



THE ATHENS INSTITUTE FOR EDUCATION AND RESEARCH

# Abstract Book

9<sup>th</sup> Annual International Conference on Civil  
Engineering  
24-27 June 2019, Athens, Greece

Edited by  
Gregory T. Papanikos

2019



Abstracts  
9<sup>th</sup> Annual International  
Conference on Civil  
Engineering  
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# Preface

This book includes the abstracts of all the papers presented at the *9<sup>th</sup> Annual International Conference on Civil Engineering (24-27 June 2019)*, organized by the Athens Institute for Education and Research (ATINER).

In total 24 papers were submitted by 25 presenters, coming from 15 different countries (Australia, Canada, Chile, China, France, Germany, Hong Kong, Italy, Jordan, Romania, South Korea, Taiwan, UAE, UK, and USA). The conference was organized into 9 sessions that included a variety of topic areas such as Recent Developments in Construction and Transportation, Environmental and Innovative Design Issues, Sustainability and Resilience, and more. A full conference program can be found before the relevant abstracts. In accordance with ATINER's Publication Policy, the papers presented during this conference will be considered for inclusion in one of ATINER's many publications.

The purpose of this abstract book is to provide members of ATINER and other academics around the world with a resource through which to discover colleagues and additional research relevant to their own work. This purpose is in congruence with the overall mission of the association. ATINER was established in 1995 as an independent academic organization with the mission to become a forum where academics and researchers from all over the world could meet to exchange ideas on their research and consider the future developments of their fields of study.

It is our hope that through ATINER's conferences and publications, Athens will become a place where academics and researchers from all over the world regularly meet to discuss the developments of their discipline and present their work. Since 1995, ATINER has organized more than 400 international conferences and has published nearly 200 books. Academically, the institute is organized into 6 divisions and 37 units. Each unit organizes at least one annual conference and undertakes various small and large research projects.

For each of these events, the involvement of multiple parties is crucial. I would like to thank all the participants, the members of the organizing and academic committees, and most importantly the administration staff of ATINER for putting this conference and its subsequent publications together. Specific individuals are listed on the following page.

**Gregory T. Papanikos**  
**President**

**9<sup>th</sup> Annual International Conference on Civil Engineering**  
**24-27 June 2019, Athens, Greece**

**Scientific Committee**

All ATINER's conferences are organized by the [Academic Council](#). This conference has been organized with the assistance of the following academics, who contributed by a) setting up the program b) chairing the conference sessions, and/or c) reviewing the submitted abstracts and papers:

1. Gregory T. Papanikos, President, ATINER & Honorary Professor, University of Stirling, UK.
2. Dimitrios Goulias, Head, Civil Engineering Unit, ATINER and Associate Professor & Director of Undergraduate Studies Civil & Environmental Engineering Department, University of Maryland, USA.
3. Timothy Young, Professor, University of Tennessee, USA.
4. Hector Estrada, Professor, University of the Pacific, USA.
5. Yew-Chaye Loo, Professor Emeritus, Griffith University, Australia.
6. Fouad Mohammad, Academic Member, ATINER & Senior Lecturer, Nottingham Trent University, UK.
7. Audu Ezekiel Chinyio, Senior Lecturer, University of Wolverhampton, UK.
8. Sanaul Chowdhury, Senior Lecturer, Griffith University, Australia.



**FINAL CONFERENCE PROGRAM**  
**9<sup>th</sup> Annual International Conference on Civil Engineering, 24-27 June**  
**2019, Athens, Greece**

**Monday 24 June 2019**

**Conference Venue:** Titania Hotel, 52 Panepistimiou Avenue, Athens, Greece (close to metro station *Panepistimio*)

**07:50-08:20 Registration and Refreshments**

**08:30-09:00 (Room A - 10<sup>th</sup> Floor): Welcome and Opening Address by Gregory T. Papanikos, President, ATINER.**

**09:00-10:30 Session I (Room B - 10<sup>th</sup> Floor): Recent Developments in Construction I**

**Chair:** Dimitrios Goulias, Head, Civil Engineering Unit, ATINER and Associate Professor & Director of Undergraduate Studies Civil & Environmental Engineering Department, University of Maryland, USA.

1. Eunsoo Choi, Professor, Hongik University, South Korea, Yunkyung Ha, Graduate Student, Hongik University, South Korea, Duhyeon Kim, Graduate Student, Hongik University, South Korea, Tae Yeong Kim, Graduate Student, Hongik University, South Korea, Seong Jun Park, Graduate Student, Hongik University, South Korea & Yeon-seong Lee, Undergraduate Student, Hongik University, South Korea. SMA Confinement of HDPE Pipes: Enhancement of the Joint Fracture Resistance.
2. Ghanim Bakr, Associate Professor, Zarqa University, Jordan. Identification of Accuracy of Residential Projects Cost Estimates in Jordan.
3. Audu Ezekiel Chinyio, Senior Lecturer, University of Wolverhampton, UK. Beating Bias: Facing Gender Equality in Built Environment Sector through the Support of Technology.

**10:30-12:00 Session II (Room B - 10<sup>th</sup> Floor): Recent Developments in Construction II**

**Chair:** Audu Ezekiel Chinyio, Senior Lecturer, University of Wolverhampton, UK.

1. Kyung-Jae Shin, Professor, Kyungpook National University, South Korea. Nonlinear Analysis of Reinforced Concrete Frames Using OpenSees.
2. Sanaul Chowdhury, Senior Lecturer, Griffith University, Australia & Yew-Chaye Loo, Professor Emeritus, Griffith University, Australia. The New Australian Concrete Structures Standard AS 3600: 2018 – Aspects of its Complexity and Effectiveness.
3. Christopher Eamon, Associate Professor, Wayne State University, USA & Alex Andrew, Graduate Student, Wayne State University, USA. Long-term Cost Comparison of Competing Types of Highway Bridge Construction.

**12:00-13:30 Session III (Room B - 10<sup>th</sup> Floor): Recent Issues in Transportation**

**Chair:** Sanaul Chowdhury, Senior Lecturer, Griffith University, Australia.

1. Akmal Abdelfatah, Professor, American University of Sharjah, UAE & Osama El-Sahly, Graduate Student, American University of Sharjah, UAE. Influence of Autonomous Vehicles on Freeway Traffic Performance for Undersaturated Traffic Conditions.
2. Kuo-Liang Lin, Professor and Department Head, I-Shou University, Taiwan. A Vision-Based Method for Determining Degradation Level of a Road Marking.
3. Marian Goellner, Research Fellow, PhD Student, Ostfalia University of Applied Sciences, Germany. Fusion Structure for Environment Perception and Model-

Predictive Navigation of Autonomous Vehicles.

