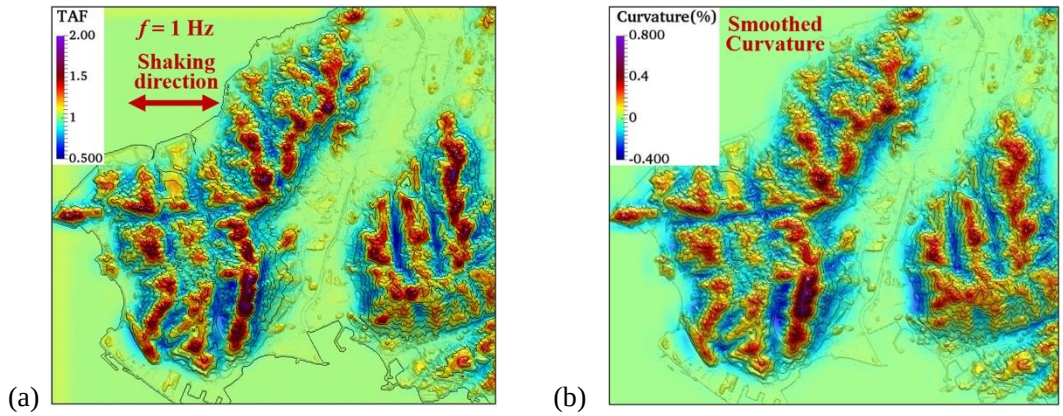

Figure 1. Correlation of (a) topographic amplification factor (TAF) on steep terrain and (b) polarized smoothed curvature

Acknowledgements

The authors acknowledge support from NSFC Joint Research Fund for Overseas Chinese Scholars and Scholars in Hong Kong and Macau Grant No. 51828902, and Hong Kong Research Grants Council GRF grant No. 16214118.

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Water transport in graphene-coated nanochannels

Yakang Jin[#1], Ran Tao[1] and Zhigang Li*[1]

[1]Department of Mechanical and Aerospace Engineering, The Hong Kong University of Science and Technology, Hong Kong S. A. R., P. R. China

*Corresponding author: E-mail: mezli@ust.hk

[#] Presenter: E-mail: yjinam@ust.hk

Abstract: In this study, we investigate pressure-driven water flows in graphene-coated copper nanochannels through molecular dynamics simulations. It is found that the flow rate in bare copper nanochannel can be significantly enhanced by a factor of 45 when the nanochannel is coated with monolayer graphene. The enhancement factor for the flow rate reaches about 90 when the nanochannel is modified with 3 or more graphene layers. The dipole relaxation time and the hydrogen bond lifetime of interfacial water molecules show that the graphene coating promotes the mobility of water molecules at the interface. The distribution of the potential of mean force and the free energy barriers also confirm that graphene coating reduces the flow resistance and 3 layers of graphene can fully screen the surface effects. The results in this work provide important information for the design of graphene-based nanofluidic systems for flow enhancement.

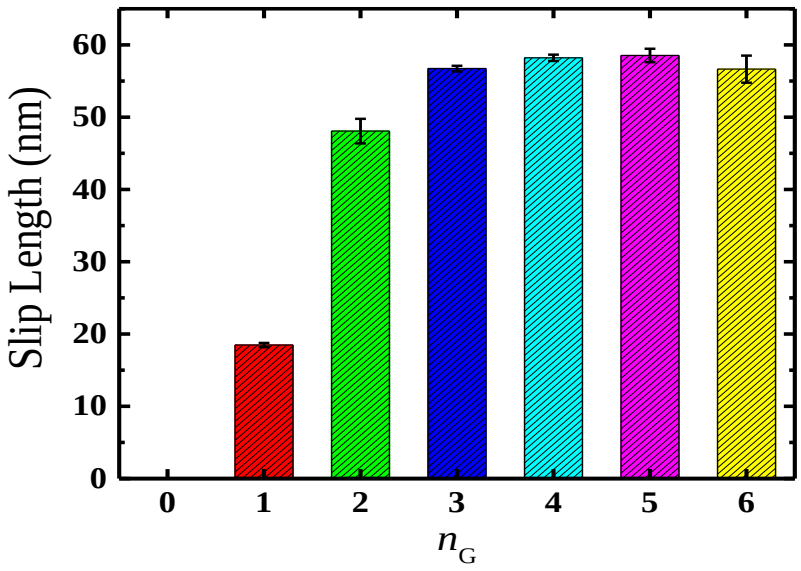

Figure 1. The slip length versus the number of graphene layers.

Acknowledgements

This work was supported by the Research Grants Council of the Hong Kong Special Administrative Region under Grant No. 16210615. Part of the simulations were performed at the National Supercomputer Center in Guangzhou, P. R. China.

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Modified Plastic-Damage Model for FRP-Repaired Concrete Columns

I.A. Tijani[#1], Y.F. Wu[2] and C.W. Lim*[1]

[1]Department of ACE, City University of Hong Kong, Hong Kong, China

[2]School of Engineering, RMIT University, Melbourne, Australia

*Corresponding author: Tel: +852 3442-7285, E-mail: bccwlim@cityu.edu.hk

[#] Presenter: iatijani2-c@my.cityu.edu.hk

Abstract: Concrete damaged plasticity model, being a plasticity model, is deemed inappropriate to simulate the reduction of elastic stiffness which occurred in a fiber-reinforced polymer (FRP) repaired concrete prior to repair. However, with necessary modifications, the concrete damage plasticity model is capable of predicting the dilation behavior of repaired concrete. This study presents a modified plastic-damage model within the context of concrete damaged plasticity model in ABAQUS for modeling of a uniformly FRP-confined repaired concrete under monotonic loading. The proposed modifications comprise of infliction damage, elastic stiffness, yield criterion, flow rule and a strain hardening/softening rule. The distinct features of the proposed model of damaged concrete, which is elastic stiffness reduction, is encompassed in the model. The dilation model is expressed as a function of the lateral stiffness of the FRP-jacket. The finite element predictions are shown to be in close agreement with the obtained test results of the repaired concrete.

Acknowledgments

The authors wish to thank the Science Technology and Innovation Committee of Shenzhen Municipality (Project No. Basic 20170019) and City University of Hong Kong (Project No. 9680213) for their support.

In situ nanomechanical characterization of ceramic/metal nanocomposites

Chaoqun Dang[#1], **Yang Lu***[1, 2]

[1]Department of Mechanical & Biomedical Engineering, City University of Hong Kong, Kowloon, Hong Kong SAR, China

[2]Hong Kong Branch of National Precious Metals Material Engineering Research Center (NPMM), 83 Tat Chee Avenue, Kowloon, Hong Kong, China

*Corresponding author: yanglu@cityu.edu.hk

[#] Presenter: cqdang2-c@my.cityu.edu.hk

Abstract: For most engineering structural materials, the attainment of both strength and toughness is a significant necessity; in general, these properties are mutually exclusive. Toughness improvement of inherent brittle materials has remained a challenge. Traditionally the approach of improving the toughness of the brittle composites by incorporating relatively softer materials balances their strength and toughness. Here, we study the mechanical responses of co-doped and multilayered ceramic/metal nanocomposites by NanoIndenter. Micropillar compression tests were performed to identify the elastic modulus, fracture strength, deformation mechanism and failure mechanism. We believe that this work could be useful for applications of ceramic/metal coatings in micro- and nanoscale devices/components, but also have important implications for their fracture mechanisms and thus for the improvement of ceramic/metal coating design.

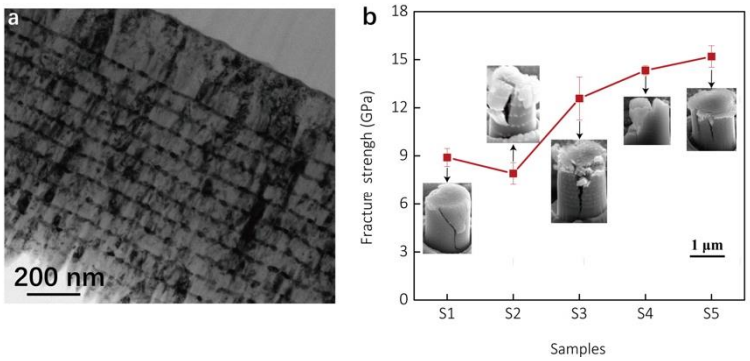

Figure 1. Typical TEM image and fracture strength of ceramic/metal nanocomposites.

Acknowledgements

The authors wish to thank Hong Kong Research Grant Council (No. CityU 11212915 and CityU 11205018), City University of Hong Kong (No. 9680108) and Hong Kong Branch of National Precious Metals Material Engineering Research Center (NPMM).

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3D Printed Gradient Composite Microlattice Mandibular Prosthesis

Ran Xiao[1,2,3,#], Libo Gao[1,2,3,4], Xiaobin Feng[1,2,3], Rong Fan[1,2,3,5], and Yang Lu[1, 2, 3,*]

[1]Department of Mechanical Engineering, City University of Hong Kong, Hong Kong, China

[2]Nano-Manufacturing Laboratory (NML), Shenzhen Research Institute of City University of Hong Kong, Shenzhen, China

[3]CityU-Xidian Joint Laboratory of Micro/Nano-Manufacturing, Shenzhen, China

[4]School of Mechano-Electronic Engineering, Xidian University, Xian 710071, China

[5]School of Automotive Engineering, Dalian University of Technology, Liaoning, China

*Corresponding author: Tel: +852 3442-4061, E-mail: yanglu@cityu.edu.hk

[#] Presenter: E-mail: ranxiao4-c@my.cityu.edu.hk

Abstract:

This study shows a novel mandibular prosthesis design method based on 3D printed microlattices coated with titanium film, to enhance its compressive strength. Compression test was conducted on the composite lattices, and thus established the correlations between the porosity of the lattice and its compressive crushing strength. At the same time, mandibular stress state under compressive condition was obtained by finite element method, and the compressive crushing strength of the lattice and the mandibular stress were interconnected. Thus, the correlations between the porosity of composite microlattices and the compressive stress state of human bones were established successfully. As a result, according to the stress distribution of human mandible, there were nearly 20% porosity gradient difference existed inner the human mandible, showing the superiority of this design method for mandibular prosthesis, as well as for other orthopaedics implants.

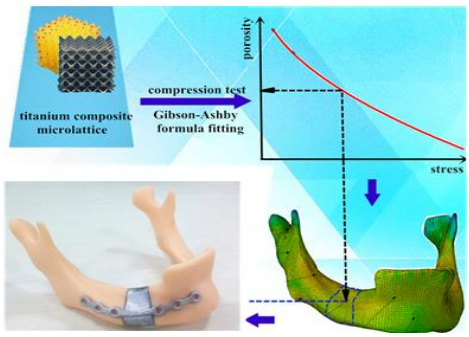

Figure 1. Novel mandibular prosthesis design method (under review)

Acknowledgement

The authors gratefully thank the funding supports from Shenzhen Science and Technology Innovation Committee under the grant JCYJ20170818103206501. Part of this work was supported by City University of Hong Kong (Project Nos. 6000604 and 9667153).

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Experimental and theoretical study of a bio-inspired flow energy harvester

F.W. Zhao[#1], M. N. Mumtaz Qadri[2] and H. Tang[*1]

[1] Department of Mechanical Engineering, The Hong Kong Polytechnic University, Hong Kong, China

[2] Department of Aerospace Engineering, College of Aeronautical Engineering, National University of Sciences and Technology, Risalpur, Pakistan

*Corresponding author: Tel: +852 2766-7815, E-mail: h.tang@polyu.edu.hk

[#] Presenter: E-mail: f.w.zhao@connect.polyu.hk

Abstract: Inspired by birds and fishes, a new energy harvesting concept has been developed recently, where a passively flapping hydrofoil is utilized to extract energy from air/water flows. Compared with traditional techniques, it has some advantages, including better performance at low Reynolds numbers, better filling factor, more structurally robust, better environmental adaptability and less 3D losses. Past researches in this field have indicated that the power efficiency of oscillating hydrofoils is comparable to rotary turbines[1]. Till now, however, the majority of existing works were focused on fully prescribed or semi-passive systems, and research on fully passive systems was very limited. To fill this gap, we designed and fabricated a bio-inspired flow energy harvester based on a fully passive, rigid flapping hydrofoil, as shown in FIG. 1. Experiments were then conducted to investigate its performance with various parameter combinations and flow conditions. A high power efficiency (> 40%) was achieved. Furthermore, we evaluated the aerodynamic forces, power extraction, and efficiency of such a bio-inspired flow energy harvester using a theoretical model. Motivated by existing models of freely falling cards and insect flight, a quasi-steady model was developed and validated by experimental data. It was then applied in a parametric study to explore the effects of several key parameters on the energy harvester performance.

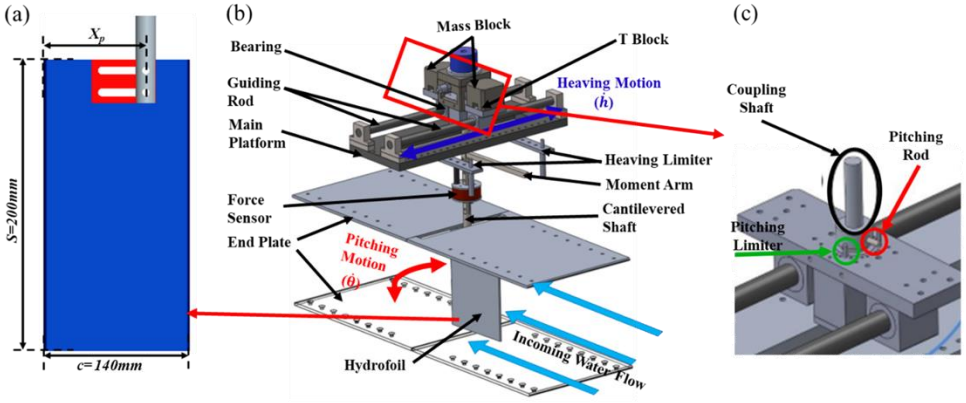

Figure 1. Schematic of (a) a plate hydrofoil; (b) the experimental setup of a passively oscillating flow energy harvester. (c) a close-up view of the top part of the setup.

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Surface Effects on Mechanical Properties of Nanowires from Molecular Dynamics Simulations

Chun Tang

Faculty of Civil Engineering and Mechanics, Jiangsu University, Zhenjiang, 212013, Jiangsu Province

Email: tangchun@ujs.edu.cn

Abstract: As the size of materials and structures goes down to the nanoscale, the surface to volume ratio increases significantly and plays a central role in determining the mechanical and electronical properties of these nanomaterials. The exact influence of the surface effect on the mechanical properties of low dimensional materials depends on many factors such as the intrinsic nature of the chemical bonds, the thickness of the surface layers and so on. In this work, we report molecular dynamics simulations on the mechanical properties of one dimensional nanowires including amorphous SiO2 and piezoelectric ZnO nanowires. Our results show that due to the surface reconstruction, a secondary bond angle peak appears, the value is below that of the main peak angle. This secondary peak is mainly distributed on the surface layer, leading to compressive surface stress, leading to abnormal relationship between the nanowire diameter and their elastic modulus, fracture stress, etc. Surface effect is also found to strongly modulate the piezoresistance coefficients of ZnO nanowires of various cross sectional shapes. The uncovered mechanism is found to be useful in explaining experimental results.

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DDA modelling of sand particles reconstructed by spherical harmonics — A preliminary study

H. Fan [#1], G. Wang[1], D. Huang *[2]

[1] Department of Civil and Environmental Engineering, Hong Kong University of Science and Technology

[2] Department of Hydraulic Engineering, Tsinghua University, China

*Corresponding author: E-mail: huangdr@ust.hk

[#] Presenter: E-mail: fanhuo@ust.hk

Abstract: Based on the micro X-ray computed tomography (μCT) data, the spherical harmonic (SH) function can be employed to reconstruct natural sand particle, referred to as SH-sand, whose shape is usually irregular and whose surface texture is usually very complex (Shen and Makedon 2000, Zhou et al. 2015). Thanks to these analytic functions, the closest points between SH-sands can be identified by resorting to the geometric iteration method. To capture the kinematics and kinetics characteristics of the SH-sand, this study deduces the formula of discontinuous deformation analysis (DDA) from principle of minimum potential energy, in which the degree of freedoms and interpolation matrix are both independent of geometry of particles. As a result, a framework for simulating the dynamic behaviour of SH-sand is established. Our primary research shows that the proposed methodology is valid. In the next step, some more complex and realistic applications (e.g. Wang and Wei 2016) will be investigated.

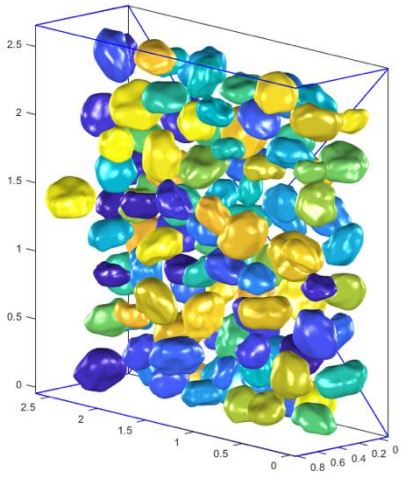

Figure 1. Some random SH-sands.

Acknowledgements

The study is supported by NSFC-RGC Joint research scheme N_HKUST621/18 and RGC General Research Fund grant No.16204618, Theme-based Research T22-603/15N.

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基于动力测试的高桩码头结构损伤识别技术研究

Ruihu Zhu#*[1],Jingbo Su[1] , Jinqin Hao[1], Ang Li[1]

[1] College of Harbour, Coastal and Offshore Engineering, Hohai University, Nanjing 210098, China;

*Corresponding author: Tel: +8613770704156, E-mail: ruihuzhu@hhu.edu.cn

Presenter: E-mail: ruihuzhu@hhu.edu.cn

摘要：结构动力损伤识别已在桥梁等大型土木工程中应用，但高桩码头动力损伤识别要应用于实际工程还需要进一步完善。本文建立物理模型试验模拟高桩码头基桩损伤，通过冲击荷载试验下结构的固有频率变化及动力响应规律分析，研究敏感反映高桩码头基桩损伤情况下的动力指纹，为高桩码头动力损伤识别提供依据。

通过采集不同损伤程度的下的桩顶应变、加速度响应，并根据实验数据分析高桩码头的固有频率和桩顶弯矩，得出以下结论：（1）当码头某一直桩发生破损时，不同排架同一位置的直桩桩顶处的应变和弯矩线性关系能够较好地反应基桩的损伤：当某根桩发生破损时该桩桩顶处的响应值发生改变，各桩桩顶处各响应值的线性关系发生了改变，破损桩桩顶处的位移值变大而应变和弯矩值出现显著减小，如图 1、图 2。（2）对于斜桩而言，识别规律与斜桩的倾斜方向有关，当斜桩的倾斜方向与荷载冲击方向所成夹角为锐角，则该桩发生破损时位移、应变和弯矩等响应值的变化并不大，对损伤桩位的识别并不明显，对于部分斜桩的损伤识别有待于进一步研究。（3）结构的固有频率这一指标在结构损伤后会有减小的趋势，但在结构损伤初期不明显且不能识别结构的损伤位置，该指标在结构损伤识别中能仅能识别出码头整体结构的损伤程度且识别效果较差。（4）在对高桩码头基桩进行安全性评估时，可通过动力损伤识别方法对损伤桩位进行初步定位，并对损伤程度进行初步判断；然后通过对损伤桩基的进一步检测确定具体的损伤类型与损伤程度，进而制定详细准确的维修、加固方案。

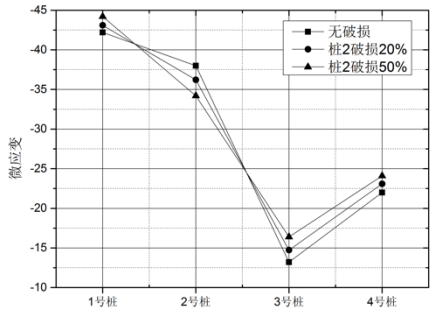

图 1 左侧受力时各桩桩前应变数据

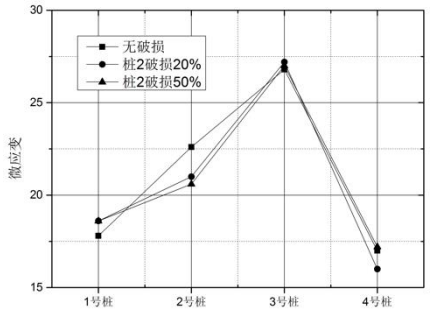

图 2 中间受力时各桩桩后应变数据

Acknowledgements

The authors wish to thank the National Natural Science Foundation of China(grant nos 51709093 and51679081).

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