



**2017 CSCE Annual Conference
Vancouver, British Columbia**

BOOK OF ABSTRACT



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-005

Bridge Engineering and Construction With Ultra High Performance Concrete

Paul White

Abstract:

This paper will introduce the latest technology in cementitious composites termed ultra high performance concrete (UHPC). UHPC is the result of two decades of research and was introduced into North America in the mid-1990's. Upon introduction in North America, testing began by the United States Federal Agencies interested in its capabilities in exceptional strength and durability. Included is the Army Corp of Engineers who began testing it for durability in a marine environment subjected to immersion in sea water and freeze thaw conditions. The Federal Highway Authority then began testing UHPC in the early 2000's for strength, bonding, fatigue resistance, cyclic loading, freeze thaw, shrinkage, tensile strength, and in the fall of 2014 published the first design guidelines for the design with UHPC. This paper will introduce the components of UHPC, and the engineering and construction with UHPC by show-casing the design and construction of a completed project in the United States. This paper will also present the applications with UHPC as innovative solutions to improving the design, construction, and long term serviceability with reduced life cycle costs.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-007

Investigation of Ideal Time Period for Kinematic Surveys

Carlos Gil Mendoza
Mike Mustafa Berber

Abstract:

Thanks to rapid advancements in technology, nowadays, kinematic GNSS (Global Navigation Satellite System) data processing can also be done using online services. In the not very distant past, many organizations have begun providing online GNSS data processing services. Currently, some of these organizations also provide kinematic data processing option. To take advantage of this option, users only need to specify the mode of processing. Yet, there is not a certain time frame recommended for initialization and occupation time for kinematic surveys. In this study, ideal time period for kinematic surveys are investigated on a GNSS network. The results indicate that one common initialization and occupation time is not possible for all online GNSS data processing services.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-008

Contribution of GLONASS Satellites to GNSS Solutions

Mike Dorsey
Mike Mustafa Berber

Abstract:

Although GLONASS satellite system has been around for a while, the contribution of these satellites to solutions needs further investigation. For this purpose, GPS and GLONASS data collected at five points are analyzed. For the analyses, GPS only, GLONASS only and combined solutions are tested and also the effects of observation period and precise ephemeris are examined. The results indicate that for short observation periods if GPS satellites are not available, inclusion of GLONASS satellites to the solutions may be considered. Otherwise, the contribution of GLONASS satellites to the solutions is questionable for short surveys.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-010

Effect of Type and Content of Warm-Mix Additives on High-Viscosity Asphalt

Xiaoyan Zheng
Tao Ji
Abd El Halim
Said Easa

Abstract:

High-viscosity asphalt (HVA) is a kind of asphalt modified with styrene-butadiene-styrene (SBS), plasticizer, and crosslinker. HVA is widely used in open-graded friction course around the world, especially in China and Japan. Most previous studies have focused on improving the performance of in-service HVA pavements at different temperatures. However, there is a need to ensure that HVA can also perform well at high temperature during construction to improve workability of mixture. The purpose of this study was to use warm-mix additives (WMA) to reduce viscosity during construction and keep acceptable performance at high and low temperatures. To accomplish this objective, an experimental investigation was developed and performed. Three types of warm-mix additives (RH, EC-120, and Sasobit) with three different contents (2%, 3%, and, 4%) were mixed with HVA. An HVA without WMA was used as a control sample. Physical tests were conducted for the control sample and various combinations of WMA types and contents. The physical tests included viscosity (135?), motive viscosity (60?), penetration (25?), softening point, tenacity (25?), toughness (25?), and ductility before and after ageing (thin film oven test). The physical tests were used to establish the feasible region of the combinations of types and contents of WMA that satisfies all specifications. The control and a selected optimal sample within the feasible region were used to conduct rheological tests that included dynamic shear rheometer (DSR) and bending beam rheometer (BBR) to evaluate the rheological performance of HVA with and without WMA. The test results show that the WMA additives have a significant effect on reducing viscosity (135?) of HVA during construction while considerably improving motive viscosity (60?), which is a key parameter to high-temperature performance. In addition, after ageing the softening point and penetration were slightly reduced, and tenacity and toughness were somewhat improved.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-013

A Method to Estimate Turn Movement Percentages Using Approach Volumes and Intersection Characteristics

Alexander Van Hout
Randy Machemehl

Abstract:

When preparing for a roadway construction project, there is often a need to evaluate the impacts of detour routes, lane closures, and other temporary changes to local traffic patterns. This analysis generally needs to be completed in a very short amount of time to keep the construction project on schedule. Microsimulation is a tool that is frequently used to test experimental scenarios and evaluate options for managing work zone traffic flows that would be too complicated or too time consuming to explore with analytical or numerical models. Additionally, microsimulation provides a high level of detail and offers visualizations that would be lost with other modeling techniques. When constructing microsimulation models, turn movement volumes at intersections are necessary inputs. Typically, these volumes are determined by collecting data in the field. However, in a resource-constrained or time-constrained situation turn movement volumes must be estimated. A number of iterative methods exist for reconstructing the most likely intersection turn volumes given only tube counts on the approaches. However, publicly available count data are often taken on different days and may not be of sufficiently high quality to justify the use of these iterative methods. This paper presents a four-step empirically derived procedure for estimating typical intersection turn volumes. This procedure requires only basic arithmetic, is very quick to implement, and will work with data of low quality when it is not practical to collect new data in the field.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-014

A proactive approach to pipeline management: City of Vancouver Case Study

Justin Hebner

Abstract:

A proactive approach in pipeline management includes identification of problematic pipe sections before major failures occur. This provides utilities with financial benefits, whilst keeping the environment, safety and public relations a priority. Pipeline operators have inspection technologies that enable them to determine the condition of their pipeline assets. By combining regular inspections and risk analysis an operator develops an understanding of past events, current events, and what events may happen.

In March 2016, the City of Vancouver (COV) teamed with Pure Technologies to perform a condition assessment and risk analysis on their 30 year old 900/750-millimetre Powell-Clark Feeder Main. Because this water main needed to remain in service during the assessment, the 6,000 meter concrete pipeline was inspected using free-swimming leak detection and electromagnetic technology. Planning for the test included a detailed review of the record drawings; manufacturer information; identifying insertion, extraction, and tracking locations; and contingency planning. The assessment technologies used by COV assist in 1) identifying, localizing, and quantifying the presence of damage in the pipe wall and leaks in individual segments of pipe along the pipeline and 2) providing risk analysis and repair prioritization for pipes identified with damage and leakage. As such, Pure Technologies was able to categorize the structural damage found for COV, allowing them to prioritize its rehabilitation program and allocate funds accordingly. The project demonstrates that by using quantitative data from assessment projects, a customized pipe rehabilitation solution can be built that saves money and resources allowing COV to make more informed decisions regarding the aging infrastructure.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-015

Sensitivity of Transmission Line Towers to Seismic Effects

Rodrigo Freire De Macedo
Lucia Tirca

Abstract:

Steel lattice transmission line towers (TL) are widely used as supporting structures for overhead powerlines. In general, they are designed for conductor weight and environmental loads such as ice and wind. Due to an overall perception that these structures have a relatively low vulnerability to earthquake loads, usually, the earthquakes effects are not considered in design. For instance, the current design standards used in Canada do not require a design check for earthquake loads, although a significant percentage of transmission line infrastructures is located on Western and Eastern Canada where the seismic risk is considered high and moderate-to-high, respectively.

The purpose of this study is to evaluate the sensitivity of TL towers to seismic ground motions. To carry out this task, two guyed towers and two self-supporting towers, designed according to the current standard provisions, are selected. Detailed three-dimensional finite element models of these towers are developed and subjected to nonlinear time-history analysis. Herein, ground motion records are selected to match the earthquake magnitude and geological profile representative for Western Canada. To investigate the behaviour of these towers, the responses in term of axial forces triggered in tower members are compared with those resulted from the standard load cases, typically used in design. From this comparison, it is found that guyed towers are more sensitive to seismic ground motions than self-supporting towers. Furthermore, the seismic load case governs the design of primary members of guyed towers. Meanwhile, the dynamic interaction between the overhead powerlines and their supporting guyed towers is evaluated. This is done by carrying out detailed nonlinear transient simulations of the coupled tower-conductor system for a set of earthquake ground motion records of different frequency contents and by comparing the results of these simulations with the ones carried out for the free-standing towers.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-019

Proposed Passing Collision Warning System for Two-Lane Highways

Udai Hassein
Maksym Diachuk
Said Easa

Abstract:

Passing collisions are one of the most dangerous traffic safety problems. These collisions occur when the driver of the passing vehicle is distracted or does not appropriately assess the situation. This paper provides the framework and algorithm design for a passing collision warning system that assists unprotected passing drivers on two lane highways. The system uses an available radar sensor to detect opposing vehicles travelling in the left lane and calculates their position, speed, and acceleration rates in order to estimate the time to collision and compare it with the time required for the passing vehicle to clear the path. The realistic initial time, passing time, and acceleration models were established using actual experimental field data collected using a Global Positioning System (GPS) data logger device that was installed in passing, impeding, and opposing vehicles and used to record the position and speed of different passing vehicles at 1s intervals. The algorithm considers the time needed for the driver of the passing vehicle to recognize the message displayed by the warning system and react to it. The Matlab Simulink simulator model was used to create the algorithm for the proposed warning system. The simulation model for two lane highways determines the location, speed, and acceleration rate of the opposing vehicle at two different time intervals. The different factors that impact system accuracy were also examined.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-024

The uOttawa Capstone Experience

Alan Perks
Colin Rennie

Abstract:

Capstone projects prepare 4th year civil engineering students to begin their practice with experience in interdisciplinary teamwork, modern business practices, and a better understanding of how civil infrastructure projects are designed under complex social, environmental and economic pressures. The University of Ottawa's Department of Civil Engineering has embraced the practice of innovative, interdisciplinary Capstone projects as the best mechanism for preparing graduating civil engineers for professional and business success. Business and industry collaborators are invited to suggest projects that benefit not only the student teams, but also the business itself in terms of providing useful research, analysis and design reports. The goal is a "win-win" capstone project. Teams of 5-6 students working under the supervision of faculty advisors, over a full academic year, represents a significant benefit to collaborating agencies. This paper outlines Capstone experience gained at uOttawa, including the process, the projects, and the lessons learned in implementing design projects with a variety of collaborators.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-025

Three Important Wind-Resistant Design Lessons From Two Visits to Areas Devastated by One Super Typhoon

Ronwaldo Emmanuel Aquino
Yukio Tamura

Abstract:

Typhoon Haiyan made landfall in the central part of the Philippines on November 8, 2013, and was said to be the strongest tropical cyclone ever recorded as of that time, based on a peak 1-minute sustained wind speed as high as 315 km/h, estimated by the US Joint Typhoon Warning Center. In December 2013, a joint survey team from the Philippine Institute of Civil Engineers (PICE) and the Japan Society of Civil Engineers (JSCE) visited the Haiyan-devastated areas to inspect wind-related damages and to investigate actual storm surge levels. Another team whose formation was initiated by the Japan International Cooperation Agency (JICA) visited the affected areas in January 2014. The first author lead the wind damage survey subgroup of the December 2013 survey team, while the second author was the primary wind engineering specialist on the January 2014 survey team. This paper is intended to be a compilation of lessons learned from the observations during the two surveys, specifically in the field of wind-resistant design of low- to medium-rise buildings and whole communities. The paper groups these lessons learned into three topics. The first is on the forensic determination of peak typhoon wind speed without any direct measurements. The second is on holistic design being good design practice, specifically emphasizing the importance of design and maintenance of components and cladding. The last topic is on the need for more public education on wind-resistant design principles and standards.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-026

Seismic Assessment of Stone Masonry Building Using the Equivalent Frame Model

Hasan Ayouby
Ashutosh Bagchi
Lucia Tirca

Abstract:

In Montreal there are several low-rise stone masonry buildings that were built in the nineteenth century. To preserve their architectural value, the seismic assessment and a retrofit action is required.

To conduct this study applied on heterogeneous structures, all parameters that contribute to the seismic response need to be taken into account. These parameters are: the mechanical properties of stone and mortar materials, their compressive and shear strength, the size and location of openings and the site class at the building location. Further, to study the impact of these parameters on the building response, a simplified numerical method that suits the engineering practice is needed. With the availability of advanced technology, simulation software using experimental test data plays a major role in understanding the behavior of these structures. Hence, the macro-modeling technique using the equivalent frame model (EFM) provides a suitable tool for analyzing this structural system because it allows the use of time-history analysis with low computational burden. In the present work, the EFM model is implemented in SAP2000 by using data from experimental tests results. This method is applied to assess a two-storey stone masonry heritage building located in Montreal on site class C.