4. Sarvani Sonduru Pantangi, Graduate Research Assistant, University at Buffalo, The State University of New York, USA, Md Tawfiq Sarwar, Assistant Professor, East West University, Bangladesh, Abhishek Bhargava, Data Scientist, Advisory Services, USA, Grigorios Fountas, Lecturer, Edinburgh Napier University, UK, Satish Mohan, Associate Professor, University at Buffalo, The State University of New York, USA & Panagiotis Ch. Anastasopoulos, Associate Professor, University at Buffalo, The State University of New York, USA. Public-Private Partnerships for Roadway Construction and Preservation, and Traffic Safety: An Exploratory Empirical Analysis of Crash Frequencies.

**13:30-14:30 Lunch**

**14:30-16:00 Session IV (Room B - 10<sup>th</sup> Floor): Environmental Engineering**

**Chair:** Timothy Young, Professor, University of Tennessee, USA.

1. Guojian He, Associate Professor, Tsinghua University, China, Hongwei Fang, Professor, Tsinghua University, China, Xu Han, PhD Student, Tsinghua University, China & Lei Huang, Assistant Research Fellow, Tsinghua University, China. The Impacts Analysis of Plant Shape and Spatial Distribution on the Flow Properties.
2. Lei Huang, Assistant Research Fellow, Tsinghua University, China & Hongwei Fang, Professor, Tsinghua University, China. Characteristics of Bacterial Community in the Surface Sediment of Three Gorges Reservoir.
3. Camilo Souto, PhD Candidate, Universidad de Concepción, Chile, Octavio Lagos, Associate Professor, Universidad de Concepción, Chile, Eduardo Holzapfel, Professor, Universidad de Concepción, Chile & Daniele Zaccaria, Specialist, University of California, Davis, USA. A Modified Surface Energy Balance to Soil Evaporation on Partially Wetted Orchards with Drip Irrigation Systems.
4. Marwan Batiha, Professor, Al-Hussein Bin Talal University, Jordan. Synthesis, Characterization and Properties of Bottom Ash Based Geopolymer from Medical Wastes Incineration.
5. Ziad Al-Ghazawi, Associate Professor, Jordan University of Science and Technology, Jordan, Khaldoon Bani-Hani, Professor, Jordan University of Science and Technology, Jordan & Rami Alawneh, Professor, Jordan University of Science and Technology, Jordan. Testing and Evaluation of the Use of Digital Image Analysis and Artificial Neural Networks in Monitoring Wastewater Quality.

**21:00-23:00 Greek Night and Dinner**

**Tuesday 25 June 2019**

**08:30-12:00 Session V: An Educational Urban Walk in Modern and Ancient Athens**

Group Discussion on Ancient and Modern Athens.  
Visit to the Most Important Historical and Cultural Monuments of the City (be prepared to walk and talk as in the ancient peripatetic school of Aristotle)

**Conference Venue:** University of Athens (Kapodistriako), 48 Akadimias Street, Athens, Greece ([map](#), close to metro station *Panepistimio*)

**12:30-14:00 Session VI (Room B): Sustainability, Resilience and Other Issues**

**Chair:** Fouad Mohammad, Senior Lecturer, Nottingham Trent University, UK.

1. John Sansalone, Professor, University of Florida, USA. Permeable Pavement as Green and Low Impact Development Urban Infrastructure.
2. Norma Jean Mattei, Professor, University of New Orleans, USA. Barriers to Sustainable and Resilient Inland Waterway Infrastructure in the United States.
3. Onur Kuzgunkaya, Associate Professor, Concordia University, Canada, Navneet Vidyarathi, Associate Professor, Concordia University, Canada & Masoud Amel Monirian, PhD Student, Concordia University, Canada. Mixed-Integer Second-Order Cone Programming: An Application in the Design of Preventive Healthcare Facility Network.
4. Anna Mazzi, Assistant Professor, University of Padova, Italy & Beatrice Gatto, Master Student, University of Padova, Italy. Circular Economy Concept in Sustainable Building Design.

**14:00-15:00 Lunch**

**15:00-16:00 Session VII (Room B): Special Topics: Design, Construction and Machine Learning**

**Chair:** Yew-Chaye Loo, Professor Emeritus, Griffith University, Australia.

1. Hector Estrada, Professor, University of the Pacific, USA. Performance Based Design (PBD): A Renovating Seismic Design in Building Codes.
2. Fouad Mohammad, Senior Lecturer, Nottingham Trent University, UK & Michael Wright, Principal Structural Engineer, Arc Partnership, UK. Optimum Design of Cold-Formed Steel Mono-Pitch Portal Frames According to BS 5950.
3. Andreea Mihailescu, Research Scientist / Development Engineer, Lasers Department, National Institute for Lasers, Plasma and Radiation Physics / Politehnica University of Bucharest, Romania. Machine Learning for Intelligent Wireless Sensors Networks, Wearables and Autonomous Unmanned Systems.

**16:00-17:00 Session VIII (Room B): Recent Developments in Construction III**

**Chair:** Hector Estrada, Professor, University of the Pacific, USA.

1. Fawzi Bouras, PhD Student, University of Orleans - LafargeHolcim, France, Nouffou Tapsoba, LafargeHolcim, France, Mylène Martin, LafargeHolcim, France, Serge Sabio, LafargeHolcim, France, Alain Jacquet, LafargeHolcim, France, Kevin Beck, University of Orleans, France, Naima Belayachi, University of Orleans, France, Marwen Bouasker, University of Orleans, France & Muzahim Al-Mukhtar, University of Orleans, France. Effect of Hydrated Lime and Cement on the Engineering Behavior of Highly Expansive Clay.
2. Zhuoya Wu, PhD Student, The University of Hong Kong (HKU), Hong Kong. High Strength Concrete Tests under Elevated Temperature.

**20:30-22:00 Dinner**

**Wednesday 26 June 2019**  
**Mycenae and Island of Poros Visit**  
**Educational Island Tour**

**Thursday 27 June 2019**  
**Delphi Visit**

**Friday 28 June 2019**  
**Ancient Corinth and Cape Sounion**

**Akmal Abdelfatah**

Professor, American University of Sharjah, UAE

&

**Osama El-Sahly**

Graduate Student, American University of Sharjah, UAE

## **Influence of Autonomous Vehicles on Freeway Traffic Performance for Undersaturated Traffic Conditions**

Autonomous vehicles (AVs) are smart driving technology that are expected to alter the perception of transportation and become the next generation of vehicles. One of the major challenges that are expected to happen is the interaction between AVs and regular vehicles (RVs) in the traffic fleet, using the same roads, as the mode share for AVs (percentage of AVs) would not be 100% in the early stages of adoption. The purpose of this study is to evaluate the impacts of AVs on freeway traffic performance at different mode share values of AVs ranging from 0% to 100% and at two different undersaturated traffic volume levels (for demand to capacity ratio of 0.6 and 0.8). The study considered a section of a major freeway in Dubai, UAE as the test corridor for the study. VISSIM 10 was used to develop a microsimulation model to evaluate different scenarios that represent different mode share of AVs and different demand to capacity ratios. The results showed that increasing AVs mode share from 5% to 100% yields the following:

- The average speed at 0.6 demand to capacity ratio improved by about 5% (at 5% AVs) to about 10% (at 100% AVs). While at 0.8 demand to capacity ratio the improvement ranges from about 5% (at 5% AVs) to about 15% (at 100% AVs).
- At 0.6 demand to capacity ratio the travel time decreased by less than 1% (at 5% AVs) to about 8% (at 100% AVs). While the reduction at 0.8 demand to capacity ratio is about 4% (at 5% AVs) and about 12% (at 100% AVs).
- A reduction in delay at 0.6 demand to capacity ratio that ranges from about 18% (at 5% AVs) to about 97% (at 100% AVs). While the reduction at 0.8 demand to capacity ratio that ranges from about 11% (at 5% AVs) to about 94% (at 100% AVs).

The improvement in traffic performance when AVs mode share increases from 0% to 100% is because RVs are replaced by AVs that can travel with higher constant speed and with a smaller time headway.

T-test was carried out to examine the difference between scenarios' average speeds and between the average speed of both AVs and RVs. The test showed that there is a significant difference between the AVs and RVs

performance at demand to capacity ratio of 0.6 and 0.8, for all AVs mode shares because the low congestion at this demand to capacity ratios, so AVs can travel freely with speeds significantly higher than RVs.

**Ziad Al-Ghazawi**

Associate Professor, Jordan University of Science and Technology, Jordan

**Khaldoon Bani-Hani**

Professor, Jordan University of Science and Technology, Jordan

&

**Rami Alawneh**

Professor, Jordan University of Science and Technology, Jordan

## **Testing and Evaluation of the Use of Digital Image Analysis and Artificial Neural Networks in Monitoring Wastewater Quality**

Monitoring wastewater treatment plants in Jordan has mostly focused on a few effluent parameters to meet the regulations of Water Authority of Jordan (WAJ) and other ministries. Image-based monitoring of wastewater quality parameters provides an easy tool to improve plant efficiency and accurate process control. This study used the digital image analysis (DIA) and artificial neural networks (ANN) techniques to develop an economical method for monitoring wastewater quality in terms of BOD<sub>5</sub>, SS and Turbidity. The study used two types of wastewater samples including real wastewater samples, which were collected from Jordan University of Science and Technology's wastewater treatment plant (WWTP) and Wadi Arab WWTP, in addition to synthetic wastewater samples which were prepared by dilution of real wastewater with de-ionized distilled water. Two ANN models were developed to classify wastewater digital images and to predict wastewater quality parameters. The first ANN model was developed for predicting BOD<sub>5</sub> concentration in wastewater, the second ANN model was developed for predicting SS concentration and Turbidity content in wastewater. The color indices associated with each wastewater image pixels were used as the only inputs for each ANN model. The results showed good correlations between observed and predicted values of BOD<sub>5</sub>, SS and turbidity. Finally, ANN models were able to classify wastewater digital images and to predict BOD<sub>5</sub>, SS and turbidity in wastewater from digital images color indices.

**Ghanim Bakr**

Associate Professor, Zarqa University, Jordan

## **Identification of Accuracy of Residential Projects Cost Estimates in Jordan**

The main objective of this study is to identify and evaluate the significant factors that affect the precision of cost estimation in the residential construction projects in Jordan.

The methodology adopted for this study has been carried out through data collection from 8 residential projects implemented in the last three years, literature review, interviews with 6 projects managers; questionnaire which included 59 factors distributed over seven groups, and analysis and ranking of these factors depending on the severity index and other statistical parameters.

The analysis of data showed that the percentage of deviation (between the estimated and actual costs) for the 12 elements in the 8 projects were between -36.78% and 32.12%. For the whole projects the range was between -2.35% and 9.45%. The standard deviations for the different elements were between 10 and 18.26 and for 8 projects were 3.85.

The survey revealed the most significant factors that affect the estimation accuracy are: The level of experience of estimation team, Client's financial capabilities, experience of the project's team, time allowed for estimation, complexity and constructability of the project, and the availability and prices for labor and material.

The output of this survey could help the professionals involve in the estimation process to prepare more reliable and efficient prices for different elements of work at the pre-tender phase of the project.

**Marwan Batiha**

Professor, Al-Hussein Bin Talal University, Jordan

## **Synthesis, Characterization and Properties of Bottom Ash Based Geopolymer from Medical Wastes Incineration**

Jordan has witnessed a rapid development in private and public medical care establishment. This results in a significant increase in the generation of clinical waste. An investigation of the handling, storage, transport and disposal practices at Jordanian hospitals, medical laboratories and pharmaceutical plants was conducted to ensure a safe disposal and avoid risk to public health. The disposal process is to convert this hazardous waste to ash by using an incineration process.

The ash was characterized in terms of particle size distribution, chemical and mineralogical composition in order to convert it into geopolymer. The major elements found in the medical waste ash were Ca, Si, Al, Na, Cl, Fe, Ti, S, Mg, Ba and K, while the main mineral phases found in the ash were calcite, halite, sylvite, hematite, hydrochlorborite, cristobalite, melanterite and chlormayenite.

During polymerization process, Silicon and aluminum ratio, solid and water ratio, the fineness of obtained ash, the concentration of alkali, curing temperature and curing time were studied.

A geopolymer was prepared by mixing a ground ash (different particle size) with different NaOH concentrations with a ratio of 1.25 ash to NaOH. The obtained mixtures were pre-cured at different temperatures and time. The product along with the ash were characterized using XRF and XRD. It was found that higher concentration of sodium hydroxide solution and long curing time results in higher compressive strength of bottom ash based geopolymer.



**Fawzi Bouras**

PhD Student, University of Orleans - LafargeHolcim, France

**Nouffou Tapsoba**

LafargeHolcim, France

**Mylène Martin**

LafargeHolcim, France

**Serge Sabio**

LafargeHolcim, France

**Alain Jacquet**

LafargeHolcim, France

**Kevin Beck**

University of Orleans, France

**Naima Belayachi**

University of Orleans, France

**Marwen Bouasker**

University of Orleans, France

&

**Muzahim Al-Mukhtar**

University of Orleans, France

## **Effect of Hydrated Lime and Cement on the Engineering Behavior of Highly Expansive Clay**

In order to improve the rate of reuse of the in situ clay soils in road construction, lime treatment techniques have largely been developed across the world. In fact, lime is an efficient additive to improve various engineering properties of cohesive soils. However, the access to lime can be difficult in some countries where the lime's production is insufficient and its quality doesn't allow it to be used in road treatment. Cement is largely used like an alternative solution to lime for different engineering projects.

