CONTENT

FOREWORD

The International Symposium on Reliability of Multi-disciplinary Engineering Systems under Uncertainty, held on 8-11 December 2019, is organized by the National Taiwan University of Science and Technology (Taiwan Tech) in Taipei, Taiwan.

The performance reliability and safety of built infrastructure systems are issues that are of major concern to all disciplines of engineering. Invariably, the determination of the reliability or safety of any engineering system must be considered or evaluated under conditions of uncertainty, and thus requires quantitative assessment in terms of probability. Since such issues are common and important in all disciplines of engineering, the international symposium is organized to address many of the relevant issues related to major infrastructure systems. As engineers, our mission is to improve the public safety, facilitate the economic growth, and protect the environment as well as eco systems. With this international symposium, we hope to strengthen the consensus of all sectors of government, academy, industry, and research institutions.

This Symposium contains 14 keynote speeches, 10 organized sessions, and 65 papers in total from many parts of the world, including USA, Denmark, China, Japan, Korea, Singapore, Indonesia, Vietnam, Taiwan, etc. The total number of participants from the government, the academia and the industry are expected to be more than 200.

The Symposium is held under the sponsorship of the Ministry of Education, the Ministry of Science and Technology, the Taiwan Tech, and a number of supporting organizations. In particularly, the faculty and staff of the Department of Civil and Construction Engineering and Taiwan Building Technology Center (TBTC) are responsible for the Secretariat of the Symposium.

Finally, I would like to express my sincere gratitude to all the keynote speakers, the session organizers, the authors, the sponsors, and the participants for their contributions; to the members of the Steering Committee, the International Scientific Committee, and the Local Organizing Committee for their devoted time and efforts that makes ISRMES2019 a successful event.

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Symposium Chair

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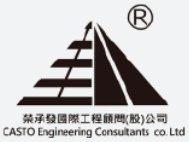
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GENERAL INFORMATION

Date 8~11 Dec, 2019

Venue Keynote Speeches / Opening & Closing Ceremony:
Room 101, International Building (IB), NTUST

Organized Sessions:
Room 101, 201 and 202, International Building (IB), NTUST

Lunch:
Room 201 and 202, International Building (IB), NTUST

Language English

Website https://www.isrmes2019.ntust.edu.tw/

Welcome Reception

17:30~20:00, Sunday, Dec.08, 2019
Howard Civil Service International House
No.30, Sec. 3, Xinsheng S. Rd., Da'an Dist., Taipei, Taiwan

Banquet La mar'ee
18:00~20:30, Monday Dec. 09, 2019
2F, No.16, Siyuan St., Zhongzheng Dist., Taipei, Taiwan

Post-Symposium Tour

Danjiang Bridge
13:30~17:30, Wednesday Dec. 11, 2019
Meet point @ Registration Desk

Access to Wireless Internet

Turn on wifi on your device and connect "NTUST-UAM". The portal window pops up automatically or open your browser. Input the user ID and password that you can get at the Registration Desk.

TECHNICAL PROGRAM

ISRMES 2019

INTERNATIONAL SYMPOSIUM ON RELIABILITY OF MULTI-DISCIPLINARY ENGINEERING SYSTEMS UNDER UNCERTAINTY

多領域工程系統可靠度及風險管理國際研討會

Date	Sun, Dec. 8
17:30-20:00	Welcome Reception @Howard Civil Service International House

Date	Mon, Dec. 9
08:00-09:00	Registration
09:00-09:30	Opening Ceremony
09:30-10:00	Keynote Speech by Prof. Alfredo H-S. Ang Reliability-based Optimal Design of Civil Infrastructure Systems Chair: Prof. Shi-Shuenn Chen
10:00-10:30	Keynote Speech by Prof. Bruce R. Ellingwood Performance-Based Engineering of Buildings For Natural Hazards: Practical Implementation of Reliability and Risk-informed Decision Chair: Prof. Shi-Shuenn Chen
10:30-11:00	Coffee Break
11:00-11:30	Keynote Speech by Prof. Dan Frangopol Reliability, Risk, Resilience And Sustainability of Infrastructure Systems Chair: Prof. Alfredo Ang
11:30-12:00	Keynote Speech by Prof. John Dalsgaard Sørensen Reliability Assessment of Wind Energy Structures Chair: Prof. Alfredo Ang
12:00-12:30	Keynote Speech by Prof. Jui-Sheng Chou Toward Reliable Design for Mitigating Operational Risk in Wind Energy Projects Chair: Prof. Alfredo Ang
12:30-13:30	Lunch Break

13:30-14:50	Organized Sessions	
	MA1: Structural Resilience and Reliability @IB201 Chair: Prof. Yangang Zhao ◆ MA1-1: Structural monitoring of passive control of vibration structure by Tsutomu Ochiai ◆ MA1-2: Collision Experiment and simulation analysis of base-isolated building model to rigid retaining wall by small shaking table test by Takumi Horikago ◆ MA1-3: r Seismic esilience assessment of steel frames by Fang-Wen GE ◆ MA1-4: Study on confinement path of FRP-confined concrete column by Jian-Ming Li ◆ MA1-5: Reliability analysis of total construction duration based on cubic normal distribution by LU REN ◆ MA1-6: A Study on strength and deformation capacity after bending strength of post-tensioning precast beams using unbounded tendons by Rikuto Takeuchi	MB1: Engineering System Risks Under Extreme Storm Conditions @IB202 Chair: Prof. Limin Zhang ◆ MB1-1: Engineering system risks under extreme storm conditions by Limin Zhang ◆ MB1-2: Simulation of distributed geotechnical hazards on a drum centrifuge by Wenjun Lu ◆ MB1-3: Flood and its impact on urban systems under extreme rainstorms: A case study in Hong Kong by Yejia Qiang ◆ MB1-4: Natural terrain landslide risk to population under extreme storms by T. Abimbola Owolabi
14:50-15:20	Coffee Break	
15:20-17:30	Organized Session MA2: Reliability on Offshore Wind Power Engineering @IB101 Chairs: Prof. John Dalsgaard Sørensen / Prof. I-Tung Yang ◆ MA2-1: Preliminary study on the risk evaluation of offshore wind power industrialization in Taiwan by Xin-Hua Lin ◆ MA2-2: The uncertainty analyses of availability of an offshore wind farm applied by the Monte Carlo simulation by Shih-Kai Ciou ◆ MA2-3: Introduction to statistical of soil parameters for offshore wind turbine foundation design by Jhan-Ming Jhou ◆ MA2-4: Application of reliability on offshore WTG support structure design by Wei-Chao Hsu ◆ MA2-5: Case study of applying risk assessment and risk management- onshore cable crossing of multiple offshore wind farms in Taiwan by Hsin-Pei Chou ◆ MA2-6: A study of the risk management of offshore wind powers project in Taiwan by Bring-C-hiang Lam	
18:00-20:30	Banquet @La ma'ee	

Date	Tue, Dec.10
08:00-09:00	Registration
09:00-09:30	Keynote Speech by Prof. Armen Der Kiureghian Measures of Component Importance in System Reliability Analysis Chair: Prof. Dan Frangopol
09:30-10:00	Keynote Speech by Prof. Jie Li Life-Cycle Reliability Analysis of Engineering Structures Chair: Prof. Dan Frangopol
10:00-10:30	Keynote Speech by Prof. Billie Spencer Min-Max Formulation for Topology Optimization of Structures subjected to Stochastic Excitation Chair: Prof. Dan Frangopol
10:30-11:00	Coffee Break
11:00-11:30	Keynote Speech by Prof. Yangang Zhao Structural Reliability Analysis Without Exclusion of the Epistemic Uncertainty in Distribution Parameters Chair: Prof. Kok Kwang Phoon
11:30-12:00	Keynote Speech by Prof. Jianye Ching Constructing Site-specific Multivariate Probability Distribution Model: Hybridization versus Hierarchical Bayesian Analysis Chair: Prof. Kok Kwang Phoon
12:00-12:30	Keynote Speech by Prof. Kok Kwang Phoon Chicken (Method) and Egg (Data) - Which Comes First? Chair: Prof. Shi-Shuenn Chen
12:30-13:30	Lunch Break

13:30-14:50	Organized Sessions	
	TA1: Reliability-based Codes for Design and Maintenance @IB201 Chair: Prof. Sang-Hyo Kim ◆ TA1-1: Development of reliability-based limit state design code of underground RC box for electric power lines by Sang-Hyo Kim ◆ TA1-2: Probabilistic resistance models for flexural members of underground RC boxes considering construction errors and tolerances by Dae-Yoon Kim ◆ TA1-3: Traffic load model for limit state design of underground RC boxes by Tuguldur Boldoo ◆ TA1-4: Centrifuge tests to access variability of the vertical and lateral earth pressures acting on underground reinforced concrete boxes by Sang Inn Woo ◆ TA1-5: Probabilistic approach for rotational stiffness of wedge joint connecting vertical and horizontal members of temporary steel supports by Jeong-Hun Won	TB1: Reliability of High-Speed Railway Systems @IB202 Chair: Prof. Zhao-Hui Lu / Prof. Yangang Zhao ◆ TB1-1: System reliability of CRTS II track slab considering both safe and serviceable failure modes by XUAN-YI ZHANG ◆ TB1-2: Reliability assessment of CRTS II track slab considering correlated random variables by HAO-RUI JIANG ◆ TB1-3: Time-dependent reliability evaluation of CRTS II track slab based on conditional probability method by BAO-ZHENG JIN ◆ TB1-4: Approximate method for fitting the extreme value distributions of non-linear stochastic dynamic systems by LONG-WEN ZHANG ◆ TB1-5: Random dynamic analysis and reliability assessment of high-speed train-bridge coupled system under earthquake excitation by JIANFENG MAO ◆ TB1-6: Moment method with an optimized performance function for system reliability by DONG-ZHU HU
14:50-15:20	Coffee Break	
15:20-16:40	Organized Sessions	
	TA2: Seismic Risk Assessment for A Resilient City @IB201 Chairs: Prof. Yin-Nan Huang ◆ TA2-1: Seismic impact analysis under an extreme scenario for resilient cities by Bing-Ru Wu ◆ TA2-2: Some reflections on the seismic risk in Taipei and the residents' mitigation behaviors for that by Yen-Lien Kuo ◆ TA2-3: Applying TELES on evaluation of evacuation shelter capacity of New Taipei City, Taiwan by Yong-Jun Lin ◆ TA2-4: Seismic assessment of potable water systems following earthquakes by Gee-Yu Liu ◆ TA2-5: The association of injury pattern, entrapment location and extrication time in the 2016 Taiwan earthquake by Chih-Hao Lin	TB2: Taiwan Road Disaster Prevention and Maintenance Strategy @IB202 Chair: Prof. Min-Yuan Cheng ◆ TB2-1: Bridge health monitoring based on static and dynamic responses utilizing MEMS accelerometers by John Thedy ◆ TB2-2: Optimizing deteriorating bridge maintenance strategy through risk assessment and hybrid computational intelligence technique by Richard Antoni Gosno ◆ TB2-3: Taiwan road early nature disaster prevention System-Trends by Min-Yuan Cheng ◆ TB2-4: Internal forces diagnosing approach of an existing structure through geometric-iterative method by Muhammad Ibnu Syamsi

16:40-18:00	TA3: Reliability of Civil Infrastructure Systems Under Stochastic Environment @IB201 Chair: Prof. Junho Song ◆ TA3-1: Effects of variabilities in ground motions and shear wave velocities on site response analyses for South Korea by Hwan-Woo Seo ◆ TA3-2: Optimal decision-making on pipeline sizes of water networks under seismic conditions by Sungsik Yoon ◆ TA3-3: Identification of stochastic pavement roughness class from vehicle dynamic response by Robin E Kim ◆ TA3-4: Ground motion response spectra for safety-related nuclear facilities in soil sites by Jin Ho Lee ◆ TA3-5: Bayesian network for structures subjected to sequence of main and aftershocks by Changuk Mun	TB3: Stochastic Dynamics of Nonlinear Structures @IB202 Chair: Prof. Jianbing Chen ◆ TB3-1: Investigation on wind-induced dynamic tension load on transmission line by aeroelastic wind tunnel testing by Daihai Wang ◆ TB3-2: A multi-harmonic balance method for determining steady state response of hysteresis systems endowed with fractional derivatives by Fan Kong ◆ TB3-3: A new reliability method combine dimension reduction and probability density evolution method by Zhong Ming Jiang ◆ TB3-4: A mixture distribution with low-order fractional moments for efficient seismic reliability analysis of nonlinear structures by Jun Xu ◆ TB3-5: Numerical studies on the probability of true damage detection for buildings under uncertain soil properties and measurement noises by Jun-Yang Shi

Date	Wed, Dec.11
08:00-09:00	Registration
09:00-09:30	Keynote Speech by Prof. Junho Song Gaussian Mixture Based Equivalent Linearization Method (GM-ELM): Genesis, Developments and Earthquake Engineering Applications Chair: Prof. Yangang Zhao
09:30-10:00	Keynote Speech by Prof. Jianbing Chen A new PDEM-consistent functional perspective to the response and reliability of structural systems involving uncertainty parameters Chair: Prof. Yangang Zhao
10:00-10:30	Keynote Speech by Prof. Zhao-Hui Lu Time-Dependent Reliability Assessment Of High-Speed Railway Ballastless Track-Bridge Structural System Chair: Prof. Yangang Zhao
10:30-11:00	Coffee Break
11:00-12:20	Organized Session FA1: Risk-Based Design and Maintenance of Infrastructures Against Natural Hazards@IB101 Chair: Prof. Kuo-Wei Liao ◆ FA1-1: K-MER-based pattern recognition in 3d bridge inspection by Po-Ting Lin ◆ FA1-2: Reliability-based design optimization using symbiotic organism search and subset simulation by Handy Prayogo ◆ FA1-3: Probability-based seismic assessments for bridges by Chang-Wei Huang ◆ FA1-4: Reliability Analysis for Wind-Induced Vibrations of Torsionally Coupled Systems by Ming-Yi Liu ◆ FA1-5: Reliability analysis of a river bridge considering climate change effect by Kuo-Wei Liao ◆ FA1-6: Variation of friction coefficients on functional bearing model (FBM) bridge under the near fault earthquakes by Alfinna Mahya Ummati
12:20-12:30	**Closing Ceremony**
12:30-13:30	Lunch Break
13:30-17:30	**Post-Symposium Tour: Danjiang Bridge**

MEMO

KEYNOTE SPEECHES

ISRMES 2019

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多領域工程系統可靠度及風險管理國際研討會

KEYNOTE SPEAKER 01

Prof. Alfredo H-S. Ang

- NAE Member
- Emeritus Professor, University of California, USA

Research Interests

- Structural and earthquake engineering, risk and reliability analysis

Biography

Dr. Ang is currently Research Professor and Professor Emeritus at the University of California in Irvine, California, USA. He is also Professor Emeritus at the University of Illinois at Urbana-Champaign since 1988 where he received his Ph.D. in 1959 and was on the faculty of Civil Engineering from 1959 through 1988. His main area of research is on the application of probability and reliability in civil and structural engineering, with emphasis on safety of engineering systems, including seismic risk and earthquake engineering, quantitative risk assessment (QRA) and life-cycle cost consideration. He has published about 400 papers and articles, and also a two-volume textbook on probability concepts in engineering, which have been translated into several languages; the 2nd edition of Vol I was published in February 2006. During his academic career, he has directed 55 Ph.D. students and countless postdoctoral researchers from many parts of the world. He has given keynote papers in numerous major national and international conferences.

During his career, he has been serving as consultant and technical adviser to government and industry, both in the U.S. and abroad, including the U.S. Department of Defense on nuclear defense, the U.S. Navy on surface effect ships and the mobile offshore base, the U.S. Air Force on missile defense, and the U.S. Coast Guard on marine and offshore structures. He has been involved in a number of other major studies and projects on the seismic safety analysis and design of nuclear power plants in the U.S., Japan, Taiwan, and Korea, and earthquake resistant design of buildings and other critical infrastructures.

He is active in several engineering societies particularly in the American Society of Civil Engineers where he served as International Director on the Board of Directors in 1998-2001, and as Chair of numerous technical committees including the Structural and Engineering Mechanics Divisions executive committees. He is currently the ASCE representative to the Asian Civil Engineering Coordinating Council (ACECC), and a member of the International Activities Committee. He is also a Fellow of the ASME (American Society of Mechanical Engineers), Associate Fellow of the AIAA (American Institute of Aeronautics and Astronautics), a founding member of IASSAR (International Association of Structural Safety and Reliability), Honorary President of IALCCE (International Association of Life-Cycle Civil Engineering), and a member of several other professional and scientific societies.

