March 31 - April 1, 2019

3rd International

SYMPOSIUM ON INFRASTRUCTURE ASSET MANAGEMENT

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NYU ABU DHABI
INSTITUTE

WELCOME

Dear SIAM3 Participants and Guests

The NYU Abu Dhabi Engineering Faculty members join me in welcoming you all to the 3rd International Symposium on Infrastructure Asset Management, here at the NYU Abu Dhabi Institute Conference Center.

This by-invitation-only symposium series was initiated by our friend and distinguished colleague, Kiyoshi Kobayashi, to serve as a forum for a select group of scholars in the field of Infrastructure Management and to present and have in-depth discussions about the latest advances in the field. A core group, consisting of Kiyoshi, Kioyuki, Bryan, Sue, Pablo and myself, took it upon ourselves to hold the meetings every year and a half, and to invite a small number of scholars to each event.

The first meeting took place in January 2016 at Kyoto University in Japan with the second meeting hosted at ETH Zürich in June 2017.

It is unfortunate that Kiyoshi, the founder of SIAM, is unable to join us this time, as he is transitioning into a well-deserved retirement during the symposium. We wish him all the best as he starts this restful stage of his life, although for those of us who know him, he is unlikely to stop his usual dynamic engagement in research and scholarship.

The presentations for this year have been organized according to the following themes:

Theme A: Infrastructure Performance Modeling
Theme B: Decision Making and Optimization
Theme C: Hazards, Risk and Resilience

A special thanks to the NYU Abu Dhabi Institute for their sponsorship and support, and to the Engineering Division staff, especially Nada Hariz, for managing the travel and accommodations for many of you.

I look forward to another successful symposium, and I welcome you to Abu Dhabi.

Samer Madanat
March 18, 2019

COMMITTEES

STEERING COMMITTEE

Bryan T. Adey
Chair of Infrastructure Management, Institute of Construction and Infrastructure Management (IBI), ETH Zürich, Switzerland

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Associate Professor of Civil and Environmental Engineering, Northwestern University, USA

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Kiyoshi Kobayashi
Director of the Management Research Center of the Graduate School of Management and Professor of Engineering, Infrastructure Economics and Management at the Department of Urban Management of Kyoto University, Japan

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Sue McNeil
Professor, and Chair, Civil and Environmental Engineering, University of Delaware, USA

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Nada Hariz
Office Manager & Executive Assistant,
NYU Abu Dhabi

PROGRAM

Institute Conference Center, Multi-Purpose Rooms 002 & 003

DAY 1 I MARCH 31, 2019

Breakfast and registration — **09:00 AM - 09:45 AM**
Institute Conference Center (A6), Meeting Room Foyer

Introduction & Welcome Remarks — 09:45 AM - 10:00 AM
Samer Madanat, New York University Abu Dhabi

Theme A I Infrastructure Performance Modeling

Modeling the Accuracy of Airfield Pavement Deterioration Forecasts — 10:00 AM - 10:35 AM
Rabi Mishalani, The Ohio State University

Imperfect Data and their Impact on Deterioration Modelling in Infrastructure Asset Management — 10:35 AM - 11:10 AM
Xianxun Yuan (Arnold), Ryerson University

Break and refreshments — **11:10 AM - 11:30 AM**
Institute Conference Center (A6), Meeting Room Foyer

Relevance of the Discount Rate to the Optimal Structure Design Service Life of Asphalt Concrete Pavement — 11:30 AM - 12:05 PM
Adrián Ricardo Archilla, University of Hawai'i at Manoa

Effect of Preventive Maintenance for Bridge Expansion Joints Against Corrosion at Steel Girder Ends — 12:05 PM - 12:40 PM
Daijiro Mizutani, Tohoku University

Lunch — **12:40 PM - 14:30 PM**
Institute Conference Center (A6), Meeting Room Foyer

Decision Making on Renewal Priority for RC Slab Bridges based on Prediction Result of Individual Damages — 14:30 PM - 15:05 PM
Yohei Ninomiya, Osaka University

Improving Highway Safety by Objective Aggregate Classification — 15:05 PM - 15:40 PM
Jorge A. Prozzi, The University of Texas at Austin

Break and refreshments — **15:40 PM - 16:00 PM**
Institute Conference Center (A6), Meeting Room Foyer

Theme B I Decision Making and Optimization

Optimal Inspection, Maintenance, and Reconstruction Planning for Pavement Systems Accounting for Model Uncertainty and Heterogeneity — 16:00 PM - 16:35 PM
Jinwoo Lee, Korea Advanced Institute of Science and Technology

A Theorem to Eliminate the Mathematical Complexity of Discounting in a Class of Infrastructure Management Problems — 16:35 PM - 17:10 PM
Craig Richmond, ETH Zürich

Location Optimization of Battery Swapping Stations for Electric Scooters — 17:10 PM - 17:45 PM
James C. Chu, National Taiwan University

DAY 2 | APRIL 1, 2019

Breakfast and registration — **08:30 AM - 09:20 AM**
Institute Conference Center (A6), Meeting Room Foyer

Theme B | Decision Making and Optimization

Trading off costs, environmental impact, and levels of service in the optimal design of transit bus fleets — 09:25 AM - 10:00 AM
Pablo Durango-Cohen, Northwestern University

Infrastructure Asset Management as a Biobjective Robust Optimization Problem — 10:00 AM - 10:35 AM
Kenneth Kuhn, Uber

Infrastructure Repair Project Scheduling Considering the Impacts to Neighbouring Businesses and Roadway Users: A Proposed Solution Methodology — 10:35 AM - 11:10 AM
Samuel Labi, Purdue University

Break and refreshments — **11:10 AM - 11:30 AM**
Institute Conference Center (A6), Meeting Room Foyer

A Network Flow Model Approach to Determining Optimal Intervention Programs for Railway Infrastructure Networks — 11:30 AM - 12:05 PM
Marcel Burkhalter, ETH Zürich

A Mathematical Programming Model for The Selection of Network-Level Railway Maintenance Strategies — 12:05 PM - 12:40 PM
Claudia Fecarotti, Eindhoven University of Technology

Lunch — **12:40 PM - 14:30 PM**
Institute Conference Center (A6), Meeting Room Foyer

Theme C | Hazards, Risk and Resilience

Estimating Service Risks due to Single Building Schools Affected by Natural Hazards — 14:30 PM - 15:05 PM
Bryan T. Adey, ETH Zürich

Utililizing Asset Management Tools to Managed Risk Related to Climate Change Transportation Infrastructure — 15:05 PM - 15:40 PM
Susan Tighe, University of Waterloo

Break and refreshments — **15:40 PM - 16:00 PM**
Institute Conference Center (A6), Meeting Room Foyer

Using Resilience in Risk-Based Asset Management Plans — 16:00 PM - 16:35 PM
Sue McNeil, University of Delaware

Post-Hazard Restoration of Infrastructure Systems — 16:35 PM - 17:10 PM
Jürgen Hackl, ETH Zürich

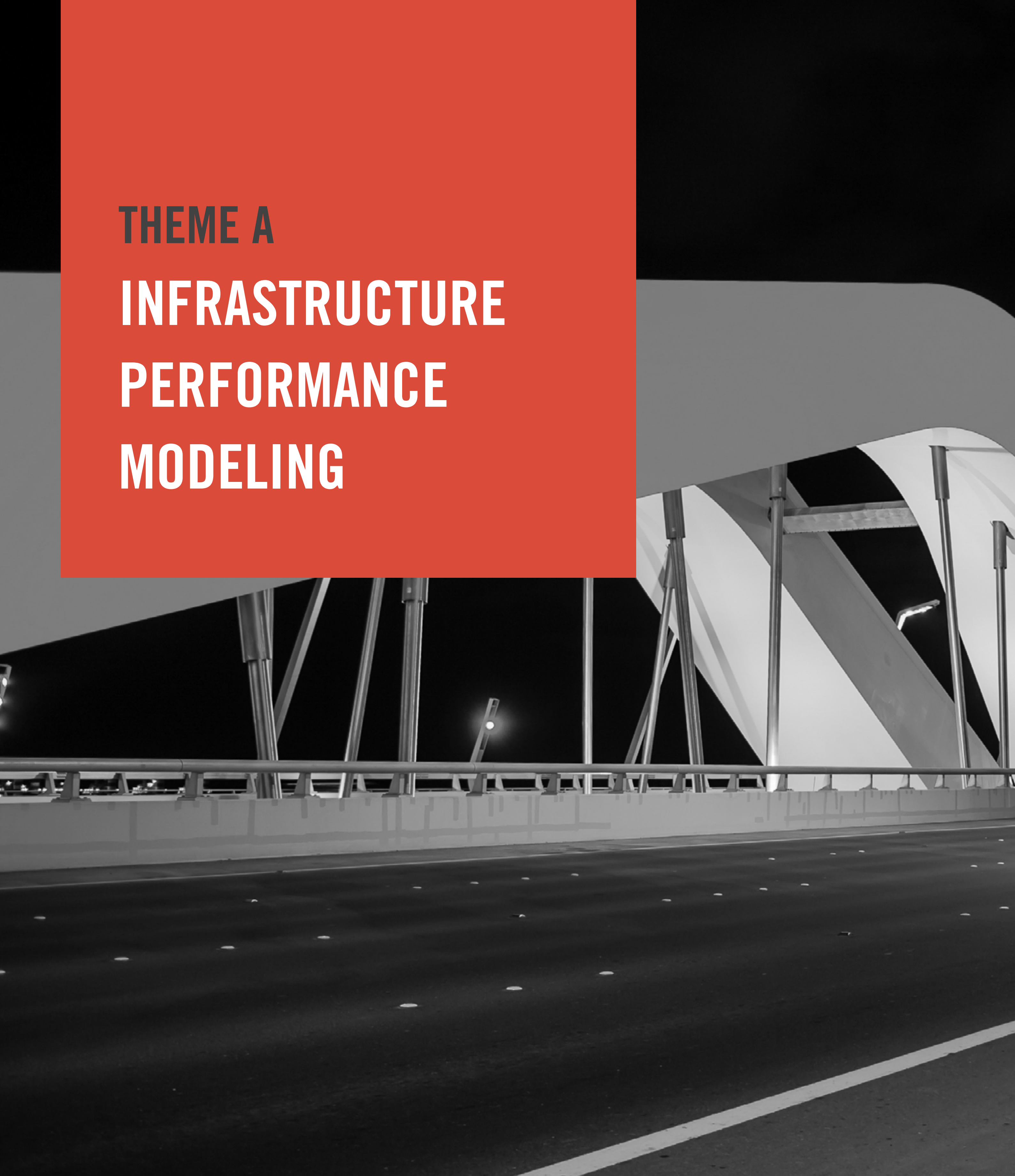
Promoting Societal Well-Being by Designing Sustainable and Resilient Infrastructure: Engineering Tools and Broader Interdisciplinary Considerations — 17:10 PM - 17:45 PM
Paolo Gardoni, University of Illinois at Urbana-Champaign

The Benefits of Cooperative Policies for Transportation Network Protection from Sea Level Rise: A case Study of the San Francisco Bay Area — 17:45 PM - 18:20 PM
Ilia Papakonstantinou, New York University

Closing Remarks — 18:30 PM
Borja Garcia de Soto, New York University Abu Dhabi

THEME A

INFRASTRUCTURE PERFORMANCE MODELING



RABI MISHALANI

The Ohio State University

Rabi Mishalani is a Professor at The Ohio State University with the Department of Civil, Environmental and Geodetic Engineering. His areas of expertise include the application of probabilistic modeling, statistical inference, experimental design and evaluation, and optimization to transportation systems analysis.

His interests include infrastructure systems monitoring and maintenance decision-making, public transportation service planning and operations, air quality monitoring using sensor-equipped transit vehicles, dynamic transportation network surveillance and management, travel behavior response to mobility-as-a-service systems, and urban logistics. He is the co-founder and co-director of OSU's Campus Transit Lab, a living laboratory (based on the transit system owned and operated by OSU) that supports research, education, and outreach.

Prior to joining the faculty at OSU in September 1997, he was a Research Associate at Massachusetts Institute of Technology with the Center for Transportation and Logistics. Dr. Mishalani received his Ph.D. and S.M. degrees from MIT in 1993 and 1989, respectively, and his B.E. degree from American University of Beirut in 1987.

Abstract I MODELING THE ACCURACY OF AIRFIELD PAVEMENT DETERIORATION FORECASTS

Pavement Condition Index (PCI) values determined from pavement distress data are used to model and forecast pavement deterioration, determine maintenance and repair requirements, and estimate future budgets. It is important for the PCI forecasts to be accurate to ensure that decision makers are making effective infrastructure investments.

The objective of this study is to develop an approach to quantify and investigate the error in forecasting the PCI of homogeneous pavement sections. The developed approach is applied to United States Air Force airfields.

Historical airfield PCI forecasts and the corresponding PCI values determined from subsequent distress observations at six Air Force installations across the United States are used to determine forecast errors that, in turn, are used to develop a systematic forecast error models. Factors such as forecast horizon, pavement age, condition, climate, and location are considered in developing and estimating error models using ordinary least squares.

The estimated models are evaluated in terms of their effectiveness in correcting for systematic forecast errors.

The results indicate that forecast error corrections are in general meaningful. Notably, the corrections lead to larger improvements in the cases of longer forecast horizons, which is particularly encouraging.

XIANXUN YUAN (ARNOLD)

Ryerson University

Dr. Arnold Yuan is currently an associate professor of the Department of Civil Engineering, Ryerson University. A structural engineer by training, Dr. Yuan has been focusing on engineering risk and reliability, system safety, infrastructure asset management, and construction management.

He has studied many different engineering systems including building structures, bridges, highway pavements, nuclear power plants, water mains and sewers, and recently sidewalks. In May 2014, Dr. Yuan was appointed as the founding Director of Ryerson Institute for Infrastructure Innovation.

Abstract I IMPERFECT DATA AND THEIR IMPACTS ON DETERIORATION MODELLING IN INFRASTRUCTURE ASSET MANAGEMENT

Deterioration modelling represents one of the most important analytical components in infrastructure asset management. While a limited number of mechanistic models have been used occasionally, most of the deterioration models used in practice were empirically developed. Therefore, the credibility of deterioration models depends heavily on the amount and quality of data that are used in the model development process.

This paper takes data imperfection as the focus of study by examining carefully different scenarios of data imperfection and investigating the additional challenges they may bring forward to deterioration modelling. A unified solution approach is proposed for all different data imperfection scenarios.

Based on rigorous probability and contemporary statistical techniques, the novel approach integrates data augmentation (DA) technique into the now widely used Markov Chain Monte Carlo (MCMC) technique to make it a seamless solution.

A few case studies the author have carried out over the past ten years are used to demonstrate the efficacy of the proposed solution strategy. The unified solution is particularly useful for the development of integrated infrastructure asset management software that is to be applied to various asset classes.

ADRIÁN RICARDO ARCHILLA

University of Hawaii

Dr. A. Ricardo Archilla is an Associate Professor in the Department of Civil and Environmental Engineering at the University of Hawaii. He received a Civil Engineering degree in 1989 from the University of San Juan, Argentina, were he graduated with honors; a M.Sc. in Civil Engineering from the University of Calgary, Canada in 1993; and a Ph.D. from the University of California at Berkeley in 2000. He was the recipient of the 2000 Milton Pikarsky Memorial Award for best Ph.D. Dissertation given annually by the Council of University Transportation Centers for best Master and Ph.D. dissertations in the U.S. in Transportation Science and Technology. His research focuses on pavement design and management, pavement materials performance testing and analysis, traffic engineering and safety, and applied statistics.

Examples of his recent research work include: 1) development of innovative specimen configurations for fatigue testing of hot mix asphalt specimens; 2) top-down fatigue cracking of hot mix asphalt pavements in high temperature environments; 3) estimation of comprehensive models for dynamic modulus of asphalt mixtures by combining data from different sources, accounting for unobserved heterogeneities, and including the effects of effects of moisture damage, anti-stripping agents, modified binders, polyolefin/aramid fibers, confinement and strain levels as well as other common mixture characteristics and testing conditions such as gradation, air voids, asphalt content, temperature, and frequency; 4) development of an innovative laboratory batching procedure that avoids biasing the results of mix designs because of fines adhered to larger particles; 5) development of data processing and analysis software for data obtained from continuous friction measurement equipment; 6) material characterization (resilient modulus, permanent deformation and fatigue) for mechanistic pavement design; 7) traffic simulation in two-lane highways; 8) models of frequency of roadway departure crashes accounting for design consistency effects, other geometric features, and directional effects; and 9) study of the travel behavior of the elderly in Hawaii. Dr. Archilla has published nearly 60 peer-reviewed journal articles, conference papers, and technical reports and presented his research contributions numerous times at prestigious international and national conferences.

Abstract | RELEVANCE OF THE DISCOUNT RATE TO THE OPTIMAL STRUCTURAL DESIGN SERVICE LIFE OF ASPHALT CONCRETE PAVEMENT

Discounting is an important element in calculations of optimal structural service life because construction costs occur in the present, but benefits accrue over time and must be discounted. Therefore, one would expect the service life to be treated as an endogenous variable to be optimized in design procedures, but this is often not the case.

This article provides a solution to the net-benefit maximizing choice of the design service life. It is a function of the Product Log function. The 1993 AASHTO Design Equation is used as the basis for the derivation. For real discount rates under 4%, design service lives over 72 years are proven to be net-benefit maximizing for the case of constant annual traffic loads. For lower discount rates, optimal service lives are considerably longer. This finding is consistent with the perpetual pavement design paradigm as well as with optimal maintenance strategies involving multiple resurfacing cycles. Discounting is shown to be a key driver of the optimal solution. Additionally, a simple method is shown on how to calculate an economically maximum pavement thickness that is independent of physical parameters. A methodology to simplify the AASHTO equation for use in analytic modelling is shown.

DAIJIRO MIZUTANI

Tohoku University

Daijiro Mizutani obtained his PhD from Osaka University in Japan in 2016 and he worked as a Research Associate in the ETH Zürich in Switzerland from 2016 to 2017.

Now he is an Assistant Professor in the International Research Institute of Disaster Science in Tohoku University in Sendai, Japan.

His research specialities are statistical modelling of deterioration processes and optimisation of inspection and repair policies in infrastructure asset management.

Abstract I EFFECT OF PREVENTIVE MAINTENANCE FOR BRIDGE EXPANSION JOINTS AGAINST CORROSION AT STEEL GIRDER ENDS

A bridge has a composite structure hierarchically composed of various members, and deterioration of one member of a bridge may effect deterioration processes of other members. It is desired to consider the conducting way of visual inspection considering the relationship among deterioration processes of members with detailed analysis using accumulated inspection data.

To investigate the relationship, in this study, corrosion at the steel girder end is focused as the specific deterioration event. The deterioration of end parts of steel girders (steel components above abutment and pier) is the main factor for the administrators' decision making for repair and replacement in bridge management.

Corrosion is one of the main deterioration event at end parts of steel girders. Moreover, the primary causes of corrosion are thought to be the water leakage from bridge expansion joint and the ponding on abutment/pier. Therefore, the lifetime improvement of bridges and the reduction of life cycle costs could be achieved by appropriately establishing the time interval of bridge expansion joints' inspection and replacement.

In this study, using a regime switching model and the Markov hazard deterioration model, the effects of the deterioration of expansion joints on the development of the corrosion at steel girder end parts are investigated.

The proposed model is demonstrated in a case study with visual inspection data of actual bridges in national roads in Japan, and the effectiveness of preventive maintenance policy of water stopping material of expansion joints on corrosion of steel girder ends are investigated.

YOYEI NINOMIYA

Osaka University

Yohei Ninomiya is a first-year PhD student in Osaka University, Japan. He obtained his Bachelor›s degree in 2016 and Master›s degree in 2018.

His research interest is developing management system of expressway.

Specifically, he studies statistical and stochastic modeling of deterioration process based on inspection data and model estimation methods.

Abstract I DECISION MAKING ON RENEWAL PRIORITY FOR RC SLAB BRIDGES BASED ON PREDICTION RESULT OF INDIVIDUAL DAMAGES

In recent years, expressway companies in Japan are planning to renew main members of the deteriorating bridges. This renewal project is called "Large-Scale Renewal Project".

In particular, some reinforced concrete slabs have various kinds and a lot of individual damages.

In this study, the authors propose the methodology to decision making on renewal priority for a number of RC slab bridges.

Here two statistical methods to analyse past inspection data for RC slab are formulated. One is to predict the future number of individual damages.

The other is to estimate deterioration risk of RC slab from the number of individual damages appears in the RC slab. The renewal priority is estimated based on the deterioration risk.

For the prediction of the number of individual damages, Weibull hazard model with Weibull distribution set as lifetime distribution is employed.

On the other hand, for the estimation of deterioration risk, cumulative logit model is employed.

Lastly, the effectiveness of proposed methods is discussed in the case study using actual inspection database that recorded individual damages such as cracks, leakages, peelings and so on in existing RC slab in expressway.

JORGE A. PROZZI

The University of Texas at Austin

Dr. Jorge A. Prozzi is a Professor in the Department of Civil Engineering at The University of Texas at Austin. He received his M.S. and Ph.D. in Civil Engineering from the University of California, Berkeley in 1998 and 2001, respectively.

Dr. Prozzi performs research on pavement materials, design and management and applications of probability and statistics to transportation problems.

He is currently the Chair of TRB Subcommittee on International Research and Technology Transfer. He is the past chair of the TRB International Activities Committee, the Data Analysis Working Group and the TRB Subcommittee for Latin American Activities. He serves as an expert panel member for projects funded by the National Cooperative Highway Research Program and he is an active member of the American Society of Civil Engineers (ASCE). In addition, he is member of several Technical TRB committees.

Dr. Prozzi is a former Associate Editor of ASCE's Journal of Infrastructure System and the WCTRS's Journal on Case Studies on Transport Policy. He is current member of the Editorial Board of Springer Journal "Frontiers of Structural and Civil Engineering (FSCE)". He has authored or co-authored 65 refereed archival journal publications, 116 refereed conference proceedings, and 115 technical reports.

Abstract I IMPROVING HIGHWAY SAFETY BY OBJECTIVE AGGREGATE CLASSIFICATION

The extent of surface friction on any given highway pavement is dependent on its surface texture. As the surface texture wears off, the tire-pavement friction reduces and the safety of the road users decreases. The type of coarse aggregates used in the pavement surface plays a vital role in this process. The aggregate's resistance to polishing should be considered in the selection of the materials as failing to consider this aspect will result in increasing the risk of accidents. This study presents an analysis of the polishing resistance of typical aggregate used in Texas for highway construction.

In order to investigate the polishing resistance, the researchers assessed the evolution of aggregate surface texture. A Micro-Deval polishing machine and a laser scanner were utilized. Following the polishing process, the surface properties of the aggregates were evaluated using a laser scanner to determine the rate of change in the surface texture. Texture measurements were carried out by using commonly used parameters.

In terms of data analysis, clustering analysis was performed to group aggregate texture into acceptable and non-acceptable classes for friction purposes. Bayesian inference was used in this study to estimate the unknown set of parameters of the various clusters. Gibbs sampler, a Markov Chain Monte Carlo (MCMC) algorithm, was utilized to iteratively generate samples from the conditional distributions.

The results showed a 92% match to current methods but has two significant benefits: 1) it does not eliminate all limestone aggregates and 2) it is more effective in terms of time.

THEME B
DECISION MAKING AND OPTIMIZATION

JINWOO LEE

Korea Advanced Institute of Science and Technology

Dr. Lee currently holds the position of Assistant Professor in the CCS Graduate School for Green Transportation at the Korea Advanced Institute of Science and Technology (KAIST).

Dr. Lee received his B.Sc. in Civil and Environmental Engineering from the KAIST in 2010 and M.S. in Civil and Environmental Engineering from University of California, Berkeley in 2012.

He earned his Ph.D. in Civil and Environmental Engineering from University of California, Berkeley in 2015 with thesis titled, "Joint Optimization of Pavement Management and Reconstruction Policies for Segment and System Problems".

Following his graduation, he worked as a postdoctoral associate at New York University Abu Dhabi from 2015 to 2017 and a research assistant professor in the Department of Electrical Engineering at Hong Kong Polytechnic University from 2017 to 2019.

Dr. Lee's research interests focus on environment-friendly transportation infrastructure systems and transportation safety.

Abstract I OPTIMAL INSPECTION, MAINTENANCE, AND RECONSTRUCTION PLANNING FOR PAVEMENT SYSTEMS ACCOUNTING FOR MODEL UNCERTAINTY AND HETEROGENEITY

We present a methodology for the joint optimization of inspection scheduling and maintenance and reconstruction (M&R) planning for pavement systems under model uncertainty and segment-specific heterogeneity.

We mainly focus on the trade-off that conducting more inspections reduces adverse impacts of model uncertainty inherent in pavement deterioration processes but budget for M&R activities at the same time.

The proposed bottom-up approach decomposes the system-level problem into multiple segment-level problems, and an approximate dynamic programming algorithm is applied to the decomposed segment-level problems to overcome the curse of dimensionality.

Moreover, we utilize a statistical learning method to update the deterioration prediction at each time step based on the collected inspection results so that the model uncertainty gradually decreases during the rolling-horizon procedure as the sample size of inspection results increases.

We demonstrate the proposed stochastic optimization framework through a numerical case study, comprised of 50 heterogenous pavement segments under a combined budget for both inspection and M&R activities.

Several managerial insights and implications are discussed, such as the optimal inspection schedules are less sensitive to the budget constraint than the other activities.

CRAIG RICHMOND

ETH Zürich

Dr. Richmond received his Ph.D. from the University of Pittsburgh in Regional Economics in 1997. He simulated Nash Price-Equilibrium in the US ferrous scrap model. By the time of his defence, he was already working in Switzerland at Credit Suisse Private Bank. Thereafter followed a number of positions in Banking in Basel, Zürich and London.

Here he built a series of quantitative models and application in the areas of benchmarking and risk. His last operational position in Banking was as the Head of IT and Back-Office for a small private bank in Zürich. The financial crisis starting in late 2008 resulted in Dr. Richmond switching to a position at the ETH in Infrastructure Management. What began as a part-time position grew into a passion.

Beginning from a project to benchmark expenditures in constructive maintenance, Dr. Richmond began to apply mathematical tools from economics to the design of asphalt pavement. Although his interest is in fact benchmarking, many of the results have implications for actual design.

Abstract I A THEOREM TO ELIMINATE THE MATHEMATICAL COMPLEXITY OF DISCOUNTING IN A CLASS OF INFRASTRUCTURE MANAGEMENT PROBLEMS

A theorem is presented that can be used to simplify the mathematical formulation of an important class of cost-benefit optimization problems with respect to infrastructure maintenance. The theorem applies to all problems where a researcher is interested in maintenance strategies per se and would therefore find it reasonable to formulate the problem on an infinite time horizon but without reference to a specific starting point in time.

Because all such problems involve comparisons of costs and benefits over a time horizon, the objective to be minimized or maximized must be formulated as a discounted present value. The discounting adds mathematical complexity.

The theorem states that the same problem, formulated as a single period problem on a “uniform network”, will lead to the same ranking of solutions. That is, one can find the optimal solution while excluding a consideration of discounting. There is also no need for the problem to truly be a uniform network.

One can justify the same mathematical formulation by stating the cost-benefit objective as an expected value, where the expectation is calculated over potential starting points for discounting within the renewal cycle. An important application that flows directly from the theorem is with respect to the calculation of cost shares by user groups.

Finally, an example application of the theorem is provided as a case study using the AASHTO 1993 pavement design equation.

JAMES C. CHU

National Taiwan University

James C. Chu received his B.S. and M.S. degrees from National Taiwan University in 1997 and 1999, respectively, and his Ph.D. degree from Northwestern University in 2007. He has been a full professor with the Department of Civil Engineering, National Taiwan University since 2018.

He is interested in applying operations research, statistics, econometrics, and information technologies on the management of operations, maintenance, and hazard mitigation for transportation facilities.

The major areas of his research are transportation infrastructure life-cycle management, modeling and applications of pedestrian dynamics, and public transportation planning and operations. He has been Associate Editor of the Journal of Infrastructure Systems since 2013.

Abstract I LOCATION OPTIMIZATION OF BATTERY SWAPPING STATIONS FOR ELECTRIC SCOOTERS

Scooters are one of the major transportation modes in Taiwan. Apart from raising environmental consciousness, the government has been devoted to popularizing electric scooters.

Compared with gasoline-fueled scooters, electric scooters have a lower driving range and require more frequent refueling.

One of the approaches to refuel electric scooters is to swap batteries at a battery swapping station. The advantage of this approach is that it takes only minutes or seconds to complete. Backup batteries may also be stored in scooters to extend their driving range.

This study focuses on electric scooters adopting the battery swapping approach. As the efficiency of refueling is one of the main concerns of electric scooter users, this study develops a discrete-event system simulation model for the battery swapping systems of electric scooters, which include scooter users, batteries, and swapping stations.

The model can be used to analyze the performance of battery swapping systems. In a numerical example, the simulation model is applied to optimize the location and capacity of swapping stations. A sensitivity analysis is conducted to further understand the effects of factors such as budget, power threshold of swapping batteries, power consumption rates, and battery charging rates on the locations of swapping stations.

The simulation model is shown to have the potential to aid the planning and design of electric scooter systems and benefit the popularization of electric scooters.

PABLO DURANGO-COHEN

Northwestern University

Pablo L. Durango-Cohen is an associate professor in the Transportation Systems Analysis and Planning Program at Northwestern University. He completed his Ph.D. in 2002 in Industrial Engineering and Operations Research at the University of California, Berkeley.

His research activities involve developing and analyzing optimization and econometric models to support monitoring, management and operation of transportation infrastructure systems. He has also published in transportation economics and policy, as well as in environmental design and life-cycle assessment of transportation systems.

Among others, his research has been recognized with a Faculty Early CAREER Development Award from the National Science Foundation in 2006, and with a Young Author Prize at the 2007 World Congress on Transport Research. Among Prof. Durango-Cohen's professional activities, he serves as Associate Editor for the ASCE Journal of Infrastructure Systems, and in 2012, he served in a Transportation Research Board panel to review the Federal Transit Administration's Transit Economic Requirements Model (TERM).

Abstract I Trading off costs, environmental impact, and levels of service in the optimal design of transit bus fleets

The development of a systematic framework to support the design of transit bus fleets is justified by the significant and long-lasting implications associated with decisions to purchase transit vehicles, as well as by developments in fuel propulsion and battery technologies over the last 2 decades that have increased the options available to transit operators, and, in turn, the com- plexity of assessing the corresponding tradeoffs. The need to evaluate these tradeoffs is, in part, driven by the emergence of environmental impact mitigation, i.e., emissions reductions, as a critical concern of transit operators and governments around the world.

To address these concerns, we present an optimization model to support the design of transit bus fleets while accounting for costs, level-of-service requirements, and environmental impact. Methodologically, the work bridges applications of Economic Input-Output analysis to conduct environmental lifecycle assessment, with seminal work in production economics.

We apply the framework to support design of bus fleets consisting of 4 bus types differing in their fuel-propulsion technology: ultra-low sulfur diesel, hybrid diesel-electric, compressed nat- ural gas, and hydrogen fuel-cell. The 4 bus types were assessed in the National Renewable Energy Laboratory transit bus evaluation and demonstration studies conducted over the period 2003–2009. The nominal problem herein is to minimize acquisition, operation and disposal costs. Constraints in the model are used to impose a minimum frequency of service, i.e., headway, and to ensure that route capacity satisfies passenger demand.

Environmental impact is considered along the following dimensions: energy consumption, and emissions of greenhouse gasses, par- ticulate matter, and nitrous oxides. Results show that fleet heterogeneity increases in scenarios where demand fluctuates, i.e., peak vs. off-peak. Perhaps even more interesting, we show how the dual/shadow prices provide a (monetary) measure of the tradeoffs among level of service and environmental impact, and discuss how they can be used to obtain robust fleet configurations.

KENNETH KUHN

Uber

Kenneth Kuhn received a Ph.D. in Civil Engineering from the University of California, Berkeley in 2006, working on infrastructure asset management, under the supervision of Dr. Samer Madanat. He taught at the University of Canterbury in New Zealand for three years and then at the Pardee RAND Graduate School for another six years.

He has been an Associate Editor of the Journal of Infrastructure Systems and on the Editorial Board of Transportation Research Part C - Emerging Technologies.

He is currently a Senior Data Scientist at Uber working on the Marketplace team.

Abstract | INFRASTRUCTURE ASSET MANAGEMENT AS A BIOBJECTIVE ROBUST OPTIMIZATION PROBLEM

There are two fundamental and competing goals of infrastructure asset management: preserve the conditions of facilities and minimize the costs of the exercise. Uncertainty regarding deterioration processes including the precise effects of maintenance activities presents an intrinsic complication.

The problem is a biobjective optimization problem where one objective is uncertain.

There are several different definitions of optimality for such problems, including highly, strictly, and lightly robust efficient solutions.

The first includes policies which are efficient, not dominated, in any scenario. This definition rules out actions that are ineffective in any single scenario, a problematic characteristic in the context of infrastructure asset management. The second definition refers to policies which are efficient when focusing on worst-case performance.

Implementation would be similar to robust optimization-based approaches to infrastructure asset management, but would recognize the biobjective nature of the problem. Such an approach could be used to show how different levels of funding relate to different guarantees on infrastructure condition.

Lightly robust efficient solutions include the most robust policies that offer performance within some user-specified bound of optimality for a (given) nominal scenario.

The concept would be useful in cases where models of deterioration and maintenance activity effectiveness are available but uncertainty remains.

Further study into alternative definitions of optimality and algorithms for identifying robust optimal maintenance policies is warranted.

SAMUEL LABI

Purdue University

Dr. Labi, Ph.D. 2001 (Purdue), is a professor at Purdue University's Lyles School of Civil Engineering. He also the director of Purdue's Next Generation Transportation Systems Center (NEXTRANS) and associate director of the University Transportation Center for Connected and Automated Transportation (CCAT). He has published over 100 scientific articles in peer-reviewed archival journals. He has also published 2 textbooks used in universities worldwide: Transportation Decision Making (in 2008) and Civil Engineering Systems (in 2014).

Dr. Labi serves as editorial board member for the Computer-Aided Civil and Infrastructure Engineering journal, the ASCE Journals of Infrastructure Systems and Risk & Uncertainty Part A, and guest editor of Infrastructure Asset Management journal. He is the chair of ASCE's economics and finance committee, secretary of TRB's asset management committee, and member of ASCE's infrastructure systems committee.

His major research awards include ASCE's Frank Masters Award (2014) for outstanding and innovative work in advancing the area of transportation systems, American Society of Tests and Materials (ASTM)'s Mather Award (2007) for outstanding paper in concrete materials, TRB's K.B. Woods (2008) for outstanding journal paper in design & construction, and TRB's Grant Mickel (2018) award for outstanding journal paper in operations & maintenance.

Abstract I INFRASTRUCTURE REPAIR PROJECT SCHEDULING CONSIDERING THE IMPACTS TO NEIGHBOURING BUSINESSES AND ROADWAY USERS: A PROPOSED SOLUTION METHODOLOGY

Infrastructure repair and expansion projects are often associated with partial or full downtime which result in user costs in terms of delay, discomfort, and inconvenience, and community disruptions in terms of interruption of social activity and reduction in business productivity.

This paper presents and demonstrates a bi-level methodology for developing an optimal schedule for multiple infrastructure projects within a specified work period such as a repair or construction season.

The goal is to minimize the overall cost to infrastructure users and the cost of disruption to the community (adjacent businesses)over the work season.

The infrastructure project scheduling problem is formulated as a mixed-integer nonlinear program, and solved using the local decomposition method.

The methodology is demonstrated using a case study network with two project types typically encountered in road infrastructure systems management: capacity expansion and rehabilitation.

The results of the numerical experiment suggest that for network-wide project scheduling, consideration of both business disruption cost and users travel time can yield optimal schedules that significantly differ than those that consider user travel time only.

MARCEL BURKHALTER

ETH Zürich

Marcel Burkhalter is a doctoral student at the group of infrastructure management of the Swiss Federal Institute of Technology in Zürich (ETHZ).

He obtained a Master's of Science in Civil Engineering at ETH Zürich in 2016.

Abstract I A NETWORK FLOW MODEL APPROACH TO DETERMINING OPTIMAL INTERVENTION PROGRAMS FOR RAILWAY INFRASTRUCTURE NETWORKS

The determination of the optimal interventions to execute on rail infrastructure networks is a challenging task, due to the many types of objects (e.g., bridges, tracks, and switches), how the objects work together to provide service, and the possible reductions in costs and service disruptions as obtained by grouping interventions.

Although railway infrastructure managers are using computer systems to help them determine intervention programs, there are none that result in the highest net benefits while taking into consideration all of these aspects.

This paper presents a network flow model approach that allows for determining the optimal intervention programs for railway infrastructure networks while taking into considerations different types of objects, how the objects work together to provide service, and object and object-traffic dependencies.
The network flow models are formulated as mixed integer linear programs, where the optimal intervention program is found by using the simplex and branch and bound algorithms.

The modelling approach is illustrated by using it to determine the optimal intervention program for a 2200 m multi-track railway line consisting of 11 track sections, 23 switches, and 39 bridges.

It is shown that the proposed constrained network flow model can be used to determine the optimal intervention program within a reasonable amount of time, when compared to more traditional models and search algorithms.

CLAUDIA FECAROTTI

Eindhoven University of Technology

Claudia Fecarotti is Assistant Professor (Tenure Track) in Resilient Asset Management and Maintenance at the Eindhoven University of Technology (TUe), Netherlands, since January 2019. She is a member of the Operations, Planning, Accounting and Control Group (OPAC), Department of Industrial Engineering and Innovation Science. Before joining TUe and since 2013, she was a Research Associate within the Resilience Engineering Research Group (RERG) at the University of Nottingham, where she also obtained her PhD in Reliability Engineering and Infrastructure Asset Management in 2018 from the Dept. of Civil Engineering.

Claudia is currently an associate member of the RERG. She holds a BSc in Civil Engineering and a MSc in Transportation Systems and Infrastructures from the University of Palermo, Italy. Her research interests are in the areas of infrastructure asset management, risk and reliability engineering, systems performance modelling, maintenance modelling and optimisation. She conducts research into the development of both predictive and optimisation models to improve the design, maintenance and operations of engineering systems and infrastructures in order to (i) reduce the frequency of failures and their consequences while improving the system fault tolerance, (ii) improve system performance and service levels, and (iii) minimise the total costs of ownership. Main application domains have been road infrastructures, fuel cell systems, railway systems and off-shore oil and gas. She aims at conducting rigorous research which is also relevant to industry and society so as to bridge the gap between purely methodological approaches and practical industrial needs. Claudia is an author of 8 papers published in peer review international journals and 15 contributions to peer review international conferences in the field of civil and reliability engineering. She is also recipient of two awards by The Institution of Mechanical Engineers (IMechE): (1) the IMechE's Best Young Researcher Award 2013 for the research "Modelling railway service reliability", and (2) the IMechE's Donald Julius Groen Prize 2017 for the best paper published in the international journal Part O: Journal of Risk and Reliability Engineering, "A Petri net model for railway bridges maintenance".

Abstract I A MATHEMATICAL PROGRAMMING MODEL FOR THE SELECTION OF NETWORK-LEVEL RAILWAY MAINTENANCE STRATEGIES

A main challenge in railway asset management is to select long-term maintenance strategies for each asset on the network in order to effectively manage the railway infrastructure given that performance and safety targets have to be met under budget constraints. Due to economic, functional and operational dependencies between different assets and different sections of the network, optimal solutions at network level not always include the best policies available for each asset group.

A network-level optimisation model is presented, aimed at selecting the best combination of maintenance strategies to manage each section of the network in order to minimise the impact of the assets conditions on service, given budget constraints and availability targets. The optimisation problem is formulated as a nonlinear integer programming model. The availability of railway lines is computed by exploiting the analogy with series-parallel networks. By varying the model parameters, a scenario analysis is performed so that the infrastructure manager is provided with a range of solutions for different combination of the available budget and performance targets. The results of the scenario analysis also enable a better understanding of the influence of the system parameters, including those related to the network topology.

THEME C
HAZARDS, RISK AND RESILIENCE

BRYAN T. ADEY

ETH Zürich

Prof. Dr. Bryan T. Adey is a Professor for Infrastructure Management, and the head of the Institute for Construction and Infrastructure Management, in the Department of Civil, Environmental and Geomatic Engineering, at the Swiss Federal Institute of Technology in Zürich (ETHZ), Switzerland. Prof.

Adey's research is focused on improving the effectiveness and efficiency of infrastructure management.

Abstract I ESTIMATING SERVICE RISKS DUE TO SINGLE BUILDING SCHOOLS AFFECTED BY NATURAL HAZARDS

Schools around the world provide essential services to the public. If they fail, for example due to an earthquake, these services are at least temporarily lost. The managers of school infrastructure are, of course, interested in ensuring that the probability and consequences of service losses are minimal.

In order for managers to determine how to best allocate funds to strengthen schools to minimize natural hazard risk, it is necessary to both accurately and systematically estimate this risk.

With this in mind, as well as the fact that no such methodology currently exists, this paper proposes a methodology to estimate the risk related to a single building school.

The methodology provides an overview of how schools might be affected by natural hazards and how stakeholders might be affected from schools not functioning as intended due to these hazards. To ensure versatility, the methodology allows managers to use many types of data and many types of model with different levels of complexity.

A discussion of the advantages and disadvantageous of the methodology, as well as an outlook for future work are given.

SUSAN TIGHE

University of Waterloo

Susan Tighe, PhD, PEng, FCAE received her BASc (1993) in Chemical Engineering from Queen's University, her MASc Civil Engineering (1997) and PhD (2000) in Civil Engineering from the University of Waterloo. She has been a Professional Engineer in the Province of Ontario since 1995 and has been a Professor in the Department of Civil and Environmental Engineering since 2000. She holds the Norman W. McLeod Endowed Chair in Sustainable Pavement Engineering and is Past President of the Canadian Society for Civil Engineering. She was appointed Deputy Provost and Associate Vice President Integrated Planning and Budgeting in July 2017.

Susan has gained national and international recognition for her outstanding contributions to the development, design, and management of sustainable concrete and asphalt transportation infrastructure. She has been involved with projects in Africa, India, Chile, India, China, Australia, New Zealand and throughout North America and is an author of over 400 technical publications in pavements and infrastructure, including being the principal investigator on the 2013 Transportation Association of Canada Pavement Asset Design and Management Guide and is involved in a number of national and international research projects.

Susan's reputation as a scholar, educator, and professional engineer is well illustrated by the breadth of her honours and awards including Canada's Top 40 Under 40, New College of Scholars Royal Society of Canada, Fellow Canadian Academy of Engineering and the Ontario Society of Professional Engineers Medal for Research and Development. She has also received academic Fellowships including the Erskine Fellowship at the University of Canterbury in New Zealand, the U.K. Royal Academy of Engineering University of Nottingham in England and the Queensland Pavement Center located at University of the Sunshine Coast Australia.

Abstract I UTILIZING ASSET MANAGEMENT TOOLS TO MANAGED RISK RELATED TO CLIMATE CHANGE TRANSPORTATION INFRASTRUCTURE

Transportation infrastructure is experiencing changed climate conditions due to global warming and human activity. Extreme weather events, such as flooding and freezing rain, have become increasing concerns in pavement vulnerability analysis and maintenance & rehabilitation management.

With these increased natural hazards, there has been recent work conducted to determine how transportation agencies can better manage these risks.

Various fragility modeling frameworks will be presented which evaluate the risk associated with these natural disasters within the context of asset management. Various hazards are assessed in terms of load, pavement condition, human interferences and climate behavior after the natural disaster. A case study will be presented.
For longer duration extreme events, different pavement structures behave differently. Infrastructure deterioration increases as the number of event cycles increase. The loss of functions can be significant due to the extreme events.

Recommendations for build-in resilience strategies for floods and other potential natural hazards will also proposed for future infrastructure design and hazard management.

SUE McNEIL

University of Delaware

Sue McNeil is Professor of Civil and Environmental Engineering and Urban Planning and Public Affairs at University of Delaware. She serves as the department chair and is also a Core faculty member in the Disaster Research Center at University of Delaware.

Her most recent research includes the impact of natural hazards and climate change on physical infrastructure and asset management with particular emphasis on resilience.

Abstract | USING RESILIENCE IN RISK-BASED ASSET MANAGEMENT PLANS

Each State is required to develop a risk-based asset management plan for the National Highway System (NHS) to improve or preserve the condition of the assets and the performance of the system.

Mechanisms for accounting for risk in the transportation asset management plans (TAMP) vary with the nature of the risks in terms of both the exposure and the consequences. At the same time, recent catastrophic hurricanes, such as Mathew (October, 2016) and Harvey (August, 2017), caused significant inland floods in Robeson County, North Carolina and Houston, Texas, respectively.

The damage to transportation infrastructure has focused attention on the resilience of transportation networks. The floods not only directly impede and disrupt local, regional and national travel on the highway network but also pose challenges to further evacuation, rescue and the delivery of resources. In the recovery stage, damage to the network also compromises mobility and accessibility.

Resilient transportation networks, capable of maintaining the designed capacity and mobility through the hazard event and able to recover the loss of functionality rapidly after the disasters, play a critical and holistic role in modern society and has been recognized by FHWA and state agencies, and academic research.

Although the need for resilient transportation networks is recognized, an integrated, consistent, well-understood method to assess or quantify the resilience of transportation networks is still lacking. For example, individual measures of resilience, robustness, rapidity, resourcefulness, and redundancy, different resilience perspectives, provide inconsistent and difficult to interpret performance measures.

This paper presents the concept of resilience in the context of the performance of the transportation network and flood hazards and the role of resilience in a risk based asset management plan using examples from past events. Performance resilience measures, such as those derived from travel time, connectivity, and capacity, quantify the network performance and identify the critical links.

However, applying those performance measures in evaluating the flood resilience of the network may not reflect the actual recovery needs after the floods recede and roads reopen. The physical damage to inundated roads, embankment erosion, and damaged drainage structures can make links of the network impassible. Therefore, integrating the concept of resilience into transportation asset management plans requires technical performance measures that reflect the inundation duration and the various stages of the disaster cycle (preparedness, response, recovery and mitigation) with an emphasis on recovery.

JÜRGEN HACKL

ETH Zürich

Jürgen Hackl is a researcher at the Infrastructure Management Group at ETH Zürich. His research interests lie in infrastructure risk and resilience and span both computational modelling and network science.

Much of his work has been on improving the understanding, design, and performance of complex interdependent infrastructure systems, affected by natural hazards.

Presently, he works on getting a better understanding of how the topology of the system influences dynamic processes and how this can be used to decrease the complexity of computational models.

Abstract I POST-HAZARD RESTORATION OF INFRASTRUCTURE SYSTEMS

Coping with the resilience of infrastructure systems is important in order to be prepared for disruptive events such as natural hazards.

It is essential to understand how and in what order damaged infrastructure objects should be restored so that they can provide adequate service again.

Infrastructure managers making such decisions must also take into account other constraints such as available funds, personnel, available resources, and any external constraints, e.g. which objects on which roads should have priority.

In this work, a mathematical optimization model was used to determine such a restoration program, by minimizing the direct and indirect costs of the event, considering constraints such as budget, resource and traffic flow.

With this approach, a restoration programme for a real road network in Switzerland after the occurrence of an extreme flood event is investigated.

PAOLO GARDONI

University of Illinois at Urbana-Champaign

Paolo Gardoni is a Professor and Excellence Faculty Scholar in the Department of Civil and Environmental Engineering at the University of Illinois at Urbana-Champaign. He is the Director of the MAE Center that focuses on creating a Multi-hazard Approach to Engineering, and the Associate Director of the NIST-funded Center of Excellence for Risk-based Community Resilience Planning.

Dr. Gardoni is the founder and Editor-in-Chief of the international journal Sustainable and Resilient Infrastructure published by Taylor and Francis Group. He is a member of the Board of Directors of the International Civil Engineering Risk and Reliability Association (CERRA), of the Advisory Council of the International Forum on Engineering Decision Making (IFED), and of a number of national and international committees and associations that focus on risk and reliability analysis.

Dr. Gardoni's research interests include sustainable and resilient infrastructure; reliability, risk and life cycle analysis; decision making under uncertainty; performance assessment of deteriorating systems; ethical, social, and legal dimensions of risk; and policies for natural hazard mitigation and disaster recovery. He is the author of over 130 refereed journal papers and 7 edited volumes. He h as received over $29 million in research funding from multiple national and international agencies including the National Science Foundation (NSF), the Qatar National Research Funds (QNRF), the National Institute of Standards and Technology (NIST), the Nuclear Regulatory Commission (NRC) and the United States Army Corps of Engineers. Dr. Gardoni has given over 40 invited and keynote lectures around the world.

Abstract I INFRASTRUCTURE ASSET MANAGEMENT AS A BIOBJECTIVE ROBUST OPTIMIZATION PROBLEM

Modern societies rely on large-scale interdependent networks and systems, including transportation, water and wastewater, electric power, communication and information networks, that are critical for economic growth and societal well-being. Such infrastructure are vulnerable to natural hazards, such as earthquakes and tsunamis, hurricanes, tornadoes, floods, and wildfires; as well as anthropogenic hazards from industrial accidents, disease and malevolence.

Past disasters have shown that the societal consequences of the damage and failure of infrastructure often significantly exceed the physical damage to such systems. In addition, the extent of impact on society is typically not limited to the immediate aftermath of a hazardous event but can be long term.

Furthermore, population growth, economic development in regions particularly vulnerable to natural hazards such as coastal regions, and climate change can exacerbate the risks.

This presentation introduces the concepts of sustainability and resilience as two of the most important characteristics of infrastructure in terms of addressing societal needs, and presents some of the engineering tools for the development of sustainable and resilient infrastructure including models for the deterioration and recovery of infrastructure components, systems and communities.

The presentation also includes a broader discussion of interdisciplinary considerations that should be accounted for to achieve sustainable and resilient infrastructure.

ILIA PAPAKONSTANTINOU

New York Universtiy

Ilia Papakonstantinou is a PhD candidate in Transportation Planning and Engineering, New York University, working with Prof. Samer Madanat.

She received her Diploma in Electrical and Computer Engineering from National Technical University of Athens, Greece, in 2011 and earned her Master of Science (MSc.) in Engineering Systems and Management, from Masdar Institute of Science and Technology, United Arab Emirates, in 2015.

Ilia's primary research interests lie in environmentally managed transportation infrastructure systems. In the past, Ilia has worked as an instructor in the Engineering Department at NYUAD, while she has also worked as an electrical engineer in the area of renewable energy sources.

Abstract I THE BENEFITS OF COOPERATIVE POLICIES FOR TRANSPORTATION NETWORK PROTECTION FROM SEA LEVEL RISE: A CASE STUDY OF THE SAN FRANCISCO BAY AREA

This research investigates the influence of decision-maker behavior on policies that are likely to be adopted for the protection of highway infrastructure against inundations resulting from sea level rise.

We analyze two different types of games to represent decision-maker behavior, and use the San Francisco Bay Area shoreline under 0.5m sea level rise as a case study.

The objective of the decision-makers is to minimize the traffic delay caused by inundations in the transportation network that lies in the geographical boundaries of their counties.

Our model considers hydrodynamic interactions, traffic flow patterns changes as a result of inundations, and budget constraints on the protection costs. The hydrodynamics in the Bay Area are affected by the shoreline protection strategy: protection of the shoreline of a county may lead to increased inundations in another, unprotected, county.

Furthermore, closure of a highway link in one county affects traffic delays in other counties due to traffic re-routing. Thus, protection decisions made by a county have potential impacts on several other counties, and therefore counties must take into account other counties' actions.

Both competitive (Nash) and cooperative games are analyzed. It is shown, through several examples, that cooperation among counties increases benefits (reduction of Vehicle Hours Traveled) for all participants in most cases. In some cases, cooperation also reduces protection costs.

SAMER MADANAT

New York University Abu Dhabi

Samer Madanat, Dean of Engineering at NYUAD, is the Xenel Professor of Engineering, former Chair of the Department of Civil & Environmental Engineering and former Director of the Institute of Transportation Studies at the University of California at Berkeley.
He received a BSc in Civil Engineering from the University of Jordan in 1986, and a MS and PhD in Transportation Systems from MIT in 1988 and 1991, respectively. Madanat's research and teaching interests are in the area of Transportation Infrastructure Management, with an emphasis on modeling facility performance, the development of optimal management policies under uncertainty, and developing solutions for improving the sustainability of transportation systems.

From 2001 to 2011, Madanat served as the Editor-in-Chief of the ASCE Journal of Infrastructure Systems. He is currently Editor of Transport Policy, Associate Editor of the European Journal of Transportation and Logistics, and an editorial board member of Transportation Research D, and Computer-Aided Civil and Infrastructure Systems. He serves on several advisory committees, including for the National Research Council, and has served as an external reviewer of Civil Engineering departments at MIT, Nanyang Technological University of Singapore, and Tongji University. Several of his former students and post-doctoral researchers are currently faculty members at universities in the US and around the world.

BORJA GARCIA DE SOTO

New York University Abu Dhabi

Borja García de Soto is an Assistant Professor of Civil and Urban Engineering at New York University Abu Dhabi, and holds an appointment as Global Network Assistant Professor in the Department of Civil and Urban Engineering at the Tandon School of Engineering at New York University (NYU). He is the director of the S.M.A.R.T. Construction Research Group at NYU Abu Dhabi and conducts research in the areas of construction automation, artificial intelligence, lean construction, integrated delivery systems, and BIM.

With over ten years of professional experience in the construction industry and Professional Engineer (PE) licenses in California and Florida, Borja has international experience in multiple aspects of project management, including project cost estimating, risk management and control, delay analysis and forensic engineering.

Borja received his PhD from ETH Zurich. He also holds an MSc in Civil Engineering with a concentration in engineering and project management from the University of California at Berkeley, an MSc in Civil Engineering with a concentration in structural design from Florida International University (FIU), and a BSc in Civil Engineering (graduated cum laude) also from FIU.

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