This study aims to present a modeling procedure for engineering practice while taking into account the presence of steel beams and steel ties that are added in stone masonry structures built in the nineteenth century.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-030

Stream-flow Forecasting using Wavelet Ensemble Neural Network Models

Bahaa Khalil
Mohammed Elenany
Bahaa Khalil

Abstract:

Streamflow forecasting studies have shown that data-driven models are simpler, faster to develop, and provide more accurate and precise results than physical or numerical-based models. In this study, five data-driven models were examined for the forecasting of streamflow at Athabasca River in Alberta, Canada, for 1 day, 3 days and 7 days ahead lead-times. The five models are multiple linear regression (MLR), artificial neural network (ANN), two models that are based on de-noising the model predictors using the wavelet-transform (W-MLR, W-ANN), and a W-ensemble ANN (W-ENN) model. The total precipitation, and mean air temperature were used as predictors. The ANN models performed better than the MLR models, and both MLR and ANN models performed significantly better after de-noising the predictors using wavelet-transforms. Overall, the W-ENN model performed best for each of the three lead-times. These results highlight the ability of wavelet-transforms to decompose non-stationary data into discrete wavelet-components, highlighting cyclic patterns and trends in the time-series at varying temporal scales, rendering the data readily usable in forecasting. The good performance of the W-ENN model highlights the usefulness of ensemble modeling, and ensuring model robustness along with improved reliability by reducing variance.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-036

The Economic Case for Metro Passenger Rail in Kuwait

Esraa Jamal
Gordon Lovegrove

Abstract:

This presentation evaluates the environmental, economic, and social costs and benefits of a possible future Kuwait Metro Rail (KMR) project using a Social Cost Benefit Analysis (SCBA) methodology. SCBA differs from traditional engineering cost-benefit analyses (CBA). In addition to direct project costs (e.g. construction, running stock, operations, maintenance) and benefits (e.g. revenue) of traditional CBA, SCBA takes a triple-bottom-line sustainability-focused approach that considers other costs and benefits that are indirect and external to those accrued to the project. Costs and benefits over the life of a metro rail system were estimated mainly from the recent Middle Eastern metro rail project in Dubai and discounted to calculate Net Present Value (NPV) as well as Benefit-Cost Ratio (B/C ratio). This research is providing improved data for better-informed decision-making by the Kuwaiti government regarding a possible future Kuwait Metro Rail project value to its community. Also, it sets out a clear, science-based methodology to analysis future investments in other similar projects in the region. Using this recommended methodology, the KMR project was found to have an NPV of greater than \$ 86 Billion, and a BCR greater than 5 to 1, which suggests a strong economic feasibility, even after sensitivity testing to show the robustness of the results. Moreover, risk analysis using Monte Carlo simulation (MCS) revealed that there is no chance of a negative NPV, with a mean greater than \$ 24 Billion. SCBA has been demonstrated as a valuable decision-making tool that can be relied on by the Kuwaiti government and lays an important sustainability-based foundation to be referenced by other Canadian engineers working on Middle Eastern projects.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-038

**Renewable energy technology selection for community energy systems:
A case study for British Columbia**

Hirushie Karunathilake
Kasun Hewage
Rehan Sadiq

Abstract:

Energy system planning is a complex problem, where a number of conflicting priorities need to be considered with regards to energy use, environment and socio-economic impacts, and stakeholder requirements. When selecting the supply sources for a net-zero community energy system, renewable energy (RE) technologies need to be evaluated and compared based on their performance under the above aspects. Multi-attribute decision making (MADM) techniques can be used to compare and select RE alternatives, based on the decision makers' requirements and priorities. In this study, selection of RE technologies for a net-zero community energy system is explored within the context of British Columbia, Canada. Indicators were developed to represent performance criteria for assessing technologies in community energy systems, under technical, economic, environmental, and social categories. Life cycle impact assessment and life cycle cost data were used to estimate the environmental and economic performance indicator values, respectively. Benchmarks defined through critical literature review were used to screen and select the most suitable technologies, filtering out the ones with unsatisfactory performance levels. The performance scores for the RE technologies under the defined indicators on technical, environmental, economic, and social criteria were analysed through fuzzy TOPSIS method. The RE alternatives were thus ranked based on their overall performance under three decision scenarios which reflect different priorities in community-level infrastructure planning. The findings of the study can assist community developers and decision makers in selecting the most suitable energy technologies for net-zero energy systems at community level.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-042

Response of stream temperature to precipitation (a case study of the Chestnut Branch, New Jersey, United States)

Abena Amponsah
Joseph Daraio

Abstract:

Stream temperature is one of the prominent factors that dictates biotic and abiotic processes in a stream. Stream temperature is affected by streamside land use, air temperature, wind speed, solar radiation, groundwater influx, depth and turbidity. With projected rising air temperatures and extremes of precipitation due to climate change, it is anticipated that stream temperatures will rise in the future. Understanding the response of stream temperature to different external variables can provide valuable information for the management and protection of freshwater systems. The aim of this paper is to evaluate the relationship between stream temperature and precipitation for Chestnut Branch, a stream in New Jersey, USA, using a Bayesian learning network (BLN), which is a graphical model that consists of probabilistic connections among factors of interest. The BLN will be contrasted with a regression model, a method most commonly used in environmental research to establish relationships among variables and to predict the response of variables of interest. Stream temperature and meteorological data (precipitation, wind speed, dew point, air temperature and solar radiation) were gathered at 15 minutes intervals for the fall, winter, spring and summer seasons in 2013-2014. The data was analyzed to establish the response between stream temperature and climatic factors using a BLN. The results show that stream temperature decreased during precipitation events. The verification of this relationship can provide insights into methods that can be employed in stream temperature reduction, when projected rises in temperature occur, as part of management techniques that govern small watersheds.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-046

Evaluation & Improvement of Construction Materials Procurement in Developing Countries

Mohamed Abdel-Aziz
Tarek Zaki

Abstract:

Construction materials management is an important and a complex aspect of project planning and control. The supply of materials has a direct impact on the success of the project. This paper presents a study to identify and analyze the common procurement problems facing the Egyptian construction industry and proposing a framework for a model in an attempt to standardize the process. The procurement problems and suggested solutions were collected via semi-structured direct interviews with industry professionals. By analyzing and ranking the data, the common procurement problems and their suggested solutions were identified. A framework for a model was developed using an expert system process chart to model the procurement processes based on the logic obtained from expert recommendations. The framework also incorporates a supplier selection module which uses the Analytical Hierarchical Process (AHP) method in the supplier selection which was validated with a hypothetical case study. Results show that the procurement process is systematic and developing a framework for a system could be a head start for companies to develop their own software to improve the overall efficiency of the process. This paper attempts to create a road map for a contractor to follow to standardize and create an overall integrated system with assigned responsibilities for the procurement process. Procurement plans are not enough for monitoring and controlling the process, firms should work on employing material information systems that integrate all aspects related to material management.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-049

Exploring Fusing Wearables and Mobile Technologies to Optimize Energy Demand and Occupant Comfort

Moatassem Abdallah
Caroline Clevenger
Tam Vu

Abstract:

This research investigates a system capable of measuring and simulating occupant thermal comfort using mobile and wearable devices to adaptively control indoor environmental conditions to minimize energy and maximize comfort using smart-building technologies. Such research suggests a ground-breaking technical solution that provides new inputs for energy management and information systems using novel occupant-centered building sensor hardware-software methods and a set of custom metrics to evaluate thermal comfort of building occupants by fusing traditional human vital and physiological data streams. Recent technologies of wearable devices such as wristband devices are now able to capture a number of important and relevant parameters. To date, the team has successfully used ambient air temperature, relative humidity, skin temperature, perspiration rate, and heart rate, to explore new algorithms capable of assessing, in real-time, individual thermal comfort in buildings. The outcome is transformative as the potential of the proposed cost effective and unobtrusive system is to generate calibrated and adaptive assessment of individual thermal comfort based on actual occupant and spatial data. Broader impacts seek to collect and leverage big data regarding a range of individual behaviors and physiological signals within buildings.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-051

Crystal to Iqaluit – 75 Years of Planning Engineering and Building

Kenneth Johnson

Abstract:

The City of Iqaluit is amongst a unique group of Canadian communities that originated entirely from a military presence, and not from some commercial venture, such as a trading post. From its origin as an airbase, Crystall II, then Frobisher Bay (1964), and finally Iqaluit (1987) has experienced 75 years of transformation and adaptation. Its modern origins began in July 1941, a United States Army Air Forces team investigated the Frobisher Bay region for a potential airfield as part of a great circle route to Europe. A non military direction for the community came with John Diefenbaker's 1958 election announcement of his Northern Vision. In March 1958 a speech by government regarding a grand vision for Frobisher Bay (Iqaluit), but the grand vision came and went when Diefenbaker lost power in 1962. Further community planning was completed in the years that followed, and these concepts were more realistic in the reflection of the climate, and terrain of the community. In 1963 the remaining military forces left, creating a Canadian government center and a community in the eastern arctic. Within the community itself, a central area became the community focus along with several residential areas. The community's infrastructure included a piped water and sewer system. In the mid 1980's planning occurred for a new expansion to the community which would be substantially served with a piped system that employed a buried system of insulated plastic pipe and steel manholes. In the approach to the creation of the Nunavut territory in 1999, the Town of Iqaluit had to fight for the right to be the territorial capital, competing against other regional centres. As much as Iqaluit is a "big city" in the context of the Nunavut Territory, the community remains an arctic community at heart on the edge of a frontier.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-052

Ode to the Road – the Alaska Highway at 75 Years Old

Kenneth Johnson
Alistair MacKenzie

Abstract:

The completion of the Alaska highway occurred 75 years ago, and the project remains an engineering milestone in the far north. When World War Two broke out in Europe in 1939, and the United States chose not to provide any direct aid to the Allies, however, British covert operations were in full operation within America. Nazi Germany developed battle plans to invade, and conquer Russia for its resources, and then shift its focus on the conquest of the British Isles. With this knowledge Britain and the United States knew that support to Russia was an absolute military necessity in order to eventually defeat Nazi Germany. The supply of materials and equipment to defend Russia was organized through a number of routes. The shortest and fastest route for delivery of planes was a polar route from the United States, through Canada, Alaska, and Siberia. Upon the invasion of Russia by Nazi Germany, the work began to upgrade this local supply route into the Northwest Staging Route. The Route had two major functions during the second world war. Firstly, it was a significant factor in the route location for the Alaska Highway, and it was very useful in the highway construction. Secondly, the airfields were used to ferry planes to Fairbanks to be picked up by Russian crews. Six months before the invasion of Pearl Harbour by the Japanese Imperial Navy, Americans were in northern British Columbia readying for the eventual activity associated with the Alaska Highway. However, at the time the American people were still not in favour of entering the war, and it was not until the Pearl Harbour attack that the resources were applied to the 9 month construction of “the road”.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-054

Kimmirut, Nunavut - Wastewater Planning Study

Kenneth Johnson
Sarah Ali

Abstract:

Kimmirut is an Arctic community of 489 people at the south end of Baffin Island in Territory of Nunavut. The existing wastewater treatment system used by the community is a trench discharge that drains over a steep embankment, followed by a gradual drop through vegetation to the ocean. Some treatment is achieved through this discharge, although it may be limited to preliminary treatment only. From a regulatory perspective the existing system is unacceptable, and therefore the Government of Nunavut initiated a wastewater planning study to identify potential sites and potential processes to improve the quality of the wastewater discharge. A broad range of wastewater treatment processes were considered, including a mechanical treatment system, and these processes were applied to sites selected from an initial area analysis. This analysis culminated in the selection of 12 sites that were analyzed to develop conceptual treatment configurations; the analysis included site reconnaissance where possible. Independent fisheries, wetland, and geotechnical reviews were also completed to provide additional information for the analysis and advancement of options that could develop from any of the 12 selected sites. Based upon a decision analysis of the 12 sites, a retention lagoon system emerged as the best rated option to pursue for the community. It was recommended that this this option should be incrementally advanced to implementation. The incremental steps should include consultation with the community and the regulatory community, reconfiguration of the concept, final acceptance of the concept, consultation during the engineering process, and finally tendering and construction.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-055

Pump Stations Condition Assessment and Rehabilitation Plan in Edmonton

Sid Lodewyk
Luke Kurach
Hongliang Wang

Abstract:

The City of Edmonton Drainage Services Branch operates the Sanitary Utility (collection and transmission of wastewater) and the Land Drainage Utility (collection and transmission of stormwater). The sewer collection and conveyance systems are extensive, valuable, and complex systems that consist of pipelines, outfalls, pumping stations, forcemains, stormwater management facilities, and other facilities. Pump stations are important assets that provide conveyance service to city's neighbourhoods. The city of Edmonton currently has 88 pump stations including 64 sanitary pump stations, 3 combined stations, 13 storm stations and 4 dual stations (i.e. Both sanitary and storm stations are in the same building). More than 70% of pump stations are older than 20 years. Aging of the pump stations and growing risk for deterioration, leaking and odour issues is inevitable. Maintaining an acceptable level of environmental protection and service requires rehabilitation of the pump stations on an on-going basis. In order to meet the requirement, an assessment tool has been developed and used for condition assessment of pump stations. The tool is a risk-based approach considering both the likelihood and consequence of asset failure. 88 pump stations were assessed in this study. The results show that 93% of the pump stations are in good or fair condition. Based on the prioritization list, a rehabilitation plan has been developed for future years. The assessment provides the best information for determining and prioritizing pump stations rehabilitation needs..



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-056

Sustainable Rehabilitation and Upgrade to Underground Telecommunication Structures

Wamid Shamon
Dan Kornblum

Abstract:

Underground telecommunication structures (UTS) are considered to be a substantial component of public infrastructure and therefore have become an essential part in any scheme that involves the design/construction of new infrastructure projects or the rehabilitation, upgrading, and/or renewal of existing infrastructure including relocation of any adversely impacted UTS to comply and accommodate specific project requirements. The existence of UTS is as old as the infrastructure containing or housing them, such as roadways, bridges, tunnels, culverts, waterways, railways, etc. and in some cases even older than the infrastructure (e.g. road widening encroaching existing UTS).

An aged underground telecommunication structure means old material in varying states of deterioration, and non-compliance with current standards/requirements. This in turn means a potential interruption in the provided services and a potential hazard to the structures and the housing infrastructure. Therefore, any rehabilitation or addition to the main housing structure should include rehabilitation and upgrade of the UTS contained therein. Building a resilient underground telecommunication structure provides a safe haven for the telecommunication industry which is becoming vital for the development of information technology and social communication that urban centers, with a growing spread to sub-urban and rural communities, should be equipped with, especially under the pressure of the rapid community expansions underway supported by the high volume housing industry. Upgrades to existing UTS in older urban areas carry another set of challenges both in design and construction where congestion of existing utilities and road allowances impose major constraints to any rehabilitation project.

This paper provides an overview of the types of UTS, some methods, and processes required to investigate and assess the conditions of existing UTS as well as determine recommendations on rehabilitation approaches.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-057

Improving Disaster Resilience of Power Distribution Network Using Photogrammetry Technology

Mahdi Safa
Seokyon Hwang
Berna Tokgoz

Abstract:

The resilience approach continuously investigates the competence of a system to anticipate and absorb threats. The vast and vital infrastructures are highly vulnerable to various natural disasters while the threats of adversarial natural disasters are rapidly growing. For instance, the frequency of extreme, wind-related events (e.g. hurricanes, tornados, and storms) have increased over the last twenty years. Electric power distribution system, as a critical infrastructure, is extremely liable to wind-related disasters. This study introduces a methodology to facilitate the preparation and mitigation action in order to improve resilience in electric power distribution system. Developing and implementing such a methodology in the power distribution infrastructure sector can result in tremendous productivity improvements and, operation cost and schedule savings. The main contribution of this research to the body of knowledge is developing a methodology to increase the resilience of electric power distribution networks. The proposed model has a potential to radically increase accuracy and rapidity of the assessment of resilience of this critical infrastructure by utilizing the state-of-the-art technology: photogrammetry. The proposed methodology also has a potential to mitigate existing vulnerabilities of the power distribution infrastructure by precise monitoring the health of the power distribution facilities.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-058

Designing for Post-Disaster Resilience with Thermo-Active Radiant Air Conditioning Systems

Jack Laken
Brian Hall

Abstract:

Climate change is a reality in today's world. We are experiencing an increase in frequency and intensity of extreme weather conditions - heavier rainfall, draught, extreme heat and cold as well as unique events such as ice storms and floods. With these events, governments, cities and even insurance companies are seeing significant impacts on the built environment, particularly buildings. "Extreme weather has the ability to affect short and long-term macroeconomic statistics, as evidenced: it can add or subtract 110,000 jobs from monthly North American employment - It is now the single most-watched economic statistic in the world, and generally thought to be one of the most accurate" Kenneth Rogoff, Professor of Economics and Public Policy at Harvard University. Agencies and businesses need strategies to cope with these (now) more common extreme events. One often overlooked functional attribute of a building is the ability to provide a level of habitation and operability after an extreme weather event that will allow businesses and people to continue to function without loss of employment. This paper discusses a technology that enables a building to have 'business as usual' operation in cases where extreme weather events can result in significant long term power outages. Specific to resilient design and healthy buildings is the philosophy of thermal storage using thermo-active, hollowcore precast radiant air conditioning systems that ensure a building will maintain air quality and temperature and continue to be habitable during and after extreme weather events - A post-disaster resilience strategy in the age of climate change that ensures economic viability of businesses and cities.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-059

APEGBC's Professional Practice Guidelines on Developing Climate Change Resilient Designs for Highway Infrastructure in British Columbia

Harshan Radhakrishnan
Glen Zachary
Michael MacLatchy,

Abstract:

The Association of Professional Engineers and Geoscientists of British Columbia (APEGBC) has developed professional practice guidelines that provide practice guidance and case studies to support engineers in addressing climate change and extreme weather event factors in the designs for BC Ministry of Transportation and Infrastructure (BCMoTI) owned provincial highway infrastructure. These guidelines are developed in response to the BCMoTI Technical Circular (T-06/15), which requires infrastructure design adaptation to climate change including documentation for BCMoTI projects. Highway designs already consider climatic factors, but extreme weather resiliency and climate change adaptation are being increasingly considered by professionals, based on the guidance provided by frameworks established by Engineers Canada and the American Society of Civil Engineers. These guidelines showcase the climate science as it relates to the practice of professional engineering and aims to spark a paradigm shift in engineering by supporting the development of designs based on a comprehensive climate vulnerability risk assessment and consideration of innovative approaches that include robust, flexible and low or no regret designs.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-062

Integrating Concepts and Principles from Lean Thinking and the Design for X to BIM.

