International Symposium on Reliability Engineering and Risk Management 2022

Sunday 04 September 2022 - Wednesday 07 September 2022

Scientific Programme

Mini-Symposia

Computational Methods and Applications for Stochastic Engineering Dynamics

The efficient propagation of the uncertainties of complex engineering systems constitutes one of the major challenges associated with uncertainty quantification in the field of stochastic dynamics of structural and mechanical systems. In addition, recent advances in stochastic dynamics and emerging technologies, such as in nano-mechanics and energy harvesting, dictate a highly sophisticated modeling of the related systems and corresponding excitations. In this regard, the necessity of employing novel mathematical tools and potent signal processing techniques, which lead to efficient solution frameworks for studying the behavior of engineering systems and assessing their reliability, is evident. The objective of this MS is to present recent advances and emerging cross-disciplinary approaches in the broad field of computational methods of stochastic engineering dynamics. Further, this MS intends to provide a forum for a fruitful exchange of ideas and interaction among diverse technical and scientific disciplines. Specific contributions related both to fundamental research and to engineering applications of stochastic dynamics and signal processing methodologies are welcome. A non-exhaustive list includes joint time/frequency analysis tools, sparse representation-based methodologies, stochastic/fractional calculus modeling and applications, nonlinear stochastic dynamics, stochastic model/dimension reduction techniques, Monte Carlo simulation methods, and risk/reliability assessment applications.

Data-driven inverse methods for uncertainty quantification

Recent developments in non-deterministic modelling approaches introduced a very broad spectrum of highly advanced numerical methods for reliability analysis and uncertainty quantification, including probabilistic, interval, fuzzy or imprecise methods. The application of these techniques however requires the analyst to specify the relevant uncertain model parameters with a high degree of accuracy. Since direct measurement of such model quantities is often not feasible, or in practice too expensive, data-driven inverse techniques are commonly applied.

This mini-symposium aims to gather experts researchers, academics and practising engineers concerned with data-driven inverse methods for uncertainty quantification to present their recent findings, methodological developments and innovative applications. Papers discussing advances in techniques from both frequentist and Bayesian interpretations of probability theory, as well as interval and possibilistic methods and concepts based on imprecise probabilities are invited. Next to these more traditional uncertainty quantification methods, also contributions related to machine learning are particularly welcomed.

Data-driven versus Synthetic Tools used in Hazard Impact Assessment of Built-Environment

Recent catastrophe events have shown how vulnerable communities are to disasters and how the recovery of the impacted communities are contingent on appropriate preparedness. Measurement and assessment of community disaster resilience are therefore become crucial for communities to support collective actions to reduce the associated potential social disruptions and significant economic losses; and to quickly recover from hazard events. Among the essential ingredients for evaluating disaster resilience of communities are models for the assessment of hazard performance and impacts for the built environment. While assessment of such models require both data-driven (i.e, based on data from past hazard events or experimental data) and synthetic modelling techniques, advanced probabilistic methods are also needed to systematically treat significant uncertainties associated with these impact models. This mini symposium will provide a platform to bring together researchers and practitioners aiming to provide insights on recent experiences and developments in hazard impact assessment modeling of structural and infrastructure systems. Contributions related to recent advancements in field data-collecting protocols, data-driven techniques, simulation approaches, probabilistic tools, machine-learning approaches and big analytics in context of hazard-impact modeling are welcome.

Digital methods in the lifecycle of infrastructure systems to enhance reliability of operation

Digital methods, in particular Building Information Modeling (BIM) and Structural Health Monitoring (SHM), are being used more and more in the Architecture, Engineering and Construction (AEC) Sector. However, building operation and maintenance processes mainly still follow conventional processes and are hardly supported by digital databases. The symposium is open for contributions which focus on fundamental concepts for digitally supported maintenance of infrastructure systems. The aim is to enhance availability, reliability and provide a structured data basis for the involved project participants along the lifecycle. Therefore, required methods and processes need to be defined and harmonized from different perspectives like infrastructure operators, monitoring service providers and supervision authorities. The symposium should address at least one of the following areas:

- Concepts for using Digital Twins for data organization and infrastructure management along the lifecycle.
- Digital models and linked data models as the basis for data exchange and communication processes during the operation phase.
- Innovative Methods for data analysis, economic assessments and risk calculation regarding the phase of operation to optimize lifecycle costs.

In conclusion, maintenance processes can be initiated on a data-driven basis to change the way from reactive maintenance processes to proactive approaches.

Life-cycle Reliability of High-Speed Railway Structural System

The development of Chinese high-speed railway has entered a new era of long-term safe and stable operations from the stage of large-scale constructions. Since the train loads, environmental factors, materials and structural behaviors of high-speed railway structural systems are random and time-dependent, it is of vital importance to evaluate the safety and serviceability of the high-speed railway systems based on the time-dependent reliability methods.

The main objective of this Mini Symposium is to bring together experts working in the reliability assessment and risk management of high-speed railway structural systems to share and discuss the latest developments in the field. Some relevant topics include time-dependent reliability, risk, and maintenance strategy of high-speed railway structures, such as the track system, high-speed railway bridges, high-speed railway tunnels and so on.

Machine Learning for Uncertianty Quantification and Structural Reliability

Uncertainty quantification (UQ) is the process of quantitatively characterizing the uncertainties of simulator outcomes. In both scientific and engineering computations, it has recognized as of vital importance especially in those scenarios where decision or design of products have to be implemented when some aspects of the systems are not exactly learned due to lack of knowledge or cannot be exactly learned due to intrinsic randomness of things. A typical research direction is the reliability analysis and reliability-based design optimization of structures, where both intrinsic randomness of parameters (e.g., material properties, dimension sizes, excitations, etc.) and epistemic uncertainties on the probability distributions of those parameters have to be carefully treated. A general UQ framework includes many sub-tasks such as uncertainty characterization, forward uncertainty propagation, inverse model updating, uncertainty sensitivity analysis, etc. All the sub-tasks of UQ and structural reliability pose great challenges for numerical computation.

The rapid developments of machine learning algorithms, such as deep neural network, Gaussian process regression, manifold learning, has brought new hopes for addressing the above challenges on numerical computation. However, the recent developments on this aspect is far from mature for solving all the above-mentioned tasks, and challenges, such as proper addressment of prediction errors, extraction of feature space for high-dimensional analysis, and design of training points, are still left as open problems. The aim of this mini-symposium is to collect the latest developments on all aspects of machine learning for UQ and structural reliability. The scope of the mini-symposium is not limited to the non-intrusive methods where the simulators are regarded as black boxes, but also covers those developments on intrusive methods where the physic-informed machine learning is integrated.

This activity is organized under auspices of the Committee on Probability and Statistics in Physical Sciences (C(PS)^2) of the Bernoulli Society for Mathematical Statistics and Probability.

Maritime Safety and Smart Shipping

With the rapid development of ICT and Artificial Intelligence, industrial upgrading is undergoing in the maritime industry, where many techniques have been developed to enhance maritime safety and improving the automation and intelligence of ships, equipment, and infrastructure. The maritime environment, however, is complex, harsh and even brutal for such novel techniques. Thus, it is crucial to consider the safety and reliability of such techniques in the whole-life cycle of maritime systems including design, construction, maintenance, and operation phases.

This Symposium is going to be organized associated with the 5th Workshop on Maritime Safety and Smart Shipping (MSSS), followed by previous ones in 2016, 2017, 2018, and 2020. It will bring together leading experts from academia, industry, and interest groups to consolidate and coordinate global research activities on maritime safety and smart shipping. Relevant topics are including but not limited to:

- Developments of autonomous vessels, smart infrastructure, and smart logistics;
- Developments of safety and reliability of marine engineering systems;
- Influence of human factors, climate change, Arctic navigation, and autonomous ships on maritime safety;
- Application of big data, artificial intelligence, and machine learning in maritime safety and smart shipping.

Mini Symposium on Uncertainty-informed asset management

This Mini symposium has an objective to share the knowledge in both risk and physical asset management. It is intended to create a platform for common understanding of the role and value provided by the physical asset management functions, especially in conditions of significant uncertainties (related to climate change, new technologies, market evolution, changing regulatory framework, malicious human actions, extreme weather events, pandemics, etc.) in modern organizations. Such a context creates the complexity of their operational and business environment. This complexity is not always well understood, and cannot be efficiently controlled. Such a complex world offers extraordinary opportunities for advances and prosperity in all spheres of life and activities. However, this complex world has become highly fragile and vulnerable to failure at all scales, posing serious threats to society, even when external shocks/disruptions are absent. The latest case of the COVID-19 pandemic demonstrates the above. It is affecting both all sectors of life and businesses worldwide. It convincingly shows that we need to think, plan and act globally in order to deal with such situations that will also take place in the future. Thus, modern organizations have to find ways of coping with this reality to remain economically viable. We are of opinion that the concepts of structured Asset Management (AM) and resilience put together may provide an efficient framework in this regard.

Motivation
In the presence of ongoing global competition and increasing demands from stakeholders, all companies have begun to focus on achieving higher performances, i.e. higher quality of their products/services, lower costs, and sustainability control while facing numerous above mentioned challenges. Moreover, the currently operating companies should be resilient to both internal and external hazards in a hyper-connected and complex world. To achieve these goals, effective management of physical assets becomes particularly important. This implies the necessity of proper performance of maintenance tasks, especially in the fields of setting pre-asset acquisition strategies for planning and initiating assets, asset operation and maintenance, performance monitoring, together with allied asset accounting and economics, or audit and renewal analysis. Additionally, the maintenance and asset managers should incorporate operational and business risks associated with their activities into their decision-making processes. This means, for example, using appropriate risk management models and assessing the level of risk maturity. In addition, it involves evaluating systems for their resilience to risks in manufacturing and supply chains.

Objective
This symposium aims to present the state-of-art of theoretical developments and applications in the area of resilience, risk and physical asset management in various industry sectors. The key aspects of this special session are, among others:

- development of technical systems maintenance in conditions of significant uncertainty,
- assessment of organizations’ maturity in resilience, risk and maintenance management,
- knowledge management in organizations,
- promoting research for innovative approaches to decision support systems and multi-criteria decision making methods,
- development of asset and risk management strategies,
- reliability and risk assessment in maintenance,
- resilience engineering,
- supply chain risk management,
- resilient manufacturing and logistics systems.

Model Identification and Structural Reliability Analysis with Complex and/or Combined Uncertainty for Structural Dynamic Problem under Seismic Excitation

Model identification and structural reliability analysis considering damage and aging have become increasingly hot research topics. Despite many achievements in theoretical and computational techniques, the lack of accurate and reliable techniques for interpreting or measuring data remains a challenge in the structural dynamic problems under seismic excitations. In the process of data collection, modeling, and analysis, combined uncertainties, such as aleatory and epistemic uncertainty, arises due to sensing noise, modeling error, surrounding environment, and lack of knowledge. Therefore, quantifying the uncertainties leads to improving the robustness and accuracy for assessing the seismic performance of existing structures. In this MS, possible topics of interest include but are not limited to: probabilistic modeling, filtering techniques, stochastic techniques, Bayesian approach, imprecise probability, aleatory and/or epistemic uncertainty, model updating, structural health monitoring, etc.

Non-deterministic model updating and health monitoring with uncertainty treatment

As a classical technology, Model Updating has been developed for more than 50 years to calibrate the parameters or the numerical model itself such that to tune its prediction as close as possible to the experimental measurements. One of the featured applications of the numerical model is

Structural Health Monitoring, which has benefitted from precise models to identify and localize the damage by monitoring the change of key properties of the structural system.

However, it is widely recognized that the unavoidable uncertainties in both operational experiments and numerical analyses require efforts to be dedicated to model updating and health monitoring. Non-deterministic modelling approaches enable characterization, propagation, and quantification of the inevitable uncertainties, providing predictions over a possible range of outcomes (distributional, interval, fuzzy, etc.) rather than a unique solution with maximum fidelity to a single experiment.

This mini-symposium is dedicated to gathering experts from both academia and industries to summarize the latest development on the non-deterministic approaches for numerical modelling and structure health monitoring. Contributions addressing stochastic model updating, system identification, damage localization, sensor placement optimization, uncertainty quantification are highly welcomed.

Novel Data Science for Disaster Prevention and Resilience of Civil Infrastructures

JSCE (Japan Society of Civil Engineers) and ASCE (American Society of Civil Engineers) have jointly developed a framework of infrastructure resilience (IRF: Infrastructure Resilience Framework*) to draw a sketch map to see how components related to infrastructures are interrelated and connected with the resilience of the community. The utility of IRF discussed at the Joint Japan-US Symposium on Assessment, Management, and Governance for Infrastructure Resilience which held in April 2021. Therein, the concept of ‘resilience’ has advocated the importance of in-advance preparedness to bear infrastructure disruptions events and to recover as quickly as possible or even to build back better.

In this MS, based on those discussions about the concept of IRF, we would like to be expected to deeply considering novel data science methodologies, which could enhance disaster prevention and resilience of civil infrastructures against natural disasters. Especially, in the environment that natural disasters (such as earthquakes, Tsunami, floods, typhoons, and so on) have been becoming extremely serious, it is very meaningful to discuss these themes. The MS welcomes relevant research from academic, government, and industry sectors. The invited topics include but are not limited to data analytics, big data, system identification, meta-model, data-driven approach, etc.

Optimal Structural Design under Uncertainty

Optimization is a useful tool for determining the best design configuration for a structural system according to a prescribed criterion. Nonetheless, for its practical implementation, it is necessary to cope with unavoidable uncertainty affecting structural performance. From a practical viewpoint, this leads to a double-loop problem, where the outer loop explores different design configurations by means of an optimization algorithm, while the inner loop explores different possible performance scenarios by means of an algorithm for uncertainty quantification. The numerical costs associated with such double-loop problem may become significant or even prohibitive, as they involve repeated analysis of the structural model, which can be quite complex on its own. Thus, optimal structural design under uncertainty has became a field of active research, with focus on efficient strategies for decreasing numerical efforts.

The aim of this mini-symposium is addressing the latest progress on approaches for designing complex systems and structures under uncertain conditions. The scope of the mini-symposium is broad, as it covers different topics such as uncertainty quantification, efficient optimization schemes, advanced simulation techniques, surrogate models, robust design, reliability-based design, multi-objective optimization, life-cycle optimal design, optimal inspection, and maintenance scheduling, etc. Both theoretical developments and applications involving systems of engineering interest are particularly welcomed in this session.

This activity is organized under auspices of the Committee on Probability and Statistics in Physical Sciences (C(PS)^2) of the Bernoulli Society for Mathematical Statistics and Probability and the Risk and Resilience Measurements Committee (RRMC) of the Infrastructure Resilience Division (IRD) at the American Society of Civil Engineers (ASCE).

Probabilistic approaches in geotechnical engineering

Geotechnical engineering is subject to large uncertainties, not only due to spatially variable and uncertain ground conditions, but also due to significant model uncertainties involved in the design and assessment of geotechnical structures. There is increasing awareness that explicit treatment of uncertainties through uncertainty quantification and reliability analysis can be of great benefit to geotechnical engineering practice. Furthermore, the Eurocodes are reliability-based and will in their new versions facilitate reliability verification through probabilistic methods explicitly. This special session strives to highlight recent advances in probabilistic approaches to geotechnical problems and thereby to further advance the uptake of reliability methods in practical applications. Examples are probabilistic site characterization or reliability-based design and assessment of geotechnical structures.

Reliability Analysis and Prognostics for Complex Systems

Reliability is an important consideration issue during the development of a variety of systems or products, e.g., automobiles, airplanes, semiconductors, and power plants, which ensures that their performances are maintained over a specified period of time under specific use environments. As technology evolves, system complexity increases and reliability evaluation for the systems remains an important area of research and has attracted the attention of system engineers. Once, the system is launched and used in the field, failure data or maintenance data are collected so improvements can be performed to maximize system’s availability or minimize operation cost. Recently, system monitoring and diagnostic methods using smart sensors and internet of thing (IoT) garner more attentions from variety of industrial areas.

Nowadays, innovative tools for reliability analysis and decision making in design, operation and maintenance of engineering systems are developed for safe, reliable and effective operation of these systems. This special issue on “**Reliability Analysis and Prognostics for Complex Systems**” presents a platform where researchers from academy and industry can present methodologies of coping with the uncertainties in reliability modeling & prognostics for complex systems through the use of concepts and various techniques; life tests and lifetime prediction from repairable or non-repairable systems, maintenance scheduling and modeling, Residual useful life (RUL) prediction using parametric or nonparametric methods, etc.

Keywords
- System reliability
- Maintainability & Availability for repairable or non-repairable systems
- Diagnostics & Prognostics
- Condition-based maintenance
- Maintenance modelling, planning, scheduling and optimization
- Remaining useful life estimation
- Machine learning & deep learning in maintenance modelling

Reliability Analysis under Aleatoric and Epistemic Uncertainty

Reliability analysis offers the possibility of quantifying the level of safety of engineering systems. As reliability analysis encompasses probability theory, it is well suited for problems where uncertainty is of the aleatoric type, that is, arising from inherent randomness. However, in several practical situations, uncertainty may be of the epistemic type due to issues such as lack of knowledge, conflicting sources of information, vagueness, etc. In such case, non-traditional models such as intervals or fuzzy sets may be a suitable choice for describing uncertainty. Naturally, in practice, one may be confronted with the challenge of coping with both aleatoric and epistemic uncertainty, leading to a problem of imprecise reliability analysis.

Imprecise reliability analysis offers a powerful framework for coping with uncertainties. In essence, it provides a collection of reliability analyses (performed under aleatory uncertainty) which are indexed by the model describing epistemic uncertainty. Nonetheless, its practical implementation is far from trivial, as it demands increased numerical efforts when compared with purely aleatoric reliability analysis due to the necessity propagating aleatoric and epistemic uncertainty simultaneously. Therefore, the aim of this mini-symposium is addressing the very latest development on approaches for reliability under aleatoric and epistemic uncertainty. The scope of the mini-symposium is broad, as it covers: different models for representing uncertainty such as classical probabilities, intervals, fuzzy analysis, imprecise probabilities, evidence theory, etc.; novel formulations for coping with aleatoric and epistemic uncertainty; advanced simulation methods; development and application of surrogate models, etc. Both theoretical developments and applications involving systems of engineering interest are particularly welcomed in this session.

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Reliability and Resilience of Critical Infrastructure Systems and Networks

Complex infrastructure systems and networks are a pervasive feature of modern society. They provide critical services for everyday life, such as water, food, energy, transport, communication, banking, and finance. Reliability and resilience of our infrastructure are thus of utmost importance. However, most of our critical infrastructures are interconnected, interact with one another and depend on social networks, as well. In this respect, cascading failures, where external perturbations trigger some initial local failures that lead to eventual global system failure, are especially hazardous. A deep understanding of complex failure mechanisms and of the capabilities to withstand natural hazards and man-made threats is crucial. In particular, the degree to which an infrastructure system subjected to internal or external stresses is capable of keeping or recovering the service demanded needs to be quantitatively estimated. Quantitative assessment of system and network reliability and associated risks and uncertainties is therefore a key aspect of system design, optimization, and operation.

The main objective of this Mini-Symposium is to bring together experts working in the interdisciplinary area of reliability and resilience of infrastructure systems and networks to discuss the latest developments in the field. Some relevant topics include reliability, risk, vulnerability and resilience analyses of critical infrastructures, multi-sector interdependencies of infrastructure networks, common cause failure, and cascading failures.

Resilience and Reliability Modelling of Critical Assets in the Age of Disasters & Pandemics

Disasters and major failures have taught us a need for a paradigm shift from efficiency-based decision making to resilience-based. Such shift has a direct impact on asset and supply chain management as it leads to a shift from just-in-time to a just-in-case mind set. Another paradigm shift is to move from seeking solutions through optimisation approaches to embracing uncertainty and the generation of what –if scenarios through hybrid modelling, with pros and cons in the strategic decision-making process.

Resilience as a conceptual idea is profound and considered to have a key role in dealing with disasters such as pandemics. However, there is little research on modelling resilience and integrating it with other approaches in order to systematise its operation (Labib, 2021). The concept of the resilience triangle originated from the work of Bruneau et al. (2003), and then mathematically modelled by Ayyub (2014), and recently extended and combined with Bowtie modelling and applied to managing pandemics by Labib (2021).

We encourage hybrid approaches in modelling, as well as application of advanced resilience and reliability modelling in innovative applications such as healthcare, search and rescue, asset management, and managing innovations and its barriers.

References

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Resilience Modeling for Risk-Informed Decision Support

Resilience is the ability to prepare for, absorb, and recover rapidly from naturally occurring and intentional events. Over the past decade, a substantial body of research worldwide has been accumulated that ranges from modeling of individual facilities for better performance to network models with interdependencies across nodes; and even inter-sector dependencies that provide dependencies across physical systems. More recently full community- and regional-level models have been realized that contain interacting physical, social, and economic systems to enable risk-informed decision support. In this mini-symposium, a series of (at least) three sessions is proposed that explore the application of resilience models for decision support at different scales. Presentations are invited that focus on individual networks and systems such as water networks, transportation systems, and building clusters including how a decision is informed; cross-dependent models; full community- and regional-level modeling; and interdisciplinary analyses that encompass social and economic theory and data. The presentations will be organized to begin the symposium at the detailed and complex-model level of the individual systems to inform decisions, followed by increasing levels of scale with (presumably) decreased levels of resolution or complexity until the entire community and regions are modeled and provide risk-informed decision support. Presentations focusing on all hazards are welcome including (but not limited to) climate change, earthquake, tornado, flood, hurricane/typhoon, wildfire, and human-induced events; all approaches from physics- and processed-based (e.g. discrete event simulation) to data-driven (e.g. machine learning) are welcome.

Risk-based damage assessment and prediction of infrastructure systems subjected to natural hazards

Infrastructure systems play a critical role in assuring modern society's functionalities. Natural hazards (e.g., strong winds, earthquakes) are responsible for significant damage and socioeconomic ripple effects of these systems. One example is that an extreme winter weather struck much of the U.S. in February 2021, and caused a severe blackout along with several snow and ice storms, leaving millions of people without power. Motivated by the significant catastrophes caused by hazardous events, as well as increasing public awareness of the need to mitigate hazard damage and losses from such hazard events, it is expected that the infrastructure systems must possess an acceptable level of functionality before, during and after hazardous events to achieve community resilience goals. Under this context, assessment and prediction of the potential for damage to community's infrastructure systems exposed to extreme natural hazards is an essential component for measuring and optimising resilience enhancement strategies for communities. To this end, a probabilistic framework should be employed, taking into account the uncertainties associated with the hazard-resisting capacities of the infrastructure systems as well as those associated with such extreme events. The objective of this special session is to present, discuss, and disseminate the recent developments in the approaches for risk-based the damage assessment and prediction of infrastructure systems subjected to natural hazards.

Risk-informed Digital Twins of Buildings, Bridges, Offshore structures: frameworks, methods, and tools

Motivation

The Digital Twin (DT) is a virtual replica of buildings, processes, structures, people, systems created and maintained in order to answer questions about its physical part, the Physical Twin (PT). In the case of the built environment, the PT may be represented by buildings, bridges, offshore structures. Full synchronization between the DT and the PT will provide a perpetual learning process and updating between the two twins. However, multiple sources of uncertainty during the lifecycle challenge our prediction capabilities. It follows the significance of the Risk-Informed Digital Twin (RDT) where tools of data-driven Uncertainty Quantification in all its facets (probabilistic, non-probabilistic or hybrid), Risk Analysis and decision making under uncertainty are fully integrated.

Objective

The scope of this Special Session is to bring together expert practitioners, researchers and academics to develop methods, frameworks and tools in this broad area, including but not limited to Structural Health Monitoring, Value of Information, Uncertainty Quantification (probabilistic approaches, interval model, fuzzy sets, Bayesian model, imprecise probabilities, probabilistic sensitivity analysis), surrogate modelling using active learning technologies, structural reliability, stochastic dynamic analysis, machine learning, reinforcement learning, lifecycle optimal design and management under uncertainty. Contributions addressing practical applications are also encouraged, e.g. buildings, bridges, offshore, geotechnical systems, up to urban systems and regional scale analysis.

Stochastic finite element methods and their applications on model updating

Stochastic finite element method is an important tool widely used in many aspects such as reliability analysis, safety assessment and model updating et al. At present, various stochastic finite element methods have been developed. As typical representatives among these methods, the perturbation methods and the Garlekin based methods like PC and GPC, have been successfully applied to solve the stochastic problems in extensive industrial fields. However, highly accurate and efficient stochastic finite element methods are still developing to implement the stochastic analysis of large scale structural models. This research direction has been attracting many researchers' attention.

Model updating is a key content in structural health monitoring. When considering the randomness of structural modelling and measurenmt data, the stochastic model updating becomes unavoidable. To solve stochastic model updating problems, the stochastic finite element methods can play a significant role instead of the usually used Bayessian methods. This direction is a hot topic in current structural model updating, which has a very good application prospect in practical structural health monitoring.

This mini-symposium tries to bring the experts, scholars and engineers in various research fields together to discuss the development of SFEMs and SFEM based model updating methods in the future.

Understanding of Risk for Sustainable Engineering

Save and efficient functionality of infrastructure is a vital requirement for economic growth and societal welfare. One key challenge for engineers is to optimally balance the investment in infrastructure, economic and societal benefits, as well as the environmental compatibility that it may generate. Such considerations involve the responsible evaluation and weighing of risks, typically carried out by collaborative research teams. Another key challenge pertains to the communication and understanding of risks and the acceptance of risks in society. Psychological research has stressed the importance of risk communication and identified cognitive and affective factors as individual predictors of risk perception and acceptance. Recent studies point to the complexities of social processes involved in the acceptance of risks including the role of social trust. Because aligning technical, economic and environmental reasonability with societal acceptance is crucial for authorities and decision-makers, understanding the social dynamics of risk acceptance is most essential.

This Mini Symposium is exploring pathways for building a thorough understanding of risk in the context of civil infrastructures. Contributions may address (i) the perception and balance of threats, hazard and risk associated with natural excitations and man-made influences of our infrastructure and with its performance and safety, (ii) the derivation of adequate risk indicators (iii) the communication of risks involving the consequences of low performance or failure, specifically in education, public and social media, (iv) expectations on the safety and performance of infrastructure involving the role of social relationships, networks and cultural contexts, (v) methods to illustrate and visualize risk for common understanding among the society etc. We specifically invite contributions from psychology, social and educational sciences, ecology and environmental sciences or with strong links into those disciplines. We further aim at presenting both theoretical and empirical contributions based on a variety of quantitative and qualitative methods including interviews, experiments, cross-sectional or longitudinal correlational analyses, as well as social network analyses.

Reliability and Maintenance for Internet of Things and 5G+ Networks

Internet of Things (IoTs), as the foundation of cyber-physical systems (CPSs), connect real-world industrial systems or products through Internet-based cyber networks, potentially achieving coordinated monitoring, communication, computing, control and decision-making among large-scale interconnected physical entities.

In this context, the 5G+ wireless communication network represents a critical part of the modern/future CPSs, providing solid infrastructure functions, such as the ultra-reliable low latency communication (uRLLC) for critical information transmission, and, the massive machine-type communication (mMTC) for the internet of massive industrial devices.

The reliability analysis of IoTs and 5G+ networks is a key issue for their success, and a challenging one. The capability of the cyber services to satisfy the demands from the physical counterparts can be a bottleneck by its own, for Quality of Service (QoS) performance, including the end-to-end latency, data rate and package loss in communication systems. Then, the quantification of the relation between the cyber QoS performance and the reliability of the corresponding physical production/service quality is essential for the reliability-and-maintenance based design of future 5G+ networks/IoTs/CPSs.

In this session, we aim to discuss the following topics (and others) related to reliability and maintenance analysis of IoTs and 5G+ networks:

1. Definition and assessment of the end-to-end service reliability of IoTs and 5G+ networks.
2. Reliability allocation and maintenance scheduling for 5G+ networks in service of industrial/consumer objectives.
3. Maintenance scheduling policy design for industrial systems under IoTs.
4. Risk analysis for future industrial systems, IoTs, 5G+ communication networks, and CPSs.

Keywords: reliability, maintenance, 5G, IoT, QoS, end-to-end production/service performances

General Session Topics

Structural Reliability

System Reliability

Risk Assessment and Management

Resilience Engineering

Design under Uncertainty

Prognostics and Maintenance

Health Monitoring and System Identification

Geotechnical and Environmental Risk

Economic and Financial Risk

Product Reliability

Asset Management

Decision Making under Uncertainty

Business Continuity

Other topics