The objective of this study is to compare and understand the effect of these binders on a highly expansive clayey soil by a comprehensive series of laboratory tests. The clayey soil was treated with lime and Portland cement (CEM I 52,5 N) in order to study the changes in the main geotechnical properties. Plasticity index, Volumetric swelling and unconfined compressive strength measurements were performed at room temperature of 20 °C with 6, 10 and 20% of binder's additions.

The experimental results indicate improvement in the geotechnical properties of the treated clayey soil with the binders used. The lime addition causes a significant improvement at short terms in soil properties by reducing plasticity. These improvements can be attributed to the cation exchange and the flocculation-agglomeration of the clay particles due to the lime addition. However, a higher increasing of the unconfined

compressive strength is noted with cement treatment. The hydration of cement produced calcium silicate hydrates, which are responsible for the improvement in the strength properties of the binder treated soils. Volumetric swelling is reduced due to the binder additions. Cation exchange and the development of lime's pozzolanic reaction and the hydration of cement participate to reduce the absorption capacity of clay minerals in the soil treated.

**Audu Ezekiel Chinyio**

Senior Lecturer, University of Wolverhampton, UK

## **Beating Bias: Facing Gender Equality in Built Environment Sector through the Support of Technology**

**Background:** Up to 2016, the UK Office of National Statistics was reporting a very high disproportionate of workers in Built Environment (BE) sector (93.6% males VS 6.4% females). The gender imbalance in the BE is attributable to several factors i.e. the prevalence of highly physical work in some construction activities, extensive working hours, very high competition amongst colleagues, undermining of women's capabilities, and greater difficulty for women to balance between work and family.

**Aim:** The aim of this paper is to show how a digital solution (an app) may represent a valid tool to promote a more gender equality approach in BE.

**Methods:** The development of this app (Streblo) was based on several inputs collected from different construction workers (N = 20) and IT academic staff (N = 3). Qualitative data was collected from observations, interviews (with 5 operational managers and 15 supervisors while two academic staff in Informatics Engineers and one specialist in the BE were consulted), and field notes using an ethnographic approach. Data was content analysed upon which Streblo was designed to support daily work activities and promote the management and distribution of tasks and skills.

**Results:** The suggestions generated from the analysis led directly to the development of Streblo's features and functionalities. Many aspects of these functionalities are intended to favour a more balanced gender environment. For example, Streblo can permit the remote management of deadlines and tasks, improved digital communications, the conduct of different activities and monitor the level of stress and difficulties of workers in their daily routines. Streblo has the potential to reduce disparities and differences between male and female workers. Streblo will be applicable to both Civil Engineering and other types of construction projects or activities.

**Discussion:** Digital and advance technologies are transforming many physically demanding activities in the BE. Streblo represents a novel digital solution able to support a more-friendly and gender-neutral operational BE which has hitherto been described as a male dominated sector.

**Eunsoo Choi**

Professor, Hongik University, South Korea

**Yunhyu Ha**

Graduate Student, Hongik University, South Korea

**Duhyeon Kim**

Graduate Student, Hongik University, South Korea

**Tae Yeong Kim**

Graduate Student, Hongik University, South Korea

**Seong Jun Park**

Graduate Student, Hongik University, South Korea

&

**Yeon-seong Lee**

Undergraduate Student, Hongik University, South Korea

**SMA Confinement of HDPE Pipes:  
Enhancement of the Joint Fracture Resistance**

This study was to provide a new aspect of application of shape memory alloys (SMAs) in civil engineering. The high-density polyethylene (HDPE) have been used for construction of pipelines for several years. The main problem of using HDPE for pipes is the joint of two adjacent pipes. In case of having a perfect joint, the HDPE pipeline can bare the internal pressure up to 90 MPa. However, in practice, it can rarely achieve to a perfect pipe joint due to the complicated process, so, it prone to fracture in low internal pressure. To overcome this, this study investigated the efficiency of wrapping and confinement of HDPE pipe at the joint to enhance the internal pressure baring capacity. For this aim, the NiTi SMA wires were used for the confinement of the pipe joint. Then, the pipe system was connected to two high speed water injector system at both sides to provide full flow through the pipes. To track and measurement of the displacement LVDT together with high speed camera were used. Results showed that SMA confinement of the joint could efficiently enhance the resistance of the pipe joint as that of a perfect joint.

**Sanaul Chowdhury**  
Senior Lecturer, Griffith University, Australia  
&  
**Yew-Chaye Loo**  
Professor Emeritus, Griffith University, Australia

## **The New Australian Concrete Structures Standard AS 3600: 2018 - Aspects of Its Complexity and Effectiveness**

Australian Standard for Concrete Structures AS 3600-1988, the first of the AS 3600 series, was published in March 1988. Since then, AS 3600 has been revised four times and published consecutively at between six to nine-year intervals as AS 3600-1994, AS 3600-2001, AS 3600-2009 and the latest, AS 3600-2018.

The changes incorporated in AS 3600-2018 concern mainly the following topics:

1. Stress-block configuration for bending analysis and design of reinforced and prestressed members
2. Shear and torsional strengths of reinforced and prestressed members
3. Values of the strength capacity reduction factor,  $\phi$
4. Effective moment of inertia for deflection calculations

As part of a review, a summary of the relevant new design procedures and associated formulas have been prepared.

Research worldwide on the mechanics and strength of concrete structures - a rather mature discipline - is sustaining a state of diminishing return. Australia is no exception. In particular, the modifications identified above have led to more complicated processes which require increased computational efforts. Academically, such added complexity may be considered as a disciplinary upgrade. Concrete engineering practitioners, on the other hand, deserve to be advised of the effectiveness, or worthiness, of such an advance.

In each of the concerned topics and for practical problems, analysis and design calculations have been carried out using the updated specifications given in AS 3600-2018, as well as those existing in the superseded AS 3600-2009. Based on the analysis results and design outcomes, observations are made in regard to the complexity and effectiveness of this Australia's premier concrete structures code.

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&

**Alex Andrew**

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## **Long-term Cost Comparison of Competing Types of Highway Bridge Construction**

In recent years, government agencies have become increasingly concerned with the long-term costs of maintaining civil infrastructure. Although one type of construction may have lower initial cost, high maintenance costs over the lifetime of the structure may render it a less desirable choice than an alternative that is initially more costly. A prime example of this concern can be seen in the proliferation of alternative types of construction available for bridges on the transportation network, where competing materials for structural members and various types of deck construction are available. Although numerous life cycle cost analyses of bridges have been conducted in prior research, the large majority of studies have investigated a small number of alternatives. This makes broader comparisons across various different types of construction difficult, where different assumptions with regard to costs, deterioration, and maintenance requirements have been used.

To address this issue, in this research a life-cycle cost analysis is conducted for thirteen common highway bridge construction alternatives used on typical two-lane highway bridge geometries. Structures are composed of either prestressed concrete or steel girders and support a reinforced concrete deck. Additional construction types considered include combinations of alternatives in deck and beam reinforcement (uncoated steel; epoxy-coated steel; stainless steel; and carbon fiber bars), and type of deck and beam concrete (standard; high performance; internally-cured high performance; and engineered cementitious). For each alternative, different maintenance scheduling activities are used such that each structure meets the same level of serviceability at any time. Agency and user costs over the lifetime of the structures are considered, and include the initial cost of construction and various maintenance activities such as beam replacement, deck overlay, cathodic protection, deck patching, beam end repair, deck replacement, and demolition and reconstruction. User costs include those of time, vehicle operation, and crashes due to maintenance and construction. In the analysis, all costs are converted to equivalent present value for consistent comparison. Expected cost results for all alternatives are given for each year up to 100 years in the life cycle, such that break even points can be identified and long term recommendations made.

**Marian Goellner**

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## **Fusion Structure for Environment Perception and Model-Predictive Navigation of Autonomous Vehicles**

A research focus of the Research group for Control Engineering and Vehicle Mechatronics at Ostfalia University is on autonomous driving using existing function carriers and research vehicles. An important part of autonomous driving is the recognition and classification of other road users as well as the detection of obstacles. Together with roadway detection and global position data, a trajectory is to be generated which can be followed by an autonomous vehicle with the aid of predictive control technology.

The paper describes the entire process from the acquisition of measurement data to the fusion of the data to an environment map, the generation of trajectories on this map and the subsequent model-predictive trajectory control.

First, the preparation and pre-processing of the sensory input to ensure error-free and exact detection is to be demonstrated. It is not only important to collect static and dynamic information about the contour of the surrounding terrain and the objects moving in it, but also to classify these objects. Classification can be used to make model-based statements about future movements of the object. It is possible, for example, that a stationary car is detected as an immobile object, but the classification can be used to calculate preventive scenarios that predict the car's future movement. The data obtained are then used for autonomous driving of a machine and are therefore safety-critical. As described in the full paper, the usable measuring principles of the sensors suitable for environmental detection can be deceived by various external influences. One way to compensate for the individual disadvantages of environmental sensors is to merge, assign and validate the measured data with a data fusion process.

The fusion results are detailed objects in the environment, which can be fully described by classification and localization. These objects can now be drawn together with static obstacles such as road markings or walls in a time-varying environment map.

By projecting the global target vector, a local trajectory can now be superimposed in this map.

By optimization methods a trajectory optimal in time and energy is represented in form of a sequence of waypoints to be traveled, which are passed to a subordinate control as set points. If simple linear controllers are used to follow these points, the trajectory is traversed with the

appropriate control quality, but reacts to the changes in the target coordinates as well as to a set point step. Better results thus provide control strategies which take into account the next expected set point.

A valid approach to the tracking is a model predictive control algorithm which allows the prediction of future driving conditions and thus allows the direct integration of following waypoints. On the basis of an extended state space model of the model plant, the future course of the state variables of the system can be predicted. Since the underlying model description usually does not completely correspond to the real system, the principle of the "Receding horizon control" is to be applied here.



**Hector Estrada**

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**Performance Based Design (PBD):  
A Renovating Seismic Design in Building Codes**

There are a number of shortcomings in most current building code specifications; in particular, they only address the life-safety function of buildings in the event of a rare natural disaster that causes a sudden drastic increase in load – an extreme event. Performance Based Design (PBD) provides a more specific set of requirements for different levels of intensity and occurrence intervals of a natural disaster, allowing engineers to focus on the serviceability of buildings. A serviceable building must perform all original functions for which it was intended, including life-safety. Allowing a building to be serviceable after going through a rare natural disaster decreases the total building cost, and reduces its carbon footprint, over its lifespan. This paper focuses on the current shortcomings of seismic design in building codes and provides an overview of seismic performance based structural design in the context of sustainability. It also covers the recent developments in PBD introduced in the 2010 edition of the American Society of Civil Engineers (ASCE), Minimum Design Loads for Buildings and Other Structures better known as ASCE/SEI 7. We also discuss PBD for existing buildings; particularly the difference between life-safety and collapse prevention.

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**Hongwei Fang**

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**Xu Han**

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&

**Lei Huang**

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## **The Impacts Analysis of Plant Shape and Spatial Distribution on the Flow Properties**

Vegetation in shallow water systems, such as rivers and wetlands, plays an important role in altering flow resistance and turbulence. Submerged or emergent vegetation reacts to the drag of water by either remaining erect, oscillation in response to turbulent fluctuations, or bending. There are extensive research focused on the plant-flow interactions. However, given the variety for plants and their temporal and spatial variability, in addition to the wide range of flow and morphological conditions in nature, significant knowledge gaps still exist. To get the details of the velocity distribution around the plants in three-dimensional direction, Large Eddy Simulation is used in this study. Three plant shapes with different configurations are formed with Immersion Boundary Method. The river bed is formed by five layer packed particles so that both permeability and roughness can be considered. Based on the LES model, three dimensional velocity is simulated. The relationship between the turbulent events and eddy and the plants shapes are analyzed. Moreover, using the double average method, the form-induced normal and shear stresses are calculated for different plant shapes and different spatial distribution. It can be seen the significantly influence under and over-canopy flow behaviour, as well as the interfering wakes among the stems. Element scale (stem scale) turbulence is generated within the canopy. These phenomena will affect the sediment transport and the mass diffusion. Then, the drag and the drag coefficient distribution are calculated in different cases. The results show that not only the additional drag exerted by plants can reduce the mean flow velocity, but also the plant form and the spatial distribution can have a significant effect on the mean flow field. These results are applied to the ecological restoration of the Yongding River in Beijing. The plant types and density are suggested for the engineering design and the evaluation of the flood risk and the sediment transport.

**Lei Huang**

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&

**Hongwei Fang**

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## **Characteristics of Bacterial Community in the Surface Sediment of Three Gorges Reservoir**

Bacteria are ubiquitous in aqueous environment and crucial for the biogeochemical processes. The characteristics and distribution of bacterial community will be an important reflection of human activities. In this study, surface sediment samples were collected from the Three Gorges Reservoir (TGR) in June, 2015 to characterize the bacterial communities using 16S rRNA gene sequencing, including sediment samples from the dam area, mainstream, urban area, and tributaries. The responses of bacterial communities to environmental variables are then statistically analyzed using the Redundancy analysis (RDA) and heatmap. Results show that *Proteobacteria*, *Acidobacteria*, *Chloroflexi*, *Bacteroidetes*, *Firmicutes*, *Nitrospirae* are the dominant phyla of the bacterial communities, accounting for over 80% of the total abundance. There is a greater abundance of *Proteobacteria* and *Nitrospirae* in the mainstream sites, while more *Acidobacteria*, *Chloroflexi*, and *Bacteroidetes* in the urban area sites, and more *Firmicutes* in the tributary sites. The bacterial communities are affected by environmental variables such as the sediment size  $D_{50}$ , water depth, dissolved oxygen  $DO$ , and potential ecological risk index  $R_I$ . For example, *Firmicutes* is negatively correlated with the  $DO$  concentration, i.e. preferring an anaerobic condition. *Cyanobacteria* is positively correlated with the water depth, probably due to the eutrophication of the reservoir. *Aminicenantes*, *Armatimonadetes*, *Actinobacteria*, and *Caldiserica* are all positively correlated with the  $R_I$  index, implying a potential effect of heavy metal distribution on the bacterial communities. The reservoir operation results in sediment sorting and increasing water depth along the mainstream, as well as heavy metal accumulation in the surface sediment, thus exerting effects on the characteristics of bacterial community and accordingly affecting the biogeochemical processes. Overall, there is no significant difference of the community richness and diversity among these sediment samples. This study will provide a better understand of the effects of impoundment on bacterial community and the resultant ecological implications.

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**Navneet Vidyarthi**

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**Masoud Amel Monirian**

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## **Mixed-Integer Second-Order Cone Programming: An Application in the Design of Preventive Healthcare Facility Network**

Preventive healthcare (PH) programs and services aim at reducing the likelihood and severity of potentially life-threatening illness by early detection and prevention. The effectiveness of these programs depends on the participation level and the accessibility of the users to the facilities providing the services. Factors that impact the accessibility include the number, type, and location of the facilities as well as the assignment of the clients to these facilities. In this paper, we study the impact of system-optimal (i.e., directed) choice on the design of the preventive healthcare facility network under congestion. We present a model that simultaneously determines the location and the size of the facilities as well as the allocation of clients to these facilities so as to minimize the weighted sum of the total travel time and the congestion associated with waiting and service delay at the facilities. The problem is set up as a network of spatially distributed M/G/1 queues and formulated as a nonlinear mixed integer program. We use Mixed-Integer Second-Order Cone Programs (MISOCPs) as an efficient procedure for non-linear models. Ten different MISOCPs reformulations, containing strong valid inequalities, are developed and compared. We also compare MISOCP reformulations against a piecewise linear approximation and cutting plane algorithm exact solution approach ( $\epsilon$ -optimal) to show the quality of the solutions generated by the MISOCPs. The results show that the MISOCPs can perform better in many cases where the piecewise approximation is inefficient. Moreover, the results show that the optimal PH facility network design can reduce the total time spent by clients which can be determined within a reasonable CPU time by MISOCPs.

**Kuo-Liang Lin**

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## **A Vision-Based Method for Determining Degradation Level of a Road Marking**

Road marking provides informative guidance for vehicle drivers and is a critical aid in maintaining road safety. Quality of road marking plays an important role in providing satisfactory functional condition of a road pavement. Pavement marking degrades as traffic goes, so quality inspection must be made regularly to ensure its serviceability. This paper proposes a quality inspection method for determining the level of degradation of a road marking utilizing machine vision technologies. The method is executed by a determination unit including a processor, a database of reference image, and an image-capturing device having a plurality of shutter speeds. An analytical algorithm is incorporated with the system so that the method can adapt to different illumination situations. After receiving examined road marking image, the analytical algorithm generates an image according to the selected shutter speed by assessing surrounding illumination level, then retrieves one of the reference data from the database that has the same shutter speed as the examined road marking, and next performs a difference determination procedure between the retrieved reference data and the examined data. Finally, the processor outputs a normalized result of the level of degradation of the examined road marking. As such, accurate determination on the level of degradation of the examined road marking can be achieved. The proposed method is demonstrated through several real cases to show how it works. In the end, a test comparing the inspection results between the proposed method and expert inspection is conducted to prove the accountability of the proposed method.

**Norma Jean Mattei**  
Professor, University of New Orleans, USA

## **Barriers to Sustainable and Resilient Inland Waterway Infrastructure in the United States**

The Mississippi River basin drains 41% of the continental United States. Locks, dams and other infrastructure such as the Mississippi River and Tributaries Project (MR&T) were constructed on the river and its tributaries, beginning in the 1930's, that allowed for the expansion of the nation and played a substantial part in building the US' economic might. Currently there are four "revolutions" that are impacting the greater Mississippi River watershed. The first is an explosive growth in agricultural productivity of the nation's breadbasket, increasing the demand for water, rail and overland transportation demands. Energy production, "revolution"2, has increased with the advent of economic fracking. This also puts stress on the transportation system as frack sand and energy products must be moved to refining facilities and then to market. Thirdly, manufacturing is returning to the Mississippi valley, spurred by cheap fuel costs and the advantage of the inland waterway transportation system. The last "revolution is the impacts of climate change and the focus on the creation of resilient infrastructure. With increased stress placed on the United State's inland waterways, investment and recapitalization is needed in creating a more resilient waterway system. A brief history of the inland waterway system will first be discussed. The four "revolutions will be explained in detail. Barriers to creating a more resilient system will be presented, ending with some proposed solutions.

**Anna Mazzi**

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&

**Beatrice Gatto**

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## **Circular Economy Concept in Sustainable Building Design**

In the last decades, in industrialized Countries, the environmental problems of waste production are enormously increased. One of the most responsible sectors of this phenomenon is building construction and demolition. In order to reduce waste quantities and improve the possibilities of reuse and recovery of everything that may still have a possibility of use, European Union has recently adopted Circular Economy. Coherently with this approach, the EU framework directive on waste commits EU Members to achieve the 70% reduction in the weight of construction waste, by adoption of reuse, recycling and recovery, avoiding landfill as much as possible.

Selective demolition is a realistic alternative to avoid the environmental impacts related the demolition building: it allows an effective recovery of materials derived from a building demolition, as direct reuse (without any treatment) or recycling (with ad-hoc treatment activities), and it minimizes the amount of waste that must be sent to incineration or landfill (according to their dangerousness).

However, selective demolition is still a rare practice today, as demonstrated by the literature review of recent scientific papers. The most frequently methods of processing waste materials on construction and demolition do not have any waste selection system, because a selective demolition is too expensive, and when a building is demolished nobody is willing to pay additional costs for waste selection.

Therefore, selective demolition is a viable solution for sustainable management of construction waste only if it is a constructive specification from the building design. Indeed, the selective demolition in design phase of building allows giving an added economic value to justify the subsequent recovery activities of materials coming from demolition.

To confirm this point of view, we summarize the results related an Italian case study, concerning the environmental impact assessment of demolition activities of a single house. The case study shows the environmental convenience of selective demolition compared to traditional non-selective demolition, especially if in design selective demolition is defined.

Hence, the next challenge for sustainable construction includes sustainable demolition criteria in building design.

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**Machine Learning for Intelligent Wireless Sensors Networks,  
Wearables and Autonomous Unmanned Systems**

With an estimated of over 26 billion connected devices by 2020, the Internet of Things (IoT) is increasingly becoming more than a growing technological trend, namely a vital part of many solutions to problems of global concern. Industry 4.0, smart farming, smart cities and personalized intelligent healthcare services comprise most of the IoT applications today. At the same time, the wide availability of broadband internet along with the decreasing costs of connection as well as of smartphones or tablets create the perfect environment for either new or IoT transformed solutions.

While connectivity problems are less likely to pose major issues, the real challenge for IoT is to offer devices an intelligent functionality and to make them reliable at all times and in any conditions. This basically means to have robust machine learning (ML) running on your device. However, since the common trend is to use low-cost and low-power electronics, incorporating machine learning or deep learning algorithms that run with data collected from sensors can be extremely demanding for such electronics and the limited onboard memory. Hence, most of the existing smart IoT solutions are based on cloud communication, namely on sending acquired data to a cloud running ML algorithms. On the other hand, Industrial IoT (IIoT) is starting to rely more and more on edge computing.

This presentation is meant to offer an overview of self-designed and implemented machine learning solutions for intelligent wireless gas sensors networks, wearables and autonomous unmanned water surface biovehicles for offshore plastic waste degradation. The intelligent wireless gas sensors network was developed in our laboratory and is currently undergoing heavy testing. Its main purpose is to serve detecting common greenhouse gases related to industrial activities, to issue level and toxicity alerts and to subsequently predict the nature of the fault and equipment malfunction. Two intelligent wearables were designed for smart farming and for personalized remote healthcare respectively. They were part of two distinct projects submitted this year to the Google AI Impact Challenge, the main highlight of the wearables being the ML algorithms adapted to run on device. The last item showcased is the hybrid ML solution on board of an intelligent autonomous unmanned water surface vehicle that detects, collects and degrades plastic waste offshore in an



environmentally friendly manner, while using the by-products of the degradation process to create energy for self-power and nutrients for marine life. This vehicle is this year's second-runner of a national tech challenge competition.

Concluding remarks address general guidelines on how to design and add a suitable AI functionality to an IoT solution in accordance to its designation, to the electronics budget and to limitations imposed by connectivity and power consumption. A discussion on the deployment of digital twins for design and test purposes will also be provided.

**Fouad Mohammad**

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&

**Michael Wright**

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## **Optimum Design of Cold-Formed Steel Mono-Pitch Portal Frames According to BS 5950**

Steel portal frames are usually common in construction industry, particularly for single-storey structures where the requirement for wide spans is a priority. Typical examples are warehouses, hangars, agricultural buildings and sports venues. The use of cold-formed steel (CFS) portal frames has several advantages such as ease of transport and handling, high strength-to-weight ratio, flexibility of cross-sections, non-combustibility, durability and recyclability. This implies that CFS portal frames provide sustainable construction which require less material to carry the same load compared to other materials and reduces the amount of waste material on site.

This research deals with the optimum design in terms of minimum weight of CFS mono-pitch portal frames. The columns and rafters of the frame were chosen to be compound I-sections, made up of back to back lipped channels. The CFS sections were formed from sheet metal with thicknesses starting at 2mm increasing to 3.2mm. The frame spans investigated were 7.5m to 12.5m with frame spacing of 3m to 6m. The minimum weight of the CFS portal frame was ascertained through optimisation process, using the Generalised Reduced Gradient (GRG) method. Implementation of GRG was accomplished using Microsoft Excel Solver. The design constraints were set in accordance to limit state principles of BS 5950. Linear elastic analysis was employed for finding the internal forces at the critical sections of the frame. The results and analysis confirm the effectiveness of optimisation as a major structural engineering tool. The findings also demonstrated that minimum weight CFS portal frames have structural capability of performing at spans up to 10.5m dependant on the frame spacing. The results of this investigation were compiled into practical design charts for initial sizing of CFS portal frame members.

**John Sansalone**  
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## **Permeable Pavement as Green and Low Impact Development Urban Infrastructure**

The constructed environs and anthropogenic activities can alter the restorative capacity of the ecological and water balance of the pre-constructed environs. Given the potential impacts of the constructed environs and activities there have been recent controls and regulatory guidance. While there are valid arguments as to the accuracy of the term “Low Impact Development” (LID), the term has been utilized for decades to describe methods and procedures to reduce or lower the impact of constructed environs and activities utilizing components of permeable infrastructure to mitigate impacts of built environs on the urban hydrologic cycle. Permeable pavement with partial exfiltration can allow variable quantities of particulate matter (PM) filtration and hydrologic restoration in the urban rainfall-runoff cycle. Physical and computational fluid dynamics (CFD) of unsteady PM filtration were coupled to model a partial exfiltration system (PES). An unsteady CFD model was validated with monitoring of hydrologic phenomena as well as influent and effluent particle size distributions (PSDs).

This study has applied computational fluid dynamic (CFD) model to simulate the filtration performance of permeable pavement as part of a partial exfiltration system (PES) subject to event-based physical validation and continuous simulation. A user-defined discrete phase model (DPM) was applied in the CFD model for unsteady particle tracking during a storm event. Four storm events collected at an urban site, Cincinnati, Ohio, were used to validate and evaluate the simulation of a PES system (a partial exfiltration reactor with oxide-coated media) performance in CFD model. RMSEs between modeled and measured effluent PSDs are all less than 10% for four studied events, indicating that CFD model is suitable for the simulation of PES and CPP performance under unsteady flow conditions with application of user-defined DPM. The performance of PES and CPP was also examined by the CFD model as a function of different flow rates. A decrease trend of removal efficiency on particles was reported with increasing flow rate. Results indicate a high removal efficiency of particles (>90%) for the PES under any possible flow rate condition. Beyond that, the performance of PES was investigated on an annual basis. Without considering the bypass flow, removal efficiency of influent particles by the PES is 97% over the representative year of 2005, and 68% for the entire runoff volume as considering bypass effect. Overall, the application of CFD model is a feasible and viable tool to simulate and predict the performance of LID systems (PES in this study), as green

infrastructure and for sustainable urban drainage systems in lieu of more traditional best management practices.

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## **Nonlinear Analysis of Reinforced Concrete Frames Using OpenSees**

Earthquakes of 5.8 and 5.4 Richter scale recently took place one after another in Korea, making the Korean peninsula no longer earthquake safe zone but 'earthquake danger zone'. Characteristics of earthquake is such that it cannot be contained by human means and its place and time cannot be foreseen. Therefore, seismic reinforcement must expand to include current architectures of low seismic resistance in order to prepare for earthquakes of larger scale in the future. Since all architectures of Korea cannot practically reinforced with new seismic design standard, the current seismic design must be revised through various seismic reinforcement methods in consideration of economic feasibility. This study investigated the performance of various seismic reinforcement systems such as X-braced steel rod reinforcement, steel shear wall with circular opening reinforcement, and slit damper reinforcement through shaking table test and computational analyses of domestic and overseas seismic data in order to establish a proper seismic reinforcement plan.

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**Public-Private Partnerships for Roadway Construction and  
Preservation, and Traffic Safety: An Exploratory Empirical  
Analysis of Crash Frequencies**

Public-Private Partnerships (PPP) in transportation infrastructure projects constitute a promising alternative to the traditional approaches where the project is either done in-house or is done by hiring contractors to accomplish specific tasks, depending on the availability of transportation agency's resources. PPP contracts ensure greater private sector participation and responsibility in project delivery. Various contracting approaches have been used over the past couple of decades. This paper seeks to provide new insights into the effectiveness of six different PPP contracting approaches, namely Traditional, Performance-Based-Contracting (PBC), Warranties, Incentives/Disincentives (I/D), Cost-Plus-Time (A+B), Design-Build and its derivatives (DBOM), and Lane rentals from a transportation safety perspective. To that end, the frequency of crashes that occurred during the contract execution period, as well as their influential factors are investigated and compared among the six PPP types. Through this comparison, their safety performance can be assessed and possible safety challenges can be identified. Using data from 645 PPP contracts that were executed across multiple states in the US between 1996 and 2011, statistical models of crash frequency were developed. For model estimation, the correlated random parameters negative binomial and Poisson with heterogeneity in means modeling approach has been employed. Correlated random parameters and heterogeneity in means can account for the effect of unobserved characteristics (i.e., unobserved heterogeneity) on crash frequencies at

multiple levels of statistical estimation. Specifically, the model parameters are allowed to vary across the observations according to pre-specified distributions, whereas the means of the latter distributions are also allowed to vary as a function of exogenous variables. The results show that several contract characteristics (contract cost, duration, size in lane-mile), pavement condition, road geometry (shoulder width, median, intersection), traffic characteristics (AADT, truck percentage), and contract work activities affect the frequency of crashes during the contract execution. Contracts associated with higher cost, shorter duration, fewer lane-miles, more asset work activities, as well as contracts executed at sites with good pavement and drainage conditions and sites with more lanes, curves, and junctions, were all found to result in lower crash frequencies. Overall, Cost-Plus-Time (A+B) and Incentives/Disincentives (I/D) were found to exhibit higher safety performance relative to the other PPP types considered in this study.

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## **A Modified Surface Energy Balance to Soil Evaporation on Partially Wetted Orchards with Drip Irrigation Systems**

A surface energy balance model based on previous multiple-layer model approaches was extended to estimate the crop transpiration and soil evaporation for orchards that are normally partially wetted by drip irrigation systems. Previously, Lagos et al., (2009; 2012) modified and extended the Choudhury and Monteith model (Choudhury and Monteith, (1988)) for partially vegetated surfaces to include the partition of evapotranspiration (ET) into soil/residue evaporation and plant transpiration. However, in this approach, soil evaporation (E) has still not yet been able to discriminate areas that are irrigated and areas that are not wetted by normally used micro-irrigation systems. A previous attempt to include partially wetted soil areas in ET, using the method known as dual crop coefficient and reference ET, was made (Allen et al., (2005)), but to our knowledge, there are no other approaches with which a surface energy balance (SEB) model can discriminate irrigated and non-irrigated areas. Therefore, this research proposes to develop and extend a multiple-layer surface energy balance model, which may be suitable for partially wetted surfaces (SEB-PW), accounting for the effects of soil evaporation on the total ET. The aim of this work is to describe the development of the model and provide a sensitivity analysis of the model parameters and variables. In addition, to preliminarily assess the model performance, simulated ET, E and crop transpiration, the components are compared with measurements of two surface renewal systems and micro-lysimeters at two vineyards sites. The proposed surface energy balance (SEB-PW) model estimates the latent, sensible and soil heat fluxes and has an advantage over conventional methods, as this approach separates the total evapotranspiration into dry and wet soil evaporation and crop transpiration. The model describes the energy balance and flux resistances for the evaporation from dry and wet soil areas below the canopy, evaporation from dry and wet soil areas between rows, crop transpiration and total crop ET. The model development, sensitivity analysis and a preliminary model evaluation are presented. The evaluation shows that



simulated hourly amounts of ET have a good correlation with the surface renewal method and micro-lysimeters measurements from an irrigated vineyard for a range of crop canopy covers. Hourly ET estimations were evaluated, with a root mean square error (RMSE), mean absolute error (MAE), a Nash-Sutcliffe coefficient ( $C_{NS}$ ) and an index of agreement ( $d_a$ ) of  $58.6 \text{ W m}^{-2}$ ,  $35.6 \text{ W m}^{-2}$ , 0.85 and 0.94, respectively. Daily E estimations were evaluated, with an RMSE, MAE,  $C_{NS}$  and  $d_a$  of  $0.27 \text{ mm d}^{-1}$ ,  $0.21 \text{ mm d}^{-1}$ , 0.87 and 0.94, respectively. The daily E estimation has a coefficient of determination ( $r^2$ ) of 0.85, when compared with the micro-lysimeter measurements, and E can reach values from 28 to 46% of the total ET, after an irrigation event. The proposed SEB-PW model may be used to estimate the effect and importance of dry and wet soil evaporation areas in connection with the total ET and may help in water balances studies and the optimization of irrigation management.

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## **High Strength Concrete Tests under Elevated Temperature**

In recent years, application of high strength concrete (HSC) has attracted increasing interest in the construction industry due to its significant economic, architectural, and structural advantages, compared to the conventional normal strength concrete (NSC). However, under fire condition, which is one of the most common hazards that attack building structures, HSC members may be subjected to explosive spalling. Explosive spalling refers to a sudden and violent breaking away of a surface layer of heated concrete. Strength reduction of structural members may occur, leading to severe consequence such as failure of members or even collapse of the whole structure. A newly designed 2-layered cylindrical specimen consisting of an HSC core and an NSC outer layer is proposed. The NSC layer is designed to act as an outer layer insulation to reduce the thermal gradient and also as a lateral confinement to prevent the HSC core from spalling. Compression and thermal tests are performed on the specimens to investigate the strength and behavior under elevated temperature. Test results verify the feasibility of 2-layered specimens and provide insights for the applicability of 2-layered columns in practical construction projects.