Mathieu Fokwa Soh
Sylvie Doré
Daniel Forgues

Abstract:

The construction industry is gradually integrating BIM (Building Information Modeling), without taking full advantage of the benefits that it can bring to the collaboration between the different stages and actors of a project, for example between the design and realization stages (Nawi et al., 2014). Also, Koskela (2000), one of the pioneers of Lean construction, proposes the use of the TFV theory (*Transformation-Flow-Value theory*), as an effective approach to the management of production in construction projects, without formalizing the link between design and construction phases. Yet, the lack of collaboration between these two phases causes lot of rework, lot of waste of time and material, and, according to Forbes and Ahmed (2010), millions of US dollars in loss each year in USA. However, in the manufacturing industry, the collaboration between design and production teams is well established and formalized through different methods and design rules, such as Design for Manufacturing and Assembly (Boothroyd, 1994). These rules guide the work of the designers who act upstream of the manufacturing of parts and of their assembly, in order to guide design decisions that promote a reduction of time and cost, while increasing the quality of products. The main objective of this presentation is to highlight the links between *BIM*, *Lean construction* and *design rules*, through a new concept that we will call *design for TFV*. This concept may become a major step in the progressive integration of design rules within the construction industry.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-063

An Examination of Competition on Traditional and Design-Build Highway Construction Projects

Douglas Alleman
Scott Stanford
Arthur Antoine
Kelly Sheeran
Keith Molenaar

Abstract:

With the rise of alternative delivery methods and best-value selection, owners are no longer bound to choose the lowest bid. Thus, previous assumptions about maximizing competition to achieve the lowest possible price need to be re-evaluated. Likewise, owners reviewing lengthy technical proposals must consider their administrative burden and whether greater competition is always advantageous. Previous studies have used neoclassical economic theory to suggest the industry offers “perfect competition” and that more competition typically results in lower bid prices. Additionally, most public sector procurement policies were traditionally designed to maximize competition to ensure a fair price. However, most of these studies were conducted in a design-bid-build, low-bid scenario where maximizing the number of sealed bids was generally seen as advantageous for the owner. The purpose of this study is to examine the relationship between delivery methods, competition, and bid prices in the context of U.S. transportation projects. The study includes an empirical analysis of 99 design-bid-build projects and 90 design-build projects from across the U.S. The results confirm that an increased number of bidders correlates with lower award growth (i.e., bid price vs. owner’s estimate) for design-bid-build projects, as well as design-build projects procured by low bid. For design-build projects procured by best-value, bid prices do not appear to benefit from receiving more than four bids. This study contributes to the body of knowledge on delivery methods and on the role of competition in the construction industry. It also has implications for policy makers on how to balance the need for competition and fair price with flexibility required to achieve best value. Furthermore, the study will help inform practitioners on determining an optimum range of bidders under different delivery methods.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-064

Design of a Landmark Cable-stayed Bridge and a Conventional Steel Box Girder Bridge Alternative for Cost Analysis

Rashad Jabr
Philip Bou Doumit
Mina Agaybi
Rouyan Shafiei
Marina Riad
S. Salib
K. Sennah

Abstract:

This paper proposes three designs of a two-span bridge in Greater Toronto Area (GTA) as part of the capstone project course in the fourth year of an undergraduate program. The first bridge configuration is a cable-stayed bridge, while the second and the third bridge configuration are of conventional bridge types such as composite slab-over steel I-girder and box-girder superstructures, respectively. All three bridges were proposed to be built with semi-integral concept at their end supports over abutments. Unlike conventional bridges, an elegant cables-tower assembly along with a decking structure supports a cable-stayed bridge. Such hybrid system allows for shallow decks and multiple load paths/structural redundancy. Further, by utilizing high corrosion resistance materials, e.g. galvanized stay cables, the bridge can undergo minimal repairs throughout its expected life span which signifies its durability/sustainability. Yet, these types of bridges are relatively expensive and various challenges are associated with their design/construction due to the complexity of the structure geometry, unique behaviour and sophisticated construction staging. Therefore, a detailed structural analysis of the cable-stayed bridge was carried out through a finite element modelling (FEM) process that represents the sequence of construction including the cables pre-tensioning phase. Meantime, the other two alternative bridge configurations were analysed per the simplified method of analysis specified in the 2014 version of the Canadian Highway Bridge Design Code. The conducted cost analysis showed the slab-over-steel I-girder bridge system to provide the least construction cost, followed by the slab-over-steel box-girder bridges. However, the increase in cost of the cable-stayed bridge, by about 23%, can be justified given its superior aesthetics which fits the selection criterion of the desired landmark structure.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-069

Low Impact Development Practices for Stormwater Management for Road Reconstructions in Southern Ontario

Matthew Senior
Ron Scheckenberger
Neal Smith
Jason Stahl

Abstract:

Roadway reconstruction projects are one of the most common infrastructure projects in the public sector. These projects often involve a renewal of aging, failing infrastructure, or can be the result of local development pressures which requires a widening of the existing roadway. In all roadway reconstruction projects, stormwater management (SWM) is a key consideration. At a minimum, regulatory authorities typically expect the control of runoff (peak flows) to pre-reconstruction values, as well as water quality treatment of any new paved areas. Increasingly however, regulatory authorities are requiring more stringent SWM controls for reconstruction projects, including requirements for the promotion of on-site retention and infiltration of stormwater runoff (volume controls and water quality). Low Impact Development Best Management Practices (LID BMPs) refer to a suite of SWM controls which promote at-source management of stormwater, and focus on the use of retention, infiltration, and filtration of runoff. LID BMPs are being used increasingly for road reconstruction projects to address the requirements of regulatory authorities, and to promote a more sustainable, resilient, and often more cost-effective solution to SWM requirements. The suite of different LID BMPs provides a variety of options for designers to account for the specific opportunities and constraints of the site in question. Recent road reconstruction projects in various Southern Ontario municipalities are presented as examples. Successful applications of LID BMPs are demonstrated, including innovative approaches. Challenging applications, including high density development areas and areas with relatively impermeable soils and high groundwater levels, are also presented. The differing perspectives of stakeholders are considered, including municipalities (engineering and operations and maintenance groups), regulatory authorities, and designers.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-070

Stadium Vibration Assessment for Serviceability Considering the Vibration Duration

Ngoan Do
Mustafa Gul
Osama Abdeljaber
Onur Avci

Abstract:

Vibration problems in grandstand structures have been getting more attention due to the increasing slenderness of the architectural components and the complexity of the crowd loading for structural designers. The vibration serviceability checks under these conditions becomes a challenge in the design and operation stages. Regarding human comfort and tolerance to vibration, excessive vibrations due to occupant activities may affect their comfort or even cause panic, especially passive occupants who do not participate in generating the source of vibrations. Although durations of excessive vibrations have been proved as one of the most important factors affecting occupants' comfort, it remains a big challenge to be solved. In addition, the currently available approaches using raw acceleration, weighted RMS acceleration, Vibration dose values (VDV), etc. are not sufficient for serviceability assessment due to the lack of detailed guidance for obtaining the integration time and taking the duration of vibration into account. Therefore, in this current study, a new parameter and framework are proposed where the duration of vibration is incorporated with conventional data processing. The aim is to better examine vibration levels of structures and the corresponding likely reactions with an emphasis on grandstand structures. The experimental study shows that the proposed framework can successfully address the impact of duration time on determining the levels of vibrations and human comfort levels using the proposed parameter, and perception ranges.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-071

System Dynamics Model for the Valuation Real Options in Public-private Partnerships

Gregory Fitch
Ibrahim Odeh

Abstract:

Public-private partnerships are increasingly being sought for infrastructure procurement because of their ability to alleviate government budgets, promote innovation and implement new technologies. Public-private partnerships, however, tend to be long-term and often need to account for future yet-to-be seen variables that potentially impact the feasibility of this procurement method. This is especially true when the public-private partnership exists within a portfolio of competing assets across transportation infrastructure systems. The current research presents a system dynamics model that is used to analyze the complexity of a transportation infrastructure asset procured through a public-private partnership within such a portfolio. An illustrative case demonstrates how discreet and continuous events can potentially impact the successful procurement of infrastructure within a portfolio of competing assets comprising a regional transportation system. This paper contributes to the existing body of knowledge by showing how a system dynamics model can simulate the real world causal relationships that impact the procurement process of infrastructure within a public-private partnership. The simulation results from the system dynamics model are then used for the valuation of real options that enhance the feasibility and economic sustainability of infrastructure during the contract term of the public-private partnership.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-072

Using Eye Tracking Technology to Evaluate Focal Attention and its Affect on Hazard Recognition

Dylan Hardison
Matthew Sears
Matthew Hallowell
Paul Goodrum

Abstract:

Recent evidence indicates that construction workers fail to recognize many safety hazards that arise during construction activities. Previous research has focused hazard recognition skill but has not examined if the proportion of hazards *viewed* correlates with hazard recognition *performance*. To study this topic 18 subjects were fitted with mobile binocular eye tracking glasses, presented with a random sequence of three photographs of construction work spaces, and asked to recognize all of the safety hazards present in each photograph. Voice narrations and eye tracking data were collected as participants identified hazards and were used to compare the proportion of hazards viewed with the proportion of identified safety hazards. The results reveal that there is no correlation between the proportion of fixations on hazards and hazard recognition despite assumptions made in previous research. This study departs from the current body of knowledge by providing a metric to evaluate locational attentional fixation data and attempts to recognize the optimum proportion of focused and distributed attention for obtaining an appropriate level of situational awareness necessary for complex hazard recognition tasks.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-080

A Sensor Clustering based Damage Detection Framework for Structural Health Monitoring of Railway Bridges Using Bridge Acceleration Response

Md Riasat Azim
Mustafa Gul

Abstract:

Bridges are critical components of the railway infrastructure system and the majority of these bridges are approaching their estimated design life. It is paramount that; these systems are maintained effectively. Amid the previous few decades, the demands on the bridges have been increasing both in terms of axle loads and operational frequency. Therefore, crafting powerful Structural Health Monitoring (SHM) systems for railroad infrastructure is relied upon to help the proprietors with their decision-making policies. Hence, developing damage investigation strategies specifically tailored for railroad bridges is the principle goal of this on-going study.

In this paper, we present our preliminary findings to build up a damage identification framework based on acceleration measurements for railroad bridges. It is demonstrated that the proposed methodology offers a robust damage assessment approach. Initially, a Finite Element Model (FEM) of a railway bridge is developed. The model is then utilized to conduct numerical studies and gather acceleration response under moving train for both baseline and damaged conditions. This info is then further scrutinized by a sensor clustering based damage identification technique using time-series modeling. The damage in the bridge is investigated by observing the damage features of the damaged and undamaged bridge. The investigation demonstrates the damage features by comparing the fit ratios of locations of interest so that damage could be identified and located. The relative severity of the damage can also be assessed by observing the magnitude of the changes in the damage features. The types of damage considered in this paper are stiffness reduction in a member or connection and change in global boundary conditions (i.e., support).

Assessing the condition of our railway bridges continuously in this manner and early detection of potential structural changes are deemed very valuable for the infrastructure owners for developing more economical and effective maintenance strategies.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-081

The Effects of Spatial Cognition on Individual Wayfinding Performance

Sara Al-Haddad
Antoine Verghote
Paul Goodrum

Abstract:

An experiment was conducted to analyze the effects of different information formats and spatial cognition on individual wayfinding in unknown environments. Participants were asked to memorize either a set of 2D drawings or a three-dimensional (3D) model before navigating through a series of checkpoints in an unfamiliar environment. Individual wayfinding is dependent on an individual's use of route knowledge or survey knowledge. Route knowledge was assessed from the start of the route to Checkpoint A (i.e. the first checkpoint). Meanwhile, survey knowledge was assessed from Checkpoint A to Checkpoint B. Spatial cognition of participants was measured by administering the card rotation and cube comparison tests. The research found that 3D models have a beneficial impact on the success of individual wayfinding. Furthermore, the success rate of the participants with low spatial cognition improved significantly when using a 3D model rather than a set of 2D drawings. However, the success rates of participants with high spatial cognition was not affected by the information format. This research will aid in understanding the relationship of cognitive spatial abilities, task performance, and information displays on people with demanding and stressful jobs, such as first responders and construction workers. Further research, with a larger sample size and longer route, is required to confirm the results concluded in the study. Additionally, research suggests that realistic rendering and color might have a beneficial effect on decreasing workload memory when navigating through a space.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-085

Innovative solution for sustainable road construction

Meisam Norouzi
Sanat Pokharel
Derek Breault
Marc Breault

Abstract:

Economic development remained the only goal until the impact of development on the environment and society started to show up. The other two pillars of sustainability, environmental and societal factors, came into picture after the fact. The Brundtland commission's definition of sustainable development as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs was therefore a timely intervention. In the recent years Kyoto and Paris Summits have put even more emphasis on sustainable development.

Construction Sustainability is one of the major constituent of sustainable development. Unlike the environmental and societal impacts, economic impact of a development project can be easily quantified as the benefits are tangible. CO₂ emission is now accepted as one of the quantifiable environmental factor that is seen as a measure of project sustainability. Construction will continue to happen to meet the development needs but going forward sustainability would dictate its methods. Heavy road construction activities are a large contributor to CO₂ emission. The conventional construction practice focuses mainly on structural strength of roads for the expected traffic conditions rather than the impact of the development in sustainability terms. This paper discusses an innovative method utilizing nano-polymeric alloy Geocell that reinforce the road structure to provide the same structural capacity while reducing the amount of virgin construction material and activity required to build the roads which in turn will result in less CO₂ emission. Sustainable alternative design option is discussed with one of the recently completed projects in Alberta for CO₂ emission during the life cycle of the road structure compared with the conventional method. It is illustrated in detail how using an innovative Geocell design saved up to 40% of CO₂ emission during the life cycle of a road infrastructure.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-088

A Proposed Sandbag Housing Unit for Poor and Disadvantaged Areas

Ahmed Shaker
Habiba Abdullah
Mahmoud Abo El Ghait
Mostafa Nassar
Yara Mahmoud
Ahmed Hamza
Eman El Nahas
Amr Fathy
Ezzat Fahmy
Mohamed Abou-Zeid

Abstract:

Providing adequate shelters particularly for the poor in developing countries is a challenging matter. Egypt, as an example, has an estimated 11.8 million living in slums this lead us to come with a solution to construct a low-cost housing model that can be easily constructed. This study aims at providing a prototype for a one-room shelter using sandbags. Waste sand bags of two types were filled with various contents of sand, as a parameter, and used to construct a 10 m² shelters. Two types of roofing were proposed: one with arched bags of different dimensions while the other was a flat roof with polymeric sheet and wooden purling. An actual physical model was built on site which was useful to carry out a small-scale feasibility study in order to assess the economic merits of the proposed shelter considering materials cost, workmanship, rate of production and the use of land, environmental merits among others.

The study reveals that such prototype has a good potential in slum areas in the vicinity of desert areas where sand is in abundance and waste materials and landfills are within short distances. Future work including pilot models in the slums is highly recommended.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-089

Spatio-Parametric Rail Risk Assessment for Developments Near Freight Rail

Nadia Porter
Jesse Kostelyk
Joyce Tang
Chris Wolf

Abstract:

Railway operations are a backbone of the Canadian economy. Over the last decade, Canada has experienced an increase both in rail traffic and in the transportation of Dangerous Goods by rail. Due to recent catastrophic events affecting communities adjacent to railways, railway operations in Canada have been subject to increased scrutiny and public awareness, particularly in those areas that are close to urban developments. This increased awareness has led to changes in policy and guidelines for developments in proximity to railway operations. Legislation changes making railway data more accessible to the public have made more customized analysis of the risk of railway operations to adjacent developments possible, yet there are few methodologies available to guide industry in making these assessments. This paper describes a Spatio-Parametric Approach to Rail Risk (SPARR) model that integrates research on rail safety best practices precedents from around the world, input from stakeholders, multiple-substance explosion modeling, failure analysis, and Monte Carlo simulation with site-specific data and geometry. A case study is presented to demonstrate the proposed risk quantification method. The results of the risk assessment show how this comprehensive model can assess the risks to the public along a rail corridor and aid policy-making and industry stakeholders in optimizing development and designs and establishing flexible response strategies.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-090

Mitigation of Erosion Impacts from 30 Avenue Storm Sewer Overflow to Whitemud Creek

Christopher Jones
Arjun Aryal
C. Beth Robertson
Eugene Yaremko
Nallamuthu Rajaratnam
Greg Tippett

Abstract:

The 30th Avenue storm trunk collects storm runoff from a 5,200 ha basin in South Edmonton and conveys runoff to the North Saskatchewan River. The storm trunk is 5,100 mm in diameter except for twin 1,950 mm pipes under Whitemud Creek. The reduction in flow area from 20 m² to 6 m² causes a significant bottleneck. Before 2004, the manhole located adjacent to the creek was capped with concrete. A severe storm in July 2004 broke the concrete cap and caused overflow into the creek and significant damage to the banks of Whitemud Creek adjacent to the overflow manhole. After this storm, the City installed a steel grate on the manhole and rip rap along the creek banks to permit overflows to occur, hopefully without damaging the creek banks. However, overflow events during heavy rain in 2012 and 2016 caused similar damage and release of sediment into the creek. The City is now tasked with rectifying this recurring issue.

The City has investigated many options to address the overflow problems, including elimination of the bottleneck using a new storm tunnel under the creek to constructing a properly designed overflow channel to accommodate the flows. Computer modeling and other assessments were conducted to understand the hydraulics of the bottleneck location, estimate the overflow rates and assess the downstream impacts of the overflows on Whitemud Creek. The decision was made to construct a properly designed overflow channel to safely convey overflow stormwater into the creek.

This paper will focus on the options considered, the hydraulic modeling (1D and 2D) to assess the impact of the overflow on Whitemud Creek and design of the overflow channel. Public consultation and safety will also be addressed, as Whitemud Creek Ravine is popular among recreationalists and there are properties located along the top of the ravine.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-091

Life Cycle Sustainability Assessment of Water and Wastewater Infrastructure Systems

Hamed Mohammadifardi
Mark Knight
Andre Unger

Abstract:

The development of reliable, rational, and defensible renovation plans for water and wastewater systems requires a better understanding of the interrelated behavior of social, environmental, and economic systems, while ensuring compliance with existing and changing regulatory policies such as the Ontario 2010 Water Opportunities and Water Conservation Act (WOWCA, 2010), which requires water utilities to prepare long-term plans (10 plus years) for financial self-sustainability, or the Green Energy Act of 2009 (GEA, 2009), which calls public agencies, including municipalities, to prepare an energy conservation and efficiency strategy when planning their capital investments. Complying with these different requirements calls for comprehensive sustainability assessment that integrates social, environmental, and economic dimensions. The focus of this study is to discuss the implementation of sustainability assessment into a working system dynamics model that incorporates an environmental life cycle assessment perspective to appropriately consider the full spectrum of sustainability aspects (social, environmental, and economic). Scenarios are presented as alternative management strategies to discuss the utility/importance of considering environmental impact in the decision-making process. The strategic decisions are ranked based on their benefits to utilities, consumers, and the environment. Results of the applied models are discussed and conclusions are drawn.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-095

Seismic Displacement Demand Estimation for Fragility Assessment of Reinforced Concrete Frame Buildings

Ahmad Abo-El-Ezz
Marie-José Nollet
Guillaume Limousin

Abstract:

The seismic risk assessment process is central to planning mitigation, preparedness and emergency response measures in earthquake prone regions. Seismic risk assessment at regional scales involves seismic hazard, inventory of assets at risk and respective vulnerability. Vulnerability refers to the susceptibility to earthquake impacts defined by the potential physical damage and resulting economic and social losses. Central to the vulnerability modelling is the concept of a fragility function that correlates the expected structural damage to increasing levels of seismic intensity. Fragility functions combine a probabilistic seismic demand model and a probabilistic damage model. The probabilistic seismic demand model correlates a seismic intensity measure (IM) such as the spectral acceleration at the fundamental period of the building, $S_a(T_1)$, to an engineering demand parameter (EDP) that better correlates with damage such as the maximum inter-story drift. The probabilistic damage model correlates the EDP to threshold damage states (e.g. slight, moderate, extensive, and complete). This paper presents the development of a new simplified probabilistic seismic demand model applicable for fragility analysis of ductile medium and high rise reinforced concrete moment resisting frame buildings (RC-MRF). The model provides a direct correlation between the maximum inter-story drift to the $S_a(T_1)$ using a new period dependent displacement coefficient. A database was compiled from literature sources of maximum inter-story drift seismic demand predictions using nonlinear finite element models for ductile RC-MRF that were subjected to increasing levels of ground motion intensities. The model was applied to develop fragility functions for a case study ductile 18 story high-rise RC-MRF building that conforms to the provisions of the 2005 National Building Code of Canada.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-098

Assessment of Post-Earthquake Functionality of Acceleration-Sensitive Systems in Hospitals

Ahmad Abo-El-Ezz
Youance Suze
Marie-José Nollet,
Ghyslaine McClure,
Rola Assi

Abstract:

As critical infrastructures, hospitals are key components for community post-earthquake emergency response and need to be functional immediately after an earthquake event. Their functionality is highly correlated to the performance of their acceleration-sensitive operational and functional systems such as the mechanical and electrical systems for medical air, fire protection, heating-ventilation-air conditioning (HVAC) and water distribution. These systems are susceptible to damage from amplified earthquake-induced floor accelerations. The non-functionality of these systems typically results in the disruption of the normal operation of the hospital which can lead to evacuation even without significant damage to the building structural system. The quantitative evaluation of the post-earthquake functionality based on the concept of fragility functions of these systems is essential for informed-decisions related to mitigation planning. A fragility function represents a relationship between a seismic intensity measure (e.g. peak ground acceleration) and the probability of non-functionality of the system. This paper presents a methodology for the development of fragility functions for functionality assessment of acceleration-sensitive systems in hospitals. For a specific system (e.g. fire protection), the system-level fragility function is developed based on a logic-tree analysis of the probability of failure of system components (e.g. pumps, pipes, sprinklers) in order to estimate the probability of the system non-functionality (e.g. probability that the fire protection system is non-functional given a specific seismic intensity). Peak floor acceleration is used as the demand parameter for the estimation of failure probability of the system components. The methodology is demonstrated by an example application to develop fire-protection system fragility function for a case study seven story hospital in Montreal, Quebec. The methodology is particularly useful for hospital stakeholders for informed decisions to enhance post-earthquake hospital functionality.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-099

Unleashing the Cost Savings of Optimized Road Asset Management to Municipalities

Michael Maher
Roozbeh Rashedi

Abstract:

There is a belief within the municipal sector that we will eventually solve the infrastructure deficit and bring all our roads up to an acceptable standard. This is unlikely to happen. However, in the meantime municipal expenditures on road rehabilitation continues to be largely based on a “worst first” approach, where the most deteriorated roads, which require total reconstruction, are prioritized at the expense of preservation.

Road preservation treatments are not ‘second class’ options but an essential component of a well-managed road network. Our municipal roads are generally very well built from a structural perspective. This is because in Canada we need to include thick granular layers to mitigate against frost action. So our roads deteriorate from the top down due to environmental exposure and traffic damage, e.g., aging and brittle asphalt, low-temperature cracking, raveling, etc. These distresses can be easily addressed by timely application of thin preservation treatments. So a fundamental shift is needed in our approach to road asset management by moving away from spending the bulk of our road budgets on expensive rehabilitation treatments to spending it on extending the lives of our good roads.

This paper will present a new approach to maintaining municipal road assets underpinned by a powerful analytical optimization tool developed at the University of Waterloo. This decision support tool uses advanced mathematical programming to model big data and performs a multi-year analysis to maximize network performance over the entire planning horizon, considering all the municipal constraints. This optimized capital planning tool allows the entire array of road preservation and rehabilitation treatments to be realistically modelled to give municipalities the ability to quickly see how much money they can save, or spend more wisely. To date, some 50 municipalities from across Canada have committed to helping to develop and implement this new software.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-102

Decision-Making Framework for Integrated Asset Management

Soliman Abu-Samra
Ahmed Mohammed
Tarek Zayed

Abstract:

Tackling the inefficiency and financial burdens imposed by under-performing assets is an issue that negatively impacts the country's economic development where; Canada's infrastructure 2016 report displayed 33% of the assets in critical conditions, requiring immediate actions, and a steeply growing budget deficit estimated at \$123 billion. Moreover, the gigantic number of assets' intervention activities leads to detrimental social, environmental, and economic impacts on the community. Therefore, integrating the corridor intervention activities is needed to minimize the community disruption and maintain an acceptable level of service throughout the assets' life-cycle. This paper presents an integrated multi-objective asset management framework for corridor infrastructure, road and water networks, which aids the asset managers to trade-off intervention alternatives on both single and integrated asset management levels. The framework revolves through 4 integrated models as follows: (1) Central Database model, (2) Deterioration model, (3) Life Cycle Costing model, and (4) Optimization model. The multi-objective optimization framework considers the following objectives: (1) Physical state, (2) Life-cycle costs, (3) User costs, and (4) Replacement value. It basically relies on a combination of meta-heuristics and goal optimization in reaching a near-optimum solution. The framework was implemented on the city of Kelowna's road and water networks where; the results showed 33% and 50% savings in the integrated system's life-cycle costs and user costs respectively over the silo asset management. Furthermore, it visualized a high potential of scaling up the framework to include other corridor infrastructure such as; sewer, electricity, gas, telecom, provided that the necessary information is shared among entities.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-106

Integrating Building Information Modeling (BIM) with Sustainable Universal Design Strategies to Evaluate the Costs and Benefits of Building Projects

Bader Alsayyar
Ahmad Jrade

Abstract:

Building Information Modeling (BIM) is a well-known innovative approach in project design and construction. The use of BIM enables designers to control project cost from the early stage of its life cycle. The cost impact resulted from the construction of sustainable building is one of the main resources that designers should consider when designing such type of buildings. As the North American population is aging Universal Design (SD) requirements (design that accommodate the needs of human regardless of their ages and abilities) should be considered in conjunction with the sustainable design criteria to achieve sustainable universal design (SUD). The aim of this research is to investigate the environmental and economic benefits associated with adopting the concept of SUD applied for building projects. Therefore, this paper describes the methodology used to develop a model that is able to integrate BIM tools with SUD requirements and strategies (i.e. Energy use, material use, and indoor environmental quality and barrier free environment) and to evaluate the associated costs at the early stage of buildings life cycle (conceptual design). The proposed integrated model consists of the following six main components: a knowledge-based module, which is created to establish a database necessary to store the SUD principles and strategies; an expert system (ES) module which role is to work as an advisory system while designing SU buildings; a 3D BIM module that mainly incorporates predesigned families that are devoted to illustrate items necessary for the SUD, such as hand rails, doors, windows, plumbing fixtures, and their associated materials. All of the mentioned items will be according to the standards (i.e. Canadian national code, LEED, and other international standard, and Unifromat II (WBS)); a life cycle cost analysis (LCCA) module that illustrates the associated costs of the selected materials and components; a life cycle assessment module that



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-114

Groundwater Vulnerability Assessment Using GIS Based Modified DRASTIC Model in Agriculture Areas

Narges Gheisari
Majid Sartaj
Bahram Daneshfar

Abstract:

Intense agriculture activities and fertilizer application result in groundwater contamination, which has become a critical issue in recent years. Sustainable development, especially in arid and semi-arid regions, relies on the availability of good quality water resources. One of the important components in groundwater management plan is vulnerability assessment of aquifers to contamination. Groundwater susceptibility to pollution can be determined using DRASTIC model. This model is the most widely used method for vulnerability mapping which consists of seven hydrogeological factors. Despite its popularity, this technique disregards the type of pollution and the effect of regional characteristics. Also, there is not a specific validation method to demonstrate the accuracy of this method. Thus, this model must be modified according to specifications of pollutants and aquifers. The more accurate and reliable vulnerability assessment can be implemented by adjusting rates and weights of DRASTIC parameters. The calibration can be achieved by modifying the weight of each parameter and the rates using single parameter sensitivity analysis (SPSA) and Wilcoxon rank-sum non parametric statistical test respectively. The main goal of this research was to develop an integrated GIS based DRASTIC model using statistical methods in for adjusting rates and weights of original DRASTIC. The relationship between each parameter and nitrate concentration in groundwater was identified using Wilcoxon rank-sum non parametric statistical test. Also, the weight of each parameter were modified by SPSA. This methodology was implemented for the Shahrekord aquifer, as study area, located in southwest of Iran. Nitrate concentrations in 17 monitoring wells were tested and measured to correlate DRASTIC index to contamination in the aquifer. As a consequence, the new rates and weights were calculated to estimate vulnerability index in different regions. Pearson's correlation results indicated that the modified DRASTIC is more efficient than standard DRASTIC and it showed higher correlation coefficient.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-117

Developing a Maturity Model to Evaluate the Health and Safety of Sustainable Building Projects

Orogun Bezalel
Mohamed Issa

Abstract:

The health and safety (H&S) performance of sustainable building (SB) projects, which constitute a fundamental part of social sustainability has traditionally been ignored when evaluating the sustainability of these projects in favour of other environmental aspects such as energy and indoor environmental quality. This has made some of these projects more prone to on-site accidents than non-SB projects, reinforcing the need to move the H&S objectives of SB projects from mere compliance with existing guidance to high performance. This paper reports on a research project aiming to develop a model to evaluate the maturity of the H&S practices implemented on SB projects. The model defines five different levels of maturity ranging from “ad hoc and chaotic” to “sustainable” in order to identify the performance gap in H&S performance and improvements needed to bridge that gap. The model is based on the interaction of three different dimensions of performance as core components of sustainable H&S systems: people, process and building. It is part of an ongoing research initiative aiming to evaluate the H&S performance of SB projects conducted by the Construction Engineering and Management Group at the University of Manitoba. This research intends to provide a tool that supports continuous improvement, assesses H&S performance and addresses areas needing improvement in order to reduce and ultimately prevent accidents and injuries on SB projects. The research should also provide strategic knowledge to H&S regulators that would enable them to improve existing H&S guidance and define sustainable H&S best practices for SB projects in particular.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-118

Earl Bales Park Stormwater Management Facility and Water Supply System

Steven Van Haren

Abstract:

The Earl Bales Park Stormwater Management Facility and Water Supply system is the first in a series of responses to a forward-looking strategy the City of Toronto has implemented to tackle sources on non-point impacts contained in uncontrolled runoff from historic development areas. Overall, the project demonstrates an increased stewardship role by the project team to address sources of non-point water quality impacts for a large urban area and implement a solution that provides benefits for all affected parties.

The project is a large Stormwater Management Pond facility designed to provide water quality improvements to untreated stormwater discharges from the approximate area encompassed by Downsview Airport to Bathurst Street and Steeles Avenue to the 401. This facility will provide a measurable reduction in sediment, bacterial, and excess nutrient loadings to the Don River and eventually to Lake Ontario, enhancing fish habitat and reducing the taking of river water for human purposes. In addition, the facility reduces erosion in the adjacent valley lands by removing sources of excess manmade energy.

The project fosters behavioural and attitude change by providing a demonstrable and scalable rainwater harvesting system to illustrate the environmental benefits of alternative water sourcing for public uses, such as golf course irrigation and snow-making.

Various original and innovative aspects of the project include early stakeholder partnering and public outreach to facilitate the expansion of the facility beyond the strict property lines, allowing for sufficient facility scale for maximized water quality treatment and additional benefits such as cut/fill balancing, minimizing the project's overall carbon footprint (by requiring less off-site trucking). In addition, the project has implemented many public amenities such as pond interior walkways and aesthetic retaining walls and observation platforms to facilitate an increased public presence in the area that was a previously little used trail.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-121

Leveraging Telematics and Real-time Sensor Data to Increase Safety of Equipment-Intensive Construction Operations

Kelsey Chan
Joseph Louis

Abstract:

The number of safety incidents due to heavy equipment on construction sites has been increasing throughout the years, even though various safety techniques have been implemented into the equipment and worksites. The dynamically evolving nature of the typical construction worksite puts laborers in close proximity to heavy construction equipment for long periods of time that increases the potential struck-by accidents. Regulatory agencies such as OSHA have provided safety recommendations for a variety of construction activities including those involving heavy equipment. Despite these regulations, there is no way of ensuring that they are implemented or followed on the construction site.

This research proposes a framework to automatically check for the safety transgressions on heavy civil worksites by using real-time data generated from equipment sensors and telematics data as input to a rules-based system generated from the relevant safety practices recommended by regulatory authorities. This paper describes the analysis of safety literature available and its conversion to a rules-based system for checking against equipment sensor and telematics information collected from the worksite. This analysis informs the creation of safety systems that can be put in place to provide contractors and construction managers with the tools to automatically warn of imminent safety threats and also to assess safety measures that are currently employed in their worksite. Initial results of applying this framework to earthmoving operations are discussed in this paper. This research provides a framework that integrates existing safety standards with real-time sensor and telematics data that can be obtained from equipment in order to reduce fatality rates and accident occurrences on construction sites. Apart from its contributions to construction safety, this framework also provides for a novel use of telematics data, which is currently used only for equipment centric analysis.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-122

Hard and Soft Solutions for Stormwater Management

Yvonne Battista
Genevieve Kenny

Abstract:

In light of the July 2013 severe flooding in Toronto, municipalities, property owners and managers are becoming increasingly aware of the importance of designing sites to reduce the impact of storm events on property damage and City infrastructure.

The City of Toronto has also recently introduced a Wet Weather Flow Management Policy for new developments, adopted by City Council to manage the adverse effects of runoff and improve the ecosystem and health of the watersheds.

In this presentation a civil engineer and landscape architect will discuss the need and opportunities for stormwater management and treatment both in urban and naturalized settings. Three projects will be used to highlight the integrated team design process, and will touch on technical design elements.

Bayside is Toronto's new waterfront neighborhood that underwent an intense collaborative design effort to elegantly integrate stormwater management, municipal servicing and public realm design, which includes the award winning Water's Edge Promenade.

University of Ontario Institute of Technology /Durham College is a 20 acre campus in Oshawa with passive rainwater harvesting through vegetated bios-wales and catch basins, which lead to sculptural and functional stormwater ponds.

West Don Lands stormwater quality treatment facility and outfall, which enables the 2015 Pan Am games in Toronto, works with existing municipal and transportation infrastructure while providing synergies for future developments.

Learning Outcomes:

1. Strategies to reduce the impact of storm events on site and City infrastructure while improving water quality.
2. An understanding of how stormwater management systems are also designed to filter the water as it moves through various stages.
3. Appreciation for the integrated design process, and the roles of various consultants on the team.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-123

Using Feather Fibers as a Substitute to Synthetic Fibers in Concrete Reinforcement

Abdelrahman Abdelshafy
Tamer Breakah
Omar El Kholy

Abstract:

Due to the negative environmental impact caused by the disposal methods of poultry waste, an alternative solution was undertaken to employ such wastes in concrete reinforcement. An experimental investigation was initiated; to determine the sustainability of using feather fibers as a substitute to synthetic fibers, in concrete mix design. The process was divided into two phases; Phase 1, included the preparation of three feather fiber reinforced concrete mix designs (Chicken, Duck, Turkey) to be tested against, two control mix designs (Normal Concrete, Fiber Reinforced Concrete) in order to select the feathers that have better potential in concrete. Feather and synthetic fibers were, initially, kept at a 1.0% volumetric ratio in the mix design. The duck fiber reinforced specimen yielded the highest results in compressive strength enhancement. The specimens were also tested for flexural strengths, chemical attacks and harsh conditions, in which all feather fiber specimens yielded the least results. For Phase 2, the feather fiber specimen incorporating was then subjected to alterations in the mix design to try and obtain higher results than varying the percentage of fibers and the concrete strength.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-124

Extended Decision Making Framework for Sustainable Pavement Management

Xiaoyan Zheng
Said Easa
Tao Ji

Abstract:

Sustainable pavement management (SPM) is characterized by economic cost, environmental burdens and social impacts, which are respectively evaluated by life cycle cost analysis (LCCA), life cycle assessment (LCA), social life cycle assessment (SLCA). Despite current progress on SPM, several opportunities for improvements remain. In *pavement LCA*, environmental impacts in use phase are much less prevalent and still have gaps in the assessment methodology. *Pavement SLCA* is often ignored due to unavailability of raw data (eg., geography and culture), complexity of quantifying social impacts, and lack of standard methods. Therefore, SLCA is still at a nascent stage and needs to be investigated further. Another area that is barely addressed in SPM is decision-making. The concept of SPM is multi-criteria and multi-dimensional, as decision making is complex and fuzzy process. Additionally, the sustainable project needs to be assessed by experts from various fields.

The purpose of this paper is to propose a decision making framework integrated LCCA, LCA and SCLA modules in order to optimize alternative pavement design and maintenance strategies. In the pavement LCA module, some deficits in the pavement use phase, including pavement rolling resistance, albedo, and lighting are incorporated into this module. In addition, uncertainty analysis is included in pavement LCA using Monte-Carlo simulation. The pavement SLCA module is integrated into this framework, and approach for performing SLCA is proposed and social impact indicators, including traffic noise and traffic safety, are quantified. The outputs of the three modules are integrated using multi-objective optimization. The proposed tools for the decision model combine fuzzy analytic hierarchy process, data envelopment analysis, and ant colony optimization technique.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-127

Considerations for Winter Construction of Mechanically Stabilized (MSE) Walls

Ertiana Rrokaj
Celenia Vivas
Daniel Calatrava

Abstract:

For over 50 years, since the invention of the Mechanically Stabilized Earth (MSE) walls in France, this type of wall has been constructed to fulfill a variety of crossing and retaining solutions, including applications from simple retaining walls supporting roads, true bridge abutments, to very complex dam structures. As the demand for infrastructure increases, to meet with project schedules, there exists a greater need for the construction of MSE walls without interruptions over the installation period, which includes the winter season. Although this practice has been avoided, in part due to the multiple challenges presented by harsh Canadian winter conditions, MSE walls have proven their flexibility to meet any construction schedule and condition, in part due to the development, by the inventor company of MSE walls, of construction guidelines for winter specifications. The purpose of this paper is to identify the main challenges faced in the construction of MSE walls during Canadian winters, and to recommend solutions for mitigating the effects of those challenges. Among them, the following have been identified: (a) Considerations in Design through the Selection of Backfill, (b) Manufacture of Concrete Panels, and (c) Challenges in Installation, subcategorized into (i) Health and Safety, (ii) Backfill compaction, and (iii) Materials storage. The main conclusion is that with the proper construction methodology, MSE structures can be designed, produced, and installed all year round.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-128

Resilient Infrastructure Planning - Risk-based Analysis Procedure

Gary St Michel
Alan Reggin
Albert Leung

Abstract:

In recent years, civil infrastructure asset management has increasingly relied on risk as a basis for prioritizing capital expenditures related to existing infrastructure assets. The US Army Corp of Engineers has developed, and now uses, a methodology whereby the Probability of Unsatisfactory Performance of an asset is predicted and the consequences of the unsatisfactory performance are quantified and monetized. The technique is published in the USACE document EC 1110-2-6062 "*Risk and Reliability Engineering for Major Rehabilitation Studies*".

The authors have recently combined this USACE Risk and Reliability technique with traditional Life Cycle Cost Analysis based Asset Management. In the analysis, reduction in risk associated with alternative courses of preservation activities (called strategies) for a given asset, is calculated and considered as part of the benefit of the strategy. A cost/benefit comparison between the various life cycle preservation strategies for a given asset informs the owner as to how much capital expenditure and which course of preservation activities can be justified. The technique also readily provides for cross-asset comparisons and capital allocation where an agency has a portfolio of diverse assets. That methodology was published as part of the ASCE's Ports 2016 Conference and entitled, "*A Risk-Based Structural Assessment Approach for Port Metro Vancouver's Asset Management*".

Taking the process one step further, the authors have developed a methodology for bringing consideration of asset resiliency to climate change into the infrastructure asset management life cycle cost analysis. This paper first briefly summarizes the Risk and Reliability based life cycle cost analysis approach and then presents the technique for monetizing the climate based risk and demonstrates how owner agencies can inform themselves regarding how much expenditure can be justified in making infrastructure more resilient to either climate change or age-related deterioration.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-131

Dynamic Artificial Neural Network to Improve Road Safety Studies

Farhad Faghihi
Gordon Lovegrove

Abstract:

The pre-defined assumptions of the widely used generalized linear statistical models are often violated in road traffic safety studies. On the other hand, data on road safety use are often collected on sequentially measurements over successive times. The common feature of such time-related data, called time series data, is seasonal patterns. Ignoring the seasonal variation will result in under or over-estimation of road safety estimation. This presentation is an attempt to overcome the above weaknesses by means of artificial neural network. The proposed models are evaluated using traffic collision claims of Kelowna, BC, in 12 consecutive years from 2004 to 2015.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-133

Residual Capacity of Blast-Damaged Reinforced Concrete Columns

Isaac Kwaffo
Abass Braimah

Abstract:

The progressive collapse of the Alfred P. Murrah building in Oklahoma City in 1994 sparked much research to understanding the response of reinforced concrete columns to blast loading. The research thrusts have been in both the experimental and analytical spheres. Whereas much has been reported on the response of reinforced concrete columns to far-field loading, scant information exist on the response of these columns to near-field loading. Moreover, there is a dearth of knowledge on the residual capacity of blast damaged reinforced concrete elements. This paper reports on follow on testing of reinforced concrete columns previously tested under near-field blast loading. The reinforced concrete columns were not specifically designed for blast load resistance. They were detailed in accordance with the CSA A23.3 code as columns for gravity load resistance or columns for gravity load resistance but also expected to have enough ductility to resist the lateral deformations of the seismic force resisting system. The two column types were tested under live explosions at scaled distances of less than $1.0 \text{ m/kg}^{1/3}$. The columns surviving the live explosion testing were tested statically in the structures laboratory to failure. The test procedure involved loading the columns axially to the design service load level and, additionally, laterally under four point bending to determine their lateral capacity. This paper presents the experimental results of the residual capacity testing currently underway.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-137

Implementing Performance-Based Analysis in Supply Chain Management

Nayera El-Gharably
Said Easa
Ashraf El Damatty

Abstract:

Supply chain is an integrated manufacturing process where raw materials are converted into final products, then delivered to customers. Supply chain management (SCM) consists of two basic processes: (a) production planning and inventory control process and (b) distribution and logistics process. The objective SCM is to maximize competitiveness and profitability for the company and the entire supply chain network, including end-customer. This is achieved by synchronizing customer requirements with the flow of materials from suppliers, reducing inventory investment in the chain, and increasing customer satisfaction. Given the inherent complexity in SCM, selecting appropriate performance measures for supply chain analysis is critical. Traditional SCM evaluation methods focus on the well-known financial measures (e.g. net present value). Such methods are best suited for simple SCM applications. In addition, modeling transportation operations in SCM lacks a concise representation of the transportation cost function.

The purpose of this paper is to propose a framework that integrates relevant performance measures and decision variables in SCM. The supply chain measurement system includes resource measures, output measures, and flexibility measures. The framework adopts a transportation optimization module and a supply chain module for routing decision using private or outsourced fleet. The optimization module incorporates not only transportation cost, but also other relevant performance measures. In addition, the framework includes a decision support system that integrates various performance measures and the trade-off among them. Finally, risk assessment is implemented to minimize supply chain disruptions and uncertainties using stochastic analytical model. Some components of the framework are validated using Monte Carlo simulation. The proposed framework should be a valuable assessment tool for the newer generation of SCM applications.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-145

The Role of Coastal Engineering and Innovation for Sustainable Adaptation of Four Coastal Defence against Sea Level Rise

John Readshaw
Grant Lamont
Sherry Lim
Philippe St-Germain
Jessica Wilson

Abstract:

Climate change and related sea level rise will affect all of Canada's coastlines, posing significant planning challenges for communities. With conventional coastal defence approaches having well known limitations, alternatives need to be developed, validated, and implemented. As every section of shoreline is unique, this paper demonstrates the role of Coastal Engineering in assessing the metocean conditions, the resulting wave-shoreline interaction and the multidisciplinary coordination necessary to optimize the shoreline adaptation while minimizing the complete life cycle costs and implications. Shorelines provide important ecological services and new coastal protection systems that either minimize disruption to or enhance the ecological services are needed. Coastal Engineers are key leaders of the multidisciplinary teams necessary to respond to the growing challenges.

This paper presents two projects in British Columbia (BC) that demonstrate how Coastal Engineering adds significant value to project outcomes. In the first project, detailed analysis of wind and wave modelling lead to a refined understanding of flood risk during storms faced by a community on Vancouver Island, BC. This work means that the community can plan and optimize its response in a manner that preserves ongoing land use and values while still addressing the critical risk areas. In the second project, the importance and value of innovation in the adaptation of coastal defences to ensure that they are sustainable, effective and economical is demonstrated with an example from the ongoing upgrading of the existing sea dike at Boundary Bay, BC. This ongoing work combines classical dike design principles, detailed numerical modeling of wave overtopping, and intentional use of ecosystems and natural processes to dissipate wave energy to reduce the magnitude of overtopping. This analysis can result in the design of a "Living Dike", with increased benefits to the environment and which can be subsequently upgraded as and when needed as sea level rises.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-148

Impact of Flaggers on Safety and Mobility of Highway Work Zones

Ahmed Abdelmohsen
Khaled El-Rayes

Abstract:

Standard specifications for road and bridge construction in many Departments of Transportation require that a flagger be utilized at all times to direct traffic in lane closure work zones on multilane highways. Utilizing flaggers as specified by these standards introduces inherent risks and varying effectiveness by positioning flaggers next to the active traffic. This paper presents the findings of a comprehensive study to assess the effectiveness and essential role of flaggers in directing work zone traffic on multilane highways and to consider alternative means of providing this function. The objectives of this study are to (1) conduct a national survey of state DOTs to gather their feedback on the essential roles, effectiveness and risks of utilizing flaggers to direct work zone traffic on multilane highways; and (2) investigate the feasibility and effectiveness of work zone safety measures that can be used to supplement or replace the use of flaggers, such as intrusion alarm systems, portable changeable message signs, and portable speed monitoring displays. A total of 100 responses were gathered in this national survey that consisted of two main sections. The first section asked respondents to identify the need, benefits, and risks of using flaggers in and around work zones. The second section evaluated the effectiveness of using flaggers and other various safety measures in improving the safety of work zone access and egress points. The main findings of this study on the roles and effectiveness of flaggers for directing work zone traffic control can be used to guide decision makers in changing and/or expanding existing standards and policies to improve work zone safety and mobility performance on road and bridge construction projects.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-151

Early Adopters: Their Journey towards Designing Sustainable Infrastructure Using the Envision® Rating System

Eric Dunford
Rob Costanzo
Cozmin Radu
Lourette Swanepoel

Abstract:

The Envision® Framework and Rating System for Sustainable Infrastructure was launched in 2012 by the Institute for Sustainable Infrastructure (ISI), and the Harvard Graduate School of Design's Zofnass Program for Sustainable Infrastructure. The program has grown exponentially in the US and in Canada since then with over 5,600 Envision Professionals and 30+ certified projects. This collaborative session will take a closer look at what Envision is all about and explore three examples of how public agencies are using Envision for various types of infrastructure.

Port Metro Vancouver's Low Level Road project is the first transportation project to receive an Envision Platinum award for sustainable infrastructure. Since the award, the Port has been active in integrating Envision into their capital projects.

The City of Surrey and Orgaworld received the first Envision award for a Waste Management project. The Surrey Organic Biofuel Facility will process the City's organic waste into a 100% renewable natural gas used by waste fleet vehicles.

The Grand Bend Area Wastewater Treatment Facility, located in Ontario on the shoreline of Lake Huron, was the first ISI Envision verification in Canada, and first wastewater facility to be verified in North America. This has sparked a few rural municipalities to address legacy wastewater management issues through innovative and 'green' approaches. Lessons learned from Grand Bend are being applied for the redevelopment of a similar wastewater facility in Port Stanley, Ontario.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-154

A Simple Doe-Based Replacement Model for Penman's Evaporation Equation

Leonard Lye

Abstract:

Penman's equation for the estimation of evaporation from measured climatic variables is the most well-known and considered to be the most accurate method for open water evaporation. It is based on a weighted combination of evaporation estimated using energy balance and aerodynamic methods. However, usage of Penman's equation is not straightforward. It requires applying a series of equations and reference to at least one table. In addition, it is difficult to determine from the series of equations, the relative contribution of the climatic variables to the estimated evaporation and how the variables interacts with one another. In this paper, a simple replacement model obtained by applying statistical design of experiment (DOE) methodology will be demonstrated. The replacement model is based on a simple two-level factorial design. The model obtained is a simple one line regression equation and the effects of each variable and their interactions are clearly seen and explained. Moreover, the replacement model gives practically identical results to those obtained by the full Penman's equation.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-155

Transportation Association of Canada's New Document - Guideline for the Coordination of Utility Relocation of Utilities

Ophir Wainer
Lawrence Arcand

Abstract:

The Transportation Association of Canada's (TAC) Public Utilities Management Subcommittee has just published a new document - Guideline for the Coordination of Utility Relocations. The purpose of the guideline is to assist various ROW owners and Utility agencies to develop or enhance their utility coordination processes. For Utilities with infrastructure in a variety of areas it gives them a consistent process they can follow when working with any ROW owner. For ROW owners it allows them to learn from the best practices and procedures of different parties and implement a process that will be readily accepted and adopted by utility agencies.

This presentation will review the key aspects of the new Guideline, highlighting the Objectives, Intended Audiances and some of the new developments being made. Major themes contained in the guideline such as the use of Utility Coordinators, and SUE mapping as per ASCE 38-02 will be reviewed.

The audience will have an opportunity to ask questions about the new guideline and determine how it can best be incorporated into their community or business.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-156

A Case Study on Improving Standardization in the Conception Phase by Developing Tools and Protocols

Martin Michaud
Forgues Daniel
Claudiane Ouellet-Plamondon

Abstract:

In the Architecture, Engineering and Construction (AEC) industry, the variability nature of construction projects leads to the presence of waste. The standardization of activities and processes can help reduce variability and thus reduce the amount of waste. This paper presents an action research approach to develop and implement a framework to help creating an improved visual mapping of the information flows between the departments of an architectural firm. The aim is to use the principles of Value Stream Mapping (VSM) from Lean Production and BIM processes to improve standardization in the information flow. The focus is made on the information flow between the various departments of an architectural firm. This study contributes to the field through the development and validation of a framework used to improve standardization in the information flow. Moreover, the findings presented offer practical implications by helping with the improved interoperability of interdisciplinary professional work with standardized processes and activities.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-158

A Semi-Automated Approach for Detecting Building Spaces with Deteriorating Performance Using BIM and Energy Simulation

Firas Shalabi
Yelda Turkan

Abstract:

Facility managers constantly face energy performance issues, which result from the mismatch between a facility's actual energy performance and its predicted performance, i.e. design energy simulation results. While the gap between the predicted and actual energy performance may be caused by several factors stem from any phase in a facility's life cycle, facility managers are the ones responsible for reducing it. Nevertheless, they lack tools and methods for detecting spaces with deteriorated equipment or system malfunctions in a timely manner, which only contributes to the energy performance gap in a given facility. Therefore, this paper proposes a semi-automated approach that enables detecting spaces with deteriorated energy performance within a facility using BIM and energy simulation results. The approach automatically aggregates data from two different FM systems; namely Building Energy Management Systems (BEMS) and Computerized Maintenance Management Systems (CMMS); and use them to run energy simulations in IFC- Building Information Modeling (BIM) environment. However, the comparison between the actual and predicted energy performance is done manually by the facility manager. The proposed approach was validated using data obtained from an unoccupied educational building. The results showed that the approach is able to aggregate space oriented information and present them in IFC-BIM environment. This study supplements the existing body of knowledge in this domain by providing a framework which enables facility managers detect spaces with energy overconsumption within their facilities. The proposed approach could enhance current maintenance planning practices and help improve facilities energy performance.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-167

Corporate-Level Risk Analysis for Industrial Projects

Maryam Shahtaheri
Mikhail Hanna
Carl T. Haas

Abstract:

The planning and execution of design, procurement and construction (EPC) of capital projects is a lengthy and complex endeavor due to various technical and non-technical factors. Uncertainty and risk events further add to this complexity and as a result many projects suffer from significant cost overruns and schedule delays. One way to account for such overruns is to accurately establish and assess a project's risk (threat and opportunity) profile, including the confidence in achieving cost, schedule, and/or other project objectives (e.g., quality) projections. An accurate assessment of risk and uncertainty leads to a reasonable estimate of contingency. It also results in prioritizing the mitigation of risks with the greatest impact on the project outcomes. Furthermore, it enables decision-makers and stakeholders to have an enhanced understanding of project drivers, increased certainty in project-based decisions, and improved ability to successfully achieve desired outcomes. This paper highlights the main steps required to conduct a practical risk and uncertainty analysis at a corporate level using operational experience provided by an industry partner.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-171

Conceptual Design for a Mechanistic Rule Based System for Highway Pavement Integrity Assessment

Muhammad Mubaraki

Abstract:

The traditional process of pavement condition assessment has been utilized with the purpose of developing pavement management systems. With the modern pavement assessment technology, analysts and stake holders are flooded with overwhelming streams of pavement data. As a result, current pavement management systems started to become statistical data analysis tools and losing sight of the underlying engineering mechanics that play the major role in defining pavement condition. Hence, in this paper a rule based model for pavement assessment has been developed and presented. The developed model is defined as an abstracted state machine with a predefined states connected with sequential logical links that defines the transition from pavement state to the other state(s). Two domains were defined for the pavement states and were built using two types of pavement surface distress, cracks and rutting in conjunction with roughness data. The pavement data was obtained from the Ministry of Transport in Saudi Arabia, for the highway segment connecting Jazan-Jeddah.

This system can be used to identify critical cases that need urgent attention in order to avoid costly rehabilitation work. The proposed rule based system was based only on a single data set for a route located in Saudi Arabia. It is also important to emphasize that the current transition links for both domains are based on logical and expert judgment. Such transitional links should follow probabilistic values which can be obtained from historical data to incorporate exogenous factors that are not taken into account in the model. It is understandable that the portability of this system is limited and each area needs to calibrate a system based on their own pavement.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-177

Vehicle Dynamics-Based Circulatory Width of Single-Lane Roundabout

Maksym Diachuk
Said Easa

Abstract:

Current guidelines for roundabout circulatory roadway width are based on a static method that does not consider circulatory speed. In addition, the roundabout entry width is based on practical experience. At single-lane roundabouts, the circulatory roadway should accommodate the design vehicle. Appropriate vehicle-turning templates or CAD-based computer programs are normally used to determine the swept path of the design vehicle throughout the turning movements.

This paper presents a method for determining the circulatory and entry widths based on a two-dimensional dynamic model that involves a system of differential equations. The method considers the interactions between the vehicle and the road geometric elements, including tire sideslip, vehicle weight, vehicle speed, and vehicle stability. Three design vehicles are considered: Heavy single-unit truck (WB-12), tractor-semitrailer truck (WB-20), and standard single-unit bus (B-12). Design guidelines for the required circulatory width are established for different circulatory speeds (20-40 km/h) and different inscribed circle diameters (35-80 m). To simplify the guidelines, for each design vehicle and inscribed circle diameter, regression models were developed for the circulatory roadway width as a power function of the circulatory speed. Guidelines for entry width were also established for typical conditions. The results show that the proposed method provides values of the circulatory roadway width that are less than those of the current static method. The difference ranges from 0.4-0.6 m for City Bus, 0.7-1.0 m for WB-12, and 1.3-2.0 m for WB-20. The proposed guidelines would be useful in case of space restrictions.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-180

Adaptation Platform Infrastructure and Buildings Working Group - Canadian Infrastructure and Buildings Adaptation State of Play Project

Dan Sandink

Abstract:

Successfully planning for and managing the impacts of climate change requires not only the understanding of the risks and opportunities created by a changing climate but also information sharing and collaboration among multiple levels of stakeholders and decision-makers. The Climate Change Impacts and Adaptation Division (CCIAD) of Natural Resources Canada is leading the implementation of Canada's Adaptation Platform, which brings together national industry associations, national professional organizations, representatives from federal, provincial and territorial, and municipal governments, as well as other relevant organizations to advance action on adaptation.

The multi-stakeholder Infrastructure and Buildings Working Group (IBWG) is part of Canada's Adaptation Platform. The IBWG was established by the Institute for Catastrophic Loss Reduction (ICLR) and Engineers Canada, in consultation with Natural Resources Canada, in 2013. The IBWG's purpose is to build capacity, generate evidence and provide outreach to increase the capability of infrastructure managers, municipalities, builders, insurers, engineers and other relevant stakeholders to adapt and facilitate adaptation to climate change. The IBWG is comprised of climate change adaptation stakeholders from federal and provincial governments, private industry and non-profits from across Canada.

The purpose of the State of Play project is to provide an overview of the state of adaptation for Canada's infrastructure and buildings, with an emphasis on infrastructure that services communities, and both engineered and non-engineered buildings, and to identify gaps and opportunities and potential options for addressing them. The project is focusing on the following infrastructure categories: Water, stormwater and wastewater infrastructure; Urban public transportation systems, including urban roads; New and existing engineered buildings, with an emphasis on public service buildings (e.g., affordable housing complexes, Hospitals/healthcare facilities, correctional facilities, etc.), and; New and existing non-engineered buildings (i.e., low-rise, residential structures). The presentation will review major findings of this national adaptation assessment project.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-181

The Effect of the Silo-Storage on the Rheological Behavior of a Surface Course Asphalt Mix Containing Reclaimed Asphalt Pavement (RAP)

Kadhim Hawraa
Peter Mikhailenko
Hassan Baaj
Susan Tighe

Abstract:

The extent of diffusion/blending between aged binder from reclaimed asphalt pavement (RAP) and virgin binder in asphalt mixtures could affect both the performance of the produced Hot Mix Asphalt (HMA) and the economic competitiveness of the recycling process. During the production process of HMA with RAP, it is generally understood that a partial blending occurs between aged and virgin binders. The degree of blending could be increased, and the blending could be accelerated by increasing the time of silo storage after the mixing. Nevertheless, a limited number of studies have considered the time-temperature effects of the silo storage on the diffusion mechanism between virgin and RAP binders. In this study, the kinematics of blending of aged and virgin binders are examined by considering the time-temperature effect of silo storage on the rheological properties of HMA containing RAP. HMA samples of an HL-3 mix designed with 15% RAP were collected after production from the asphalt plant at different silo-storage intervals (1, 4, 8, and 12 hours), with their temperature being closely monitored and recorded. The resulting mixes were compacted on-site, and their rheological properties were characterised using the Complex Modulus Test. The analysis of these results indicates that the silo storage time had a strong impact on the rheological behaviour, which indicated a better blending of aged and virgin binders with higher storage time.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-184

A Stochastic Modeling Approach for Risk Management of Water Resources Systems

Zoe Li
Brian Baetz
Maysara Ghaith

Abstract:

Recently, water related hazards have imposed significant pressure on our infrastructure, jeopardizing public safety and hampering economic growth. The modeling and analysis of water related hazards are crucial to the effective risk management of water infrastructure systems. Complex features of water resources systems, such as nonlinearity, dynamics and uncertainty, have brought major challenges to research in this area. This study presents a stochastic modeling approach for quantifying and analyzing various uncertainties associated with water resources systems. Based on probabilistic chaos expansion (PCE) and multivariate analysis, a probabilistic simulation method is developed to construct a surrogate for complex hydrological models and to support efficient stochastic simulations. Stepwise cluster analysis (SCA) is used to establish complex nonlinear relationships among various system components. PCEs are established based on the probabilistic collocation method to generate probabilistic runoff time series. The proposed approach is demonstrated using the climatic and hydrological data from two watersheds, i.e., the Grand River Watershed in Canada and the Xiangxi River Watershed in China. Results show that the proposed approach is effective in tackling the complexities in water resources systems, particularly with respect to the inherent uncertainties involved in hydrological modeling. This work can provide robust decision support for risk management of water resources systems, such as hydraulic infrastructure design, reservoir operation, and floodplain planning. The developed modeling framework will help decision makers not only to improve their effectiveness in managing water risks, but also to enhance their preparedness for and response to water related hazards.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-186

Prediction of Impact Force-Time History In Sandy Soils

Adnan Ali
Balqees Ahmed

Abstract:

A dynamic problem that is represented by impact acting on a soil medium (short-period dynamic load) is rather different from the case of impact acting on a structure such as a beam or a pile. In case of a pile, the resulting impulsive wave as per Clough and Penzien (2003) is having a standard amplitude, shape, frequency, and duration; therefore, the impulsive load wave is almost of an ideal shape as. However, in case of an impact load acting on a soil medium neither the shape nor the amplitude can be evaluated by any available methodology currently available. An experimental study of the behavior of dry dense, medium, and loose sandy soils subjected to a single impulsive load is carried out. Such sand models were tested under different impulsive energies caused by different falling masses from different heights. Tests were conducted using the falling weight deflectometer (FWD) to provide the single pulse energy. It was found that that the amplitude of the resulting force-time history is a function of the degree of confinement on the footing, the embedment depth, footing area, density of soil in addition to the energy of impact (falling mass and height of fall). The shape of the impulsive wave was found to be, therefore, of mostly a single pulse; with or without a negative phase. Moreover, it could be of an ideal half sine wave or a part of half sine wave with a nonzero residual inelastic force (represented by the falling weight). It could be of a very short duration or relatively long one and finally, the frequency of the resulting impulsive wave could be greater or even smaller than the natural frequency of the foundation soil medium.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-187

Impact Load Effects on Corroded Reinforced Concrete Beams

Abass Braimah
Jayashree Sambasivam Muralidharan
Burkan Isgor

Abstract:

Bridge and road infrastructure in North America and around the world where deicing salts are used is suffering deterioration due to corrosion of steel reinforcement. A lot of research in the past several decades has been targeted at reducing corrosion or replacement of the corrosion-prone steel in bridge deck slabs and supporting structures. Little to no research has been targeted at the barriers which also suffer corrosion deterioration and are likely to be subjected to severe impact loading.

The research reported in this paper is from a preliminary program designed to investigate the effect of impact loading on corroded reinforced concrete elements. Small-scale reinforced concrete beams were subjected to accelerated current-impressed corrosion in the laboratory and then were subjected to impact loading in a drop-mass test frame. Two different degrees of corrosion were investigated: 2.67% and 5.11%. A control beam with no corrosion was also tested for comparison.

The impact test results show that the higher the level of corrosion the lower the impact resistance of the beams. These preliminary results highlight the importance of investigating the effect of impact loading on corroded vehicle guards as they are likely to present a safety hazard to vehicular traffic on bridges.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-199

Engineering Sustainable Communities

Stephanie Dalo
Gordon Lovegrove

Abstract:

Canada's commitment to the Paris Agreement was ratified less than a year after the Paris climate conference (COP21) in December, 2015 when Prime Minister, Justin Trudeau, announced a 'floor' carbon price of \$10 a tonne in 2018, rising by \$10 each year to \$50 per tonne by 2022.

Our societal and environmental problems are complex and intractable, but through the implementation of a holistic Sustainable Community Rating System, practitioners can rely on the tools at hand to guide them towards developing creative solutions to reduce a project's carbon footprint.

Existing tools and rating systems are already in place to provide guidance in areas of quality of life, leadership, resource allocation, natural world and climate and risk. This paper will lay out the basis of my thesis that will be undertaken at the University of British Columbia Okanagan. It will investigate the prospective integration of current tools such as Envision™, Canadian Healthy Development Index (HDI) and the Dutch Sustainable Transport Safety (STS), etc., into one holistic Sustainable Community Rating System, with the purpose of addressing the full range of environmental, social and economic impacts to support practitioners to incorporate sustainability in design, construction and operations. Often, the cause of rework or work stoppage boils down to failure of proper communication between owners, engineers, contractors, community members and in some extreme cases, a lack of regard for First Nations. This tool will expand from existing rating systems to incorporate Canadian climate, improve consultations with First Nations, and enhance communications between all parties involved in infrastructure development.

Sustainable development, climate change mitigation, and adaptation will need to be at the centre of the engineering agenda, because engineering will be at the very centre of efforts to building a carbon-free future.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-203

Regenerative Approach to Building Energy Retrofit Project Development and Construction

Mahsa Safari
David Riley

Abstract:

The development of construction projects focused on the upgrades and improvements to buildings for energy efficiency have significant appeal to building owners, energy service providers and utilities. This interest stems from multiple factors including the resulting savings in energy costs, the potential to deploy new and efficiency technologies, the introduction of advance controls, and the shift of buildings from loads on the grid to controllable assets that can contribute to peak load reduction and resiliency. Another enticing feature of building energy retrofits is the fact that construction loans can be secured based on the predicted energy savings of these project. This fact, coupled with the significant stock of old and new buildings that were built with little regard for energy efficiency, have encouraged efforts to pursue energy retrofit project. While large facilities often have easily predictable scale and energy saving potential, they are often pursued in a manner that achieves only “low hanging fruit” and often fall short of their potential as a deep energy retrofit. Small and medium sized buildings face even more significant challenges due to the lack of owners’ ability to manage and finance energy efficiency improvements. This research examines a regenerative approach to energy efficiency project development and construction in a regionally focused approach. The use of regenerative business principles, process mapping, and risk analysis to better describe and inform retrofit project investments is presented. Three resulting strategies to reduce risk and advance energy retrofit projects are described. Lessons learned through the application of this approach on multiple small and medium sized retrofit projects are also presented.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-204

Mapping Potential of Wind Energy in New York City

Samaneh Gholitabar
Fletcher Griffis

Abstract:

An important step toward planning and deploying urban wind resources is to determine the local wind levels in an urban environment. Local weather services commonly report open area wind levels. Local wind patterns can deviate significantly from open area wind level. A semi-analytical methodology is employed in this research to calculate local wind levels in New York City. The model upscales the open country wind level to the urban boundary layer; it then downscales the wind level to the average building height of urban localities through two downscaling steps. The analysis is implemented in a geographic information system (GIS) framework. The detailed information regarding building geometries in Manhattan is available to the public were used to calculate the aerodynamic parameters of the city. The results include aerodynamic maps of the city, along with a wind localization index that can be used to calculate local wind level at any location in the city as a function of the open county wind level, which is available through local weather services. The results of the model can be used in urban renewable energy planning, among other applications.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-206

Resource Optimization Using Genetic Algorithm in the Simulation-Based Project Planning Method

Payam Hadavi
Mehdi Tavakolan

Abstract:

Resource allocation strategy directly affects project time and cost. Considering an accurate method of planning is required to evaluate the effect of resources, and to optimize resource allocation plan. Current scheduling software programs in industry, like MS Project and Primavera, do not provide resource-oriented planning. The method, therefore, should be capable to automatically update plan, based on different resource allocation scenarios. Automatic optimization tools are also not applicable in the common software programs. Resource allocation plan, therefore, should be enhanced manually by frequently changing resource parameters and checking results, which is difficult, time-consuming, and error-prone. In this research, the Genetic Algorithm is applied on a simulation-based project planning method, to automatically optimize number of resources, based on monthly average budget. In this paper, literature related to the subject will be reviewed, and optimization program will be illustrated. Then modeling process and capabilities of the method will be shown in an actual case study on a residential building.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-207

Well-Managed Environmental Compliance Program Supports Delivering Sustainable Energy from a Large Hydroelectric Development in Labrador

Diane Ingraham
Wayne Tucker

Abstract:

A 824 MW Hydroelectric Development Project (Project), on the Lower Churchill River in Labrador, is a multiyear project designed to generate and transmit power throughout Newfoundland and Labrador and further supplying the Maritime provinces and New England states. Before commencement of this complex construction project, regulatory matters affecting the undertaking needed to be addressed. The Environmental Assessment identified requirements and commitments to manage, mitigate and monitor the impact of the Project and put in place the appropriate strategies and plans required for compliance. This paper discusses the experiences of one Aboriginal partnership company tasked with a Regulatory Compliance and Environmental Compliance Program (Program) it undertook to assist the client in meeting its commitments to regulators. The Program, which started in 2013 and scheduled for completion in early 2018, comprises 3 overlapping projects: (1) Avifauna Management, (2) Historic Resources Mitigation, and (3) Environmental Effects Monitoring. Program complexities included multi-year seasonal and overlapping cyclical nature of work attuned to breeding patterns of sensitive indicator species, ability to do weather dependent work in remote locations, working ahead of the main construction activities, inclusion of local communities and service providers, training, health and safety issues, and high visibility as a major project permanently changing the landscape and surrounding communities. Program management best practices were established from the outset and refined and enhanced over the duration of the work. This paper presents and overview of the Program and the results it has achieved.



GEN-211

Comparative Study of Different Methods for Noise Reduction in the Ambient Vibration Signal of Structures for Modal Identification

Ardalan Sabamehr
Shervin Khazaeli
Mehrdad Mehrdad Mirshafiei
Ashutosh Bagchi

Abstract:

Modal analysis based on ambient vibration is a powerful method for structural health monitoring. The ambient vibration signals are often very weak and polluted by strong noise which makes modal identification challenging. Signal processing algorithms can be used to tackle the problem. In this paper, finite element frame model of a structure is simulated with white Gaussian noise as an ambient force. One of the effective methods to reduce noise level in an ambient vibration signals is to pass it through the Singular Value Decomposition (SVD) algorithm. It can separate the modes in such a way that the topmost curve of SVD has the lowest noise level and bottommost curve has the largest. Additional techniques can be employed to enhance SVD results, such as low-pass filtering and wavelet noise reduction. Therefore, two scenarios have been considered in the finite element model: a combination of low-pass filter and SVD, and Wavelet and SVD. We also investigate data decimation to increase the signal-to-noise ratio (SNR). The simulation results are then compared according to SNR in SVD. Finally, the techniques have been applied to the field data obtained from the ambient vibration test of a building.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-216

Time-Cost-Environmental Trade-Off Analysis for Business Commute Systems

Moatassem Abdallah
Aly Tawfik
Caroline Clevenger

Abstract:

Half of transportation related emissions are reported to be from passenger cars and light-duty trucks such as sport utility vehicles, pickup trucks, and minivans. Furthermore, business transportation plans are frequently non optimized; relying instead on mainly on personnel convenience, time, and cost rather than environmental impacts and savings. This paper presents the development of an optimization model that is capable of identifying the optimal selection of individualized business commute alternatives in order to minimize GHG and air pollution emissions, commute time and cost. This model identifies the optimal commute mode for each commuter (e.g. drive car, carpool, use public transit or walk) that minimizes the aggregate negative environmental impacts, time, and cost of businesses while maintaining convenience. The optimization model is integrated with a geographical information system (GIS) to identify business commute attributes such as emissions and commute cost and time of each commute alternative. The performance of the developed optimization model is tested and verified using a case study of student community. Results of the case study are promising and illustrate the capabilities of the optimization model in minimizing business commute emissions, time, and cost.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-219

Efficacy of an Extensive Green Roof in Combination with Storage in Runoff Management from Storms of Varying Intensities

Biman Paudel
Rajesh Seth
Donald Carpenter

Abstract:

Provision of green roofs in an urban environment can have several benefits including reduction of urban heat island effect, energy savings through insulation, and reduction in stormwater runoff. While green roofs may be effective in controlling runoff from small low intensity storms, their efficacy in runoff management for higher intensity storms may be limited.

In this study, the efficacy of a 10 cm extensive green roof in combination with varying storage capacity was evaluated for runoff management from storm of recurrence intervals varying between 2 – 100 years in the Windsor Essex Region. Design storms were simulated using NRCS Type II rainfalls with storm period of 24 hours and recurrence intervals of 2 - 100 years for Southeast Lower Michigan. A simple mass balance model previously developed and tested was used to simulate runoff control by the green roof. The results show that stormwater retention by the green roof was not sufficient to reduce the peak runoff to pre-developmental levels or lower for any of the 2 – 100 year storms. However, the green roof in combination with varying amounts of additional storage can be effectively used to achieve different stormwater runoff management targets. For an area of 1000 m² in the Windsor Essex Region, a 10 cm extensive green roof in combination with an additional storage of 40 m³ can reduce the peak flow to pre-developmental levels for all of 2 – 100 year storms. Increasing the additional storage to 90 m³ can allow for retention of the entire stormwater runoff from storms of up to 100 years recurrence interval. The captured runoff can be beneficially reused for alternate uses such as toilet flushing or landscape irrigation, which also reduces the need of municipal water supplied.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-221

Surviving the Earthquakes of New Zealand - How Advanced Composite Retrofit Techniques Provided Resilient Infrastructure

Scott Arnold
Amber Wagner

Abstract:

On November 14, 2016 the M7.8 Kaikoura earthquake hit near Wellington New Zealand and set off over 900 aftershocks. We received word that the severe ground displacements had caused damage to areas that contain structures that had been retrofitted with our advanced composite systems. Our local personnel surveyed some of the damage near an office building that was affected. The office building, Shed 39, not only survived the event, but was also fit to remain in service. An adjacent building that was only 10-years old will be demolished due to the sustained damage and several other nearby buildings were taken out of service due to safety concerns. The retrofit of the building included unique detailing that involved advanced composite anchors along with a technique to allow for movement across construction joints. We have sent our engineers to inspect several other structures in the area that were also retrofitted with our advanced composite systems and to work with the local engineers to learn from these events. This presentation will highlight the buildings and bridge structures that have been proof tested and quickly review the various design and detailing approaches that helped to create resilient structures.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-227

Shelter in Place Design for Toxic and Flammable Hazards

Anay Raibagkar

Abstract:

This case study will present findings from a project where BakerRisk developed risk mitigation options to protect the occupants of a control room building from the consequences posed by toxic hazards in a Chemical Processing facility.

The primary hazards considered in the study were Ammonia and, hydrogen sulfide. For the purpose of determining the maximum concentrations that would occur inside the building, infiltration rate for the building was determined using a CO₂ tracer gas test. Furthermore, infiltration rate for various weather conditions was predicted using analytical models.

First a dispersion analysis was performed to calculate the toxic concentration outside the building. Analysis showed that the hydrogen sulfide cloud reached the building in 5 minutes or less and the maximum exterior toxic concentration at the building would be 600 parts per million (ppm). Hydrogen sulfide infiltration driven by the HVAC and the building's infiltration rate showed the interior toxic concentration at 60 min would reach 134 ppm. This corresponds to a concentration dosage that exceeded the dose required to sustain a vulnerability of 0.1%.

Based on these findings, BakerRisk developed three design recommendations for mitigation of toxic exposure. First option utilized a clean air supply to create a positive pressure environment within the building. The second option considered the use of a direct air supply (Air Bottles) for the operators in the control room to provide breathing air for the maximum expected duration of the emergency operation. The last option consisted of increasing the leak tightness of the building and using gas scrubbers to clean the toxics that would infiltrate in the building. The presentation of the case study will include a discussion on the hazards, methodology and the proposed mitigation measures.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-228

Planning for and Responding to Water Shortages Using Simple, In-House Computer Models - City of Camrose

Jeremy Enarson

Abstract:

In 2013, the City of Camrose received approval from the Province of Alberta to withdraw an additional 1.58 million cubic metres of raw water from the City's primary water source, Driedmeat Lake (part of the Battle River Watershed). The City requested this new license to facilitate future municipal growth, as well as to support the raw water needs of a new industrial facility that was developing in the area. However, as water allocations from the Battle River was nearing its upper limit, part of the Province's approval of this license included a requirement for the City to develop a water shortage response plan (WSRP), which would be implemented during times of potential water shortage (i.e. extended drought situations).

Over the course of the next two years, the City worked to develop its now-approved WSRP. As part of that plan, the City created an in-house spreadsheet model to track the water flows into and out of Driedmeat Lake, predicting the amount of water remaining in the lake and thus predicting the amount of time available before the Province would impose mandatory water restrictions on the City. A draft plan was presented to City Council in the fall of 2016, after which the draft plan was circulated to the community and to the City's regional partners for review and input. The plan was ultimately brought back to Council in early 2017 and was recently approved by City Council.

The purpose of this presentation is to provide an overview of the process used in developing the final WSRP and the spreadsheet model that the plan is based on. While being a fairly simplistic representation of the lake, the model provides results that are reasonably accurate to allow City Administration to prepare the community and its regional partners for potential water shortage situations.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-233

Civil Engineers and Canada's Sesquicentennial - Building Canada's Infrastructure for more than 150 Years

Alistair MacKenzie

Abstract:

Civil Engineers build the infrastructure that supports our daily lives and adds to our quality of life and Civil Engineers have been building Canada's infrastructure from long before Confederation. Canada has a rich and varied Civil Engineering Heritage. This Case Study looks at the development of Civil Engineering in Canada from its earliest roots and discusses the most significant early infrastructure works which influenced this development.

Native Americans built many elaborate earthworks in the remote past, their purpose as yet unexplained. They later developed very successful and innovative shelter building techniques and developed of water transportation routes which covered vast areas of the country. The Companies running the fur trade further developed these aboriginal water routes to their advantage, including the first canal in Canada and they also built a number of significant fortifications for protection.

First, the French, and later the British Military followed this up by constructing further forts and it was the British Military who constructed the first canals on the St. Lawrence and Ottawa Rivers.

From this point, the "Military" engineering gave way to "Civil" works with further canal building, quickly followed by the "railway age". The Construction of the transcontinental Canadian Pacific Railway, together with the Intercolonial Railway were key works which transformed the fragile Confederation of 1867 into a true country.

Since that time we have seen the growth of both "homegrown" and "imported" talent which has developed the Civil Engineering profession into today's strong profession. This Case Study examines a number of those key infrastructure projects of the past which laid the foundation for present day Civil Engineering successes.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-235

Deployment of a Large-Area Geotechnical Monitoring System in an Arctic Mine

Vincent Le Borgne
Jean-Marie Br  h  

Abstract:

Construction and management of dams and dikes in arctic mines is still to this day a challenge. One sometimes overlooked component of these structures, which contributes to their successful management and long term health, is a modern instrumentation system. GKM Consultants, in collaboration with Agnico Eagle Mines, has developed, installed and maintained a complex network of geotechnical instruments at the Meadowbank mine. Located in Nunavut, the Meadowbank mine is an open-pit gold mine being excavated below the groundwater level in very close proximity to a number of lakes. The monitoring program measures piezometric pressures, ground temperatures and soil displacement.

The three main types of instruments which were installed each posed their own challenges. Thermistor strings, while a critical component of many arctic projects, can prove to be very difficult to install in temperatures below -20  C. The ever changing configuration of the dikes requires creative solutions for extending cables and maintaining function of both thermistors and piezometers over many iterations. Time Domain Reflectometry (TDR) cables were used to measure soil deformation of in the vicinity of the pits. While periodic manual acquisition of measurements is sufficient for some locations, many critical instrumented sections require constant monitoring.

The large-scale deployment of the geotechnical monitoring system over an area of several square kilometers in difficult to access terrain, requires a unique and custom-made communications system. By properly tailoring the network and its radio links, it is possible to offer constant coverage of the critical parts of the exploitation and residue dams. By combining this system with an online data visualization software, it is possible for engineers and managers to access in near real-time the current state of the worksite.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-236

Climate Change Vulnerability and Risk Assessment of Akwesasne Water and Wastewater Infrastructure

Guy Felio
Elmer Lickers
Henry Lickers
Jay Benedict

Abstract:

Akwesasne is a community of approximately 12,300 people (2016) distributed over an area of 11,720 acres and governed by The Mohawk Council of Akwesasne (MCA). The community comprises three districts: Kawehno:ke (Cornwall Island, Ontario), Kana:takon (St. Regis, Quebec) and Tsi Snaihne (Snye, Quebec). MCA operates the Community's water and wastewater system to service the population of the three districts. As many other communities in Canada, Akwesasne is not immune to extreme weather and climate uncertainty, and has experienced meteorological events that have caused service disruptions and damage to its infrastructure.

In 2016, Akwesasne in collaboration with the Ontario First Nations Technical Services Corporation (OFNTSC) and Engineers Canada, obtained funding from Indigenous and Northern Affairs Canada (INAC) to conduct a vulnerability assessment of its water and wastewater (W/WW) infrastructure using the PIEVC Protocol. The infrastructure assessed in this project is typical of water and wastewater systems found in small to medium size communities. It is particular however because of the geography of the territory served and the presence of the St. Lawrence River. This represents two challenges:

- Independent systems for Cornwall Island and St. Regis/Snye
- Access to St. Regis and Snye requiring crossing through the USA.

In general, future climate projections for the area show rising temperature trends higher in winter than summer. Although total annual or seasonal precipitation projections do not show definite trends up or down, recent weather and climate models indicate changes in precipitation patterns, for example: increased number of freezing rain events; winter rain; drought and heat waves followed by short duration/high intensity rain events. The presentation provides a description of the infrastructure assessed, risks under current and future climate projection, and the risk mitigation and adaptation measures recommended to the operators and owners of the systems.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-237

Structural Upgrade of a Deficient Steel Structure using an Integrated Reliability-Based Approach

Milos Rajic
Fadi Oudah
Patrick Polujan
Glen Norlander
Jasmine Bagga
Zoran Paunovic
James Chen

Abstract:

Amec Foster Wheeler's Special Structures group was recently involved in a challenging structural upgrade project. The project aimed at assessing the condition of existing 100 m tall Coker towers at one of Alberta Oil Sand plants. The structures were found deficient under code-specified wind loads. North American design codes and standards lack proper guidelines for risk evaluation of deficient steel structures subjected to extreme wind events. Amec Foster Wheeler developed a unique assessment and a design approach to suite the client needs and to rationalize the safety of the structures. The approach integrates two pioneering Structural Engineering tools to develop an upgrade program for the deficient structures; pushover analysis, and reliability-based design. The pushover analysis was utilized to identify the structural members that are critical to the overall stability, deformation capacity, and strength of the overall structure. The reliability-based design approach was implemented to selectively upgrade or strengthen the critical members to achieve a code-specified safety limit against the governing design loads. The unique approach implemented in this work was focused on the overall stability of the structural system, as opposed to conventional component-based structural assessment. The novel approach yielded a safe structure with limited upgrade work.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-239

Case Study on the Design and Construction of the Deltaport Causeway Overpass

Stuart Culpan
Jianping Jiang

Abstract:

The Deltaport Causeway Overpass in Vancouver B.C. was the centerpiece of a \$45 million upgrade of the transportation infrastructure at Canada's busiest container port terminal. The project included the design and construction of a curved overpass located on a narrow causeway in an area of highly sensitive soils. The aim of the project was to improve vehicle access to the terminal by separating road and railway traffic at a critical bottleneck junction, and to contribute an additional 200,000 container units of annual capacity at the port.

This case study will describe the technical challenges and the innovative engineering solutions that were implemented to accommodate the tight geometric constraints of the site while maintaining minimal impacts to terminal operations. The key technical challenges included:

- (1) The close proximity of the rail tracks required that the bridge have very slender columns. The innovative design used small-diameter reinforced concrete columns with an externally-bonded fiber-reinforced polymer (FRP) wrap. The FRP wrap confined the concrete core, and ensured sufficient ductility to meet the structural design capacity;
- (2) The depth to bedrock precluded the installation of deep-pile foundations and a shallow piling system was selected. The piles were constructed using expanded-base concrete 'Franki' piles that were founded within a zone of stone-column ground improvement. The piles were built by driving a zero-slump concrete mix out the bottom of a steel casing to form the load-bearing compression and tension bulbs;
- (3) The potentially liquefiable soils at the site dictated the use of a state-of-the-art lightweight-fill solution for the bridge-approach embankments. The three approaches were constructed using expanded polystyrene (EPS) blocks, aka "geofoam". By harnessing the super lightweight properties of EPS-geofoam the embankments were constructed at a relatively shallow depth, and limited the weight applied to the load-sensitive foundation soils.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-240

The Use of Orthotropic Steel Deck for Short Span Movable Bridges

Éric Lévesque
Maxime Ampleman

Abstract:

The superstructures of the Hastings swing bridge (2016) and the Kingston Mills swing bridge (2017), two small bridges in Ontario, have recently been replaced and rehabilitated. The Hastings swing bridge is located in the Village of Hastings, Ontario, Canada. The structure is a 2,200 square foot (204 square meter) swing bridge. Canam-Bridges replaced its 83.8 foot (25.6 meters) long by 26.7 foot (8.2 meters) wide superstructure (deck + main stringers + superstructure frame). The Kingston Mills swing bridge is located in Kingston, Ontario, Canada. The general contractor replaced the deck superstructure in 2017 and also rehabilitated some existing elements. The structure is a 1,440 square foot (134 square meters) swing bridge with a length of 55.9 foot (17.0 meters) and a width of 25.7 foot (7.8 meters). Both movable bridges are owned by Parks Canada. For the two bridges, the main challenges were similar. First, the weight of the new bridge superstructure and deck had to be low enough for the existing mechanical and electrical elements in the substructure to support its movement. Second, the demolition and reconstruction of the bridge had to be completed quickly during winter in order to avoid disturbing the navigation season.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-241

Philip Avenue Overpass Project

Amrita Banerjee
Reda Aiouch

Abstract:

The Philip Avenue Overpass project was included in the North Shore Trade Area Study to improve the existing rail corridor between Lions Gate Bridge and the Ironworkers Memorial Second Narrows Bridge.

The project includes:

- A bridge crossing CN railway and local roads;
- Lightweight fill approach embankments;
- Reconfiguration of the CN Transload facility and Kinder Morgan Vancouver Wharves terminal;
- Extensive utility relocations;
- Ground improvement;
- