出國報告（出國類別：其他-出席國際會議）

2013 計算及實驗工程與科學國際會議

服務機關：國立高雄第一科技大學營建工程系
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派赴國家：美國
出國期間：2013 年 5 月 24 日至 2013 年 5 月 31 日
報告日期：2013 年 6 月 3 日

摘要

2013 計算及實驗工程與科學國際會議 ICCES’ 13 (International Conference on Computational& Experimental Engineering and Science)，每一年召開一次，今年在美國西雅圖(Seattle)舉行。 自 2013 年 5 月 24 日至 2013 年 5 月 28 日止，為期共五天。 此次會議所發表的論文約有參佰多篇左右，參加會議的人員約參佰多人。 除了一些美國學者、教授外， 有來自全世界的學者、教授，如德國、加拿大、英國、日本、東歐、北歐、法國、印度及我國和中國大陸等多國， 參加此會議。個人除了發表自己的論文以外，並出席參加了許多演講。因此，本人於短短幾天之間，知道很多不同領域方面的研究新方向，覺得獲益不少。 另外幾位演講學者的演講非常精彩，內容均是較新的研究題材及領域，可啟發聽眾的思考及創新性。個人參加此會議目的在於學習與了解這些研究新方向，希望可提昇個人及國家之工程與科學方面的學術水準。並且希望將來可與國際學者在工程與科學方面作進一步的研究合作。

目錄 頁碼

(一). 參加會議目的

2013 計算及實驗工程與科學國際會議在探討工程與科學方面的研究新方向包含複雜系統的多功能分析、複合材料及結構之力學行為、塑性力學、計算及實驗力學、流體力學、微機電系統、醫學及生物之奈米工程、計算生物學及計算力學、智慧材料、計算固體力學及奈米力學、奈米材料等等。此次會議共分成 27 個主題，不過各主題依論文類別再細分為多個場次(Session)，每場次計有四位至五位學者或專家參與發表論文。各主題皆固定在一小型會議室進行，與會的論文同時包含理論與實務兩方面。個人發表的論文主要探討以隨機有限單元法研究含有流體及受到移動外力之雙層壁奈米碳管之非線性振動，主要屬固體力學(Solid Mechanics)領域。個人並參與了其他一些演講、以及一些 symposium 之場次，並與一些國際學者交換意見，並且討論將來國際合作機會。 個人參加此會議目的在於學習與了解這些研究新方向，希望可提昇個人及國家之工程與科學方面的學術水準。並且希望將來可與國際學者在工程與科學方面作進一步的研究合作。

(二). 參加會議過程

2013 計算及實驗工程與科學國際會議 ICCES' 13 (International Conference on Computational & Experimental Engineering and Science)，此會議近來每一年召開一次，今年在美國西雅圖(Seattle)舉行。西雅圖不僅是美西渡假勝地，風景秀麗，且是美國幾家科技大公司之 Headquarters 之重鎮如 Microsoft, Boeing, Amazon, 且是美國幾家大公司之 Headquarters 如 Starbucks, Alaska Airlines, Nordstrom, Zillow.com, Expedia.com。2013 計算及實驗工程與科學國際會議自 2013 年 5 月 24 日至 2013 年 5 月 28 日止，為期共五天。此次 2013 計算及實驗工程與科學國際會議主題主要在探討工程與科學方面的研究新方向,並如何達成全球化共同合作。故其領域涵蓋複雜系統的多功能分析、複合材料及結構之力學行為、塑性力學、計算及實驗力學、流體力學、微機電系統、醫學及生物之奈米工程、計算生物學及計算力學、智慧材料、計算固體力學及奈米力學、奈米材料等等。此次 2013 計算及實驗工程與科學國際會議，屬中小型會議型態，據大會主席報告，此次發表的論文約有參佰多篇左右，參加會議的人員約參佰多人。 除了一些美國學者、教授外， 有來自全世界的學者、教授，如德國、加拿大、英國、日本、東歐、北歐、法國、印度及我國和中國大陸等多國， 參加此會議。 本次會議並邀請一些國際著名的學者到會中演講，大部份的會議(Session)多有一場至數場主題學術性演講(Keynote Lectures or Theme Lectures)。

此次會議共分成 27 個主題，不過各主題依論文類別再細分為多個場次(Session)，每場次計有四位至五位學者或專家參與發表論文。各主題皆固定在一小型會議室進行，與會的論文同時包含理論與實務兩方面。由這些場次主題來看，可謂內容豐富，亦可見主辦者之用心。而固定會議室之安排，使得各主題之與會學者皆能持續地與其相關領域學者作深入討論，不致於奔波至不同會場聽取類似主題的論文報告。

個人發表的論文主要探討以隨機有限單元法研究含有流體及受到移動外力之雙層壁奈米碳管之非線性振動 (Stochastic FEM on nonlinear vibration of fluid-conveying double-walled carbon nanotubes subjected to a moving load) 。
主要屬固體力學(Solid Mechanics)領域, 發表的論文被安排在會議第二天 5 月 25 日上午 10:00 至 12:30 之「D06: Symposium in Honour of Prof. Wen-Hwa Chen (Dynamics)」場次。該場次有五篇文章發表，每人計有 15 分鐘之發表與 3 分鐘之討論時間。此五篇文章皆與固體力學相關，在此場次中，個人是第一位發表者。個人發表論文之後, 大約有四位學者對個人發表之論文有興趣, 並詢問一些問題。個人並參與了其他一些演講、以及一些 symposium 之場次，並與一些國際學者交換意見, 並且討論將來國際合作機會。個人參加此會議之目的及任務在於學習與了解這些與固體力學相關之研究新方向, 希望可提昇個人及國家之工程與科學方面的學術水準。並且希望將來可與國際學者在工程與科學方面作進一步的研究合作。個人在與一些國際學者交換與固體力學相關意見之後,覺得不僅個人發表自己之論文之外, 且讓這些國際學者知道個人是來自台灣, 個人出席 2013 計算及實驗工程與科學國際會議之任務及目標已達成。

個人發表的論文內容為探討含有流體之雙層壁奈米碳管之非線性振動之隨機動態行為。我們不僅考慮幾何非線性之效應，我們並且考慮凡德瓦(Van der Waals)力之非線性效應。此外，我們並利用非局部彈性理論來研究雙層壁奈米碳管之非線性振動行為。我們利用漢米頓(Hamilton)理論來推導含有流體之雙層壁奈米碳管的非線性控制方程式。我們假設雙層壁奈米碳管的彈性楊氏係數對位置而言是隨機的，以真正描述雙層壁奈米碳管的隨機材料性質。利用微擾法及有線單元法，我們可求解非線性微分方程式。我們可以求出雙層壁奈米碳管的一些統計動態效應，如:位移振幅之平均值及標準偏差，我們並且研究流體速度及小尺寸係數對雙層壁奈米碳管之統計動態反應之影響。我們可以推導出以下結論:位移振幅之平均值及標準偏差隨著小尺寸係數之增加而非線性的增加，且隨著流體速度的增加而增加。並且，小尺寸係數對於雙層壁奈米碳管之位移振幅的平均值，標準偏差及變化係數(COV)有顯著之影響。

(三). 與會心得

個人發表的論文題目為: “以隨機有限單元法研究含有流體及受到移動外力之雙層壁奈米碳管之非線性振動(Stochastic FEM on nonlinear vibration of fluid-conveying double-walled carbon nanotubes subjected to a moving load) ”，個人除了發表自己的論文以外，並出席參加了許多演講。 此次發表的論文包羅萬象， 除了有振動方面之文章外，還有複雜系統的多功能分析、複合材料及結構之力學行為、塑性力學、計算及實驗力學、流體力學、微機電系統、醫學及生物之奈米工程、計算生物學及計算力學、智慧材料、計算固體力學及奈米力學、奈米材料等等。 因此，本人於短短幾天之間，知道很多不同領域方面的研究新方向，覺得獲益不少。 另外幾位演講學者的演講非常精彩，內容均是較新的研究題材及領域，可啟發聽眾的思考及創新性。

(四). 攜回資料名稱及內容

1. 大會議程。如附件 1。

(五). 與會建議

個人參加此會議已多次，以往大會多會給與會者論文集 (CD),每篇論文包括摘要或六頁重要論文結果。但今年大會並沒有給與會者論文集，個人已向大會建議之。

(六). 附件

1. 大會議程。
2. 個人發表的論文全文。

Technical Program: ICCES'13 Seattle, USA

May 24 - May 28, 2013, Seattle, USA

Theme Opening Ceremony — Date: May-24 — Room: P
Session P01: Opening Ceremony — Time: 11:00AM-12:30PM

Paper	Title	Author	Time	
ICCES1320130429338	Leadership Matters	John White	11:00AM-11:45AM	*plenary

Theme Advances in Materials Science and Engineering — Date: May-24 — Room: A
Session A01: Symposium in Honour of Dr. Vinod Tewary — Time: 8:00AM-10:30AM

Paper	Title	Author	Time	
ICCES1320130412300	Modeling of phonon transport in graphene with antidots for thermoelectric applications	V.K. Tewary	8:00AM-8:30AM	*award
ICCES1320130121104	Effect of in situ high magnetic field application on the growth of molecular-beam-vapor-deposited Ni45Fe55 nanocrystalline films	Guojian Li, Yongze Cao, Qiang Wang, Jiaojiao Du, Jicheng He	8:30AM-8:55AM	*keynote
ICCES1320130412298	Computational Modeling of Nanostructured Materials for Novel Energy Application	Ming Hu	8:55AM-9:13AM	
ICCES1320130226191	Raman Spectroscopy and Molecular Dynamics Simulation Studies of Carbon Nanotubes	Prabhakar Misra, Daniel Casimir and Raul Garcia-Sanchez	9:13AM-9:31AM	
ICCES1320130304217	Multilayer Graphene/Noble Metal Systems for Low - Loss Plasmonics Applications	L. Rast, T. J. Sullivan, and V. K. Tewary	9:31AM-9:49AM	
ICCES1320130328278	Laser induced local structural and property modification	Yong Zhang	9:49AM-10:14AM	*keynote
ICCES1320130508366	Atomic Origins of Plasticity in Crystalline and Amorphous Quasi-1D Nanostructures	Lisa Y. Chen, Mo-rigen He, Daniel J. Magagnosc, Kathryn F. Murphy, Daniel S. Gianola	10:14AM-10:32AM	

Theme Advances in Materials Science and Engineering — Date: May-24 — Room: A
Session A03: Metamaterials — Time: 1:30PM-3:30PM

Paper	Title	Author	Time
ICCES1320130207146	Recent Progress on LTCC-Based Super-Compact Multilayer Composite Right/Left-Handed Transmission Lines	Yasushi Horii	1:30PM-1:55PM
ICCES1320130216166	Enhanced Bandwidth of a Slotted Mushroom Zeroth-Order Resonator Antenna based on Metamaterials	Cheri-Hee Lee, Jonghun Lee, Dong-Sik Woo, Kang-Wook Kim	1:55PM-2:20PM
ICCES1320130301212	Holographic Metasurfaces	Patrice Genevet, Jiao Lin, Federico Capasso	2:20PM-2:45PM
ICCES1320130218170	Theory and Design of Artificial-Impedance-Surface Antennas	D.J. Gregoire and J.S. Colburn	2:45PM-3:10PM
ICCES1320130305228	Metamaterials with Quantum Gain	Kosmas L. tsakmakidis and Ortwin Hess	3:10PM-3:35PM

Theme Advances in Materials Science and Engineering — Date: May-24 — Room: A
Session A04: Metamaterials — Time: 4:00PM-6:30PM

Paper	Title	Author	Time	
ICCES1320130215163	Building Blocks in Photonic Metamaterials and Their Application for Subwavelength Optical Devices	Masanobu Iwanaga	4:00PM-4:25PM	
ICCES1320130226193	Quantitative Metamaterial Property Extraction	D. Schurig	4:25PM-4:50PM	*keynote
ICCES1320130224184	Optical Hyperspace: light propagation and related phenomena in metamaterials with hyperbolic dispersion	E. E. Narimanov	4:50PM-5:15PM	
ICCES1320130227200	Radiation pressure on nanostructured optical materials	Jeremy N. Munday	5:15PM-5:40PM	
ICCES1320130213152	Metamaterial Based Spatial Light Modulators for THz Imaging	Claire M. Watts, David Shrekenhamer, Willie J. Padilla	5:40PM-5:58PM	
ICCES1320130313246	Plasmonic switching using an electromagnetically induced transparency feature	B. S. Ham	5:58PM-6:23PM	

Theme Advances in Materials Science and Engineering — Date: May-25 — Room: A
Session A05: Metamaterials — Time: 8:00AM-10:00AM

Paper	Title	Author	Time

ICCES1320130406291	Emerging Trends in Metamaterials and Plasmonics	David R. Smith	8:00AM-8:40AM	*theme
ICCES1320130214158	Temporal Control of Terahertz Waves with Metamaterials	F. Miyamaru	8:40AM-9:05AM	
ICCES1320130224181	A physical modeling explaining the giant plasmonic enhancement difference between fluorescence, resonance and non-resonance Raman scattering	Greg Sun	9:05AM-9:30AM	
ICCES1320130215164	Routing of deep-subwavelength optical beams without reflection and diffraction using infinitely anisotropic metamaterials	Peter B. Catrysse and Shanhui Fan	9:30AM-9:55AM	

Theme	**Multidisciplinary Analysis & Synthesis of Complex Systems**		**Date: May-25**	**Room: A**
Session	**A06: Calculations and Experiments for Petroleum Engineering (Materials)**		**Time: 10:30AM-12:30PM**	
Paper	**Title**	**Author**	**Time**	
ICCES1320130119073	Adaptability Evaluation of Coal-bed Methane Well Completion Methods based on Multi-objective Decision-making Method	Gang Yang, Zhiming Wang	10:30AM-10:48AM	
ICCES1320130411297	A novel temperature-resistant and salt-tolerant surfactant for enhanced oil recovery	Jixiang Guo,Xiao Shi, Jingjing Cao, Wenming Wu, Lei Wang	10:48AM-11:06AM	
ICCES1320130204136	Permeation Mechanism and Optimal Design Method of fishbone well pattern for oil production	Shao-hua Gu, Yue-tian Liu, Long-yu Han, Cheng-xia Wu	11:06AM-11:31AM	*keynote
ICCES1320130120081	Pulsed Power for Magnetic Induction Communication	Di Niu , Kai Shuang, Weigen Li	11:31AM-11:49AM	
ICCES1320130120079	Feasibility Research of Steam-Assisted-Gravity-Drainage Process in Bohai Offshore Heavy Oil Reservoirs	Xiaohu Dong, Huiqing Liu, Xiaohong Liu, Zhennan Gao	11:49AM-12:07PM	
ICCES1320130119074	Comparative Study on Passive Inflow Control Devices by Numerical Simulation	Quanshu Zeng, Zhiming Wang	12:07PM-12:25PM	

Theme	**Solid Mechanics**		**Date: May-25**	**Room: A**
Session	**A07: Symposium in Honour of Prof. Wen-Hwa Chen (Materials)**		**Time: 1:30PM-3:30PM**	
Paper	**Title**	**Author**	**Time**	
ICCES1320121224024	Tensile Creep Study and Mechanical Properties of Carbon Fiber Nano-Composites	Yi-Luen Li, Wei-Jen Chen, Chin-Lung Chiang, Ming-Chuen Yip	1:30PM-1:55PM	*keynote
ICCES1320121214019	Correspondence Relations for Fracture Parameters of Interface Corners in Anisotropic Viscoelastic Materials	Chyanbin Hwu, Tai-Liang Kuo	1:55PM-2:13PM	
ICCES1320121224026	Solutions of a Crack Interacting with Tri-Material Composite in Plane Elasticity	C.K. Chao and A. Wikarta	2:13PM-2:38PM	*keynote
ICCES1320121226027	Development of the coupled IEM/FEM algorithm for Mindlin–Reissner plate theory applied on bending plate containing through-thickness holes	De-Shin Liu, Chin-Yi Tu, Cho-Liang Chung	2:38PM-2:56PM	
ICCES1320121230043	Combination of Finite Element Analysis with Accelerated Life Testing in Studying the Reliability of Electronic Packaging	Wen-Fang Wu, Si-Lih Chen and Po-Lun Chou	2:56PM-3:14PM	

Theme	**Advances in Materials Science and Engineering**		**Date: May-25**	**Room: A**
Session	**A08A: Metamaterials**		**Time: 4:00PM-5:15PM**	
Paper	**Title**	**Author**	**Time**	
ICCES1320130305224	Computational Modeling of Metamaterials: Complex Building Blocks and Large Area	Hossein Mosallaei	4:00PM-4:18PM	
ICCES1320130210149	Perfect invisibility using negative refractive index metamaterials	Tomoshiro Ochiai	4:18PM-4:43PM	
ICCES1320130224180	Active Metamaterials for Modulators and Detectors	Sameer Sonkusale	4:43PM-5:08PM	

Theme	**Advances in Materials Science and Engineering**		**Date: May-25**	**Room: A**
Session	**A08B: Symposium in Honour of Dr. Vinod Tewary**		**Time: 5:15PM-6:30PM**	
Paper	**Title**	**Author**	**Time**	
ICCES1320130122109	3D Architectures of Carbon Nanostructured Materials	Yung Joon Jung	5:15PM-5:33PM	
ICCES1320130123116	Effects of high magnetic field and post-annealing on the evaporated Ni/Si (100) thin films	Jiaojiao Du, Guojian Li, Qiang Wang, Yongze Cao, Yonghui Ma, Jicheng He	5:33PM-5:51PM	

ICCES1320130418306	Electronic properties of III-V quantum dots via effective mass and linear scaling tight-binding models	Harley T. Johnson and Brian McGuigan	5:51PM-6:16PM	*keynote

Theme	Advances in Materials Science and Engineering		Date: May-27	Room: A
Session	A09: Symposium in Honour of Dr. Vinod Tewary		Time: 8:00AM-9:10AM	
Paper	**Title**	**Author**	**Time**	
ICCES1320130325271	Real-Time "Health" Monitoring of Structures & Components with Advanced NDE, Multi-Scale Modeling, & Modern Statistics	Jeffrey T. Fong, James J. Filliben, N. Alan Heckert, and William F. Guthrie	8:00AM-8:25AM	*keynote
ICCES1320130408294	Interactions of same-row vacancies on rutile TiO2(110)	Cristian V. Ciobanu	8:25AM-8:50AM	*keynote
ICCES1320130416304	Recent Progress on Synthesis and Characterization of Boron-based One-Dimensional Nanostructures	Terry Xu	8:50AM-9:08AM	

Theme	Advances in Materials Science and Engineering		Date: May-27	Room: A
Session	A10: Metamaterials		Time: 9:15AM-12:30PM	
Paper	**Title**	**Author**	**Time**	
ICCES1320130227199	Collective response of metamaterial arrays	Stewart Jenkins and Janne Ruostekoski	9:15AM-9:40AM	
ICCES1320130216165	Liquid crystal based plasmonic metamaterials	T. Scharf, J. Dintinger, B.J. Tang, G. H. Mehl, X. Zeng, G. Ungar, S. Mühlig, T. Kienzler and C. Rockstuhl	9:40AM-10:05AM	*keynote
ICCES1320130224182	Gradient index optical cavities	Aaron J. Danner, Tomáš Tyc, Alireza Akbarzadeh	10:30AM-10:48AM	
ICCES1320130214159	Soft Computing for Terahertz Metamaterial Absorber Design for Biomedical Application	Balamati Choudhury, B. Thiruveni, Pavani Vijay Reddy, R. M. Jha	10:48AM-11:06AM	
ICCES1320130214157	EM Analysis of Metamaterial based Radar Absorbing Structure (RAS) with Dual-resonant Characteristics	Shiv Narayan , S. Latha, and R. M. Jha	11:06AM-11:24AM	
ICCES1320130215161	Chiral meta-molecule and meta-interface	Satoshi Tomita	11:24AM-11:49AM	

Theme	Solid Mechanics		Date: May-24	Room: B
Session	B01: Symposium in Honour of Prof. Wen-Hwa Chen		Time: 8:00AM-10:30AM	
Paper	**Title**	**Author**	**Time**	
ICCES1320130318262	Meshless Analysis for Three-dimensional Problems with Complicated Geometry and Extremely Large Deformation	Wen-Hwa Chen	8:00AM-8:40AM	*theme
ICCES1320121227028	Analysis with STL geometry	Ming-Hsiao Lee	8:40AM-8:58AM	
ICCES1320121228031	The design of a pneumatic wind energy collection and storage system	Dein Shaw, Yuan-Cheng Sun and Chien-Ting Liu	8:58AM-9:16AM	
ICCES1320121229041	The Mechanical Properties of Carbon Nanotubes Ropes Using Atomistic-Continuum Mechanics and the Equivalent Methods	C.J. Huang, T.Y. Hung and K.N. Chiang	9:16AM-9:41AM	*keynote
ICCES1320130101051	Studies on Nanomechanical Properties of Visco-Elastoplastic Material of Dragonfly Wing Membrane using Nanoindentation	K.Ting, C.H. Chang,J.S. Wu, K.T. Chen, C.H. Huang	9:41AM-9:59AM	
ICCES1320121210012	Image Processing Study on Monitoring Individual Drosophila	Yu-Ching Lin, Hung-Yin Tsai	9:59AM-10:17AM	
ICCES1320130313245	CAPACITIVELY CATENARY FEEDBACK CONTROL FOR OPEN-TYPE DIGITAL MICROFLUDICS	Yi-Chi Kung and Rongshun Chen	10:17AM-10:35AM	

Theme	Multidisciplinary Analysis & Synthesis of Complex Systems		Date: May-24	Room: B
Session	B03: Calculations and Experiments for Petroleum Engineering (Numerical Modelli		Time: 1:30PM-3:30PM	
Paper	**Title**	**Author**	**Time**	
ICCES1320130120077	A fast forward algorithm for LWD GR log response based on geological model and it's geosteering application	CaiRui Shao, XianJun Cao, FuMing Zhang, GuoXing Chen, JiaQi Ji, JianHong Tang	1:30PM-1:48PM	
ICCES1320130119075	Solution of Nonlinear seepage model for well group in fractured low-permeability reservoirs	Gu Jian-wei , Liu Yang , Zeng Qing-dong	1:48PM-2:06PM	

ICCES1320130121095	Analysis and design of coiled tubing drilling downhole instrument bus	Tao Liu , Kai Shuang, and Hongming Cai	2:06PM-2:24PM	
ICCES1320130123115	Study on the Four-Dimensional Heterogeneity Model of Non-Marine Sandstone Reservoir	Shaochun Yang, Yaru Wen, Guoning Chen, Ke Yan	2:24PM-2:42PM	
ICCES1320130123117	Helical Buckling Analysis of tubular with Friction in Horizontal Well	Fengwu Liu and Deli Gao	2:42PM-3:00PM	
ICCES1320130311236	Stress and Fractures Study in Tight Reservoir	Guangfeng Liu, Jianguo Wang, Hongjun Lu, Shunli He, Shuai Li, Guojia Cao	3:00PM-3:25PM	*keynote

Theme	Solid Mechanics		Date: May-24	Room: B
Session	B04: Symposium in Honour of Prof. Mich Nakagaki		Time: 4:00PM-6:30PM	
Paper	**Title**	**Author**	**Time**	
ICCES1320130121103	Three Dimensional Aspects of Weld Modeling and Crack Growth in Weld Residual Stress	Frederick W. Brust	4:00PM-4:18PM	
ICCES1320130217168	J and Interaction Integral Evaluations with Tetrahedral Finite Element –Revisiting the numerical algorithms –	Hiroshi Okada, Shogo Ohata and Ryutaro Daimon	4:18PM-4:36PM	
ICCES1320130225186	Adaptive meshfree method with nodal relocation for crack problems	Seiya Hagihara, Yutaka Hayama, Shinya Taketomi and Yuichi Tadano	4:36PM-4:54PM	
ICCES1320130318259	Concept of Inherent Deformation and a Practical Method to Predict Distortion Produced on Large Thin Plate Structures during Welding Assembly	H. Murakawa, Y. Okumoto, S. Rashed, M. Sano	4:54PM-5:12PM	
ICCES1320130418307	Multi-scale Simulation of Severe Plastic Deformation Process Using Marker Integration Eulerian Finite Element Method	Takahiro Yamada and Kazumi Matsui	5:12PM-5:30PM	
ICCES1320130506345	Advanced materials and composites, deformation and failure mechanisms, fatigue and fracture	Golam Newaz	5:30PM-5:48PM	

Theme	Advances in Materials Science and Engineering		Date: May-25	Room: B
Session	B05: Symposium in Honour of Dr. Vinod Tewary (Modeling & Simulation)		Time: 8:00AM-10:00AM	
Paper	**Title**	**Author**	**Time**	
ICCES1320130402285	Numerical Simulation of Nano-Structure Formation under Ion-beam Irradiation in Binary Materials	Efraín Hernández-Rivera and Veena Tikare	8:00AM-8:18AM	
ICCES1320130311239	Group for Simulation and Theory of Atomic-scale Material Phenomena	Moneesh Upmanyu	8:18AM-8:36AM	
ICCES1320130405289	Basal Dislocations and Kinking in Graphite	Bo Yang	8:36AM-8:54AM	
ICCES1320130408295	Modeling of Interfaces in Carbon Nanotube Reinforced Ceramic Nanocomposites	Zhenhai Xia	8:54AM-9:19AM	*keynote
ICCES1320130414302	Semiconductor Quantum Dots: From Atoms to Devices	R.S. Goldman	9:19AM-9:44AM	*keynote
ICCES1320130402286	GRAPHENE BASED NANOSTRUCTURES: ELECTRONIC PROPERTIES	Ravindra Pandey	9:44AM-10:02AM	

Theme	Multidisciplinary Analysis & Synthesis of Complex Systems		Date: May-25	Room: B
Session	B06: Calculations and Experiments for Petroleum Engineering (Numerical Modelli		Time: 10:30AM-12:30PM	
Paper	**Title**	**Author**	**Time**	
ICCES1320130121097	Fluid Potential Analysis in Reservoir Development – A new method for Remaining Oil Characterization	Xu Zhaohui, Xu Huaimin, Zheng Ke, Wei Qiren	10:30AM-10:48AM	
ICCES1320130226195	A New Method of Dynamic Reserve Estimation for Dual-Porosity Gas Reservoir with Horizontal Well	Leng Tian, Hao Ma, Shun-li He, Dai-hong Gu	10:48AM-11:06AM	
ICCES1320130121101	An Semi-Analytical Models to Investigate Performance of Herringbone Wells	Guoqing Han, Xiaodong Wu, He Zhang	11:06AM-11:31AM	*keynote
ICCES1320130124122	A New Solution Algorithm for Multi-Dimensional Reservoir Simulation	Boyun Guo	11:31AM-11:56AM	*keynote
ICCES1320130317255	A Productivity Prediction Model for the Complex Well with Formation Damage	Yongsheng An	11:56AM-12:14PM	

Theme	ICCES Meshless Method 2013	Date: May-25	Room: B
Session	B07: ICCESMM'13: on MLPG, Trefftz, MFS, BEM, and Other Meshless Methods	Time: 1:30PM-3:30PM	

Paper	Title	Author	Time	
ICCES1320130406290	A set-based dynamic eigenvalue analysis method using Kriging model and PSO algorithm	ZiChun Yang, WenCai Sun	1:30PM-1:55PM	*keynote
ICCES1320130228205	Recent works on numerical methods for fractional diffusion equations	HongGuang Sun	1:55PM-2:13PM	
ICCES1320130206145	A simple meshless LBIE-LRBF method for transient elastic problems	E.J. Sellountos, T. Gortsas, D. Polyzos	2:13PM-2:31PM	
ICCES1320130317256	Newly-developed finite elements for modeling functionally graded materials (FGM) in micro- and macro-scales	Peter L. Bishay, Satya N. Atluri	2:31PM-2:49PM	
ICCES1320130424319	Numerical solution of quenching problems using orthogonal trigonometric functions	Haiyan Tian	2:49PM-3:07PM	
ICCES1320130414303	Application of the Trefftz method on the Basis of Stroh Formalism to Inverse SHM Problem of Anisotropic Elasticity	Tao. Zhang and S.N. Atluri	3:07PM-3:25PM	

Theme ICCES Meshless Method 2013 — **Date: May-25** — **Room: B**
Session B08: ICCESMM'13: on MLPG, Trefftz, MFS, BEM, and Other Meshless Methods — **Time: 4:00PM-6:30PM**

Paper	Title	Author	Time	
ICCES1320121123002	A Study of the Cutting Temperature in Milling Stainless Steels with Chamfered Main Cutting Edge Sharp Worn Tools	Chung-Shin Chang	4:00PM-4:18PM	
ICCES1320130204137	Singular Boundary Method for Exterior Wave Problems	Zhuo-Jia Fu, Wen Chen	4:18PM-4:36PM	
ICCES1320130423314	Trefftz Voronoi Cells (TVC) for Micromechanical Modeling of Heterogeneous Materials	Leiting Dong and Satya N. Atluri	4:36PM-4:54PM	
ICCES1320130101053	Finite Element Solution of a Small Perturbation in Thermo-Elastic Instability Systems	Abdullah M. Al Shabibi	4:54PM-5:12PM	
ICCES1320121210013	The canonical reduction of four-dimensional self-dual Yang-Mills theory to equations which describe pseudo-spherical surfaces	S. M. Sayed	5:12PM-5:30PM	
ICCES1320121123003	Haar Wavelet Operational Matrix Method for Solving Fractional Partial Differential Equations	Yiming Chen, Mingxu Yi	5:30PM-5:48PM	
ICCES1320130223177	Fast Regularized Boundary Integral Method for Acoustic Problems	Z.Y. Qian, Z.D. Han, and S.N. Atluri	5:48PM-6:13PM	*keynote
ICCES1320130425331	Development of Multidisciplinary Optimization Framework using PSO algorithm and its applications	Kook Jin Park, Nitesh Kumar Karma, Hee Jin Kang and Seung Jo Kim	6:13PM-6:31PM	

Theme Solid Mechanics — **Date: May-27** — **Room: B**
Session B09: Comp. Fracture Mechanics; Structural Integrity & Health Monitoring — **Time: 8:00AM-10:00AM**

Paper	Title	Author	Time	
ICCES1320130122112	Structural Analysis of a Lab-Scale PCHE Prototype under the Test Conditions of the HELP	Keenam Song and S. D. Hong	8:00AM-8:18AM	
ICCES1320130224183	Particle-based method for dynamic propagation of cracks with energy balance consideration	Kenji Oguni and Masanori Kondo	8:18AM-8:43AM	*keynote
ICCES1320130225185	Non-Destructive Assessment of the Historic	Salah Amer	8:43AM-9:01AM	
ICCES1320130422311	Challenges in Predicting Wear Rate	Zhong-Sheng Liu, Cheng Haung, Liang Ma, Jimmy Jiang, Yongxong Xie, Rob Hui	9:01AM-9:19AM	

Theme ICCES Meshless Method 2013 — **Date: May-27** — **Room: B**
Session B10: ICCESMM'13: on MLPG, Trefftz, MFS, BEM, and Other Meshless Methods — **Time: 10:30AM-12:30PM**

Paper	Title	Author	Time	
ICCES1320130423312	SGBEM Voronoi Cells (SVC) for Micromechanical Modeling of Heterogeneous Materials	Leiting Dong and Satya N. Atluri	10:30AM-10:48AM	
ICCES1320130206144	A MESHLESS APPROACH FOR MODELLING OF THREE DIMENSIONAL MACROSEGREGATION IN CONTINUOUS CASTING OF STEEL	R. Vertnik, B. Sarler	10:48AM-11:06AM	

ICCES1320130102054	A Multi-scale Characteristic Time Expansion Method with the Natural Regularization Method for Restoring Force Identification	Yung-Wei Chen, Jiang-Ren Chang, Fu-Hsuan Hsieh, Che-Wei Chen	11:06AM-11:24AM	
ICCES1320130301211	Nonlinear dynamics of a multi-coupled system with multiple delays	Xiaochen Mao	11:24AM-11:42AM	
ICCES1320130325273	Solving 2D Shallow-Water Equations by Extrapolated Local Radial Basis Function Collocation Method	Ching-Kai Chou, Chia-Peng Sun, Der-Liang Young	11:42AM-12:00PM	

Theme	**ICCES Meshless Method 2013**		**Date: May-24**	**Room: C**
Session	**C01: ICCESMM'13: Advances in Sciences and Engineering**		**Time: 8:00AM-10:30AM**	
Paper	**Title**	**Author**	**Time**	
ICCES1320130323267	Quantitative NDE and Bayesian Fatigue Modeling: Key to Improving Reliability of Aging Structures and Components	Jeffrey T. Fong	8:00AM-8:40AM	*theme
ICCES1320130429335	Challenges of Biomechanics	Konstantin Volokh	8:40AM-9:20AM	*theme
ICCES1320130429337	Universal patterns in bone composition and microstructure: a multiscale engineering science approach	Christian Hellmich	9:20AM-10:00AM	*theme
ICCES1320130426332	Representation of vector-valued hemitropic functions of a symmetric tensor and a vector.	Ellis Harold Dill	10:00AM-10:30AM	*award

Theme	**ICCES Meshless Method 2013**		**Date: May-24**	**Room: C**
Session	**C03: ICCESMM'13: on MLPG, Trefftz, MFS, BEM, and Other Meshless Methods**		**Time: 1:30PM-3:30PM**	
Paper	**Title**	**Author**	**Time**	
ICCES1320130404288	The local Radial Basis Function Finite Collocation Method a not Generalized Finite Different Meshless Scheme for High-Convergence Solution of Boundary Value Problems	H. Power, D. Stevens and A. Cliffe	1:30PM-1:55PM	*keynote
ICCES1320130122108	Meshfree MLPG modeling of magnetotelluric data: a new modeling tool in numerical geophysics	Jan Wittke, Bülent Tezkan	1:55PM-2:13PM	
ICCES1320130428333	Meshless formulations for bending of thin plates with variable stiffness	V. Sladek, J. Sladek, L. Sator	2:13PM-2:38PM	*keynote
ICCES1320130211151	Application of different variants of the BEM in numerical modeling of bioheat transfer problems	Ewa Majchrzak	2:38PM-2:56PM	
ICCES1320130227198	Localized radial basis function solutions for calcium dynamics model in ventricular myocytes	Guangming Yao	2:56PM-3:14PM	
ICCES1320130326276	On solving the nonlinear backward heat conduction problem using the double iteration algorithm	Weichung Yeih, Jiang-Jhy Chang, Chen-Yu Ku and Chia-Min Fan	3:14PM-3:32PM	

Theme	**ICCES Meshless Method 2013**		**Date: May-24**	**Room: C**
Session	**C04: ICCESMM'13: on MLPG, Trefftz, MFS, BEM, and Other Meshless Methods**		**Time: 4:00PM-6:30PM**	
Paper	**Title**	**Author**	**Time**	
ICCES1320130218169	Modeling of porous piezoelectric structures by the MLPG	J. Sladek, V. Sladek, and E. Pan	4:00PM-4:25PM	*keynote
ICCES1320130502342	The MLPG methods based on the energy invariant principles for heterogeneous materials	Z.D. Han and S. N. Atluri	4:25PM-4:43PM	
ICCES1320130124123	Fast multipole singular boundary method for large-scale plane elasticity problems	Wenzhen Qu, Wen Chen	4:43PM-5:08PM	*keynote
ICCES1320130320263	Coupled BEM-MLPG acoustic analysis for non-homogeneous media	A. Tadeu, P. Stanak, J. Sladek, V. Sladek, ITeCons	5:08PM-5:33PM	*keynote
ICCES1320130424323	Fast Evaluation of the Method of Fundamental Solutions for Solving Reaction Diffusion and Wave Propagation Problems	C.S. Chen, Ji Lin, Wen Chen	5:33PM-5:58PM	*keynote
ICCES1320121228033	Computational modeling of the micro- and macroscopic behavior of multiphase composite and functionally graded materials	Sofia G Mogilevskaya, Steven L Crouch	5:58PM-6:23PM	*keynote

Theme	**Mechanics of Fluids, gases, and Fluid/MEMS**		**Date: May-25**	**Room: C**
Session	**C05: Comp. modeling of complex fluids, particle laden flow, & fluid struct Interact**		**Time: 8:00AM-10:48AM**	
Paper	**Title**	**Author**	**Time**	

ICCES1320130311237	Modeling and simulation of particle laden thin films	Andrea Bertozzi	8:00AM-8:25AM	*keynote
ICCES1320130304218	Conservation Laws for Particle Laden Thin Films	Aliki Mavromoustaki, Andrea L. Bertozzi	8:25AM-8:43AM	
ICCES1320121215020	Shock solutions for high concentration particle-laden thin films	Li Wang and Andrea L. Bertozzi	8:43AM-9:01AM	
ICCES1320121218022	Particle segregation in spiral channels	Sungyon Lee, Yvonne Stokes, Andrea Bertozzi	9:01AM-9:19AM	
ICCES1320130311241	A second order virtual node method for elliptic problems with interfaces and irregular domains in three dimensions	Joseph Teran	9:19AM-9:44AM	*keynote
ICCES1320121228034	Semi-implicit surface tension formulation with a Lagrangian surface mesh on an Eulerian simulation grid	Craig Schroeder, Wen Zheng, Ronald Fedkiw	9:44AM-10:02AM	
ICCES1320130311243	Energetically Consistent Invertible Elasticity	Alexey Stomakhin	10:30AM-10:48AM	

Theme	**ICCES Meshless Method 2013**		**Date: May-25**	**Room: C**
Session	**C06: ICCESMM'13: on MLPG, Trefftz, MFS, BEM, and Other Meshless Methods**		**Time: 10:48AM-12:30PM**	
Paper	**Title**	**Author**	**Time**	
ICCES1320121204009	Two formulations for a fast time domain BEM in elastodynamics	B. Kager, M. Schanz, T. Traub	10:48AM-11:13AM	*keynote
ICCES1320130423313	Fracture & Fatigue Analyses: SGBEM-FEM or XFEM?	Leiting Dong and Satya N. Atluri	11:13AM-11:38AM	*keynote
ICCES1320130228203	Meshless analysis of piezoelectric sensor embedded in composite floor panel	P. Stanak, A. Tadeu , J. Sladek , V. Sladek	11:38AM-11:56AM	
ICCES1320130324268	Solving convection-diffusion problems by local maximum entropy finite element method	C. T. Wu and D. L. Young	11:56AM-12:14PM	
ICCES1320130326274	Using the method of fundamental solutions for obtaining exponentially convergent Helmholtz eigensolutions	Chia-Cheng Tsai and D. L. Young	12:14PM-12:32PM	

Theme	**ICCES Meshless Method 2013**		**Date: May-25**	**Room: C**
Session	**C07: ICCESMM'13: on MLPG, Trefftz, MFS, BEM, and Other Meshless Methods**		**Time: 1:30PM-3:30PM**	
Paper	**Title**	**Author**	**Time**	
ICCES1320130213153	A Meshless Method for Calculating 3-D Windfields	D. W. Pepper and C. Rasmussen	1:30PM-1:55PM	*keynote
ICCES1320130324270	Analysis of Multi-dimensional Burgers Equations by Localized Method of Particular Solutions	D. L. Young, C. Y. Lin , M. H. Gu and C.S. Chen	1:55PM-2:20PM	*keynote
ICCES1320130205142	A MESHLESS APPROACH FOR SIMULATION OF STEEL BILLETS ROLLING	B. Sarler, U. Hanoglu	2:20PM-2:45PM	*keynote
ICCES1320130121106	A Scalar Homotopy Method with Optimal Hybrid Search Directions for Solving Nonlinear Algebraic Equations	Weichung Yeih, Cheng-Yu Ku, Chein-Shan Liu, I-Yao Chan	2:45PM-3:03PM	
ICCES1320130317252	The Relationship between Vacuum Residua Petro-Surfonate Stucture and Its EOR Property	Bo Peng, Shenke Li, Ke Hu	3:03PM-3:21PM	

Theme	**ICCES Meshless Method 2013**		**Date: May-25**	**Room: C**
Session	**C08: ICCESMM'13: on MLPG, Trefftz, MFS, BEM, and Other Meshless Methods**		**Time: 4:00PM-6:30PM**	
Paper	**Title**	**Author**	**Time**	
ICCES1320130102055	Group Preserving Scheme for Simulating Dynamic Ship Maneuvering Behaviors	Yung-Wei Chen, Jiang-Ren Chang, Wun-Sin Jhao, Juan-Chen Huang	4:00PM-4:18PM	
ICCES1320130215162	An adaptive homogenization-based quasi-discrete approach for modeling strain localizing heterogeneous materials	P.Z. Berke, R.H.J. Peerlings, T.J. Massart, M.G.D. Geers	4:18PM-4:36PM	
ICCES1320130328279	Generalized multipole method for solving multiple scattering problems with circular boundaries	Wei-Ming Lee	4:36PM-4:54PM	
ICCES1320130113059	A Fictitious Time Integration Method for Solving Two-Dimensional Groundwater Pollution Source Identification Problems	Chih-Wen Chang	4:54PM-5:12PM	
ICCES1320130320264	Simulation of sound-fields near three-dimensional thin screens using an iterative boundary element approach	J. António, António Tadeu	5:12PM-5:37PM	*keynote

ICCES1320130211150	Numerical modeling of skin tissue heating using the interval finite difference method	Bohdan Mochnacki, Alicja Piasecka-Belkhayat	5:37PM-5:55PM	
ICCES1320130517369	Novel Solution Methods for Nonlinear Structural Dynamics	Lt Col Matt Schnoor	5:55PM-6:13PM	

Theme ICCES Meshless Method 2013 — **Date: May-27** — **Room: C**
Session C09: Cell Method and Related Meshless Methods — **Time: 8:00AM-10:00AM**

Paper	Title	Author	Time	
ICCES1320130323266	Computational physics without starting from the differential equations	Enzo TONTI	8:00AM-8:40AM	*theme
ICCES1320121229040	Thermo-electromagnetic analysis of induction heating process	Fabio Freschi, Luca Giaccone, Maurizio Repetto	8:40AM-8:58AM	
ICCES1320130102056	Nonlinear thermo-elastostatic of an exhaust manifold	C. Delprete, M. Repetto, F. Freschi, C. Rosso	8:58AM-9:16AM	
ICCES1320130205141	A Cell Method Stress Analysis in Thin Floor Tiles Subjected to Temperature Variation	Elena Ferretti	9:16AM-9:41AM	*keynote
ICCES1320130305221	GDQFEM and Cell Method Numerical Simulations of Continuous Media with Cracks and Discontinuities	E. Viola, F. Tornabene, E. Ferretti, N. Fantuzzi	9:41AM-9:59AM	

Theme ICCES Meshless Method 2013 — **Date: May-27** — **Room: C**
Session C10: Cell Method and Related Meshless Methods — **Time: 10:30AM-12:30PM**

Paper	Title	Author	Time	
ICCES1320130305222	On Static Analysis of Composite Plane State Structures via GDQFEM and Cell Method	E. Viola, F. Tornabene, E. Ferretti, N. Fantuzzi	10:30AM-10:55AM	*keynote
ICCES1320130305223	Soft Core Plane State Structures Under Static Loads Using GDQFEM and Cell Method	E. Viola, F. Tornabene, E. Ferretti, N. Fantuzzi	10:55AM-11:13AM	
ICCES1320130401282	The Cell Method: Quadratic Interpolation with Tetrahedra for 3D Scalar Fields	Martino Pani, Fulvia Taddei	11:13AM-11:31AM	
ICCES1320130424318	A Radial Basis Function Based Meshless Approach with the Cell Method	Martino Pani, Fulvia Taddei	11:31AM-11:49AM	

Theme Multidisciplinary Analysis & Synthesis of Complex Systems — **Date: May-24** — **Room: D**
Session D01: Symposium in Honour of Prof. Hehua Zhu, Advances in GeoTech Engng — **Time: 8:00AM-10:30AM**

Paper	Title	Author	Time	
ICCES1320130429336	From Practice to Theory for Engineering Services	Hehua Zhu	8:00AM-8:30AM	*award
ICCES1320130228202	A 3D Extended Arlequin Method for Quasi-Brittle Dynamic Fracture	Mohammad Silani, Hossein Talebi, Timon Rabczuk	8:30AM-8:55AM	*keynote
ICCES1320130219171	Modelling the joint growth occurred at gentle slope in fractured rock using a meshless method	Xiaoying Zhuang, Hehua Zhu, Yaoji Li, Zhouquan Cui	8:55AM-9:13AM	
ICCES1320130227197	Application of Multi-Fractal and Kriging Interpolation Method For the Re-construction of Strata	Changhong Wang, Yiyan Xu, Hehua Zhu	9:13AM-9:31AM	
ICCES1320130226196	Analysis of ground surface settlement induced by the construction of a large-diameter shield-driven tunnel in Shanghai	Xiongyao Xie, Yubing Yang, Mei Ji	9:31AM-9:56AM	*keynote
ICCES1320130329281	Long-term water seepage monitoring methods in shield tunnel	Shufei Cheng, Hongwei Huang	9:56AM-10:14AM	
ICCES1320121231047	A conceptual framework for structural health monitoring of shield tunnel structure	Y. Lu, H.H. Zhu, X.Y. Zhuang	10:14AM-10:39AM	*keynote

Theme Multidisciplinary Analysis & Synthesis of Complex Systems — **Date: May-24** — **Room: D**
Session D03: Symposium in Honour of Prof. APS Selvadurai — **Time: 1:30PM-3:30PM**

Paper	Title	Author	Time	
ICCES1320130213154	Contact and Inclusion Probblems in Biot Poromechanics	A.P.S. Selvadurai	1:30PM-2:00PM	*award
ICCES1320130120084	Statics and dynamics of Reissner thin plates with embedded fibres resistant in bending	K.P. Soldatos and A.F. Farhat	2:00PM-2:18PM	
ICCES1320130121107	A level set-based microstructure generator for the computational homogenisation of complex heterogeneous materials	B. Sonon, B. Francois, T.J. Massart	2:18PM-2:43PM	*keynote
ICCES1320130127126	On Cause of Wenchuan Earthquake with Gas Expansion and Migration along Crust Fault	Quentin Z. Q. Yue	2:43PM-3:01PM	
ICCES1320121207010	Self-Regularized BEM for Three-Dimensional Elastostatics	M.G. He and C.L. Tan	3:01PM-3:26PM	*keynote

Theme	**Solid Mechanics**		**Date: May-24**	**Room: D**
Session	**D04: Symposium in Honour of Prof. Wen-Hwa Chen**		**Time: 3:30PM-6:30PM**	
Paper	**Title**	**Author**	**Time**	
ICCES1320121224025	Design and Development of Electromagnetic-type Shock Wave Generation in Liquids	Shen-Min Liang, Ashraful Islam, Wei-Cheng Huang	3:30PM-3:48PM	
ICCES1320121228038	Vibration Analysis for Pizoelectric Thick Plate Based on Mindlin Theory	Yi-Chuang Wu and Chien-Ching Ma	4:00PM-4:25PM	*keynote
ICCES1320130120089	Dynamic Instability of Rectangular Composite Plates under Parametric Excitation	Meng-Kao Yeh, Chia-Shien Liu, Chien-Chang Chen	4:25PM-4:43PM	
ICCES1320121228037	Fracture Behaviors and Low Temperature Thermal-Mechanical Properties of Graphene Sheet Using a Modified Nosé-Hoover Thermostat	Hsien-Chie Cheng, Ching-FengYu, Kun-Ling Chen and Wen-Hwa Chen	4:43PM-5:01PM	

Theme	**Mechanics of Fluids, gases, and Fluid/MEMS**		**Date: May-25**	**Room: D**
Session	**D05: Comp. Fluid/Electromagnetic Dynamics and Parallel Computing**		**Time: 8:00AM-10:00AM**	
Paper	**Title**	**Author**	**Time**	
ICCES1320130117062	Three-dimensional Fluid Flow Simulations Using GPU-based Particle Method	K. Kakuda, T. Nagashima, Y. Hayashi, S. Obara, J. Toyotani, S. Miura, N. Katsurada, S. Higuchi and S. Matsuda	8:00AM-8:18AM	
ICCES1320130305219	Liquid metal turbulent duct flows in a magnetohydrodynamic power generator	Hiromichi Kobayashi and Yoshihiro Okuno	8:18AM-8:36AM	
ICCES1320130317253	GPU Accelerated Fluid Simulation with Implicit Surface Obstacles	S. Nakata, Y. Sakamoto	8:36AM-8:54AM	
ICCES1320130422310	Fast Implementation of Meshless Time Domain Method for Electromagnetic Wave Propagation Simulation in Complex Shaped Domain	Taku Itoh, Yoshihisa Fujita, and Soichiro Ikuno	8:54AM-9:12AM	
ICCES1320130424316	A Proposal of Hierarchical Decision Making Mechanism for Externally Expandable Game AI and its Effectiveness on Multi-core Environment	Yuki SHIHO, Kensuke KURAMOTO, Masakazu FURUICHI	9:12AM-9:30AM	
ICCES1320130430340	Finite Rotation Transient FE Simulation and Vibration Control of Smart Structures	M.N. Rao, R. Schmidt	9:30AM-9:48AM	

Theme	**Solid Mechanics**		**Date: May-25**	**Room: D**
Session	**D06: Symposium in Honour of Prof. Wen-Hwa Chen (Dynamics)**		**Time: 10:30AM-12:30PM**	
Paper	**Title**	**Author**	**Time**	
ICCES1320130217167	Stochastic FEM on nonlinear vibration of fluid-conveying double-walled carbon nanotubes subjected to a moving load	Tai-Ping Chang	10:30AM-10:48AM	
ICCES1320121211017	A GL(n,R) Differential Algebraic Equation Method for Numerical Differential of Noisy Signal	Chein-Shan Liu	10:48AM-11:06AM	
ICCES1320121220023	Dynamic stress intensity factors of collinear cracks under a uniform tensile stress wave	Shih-Ming Huang and Kuang-Chong Wu	11:06AM-11:31AM	*keynote
ICCES1320121228036	Process-dependent Thermal-Mechanical Behaviors of an Advanced Thin-Flip-Chip-on-Flex Technology with Anisotropic Conductive Adhesive Joints	Hsien-Chie Cheng , Ching-Feng Yu, Su-Tsai Lu and Wen-Hwa Chen	11:31AM-11:49AM	
ICCES1320130114060	BEM Analysis of Heat Conduction in 3D Thin Anisotropic Media	Y.C. Shiah and Wang Chi-Chang	11:49AM-12:07PM	

Theme	**Advances in Materials Science and Engineering**		**Date: May-25**	**Room: D**
Session	**D07: Mechanics of Composite Materials and Structures**		**Time: 1:30PM-3:30PM**	
Paper	**Title**	**Author**	**Time**	
ICCES1320130124118	Computer Modeling SiC/SiC Composites	E. Schnack, Y. Zhu	1:30PM-1:48PM	
ICCES1320130130130	Reliability analysis and optimal design of a composite structure under gust loads	Tae-Uk Kim	1:48PM-2:06PM	
ICCES1320130214160	Development of High Performance Temperature Sensors Made from Carbon Nanotube/Polymer Nanocomposites	Alamusi and Ning Hu	2:06PM-2:24PM	
ICCES1320130425330	Local buckling analysis of composite box-type of beams used in timber building structures	S.R. Atashipour, U.A. Girhammar	2:24PM-2:42PM	

Theme Session Paper	Multidisciplinary Analysis & Synthesis of Complex Systems D08: Symposium in Honour of Prof. Hehua Zhu, Advances in GeoTech Engng Title	 Author	Date: May-25 Time: 4:00PM-6:30PM Time	Room: D
ICCES1320121227029	Influence Analysis of a Metro Shield Tunnel that Underpasses an Underground Passage	Wei Fu	4:00PM-4:18PM	
ICCES1320130429334	Experimental study and numerical simulation on failure process of concrete segmental lining longitudinal joints	Xiaojun Li, Haiping Xia, Hehua Zhu	4:18PM-4:43PM	*keynote
ICCES1320130222176	Study on train vibration response and cumulative deformation of double arch tunnel in Kast foundation	Ming-feng Lei, Li-min Peng, Cheng-hua Shi	4:43PM-5:01PM	
ICCES1320130225188	Stability investigations around a cross harbor tunnel by a morphological visualization method	Z.X. Zhang, J. Wu,Q.H. Lei and C. Liu	5:01PM-5:19PM	
ICCES1320130227201	A dual random two-scale model for estimating the thermal expansion coefficient of early-age concrete	Shu Liu, Xian Liu	5:19PM-5:37PM	

Theme Session Paper	Multidisciplinary Analysis & Synthesis of Complex Systems D09: Symposium in Honour of Prof. APS Selvadural (Multiphysics Modeling) Title	 Author	Date: May-27 Time: 8:00AM-10:00AM Time	Room: D
ICCES1320130205138	Consolidation of compressible fluid in deep crust	Y. Ichikawa, K. Kawamura, K. Kimoto	8:00AM-8:25AM	*keynote
ICCES1320130205143	Constitutive modeling of saturated clays exhibiting both creep and swelling	Jianhua YIN	8:25AM-8:43AM	
ICCES1320130127125	Dynamic response of borehole in poroelastic medium with disturbed zone	W Kaewjuea, T Senjuntichai and RKND Rajapakse	8:43AM-9:08AM	*keynote
ICCES1320130305225	TRANSIENT RESPONSE OF RIGID FOUNDATIONS EMBEDDED IN TRANSVERSELY ISOTROPIC MEDIA THROUGH AN ITERATIVE DYNAMIC COUPLING SCHEME	J. Labaki, D. A. Damasceno and E. Mesquita	9:08AM-9:26AM	

Theme Session Paper	Multidisciplinary Analysis & Synthesis of Complex Systems D10: Image Processing and Analysis Title	 Author	Date: May-27 Time: 10:30AM-12:30PM Time	Room: D
ICCES1320130101052	Thermo-Mechanical Analysis of Restored Molar Tooth using Finite Element Analysis	R.V.uddanwadiker	10:30AM-10:55AM	*keynote
ICCES1320130208147	Intelligent feedback for robot navigation using NN-methods for electromechanical transmission control	X. M. Garcia-Cruz , O. Yu. Sergiyenko, J.I. Nieto-Hipolito, M. Rivas-Lopez, D. Hernandez-Balbuena, Felix F. Gonzalez-Navarro, L.C. Basaca, J.C. Rodriguez, V.V. Tyrsa, A. Gurko	10:55AM-11:13AM	
ICCES1320130220172	2D-to-3D extension of clinical mandible radiographs, based on X-ray physics of composites	Stefan Scheiner, Christian Hellmich, Christoph Mueller, Cornelia Kober	11:13AM-11:38AM	*keynote
ICCES1320121126007	THE EFFECT OF REGION SEGMENTATION ON OBJECT CATEGORIZATION	Chih-Fong Tsai, Zong-Yao Chen, and Jui-Sheng Chou	11:38AM-11:56AM	
ICCES1320130221174	THE ALGORITHM OF THE ENCIRCLING THERMOGRAMS CREATION IN DIAGNOSTIC SYSTEM SUPPORTING THE WOUNDS HEALING PROCESS	Miroslaw Dziewonski, Mariusz Ciesielski, Sebastian Freus	11:56AM-12:14PM	

Theme Session Paper	Multidisciplinary Analysis & Synthesis of Complex Systems E01: Calculations and Experiments for Petroleum Engineering (Multiphysics) Title	 Author	Date: May-24 Time: 8:00AM-10:30AM Time	Room: E
ICCES1320130120094	Some Advances in Modeling & Simulation for Design and Control in Critical Well Engineering	Deli Gao, Boyun Guo	8:00AM-8:40AM	*theme
ICCES1320130307231	The balanced inflow mechanism and water control technology of horizontal wells	Wu Xiaodong, Wang Yining, Wang Ruihe, Han Guoqing, An Yongsheng	8:40AM-9:05AM	*keynote
ICCES1320130118063	Investigation on nitrogen foam assisted steam flooding with sand production	Yongge Liu, Huiqing Liu, Qing Wang, Zhanxi Pang	9:05AM-9:30AM	*keynote

ICCES1320130307232	Research and application of improving the range of horizontal well steam injection heating	Yining Wang, Xiaodong Wu, Ruihe Wang, Rong Chen, Han Wu	9:30AM-9:48AM	
ICCES1320130122110	Research on influence rules of pore structure on water & polymer flooding using Micro-model	Yuan Ying-jie,Hou Ji-rui,Zhao Feng-lan,Yu Chun-sheng,Zhang Feng-min	9:48AM-10:13AM	*keynote
ICCES1320130312244	Detailed molecular characterization of heavy alkyl benzene sulfonate used for chemical flooding	Gang Liu, Jirui Hou, Fenglan Zhao, Mingyuan Li, Chenyu Wu, Fenggang Wang, Hongda Hao	10:13AM-10:31AM	

Theme Session Paper	Solid Mechanics E03: Symposium in Honour of Prof. In Lee Title	Author	Date: May-24 Time: 1:30PM-3:30PM Time	Room: E
ICCES1320130421309	Aeroelastic Analysis of a Horizontal Axis Wind Turbine Blade and its Structural Monitoring using Fiber Bragg Grating Sensors	In Lee	1:30PM-2:00PM	*award
ICCES1320121228030	Experimental flutter suppression: Wind tunnel testing	Jae-Hung Han, Jong-Won Lee, and Juho Lee	2:00PM-2:18PM	
ICCES1320121228032	Dynamic Stability Enhancement of Thin Rotating Disks by Rim Reinforcement	Kyo-Nam Koo	2:18PM-2:36PM	
ICCES1320130101048	Development of piezoelectric transducers for structural vibration monitoring and control	Lae-Hyong Kang, and Jung-Ryul Lee	2:36PM-3:01PM	*keynote
ICCES1320130101049	Nonlinear Aeroelastic Characteristics of an Aircraft wing and Missile Control Fin	Jae-Sung Bae, In Lee, Seung-Kil Paek, and Sooyong Lee	3:01PM-3:26PM	*keynote

Theme Session Paper	Multidisciplinary Analysis & Synthesis of Complex Systems E04: Calculations and Experiments for Petroleum Engineering (Multiphysics) Title	Author	Date: May-24 Time: 4:00PM-6:30PM Time	Room: E
ICCES1320130205139	The Model Design of Turbine Blade in Oil & Gas Drilling	Chunfei Tan, Baoshan Guo	4:00PM-4:18PM	
ICCES1320130120076	Study of LWD data visual interpretation and geo-steering technology in real time	SHAO CaiRui, ZHANG FuMing, CHEN GuoXing, TANG HaiQuan, Cao XianJun	4:18PM-4:43PM	*keynote
ICCES1320130308233	Quantitative Identification and 3D Modeling for Interlayer in Delta Reservoir	Yaru Wen, Shaochun Yang, Yan Wang	4:43PM-5:01PM	
ICCES1320130304216	Permeation Mechanism and Optimal Design Method	Shao-hua Gu, Yue-tian Liu, Long-yu Han, Cheng-xia Wu	5:01PM-5:19PM	
ICCES1320130318257	Complex Formulation and Evaluation of Viscosity Reducer for Heavy Oil	Bo Peng, Shengke Li, Ying Li	5:19PM-5:37PM	

Theme Session Paper	Multidisciplinary Analysis & Synthesis of Complex Systems E05: Multiphysics Modeling and Its Applications Title	Author	Date: May-25 Time: 8:00AM-10:00AM Time	Room: E
ICCES1320121210014	Numerical Analysis on Interaction between Two Zipped Wells with Continuum Damage Method	Xinpu Shen	8:00AM-8:25AM	*keynote
ICCES1320130116061	An Efficient Method for Greening the Internet with Topology Optimization	Shijia Zhu, Yujing Zeng, Fei Song, Hongke Zhang	8:25AM-8:50AM	*keynote
ICCES1320121204008	Hydraulic Fracture Propagation in Unconventional Reservoirs:The Role of Bedding Plane	Suling Wang,Yang Li,He Liu,Minzheng Jiang	8:50AM-9:08AM	
ICCES1320121208011	A New Method to Achieve Equivalent Plastic Strain Explicit Form of J2 plastic Isotropic Kinematic hardening model and Numerical Verification	Peng Cao, Decheng Feng, Changjun zhou	9:08AM-9:26AM	
ICCES1320121211015	Analysis on Building Foundation Pit Supporting Engineering Accidents	Han Zhang	9:26AM-9:44AM	
ICCES1320121211016	ABAQUS-based Analysis of Settlement Induced by Tunnel Construction	Hong Yang	9:44AM-10:02AM	

Theme	Advances In Materials Science and Engineering		Date: May-25	Room: E
Session	E06: Modeling of Mechanical Behaviour of Materials		Time: 10:30AM-12:30PM	
Paper	Title	Author	Time	
ICCES1320130409296	FATIGUE CRACK TRANSMISSION THROUGH GRAIN BOUNDARIES IN FCC CRYSTALS: A 3D Dislocation Dynamics Analysis	C. Robertson, G.V. Prasad Reddy, C. Déprés	10:30AM-10:55AM	*keynote
ICCES1320130131133	Deformation mechanisms of single-crystalline Cu nanowires under bending and torsion	Xia Tian , Junzhi Cui and Wen Chen	10:55AM-11:13AM	
ICCES1320130329280	Molecular Dynamic Simulation Study-Polytetrafluoroethylene	Rawan Al Nsour	11:13AM-11:31AM	
ICCES1320130424317	A multiscale poromicromechanical approach to wave propagation and attenuation in bone	Claire Morin and Christian Hellmich	11:31AM-11:56AM	*keynote
ICCES1320130425325	Identification of parameters of a nonlinear material model considering the effects of viscoelasticity and damage	Jan Heczko, Radek Kottner, Tomáš Kroupa	11:56AM-12:21PM	*keynote

Theme	Multidisciplinary Analysis & Synthesis of Complex Systems		Date: May-25	Room: E
Session	E07: Symposium in Honour of Prof. Hehua Zhu, Advances in GeoTech Engng (Mu		Time: 1:30PM-3:30PM	
Paper	Title	Author	Time	
ICCES1320130301214	Characterization and modeling of the multiscale pore structures for porous materials	Xiaofei Guan, Xian Liu	1:30PM-1:48PM	
ICCES1320130225190	Application of the Numerical Slip Line Method in the Slope Stability Analysis	Jie Wu, Wenbo Zheng, Yongchang Cai	1:48PM-2:06PM	
ICCES1320130305229	A PGV-based empirical model for predicting liquefaction-induced lateral deformation in gently sloping ground	Fang LIU, Ming-jing JIANG, Zhen LI	2:06PM-2:24PM	
ICCES1320130225187	Mechanical Properties of Innovative Pothole Patching Materials Featuring High Toughness, Low Viscosity Nano-Molecular Resins	K.Y. Yuan, J.W. Ju, W. Yuan, J.M. Yang, W. Kao, and L. Carlson	2:24PM-2:49PM	*keynote
ICCES1320130306230	Axial and Lateral Behaviors of Open-ended Pipe Piles in Thick Soft Soil Deposits	Yong Tan, Guoming Lin, Fangle Peng, and Shaoming Liao	2:49PM-3:14PM	*keynote

Theme	Solid Mechanics		Date: May-25	Room: E
Session	E08: Symposium in Honour of Prof. In Lee		Time: 4:00PM-6:30PM	
Paper	Title	Author	Time	
ICCES1320130101050	Analytic and Experimental Studies on Aerodynamic Characteristics of Morphing Airfoil Configurations	Seung-Hee Ko, Jae-Sung Bae, Jai-Hyuk Hwang, JinHo Roh and Kyonam Koo	4:00PM-4:18PM	
ICCES1320130103057	Shape Memory Alloys as Active Materials for Aerospace Applications	Jin-Ho Roh	4:18PM-4:36PM	
ICCES1320130107058	Development of Long-Endurance UAV Using Solar Power	Il-young Ahn, Yong-Man Yang, Soo-Yong Lee, Sang-Hyuk Park, Jae-Sung Bae, Jae-su Kwak	4:36PM-4:54PM	
ICCES1320130401283	Design of the morphing wing actuated by shape memory alloy actuator	Misun Rim, Eun-Ho Kim, Woo-Ram Kang, In Lee	4:54PM-5:12PM	
ICCES1320121231045	Separation Characteristics of Ridge-Cut Explosive Bolts with Confinement Condition	Juho Lee, Jae-Hung Han, YeungJo Lee and Hyungjin Lee	5:12PM-5:30PM	
ICCES1320130402284	Graphene-Based Carbon Nanostructures and Their Applications	ILKWON OH	5:30PM-5:48PM	
ICCES1320130408292	A metal-coated optical fiber sensor with memory effects of a metal coating and its applications	Sang-Woo Kim, In Lee, Il-Bum Kwon, Tae-Kyung Hwang	5:48PM-6:06PM	
ICCES1320130425328	Estimation of Post-earthquake Structural Integrity using Structural Seismic Records	Ji-Young Seong, Byung-Cheol Park, Seong-Hoon Jeong	6:06PM-6:24PM	

Theme	Multidisciplinary Analysis & Synthesis of Complex Systems		Date: May-27	Room: E
Session	E09: Multiphysics Modeling and its Applications		Time: 8:00AM-10:00AM	
Paper	Title	Author	Time	
ICCES1320121213018	The Dynamic Response Analysis of Concrete Gravity Dam under the Earthquake	Lu Yang, Shi-Min Li, Peng Cao, Xin-Pu Shen	8:00AM-8:18AM	
ICCES1320130120082	Applications of finite differences on convex structured grids to CFD problems with low Reynolds number	F. Dominguez-Mota, P. Fernandez-Valdez, E. Ruiz-Diaz, G. Tinoco-Guerrero and J.G. Tinoco-Ruiz	8:18AM-8:36AM	

ICCES1320130203134	Modeling and simulation of the nonlinear computed torque control in Simulink/MATLAB for an industrial robot	Receanu Danut	8:36AM-9:01AM	*keynote
ICCES1320130204135	Active Control of a Reduced Model of a Smart Structure	Nader Ghareeb and Ruediger Schmidt	9:01AM-9:19AM	
ICCES1320130220173	Investigation of tissue thermal damage process with application of direct sensitivity method	Marek Jasinski	9:19AM-9:37AM	
ICCES1320130313247	Simulating ferroelectric switching phenomena using 3D multiphysics Voronoi cells (MVC) based on radial basis functions and Washspress coordinates	Peter L. Bishay, Satya N. Atluri	9:37AM-9:55AM	

Theme	**Multidisciplinary Analysis & Synthesis of Complex Systems**		**Date: May-27**	**Room: E**
Session	**E10: Symposium in Honour of Prof. APS Selvadurai (Multiphysics Modeling)**		**Time: 10:30AM-12:30PM**	
Paper	**Title**	**Author**	**Time**	
ICCES1320130129128	On the generalized modal analysis of time-dependent problems	Ney Augusto Dumont	10:30AM-10:55AM	*keynote
ICCES1320130130129	Coupled flow-deformation analysis of unsaturated soils including hydraulic and mechanical hystereses effects	Nasser Khalili	10:55AM-11:13AM	
ICCES1320130131132	An Arbitrary Shaped Inclusion with Imperfect Interface in Antiplane Elasticity	Les Sudak	11:13AM-11:31AM	
ICCES1320130205140	NON-SINGULAR METHOD OF FUNDAMENTAL SOLUTIONS FOR COUPLED FLUID AND SOLID MECHANICS PROBLEMS	B. Sarler, Q. Liu	11:31AM-11:49AM	

Theme	**Experimental Mechanics**		**Date: May-24**	**Room: F**
Session	**F01: Symposium in Honour of Prof. Daniel Post**		**Time: 8:00AM-10:30AM**	
Paper	**Title**	**Author**	**Time**	
ICCES1320130310235	Experimental Stress Analysis: Advances by Dan Post	Daniel Post	8:00AM-9:00AM	*theme
ICCES1320130328277	Photomechanics Methods as Applied to Microelectronics Product Development	B. Han	9:00AM-9:18AM	
ICCES1320130324269	Fringe Projection Assisted Horizontal Impact Testing	Dan Schleh and Dahsin Liu	9:18AM-9:36AM	
ICCES1320130316251	4D Cameras using grating projection method with LED light sources	Yoshiharu MORIMOTO, Akihiro MASAYA, Akifumi TAKAGI and Motoharu FUJIGAKI	9:36AM-9:54AM	
ICCES1320130315250	Moire Interferometry applied to curved surfaces and residual stress measurement in rails- a tribute to Dan Post with some personal reflection	Fu-pen Chiang	9:54AM-10:19AM	*keynote

Theme	**Multidisciplinary Analysis & Synthesis of Complex Systems**		**Date: May-24**	**Room: F**
Session	**F03: Symposium in Honour of Prof. Hehua Zhu, Advances in GeoTech Engng (Fra**		**Time: 1:30PM-2:30PM**	
Paper	**Title**	**Author**	**Time**	
ICCES1320130228204	A Multi-continuum Method for Studying the Effect of Inactive Fractures on Solute Transport in 2-D Discrete Fracture Network	Zhen Wang, Jonny Rutqvist, Ying Dai	1:30PM-1:48PM	
ICCES1320130228206	Damage detection of metro tunnel structure through transmissibility function	Lei FENG, Xiongyao XIE	1:48PM-2:06PM	
ICCES1320130118065	Soil-water-air full coupling analysis on slope failure in unsaturated soil	Y. L. Xiong, B. Ye, X. H. Bao and F. Zhang	2:06PM-2:31PM	*keynote

Theme	**Experimental Mechanics**		**Date: May-24**	**Room: F**
Session	**F04: Symposium in Honour of Prof. Daniel Post**		**Time: 2:45PM-6:30PM**	
Paper	**Title**	**Author**	**Time**	
ICCES1320130414301	Full-Field Recorded Displacements and their Derivatives	W. A. Samad, A. A. Khaja, D. R. Matthys and R. E. Rowlands	2:45PM-3:03PM	
ICCES1320130308234	Measurement of Facial Strains for Studying Wrinkle Formation	S. Yoneyama, S. Arikawa, M. Murakami, M. Koike and O. Tanno	3:03PM-3:21PM	
ICCES1320130412299	Using Moiré Interferometry to Measure Residual Stresses and Shrinkage	Peter Ifju	3:21PM-3:39PM	
ICCES1320130425326	Scaled Experimental Simulation of the 2002 Mw7.9 Denali Supershear Earthquake	Michael Mello, Harsha S. Bhat, Ares J. Rosakis	4:00PM-4:25PM	*keynote

ICCES1320130326275	On the Development of the Luminescent Photoelastic Coating Technique	James Paul Hubner	4:25PM-4:50PM	*keynote
ICCES1320130213155	Investigation of Microscale Damage Evolution in High-Strength Al Alloy	Helena Jin, Wei-Yang Lu, Alejandro Mota, Jay Foulk, George Johnson	4:50PM-5:08PM	
ICCES1320130120083	A Full-Field Digital Gradient Sensor for Measuring Orthogonal Stress Gradients in Transparent Sheets at Elevated Rates of Loading	Hareesh Tippur and Chandru Periasamy	5:08PM-5:26PM	
ICCES1320130314248	Thermally-Induced Deformations of Copper Pillar Flip Chip BGA Package: Measurements and Analyses	M. Y. Tsai, J. R. Jhou, P. S. Huang, C. Y. Wu, and K. M. Chen	5:26PM-5:44PM	
ICCES1320130124121	Some Recent Advances in Digital Image Correlation	Bing Pan	5:44PM-6:02PM	
Theme	**Experimental Mechanics**		**Date: May-25**	**Room: F**
Session	**F05: Advanced Modeling and Experiments of Complex Engineering Systems**		**Time: 8:00AM-10:00AM**	
Paper	**Title**	**Author**	**Time**	
ICCES1320130325272	Evaluation of reactivity of alkali activated fly ash/slag paste	Nam-Kon Lee, Haeng-Ki Lee	8:00AM-8:25AM	*keynote
ICCES1320130124120	Mathematical model for skeletal muscle to simulate the concentric and eccentric contraction	Chetan Kuthe , Dr.R.V.Uddanwadiker	8:25AM-8:43AM	
ICCES1320130228207	Nickel Plating Bath Contamination Optimization	James O. Moody, Robert Patrick McCarthy, Naira Malaquias	8:43AM-9:01AM	
ICCES1320130424315	Finite Element Coupled Peridynamic Simulation for Dynamic Fracture	J. Lee and J.W. Hong	9:01AM-9:26AM	*keynote
ICCES1320130301213	Structural Response of Composite Panels with a Bonded Patch Repair Using Full-Field Measurement	Sameer Hamoush, Kunigal Shivakumar and Ibraheem Kateeb	9:26AM-9:44AM	
ICCES1320130304215	Study of Biomechanical Response of Human Hand-Arm to Random Vibrations of Steering Wheel of Tractor	G. Geethanjali and C. Sujatha	9:44AM-10:02AM	
Theme	**Multidisciplinary Analysis & Synthesis of Complex Systems**		**Date: May-25**	**Room: F**
Session	**F06: Calculations and Experiments for Petroleum Engineering (Experimental Stuc**		**Time: 10:30AM-12:30PM**	
Paper	**Title**	**Author**	**Time**	
ICCES1320130119067	Experimental Study of Reasonable Drawdown Pressure of Horizontal Wells in Oil Reservoirs with Bottom Water	Chuan Lu, Huiqing Liu, Keqin Lu, Cheng Liu	10:30AM-10:48AM	
ICCES1320130119070	Experimental study on the deep profile control and oil displacement technology of nanoscale polymer microspheres	Zhao Hua, Meiqin Lin, Zhaoxia Dong, Zihao Yang, Mingyuan Li, Jie Yang, Xiuling Ji	10:48AM-11:06AM	
ICCES1320130119072	Experimental Evaluation of Water Control Agents in Low permeability Reservoir with Fractures	Fenglan Zhao, Jirui Hou, Shujun Cao	11:06AM-11:24AM	
ICCES1320130120080	New evaluation method of fracture permeability based on Stoneley wave data and electric imaging log in tight fractured sandstone reservoir	ZHANG fuming, SHAO Cairui, ZHENG Guangquan, WU Yongping, CHEN Weizhong	11:24AM-11:49AM	*keynote
ICCES1320130301210	Experimental study of chemical concentration and interfacial tension variation of ASP flooding	Gang Liu, Jirui Hou, Fenglan Zhao, Mingyuan Li, Chenyu Wu, Hongda Hao, Luming Zeng, Shaopeng Wang	11:49AM-12:07PM	
ICCES1320130318258	The Experiment Study on Different Chemical Flooding After Polymer Flooding	Yanyue Li, Yiqiang Li, Gang Xiang, Zhaoxia Dong	12:07PM-12:25PM	
Theme	**Experimental Mechanics**		**Date: May-25**	**Room: F**
Session	**F07: Advanced Modeling and Experiments of Complex Engineering Systems**		**Time: 1:30PM-4:20PM**	
Paper	**Title**	**Author**	**Time**	
ICCES1320130425329	Internal Shape Optimization of Rotor Blade Cross-Section Based on Automatic Modeling Program	Yeon Cheol Kang, Jin Yeon Cho, Jeong Ho Kim and Jung Sun Park	1:30PM-1:48PM	
ICCES1320130416305	Laser Ultrasonic Wavefield Imaging for Baseline-free Crack Detection in Plates with Structural Complexities	Y.-K. An and H. Sohn	1:48PM-2:13PM	*keynote

ICCES1320130420308	A study on the Site Effects using Earthquakes Data in the Korean Peninsula	K.J.PARK, J.K. KIM	2:13PM-2:31PM	
ICCES1320130424320	Feasibility of a new building-integrated wind turbine system utilizing building skin	Jeongsu Park, Hyung-Jo Jung, Seung-Woo Lee, Jiyoung Park	2:31PM-2:49PM	
ICCES1320130424321	Evaluation of Seismic Fragility Curves of Base Isolated Structures	Hyung-Jo Jung, Seung-Hyun Eem	2:49PM-3:14PM	*keynote
ICCES1320130408293	Effect of Bioclogging on P-wave Responses in unconsolidated porous media	Tae-Hyuk Kwon, Jonathan B. Ajo-Franklin	3:14PM-3:32PM	
ICCES1320130424322	Optimal sensor placement for the structure ground vibration test based on master modes selection methodology	Xufei He, Zhongmin Deng, Zhitao Song	4:00PM-4:18PM	

Theme Solid Mechanics — Date: May-27 — Room: F
Session F09: Symposium in Honour of Prof. Wen-Hwa Chen (Multiphysics) — Time: 8:00AM-10:00AM

Paper	Title	Author	Time
ICCES1320121228035	Flexible Stress Estimations of OLED Devices Packaging Using Analytical Solutions and Numerical Simulations of Stacking Thin-Films	Chang-Chun Lee	8:00AM-8:18AM
ICCES1320121229039	Modeling of Moisture Diffusion in Permeable Particle-Reinforced Epoxy Resins Using Three-Dimensional Heterogeneous Hybrid Moisture Element Method	D.S. Liu, I.H. Lin, Z.W. Zhuang, C.L. Chung	8:18AM-8:36AM
ICCES1320121230042	Effect of discrete electordes on deformation of double clamped beam electrostaic actuator	Meng-Ju Lin	8:36AM-8:54AM
ICCES1320121230044	Taiwan's Fuel Cell Backup Power System Demonstration Program	Chia-Mei Liu,Yi-li-Lin, Chao-Ho Lan,Fang-Hei Tsau, Sheng-Yuan Huang, Lih-Chyi Wen	8:54AM-9:12AM
ICCES1320130425324	Numerical Analysis on Dual Holes Interactions	Chich-Kuan Chen	9:12AM-9:30AM
ICCES1320130118064	C-reactive Protein detection by directly measuring nanobead's Brownian diffusion in evanescent wave field	Yu-Jui Fan, Zheng-Yu Chen, Yi-Hsing Liu, and Horn-Jiunn Sheen	9:30AM-9:48AM

Theme ICCES Meshless Method 2013 — Date: May-27 — Room: F
Session F10: ICCESMM'13: on MLPG, Trefftz, MFS, BEM, and Other Meshless Methods — Time: 10:30AM-12:30PM

Paper	Title	Author	Time
ICCES1320130120086	Efficient Meshless Solutions to multi-dimensional integral and partial differential equations	Edward Kansa	10:30AM-10:48AM
ICCES1320130131131	BUCKLING RESPONSE OF FUNCTIONALLY GRADED PLATE SUBJECTED TO VARIOUS TYPES OF THERMAL LOADS	MOKHTAR. BOUAZZA, F. HAMMADI, E.A. ADDA-BEDIA	10:48AM-11:06AM
ICCES1320121217021	Mathematical Modeling for Emulsification Droplet Region in Iron Bath Reactor with H2-C Mixture Reduction	ZHANG Bo, ZHANG Hual-Wei, Niu Shuai, Li Wen-cai, LIANG Lisheng, WANG Dong-yan, HONG Xin	11:06AM-11:26AM

Theme Advances in Materials Science and Engineering — Date: May-24 — Room: G
Session G01: Material Processing and Manufacturing — Time: 8:00AM-10:30AM

Paper	Title	Author	Time
ICCES1320130507346	Machining of Aerospace Materials	Mike Watts	8:00AM-8:25AM
ICCES1320130507350	Machinability of Brittle Cellular Materials for Composite Tooling	Alex O' Oconnor and M. Ramulu	8:25AM-8:50AM
ICCES1320130507351	One shot - dry - drilling of Composites/Aluminium hybrid stacked Materials in IT8 quality	Peter Mueller-Hummel and Abdelatif Atarsia	8:50AM-9:15AM
ICCES1320130507354	Process Speeds for Drilling and Reaming CFRP and CFRP/Metallic Stacks	John Barry	9:15AM-9:40AM
ICCES1320130507355	On-line Detection of Delamination when Drilling Composite Materials using Stereo Microphone Signal Processing	Eshetu Eneyew, M. Ramulu, S. Ramachandran Suresh and Les Atlas	9:40AM-10:05AM
ICCES1320130507357	Diffusion Bonding and Friction Stir Welding of Dissimilar Titanium Alloys	Todd Marton, Brian Flinn and M. Ramulu	10:05AM-10:30AM

Theme	Advances in Materials Science and Engineering		Date: May-24	Room: G
Session	G03: Material Processing and Manufacturing		Time: 1:30PM-4:30PM	
Paper	**Title**	**Author**	**Time**	
ICCES1320130507358	Flextural Behavior of Diffusion Bonded Titanium Joints	Neha Kulakarni and M. Ramulu	1:30PM-1:55PM	
ICCES1320130507362	Microstructural characterization and Mechanical Properties of FSW Butt Joints	Andrew Cantrell	1:55PM-2:20PM	
ICCES1320130507363	Modeling the Effect of the Shot Peening Residual Stress on the Vickers Hardness of Aluminum alloy 7050-T7451	Heechang Bae	2:20PM-2:45PM	
ICCES1320130507364	Shakedown prediction of Fatigue Life Extension after Residual Stress Relaxation via the Recovery Strain	Julio Davies	2:45PM-3:10PM	
ICCES1320130425327	Numerical Analysis of Mold Filling Stage for Manufacturing Composite Wind Turbine Blade Using XFEM	Y. Jung and S.J. Kim	3:10PM-3:28PM	
ICCES1320130301208	Tensile Creep Study and Mechanical Properties of Carbon Fiber Nano-Composites	Yi-Luen Li, Ming-Yuan Shen, Wei-Jen Chen, Chin-Lung Chiang and Ming-Chuen Yip	4:00PM-4:18PM	

Theme	Advances in Materials Science and Engineering		Date: May-25	Room: G
Session	G06: Metamaterials (Panel Discussion)		Time: 10:30AM-12:10PM	
Paper	**Title**	**Author**	**Time**	
ICCES1320130119068	Metamaterials- present state and future directions (Panel Discussion)	Rakesh Mohan Jha	10:30AM-12:00PM	*theme

Theme	Poster		Date: May-24	Room: S
Session	S01: Poster		Time: 8:30AM-6:00PM	
Paper	**Title**	**Author**	**Time**	
ICCES1320130124119	Course Management System	Kristen Bhing Salvio and Reynald Jay Hidalgo	8:30AM-8:48AM	

Stochastic FEM on nonlinear vibration of fluid-conveying double-walled carbon nanotubes subjected to a moving load

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Abstract

This study uses stochastic FEM to investigate the statistical dynamic behaviors of nonlinear vibration of the fluid-conveying double-walled carbon nanotubes (DWCNTs) under a moving load by considering the effects of the geometric nonlinearity and the nonlinearity of van der Waals (vdW) force. The Young's modulus of elasticity of the DWCNTs is considered as stochastic with respect to the position to actually characterize the random material properties of the DWCNTs. Besides, the small scale effects of the nonlinear vibration of the DWCNTs are studied by using the theory of nonlocal elasticity. Based on the Hamilton's principle, the nonlinear governing equations of the fluid-conveying double-walled carbon nanotubes under a moving load are formulated. The stochastic finite element method along with the perturbation technique is adopted to study the statistical dynamic response of the DWCNTs. Some statistical dynamic response of the DWCNTs such as the mean values and standard deviations of the non-dimensional dynamic deflections are computed and checked by the Monte Carlo Simulation, meanwhile the effects of the nonlocal parameter and aspect ratio on the statistical dynamic response of the DWCNTs are investigated. It can be concluded that the nonlocal solutions of the dynamic deflections get larger with the increase of the nonlocal parameters due to the small scale effect, and as the aspect ratio increases, the small scale effect has less effect on the maxima non-dimensional dynamic deflections of the DWCNTs.

Keywords: Nonlinear vibration; Double-walled carbon nanotubes; Stochastic FEM; Perturbation technique; Small scale effect; Nonlocal elasticity theory.

1. Introduction

Since the landmark paper published by Iijima [1], carbon nanotubes (CNTs) have attracted worldwide attention due to their potential use in the fields of chemistry, physics, nano-engineering, electrical engineering, materials science, reinforced composite structures and construction engineering. Carbon nanotubes (CNTs) are used for a variety of technological and biomedical applications including

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nanocontainers for gas storage and nanopipes conveying fluids [2-8]. Some important applications of carbon nanotubes (CNTs) are such as nanotubes conveying fluids [3,7-8], different types of fluid flows like water [9], dynamic flow of methane, ethane and ethylene molecules [10] and the diffusive transport of light gases [11] had been reported, and the effects of these fluids on the mechanical properties of CNTs had been investigated. Generally there are two methods widely adopted to study the CNTs conveying fluids. One is the molecular dynamics simulations (MDS) [10-11], however, MDS needs a tremendous amount of computational time and effort so that only a very small system can be tackled. The other is the continuum mechanics model. Natsuki et al. [12] adopted a simplified Flügge shell model to investigate the wave propagation of single- and double-walled CNTs conveying fluid. The single-elastic beam model [13-14] and the multiple-elastic beam model [15-19] were also broadly adopted to study the dynamic behaviors of fluid-conveying single-walled carbon nanotubes (SWCNTs) and multi-walled carbon nanotubes (MWCNTs). The vibration frequencies of the linear system and the system's stability related to the internal moving fluid were investigated. Moreover, the nonlocal elasticity theory was incorporated into the elastic beam model to study the small scale effect on the dynamics of SWCNT conveying fluid [20]. Chang and Liu [21-22] studied small scale effects on the flow-induced instability of double-walled carbon nanotubes (DWCNTs) by using the nonlocal elasticity theory. More recently, Chang [23-24] investigated the thermal-mechanical vibration and instability of fluid-conveying single-walled carbon nanotubes (SWCNTs) based on nonlocal elasticity theory. Generally speaking, the beam models mentioned above are linear; however, the vdW forces in the interlay space of MWCNTs are essentially nonlinear. Furthermore, the slender ratios are normally large if the beam models are adopted, that is, the large deformation will occur. Therefore, it is quite essential to consider two types of nonlinear factors, namely, the geometric nonlinearity and the nonlinearity of vdW force in investigating the dynamic behaviors of fluid-conveying MWCNTs. Kuang et al. [25] investigated the dynamic behaviors of double-walled carbon nanotubes (DWCNTs) conveying fluid by considering two types of nonlinearities mentioned above.

Due to the rapid process of nanotechnology, the motion of neutral atoms and nanoparticles in nanotubes has been of remarkable interest [26]. Carbon nanotubes are utilized as molecular channels for the transportation of nanoparticles, such as water and protons [27]. In the process of these applications, carbon nanotubes might be subjected to moving load, and this causes the transverse vibration of carbon nanotubes. Therefore, it is quite necessary to investigate the dynamic behavior of carbon nanotubes under moving loads. So far, most researchers have studied static, buckling or free vibration analysis of nanotubes or nanobeams based on the local or nonlocal elasticity theory, forced vibration of DWCNTs under moving loads is rarely investigated. Until recently, Simsek [28] performed the vibration analysis of a SWCNT under action of a moving harmonic load based on nonlocal elasticity theory. Kiani and Wang [29] adopted nonlocal elasticity theory to investigate the interaction of a single-walled carbon nanotube with a moving nanoparticle.

Salvetat et al. [30] measured the flexural Young's modulus and shear modulus using AFM test on clamped–clamped nanoropes, getting values with 50% of error. Information related to statistical distributions of experimental data is also rare, and the important study from Krishnan et al. [31] provides one of the few examples available of histogram distribution of the flexural Young's modulus derived from 27 CNTs. The Young's modulus was estimated observing free-standing vibrations at room temperature using transmission electro-microscope (TEM), with a mean value of 1.3 TPa -0.4 TPa/+0.6 TPa. Pronouncedly, in [32], stochastically averaged probability amplitude for the vibration modes is computed to obtain the root-mean-square vibration profile along the length of the tubes. Uncertainty is also associated to the equivalent atomistic-continuum models adopted extensively in particular by the engineering and materials science communities. Hence, to be realistic, the Young's modulus of elasticity of carbon nanotube (CNTs) should be considered as stochastic with respect to the position to actually describe the random property of the CNTs under certain conditions.

In the present study, we investigate the stochastic dynamic behaviors of nonlinear vibration of the fluid-conveying double-walled carbon nanotubes (DWCNTs) under a moving load by considering the effects of the geometric nonlinearity and the nonlinearity of van der Waals (vdW) force. The Young's modulus of elasticity of the DWCNTs is considered as stochastic with respect to the position to actually characterize the random material properties of the DWCNTs. In addition, the small scale effects on the nonlinear vibration of the DWCNTs are studied by using the theory of nonlocal elasticity. Based on the Hamilton's principle, the nonlinear governing equations of the fluid-conveying double-walled carbon nanotubes under a moving load are formulated. The stochastic finite element method along with the perturbation technique is adopted to study the statistical response of the DWCNTs; in particular, the Newton-Raphson iteration procedure in conjunction with Newmark scheme is utilized to solve the nonlinearity of the dynamic governing equation of the DWCNTs. The effects of the nonlocal parameter, aspect ratio and the flow velocity on the statistical dynamic response of the DWCNTs are investigated.

2. Nonlinear beam model for fluid-conveying DWCNTs under a moving load

Fig. 1. Fluid-conveying DWCNTs under a moving load.

In Fig. 1, the double-walled carbon nanotubes (DWCNTs) is modeled as a double-tube pipe which is composed of the inner tube of radius R_1 and the outer tube of radius R_2. The thickness of each tube is h, the length is L, and Young's modulus of elasticity is E. It is noted that the Young's modulus of elasticity E is assumed as stochastic with respect to the position to actually describe the random material property of the DWCNTs. The internal fluid is assumed to flow steadily through the inner tube with a constant velocity U and the moving load $F(x,t)$ and the internal fluid are considered as deterministic. Besides, the boundary conditions of the DWCNTs are assumed as simply-supported at both ends.

Based on the theory of Euler–Bernoulli beam and a nonlinear strain–displacement relationship of Von Karman type, the displacement field and strain–displacement relation can be written as follows:

$$\begin{aligned}
&\overline{u}_i(x,z,t) = u_i(x,t) - z\frac{\partial w_i}{\partial x} \\
&\overline{w}_i(x,z,t) = w_i(x,t) \\
&\varepsilon_i = \frac{\partial \overline{u}_i}{\partial x} + \frac{1}{2}\left(\frac{\partial \overline{w}_i}{\partial x}\right)^2
\end{aligned} \tag{1}$$

where x is the axial coordinate, t is time, $\overline{u}_i$ and $\overline{w}_i$ denote the total displacements of the ith tube along the

x coordinate directions, u_i and w_i define the axial and transverse displacements of the ith tube on the neutral axis, ε_i the corresponding total strain, and the subscript $i = 1$ and $i = 2$. Notice that tube 1 is the inner tube while tube 2 is the outer tube.

The potential energy V stored in a DWCNTs and the virtual kinetic energy T in the DWCNTs as well as the fluid inside the DWCNTs are individually written as follows:

$$V = \frac{1}{2}\int_0^L \left[\int_{A_1} E(x) \left(\frac{\partial u_1}{\partial x} + \frac{1}{2}\left(\frac{\partial w_1}{\partial x}\right)^2 - z\frac{\partial^2 w_1}{\partial x^2} \right)^2 dA + \int_{A2} E(x) \left(\frac{\partial u_2}{\partial x} + \frac{1}{2}\left(\frac{\partial w_2}{\partial x}\right)^2 - z\frac{\partial^2 w_2}{\partial x^2} \right)^2 dA \right] dx \tag{2}$$

$$\begin{aligned} T = \frac{\rho_t}{2}\int_0^L \Bigg\{ & \int_{A_1} \left[\left(\frac{\partial u_1}{\partial t} - z\frac{\partial \dot{w}_1}{\partial x} \right)^2 + \left(\frac{\partial w_1}{\partial t} \right)^2 \right] dA \\ & + \int_{A2} \left[\left(\frac{\partial u_2}{\partial t} - z\frac{\partial \dot{w}_2}{\partial x} \right)^2 + \left(\frac{\partial w_2}{\partial t} \right)^2 \right] dA \Bigg\} dx \\ & + \int_0^L \int_{A_f} \frac{1}{2}\rho_f \Bigg[\left(\frac{\partial u_1}{\partial t} - U\cos\theta_1 \right)^2 \\ & + \left(\frac{\partial w_1}{\partial t} - U\sin\theta_1 \right)^2 + z^2 \left(\frac{\partial^2 w_1}{\partial x \partial t} \right)^2 \Bigg] dA dx \end{aligned} \tag{3}$$

where $\theta_1 = -\partial w_1/\partial x$, I_i and m_i are the moment of inertia and the mass of the ith tube per unit length; ρ_t is the mass density of the beam material; ρ_f is the mass density of the fluid inside tube 1;

U is the flow velocity, $A_1 = \pi\left[(R_1 + h)^2 - R_1 \right]^2$ and $A_2 = \pi\left[(R_2 + h)^2 - R_2 \right]^2$ are the cross-sectional areas of tube 1 and tube 2, respectively, and $A_f = \pi R_1^2$ is the cross-sectional areas of the fluid passage in tube 1.

Based on Hamilton's principle, the variational form of the equations of motion for the DWCNTs can be given by

$$\int_{t_0}^{t_1} (\delta V - \delta T - \delta\Psi)\, dt = 0 \tag{4}$$

where

$$\begin{aligned}\delta V = & -A_1\int_0^L \frac{\partial}{\partial x}[E(x)\frac{\partial u_1}{\partial x}]dx\delta u_1 - A_2\int_0^L [E(x)\frac{\partial u_2}{\partial x}]dx\delta u_2 \\ & +I_1\int_0^L \frac{\partial^2[E(x)(\partial^2 w_1/\partial x^2)]}{\partial x^2}dx\delta w_1 + I_2\int_0^L \frac{\partial^2[E(x)(\partial^2 w_2/\partial x^2)]}{\partial x^2}dx\delta w_2 \\ & -A_1\int_0^L E(x)\frac{\partial^2 w_1}{\partial x^2}\frac{\partial w_1}{\partial x}dx\delta u_1 - A_2\int_0^L E(x)\frac{\partial^2 w_2}{\partial x^2}\frac{\partial w_2}{\partial x}dx\delta u_2 \\ & -\frac{3A_1}{2}\int_0^L E(x)\frac{\partial^2 w_1}{\partial x^2}\left(\frac{\partial w_1}{\partial x}\right)^2 dx\delta w_1 - \frac{3A_2}{2}\int_0^L E(x)\frac{\partial^2 w_2}{\partial x^2}\left(\frac{\partial w_2}{\partial x}\right)^2 dx\delta w_2 \\ & -A_1\int_0^L E(x)\left(\frac{\partial^2 w_1}{\partial x^2}\frac{\partial u_1}{\partial x}+\frac{\partial^2 u_1}{\partial x^2}\frac{\partial w_1}{\partial x}\right)dx\delta w_1 \\ & -A_2\int_0^L E(x)\left(\frac{\partial^2 w_2}{\partial x^2}\frac{\partial u_2}{\partial x}+\frac{\partial^2 u_2}{\partial x^2}\frac{\partial w_2}{\partial x}\right)dx\delta w_2\end{aligned} \tag{5}$$

$$\begin{aligned}\delta T = & -\int_0^L\left((m_1+\mathrm{M})\frac{\partial^2 u_1}{\partial t^2}+\mathrm{M}U\sin\theta_1\frac{\partial^2 w_1}{\partial x\partial t}\right)dx\delta u_1 \\ & -m_2\int_0^L\frac{\partial^2 u_2}{\partial t^2}dx\delta u_2 - m_2\int_0^L\frac{\partial^2 w_2}{\partial t^2}dx\delta w_2 \\ & -\int_0^L(m_1+\mathrm{M})\frac{\partial^2 w_1}{\partial t^2}dx\delta w_1 + (\rho_t I_1+\rho_f I_f)\int_0^L\frac{\partial^4 w_1}{\partial x^2\partial t^2}dx\delta w_1 \\ & +\rho_t I_2\int_0^L\frac{\partial^4 w_2}{\partial x^2\partial t^2}dx\delta w_2 \\ & +\mathrm{M}\left[\int_0^L\left(-U\sin\theta_1\frac{\partial^2 u_1}{\partial x\partial t}+\frac{\partial u_1}{\partial t}U\cos\theta_1\frac{\partial^2 w_1}{\partial x^2}\right)\right]dx\delta w_1 \\ & +\mathrm{M}\int_0^L\left(-U\cos\theta_1\frac{\partial^2 w_1}{\partial x\partial t}-\frac{\partial w_1}{\partial t}U\sin\theta_1\frac{\partial^2 w_1}{\partial x^2}\right. \\ & \left.-U\cos\theta_1\frac{\partial^2 w_1}{\partial x\partial t}\right)\Bigg]dx\delta w_1\end{aligned} \tag{6}$$

where M is the mass of the fluid per unit length and I_f is the moment of inertia of the fluid. The virtual works due to the vdW interaction and the interaction between tube 1 and the flowing fluid and the moving load are given by

$$\begin{aligned}\delta\Psi = & \int_0^L\left[\bar{P}-MU^2\frac{\partial^2 w_1}{\partial x^2}\cos\theta_1\right]dx\delta w_1+\int_0^L\left(-\bar{P}\right)dx\delta w_2 \\ & -\int_0^L MU^2\frac{\partial^2 w_1}{\partial x^2}\sin\theta_1 dx\delta u_1+\int_0^L F(x,t)dx\delta w_2\end{aligned} \tag{7}$$

where $\bar{P}$ is the nonlinear vdW force per unit length in the interlayer of the DWCNTs, and in this study the moving load $F(x,t)$ is assumed as $F(x,t)=F_0\delta(x-x_F)$, where $\delta(\square)$ is the Dirac-delta function, x_F is the coordinate of the moving load, F_0 is the amplitude of the moving load.

The interlayer potential per unit area $\Pi(\delta)$ can be expressed in terms the interlayer spacing δ as follows:

$$\Pi(\delta)=K\left[\left(\frac{\delta_0}{\delta}\right)^4-0.4\left(\frac{\delta_0}{\delta}\right)^{10}\right] \tag{8}$$

the vdW force $\bar{P}$ is then obtained by considering the lowest-order nonlinear term in Taylor expansion of Π, which is written as [33]

$$\begin{aligned}\bar{P}&=2R_1\left[\left.\frac{\partial^2\Pi}{\partial\delta^2}\right|_{\delta=\delta_0}(\delta-\delta_0)+\frac{1}{6}\left.\frac{\partial^4\Pi}{\partial\delta^4}\right|_{\delta=\delta_0}(\delta-\delta_0)^3\right]\\&=c_1(w_2-w_1)+c_3(w_2-w_1)^3\end{aligned} \tag{9}$$

where $K=-61.665$ meV/atom; $\delta-\delta_0=w_2-w_1$; $c_1=\left.\frac{\partial^2\Pi}{\partial\delta^2}\right|_{\delta=\delta_0}2R_1$; $c_3=\frac{1}{6}\left.\frac{\partial^4\Pi}{\partial\delta^4}\right|_{\delta=\delta_0}2R_1$ and $\delta_0=0.34$nm is the equilibrium interlayer spacing.

By utilizing the Eqs. (4-7) and considering the boundary conditions of the simple ends, and the assumption that all variables and derivatives are zero at $t=t_0$ and $t=t_1$, all the terms involving $[\cdot]_0^L$ and $[\cdot]_{t_0}^{t_1}$ vanish. In addition, considering the moderate large-amplitude deflection, $\cos\theta_1\approx1$ and $\sin\theta_1\approx-\frac{\partial w_1}{\partial x}$ are adopted in the following derivation.

In the present study, the boundary conditions of the DWCNTs are assumed as simply supported, therefore, the following boundary conditions can be written for the axial displacement:

$$u_1(0,t)=u_1(L,t)=0,\quad u_2(0,t)=u_2(L,t)=0 \tag{10}$$

By neglecting the rotation inertia and utilizing Eqs. (4-10), after some tedious derivations we can obtain the coupled nonlinear governing equations for the vibration of fluid-conveying DWCNTs under a moving load as follows:

$$I_1\frac{\partial^2(E(x)(\partial^2 w_1/\partial x^2))}{\partial x^2}+MU^2\frac{\partial^2 w_1}{\partial x^2}-\int_0^L\left(\frac{\partial w_1}{\partial x}\right)^2\left(\frac{E(x)A_1}{2L}+\frac{MU^2}{2L}\right)dx\frac{\partial^2 w_1}{\partial x^2}$$

$$+\frac{3MU^2}{2}\left(\frac{\partial w_1}{\partial x}\right)^2\frac{\partial^2 w_1}{\partial x^2}+(M+m_1)\frac{\partial^2 w_1}{\partial t^2}+2MU\frac{\partial^2 w_1}{\partial x\partial t} \tag{11}$$

$$-MU\frac{\partial w_1}{\partial t}\frac{\partial w_1}{\partial x}\frac{\partial^2 w_1}{\partial x^2}=c_1(w_2-w_1)+c_3(w_2-w_1)^3$$

$$I_2\frac{\partial^2(E(x)(\partial^2 w_2/\partial x^2))}{\partial x^2}+m_2\frac{\partial^2 w_2}{\partial t^2}-\int_0^L\left(\frac{\partial w_2}{\partial x}\right)^2\left(\frac{E(x)A_2}{2L}\right)dx\frac{\partial^2 w_2}{\partial x^2} \tag{12}$$

$$=-c_1(w_2-w_1)-c_3(w_2-w_1)^3+F_0\delta(x-x_F)$$

3. Small scale effect of nonlinear vibration of DWCNTs by nonlocal elasticity theory

Based on Eringen nonlocal elasticity model [34], the stress at a reference point x in a body is considered as a function of strains of all the points in the near region. The above assumption is in agreement with the atomic theory of lattice dynamics and experimental observations on phonon dispersion.

Consider a homogeneous and isotropic elastic solid, the constitutive equation is

$$\boldsymbol{\sigma}(\mathbf{x})=\mathbf{C}_0:\int_V\alpha(|\mathbf{x}'-\mathbf{x}|,\tau)\boldsymbol{\varepsilon}(\mathbf{x}')dV(\mathbf{x}') \tag{13}$$

where symbols ':' is the inner product with double contraction, $\mathbf{C}_0$ is the elastic stiffness matrix of classical isotropic elasticity, $\boldsymbol{\sigma}(\mathbf{x})$ denotes the nonlocal stress tensor at $\mathbf{x}$, and $\boldsymbol{\varepsilon}(\mathbf{x}')$ is the strain tensor at any point $\mathbf{x}'$ in the body. The kernel function $\alpha(|\mathbf{x}'-\mathbf{x}|,\tau)$ is the nonlocal modulus, $|\mathbf{x}'-\mathbf{x}|$ is the Euclidean distance, and $\tau=e_0a/l$, where e_0 is a constant appropriate to each material, a is an internal characteristic size (e.g. size of C–C bond, lattice spacing, granular distance) and l is an external characteristic size (crack size, wave length etc.). The volume integral in Eq. (13) is over the region V occupied by the body. The kernel function is given as [34]

$$\alpha(|\mathbf{x}|,\tau)=(2\pi l^2)^{-1}K_0(\sqrt{\mathbf{x}\cdot\mathbf{x}}/l\tau) \tag{14}$$

where K_0 is the modified Bessel function.

By incorporating Eq. (13) and (14), the following equation can be derived

$$(1-e_0^2a^2\nabla^2)\boldsymbol{\sigma}=\mathbf{C}_0:\boldsymbol{\varepsilon} \tag{15}$$

It is noted that the scale $e_0 a$ in the Eq. (15) will lead to small scale effect on the response of structures in nano-size, furthermore, the classical (local) elasticity theory is recovered if the small scale coefficient $e_0 a$ is set to be zero.

Based on Eqs. (11-12) and Eq. (15) and the formulations derived by Chang [23, 24], the coupled nonlinear governing equations for the vibration of fluid-conveying DWCNTs under a moving load based on nonlocal elasticity theory are given as follows:

$$\frac{\partial^2}{\partial x^2}\left\{\left[E(x)I_1-(e_0a)^2MU^2\right]\frac{\partial^2 w_1}{\partial x^2}\right\}-2(e_oa)^2MU\frac{\partial^4 w_1}{\partial x^3\partial t}-(e_oa)^2(M+m_1)\frac{\partial^4 w_1}{\partial x^2\partial t^2}$$
$$+MU^2\frac{\partial^2 w_1}{\partial x^2}-\int_0^L\left(\frac{\partial w_1}{\partial x}\right)^2\left(\frac{E(x)A_1}{2L}+\frac{MU^2}{2L}\right)dx\frac{\partial^2 w_1}{\partial x^2}+\frac{3MU^2}{2}\left(\frac{\partial w_1}{\partial x}\right)^2\frac{\partial^2 w_1}{\partial x^2}+ \tag{16}$$
$$(M+m_1)\frac{\partial^2 w_1}{\partial t^2}+2MU\frac{\partial^2 w_1}{\partial x\partial t}-MU\frac{\partial w_1}{\partial t}\frac{\partial w_1}{\partial x}\frac{\partial^2 w_1}{\partial x^2}$$
$$=\left(1-(e_0a)^2\frac{\partial^2}{\partial x^2}\right)\left(c_1(w_2-w_1)\right)+c_3\left\{\left[\left(1-(e_0a)^2\frac{\partial^2}{\partial x^2}\right)w_2\right]-\left[\left(1-(e_0a)^2\frac{\partial^2}{\partial x^2}\right)w_1\right]\right\}^3$$

$$\frac{\partial^2}{\partial x^2}\left\{\left[E(x)I_2\right]\frac{\partial^2 w_2}{\partial x^2}\right\}+m_2\frac{\partial^2 w_2}{\partial t^2}-(e_0a)^2m_2\frac{\partial^4 w_2}{\partial x^2\partial t^2}-\int_0^L\left(\frac{\partial w_2}{\partial x}\right)^2\left(\frac{E(x)A_2}{2L}\right)dx\frac{\partial^2 w_2}{\partial x^2}$$
$$=-(1-(e_0a)^2\frac{\partial^2}{\partial x^2})(c_1(w_2-w_1))-c_3\left\{\left[\left(1-(e_0a)^2\frac{\partial^2}{\partial x^2}\right)w_2\right]-\left[\left(1-(e_0a)^2\frac{\partial^2}{\partial x^2}\right)w_1\right]\right\}^3 \tag{17}$$
$$+\left(1-(e_0a)^2\frac{\partial^2}{\partial x^2}\right)F_0\delta(x-x_F)$$

In Eqs. (16-17), it is assumed that the small scale effects on the nonlinear terms due to geometrical nonlinearity are neglected since they are normally small compared with those on the linear terms.

4. Solutions by finite element method

In the present study, the finite element method is adopted to determine the solutions to Eqs. (16-17). Using the finite element formulation, we can obtain the governing matrix equation of the structure after assembly as follows:

$$[\mathbf{M}]\ddot{\mathbf{W}}+[\mathbf{C}]\dot{\mathbf{W}}+\mathbf{R}(\mathbf{W})=\mathbf{P} \tag{18}$$

where $[\mathbf{M}]$ is the global consistent mass matrix of the structure, $[\mathbf{C}]$ is the global damping matrix of the structure, $\dot{\mathbf{W}}$ is the global velocity vector of the structure, $\ddot{\mathbf{W}}$ is the global acceleration vector of the structure, $\mathbf{W}$ is the global displacement vector of the structure, $\mathbf{P}$ is the global external force vector of the structure and $\mathbf{R}(\mathbf{W})$ is the global vector of restoring forces of the structure that depends on the displacement field.

Based on equation (18), the governing equation of the structure at time $t+\Delta t$ is given by

$$[\mathbf{M}]\ddot{\mathbf{W}}^{t+\Delta t}+[\mathbf{C}]\dot{\mathbf{W}}^{t+\Delta t}+\mathbf{R}\left(\mathbf{W}^{t+\Delta t}\right)=\mathbf{P}^{t+\Delta t} \tag{19}$$

If the vector $\mathbf{R}$ is differentiable in the neighborhood of the displacement vector $\mathbf{W}$, we can expand $\mathbf{R}$ with respect to $\mathbf{W}$ by Taylor series:

$$\mathbf{R}\left(\mathbf{W}^{t+\Delta t}\right)=\mathbf{R}\left(\mathbf{W}^{t}\right)+\frac{\partial \mathbf{R}}{\partial \mathbf{W}}\Big|_{\mathbf{W}=\mathbf{W}^{t}}\Delta\mathbf{W}+\frac{1}{2}\left(\frac{\partial^2 \mathbf{R}}{\partial \mathbf{W}^2}\right)\Big|_{\mathbf{W}=\mathbf{W}^{t}}\Delta\mathbf{W}^2+\ldots \tag{20}$$

where $\Delta\mathbf{W}=\mathbf{W}^{t+\Delta t}-\mathbf{W}^{t}$ is the incremental displacements. We define the second term of equation (20) to be the tangent stiffness matrix which are well established in the literature and neglect the higher order term beyond the second derivatives, then equation (20) can be reduced as:

$$\mathbf{R}\left(\mathbf{W}^{t+\Delta t}\right)=\mathbf{R}\left(\mathbf{W}^{t}\right)+\left[\mathbf{K}_T^t\right]\Delta\mathbf{W} \tag{21}$$

Substituting equation (21) into equation (19), we obtain

$$[\mathbf{M}]\ddot{\mathbf{W}}^{t+\Delta t}+[\mathbf{C}]\dot{\mathbf{W}}^{t+\Delta t}+\left[\mathbf{K}_T^t\right]\Delta\mathbf{W}=\mathbf{P}^{t+\Delta t}-\mathbf{R}\left(\mathbf{W}^{t}\right) \tag{22}$$

The above equation can be solved by any direct time integration method even it is nonlinear. In order to improve the solution accuracy, it is necessary to carry out the equilibrium iteration in each time step. In this study, the Newton-Raphson method in conjunction with Newmark scheme is adopted to perform the numerical analysis.

The iteration form of equation (22) can be written as

$$[\mathbf{M}]^{(i)}\ddot{\mathbf{W}}^{t+\Delta t}+[\mathbf{C}]^{(i)}\dot{\mathbf{W}}^{t+\Delta t}+\left[{}^{(i-1)}\mathbf{K}_T^t\right]^{(i)}\Delta\mathbf{W}=\mathbf{P}^{t+\Delta t}-{}^{(i-1)}\mathbf{R}^{t+\Delta t}, i=1,2,3,\ldots \tag{23}$$

where ${}^{(i)}\ddot{\mathbf{W}}^{t+\Delta t}$, ${}^{(i)}\dot{\mathbf{W}}^{t+\Delta t}$ and ${}^{(i)}\mathbf{W}^{t+\Delta t} = {}^{(i-1)}\mathbf{W}^{t+\Delta t} + {}^{(i)}\delta\mathbf{W}$ are the accelerations, velocities and the displacements at the ith iteration respectively. The converge criteria is defined by

$$\left\| {}^{(i)}\delta\mathbf{W} \right\| / \left\| {}^{(i)}\mathbf{W}^{t+\Delta t} \right\| \tag{24}$$

$\left\| \bullet \right\|$ is the Euclidean norm; the iteration repeats until the above criteria is less than a tolerance.

5. Perturbation Technique

In this study, only the Young's modulus of elasticity E is assumed to be stochastic in position, the geometric shapes and sizes of the structure and the moving load and the fluid load are assumed to be deterministic. Applying the perturbation technique, the randomly fluctuating Young's modulus of elasticity E can be assumed as:

$$E(x) = E^{(0)} + a(x) = E^{(0)} + E^{(0)}a(x) \tag{25}$$

where $E^{(0)}$ is the mean value of the Young's modulus of elasticity, $a(x)$ is random variable with zero mean, and $E^{(0)}a(x)$ is homogeneous stochastic field representing the fluctuation of the Young's modulus of elasticity around its mean value. Assuming the random variable α is uniform within the element, then the stochastic nodal displacement vector can be expanded about α by using Taylor series as:

$$\mathbf{W}^{t+\Delta t} = \mathbf{W}^{(0)t+\Delta t} + \sum_{i=1}^{NE} \mathbf{W}_i^{(1)t+\Delta t}\alpha_i + \frac{1}{2}\sum_{i=1}^{NE}\sum_{j=1}^{NE} \mathbf{W}_{ij}^{(2)t+\Delta t}\alpha_i\alpha_j + \ldots \tag{26}$$

$$\Delta\mathbf{W} = \Delta\mathbf{W}^{(0)} + \sum_{i=1}^{NE} \Delta\mathbf{W}_i^{(1)}\alpha_i + \frac{1}{2}\sum_{i=1}^{NE}\sum_{j=1}^{NE} \Delta\mathbf{W}_{ij}^{(2)}\alpha_i\alpha_j + \ldots \tag{27}$$

where the superscript (0) represents the mean value term, both i and j denote the element numbers, NE is the total number of the element and Σ means the merging with respect to element. Similarly, the restoring force vectors and the tangent stiffness matrix can be written as:

$$\mathbf{R}^t = \mathbf{R}^{(o)t} + \sum_{i=1}^{NE} \mathbf{R}_i^{(1)t}\alpha_i + \frac{1}{2}\sum_{i=1}^{NE}\sum_{j=1}^{NE} \mathbf{R}_{ij}^{(2)}\alpha_i\alpha_j + \ldots \tag{28}$$

$$\left[\mathbf{K}_T^t\right]=\left[\mathbf{K}_T^{(0)t}\right]+\sum_{i=1}^{NE}\left[\mathbf{K}_{Ti}^{(1)t}\right]\alpha_i+\frac{1}{2}\sum_{i=1}^{NE}\sum_{j=1}^{NE}\left[\mathbf{K}_{Tij}^{(2)t}\right]\alpha_i\alpha_j+\ldots \tag{29}$$

Substituting equations (27-29) into equation (22) and applying the perturbation technique to equation (22), the higher order terms are truncated, and comparing equal order terms for the random variable α, the zero, first, and second order equations for the problem are obtained, respectively.

For zero order

$$[\mathbf{M}]\ddot{\mathbf{W}}^{(0)t+\Delta t}+[\mathbf{C}]\dot{\mathbf{W}}^{(0)t+\Delta t}+\left[\mathbf{K}_T^{(0)t}\right]\Delta\mathbf{W}^{(0)}=\mathbf{P}^{t+\Delta t}-\mathbf{R}^{(0)t} \tag{30}$$

For first order

$$[\mathbf{M}]\ddot{\mathbf{W}}_i^{(1)t+\Delta t}+[\mathbf{C}]\dot{\mathbf{W}}_i^{(1)t+\Delta t}+\left[\mathbf{K}_T^{(0)t}\right]\Delta\mathbf{W}_i^{(1)}=-\left[\mathbf{K}_{Ti}^{(1)t}\right]\Delta\mathbf{W}^{(0)}-\mathbf{R}_i^{(1)t} \tag{31}$$

For second order

$$[\mathbf{M}]\ddot{\mathbf{W}}_{ij}^{(2)t+\Delta t}+[\mathbf{C}]\dot{\mathbf{W}}_{ij}^{(2)t+\Delta t}+\left[\mathbf{K}_T^{(0)t}\right]\Delta\mathbf{W}_{ij}^{(2)}=-2\left[\mathbf{K}_{Ti}^{(0)t}\right]\Delta\mathbf{W}_j^{(1)}-\left[\mathbf{K}_{Tij}^{(2)t}\right]\Delta\mathbf{W}^{(0)}-\mathbf{R}_{ij}^{(2)t} \tag{32}$$

The solutions of equations (30-32) are achieved by using the procedures described in the previous section.

6. Statistical Dynamic Analysis

The statistical dynamic responses of DWCNTs can be obtained after calculating the zero, first and second order equations in equations (30-32). For example, at any fixed time, both expected value of deflection and autocorrelation of the deflection between two different points p and q can be obtained based on the first order approximation by neglecting the third term in equation (26) as follows:

$$E[\mathbf{W}]=\mathbf{W}^{(0)} \tag{33}$$

$$\begin{aligned}\mathbf{R}_{\mathrm{W}}(x_p,x_q)&=E\left[(\mathbf{W}-E[\mathbf{W}])(\mathbf{W}-E[\mathbf{W}])^T\right]\\&=\sum_{i=1}^{NE}\sum_{j=1}^{NE}\mathbf{W}_{pi}^{(1)}\mathbf{W}_{qj}^{(1)}E\left[\alpha_i\alpha_j\right]\end{aligned} \tag{34}$$

$$E\left[\alpha_i \alpha_j\right] = R_\alpha\left(x_i - x_j\right) = R_\alpha\left(\Delta x\right) \tag{35}$$

where $E[\bullet]$ is the expectation and the $R_\alpha(\Delta x)$ is the autocorrelation function of random variable α assuming that the Gaussian stochastic process of the Young's modulus of elasticity E is homogeneous with respect to the position, x_p and x_q are the coordinate at the center of the element p and q. Based on equation (34), the stochastic process of deflection is assumed to be homogeneous with respect to position as well, $R_W\left(x_i, x_j\right)$ can be replaced by $R_W\left(\Delta x\right)$. Therefore, the autocorrelation $R_W\left(\Delta x\right)$ can be computed readily provided that the spectra density of the Young's modulus of elasticity is given. In this study, the spectral density function of random variable α is assumed to be of the following form:

$$S_\alpha\left(k_x\right) = \frac{1}{\sqrt{4\pi}} \sigma_\alpha^2 b_\alpha \exp\left[-\frac{1}{4} b_\alpha^2 \left(\kappa_x^2\right)\right] \tag{36}$$

where σ_α denote the standard deviation of the random field $a(x)$, b_α is the parameter that influence the shape of the spectrum, and κ_x is the wave lengths. Also, the autocorrelation $R_a(\Delta x)$ is the Wiener-Khintchine transform of the spectral density $S_a\left(k_x\right)$ which can be easily obtained as follows:

$$R_a\left(\Delta x\right) = \sigma_a^2 \exp\left[-\frac{\left(\Delta x^2\right)}{b_a^2}\right] \tag{37}$$

Therefore, the autocorrelation $R_W(\Delta x)$ can be obtained readily from equations (34-37). Incidentally, the variance vector of deflection indeed is the diagonal components of equation (34) as follows:

$$Var = \sum_{i=1}^{NE} \sum_{j=1}^{NE} diag\left\{\mathbf{W}_{pi}^{(1)} \mathbf{W}_{qj}^{1} E\left[\alpha_i \alpha_j\right]\right\} \tag{38}$$

7. Numerical examples and discussion

Fig. 2. Sample function $\alpha(x)$ versus position of DWCNTs.

Fig. 3. **Mean value of** $w_2(L/2,t)/D$ **versus dimensionless time T for nonlinear and linear analysis. PS=Present study, MCS=Monte Carlo Simulation.**

Fig. 4. **Standard deviation of** $w_2(L/2,t)/D$ **versus T for nonlinear and linear analysis. PS=Present study, MCS=Monte Carlo Simulation.**

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Fig. 9. **Mean values of maxima non-dimensional deflections versus the aspect ratio** L/d **for** $\bar{V}=0.2$.

Fig. 10. **Mean values of maxima non-dimensional deflections versus the aspect ratio** L/d **for** $\bar{V}=0.5$.

Fig. 11. **Mean values of maxima non-dimensional deflections versus the aspect ratio** L/d **for** $\bar{V}=0.8$.

Fig. 12. **Mean values of maxima non-dimensional deflections versus the nonlocal parameter** e_0a **for** $\bar{V}=0.2$.

Fig. 13. **Mean values of maxima non-dimensional deflections versus the nonlocal parameter** e_0a **for** $\bar{V}=0.5$.

Fig. 14. **Mean values of maxima non-dimensional deflections versus the nonlocal parameter** e_0a **for** $\bar{V}=0.8$.

Fig. 15. **Mean values of maxima non-dimensional deflections versus the aspect ratio** L/d **for** $\bar{V}=0.2$ **and** $e_0a=1.0nm$.

In the numerical computations, the simply supported boundary conditions are considered for the fluid-conveying DWCNTs under a moving load with constant velocity. The inner and the outer tubes are assumed to have the same Young's modulus, the same thickness and the same mass density. The numerical values of the parameters are adopted as follows:

Mean value of Young's modulus E=1 Tpa, tube thickness h=0.34 nm, mass density $\rho = 2300 Kg/m^3$, the mass density of water flow is $\rho_f = 1000 Kg/m^3$, the inner radius $R_1 = 0.7nm$ and the outer radius $R_2 = 1.04nm$ and the parameters for the random variable α are assumed as $s_a = 0.1, b_a = 1.0$. The length of the DWCNTs is considered as a variable for the different values of the aspect ratio L/d. A conservative estimate of the nonlocal parameter $0 \ \mathrm{T} e_0 a \quad 2.0nm$ for a SWCNT is proposed by Wang [35], hence, in the present study, the nonlocal parameter is chosen as $0 \ \mathrm{T} e_0 a \quad 2.0nm$ to investigate the small scale effects on the dynamic responses. For a constant velocity of the moving load, the non-dimensional dynamic deflection is normalized as the ratio between the dynamic deflection and the static deflection, which is $D = F_0 L^3 / 48 E^{(0)} I$, of a beam under a point load F_0 at the middle point of the beam. Therefore, the non-dimensional dynamic deflection is independent of the geometrical properties of the DWCNTs and the magnitude of the moving load. The effect of the velocity of the moving load is represented by the non-dimensional velocity parameter $\bar{V}$ which is denoted as follows:

$$\bar{V} = \frac{v_F}{v_{cr}} \tag{39}$$

where v_{cr} is the critical velocity denoted as

$$v_{cr} = \frac{w_1 L}{p} \tag{40}$$

where w_1 is the fundamental frequency of the DWCNTs. The non-dimensional time T is denoted as

$$T = \frac{x_F}{L} = \frac{v_F t}{L} \tag{41}$$

First of all, based on the spectral density of random variable $\alpha(x)$ in Eq. (36), a sample function $\alpha(x)$ versus position of DWCNTs is generated and plotted in Fig. 2 to show the randomness of the Young's modulus of DWCNTs. In the following numerical computations, the internal fluid velocity of the DWCNTs is assumed as $U = 400\ m/\sec$, the non-dimensional velocity $\bar{V} = 0.2$ is assumed for the moving load and the aspect ratio $L/d = 10$ is considered, unless they are specified otherwise. In order to see the difference between the proposed nonlinear analysis and linear analysis, the mean values and standard deviations of the non-dimensional dynamic deflections $w_2(L/2,t)/D$ of the DWCNTs are presented in Figs. 3-4 respectively in the case of $e_0a = 0.0$. As it can be seen from the figures, the magnitudes of dynamic response based on the present nonlinear analysis are less than those of the linear analysis, which is fairly rational. Besides, the numerical results from the proposed method are checked by the Monte Carlo Simulation. In Figs. 5-8, the mean values and standard deviations of the non-dimensional dynamic deflections of the DWCNTs are depicted. Fig. 5 presents the mean value of the non-dimensional dynamic deflections $w_2(L/2,t)/D$ versus the non-dimensional time T for various values of the nonlocal parameter e_0a. As it can be seen from Fig. 5, the numerical results based on the present study are checked by Monte Carlo Simulation, they are in excellent agreements. General speaking, the mean values of the non-dimensional dynamic deflections become larger as the nonlocal parameters increase when T is less than or equal to 0.92. In Fig. 6, the similar numerical results can be found except that the non-dimensional dynamic deflections $w_1(L/2,t)/D$ are for the inner tube of the DWCNTs. The magnitudes in Fig. 6 are slightly less than those in Fig. 5, which is quite reasonable. Fig. 7 presents the standard deviation of the non-dimensional dynamic deflections $w_2(L/2,t)/D$ with respect to the normalized dimensional time T for various values of the nonlocal parameter e_0a. Once again, the numerical results based on the present study are in good agreements with those estimated by Monte Carlo Simulation except that the results from Monte Carlo Simulation are slightly larger than those from the present study, it is noted that the similar results can be detected in Fig. 8 for non-dimensional dynamic deflections $w_1(L/2,t)/D$.

Fig. 9 presents the mean values of the maximum non-dimensional dynamic deflections $w_2(x,t)/D$ versus the aspect ratio L/d for various values of the nonlocal parameter e_0a at the constant moving load velocity $\bar{V} = 0.2$. As it can be detected from the figure, the maxima non-dimensional dynamic deflections computed by using the nonlocal model are larger than those of the local (classical) model thanks to the small scale effect. In Figs. 10-11, the mean values of the maximum non-dimensional dynamic deflections are presented with respect to the aspect ratio L/d for $\bar{V} = 0.5$ and $\bar{V} = 0.8$ respectively. Similar results can be drawn as those in Fig. 9 except that the magnitudes of the non-dimensional dynamic deflections are larger in Figs. 10-11. Based on the phenomena observed from Figs. 9-11, the non-dimensional dynamic deflections of the DWCNTs with the lower aspect ratios are significantly affected by the nonlocal parameter than those of the DWCNTs with relatively higher aspect ratios. Therefore, it can be concluded that the local (classical) beam model can be adopted to investigate the dynamic behavior of the slender DWCNTs with negligible relative errors when L / d^{3} 40. In Figs. 12-14, the mean values of the maxima non-dimensional deflections $w_2(x,t) / D$ are presented with respect to the nonlocal parameter e_0a for various values of the aspect ratio L / d. According to the Fig. 12, the maxima non-dimensional deflections get larger as the nonlocal parameter increases, and the effect of the nonlocal parameter depends on the aspect ratio. Figs. 13-14 show the similar results as those in Fig. 12 except that the magnitudes of the maxima non-dimensional deflections are greater in the cases of $\bar{V} = 0.5$ and $\bar{V} = 0.8$. In order to study the dynamic response of the DWCNTs due to the fluid velocity, Fig. 15 shows the mean values of maxima non-dimensional deflections with the aspect ratio L / d for $\bar{V} = 0.2$ and $e_0a = 1.0nm$. According to the results from the figure, the maxima non-dimensional dynamic deflections get larger as the flow velocity increases, which is quite reasonable.

8. Conclusions

This paper investigates the stochastic dynamic behaviors of nonlinear vibration of the fluid-conveying double-walled carbon nanotubes (DWCNTs) under a moving load by considering the effects of the geometric nonlinearity and the nonlinearity of van der Waals (vdW) force. The Young's modulus of elasticity of the DWCNTs is considered as stochastic with respect to the position to actually characterize the random material properties of the DWCNTs. In addition, the small scale effects of the nonlinear vibration of the DWCNTs are studied by using the theory of nonlocal elasticity. Based on the Hamilton's principle, the nonlinear governing equations of the fluid-conveying double-walled carbon nanotubes under a moving load are formulated. The stochastic finite element method along with the perturbation technique is adopted to study the statistical response of the DWCNTs; in particular, the Newton-Raphson iteration procedure in conjunction with Newmark scheme is utilized to solve the nonlinearity of the dynamic governing equation of the DWCNTs. Some statistical results obtained by the perturbation technique and those from the Monte Carlo simulation approach show good agreements. Some statistical dynamic response of the DWCNTs such as the mean values and standard deviations of the non-dimensional dynamic deflections are calculated, meanwhile the effects of the nonlocal parameter, aspect ratio and the flow velocity on the statistical dynamic response of the DWCNTs are investigated. It can be concluded that the nonlocal solutions of the dynamic deflections get larger with the increase of the nonlocal parameters due to the small scale effect. In addition, the effect of the nonlocal parameter depends on the aspect ratio L / d, which can be neglected for slender DWCNTs when the aspect ratio L / d is greater than 40. In addition, it is found that as the flow velocity increases, the maxima non-dimensional dynamic deflections of the DWCNTs get larger. It is noticed that the calculated stochastic dynamic response plays an important role in estimating the structural reliability of the DWCNTs.

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Legends of Figures

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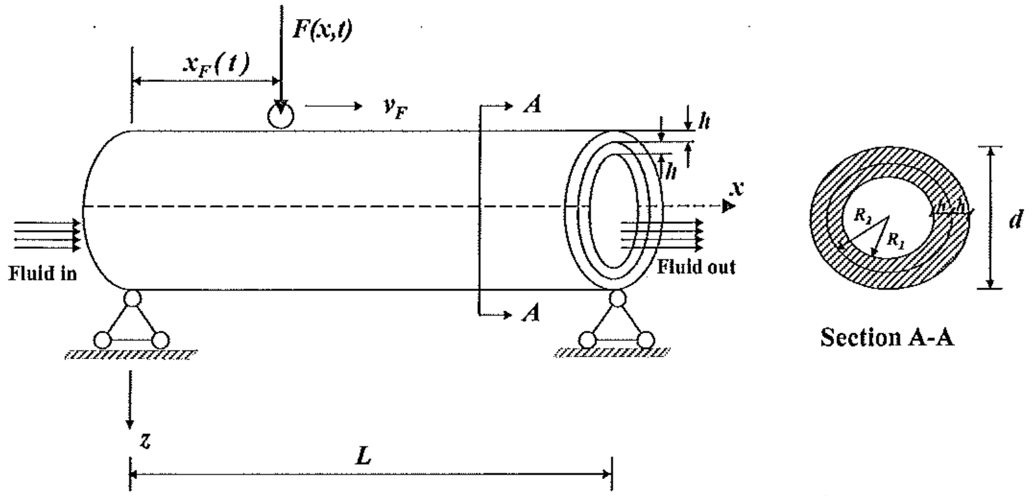

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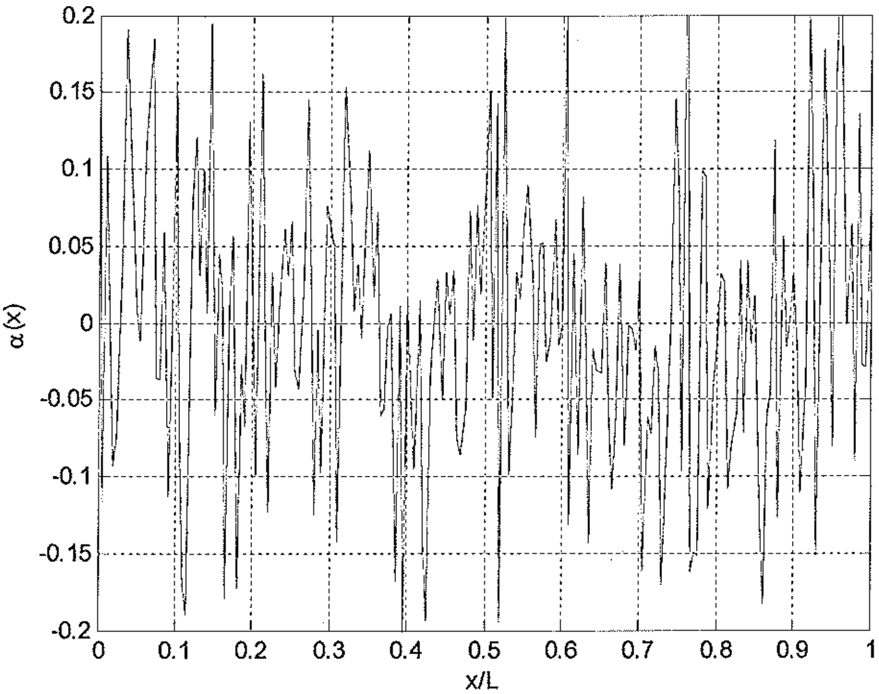

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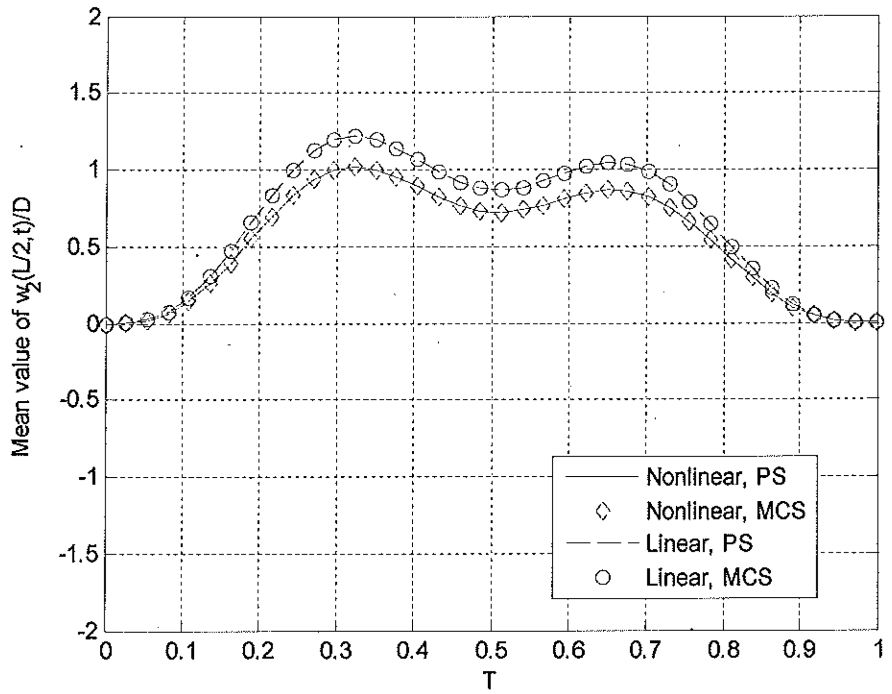

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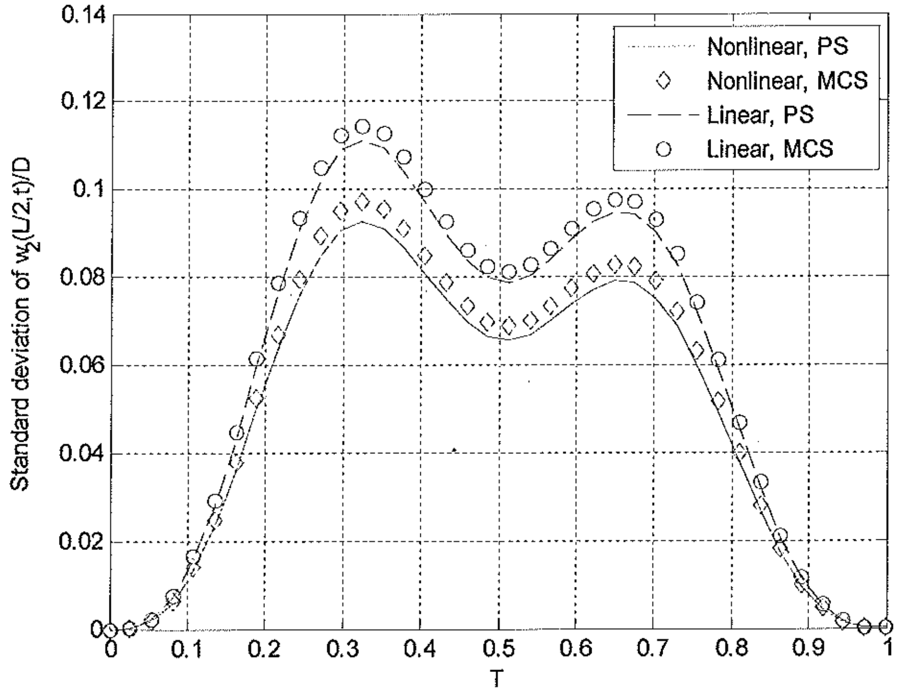

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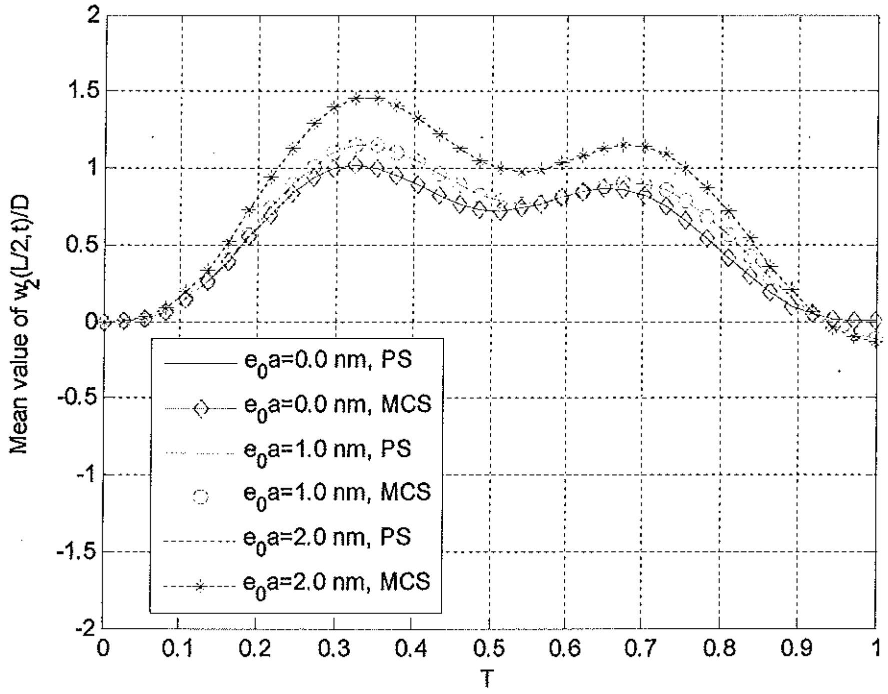

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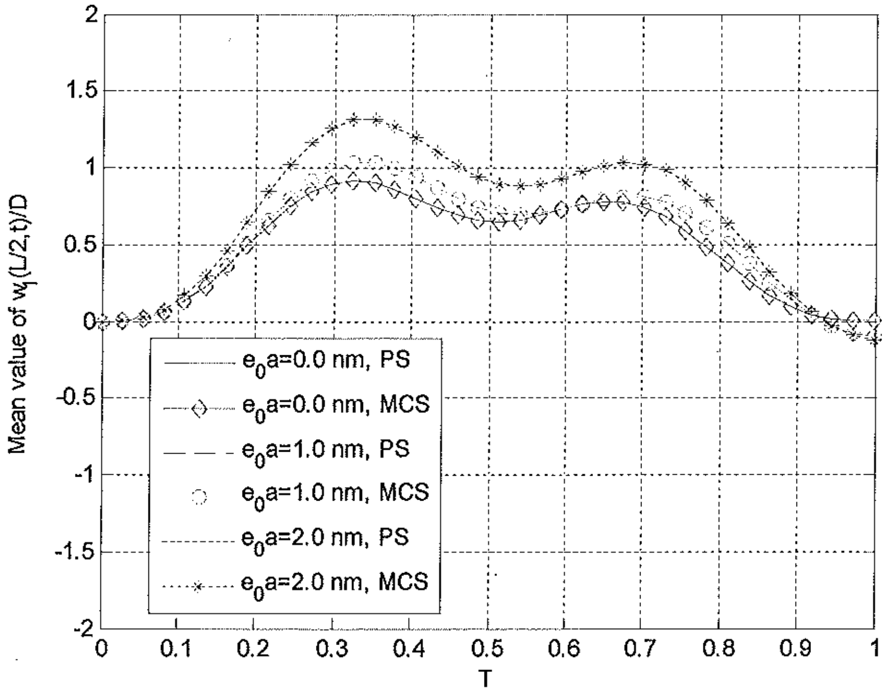

Fig. 6. Mean value of $w_1(L/2,t)/D$ versus dimensionless time T.

PS=Present study, MCS=Monte Carlo Simulation.

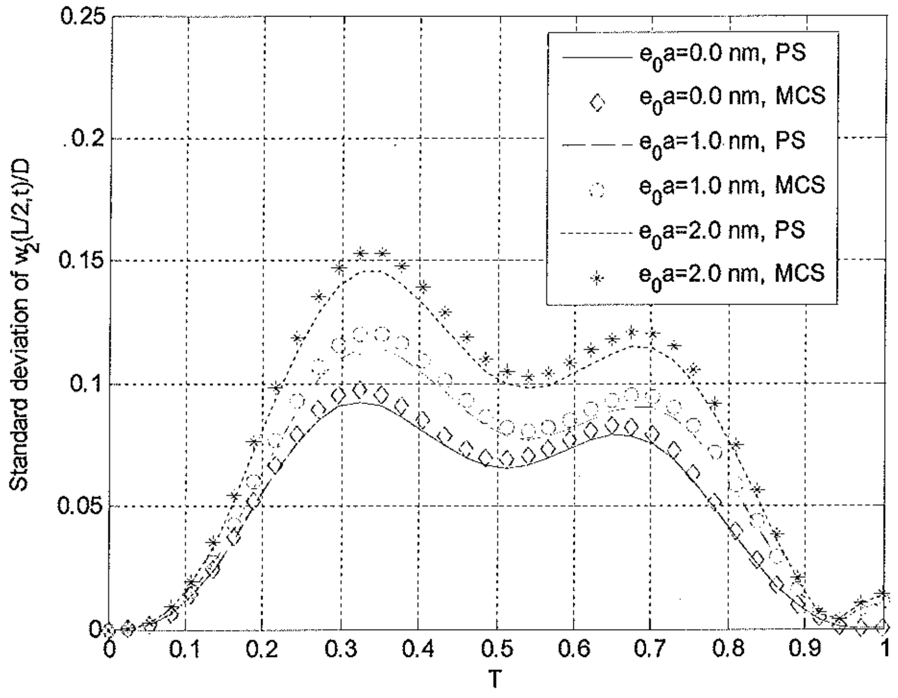

Fig. 7. Standard deviation of $w_2(L/2,t)/D$ versus dimensionless time T.

PS=Present study, MCS=Monte Carlo Simulation.

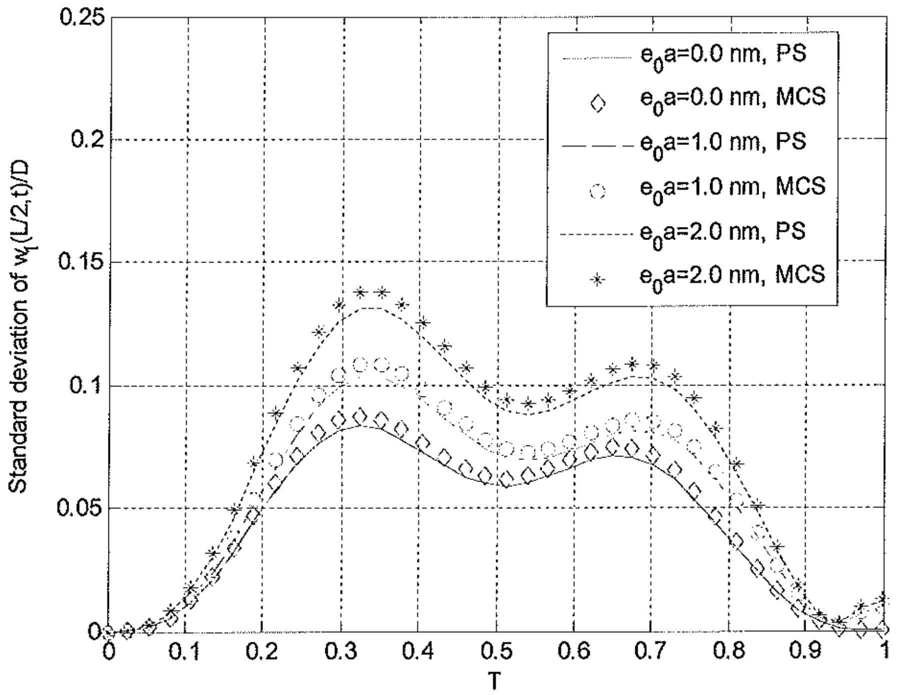

Fig. 8. Standard deviation of $w_1(L/2,t)/D$ versus dimensionless time T.

PS=Present study, MCS=Monte Carlo Simulation.

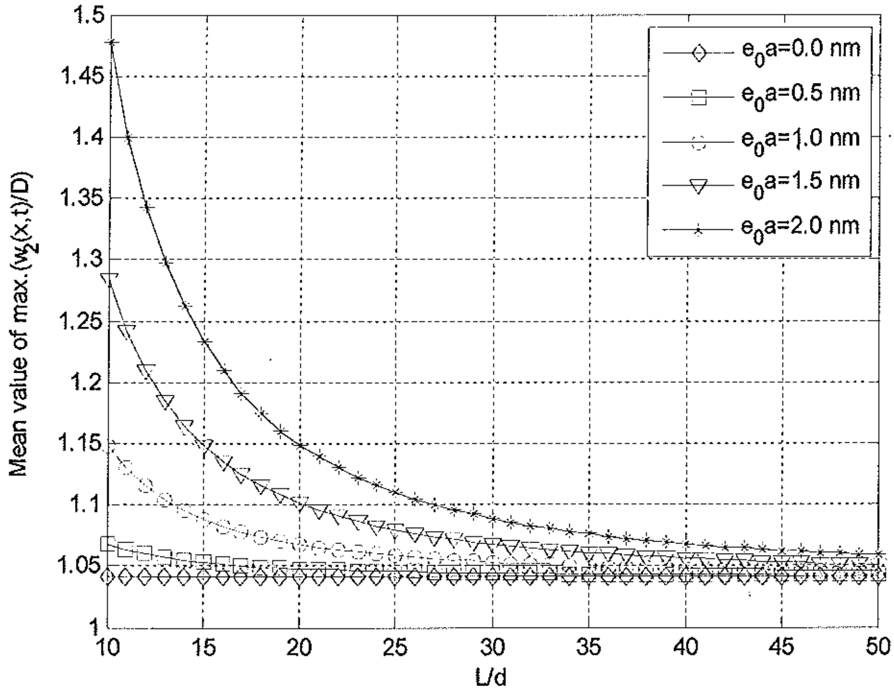

Fig. 9. Mean values of maxima non-dimensional deflections versus the aspect ratio L/d for $\bar{V} = 0.2$.

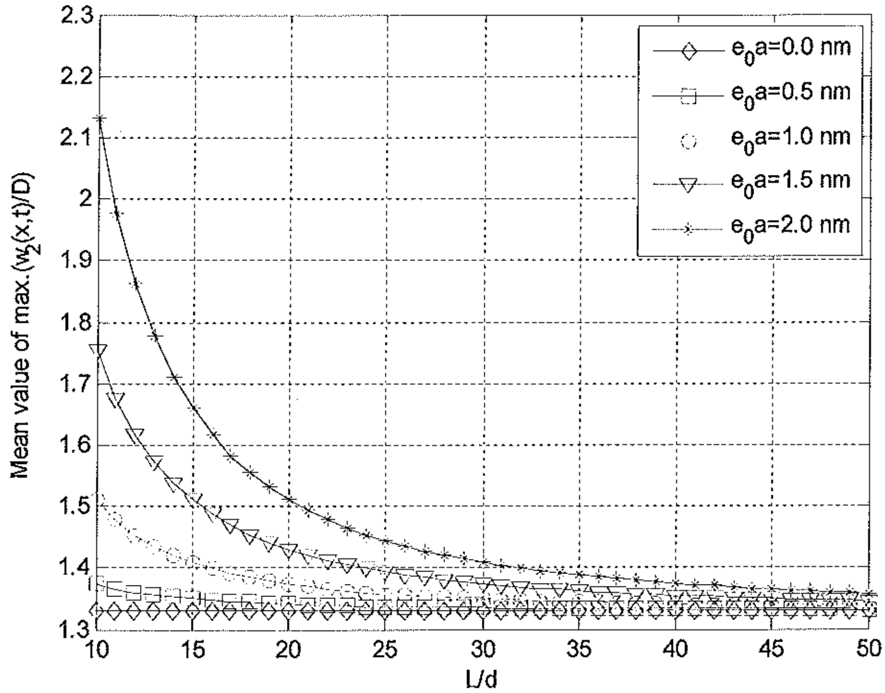

Fig. 10. Mean values of maxima non-dimensional deflections versus the aspect ratio L/d for $\bar{V} = 0.5$.

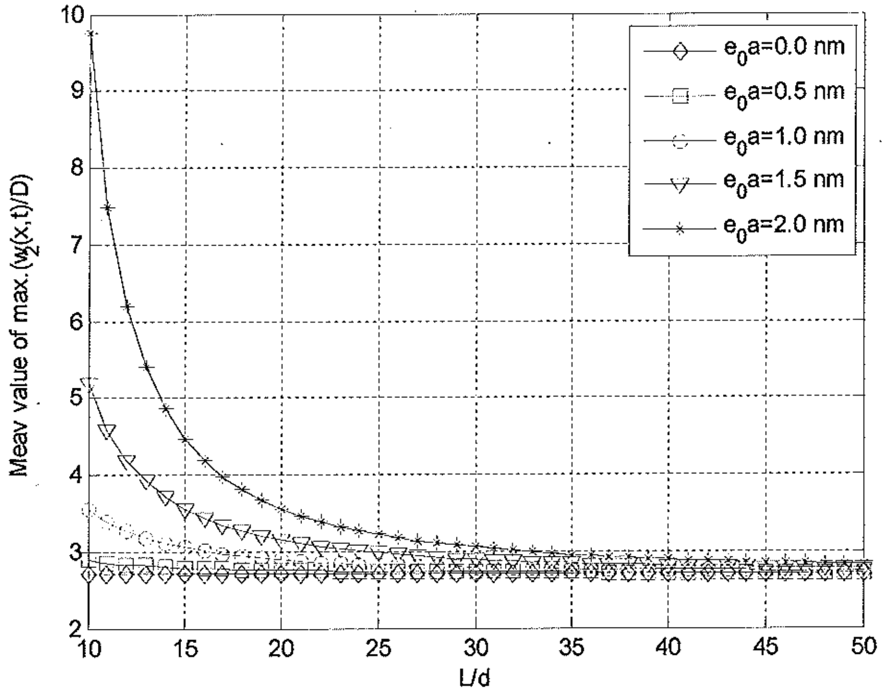

Fig. 11. Mean values of maxima non-dimensional deflections versus the aspect ratio L/d for $\bar{V}=0.8$.

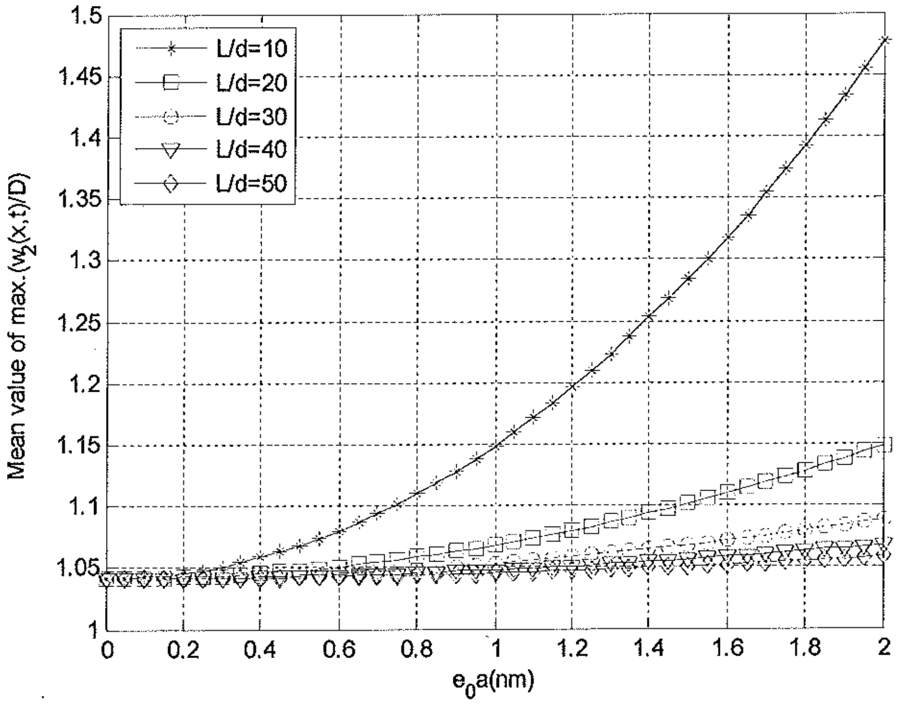

Fig. 12. Mean values of maxima non-dimensional deflections versus the nonlocal parameter e_0a for $\bar{V}=0.2$.

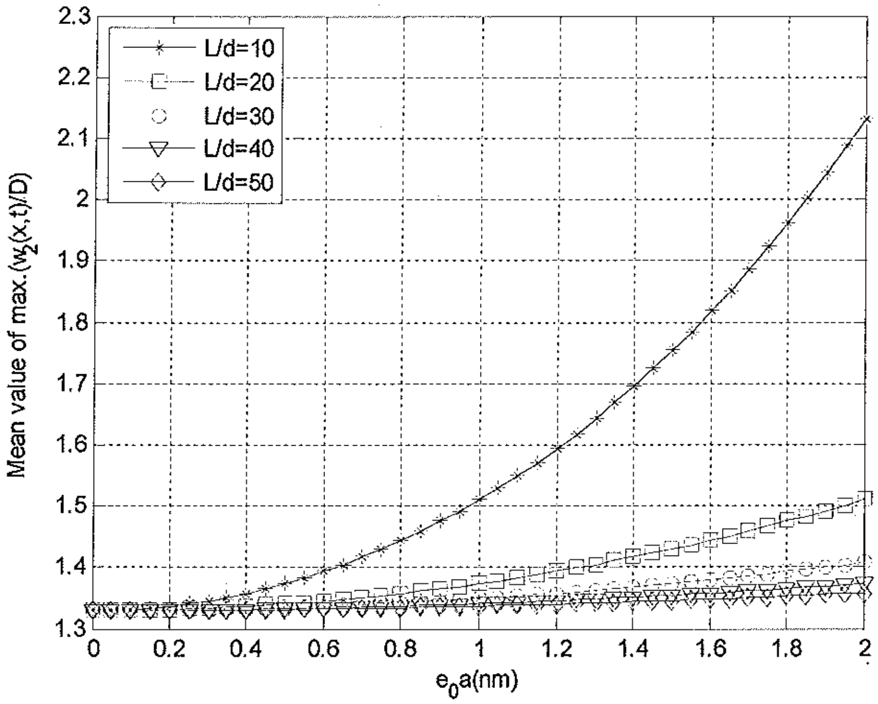

Fig. 13. Mean values of maxima non-dimensional deflections versus the nonlocal parameter e_0a for $\bar{V} = 0.5$.

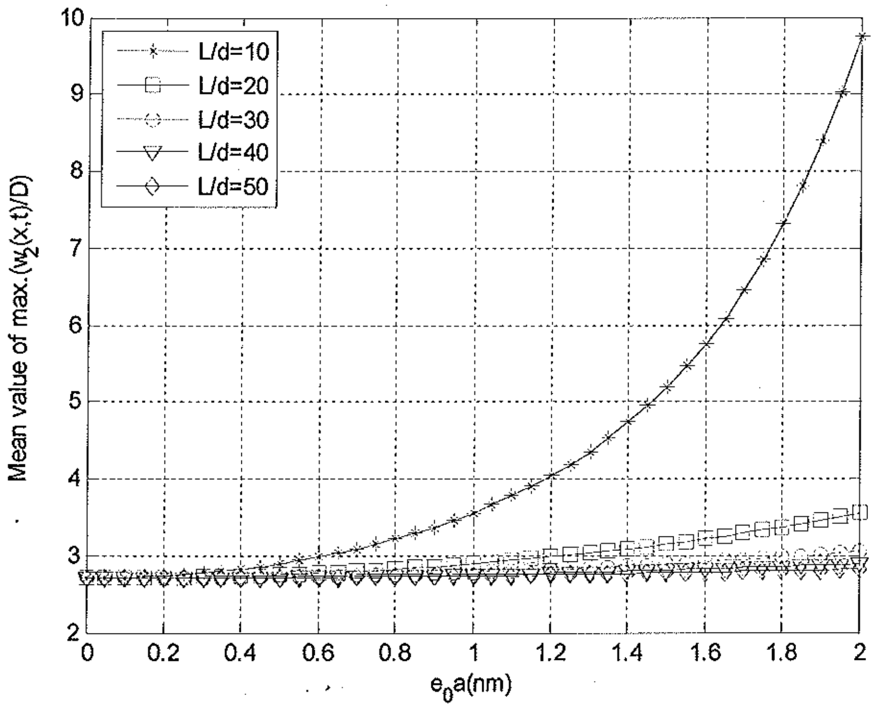

Fig. 14. Mean values of maxima non-dimensional deflections versus the nonlocal parameter e_0a for $\bar{V} = 0.8$.

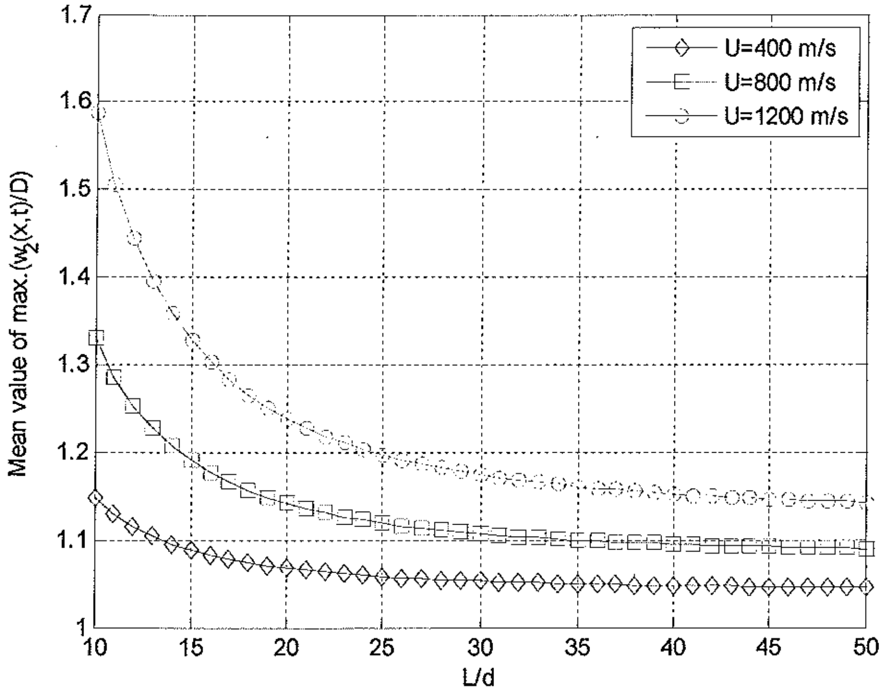

Fig. 15. Mean values of maxima non-dimensional deflections versus the aspect ratio L/d for $\bar{V}=0.2$ and $e_0a=1.0nm$.