He has received a large number of prestigious awards from ASCE and other societies, including Honorary Membership in the ASCE and the N.M Newmark Medal, A. Freudenthal Medal, E. Howard Award, Huber Research Prize, State-of-Art Award; Senior Research Award from ASEE (American Society of Engineering Education); and Research Award from IASSAR; Research Award from the University of California, Irvine; Distinguished Engineering Alumni Award from the University of Illinois; the 2005 International Prize from the Japan Society of Civil Engineers, and is a member of the prestigious US National Academy of Engineering (elected in 1976).

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8-11 December 2019, Taipei
Chen, S. S. & Ang, Alfredo. H-S. (Editors)

RELIABILITY-BASED OPTIMAL DESIGN OF CIVIL INFRASTRUCTURE SYSTEMS

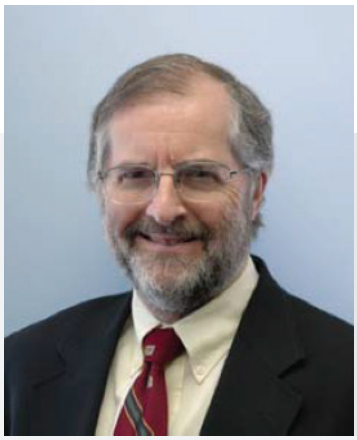
Alfredo H-S Ang
University of California, Irvine, CA, USA

Abstract

Optimality in the design of engineering systems is invariability one of the primary objectives of engineering design. For aerospace systems minimum weight is of primary concern, whereas for civil structures or infrastructure minimum cost is invariably the main objective.

Optimality, of course, must be achieved subject to a specified level of safety or reliability. In this regard, the reliability-based design of structural components has been well established. However, the reliability-based design of structures as a complete system remains an issue that has not been addressed adequately. This issue requires the assessment of the system reliability of a complete structure, considering the effects of both the aleatory and epistemic types of uncertainty. Proposed is a systematic approach for this purpose. The main issue can be addressed effectively using the PDEM (probability density evolution method) for the effects of the aleatory uncertainty, resulting in the PDF of the critical state of a system. The effects of the epistemic uncertainty can be included systematically as the error in the estimation of the critical state of the system.

To demonstrate the effectiveness of the method, two examples are illustrated: (1) the minimum life-cycle cost aseismic design of an existing high-rise building in Mexico City; and (2) the optimal design of high voltage transmission towers for life-cycle performance and reliability in China.



KEYNOTE SPEAKER 02

Prof. Bruce R. Ellingwood

- NAE Member
- Professor and College of Engineering Eminent Scholar Dept. of Civil & Environmental Engineering, Colorado State University, USA

Research Interests

- Applications of probability and statistics to structural engineering
- Structural reliability analysis
- Structural load and load combinations modeling
- Safety and serviceability criteria for structural design
- Stochastic mechanics and random vibration
- Abnormal loads and progressive collapse

Biography

Dr. Ellingwood received his undergraduate and graduate education at the University of Illinois at Urbana-Champaign. From 1975-1986, he held the position of Research Structural Engineer at the National Bureau of Standards (now the National Institute of Standards and Technology), and led the NBS Structural Engineering group from 1982 - 1986. He joined the Johns Hopkins University in 1986, was appointed Chairman of the Department of Civil Engineering in 1990, and was named the Willard and Lillian Hackerman Chair in 1997. He served on the faculty of the School of Civil and Environmental Engineering at Georgia Tech from 2000 - 2013, and was Chair of the School from 2000 - 2002. Since 2013, he has served on the faculty at Colorado State University, where he co-directs the NIST – sponsored Center of Excellence for Risk-Based Community Resilience Planning. Dr. Ellingwood's main research and professional interests involve the application of probability and statistics to structural engineering. Within the general field of structural reliability, his research has included structural load modeling, studies of performance of structures, development of safety and serviceability criteria for design, studies of abnormal loads, progressive collapse and the response of structures to fires, probabilistic risk analysis and stochastic mechanics. As Administrator of the Secretariat of the American National Standard Committee A58 (now ASCE Standard Committee 7) on Minimum Design Loads for Buildings and Other Structures from 1977 - 1984, he directed the development of the probability-based load criteria for limit states design that now appear in ASCE Standard 7 on Minimum Design Loads, the AISC Specification, ASCE Standard 16 on LRFD for Engineered Wood Construction, ACI Standard 318, and both national Model Building Codes. Dr. Ellingwood is internationally recognized as an authority on structural load modeling, reliability and risk analysis of engineered facilities, and as the leader in the technical development and implementation of probability based codified design standards for building structures. He has authored more than 400 papers and reports. He is Editor of Structural Safety, and serves on five other editorial boards. He has held numerous leadership positions in professional societies, and his research and professional service have garnered numerous awards from ASCE (including the Newmark Medal, Freudenthal Medal, Ang Award and the Norman Medal, which he has received twice), AISC and other professional organizations. He is a member of the National Academy of Engineering, a Distinguished Member of ASCE and an Inaugural Fellow of the Structural Engineering Institute of ASCE.

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PERFORMANCE-BASED ENGINEERING OF BUILDINGS FOR NATURAL HAZARDS

PRACTICAL IMPLEMENTATION OF RELIABILITY AND RISK-INFORMED DECISION

Bruce R. Ellingwood

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Abstract

Civil infrastructure facilities must be designed to withstand demands imposed by their service requirements and by environmental events such as windstorms or earthquakes. While buildings and other structures designed by current prescriptive provisions usually possess adequate levels of safety, extreme environmental or man-made events may cause them to suffer severe damage and economic losses. In an era of heightened public awareness of infrastructure performance and community resilience, structural engineers are seeking improvements to building and construction practices to achieve levels of performance beyond what currently is provided by prescriptive code provisions and to better meet owner, occupant and public expectations. Structural reliability methods have matured in the past four decades to the point that they now provide an internationally recognized framework for addressing building performance issues in modern codified structural design.

The new paradigm of performance-based engineering (PBE) enables structural engineers to achieve more reliable control of civil infrastructure performance across a range of hazards. PBE has gained acceptance in earthquake engineering and fire-resistant structural design, where the incentives to seek alternatives to prescriptive methods are strongly economic in nature, and in design for disproportionate collapse resistance, where the shortcomings of traditional prescriptive approaches to design are immediately apparent. New developments in performance-based approaches to wind engineering and other hazards will ensure that competing hazards are addressed in a balanced manner and that investments in risk reduction are targeted appropriately within financial constraints. Finally, public demands to enhance community resilience in an era of climate change, prompted by recent extreme hazard events, will require a fundamental change in the way that code and standard-writing groups approach their tasks to achieve community-wide resilience goals. Modern risk-informed decision tools will be essential to the successful implementation of PBE in providing a framework for managing the impact of uncertainties on performance and for guiding engineering decisions in an era of social and economic development, technological innovation and community resilience concerns.

Keywords

Buildings (codes); design (buildings); reliability; risk; structural engineering.

KEYNOTE SPEAKER 03

Prof. Dan M. Frangopol

- Professor
- The Fazlur R. Khan Endowed Chair of Structural Engineering and Architecture
- Professor of Civil Engineering, Department of Civil and Environmental Engineering, ATLSS Engineering Research Center, Lehigh University, Pennsylvania, USA

Research Interests

Dr. Frangopol's main research interests are in the development and application of probabilistic concepts and methods to civil and marine engineering including: structural reliability and probabilistic mechanics; life-cycle cost analysis; probability-based assessment, design, and multi-criteria life-cycle optimization of structures and infrastructure systems; structural health monitoring; life-cycle performance maintenance and management of structures and distributed infrastructure under extreme events (earthquakes, tsunamis, hurricanes, and floods); risk-based assessment and decision making; multi-hazard risk mitigation; infrastructure sustainability and resilience to disasters; and climate change adaptation.

Biography

Dr. Dan Frangopol is the inaugural holder of the Fazlur R. Khan Endowed Chair of Structural Engineering and Architecture at Lehigh University. Before joining Lehigh University in 2006, he was Professor of Civil Engineering at the University of Colorado at Boulder, where he is now Professor Emeritus. He is recognized as a leader in the field of life-cycle engineering of civil and marine structures. His main research interests are in the development and application of probabilistic concepts and methods to civil and marine engineering. Dr. Frangopol is the Founding President of the International Associations for Bridge Maintenance and Safety (IABMAS) and Life-Cycle Civil Engineering (IALCCE). He has authored/co-authored three books and many articles in archival journals including 10 prize winning papers. Dr. Frangopol delivered many plenary/keynote lectures at international conferences, symposia and workshops, and several named and distinguished lectures. He has served as a consultant or advisor to numerous companies. Dr. Frangopol is the Founding Editor of Structure and Infrastructure Engineering. He is the recipient of several medals, awards, and prizes, from ASCE, IABSE, IASSAR, and other professional organizations. Dr. Frangopol holds four honorary doctorates and 14 honorary professorships from major universities. He is a foreign member of the Academia Europaea (Academy of Europe, London), foreign member of the Royal Academy of Belgium, honorary member of the Romanian Academy, foreign member of the Academy of Technical Sciences of Romania, and a Distinguished Member of ASCE.

International Symposium on Reliability of Multi-disciplinary Engineering Systems under Uncertainty (ISRMES2019)
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RELIABILITY, RISK, RESILIENCE AND SUSTAINABILITY OF INFRASTRUCTURE SYSTEMS

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Abstract

Reliability analysis evaluates the probability of failure of engineering systems under various performance limits. It has been extensively used in structural design/standardization and more recently performance-based life-cycle management of infrastructure systems. In a multi-disciplinary setting, reliability analysis lends itself to a number of performance assessment processes associated with civil and marine infrastructure systems. These include risk, resilience, and sustainability performance of deteriorating and hazard-susceptible infrastructure assets and networks. This paper summarizes some of the recent advances in risk, resilience, and sustainability of infrastructure systems. The role of reliability analysis is highlighted.

Keywords

Reliability; Risk; Resilience; Sustainability; Life-cycle Management.

KEYNOTE SPEAKER 04

Prof. John Dalsgaard Sørensen

- Professor, Department of Civil Engineering, Aalborg University, Denmark

Research Interests

- Reliability and risk analysis within wind energy
- Wind turbines
- Civil engineering and Structural engineering

Biography

John Dalsgaard Sørensen, PhD is professor in Structural Reliability at Department of Civil Engineering, Aalborg University, Denmark. His main research fields are stochastic modelling, reliability assessment, risk-based decision making for planning of inspections and Operation & Maintenance. Application areas are buildings, bridges, offshore structures and wind turbines. Professor Sørensen has published more than 300 technical papers and co-authored several books and reports. He is involved in several national and international research projects related to risk and reliability of wind turbines and offshore structures. He also active in a number of standardization committees. Further, Prof. Sørensen is past-president in JCSS (Joint Committee on Structural safety).

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RELIABILITY ASSESSMENT OF WIND ENERGY STRUCTURES

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Abstract

Wind energy is a main contributor to the increasing demand for renewable energy. During the recent decades significant reductions in Levelized Cost of Energy (LCoE) for wind energy have been obtained through technological innovations. Wind turbines are exposed to highly dynamic loads that cause fatigue and extreme load effects which are subject to significant uncertainties. Continued reduction of cost of energy for wind energy should be performed such that the turbine components and system is designed to have sufficient reliability with respect to both extreme and fatigue loads. This paper presents models for uncertainty modelling and reliability assessment of critical wind turbine components.

The turbine components are designed to have sufficient reliability with respect to both extreme and fatigue loads but they should not be too safe (and costly). In this paper focus is failure modes related to degradation / fatigue of the considered components. This is especially important when planning inspections and maintenance.

Cost-optimal planning of inspections in relation to lifetime extension is considered in the paper and illustrative examples are presented.

Keywords

Wind turbines, reliability, stochastic modelling, inspections, lifetime extension.

KEYNOTE SPEAKER 05

Prof. Jui-Sheng Chou

- Distinguished Professor in Project Management, Dept. of Civil and Construction Engineering, National Taiwan University of Science and Technology,Taiwan

Research Interests

- Project Management; Civil & Hydraulic Engineering Informatics; Building Energy Management; Decision & Risk Analysis; Engineering Failure Analysis; Disaster Risk Reduction

Biography

Dr. Jui-Sheng Rayson Chou specializes in project management and engineering informatics. Currently, he is a Distinguished Professor with the Department of Civil and Construction Engineering at National Taiwan University of Science and Technology. Dr. Chou received his BS and MS from National Taiwan University and his PhD in Construction Engineering and Project Management at the Department of Civil, Architectural and Environmental Engineering - The University of Texas at Austin. He holds registered professional engineer licenses and serves on several professional committees. He has provided consulting services to a number of private and public engineering sectors. He is the author or co-author of over 370 journal articles, book chapters, conference papers, and technical reports related to engineering management. Many articles are published in high impact journals. He is one of the most cited scholars in the domain area of Google Scholars. As a devoted researcher and educator, he has cultivated more than 100 graduate talents and is a member of several international journal editorial boards. He is a recipient of numerous awards and honors, including nomination for the Eni Award 2020, MOST Outstanding Research Award, MOST Excellent Young Scholar Research Project twice, CCMA Best Construction Management Journal Paper of The Year twice, Best Paper Award multiple times in reputable international/domestic conferences, Innovation and Entrepreneurship Award several times, MOE Excellent Senior Faculty Award, Outstanding/Excellent Faculty Research Award five times at NTUST & NCCU, Excellent Industry-University Collaboration Faculty Award, Elsevier Outstanding Contribution in Reviewing, and Elsevier/ASCE Most Cited Articles at some time in the past. Additionally, he was awarded RISUD Visiting Fellowship (Construction Management) by the Kwong Wah Education Foundation and Del E. Webb Eminent Scholar at the Del E. Webb School of Construction as invited by The Hong Kong Polytechnic University and Arizona State University, respectively. His main teaching and research interests are engineering informatics related to technology & project management, decision analysis, quantitative analytics & intelligence, and risk reduction.

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TOWARD RELIABLE DESIGN FOR MITIGATING OPERATIONAL RISK IN WIND ENERGY PROJECTS

- LESSONS LEARNED FROM WIND TURBINE TOWER COLLAPSE AND BLADE FAILURE IN STRONG WIND -

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Abstract

In recent decades, the Taiwanese government has been vigorously promoting the development of the green energy industry, investing greatly in the photovoltaic and wind-energy sectors with the goal of developing renewable energy, the economy, and a sustainable environment. However, owing to its location, Taiwan is vulnerable to typhoons that bring fierce winds and torrential rain in the summer. These natural phenomena have damaged wind turbine blades and the collapse of many wind turbine towers in Taiwan, causing serious economic losses. This work examines the causes of these incidents and the mechanisms of turbine tower collapse and blade fracture to support risk prevention and the hazard-resistant design of wind turbines. Relevant domestic and foreign data are obtained to simulate wind turbine collapse. Next, mechanical analyses are performed using the finite element method to identify mechanisms of failure and structural weakness planes, with the ultimate goal of identifying possible causes of collapse. The structural mechanics of wind turbine blades are then analyzed using simulation models to identify the mechanisms of damage. Then, the root causes of strong wind-induced damage to, and collapses of, wind turbines are identified. Based on the results, methods for reducing the risk of such accidents are developed and solutions for improving the strong wind-resistance of wind turbine towers and their advantages are discussed. Recommendations concerning the use of weaker blades as a safety mechanism for a wind turbine tower, the torque capacity of the pitch system, and the required strength of joint bolts to be installed in steel structural connections, are made to help wind turbines and towers withstand severe storms. Hopefully, the analytical results of this study will help to prevent related engineering incidents in the future and provide a reference for stakeholders who must devise strategies to improve risk management and disaster prevention in wind power plants.

Keywords

wind turbine; natural hazard; structural failure; blade damage; tower collapse; forensic investigation; numerical simulation; reliable design; risk management.

KEYNOTE SPEAKER 06

Prof. Armen Der Kiureghian

- NAE Member
- Taisei Professor of Civil Engineering Emeritus,
  Department of Civil & Environmental Engineering
  Structural Engineering, Mechanics & Materials Program
  University of California at Berkeley
- President Emeritus, American University of Armenia, Yerevan

Research Interests

- Structural and system reliability, risk analysis, stochastic structural dynamics, earthquake engineering.

Biography

Armen Der Kiureghian received his B.S. and M.S. in Civil Engineering from the University of Tehran, Iran, and his Ph.D. in Structural Engineering from the University of Illinois at Urbana-Champaign in 1975. After three years at the University of Southern California, he joined the faculty at the University of California at Berkeley, where he has served as Assistant Professor (1978-81), Associate Professor (1981-85), Professor (1985-), Vice Chair (1990-93) and Chair (1997-2001) of the Structural Engineering, Mechanics and Materials Program and as Vice Chair for Instruction (2007-2009) in the Department of Civil & Environmental Engineering. He held the Taisei Chair in Civil Engineering from 1999 until his retirement from UC Berkeley in July 2015.

After the devastating Spitak earthquake of 1988 in Armenia, he was instrumental in establishing the American University of Armenia in Yerevan as an affiliate of the University of California. He is a Founding Member of the Board of Trustees of AUA. In addition, he served as the Founding Dean of the College of Engineering from 1991 to 2007, as the Founding Director of the Engineering Research Center from 1991 to 2004, and as Interim Provost from 2011-2012, all concurrently with his position at Berkeley. He served as the 4th President of AUA from July 2014 until June 2019, a period during which the University experienced tremendous growth in its programs, the number of students and faculty, and funding.

Der Kiureghian is a member of the American Society of Civil Engineers (ASCE), a Fellow of its Engineering Mechanics Institute (EMI), and member of the Earthquake Engineering Research Institute (EERI), the Seismological Society of America (SSA), the Earthquake Engineering Association of Armenia (EEAA), the International Association for Structural Safety and Reliability (IASSAR), and the Civil Engineering Risk and Reliability Association (CERRA). He is a past President of CERRA and was in charge of its ICASP9 conference in San Francisco, July 6-9, 2003. He also served as the Chair of the IASSAR Sub-Committee 3 on Structural Reliability and Optimization. During 1998-2004, he served on the Board of CUREE (Consortium of Universities for Research in Earthquake Engineering), including four years as the Treasurer of the Board. In the past, he has served as the Chair of the ASCE Engineering Mechanics Division Technical Committee on Probabilistic Methods and as Vice Chair of the Editorial Board of its Journal of Engineering Mechanics. He has served or is currently serving on the editorial boards of several journals, including Probabilistic Engineering Mechanics, Structural Safety, Earthquake Engineering & Structural Dynamics, International Journal of Seismology and Earthquake Engineering, Reliability Engineering and System Safety, and Structure and Infrastructure Engineering. He was honored as a distinguished alumnus of both his alma maters.

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MEASURES OF COMPONENT IMPORTANCE IN SYSTEM RELIABILITY ANALYSIS

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Abstract

A system, such as an electrical power distribution network or a transportation system, is typically composed of multiple components and the reliability of the system depends on the reliability of the components. Usually component states are inter-dependent due to common load effects, dependence between the component capacities, or because of physical dependence be-tween component functions. In such a system, the contribution of each component to the system failure probability cannot be isolated.

An important objective in assessing the reliability of a system is to identify the major contributors to the risk of failure and to find optimal ways of upgrading the system so that its reliability level is acceptable. In such a setting, it becomes important to understand the role of the system components in the overall risk and to identify the system components that are most op-timal for upgrading.

After a review of system reliability methods, this presentation will describe several measures of component importance in terms of their contributions to the system risk as well as their influence in enhancing the system reliability when the component is upgraded. Methods described include ones where complete probability information on joint component states is available, as well as those where this information is incomplete.

Concepts presented in this lecture will be demonstrated through an application to an electrical substation network that is subject to a potential earthquake ground motion.

Keywords

component reliability, importance measures, reliability upgrading, sensitivity, sys-tem reliability.

KEYNOTE SPEAKER 07

Prof. Jie Li

- Distinguished Professor
- Tongji University, China

Research Interests

- structural safety and reliability
- stochastic dynamic analysis of nonlinear structures

Biography

Prof. Jie Li is currently a Chair Professor in the Structural Engineering at Tongji University in the School of Civil Engineering, and the director of Shanghai Institute of Disaster Prevention and Relief. He specializes in the area of earthquake engineering and stochastic mechanics. Prof. Li received a Ph.D. in Civil Engineering from Tongji University, China in 1988, and received an honorary doctorate in engineering from Aalborg University, Denmark in 2013. Prof. Jie Li receives the 2014 Alfred M. Freudenthal Medal from ASCE, and awarded the second-class National Natural Science Award of China in 2016. He has been one of the first group of Cheung Kong Scholar Professors entitled by the Ministry of Education of China since 1999. Prof. Li is the author of six monographs, and is the co-author of over 400 technical publications, including over 300 peer reviewed journal papers, in the fields of earthquake engineering, nonlinear structural analysis, stochastic dynamics and reliability of structures and engineered systems. He currently serves as the President of the International Association for Structural Safety and Reliability (IASSAR), and the vice President of the Chinese Society of Vibration Engineering. He is the editor-in-chief of the Journal of Tongji University (Natural Science Series) and is in the editorial boarding committee of over 10 international and Chinese academic journals, including the International Journal of Nonlinear Mechanics and Structural Safety.

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LIFE-CYCLE RELIABILITY ANALYSIS OF ENGINEERING STRUCTURES

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Abstract

The existing structures with fatigue damage may suffer earthquakes in service period. Therefore, it is necessary to evaluate the life cycle seismic reliability of the existing structures.

This paper performs the life-cycle reliability analysis of the existing concrete structures under seismic excitations based on the physical synthesis method. By introducing the damage constitutive models of concrete, the physical equations of solid mechanics under fatigue loads are obtained. Considering the possibility of fatigue failure or seismic failure of structures, a structural failure criterion function is defined to deal with multiple failure modes. In addition, considering the characteristics of fatigue loads and earthquakes, a two-time scale probability density evolution analysis is proposed according to the probability density evolution method. On this basis, the complete equations for solving the reliability of the structures under both fatigue loads and earthquakes are derived based on the physical comprehensive method. By solving these equations, the existing engineering structure for the whole life cycle is finally obtained. Furthermore, the reliability under both fatigue loads and earthquakes are compared in details with that under fatigue loads and under earthquakes. The comparison results illustrate that the seismic ability of the existing structures is far lower than that of new structures.

Keywords

Reliability analysis, life cycle, engineering structures, fatigue loads, earthquakes, physical comprehensive method

KEYNOTE SPEAKER 08

Prof. Billie F. Spencer, Jr.

- Nathan M. & Anne M. Newmark Endowed Chair in Civil Engineering
- Director, Multi-Axial Full-Scale Sub-Structured Testing & Simulation Facility
- Director, Smart Structures Technology Laboratory

Research Interests

- Structural health monitoring, structural control, machine learning, computer vision, stochastic fatigue, stochastic topology optimization, and natural hazard mitigation

Biography

Professor B.F. Spencer Jr. is the Nathan M. and Anne M. Newmark Endowed Chair in Civil Engineering at the University of Illinois. He holds a B.S. in Mechanical Engineering (University of Missouri – Rolla 1981), and M.S. and Ph.D. in Theoretical and Applied Mechanics (University of Illinois at Urbana-Champaign 1983, 1985). He joined the faculty of the department of Civil and Environmental Engineering at the University of Illinois in 2002. Dr. Spencer served as a professor at the University of Notre Dame from 1985-2002, where he held the Leo E. and Patti Ruth Linbeck Professor of Engineering.

Dr. Spencer has taught graduate and undergraduate courses in structural mechanics, structural dynamics, and structural reliability. Dr. Spencer has directed more than $60M in funded research and published more than 700 technical papers/reports, including two books. The first is a monograph entitled, On the Reliability of Nonlinear Hysteretic Structures Subjected to Broadband Random Excitation (Springer-Verlag 1986). The second book, coauthored with Prof. K. Sobczyk, is entitled, Random Fatigue: From Data to Theory (Academic Press 1992).

Dr. Spencer has received numerous awards, including the ASCE Norman Medal, the ASCE Housner Structural Control and Monitoring Medal, the ASCE Newmark Medal, the Zhu Kezhen International Lectureship Award, the ANCRiSST Outstanding Senior Investigator Award. Dr. Spencer is a Fellow of ASCE and a Foreign Member of the Polish Academy of Sciences. He serves on the editorial board of the Journal of Structural Control and has served as associate editor for the ASCE Journal of Structural Engineering. He is the North American Editor in Chief of Smart Structures and Systems, the managing executive editor of Earthquake Engineering and Engineering Vibration, and the president of the Asia-Pacific Network of Centers for Research in Smart Structures Technology.

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MIN-MAX FORMULATION FOR TOPOLOGY OPTIMIZATION OF STRUCTURES SUBJECTED TO STOCHASTIC EXCITATION

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Abstract

Topology optimization provides a general approach to obtain optimal material layout to carry a specified load within specified constraints. Typical structural design goals require minimization the maximum among several objectives of interest; however, such an envelope function is typically non-smooth, which impairs the use of efficient gradient-based optimizers. In addition, many of the most severe dynamic loads that civil structures withstand are stochastic in nature, which should be incorporated into the optimization framework.

This study models the stochastic excitation as a zero-mean filtered white noise; an augmented state space representation is formed by combining the structure and excitation equations of motion; the stationary covariances of the structural responses of interest are obtained by solving a large-scale Lyapunov equation. The optimization problem is formulated to minimize the maximum among the covariances of the structural responses of interest. Subsequently, this min-max problem is transformed to an equivalent smooth formulation. A gradient-based method is used to update the design variables, while the sensitivities are computed using an efficient method that requires the solution of adjoint Lyapunov equations.

To illustrate the framework, topology optimization of a mid-rise building under lateral seismic excitation is performed. The results demonstrate the benefits of this approach to topology optimization of stochastically excited structures.

Keywords

Topology optimization, Min-max optimization, Stochastic dynamics, Lyapunov equation.

KEYNOTE SPEAKER 09

Prof. Yan-Gang Zhao

- Professor,
  Dept. of Architecture, faculty of Engineering,
  Kanagawa University, Japan
- Foreign associate, The Engineering Academy of Japan

Research Interests

- Structural Engineering, Structural Safety, Structural Reliability, Dynamic structural analysis.

Biography

Yan-Gang Zhao is a professor of Structural Engineering in Dept. of Architecture, Kanagawa University. He is also a pluralistic distinguished professor of Beijing University of Technology. His research interests are mainly on stochastic dynamic structural analysis and structural reliability theory, especially on system reliability analysis, dynamic reliability evaluation and structural reliability analyses based on methods of high order moments. Prof. Zhao is the author or co-author of three books and more than 200 articles in various technical journals, conference proceedings, such as ASCE journal of Structural Engineering, ASCE journal of Engineering Mechanics, Earthquake Engineering and Engineering Dynamics. He has chaired and participated more than 20 research projects including Key projects of the Natural Science Foundation of China, projects of Grant-in-aid from Ministry of Science and Education of Japan. Prof. Zhao is a member of a number of national and international committees and associations that focus on risk and reliability analysis. He received the Tokai Research Award of the Architecture Institute of Japan in1997 and the JAABE best paper award by the Architecture Institutes of Japan, Korea and China in 2003. In 2008, he received the Research Prize of Architecture Institute of Japan. In 2019, he become a foreign associate of the engineering academy of Japan.

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STRUCTURAL RELIABILITY ANALYSIS WITHOUT EXCLUSION OF THE EPISTEMIC UNCERTAINTY IN DISTRIBUTION PARAMETERS

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[2] Key Laboratory of Urban Security and Disaster Engineering, Beijing University of Technology, Beijing, China
[3] Department of Architecture, Kanagawa University, Yokohama, Japan
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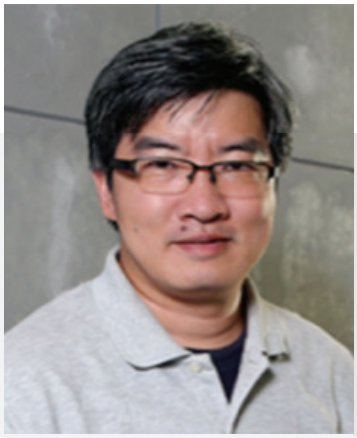
Abstract

In practical engineering, epistemic uncertainty plays an important role in structural reliability analysis, and statistical uncertainty is often a more important source than other sources of epistemic uncertainty. In the presence of statistical uncertainty, the statistical parameters (e.g., mean, standard deviation, skewness, and kurtosis) in distribution function are usually uncertain. In this case, the traditionally defined failure probability and the related reliability index become random variables, which are termed as the conditional failure probability and the corresponding conditional reliability index, respectively. Under such circumstances, it is necessary to obtain the expected and percentile value of the conditional failure probability, or even its probability distribution.

In this study, the evaluation of structural reliability considering the uncertainty in distribution parameters is investigated. Since the variability of the conditional reliability index is much smaller than that of the conditional failure probability, the determination of the probability distribution of which is the focus of this study. The first four central moments (i.e., mean, standard deviation, skewness, and kurtosis) of the conditional reliability index are computed using the Smolyak-type quadrature formula first. These moments are then employed to determine the four parameters of the cubic normal distribution used to approximate the distribution of the conditional reliability index. Finally, the probability distribution function of the conditional reliability index is utilized to obtain an explicit formula for the percentile value of the conditional failure probability. The effectiveness and accuracy of the proposed methodology for structural reliability assessment considering the uncertainty in distribution parameters are demonstrated through two examples, where Monte Carlo simulations are utilized for comparison.

Keywords

Structural reliability analysis; Epistemic Uncertainty, Distribution parameter; Conditional failure probability; Conditional reliability index; Smolyak-type quadrature formula.



KEYNOTE SPEAKER 10

Prof. Jianye-Ching

- Distinguished Professor
Geotechnical Group, Dept. of Civil Engineering National Taiwan University, Taiwan

Research Interests

- Geotechnical reliability analysis
- Basic uncertainties in soil properties
- Random fields & spatial variability
- Reliability-based geotechnical design codes
- Probabilistic site characterization
- Machine learning & big geotechnical data

Biography

Dr. Ching is Distinguished Professor in the Dept. of Civil Engineering at National Taiwan University. He graduated from National Taiwan University (BS 1993 and MS 1995), obtained the PhD degree in 2002 in University of California at Berkeley, and was a postdoctoral fellow in California Institute of Technology (2002-2004). His main research interests are geotechnical reliability analysis & reliability-based design, basic uncertainties in soil properties, random fields & spatial variability, reliability-based geotechnical design codes, and probabilistic site characterization. He is Chair of TC304 (risk) in ISSMGE and Chair-Elect of GEOSNet. He serves as Editor-in-Chief for Journal of GeoEngineering, Managing Editor for Georisk, and Editorial Board Member for Canadian Geotechnical Journal and Structural Safety.

Dr. Ching is the recipient of the Outstanding Research Award (2011, 2014) and the Wu-Da-Yu Award (2009) from the Ministry of Science and Technology of Taiwan, Republic of China. Besides, he has received the following awards and recognition: Georisk Best Paper Award (2014), Editor’ s Choice Paper from Canadian Geotechnical Journal (2014, 2017), Highly Cited Research from Structural Safety (2016), Outstanding Reviewer from Canadian Geotechnical Journal (2015, 2016), and Outstanding Reviewer from ASCE-ASME Journal of Rick and Uncertainty in Engineering System (2016).

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CONSTRUCTING SITE-SPECIFIC MULTIVARIATE PROBABILITY DISTRIBUTION MODEL: HYBRIDIZATION VERSUS HIERARCHICAL BAYESIAN ANALYSIS

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Abstract

It is challenging to construct site-specific multivariate probability distribution models because the site-specific data are usually sparse and incomplete. In contrast, there are abundant generic data in the literature for the construction of multivariate probability distribution models, but those models are non-site-specific. Is there a connection between site-specific data and non-site-specific data? How do we quantify this connection? How do we use this connection to construct a quasi-site-specific multivariate probability distribution model by combining site-specific and generic data? The author has previously proposed a hybrid method of combining the two sources of data to construct quasi-site-specific models. In the current speech, a more rigorous method, called the hierarchical Bayesian analysis, is adopted in place of the hybrid method. The outcomes of the two methods will be compared, and their cons and pros will be assessed. Recommendations about their use in the context of constructing quasi-site-specific multivariate probability distribution models will be made based on the comparison and assessment results.

Keywords

Geotechnical engineering, multivariate probability model, site characterization, hierarchical Bayesian analysis.

KEYNOTE SPEAKER 11

Prof. Kok-Kwang Phoon

- Distinguished Professor, Dept. of Civil and Environmental Engineering, National University of Singapore, Singapore
- Vice-Provost (Academic Personnel), National University of Singapore, Singapore

Research Interests

- Soil/rock databases, model factors, reliability-based design, and Bayesian machine learning in geotechnical engineering

Biography

Kok-Kwang Phoon is Professor of Civil and Environmental Engineering and Vice Provost (Academic Personnel), National University of Singapore. He obtained his BEng and MEng from the National University of Singapore and his PhD from Cornell University. He is a Professional Engineer in Singapore, an ASEAN Chartered Professional Engineer, and past President of the Geotechnical Society of Singapore. Prof Phoon is particularly interested in developing statistical and other data-driven methods to support decision making in geotechnical engineering. He is the lead editor of 3 books: Reliability of Geotechnical Structures in ISO2394 (2016)（基于 ISO2394 的岩土工程可靠度设计，中国水利水电出版 社，2018）, Risk and Reliability in Geotechnical Engineering (2015), and Reliability-Based Design in Geotechnical Engineering (2008). He was bestowed with numerous research awards, including the ASCE Norman Medal in 2005, the John Booker Medal in 2014, the Humboldt Research Award in 2017, and the Sloan Outstanding Paper Award in 2019. He is the Founding Editor of Georisk and advisory board member for the World Economic Forum (WEF) Global Risks Report. He was elected as a Fellow of the Academy of Engineering Singapore in 2012 and appointed as Distinguished Professor in NUS (2013), Luojia Distinguished Visiting Professor in Wuhan University (2018), and August-Wilhelm Scheer Visiting Professor in Technical University of Munich (2019). He is a widely sought after lecturer having delivered more than 100 talks in over 90 cities around the world, including the inaugural S.L. Lee Lecture in Singapore, 11th J.E. Jennings Memorial Lecture in South Africa, 10th Sun Jun Lecture in China, 4th Wilson Tang Lecture in the Netherlands, 10th Lumb Lecture in Hong Kong, and forthcoming: 4th Suzanne Lacasse Lecture in Taiwan.

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CHICKEN (METHOD) AND EGG (DATA) - WHICH COMES FIRST?

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Abstract

Geotechnical uncertainty representation has hitherto been focused on the method. The small sample size encountered in geotechnical engineering will not be viewed as a "curse" if methods were to be developed with the MUSIC (multivariate, uncertain and unique, sparse, incomplete, partially corrupted) nature of site data as the starting point. We have the curse of small sample size. We have the curse of de-trending. These problems emerge from methods that are developed somewhat independently of the data we actually have at hand. The authors advocate a "data-driven" perspective that requires: (1) a detailed understanding of the features of geotechnical data, which include uncertainty and spatial variability and (2) a method that can operate on all data, not simply data that fit the method. Preliminary research shows that the Bayesian compressive sampling is a possible candidate data-driven method in terms of its ability to accommodate geotechnical data features and its responsiveness to changes in these features. The chicken (method) has always come before the egg (data). It is time to put the egg before the chicken.

Keywords

Geotechnical data, MUSIC, Data-driven method, Bayesian compressive sampling.

KEYNOTE SPEAKER 12

Prof. Junho Song

- Professor, Department of Civil and Environmental Engineering, Seoul National University, South Korea

Research Interests

- Structural & System Reliability Analysis
- Reliability Based Optimization & Decision Making
- Earthquake Engineering & Random Vibrations
- Statistical/Machine Learning for Urban Infrastructure Systems under Uncertainties

Biography

Junho Song received his B.S. and M.S. in Civil Engineering from Seoul National University, Korea and his Ph.D. in Civil & Environmental Engineering from the University of California at Berkeley, USA in 2004. After working as a postdoctoral researcher at UC Berkeley (2004-2005) and a senior vulnerability engineer at Risk Management Solutions, Inc. (2005), he joined the faculty of the University of Illinois at Urbana-Champaign, USA to serve as Assistant Professor (2005-2011), Associate Professor (2011-2013), and CEE Excellence Faculty Scholar (2012-2013). In 2014, Dr. Song joined the faculty of the Department of Civil & Environmental Engineering at Seoul National University as a Young Scholar for the Next Generation, where he has been serving as Associate Professor (2014-2016), Director of the Convergence Research Center for Disaster-Hazard Resilience (2015-2017), and Professor (2016-present).

Dr. Song teaches graduate and undergraduate courses in the area of engineering risk & uncertainty, structural/system reliability, structural random vibrations, and information engineering for CEE and smart cities. He has research interests in (1) structural & system reliability analysis, (2) reliability-based design/topology optimization and decision-making, (3) risk, reliability and resilience analysis of urban communities and networks, (4) earthquake engineering & random vibrations, and (5) statistical/machine learning for urban infrastructure systems under uncertainties. Dr. Song has presented his research outcomes through 74 papers published in peer-reviewed archival journals and more than 190 conference presentations. In 2009, his technological innovations in the area of System Reliability and Optimization was recognized by an IASSAR Research Prize. In 2018, he was listed as one of the 100 Future Technologies and Leaders of Korea in 2025 by the National Academy of Engineering of Korea, and received a Shinyang Engineering Academic Award.

Dr. Song is a member of the American Society of Civil Engineers (ASCE), the Korean Society of Civil Engineers (KSCE), the Earthquake Engineering Society of Korea (EESK), the National Academy of Engineering of Korea (NAKE), and many others. He has been serving as a member of the Probabilistic Methods Committee of ASCE Engineering Mechanics Institute, four editorial boards of international journals (including Structural Safety, and Reliability Engineering & System Safety), SC3 subcommittee of International Association for Structural Safety and Reliability (IASSAR), Joint Committee on Structural Safety (JCSS), and the Board of Directors of the International Civil Engineering Risk and Reliability Association (CERRA). Dr. Song is currently serving as the President of CERRA (2019-present) and the IFIP Working Group 7.5 on Reliability and Optimization of Structural Systems (2016-present).

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GAUSSIAN MIXTURE BASED EQUIVALENT LINEARIZATION METHOD (GM-ELM): GENESIS, DEVELOPMENTS AND EARTHQUAKE ENGINEERING APPLICATIONS

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Abstract

A new nonlinear random vibration analysis method termed Gaussian mixture based equivalent linearization method (GM-ELM) was recently proposed [1]. GM-ELM approximates the probabilistic distribution of a nonlinear system response by a Gaussian mixture distribution model to decompose the non-Gaussian response of interest into multiple Gaussian responses of linear single-degree-of-freedom oscillators. Using this alternative concept of equivalent linear system (ELS) and random vibration theories, key response statistics including the mean up-crossing rate, first-passage probability and mean peak response can be obtained efficiently and accurately. GM-ELM has been further developed to improve its accuracy [2], and overcome technical challenges [3] with regard to dependency of the ELS on the ground motion intensity and requirement for the stationary condition. This paper summarizes the main idea and recent developments of GM-ELM, and presents GM-ELM based fragility analysis of nonlinear structures under nonstationary excitations. The results will be compared with those by existing random vibration analysis methods to identify merits and future research topics.

Keywords

Equivalent linearization, Fragility analysis, Gaussian mixture, Nonlinear analysis, Random vibration, Response spectrum

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KEYNOTE SPEAKER 13

Prof. Jianbing Chen

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Research Interests

- tochastic mechanics and engineeringreliability for structures and systems
- Nonlinear analysis of structures
- Concrete structures

Biography

Dr. Jianbing Chen is currently a full professor on the faculty at Tongji University in the School of Civil Engineering & State Key Laboratory of Disaster Reduction in Civil Engineering. Dr. Chen received a Ph.D. in Civil Engineering from Tongji University, China in 2002. He has been a visiting scholar/visiting professor in the University of Southern California in USA (2006-2007), Aalborg University in Denmark (2012), and Vienne University of Technology in Austria (2014).

He specializes in the area of earthquake engineering, stochastic dynamics and structural reliability. Specifically, he is working on the development of probability density evolution method (PDEM) for performance evaluation and reliability assessment of structures/engineering systems involving randomness both in the system properties and excitations. Dr. Chen is the co-author of an English book titled “Stochastic Dynamics of Structures” (John Wiley & Sons, 2009), the co-author of 3 Chinese books and over 120 peer-reviewed journal papers, in the fields of structural stochastic analysis and reliability theory. He was selected into the “NCET Plan” of Ministry of Education of China in 2007, received the Huo Ying Dong prize in 2012, “National Outstanding Scientific and Technological Workers” of China in 2014, the second-class National Natural Science Award of China in 2016 (2nd achiever), the EarlyAchievement Award of the International Association for Structural Safety and Reliability in 2017, and was granted by the National Natural Science Fund for Distinguished Young Scholars in China.

He now also serves as a member of Board of Directors of the International Civil Engineering Risk and Reliability (CERRA), a member ofthe Joint Committee on Structural Safety (JCSS), Chairman of the Random Vibration Committee of the Chinese Society forVibration Engineering (CSVE), Chairman of the Vibration Mechanics Committee of the Shanghai Society of Theoretical and Applied Mechanics (CSTAM), Associate Editor of the journal Structure and Infrastructure Engineering, and in the editorial board of the journals including Probabilistic Engineering Mechanics and Chinese Journal of Vibration Engineering, etc.

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A NEW PDEM-CONSISTENT FUNCTIONAL PERSPECTIVE TO UNCERTAINTY QUANTIFICATION OF STRUCTURAL SYSTEMS INVOLVING UNCERTAIN PARAMETERS

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Abstract

Great challenges still exist in the uncertainty quantification (UQ) and propagationof real-world complex structural systems, where uncertainties are invetibly involved, say in material or geometric parameters. Generally, due to the prohibitive computational efforts in the existing methods, besides the stochastic response analysis and reliability, difficulties exist in many aspests, including: (1) quantification of simultaneous aleotory and epistemic uncertainties; (2) global sensitivity of quantity of interest in terms of basic parameters random in nature; and (3) life-cycle reliability and reliability updating due to data accumulation and source randomness updating. The probability density evolution method (PDEM) provides an efficient solution strategy for stochatic response and reliability evluation of engineering structures. In the present paper, the new advances by advocating a novel PDEM-based functional perspective to uncertainty quantification of structuers involving random parameters are outlined. The basic idea of the new functional perspective is introduced, and then the extensions of applications to resolve the above existing difficult problems are exemplied. Problems to be further studied are also discussed.

Keywords

Uncertainty quantification,Probability density evolution method (PDEM), Functional analysis, Global sensivitiy, Change of probability measure.

KEYNOTE SPEAKER 14

Prof. Zhao-Hui Lu

- Professor, Beijing University of Technology, China

Research Interests

- Structural reliability assessment using methods of moment
- Steel corrosion and its effects on mechanical property and structural behavior
- Risk-cost optimised maintenance strategy for high-speed railway engineering structures

Biography

Dr. Zhao-Hui Lu is currently a professor of College of Architecture and Civil Engineering at Beijing University of Technology. He got his bachelor degree from Central South University in 1999, master degree from Tongji University in 2002, and Ph.D. degree from Nagoya Institute of Technology in 2007. From 2007 to 2009 he did post-doctoral study and worked as a Japan Society for the Promotion of Science (JSPS) Postdoctoral Fellow at Nagoya Institute of Technology and Kanagawa University. He has been associate professor (2009-2014) and full professor (2014-2018) at Central South University, and full professor from 2018 to present at Beijing University of Technology. His expertise includes structural reliability assessment based on method of moments and risk-cost optimised maintenance strategy for concrete structures with emphasis on high-speed railway engineering structures using time-dependent reliability method. He has chaired and participated in more than 8 research projects including the National Natural Science Fund for Excellent Young Scholars of China and Key Projects of International Cooperation and Exchanges from NSFC. Prof. Lu is the author or co-author of more than 70 articles in various technical journals such as ASCE Journal of Structural Engineering, ASCE Journal of Engineering Mechanics and conference proceedings. He was awarded the First prize of Railway Science and Technology of China Railway Association in 2014 due to his innovative and significant contribution in the field. He is the Chair of the 7th International Symposium on Reliability Engineering and Risk Management, and an active member of Committee of Structural Reliability, Bridge and Structural Engineering Branch of China Society of Civil Engineering.

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TIME-DEPENDENT RELIABILITY ASSESSMENT OF HIGH-SPEED RAILWAY BALLASTLESS TRACK-BRIDGE STRUCTURAL SYSTEM

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Abstract

By the end of 2018, the operating mileage of China's high-speed railway (CHSR) had reached 30,000 kilometers, which constitutes the world' s largest high-speed rail network, including four rail lines north to south and four lines east to west. And thus the development of CHSR has shifted from the stage of large-scale construction to the stage of long-term safe and stable operation. The ensurance of the life-cycle reliability of high-speed railway engineering structures, which is the substantial carrier of high-speed railway operation, is a key research task currently faced by China. Since the high-speed train load, the environment actions and the structural resistance are random and vary over time, time-dependent reliability method should be utilized to evaluate the service performance of engineering structures. In this study, the typical CRTS II ballastless track-bridge structural system is focused on. The condition assessment indices including safety and serviceability of the structural system subjected to combined environmental actions and mechanical loads are firstly identified. A novel and efficient approach for evaluating the time-dependent failure probability of structures with complicated, multi-dimensional and implicit performance functions involving correlated random variables is proposed and applied to conduct the time-dependent reliability analysis of the structural system. The proposed methodology provides a useful tool for further study on making the life-cycle risk-cost optimized maintenance strategy, which is assumed as a more reasonable measure for guaranteeing the safe, punctual, and efficient operation of Chinese high-speed railway.

Keywords

high-speed railway, CRTS II ballastless track-bridge structural system, condition assessment indices, safety and serviceability, time-dependent reliability.

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MA1-1

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STRUCTURAL MONITORING OF PASSIVE CONTROL OF VIBRATION STRUCTURE

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Abstract

Kanagawa University, which is a low-rise steel structure, conducts structural health monitoring. In structural health monitoring, strong earthquake motions are observed on the ground and building. In this paper, the transfer function obtained from observation records was examined. At the completion of the building, we always conduct microtremors and shaker experiments. The results of microtremors and shaker experiments were almost the same. The natural frequency in the X direction was 2.4 to 2.5 Hz. The natural frequency in the Y direction was 2.6 to 2.7 Hz. Monitoring has been conducted for 5 years. We have organized 15 earthquakes with tremendous vibration in 5 years. In earthquakes where the maximum acceleration is large in the X direction, the natural frequency tends to be slightly lower. However, such a trend could not be confirmed in the Y direction. We will continue to observe and proceed with further analysis.

Keywords

Structural Health Monitoring, Observation of Strong Earthquake Motion, Primary Natural Frequency,Passive Control of Vibration Structures, secular change.

MA1-2

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COLLISION EXPERIMENT AND SIMULATION ANALYSIS OF BASE-ISOLATED BUILDING MODEL TO RIGID RETAINING WALL BY SMALL SHAKING TABLE TEST

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Abstract

When the earthquake that is much greater than predictionoccur, base-isolated buildings have possibility to collide withthe surrounding retaining wall. Because ofthe isolator, the human life and the facility in the building may be protected, but the damage of the building is unclearunder the present conditions.By the previous researches, the building response for the collision to the retaining wall is being elucidated, but could not evaluate the building damage because the past studies do not have any damage in the building. Therefore we performed theexperiment that the base-isolated building model collide to the rigid retaining wall using the small shaking table. We confirmed the difference of the building response by changing the building stiffness and the input wave. After that, we performed numerical analysis about some experiment cases. We compared between the experiment results and analysis results, and verified the validity of the damage evaluation.

Keywords

Collision to Retaining Wall, Base-Isolated Building, Simulation Analysis,System Identification, Shaking Table Test

MA1-3

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SEISMIC RESILIENCE ASSESSMENT ON STEEL BRACED-FRAME

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Abstract

The concept of seismic resilience, i.e., the capability of the object to maintain a level of functionality after an earthquake and recover to the original state as soon as possible, has been widely accepted in structure engineering field over the past two decades. As the current situation in Japan, although research on this topic has been focused gradually, most of the studies still remain on the theoretical and application stage. Furthermore, for earthquake-prone countries like Japan, although steel braced-frames have usually been applied as a fundamental structural type to resist the seismic force, the role of braces on improving seismic resilience of steel frames has not been investigated. In this paper, a methodology based on a proposed conceptualization framework to conduct seismic resilience assessment suitable for single buildings is summarized. And following this procedure, seismic resilience assessment on two analytical steel frame models with and without braces are performed. Finally, by comparing the two calculated seismic resilience indices, braces are confirmed quantitatively as effective structural members that can enhance seismic resilience of main structures.

Keywords

seismic resilience assessment, loss function, recovery function, fragility analysis, steel frame

MA1-4

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STUDY ON CONFINEMENT PATH OF FRP-CONFINED CONCRETE COLUMN

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Abstract

Previous research has indicated that the compressive strengths of the concrete were obviously affected by the confinement paths of confined concrete in circular concrete-filled steel tube (CFST) short columns that withstands axial compression. However, investigation into the confinement paths on the compressive strengths of confined concrete in axially loaded circular fiber reinforced polymer (FRP) confined concrete columns has been still limited. The purpose of this paper is to investigate the confinement paths of confined concrete and their corresponding effects on the compressive strengths of confined concrete in axially loaded circular FRP-confined concrete columns. An experimental program with a total of 32 specimens was carried out, and the detailed parameters that include the concrete strength and layers of FRP were investigated. The results suggested that the confinement paths of confined concrete in axially loaded circular FRP-confined concrete columns were significantly affected by the column parameters, and had no lateral stage which were different from those in circular CFST short columns. Based on the test results, a compressive strength model incorporating the confinement path effects is optimized and good performance was found in comparison with the experimental results.

Keywords

Confinement path, Compressive strength, Fiber reinforced polymer (FRP) confined concrete column, Compressive strength model.

MA1-5

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RELIABILITY ANALYSIS OF TOTAL CONSTRUCTION DURATION BASED ON CUBIC NORMAL DISTRIBUTION

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Abstract

In recent years, the combination of Building Information Modeling (BIM) technology and the Project Management and Review Technology (PERT) has been widely applied to the optimization of construction schedule. Construction schedule control is one important part of the management of construction schedule. Therefore, the reliability analysis of total construction duration is necessary for construction companies. Most of the existing studies on the reliability analysis of the total construction duration prepared by PERT assumed that the total construction duration is subject to a normal distribution. However, in actual projects, the distributions of the total construction duration are usually unknown. To address this issue, a flexible distribution was utilized to represent the distribution of the total construction duration. In the proposed method, the cubic normal distribution which determined by its first four moments (mean, standard deviation, skewness and kurtosis) was adopted to fit the distribution of the total construction duration. After obtaining its cubic normal distribution, a more rational reliability analysis of the total construction duration was conducted. Through a practical engineering case, it is proved that the proposed method is more accurate and efficient.

Keywords

Reliability analysis, Cubic normal distribution, Total construction duration

MA1-6

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A STUDY ON STRENGTH AND DEFORMATION CAPACITY AFTER BENDING STRENGTH OF POST-TENSIONING PRECAST BEAMS USING UNBONDED TENDONS

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Abstract

Among the test specimens we have done in the past, there was a specimen that was shear fractured because the maximum strength was determined by the bending strength, the deformation progressed thereafter, the end concrete was crushed, and the arch mechanism strength was reduced. We think that shear failure can be suppressed by increasing the reinforcing bars at the end and restraining the concrete. Therefore, we experimented with four specimens with different shear reinforcements at the end of the specimen. As a result of the experiment, the following knowledge was obtained. Bending strength, shear strength, and shear crack strength can be roughly evaluated by the existing formulas. In a specimen with a shear span ratio of 1.5, high deformation performance can be obtained by inserting a core reinforcement in the end of specimen. And the deformation performance is higher when using the core reinforcement to increasing the rigidity than when using the high-strength reinforcing bars to increasing $P_w\sigma_y$.

Keywords

Prestressed concrete , Unbonded PC , Deformation Capacity , Shear performance.

MB1-2

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SIMULATION OF DISTRIBUTED GEOTECHNICAL HAZARDS ON A DRUM CENTRIFUGE

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Abstract

A class of distributed hazards is difficult to simulate on a beam centrifuge, such as long-distance landslides, debris flows, and hillslope and coastal erosion. A drum centrifuge, with the advantage of much longer model channel and smaller boundary effects than those of a beam centrifuge, is an alternative and a more suitable tool for studying such distributed geotechnical hazards. A modular drum centrifuge equipped with a 3D robot will be installed in the Hong Kong University of Science and Technology. The drum centrifuge will have a maximum centrifugal acceleration of 250 g and a model channel 0.7 m in width and 6.91 m in length. The 3D robot is capable of forming various models in-flight as it can serve as a sand rainer, soil pourer or model profiler. A fluid circulation system will be developed to trigger a soil slide or initiate bed erosion or a debris flow within the drum channel. A compact high-speed image capture system using a high-speed camera and particle image velocimetry (PIV) techniques, and an array of sensors will be installed to capture the flow velocity along the long drum channel.

Keywords

centrifuge modelling; drum centrifuge; 3D robot; fluid circulation system; instrument system; geotechnical hazard.

MB1-3

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FLOOD AND ITS IMPACT ON URBAN SYSTEMS UNDER EXTREME RAINSTORMS: A CASE STUDY IN HONG KONG

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Abstract

Hong Kong is a densely populated metropolis. It is faced with increasing intensity of rainstorm due to climate change. To enhance the resilience of the city, it is important to analyze the impact of flood resulted from extreme rainstorms on the city. In this study, flooding induced by an extreme rainstorm is simulated for Kowloon, Hong Kong. The urban settings, namely, building and drainage system are incorporated into the flood simulation model. To illustrate the effectiveness of drainage system in reducing the flood, flood simulation is also carried out for the case without the drainage system. The impact of flood on major roads and MTR (Mass Transit Railway) stations is investigated. The results show that the study area would be severely flooded with 16 MTR stations and more than 60 major roads affected by the flood if the drainage system did not work, while the drainage system could effectively reduce the number of affected major roads and MTR stations. The results also suggest that although current drainage system in Kowloon is capable of preventing severe flooding, some low-lying areas are still prone to flood hazard and more measures should be taken to deal with the flooding in those areas.

Keywords

flood, urban systems, extreme rainstorm, drainage system.

MB1-4

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NATURAL TERRAIN LANDSLIDE RISK TO POPULATION UNDER EXTREME STORMS

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Abstract

Many landslides can occur during a severe storm and cause unexpected consequences. Landslides in Hong Kong interact intensely with human activities in densely populated areas. This paper quantifies the elements at risk in terms of buildings and population in the buildings. The approach includes producing landslide and risk maps and quantifying the numbers of buildings of all types and exposed individuals affected by the landslides under two rainstorm scenarios of 29% and 85% Probable Maximum Precipitation (PMP). The number of persons at risk inside each building was based on estimation of number of floors, number of flats and the average number of people living in a flat in Hong Kong during the time of the event. Within the high prone areas of the western parts of Hong Kong Island, the dispersal rate of the landslides varies depending on the terrain of the area. The north-eastern part with relatively even terrain will experience fewer landslides. For the storm with a rainfall intensity of 85% PMP, the most affected buildings and population are in the residential buildings, Among the least affected buildings and population are hospitals, community and church buildings. Only one residential building is affected under the storm scenario of 29% PMP. The outcome of this study is useful for future risk assessment and management.

Keywords

Landslides, extreme storms, element at risk, climate change.

MA2-1

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PRELIMINARY STUDY ON THE RISK EVALUATION OF OFFSHORE WIND POWER INDUSTRILIZATION IN TAIWAN

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Abstract

In the past, Taiwan engineer' s experience was mainly based on onshore engineering, such as bridges, tunnels, reservoirs, etc.. But from now on, Taiwan engineering towards another realm, that is offshore engineering. This is a big leap forward for Taiwan's engineering industry, mainly due to the promotion of Taiwan's offshore wind energy policy. Offshore wind farm construction is one of the most important energy development project in Taiwan.

In addition to loading, unloading, foundation manufacturing, transition piece manufacturing and wind turbines manufacturing onshore, offshore wind farm construction includes foundation installation, wind turbine installation, cable laying, maintenance and operation, and even the decommissioning. As a result, marine engineering operations account for the significant proportion of the entire life cycle of an offshore wind farm project. It also means plenty of risks are in the process of the construction.

This article is going to evaluate risks that may be faced in the construction of offshore wind farms in Taiwan, including aspects of investigation, design, engineering construction, policy, industry, technology, and manpower. And how to reduce the risks of Taiwan offshore wind farm construction is proposed.

Keywords

Risk Evaluation, Taiwan Offshore Wind Farm Construction.

MA2-2

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THE UNCERTAINTY ANALYSES OF AVAILABILITIES OF AN OFFSHORE WIND FARM APPLIED BY THE MONTE CARLO SIMULATION

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Abstract

Based on the survey results performed by 4C Offshore, an international offshore wind power engineering consultancy, the world's top 20 offshore wind energy sites are mostly located in the Taiwan Strait. Taipower is developing TPC Phase One Offshore Wind Farm (i.e., TPC OWF), which is located off the west coast of Taiwan in the Taiwan Strait approximately 8km from shore.

However, the availabilities of wind turbine generators (i.e., WTGs) in the wind farm have been identified as critically relevant for offshore markets, where environmental conditions tend to be harsher, and weather risk has a more significant impact on servicing and repair schedules. In this study, three classes of WTG failure are categorized, including remote control, minor\major repair, as well as major replacement with a crane vessel required. Failure rates on existed onshore WTGs, along with repair resource requirements to offshore accessibility connected to wave and typhoon conditions, are inputted in an operation and maintenance model. Uncertainty analyses of availabilities of an offshore wind farm applied by Monte Carlo Simulation can be conducted afterward. The results indicated that the averaged availability of TPC OWF is approximately 87.6%, which is slightly less than OWFs in Europe due to the harsher weather conditions in offshore Taiwan.

Keywords

offshore wind, availability and accessibility, wind turbine generator, Monte Carlo Simulation, uncertainty analysis.

MA2-3

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INTRODUCTION TO STATISTICAL OF SOIL PARAMETERS FOR OFFSHORE WIND TURBINE FOUNDATION DESIGN

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Abstract

In order to cope with the objective of national renewable energy policy on developing offshore wind energy in Taiwan. Taiwanese government intended to develop the local supply chain, from fabrication, design, construction and operation. This paper would introduce how to select soil parameters for offshore wind turbine foundation design.

Soil parameters are the most important parameters of offshore wind turbine foundation design. Determine the rational soil parameter would affect the accuracy of analysis results and avoid the underestimated or overestimated design. Soil data are usually encumbered with two main types of uncertainty, including aleatory uncertainty and epistemic uncertainty. To mitigate the influence of uncertainty, statistical methods would be used. This paper is mainly referred to recommended practice DNVGL-RP C207 “Statistical representation of soil data”. The recommended practice indicates that all uncertainty types could be solved, by using a generic distribution model. With limited number of soil data, an estimation of soil parameters could be determined as characteristic values for geotechnical design. For example, in method of central estimation of soil parameters, the population mean and population standard deviation are estimated by sample mean and sample standard deviation. In method of estimation of soil parameters with confidence, the characteristic value is derived with a specific confidence, like 5% quantile in the distribution.This paper would also show some practical casesin Taiwan.

Keywords

Soil parameters, Offshore wind turbine foundation design, Statistical analysis.

MA2-4

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APPLICATION OF RELIABILITY ON OFFSHORE WTG SUPPORT STRUCTURE DESIGN

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Abstract

The design of offshore WTG support structure is always governed by environmental conditions, e.g. wind, wave current, soil, earthquake…etc. Since there exists high variability in these environmental conditions, the design loads are usually based on probability represented by return periods to reduce the risk of the uncertainties. Meanwhile, a wind farm usually has tens or hundreds WTGs but it is hard to design each support structure separately in a limited duration. In design practice, a clustering strategy, which selects several "typical" support structures with specific soil profiles and water depths, is used in the coupled analysis to envelop the response of all support structure conservatively. The selection of the typical structures is based on the statistics of results of pile-soil interaction analysis and the future variation of seabed level. The fatigue analysis also requires the possibility of loads to evaluate the damage. Offshore structural design is a new design field in Taiwan and most of environmental loads should be evaluated by designers themselves, which are based on reliability and very different from onshore structural design. The purpose of this paper is to briefly introduce the application of reliability on offshore WTG support structure design.

Keywords

offshore structure, offshore WTG support structure, clustering strategy, offshore wind, renewable energy.

MA2-5

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CASE STUDY OF APPLYING RISK ASSESSMENT AND RISK MANAGEMENT

- ONSHORE CABLE CROSSING OF MULTIPLE OFFSHORE WIND FARMS IN TAIWAN

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Abstract

The conceptual design case study is about the onshore cable crossing of multiple offshore wind farms in Taiwan. Multiple developers have their own business agreements to distinguish the rights and obligations between them. The potential risk and their liability is thus highly valued. The purpose of the conceptual design is to propose the technical suggestion, to identify and lower the risk of the cable crossing.

The methodology of risk assessment and risk management is, first identify the risk in the cable crossing and laying considering the cable temperature, environment, construction practice and business agreement; then propose the technical solutions to lower the rate of occurrence and to ease the consequence of the unfavourable incidents.

The conceptual design proposed an outcome solution that is feasible in construction practice point of view without space confliction. The occurrence rate and consequence of the risk (temperature, construction…etc.) are both significantly lowered within the controllable range and are considered acceptable. The case study can hence be deemed as a practical reference for the onshore cable route arrangement during the future offshore wind energy development in Taiwan.

Keywords

risk assessment, risk management, cable crossing, underground cable, electric power transmission.

MA2-6

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A STUDY OF THE RISK MANAGEMENT OF OFFSHORE WIND POWERS PROJECT IN TAIWAN

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Abstract

It ts well known that plenty of risks exist during the construction of a major project. To identify and allocate the risk properly is important for minimized the risk and the damage resulted. For an experienced Developer, using tools such as insurance to transfer the risks to the insurance company is a common method; however, there are risks not insurable or too expansive to buy an insurance. So using contract arrangement to transfer the risk to another party is also a common way in the construction industry. A contract shall enter in agreement by both parties, so the Developer must transfer the risk to another contract party reasonably to get the mutual assent. In Taiwan Civil Law, to protect the weak contracting party, there are requirements to void the unfair clauses in the contract too.

This article will examined the major risks of the Offshore Wind Powers Project, such as who is responsible for the timely instruction and coordination of various working parties on site, what if the incorrect geologic date supplied and causing schedule delay and additional cost, adverse whether condition and the delay penalty issue. We will check the local practice in Taiwan and compare the famous FIDC Contract Conditions with the Standard Form Contract by the Public Construction Commission Executive Yuan of ROC to know what will be reasonable for the transfer of the risks mentioned.

It is inevitable that dispute and claims happened in a major project, to reduce the impact of the dispute or claim, a good dispute resolution mechanism is very important. We will study the mechanism in Taiwan and the Dispute Broad in FIDC Contract Conditions to find the suitable mechanism to achieve a fast and inexpensive way for dispute resolution.

Keywords

Offshore Wind Powers Project, risk transfer, dispute resolution, Dispute Broad.

TA1-1

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DEVELOPMENT OF RELIABILITY-BASED LIMIT STATE DESIGN CODE OF UNDERGROUND RC BOX FOR ELECTRIC POWER LINES

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Abstract

The underground RC box-type culverts are widely adopted for the electric power lines especially in the urban area along the traffic roads in Korea. It is currently designed according to a design code, which is based mainly on the american ACI 318 code and some items adopted from those for underground culverts in AASHTO specification. Since the ACI 318 code is developed mainly for the building structures, it does not provide the proper design rules for the structures under the vertical and horizontal earth pressures. Currently, the load combinations adopted in the Korean practice are based on those in ACI 318 and are modified to include the terms with the earth pressures. This study is aimed to develop the limit state load combinations, and design loads and resistances for the underground RC boxes, considering the general design and construction practice in Korea. The typical configuration of the underground power line boxes has a width of 2.6-4.5m and a height of 2.6-3.5m. The depth of earth fill over the buried box is 1-6m, sometimes increases up to 8m or higher. The major loadings to be included are the traffic load, vertical and horizontal earth pressure, ground water pressure, and dead load. The probabilistic load models are being developed and the probabilistic characteristics of resistances of RC boxes are being evaluated based on the construction geometric errors collected from the various construction fields of the buried RC boxes as well as the tolerances allowed in the construction practices. The varying characteristics of the concrete strength are also included based on the field data. The experimental loading tests are being performed to figure out the effects of the various construction errors, such as cover depth, rebar placement, concrete properties, etc.

Keywords

Underground RC Box, Electric Power Line, Limit State Design Code, Probabilistic Load Model, Probabilistic Resistance Model, Construction Error.

TA1-2

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PROBABILISTIC RESISTANCE MODELS FOR FLEXURAL MEMBERS OF UNDERGROUND RC BOXES CONSIDERING CONSTRUCTION ERRORS AND TOLERANCES

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Abstract

The underground RC boxes are constructed in a limited working space of the excavated ground environment. Therefore, the quality control may not be proper in the construction process, such as concrete form work, rebar assembly, concrete cast and curing, etc. Since the section dimensions are not large, the minor errors may cause some serious consequences. The depths of slabs and thicknesses of walls, which are the major structural members of RC boxes, are about 240-400mm in the typical box sections. In the general construction practice some geometric tolerances are allowed. However, it has been found that the construction errors are often beyond the allowable tolerances due to the unusual work environments of the buried RC boxes. The concrete quality may not be achieved as in the normal sites. Experimental loading tests are being performed with various models, such as simple one way slabs, coner joint specimens with or without haunch between upper slab and wall, full box specimens. In addition, the field data on the construction errors have been collected to understand the general trend of geometric errors, in a systematic procedure from various construction sites of underground box culverts as well as the existing electric power line boxes. The probabilistic models of the basic design variables, such as the section dimension, effective depth of rebar, steel area, concrete strength, rebar strength, etc., are developed based on the field/rab data and the reference models adopted in previous studies. The Monte Carlo simulations will be performed to figure out the probabilistic characteristics of the flexural resistances of slab and wall members of RC box, based on the probabilistic models of basic design variables. The sensitivity analysis will be performed to evaluate the effects of the tolerance levels allowed in the general practice. Based on this study the proper and practical tolerances may be proposed.

Keywords

RC Box Culvert, Probabilistic Resistance Model, Construction Error,Allowable Tolerance, Monte Carlo Simulation.

TA1-3

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TRAFFIC LOAD MODEL FOR LIMIT STATE DESIGN OF UNDERGROUND RC BOXES

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Abstract

Most underground power line RC boxes are constructed with the shallow earth fills due to the construction cost, mainly with 1-3m depth. The traffic load may become one of major design loads. The traffic load effects distributed on the underground RC boxes are evaluated in terms of the equivalent uniform load with two formations: the first is that one design truck(KL-510) adopted in the Korean Highway Design Code(2015) is loaded and the second is that two design trucks are loaded side-by-side together. The equivalent uniformly distributed load(EUDL) is the uniform load, which generates the same load effect on the structural member as the real non-uniform loadings caused by the multiple truck wheels. The load dispersion of the wheel loads through the earth fill is modeled with typical 1:2 model, and other dispersion models are compared to verify the effects. The probabilistic characteristics of the traffic load will be generated based on the local traffic models and the influence lines. The influence lines are developed by calculating the EUDL under the loading condition of a single design truck and the other truck on the adjacent traffic lane assumed to be located with various headway distances, such as 1m to 6m. The probabilistic gross weight models of the heavy vehicles are adopted, which are based on the local data in Korea. The heavy vehicle composition model and the effect of consecutive running of heavy vehicles will be considered.

Keywords

Underground RC Box, Design Traffic Load, EUDL, Probabilistic Truck Weight Model, Consecutive Running Model.

TA1-4

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CENTRIFIGE TESTS TO ACCESS VARIABILITY OF THE VERTICAL AND LATERAL EARTH PRESSURES ACTING ON UNDERGROUND REINFORCED CONCRETE BOXES

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Abstract

This paper shows the experimental study focusing on the variability of the vertical and lateral earth pressure acting on the underground reinforced concrete box structures based on multiple centrifuge tests. For the centrifuge tests, a well-graded soil was applied for a model ground. The model ground was built up using a funnel type sand raining system to avoid the material segregation during sand raining. The model underground box has multiple stress measuring points along the top and sides to check the variability of the earth pressure. A centrifuge tests consisted of three stages (initial loading, loading, and unloading) consisting of multiple steps with a constant gravitational acceleration. The centrifuge test results show that both vertical and lateral earth pressures have great variability. Based on the centrifuge test data, this paper presents the mean and coefficient of variance of the soil-structure interaction coefficient and lateral earth pressure coefficient for the vertical and lateral earth pressure, respectively.

Keywords

Centrifuge test, underground box structures, sand, earth pressure, variability.

TA1-5

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PROBABILISTIC APPROACH FOR ROTATIONAL STIFFNESS OF WEDGE JOINT CONNECTING VERTICAL AND HORIZONTAL MEMBERS OF TEMPORARY STEEL SUPPORTS

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Abstract

The nonlinear rotational stiffness of wedge joints, which were used widely to connect vertical and horizontal members of temporary steel system supports,wasinvestigated experimentally. To predict exact behaviors of system supports, the estimation of the rotational stiffness of the jointsshould be firstly estimated. And, it is need to estimate the nonlinear stiffness of joints reflecting the characteristics of reused members, which were generally utilized. Experimental tests were conducted for both new product members and reused members in order to assess the normality of the measured data. The joint type used in this study is a wedge joint used widely for easy installation and dismantling. Results show that the nonlinear stiffness could be modelled by trilinear model. The initial rotational stiffness decreased with continued use of the joint. The lower limit of the 95% confidence interval of the initial rotational stiffness was 20.688 kNm/rad, and the upper limit was 24.262 kNm/rad.

Keywords

Rotational stiffness, wedge joint, system support, experimental test.

TB1-1

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SYSTEM RELIABILITY OF CRTS II TRACK SLAB CONSIDERING BOTH SAFE AND SERVICEABLE FAILURE MODES

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Abstract

China Railway Track System II (CRTS II) track slab is widely constructed in China's high-speed railway system, which is usually laid on simply supported bridge foundation (SSBF) to minimize the deflection and vibration. During its life cycle, CRTS II track slab will suffer from random loads, which will result in multiple possible failure modes from both the safe and serviceable viewpoints. Since each one of these possible failure modes will endanger the running quality and safety of high-speed trains, it is necessary to conduct system reliability analysis of the CRTS II track slab with a thorough consideration of these safe and serviceable failure modes. However, till now, existing reliability analysis of the CRTS II track slab consider only several failure modes from the safe view point, the system reliability analysis of the CRTS II track slab considering both the safe and serviceability has not been successfully accomplished. Furthermore, the existing methods are based on the distributions of the random variables, which are not only hard to determine but also require complicated computation. Therefore, this study analyzes the system reliability of the CRTS II track slab considering all the important safe and serviceable failure modes. To avoid the use of the distribution of the random variables, the method of moments is applied based on the first four moments of the random variables, which can be obtained easily in practical engineering. It is found that the method of moments can be efficiently applied in analyzing the system reliability of the CRTS II track slab, and considering both the safe and serviceability failure modes can provide a more comprehensive understanding of the reliability of the CRTS II track slab.

Keywords

CRTS II track slab, system reliability analysis, safety, serviceability, method of moments.

TB1-2

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RELIABILITY ASSESSMENT OF CRTS II TRACK SLAB CONSIDERING CORRELATED RANDOM VARIABLES

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Abstract

China railway track system II (CRTS II) track slab has been widely constructed in China's high-speed railway, whose reliability is important for the safe operation of the high-speed trains. Due to the changeable environment and diverse operation conditions, there are several possible failure modes of the CRTS II track slab, among which the longitudinal bending failure mode will result in deadly damage and is focused on in this study. Several studies have been carried out to analysis the reliability of CRTS II track slab corresponding to the longitudinal bending failure mode, all of which are conducted assuming the random variables are independent. However, in practice, the random variables in the limit state function of CRTS II track slab are usually correlated. Without consideration of the influence of such correlation, the reliability analysis of the CRTS II track slab may be inappropriate or even incorrect, which may endanger the operation of high-speed trains. Therefore, the reliability of CRTS II track slab is analyzed in this study considering the correlations among different random variables. For a better evaluation, the limit state performance function is constructed combining with a finite element analysis model of the CRTS II ballastless slab track. Based on the statistical moments of the random variables, the method of moments is applied to conduct the reliability analysis, where the normal and inverse normal transformations are conducted with the aid of polynomial transformation model considering correlated random variables. Comparison study is also conducted between the reliability of CRTS II track slab considering independent and correlated random variables. The results show that the method of moments can be efficiently applied for reliability analysis considering correlated random variables, and reliability analysis considering correlated random variables are more accurate compared with that considering independent random variables.

Keywords

CRTS II track slab, correlated random variables, longitudinal bending, reliability assessment, method of moments.

TB1-3

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TIME-DEPENDENT RELIABILITY EVALUATION OF CRTS II TRACK SLAB BASED ON CONDITIONAL PROBABILITY METHOD

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Abstract

The reliability of the CRTS II track slab has huge effects on the normal transportation efficiency of the railway and the operation safety of the high-speed train. Since the load and resistance of CRTS II track slab are random and related with time, the reliability of the CRTS II track slab is essentially time-dependent. To guarantee the safety of the high-speed train and ensure the efficient transportation, it is necessary to conduct appropriate time-dependent reliability analysis of the CRTS II track slab during its service life. There are only limited studies in the time-dependent reliability assessment of CRTS II track slab, all of which are pseudo time-dependent reliability conducted by point-in-time method assuming the occurrence of load is determined. Since the occurrence of the load has large randomness in practice, the assumption in the existing studies may result in inappropriate evaluation and endanger the running safety of the high-speed train. With such occurrence treated as Poisson process, the method based on the conditional probability can provide a more appropriate evaluation for the time-dependent reliability of CRTS II track slab. Therefore, the time-dependent reliability of the CRTS II track slab is investigated in the present study using conditional probability method. There are several failure modes of the CRTS II track slab, and the transverse bending failure mode is focused on in this study. An finite element (FE) model of the CRTS II BST is constructed to calculate the effects of the train load, and the performance function of CRTS II track slab is proposed combining with the constructed FE model. The result shows that the reliability of CRTS II track slab decreases significantly with the increase of service life, and the results of the conditional probability method is much more accurate compared with that of the point-in-time method.

Keywords

CRTS II track slab, time-dependent reliability, conditional probability method, transverse bending, finite element model.

TB1-4

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APPROXIMATE METHOD FOR FITTING THE EXTREME VALUE DISTRIBUTIONS OF NON-LINEAR STOCHASTIC DYNAMIC SYSTEMS

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Abstract

In this paper, an approximate method is proposed for fitting the extreme value distributions of nonlinear stochastic dynamic systems, in which the random function-spectrum representation method (RFSRM) is used to model non-stationary ground motions. The main procedure consists of two steps. First, the framework of calculating the first four moments (mean, standard deviation, skewness and kurtosis) of extreme value of structural responses is developed, in which the RFSRM is used to model non-stationary ground motions; Second, using the first four moments (mean, standard deviation, skewness and kurtosis) of extreme value, the coefficients of the fourth-moment standardization function are obtained; and then the approximate expressions of the probability density function (PDF) and cumulative distribution function (CDF) of structural extreme value are derived using the coefficients of the fourth-moment standardization function based on the theory underlying the normal and inverse normal transformation. A nonlinear single-degree-freedom-system demonstrates the efficiency, accuracy, and utility of the method for fitting the extreme value distribution in the dynamic reliability assessment of nonlinear structures, compared with the conventional spectrum representation method.

Keywords

Dynamic reliability; Third order polynomial transformation; The first four moments; Extreme value distribution; Spectral representation.

TB1-5

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RANDOM DYNAMIC ANALYSIS AND RELIABILITY ASSESSMENT OF HIGH-SPEED TRAIN-BRIDGE COUPLED SYSTEM UNDER EARTHQUAKE EXCITATION

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Abstract

The running safety of train on the high speed railway bridge can be negatively affected by the suddenly-happened earthquake excitation. This paper aims to investigate the seismically random dynamic behavior of train-cable stayed bridges interaction system using the probability density evolution method (PDEM), of which the system simultaneously involving the multi-effect of random earthquake excitation and random track irregularity. The motion equation of such system is established by coupling the vehicles and bridges through the refined random wheel/rail contact interaction. PDEM is employed to transform the random excitations into a series of deterministic representative excitations with initial probability. By solving for the corresponding deterministic probability responses, various random responses, including the time-dependent probability density evolution functions of random responses, mean values curves and standard deviations, can be obtained easily. Then, in order to establish a rapid and straightforward approach for the systematic running safety assessment of the train-bridge coupled system, the quantiles of the probability distribution are used to estimate the time-history uncertainty bounds of random responses of interest distributed in real probability functions. Case studies on the cable-stayed bridge are then presented and the influences of earthquake intensity and train speed on the system random responses are discussed. The results show that the quantiles of the probability distribution proposed are suitable for the systematic running safety assessment of the train-bridge coupled system.

Keywords

Earthquake load, Random vibration of Train-Bridge coupled system, Probability Density Evolution Method, Probability distribution, Vehicle running safety assessment.

TB1-6

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MOMENT METHOD WITH AN OPTIMIZED PERFORMANCE FUNCTION FOR SYSTEM RELIABILITY

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Abstract

System reliability analysis involving highly nonlinear performance functions is always a challenging problem because of the inaccurate failure probability. The main task of this work is try to solve this problem by developing moment method with an optimized performance function. A new criterion is proposed to minimize the nonlinearity of performance function that is transformed into standard normal space, then its application to system reliability analysis based on moment method is investigated. The accuracy and efficiency of moment method with an optimized performance function are further demonstrated through several numerical examples, including system reliability analysis with correlated random variables, nonlinear and implicit functions.

Keywords

system reliability, moment method, optimized performance function, failure probability, standard normal space.

TA2-1

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SEISMIC IMPACT ANALYSIS UNDER AN EXTREME SCENARIO FOR RESILIENT CITIES

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Abstract

The Chi-Chi earthquake (ML=7.3) resulted in 2,405 deaths and one million economic loss in 1999. In the past two decades, the disaster vulnerability has increased because of population concentration and complicate infrastructures constructed in urban areas. If a catastrophic earthquake occurred near metropolitan cities, the induced casualty and loss would be more extensive than those in the Chi-Chi earthquake. Therefore, the seismic capacity subjected to large-scale earthquakes under current environment conditions in metropolitan cities should be evaluated for disaster management. To assess the seismic capacity of exposures, we developed a mesh-based scenario simulation tool, Taiwan Earthquake Impact Research and Information Application Platform (TERIA), based on variety of inventory database collected from government agencies. TERIA is capable of analyzing the ground motion, soil liquefaction, casualty, damage of buildings, roads, bridges, portable water system, power supply system and interpreting disaster scenarios in 500 m x 500 m meshes on interactive interfaces. An extreme earthquake scenario (ML=6.6) triggered by the Shanchiao fault was chosen to examine the seismic capacity of exposures for Taipei metropolitan city. We present analytical results in terms of major theme maps for disaster mitigation planning, including emergency rescue, medical care, sheltering, and government operation. Our research accomplishment has been applied on formulation of disaster countermeasures, policy suggestions, and national earthquake drills for government. The quantitative impact analysis by scenario simulation in details could be helpful to elaborate a more thorough mitigation planning for enhancing the disaster resilience against future major earthquakes.

Keywords

Earthquake, Scenario Simulation, Impact Assessment, Disaster Reduction Planning.

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SOME REFLECTIONS ON THE SEISMIC RISK IN TAIPEI AND THE RESIDENTS' MITIGATION BEHAVIORS FOR THAT

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Abstract

According to the traditional risk assessment model, the loss of an earthquake is a function of the hazard of the event, the exposure, and the vulnerability. Since the loss estimation system, such as Taiwan Earthquake Loss Estimation System (TELES), can estimate the building loss from an earthquake event in Taiwan, the seismic risk of buildings in Taipei can be evaluated when the probability of all possible events are ready. For example, Shaw et al. (2007)[1] used HAZ-Taiwan (former version of TELES) and Monte Carlo simulation to build the exceedance probability (EP) curve to estimate the average annual loss (AAL) and probable maximum loss (PML) of buildings in Taipei. The psychological and social impacts of an earthquake can also be estimated based on the survey data. Li et al. (2009)[2] found two important social supports as recovery resources of households, which were (1) assist/support from social network members (as relatives, friends or neighbors); (2) the faith or belief of religions.

Not only the direct loss from building damages but also the economic impact of the industrial production disruption from the damage of its building can be simulated. For example, Lin et al. (2012)[3] used the regional input-output (IO) analysis for two scenario earthquakes in northern Taiwan both with a return period of 475 years - the Hsinchu Hsincheng and the Yilan Nan-ao earthquakes. The results show that the economic impact caused by the Hsincheng earthquake is greater than that resulting from the Nan-ao earthquake. The industries affected the most are the manufacturing, food services and entertainment, storage and retail trade, and public and construction industries. The Nan-ao earthquake causes relatively more losses in the food services and entertainment industries. Most of the repercussion effects of these industries are in the central and southern parts of Taiwan.

Since the seismic risk of Taipei is huge and the cost for seismic retrofit and/or rebuild for all aged buildings is huge as well, some reinforcement areas where have the highest seismic risk have to be chosen as the priority of risk reduction. The building loss and the economic impacts from that are not the only impacts. To access the comprehensive seismic risk, the social vulnerability to earthquakes can be adopted. Kuo et al. (2009)[4] is a comprehensive social vulnerability consists the susceptibility, coping and recovery capacities at household, community and region levels. This index can be used to deploy resources for emergent

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operations after an earthquake. Concerning to the seismic risk and impacts from an earthquake, the future study would be incorporating more modules, particularly infrastructures, in the loss estimation system. The financial arrangement, such as the relief and the reserve of earthquake insurance, should be determined based on AAL and PML estimations. However, the total loss and the loss of a household from an earthquake are also affected by mitigation measures including seismic retrofit and household preparedness.

In order to diversify the seismic risk, earthquake insurance is the major tool. Liao et al. (2008)[5] found that the intention to purchase earthquake insurance would be influenced by risk perception, optimistic bias, and fatalism. In order to mitigate the seismic risk, the model of residents' mitigation and preparedness behaviors have to be built to find significant determinants for risk communication. Kuo et al. (2015)[6] found that the response efficacy of preparedness, the knowledge of preparedness, the loss experience and the age of respondents could significantly increase the preparedness behaviors. The respondents who regard the evaluation has higher response efficacy, self-efficacy, willing to pay for seismic retrofitting, the attitude to mitigate earthquake risk and the age are significantly more willing to have seismic evaluation. Concerning to the alternatives of a seismic retrofit, Shaw et al. (2010)[7] evaluate Taipei apartment residents' willingness to adopt seismic retrofit and to analyze their attribute preference for seismic retrofit alternatives. Six seismic retrofit alternatives for old apartments in Taipei are designed by a structural civil engineer. According to the survey data, the social pressure, namely his estimate of the share of non-supporters in the same building, the age of the building, and the vulnerability of the building significantly affect the willingness to adopt seismic retrofit. The most important attributes of seismic retrofit alternatives are "not affecting the appearance of the building" and "not affecting the inner space". Two most preferred alternatives are beams and pillars coated with carbon fiber or steel.

The major loss of an earthquake in Taipei will be the damage to residential buildings and most of them are aged ones. In order to mitigate the risk, the seismic retrofit and rebuild would be the most important mitigation measures. The results of the above studies show that knowledge, risk perception, optimistic bias, fatalism, the building age, and the building vulnerability are important factors affecting household earthquake preparedness and the intention for seismic retrofit. Risk communication for local seismic risk is important. An effective, not affecting the appearance of the building and not affecting the inner space seismic retrofit would be easier for promotion. Since the share of non-supporters in the same building is an important factor for the willing to have seismic retrofit and rebuild supposedly, the issue of future study is the mechanism/process of generating common willing for seismic risk reduction.

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There is an interaction between mitigation and risk. A comprehensive seismic risk system including the mitigation behaviors would be a useful tool for proposing earthquake prevention and protection plan in Taipei.

Keywords

seismic risk, economic impact, mitigation behavior, preparedness, seismic retrofit.

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APPLYING TELES ON EVALUATION OF EVACUATION SHELTER CAPACITY OF NEW TAIPEI CITY, TAIWAN

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Abstract

Taiwan is located in the Rim of Fire and has frequent and intense earthquakes. For example, the Hualien Earthquake of 1986, Richter-scale of 6.8, induced the collapse of Huayang Market in New Taipei City (NTC). Chi-Chi Earthquake with Richter-scale of 7.3 in 1999 caused the collapse of two buildings in NTC, and it claimed the damages of buildings of over 50,000 all over Taiwan.

According to past experiences of earthquakes, floods or typhoons, most of the residents who had been forced to evacuee would seek help from relatives or friends, but some still need short-term public shelters provided by the government and private relief organizations or would stay in a temporary hotel or lease an apartment. It' s important to evaluate shelter capacity after large earthquakes.

In this paper, the Taiwan Earthquake Loss Estimation System (TELES) is used for scenario simulation. The scenario set its epicenter at the Shanchiao fault which is across NTC. The depth of the is 8 km with Richter-scale of 7.3. The evacuees need temporary evacuation shelters estimated by TELES is defined as large areas with open spaces for the evacuees' temporal sheltering for 1 to 1 month after the earthquake. Those shelters include disaster-prevention parks and designated evacuation shelters.

Two scenarios of the designated evacuation shelters with damages rate of 0% and 70%, respectively, are used to evaluate the capacity of NTC. When the capacity is insufficient, the countermeasures are proposed for NTC for reference.

Keywords

TELES, evaluation, evacuation, shelter, capacity, New Taipei City.

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SEISMIC ASSESSMENT OF POTABLE WATER SYSTEMS FOLLOWING EARTHQUAKES

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Abstract

In the past decade, scenario simulation has played a more and more important role in earthquake hazard mitigation. Various implementations have been proven of great help before and after the occurrence of earthquakes. Both public and private sectors can be enhanced in terms of their seismic preparedness and response if proper simulation is implemented effectively. Regarding water utilities, system-wide retrofit, emergency planning and exercise can be conducted based on seismic risk assessment to reduce the likely damage and losses prior to the occurrence of a devastating earthquake. Post-quake personnel and material dispatching, emergency water supply for hospitals and fire-fighting, temporary water supply for affected people, strategies for restoration and recovery, etc. can all benefit from the result of a scenario-based analysis.

A GIS-based Windows application Taiwan Earthquake Loss Estimation System (TELES) has been developed by the National Center for Research on Earthquake Engineering (NCREE), Taiwan. Recently, TELES has been customized for simulating the damage and loss of potable water systems following earthquakes. This new software is called Twater. It is a subsystem of TELES. Twater is able to simulate damage to the component pipelines and facilities of a potable water system, as well as any impacts to their functionality and the system' s serviceability following an earthquake event. As the input data, Twater utilizes the inventory and hierarchy of relevant system components including raw water aqueducts, water treatment plants, major clear water conveyance trunks, and water transmission and distribution pipeline networks, as well as their relationship with the water service areas in a system. This paper introduces the methodologies of Twater and its implementation to the seismic assessment of water systems in the Greater Kaohsiung area for earthquake hazard mitigation. Several earthquakes scenarios have been chosen and applied to these water systems.

Keywords

Potable water system, seismic assessment, hazard mitigation.

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THE ASSOCIATION OF INJURY PATTERN, ENTRAPMENT LOCATION AND EXTRICATION TIME IN THE 2016 TAIWAN EARTHQUAKE

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Abstract

On February 6, 2016 at 3:57 am local time, an earthquake measuring 6.4 on the Richter scale struck southern Taiwan. The earthquake' s epicenter was located at Mei-nong, Kaohsiung City and was approximately 50 km away from south-east of Tainan with a depth of 23 km. The earthquake was the deadliest to have occurred in Taiwan since the ChieChi earthquake in 1999. A total of 117 deaths and 513 injuries were recorded in the Tainan Incident Registry System. Among these casualties, 115 (98.3%) deaths and 123 (24.0%) injured patients were extricated from one particular building complex, named the Weiguan Jinlong (WJ) Complex. The WJ Complex was a joint construction consisting of 9 conjunctive buildings (with 13-16 floors). The severity of structural damage was classified according to a 6-rank damage scale, which was proposed by the Architectural Institute of Japan. A retrospective analysis was conducted using the Tainan incident registry system to explore the association of patient injury patterns and entrapped locations inside damaged buildings. The association of extrication time and age-specific mortality was also examined. We concluded that people entrapped at different heights of floors or in differently damaged buildings could have a distinct pattern of injury. Extrication time is strongly associated with earthquake-related mortality. Our findings may facilitate strategic approaches for patients entrapped in damaged buildings and can contribute to future training for field search and rescues after earthquakes.

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BRIDGE HEALTH MONITORING BASED ON STATIC AND DYNAMIC RESPONSES UTILIZING MEMS ACCELEROMETER

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Abstract

This paper introduces a Health Monitoring (BHM) procedure utilizing MEMS (Micro Electro Mechanical System) accelerometers. The acceleration sensor is used to detect bridge property changes through its static and dynamic displacement induced by moving vehicle. To demonstrate the proposed method, a small scale of highway bridge is investigated. Bridge stiffness, vehicle speed and mass is considered as design variables in this study. The proposed method is divided into two parts, the static and dynamic indicators. For static indicator, measured acceleration is filtered using low-pass filter resulting in quasi-static acceleration that could transform into rotation information. This experimental study shows that rotational value calculated from measured acceleration could be adopted as reliable bridge damage indicator. For dynamic part, instead of using frequency domain as indicator, measured acceleration is transformed into dynamic displacement thorough displacement reconstruct algorithm. Experimental result shows that frequency could not be a reliable indicator when bridge vibration is induced by moving vehicle. However, proposed rotational indicator is proved to give reliable result in differentiate intact and stiffened bridge even the changing of bridge fundamental period is small.

Keywords

Bridge Health Monitoring, Displacement Reconstruction, Static, Dynamic, Displacement, Damage Detection.

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OPTIMIZING DETERIORATING BRIDGE MAINTENANCE STRATEGY THROUGH RISK ASSESSMENT AND HYBRID COMPUTATIONAL INTELLIGENCE TECHNIQUE

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Abstract

Current bridge life cycle maintenance and restoration strategy experienced a major concern, especially in Taiwan whereas soaring numbers of earthquakes, typhoons, and rainstorms happened from time to time. To this moment, unseen aspects regarding bridge deterioration such as scouring resistance and earthquake are prone to negligence. Considering unseen aspects with seen aspects altogether might pose a better alternative for the transportation authority. Hence, this study proposed the Risk-Based Evaluation Model for Bridge Life-Cycle Maintenance Strategy (REMBMS) as a newly developed computational intelligence system to the bridge maintenance strategy. REMBMS scrutinized three essential risk factors such as component deterioration, scouring, and earthquake to minimize the expected bridge maintenance cost. Evolutionary Support Vector Machine Inference Model (ESIM) was integrated to estimate risk-related maintenance costs through Taiwan Bridge Maintenance System (TBMS) historical cases and Monte Carlo simulation was applied to obtain the maintenance probability. The time-related expected cost is obtained from multiplication of maintenance probability and its associated cost. Subsequently, Symbiotic Organisms Search (SOS) optimizes the maintenance cost to derive the effective bridge maintenance schedule. The result findings in this study offer a comprehensive preference for transportation authority with optimal schedule and budget for deteriorating bridge maintenance.

Keywords

bridge maintenance strategy, computational intelligence, bridge life cycle, risk assessment, symbiotic organisms search.

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TAIWAN ROAD EARLY NATURE DISASTER PREVENTION SYSTEM-TRENDS

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Abstract

Bridges are a vital and significant component of Taiwan’ s transportation infrastructure. Therefore, regular and comprehensive inspections of existing bridges are necessary to prevent damage and traffic disruption and reduce earthquake-related damage and casualties. However, due to the large number of bridges in Taiwan, the time and budget required to perform traditional structural analyses (preliminary assessment, detailed analysis) on every bridge to calculate yield acceleration (Ay) and collapse acceleration (Ac) values make doing so impractical. This paper integrates material degradation, pushover analysis, and artificial intelligence to create a new inference model as an alternative to traditional structural analysis. Historical cases are used to infer Ay and Ac values by mapping relationships between the preliminary assessment factors (input) of historical cases and detailed assessments of Ay and Ac values (output). Using the proposed inference model to predict Ay and Ac values, bridge maintenance planners can quickly and more cost effectively assess bridge earthquake damage probabilities as a guide to identifying priority bridge maintenance projects.

Keywords

Bridge damage evaluation, material degradation assessment, bridge pushover analysis, evolutionary support vector machine inference model (ESIM).

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INTERNAL FORCES DIAGNOSING APPROACH OF AN EXISTING STRUCTURE THROUGH GEOMETRIC-ITERATIVE METHOD

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Abstract

Evaluation of existing infrastructure is needed in order to obtain its current condition, especially for aging structure. The absence of original structure data due to certain reasons makes it much more difficult to be examined. For monitoring purposes, internal force is one of the main outputs to be carried out for knowing the structure current condition. Therefore, it would be nice if there is a method to estimate the internal forces without relying on the original document. The aim of this research is to overcome the above difficulties through a proposed inverse approach so-called geometric-iterative method.

This method is composed by combining field assessment and numerical simulation. Existing configuration, section, and material properties are information needed in the computation process. A numerical model of an existing system is constructed in innovative computation mechanics method called the Vector Form Intrinsic Finite Element (VFIFE). By putting back the internal forces obtained from loaded existing configuration iteratively, balance and converge condition will be achieved. A deformed simple truss is taken as an example to verify the feasibility of this method.

In brief, the verification process depicts that internal forces resulted from geometric-iterative methods are really close to the forward solution. Small errors obtained imply that the method is certainly suitable and feasible to be adopted for identifying internal forces of an existing structure.

Keywords

Existing structure, inverse analysis, internal force, geometric, iterative.

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EFFECTS OF VARIABILITIES IN GROUND MOTIONS AND SHEAR WAVE VELOCITIES ON SITE RESPONSE ANALYSES FOR SOUTH KOREA

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Abstract

Korea peninsula has been known as a safe zone from earthquake disasters. However, there has been a growing interest in earthquake research after the 2016 Gyeongju earthquake and the 2018 Pohang earthquake struck South Korea. In the seismic design, the seismic wave propagation characteristics are evaluated by the site response analysis(SRA), so it is necessary to obtain reliable SRA results. In this aspect, this study aimed to investigate the effect of uncertainty in shear-wave velocity and ground motions on the SRA results. The shear-wave velocity profiles obtained from the southeastern part of South Korea and seven suites of ground motions are used for the uncertainty quantification and nonlinear SRAs were also performed.

Keywords

Earthquake, Uncertainty, Shear-wave velocity, Site response anlaysis, Ground motions.

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OPTIMAL DECISION-MAKING ON PIPELINE SIZES OF WATER NETWORKS UNDER SEISMIC CONDITIONS

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Abstract

In this study, an optimal decision-making model on pipeline sizes of a water transmission network has been proposed. The purpose of the optimal decision-making model is to maximize seismic performance with limited construction cost. The proposed model estimates network performance using spatially correlated seismic attenuation law, determination of the failure status of the network component, and numerical modeling of water networks. For this purpose, MATLAB code has also been developed to enable EPANET analysis using pressure-based analysis and numerical modeling of network systems. To verify the proposed model, an actual urban water network has been adopted, taking into account the location and magnitude of the historical earthquake. In addition, two performance indices were introduced to assess network performance. The numerical results show that the optimized network model increased system serviceability and node serviceability by 9.9% and 11%, respectively, and the average node pressure of the network increased 3.6m over the existing model.

Keywords

Optimal decision making, pipeline size distribution, urban water networks, genetic algorithm, seismic risk assessment.

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IDENTIFICATION OF STOCHASTIC PAVEMENT ROUGHNESS CLASS FROM VEHICLE DYNAMIC RESPONSE

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Abstract

Roadway internationally supports over twenty trillion tonne-kilometers of freight and transport passengers each year making them critical elements in the transportation network. Not only because the pavement structures are highly visible, but also their serviceability is highly related to driver safety and network efficiency, assessing the sustainability of pavement structure becomes important. To date, the nondestructive pavement structure quality assessment has been investigated in two parts: 1) profile maintenance using surface measuring device, such as road-meter; and (2) substructure maintenance using deflectometers. Such devices can provide understandings on road structure, equipment is rather expensive in terms of time and cost. Thus, in most of pavement management system (PMS), qualitative assessment via visual inspection is firstly made followed-by in-depth instrumentations for selected spots. This paper, instead, aims to provide an efficient tool that can be used for complete inspection in PMS using measured response of a vehicle. The vehicle and the substructure's interaction model has been developed such that the vehicle response contains various characteristics of the pavement. In the interaction model, the stochastic pavement roughness is formed and realized with a state-space representation having the white noise as the primary input to the system. The total system including the roughness and the sublayer's elasticity is expressed in augmented system. The sensitivity of the system response on the pavement structure's parameter is presented to illustrate the efficiency of the proposed approach. Finally, assuming the stochastic pavement roughness is unknown, the roughness has been identified using the vehicle response by applying the particle filter technique. The results demonstrate that the augmented interaction model provides an effective tool for understanding the pavement structure.

Keywords

Pavement Maintenance; Moving Oscillator; Elastic pavement; Particle Filter; Stochastic road roughness.

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GROUND MOTION RESPONSE SPECTRA FOR SAFETY-RELATED NUCLEAR FACILITIES IN SOIL SITES

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Abstract

Ground motions response spectra (GMRS) at rock/soil sites in a region, where earthquake ground motions have dominant contents at high frequencies of 10 Hz or more, are evaluated and the effects of soil amplification on GMRS are studied. The soil amplification functions are obtained using modified earthquake ground motions which match uniform hazard response spectra (UHRS) for rock outcrop motions with various mean annual frequencies of exceedance in order to consider the effects of random earthquake ground motions consistently in a site response analysis. UHRS at soil sites are determined from the calculated seismic hazard curves. Subsequently, design factors, which will be applied to UHRS, and the corresponding GMRS are evaluated such that seismic risk for structures, systems, and components of nuclear facilities would be equal to a target seismic risk. It can be observed from example applications that GMRS at soil sites have peaks at soil natural frequencies where soil responses are amplified and can also be amplified at the frequency where rock outcrop motions have dominant components.

Keywords

Ground motion response spectra, uniform hazard response spectra, design factor, soil amplification, high frequency ground motion .

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BAYESIAN NETWORK FOR STRUCTURES SUBJECTED TO SEQUENCE OF MAIN AND AFTERSHOCKS

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Abstract

For probabilistic prediction and inference regarding structures under complex hazard of main and aftershocks, this paper proposes a new Bayesian Network (BN) framework. First, causal relationships between factors affecting a sequence of main and aftershocks are modeled by a BN. To incorporate the properties of ground motions of main and aftershocks into the BN, artificial ground motions are generated using a stochastic model describing the characteristics of main and aftershocks and their relationships. Since the damage caused by the main-shock load affects the aftershock performance of the structure, the sub-networks describing main and aftershocks are interconnected through the nodes representing the structure. To this end, nonlinear dynamic analysis is performed using generated sequences of main and aftershocks. Based on these results, a comprehensive probabilistic model is constructed using the Matrix-based Bayesian network (MBN) for efficient BN modelling. The proposed BN model can update aftershock fragility by probabilistic inference when new information about the sequential event is observed. The proposed BN framework is expected to support decision making process after the aftermath of a main shock as demonstrated by numerical examples.

Keywords

Bayesian network, Matrix-based Bayesian network, Main shock, Aftershock, Probabilistic inference, Fragility.

TB3-1

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INVESTIGATION ON WIND-INDUCED DYNAMIC TENSION LOAD ON TRANSMISSION LINEBY AEROELASTIC WIND TUNNEL TESTING

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Abstract

Overhead transmission line system is a typical wind-sensitive structure with great flexibility, light weight, low structural damping. It' s buffeting dynamic tension is always the dominant load case of the structural design of the supporting tower. By the standard aeroelastic model wind tunnel test, the three-dimension dynamic tension response of the transmission conductors are investigated using the high frequency force balance, considering three type connected insulator: I-type, V-type and strain-type. The spectrum analysis of the results show that, due to the influence of aerodynamic damping, the background component accounts for dominant contribution, and the resonant component is mainly contributed by the first symmetric out-of-plane modal response. Furthermore, the close-form solution are discussed and validated by the results of the aero-elastic wind tunnel testing in frequency domain. This study provides basic wind load test data and analysis methods for the prediction of wind-induced buffeting tension loads in transmission tower structures.

Keywords

Transmission Line, Dynamic Tension, the background component, the resonant compoent, Aeroelastic Wind Tunnel Test.

TB3-2

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A MULTI-HARMONIC BALANCE METHOD FOR DETERMINING STEADY STATE RESPONSE OF HYSTERESIS SYSTEMS ENDOWED WITH FRACTIONAL DERIVATIVES

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Abstract

A multi-harmonic balance method for steady-state response determination of a Bouc-Wen hysteretic dynamic system subject to harmonic excitation and endowed with fractional derivative element is developed in this paper. The problem may arise in, for example, a base isolated structure with lead-core rubber bearing subject to seismic excitations. Specifically, by relying on the spectral representation for the response and excitation, and utilizing the Galerkin approximation method, the equation of motion in the form of a differential equation endowed with fractional element is transferred into a set of algebraic equations. To solve the algebraic equations, the time/frequency domain alteration with the Fast Fourier Transform (FFT) is introduced to deal with the non-linear hysteresis term. An efficient Levenberg-Marquardt (LM) algorithm is used to seek the solution of the algebraic equations. The system steady-state response calculated by the proposed method are juxtaposed with that obtained by a time domain integration method. Pertinent numerical examples demonstrate the efficiency and the reliability of the proposed method.

Keywords

Multi-harmonic balance, hysteresis system, fractional derivative, Levenberg-Marquardt algorithm, frequency response curve.

TB3-3

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A NEW SUPERVISED DIMENSION REDUCTION REDUCTION METHOD FOR HIGH-DIMENSIONAL RELIABILITY PROBLEMS

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Abstract

In stochastic dynamic response analysis, high dimensional uncertainty is hard to deal with because "the curse of dimension" will make most surrogate model meth-od and sample method impracticable. Dimension reduction is a newly and promis-ing technology, it can be used in many engineering problems with high dimension issue. In this article, a novel reliability analysis methodology based on a supervised dimension reduction method named "ASK" is introduced to solve high-dimensional reliability problem. This method aims at finding a subspace whose dimensionality is lower than the original input space. In this subspace, the variability of the quantity of interest can be best estimated through doing eigenvalue decomposition to the gradients matrix. By projecting the former high dimensional input to a set of new coordinates, a low dimensional kriging metamodel can be established with an observable improvement of the accuracy and simplicity. Then, we can use PDEM-based method or MCS to perform the system reliability analysis.The result shows that the new method is effective and reliable especially when the dimension of the random variable is high.

Keywords

High-dimension, reliability analysis, dimension reduction, metamodel, PDEM.

TB3-4

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A MIXTURE DISTRIBUTION WITH LOW-ORDER FRACTIONAL MOMENTS FOR EFFICIENT SEISMIC RELIABILITY ANALYSIS OF NONLINEAR STRUCTURES

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Abstract

In this paper, an efficient approach is proposed for seismic reliability analysis of nonlinear structures with random parameters subjected to non-stationary stochastic ground motions. First, the first-passage reliability problem is equivalently transformed to the evaluation of the extreme value distribution (EVD) of the response. A mixture of inverse Gaussian and Lognormal distributions (MIGLD) is then proposed to reconstruct the EVD in the entire distribution domain, where the fractional moments are suggested as constraints to specify the unknown parameters. Only five low-order fractional moments of the EVD are actually required in the proposed method due to the inherent advantages of fractional moment. Then, the recently developed Latinized partially stratified sampling (LPSS) approach, is introduced to evaluate the fractional moments of the EVD with a small sample size. In this regard, the EVD could be reconstructed accurately in the entire domain with high efficiency, particularly in the distribution tail, and the corresponding failure probabilities can be readily obtained. Two numerical examples involving both linear and nonlinear shear-frame structures under non-stationary stochastic seismic ground motions are investigated to verify the efficacy of the proposed approach. The results indicate that the proposed method can result in accurate seismic reliability of nonlinear structures with high efficiency.

Keywords

Seismic reliability, Mixture distribution, Extreme value distribution, Fractional moments, Nonlinear structures.

TB3-5

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NUMERICAL STUDIES ON THE PROBABILITY OF TRUE DAMAGE DETECTION FOR BUILDINGS UNDER UNCERTAIN SOIL PROPERTIES AND MEASUREMENT NOISES

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Abstract

Buildings are a significant part of civil infrastructure, which may experience natural hazards over their lifespan. The natural hazards imposed to building structures make it increasingly important to monitor structural health in a longer lifetime period. Several methods have been developed on global condition assessment for structures in recent years. This paper aims to investigate the effectiveness of three vibration-based damage detection (VBDD) methods for building structures embedded in soil through numerical studies. The effects of uncertain soil rigidities and simulated measurement noises on the detection probability of the VBDD methods are also studied. The numerical results show that the soil rigidities considerably influence the effectiveness of the VBDD methods due to dynamic soil-structure interaction. In addition, the increasing measurement noises are found to not only significantly reduce the mean detection probability but also enlarge the variation of the detection probability for all three VBDD methods used in this study. Therefore, the impacts of soil uncertainties and measurement noises shall be well considered in the development of robust health monitoring methods for building structures.

Keywords

Damage assessment, detection probability, soil-structure interaction.

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K-MER-BASED PATTERN RECOGNITION IN 3D BRIDGE INSPECTION

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Abstract

As regulated by Specification for Inspection and Retrofit of Highway Bridges by Ministry of Transportation and Communications (MOTC) in Taiwan, bridges are to be visually inspected regularly. To enhance the efficiency of the visual inspection, images of damaged areas of the bridges have been taken by operators or unmanned vehicles. Image processing techniques were then used to automatically identify the damage patterns. However, the said vision-based inspection processes could be completely automated yet. Inspection images could be taken at any angle and may not be perpendicular to the normal vector of the inspected area. In this paper, a 3D inspection system with crack pattern recognition based on K-mer is presented. First, a camera was used to take pictures of the bridge structures as a 3D scanner was used to capture the 3D geometry of the inspected area at the same time. The normal vector of the inspected area was then calculated based on the obtained 3D point cloud. It could be done by finding the closest plane for the selected point cloud by Least Square Approximation (LSA) and computing the normal vector of the estimated plane. The angle between the normal vector of the inspected area and the vector pointing out of the camera could be computed in terms of the arccosine of dot product of the normalization of these two vectors. The 2D inspection image was then transformed by rotating it back to the perpendicular view by the calculated tilting angle. Next, a series of image processing steps were applied to automatically identify the image pixels of the structural cracks. K-mer-based Pattern Recognition (KPR) was used to encode the shapes and frequencies of the identified crack patterns. Finally, the crack patterns were classified based on the K-mer-based frequency analysis.

Keywords

K-mer, optical inspection, image processing, stereovision, machine learning.

FA1-2

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REALIBILITY-BASED DESIGN OPTIMIZATION USING SYMBIOTIC ORGANISM SEARCH AND SUBSET SIMULATION

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Abstract

This paper introduce a new framework called SOS-SS to solve reliability design based optimization problem (RDBO). However, RDBO problems require a considerable computational effort to solve. The proposed framework combines Symbiotic Organism Search (SOS), Subset Simulation (SS), and Finite Element Method (FEM) into one algorithm framework to improve the efficiency of solving RDBO problems. The framework is tested using 10-bar truss problem and compared with other popular metaheuristic technique. The obtained result showed that SOS-SS was able to achieve better result than PSO (Particle Swarm Optimization) and GA (Genetic Algorithm).

Keywords

Reliability-based design optimization, Symbiotic Organism Search, Subset Simulation, Metaheuristic.

FA1-3

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PROBABILITY-BASED SEISMIC ASSESSMENT FOR BRIDGES

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Abstract

In this study, the incremental dynamic analyses (IDA) are performed using 20 sets of ground motion acceleration time histories to investigate the responses of a multi-span bridge. The seismic hazard analyses and the response curves from incremental dynamic analyses (IDA curves) are combined to estimate the limit state displacements of this bridges corresponding to different return period earthquakes. The estimated limit-state displacement can be used to vrify the allowable displacements which are specified in the highway bridge seismic design code for different performance levels. Numerical results demonstrate that the displacement requirements from the refined seismic assessments (based on pushover analyses) for level I and level II earthquakes are consistent with those from IDA curves (based on seismic hazard analyses). However, the displacement requirements from the refined seismic assessment are much less than that from IDA curves for level III earthquake (corresponding to 2500-year return period), which could result in unconservative seismic assessments particularly for near fault ground motions.

Keywords

Increment dynamic analyses, Seismic hazard analyses, Return period, Seismic assessment.

FA1-4

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RELIABILITY ANALYSIS FOR WIND-INDUCED VIBRATIONS OF TORSIONALLY COUPLED SYSTEMS

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Abstract

The objective of this paper is to conduct the reliability analysis of high-rise buildings under wind loads. Numerical examples are provided to capture the dynamic effects of structures with eccentricity between the elastic and mass centers. The framework of this research consists of two stages. The first stage includes two parts: the deterministic analysis of wind-induced acceleration for a variety of attack angles, i.e., the demand, and the determination of allowable acceleration based on the occupant comfort criteria for wind-excited buildings, i.e., the capacity. According to the results obtained in the first stage, the reliability analysis is conducted in the second stage, which can predict the probability of dissatisfaction with occupant comfort criteria for a variety of probability distributions of the structural eccentricity. The findings indicate that, compared to the lognormal and type I extreme value distributions, the normal distribution can be used to more conservatively simulate the uncertainties of the eccentricity between the elastic and mass centers. Furthermore, the probability of dissatisfaction with occupant comfort criteria of the torsionally coupled system is relatively higher than that of the torsionally uncoupled system for each attack angle due to the coupled mode effects.

Keywords

Reliability analysis, Torsionally coupled system, Wind load, Elastic center, Attack angle.

FA1-5

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RELIABILITY ANALYSIS OF A RIVER BRIDGE CONSIDERING CLIMATE CHANGE EFFECT

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Abstract

This study aims to assess the safety impact of a bridge considering many importnat uncettainties including the influence of climate change. To demonstrate the proposed methodology, several bridges are selected as the research object. This study consists of three parts. First, generating future meteorological data under climate change scenarios via GCM (General Circulation Model) with history meteorological data (include 1986-2005 years daily rainfall and temperature), and converting the generated future meteorological data into the watershed runoff using GWLF (Generalized Watershed Loading Function). Second, acquiring stream level and flow velocity at bridge sites via 2D HEC-RAS model using the outcomes of GWLF, the goal of this part is to estimate the scouring depth of each pier. Third, establishing SAP2000 bridge model to assess the structural behaviors with different scour depths and earthquake intensity. Demands of displacement ductility are derived from pushover analysis and time history analysis. The capacity of displacement ductility is adopted form FEMA to establish the fragility curves.

Keywords

Displacement ductility, uncertainty, climate effect, bridge.

FA1-6

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VARIATION OF FRICTION COEFFICIENTS ON FUNCTIONAL BEARING MODEL (FBM) BRIDGE UNDER THE NEAR FAULT EARTHQUAKES

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Abstract

A single span bridge with rubber bearing as the support system analyzed to observe the effect of variation of friction coefficient on both surface friction between deck-support and support-column cap beam. Two range of friction coefficient have been studied, in range of 0,2 – 0,4 based on CALTRANS Design Code and 0,35 – 0,5 based on Experimental Result. A rubber bearing system applied in a bride without any anchor system, the correlation of the friction force and the shear force on top and bottom surface friction of the rubber bearing system will much more important to observe to avoid the excessive sliding displacement which increase the possibility of bridge falling under the earthquakes. Less number of friction coefficient allows the system to move more flexible, but the high number of friction force will limit the sliding displacement which cause the rubber working more in absorbing the energy. Thus, the purpose is to observe which range of friction coefficient that preferable to choose correlated with the percentage of energy absorptions.

Rubber bearing system as mentioned is a bearing which combine rubber element and friction surface interconnection between bearing-deck (Top surface friction) and bearing-column (bottom surface friction). Many researchers assumed a rubber bearing system into 1 link which have rubber and friction parameter altogether, this way is possible and commonly used in many research, but to find how many contribution of each element to respond the external force may be difficult to analyze. Functional Bearing Model (FBM) is how to analyze the rubber bearing system in several links based on how many constituent element on it. This research is an improvement idea of the previous FBM concept which proposed by Liu, et al. on 2013, take an anchor system on the bottom surface friction, they assumed the rubber bearing system into two links consist of rubber element and top srface friction element. Here proposed three links assumption, by means there is no anchor system on the rubber bearing system. These three springs are: top surface friction link, rubber link, and bottom surface friction link. It was inspired on the recent conditions, that many bearing put in beetween column and deck without any anchor system make the bearing easy to remove when it broken due to the failure which mostly happens on the bearing system as the structure weak element. Make sure these idea is suitable for the bridge analysis with compare the deck displacement and deck acceleration of

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(Continued)

both experiment and FBM 3 links analysis. Observing the result are close each other, thus FBM 3 springs is properly used in determining the rubber bearing system.

Put variation of the friction force on both friction elements, proven that variation of the friction force may take several contribution for the rubber bearing respond. In cummulative displacement of column drift, bottom sliding displacement, rubber deformation, top sliding displacement, and deck displacement. Rubber take 25% in contributing the displacement. In cummulative, displacement on top surface friction is much more larger than bottom surface friction, which mean even without anchor system, bottom surface friction may give a few movement, since the prone area is on top surface friction. In rubber bearing system, rubber element will deformed 3-4 cm and the excess energy will be dissipate by the frictions element. If the same friction values applied on both surface friction, from 100% of the total excess energy will be dissipate 50% on the top surface friction and 50% more on the bottom surface friction. For the different friction coefficient values between top and bottom surface friction, top surface friction dissipate more energy than the bottom surface since the friction coefficient is lesser. Comparing friction coefficient based on design code and experimental, friction coefficient values in range of B1-B4 work well in absorbing the energy respect to the input energy, which means the values based on the experimental are preferably used than the value of design code. Defining the number of the friction coefficient values is quitly important since applying too small values might be oversliding and too high values might prohibit the movement.

Keywords

Rubber Bearing, Functional Bearing Model, Friction Coefficient.

MEMO

MEMO

Taiwan Regional Engineering Contractors Association, TRECA

Introduction

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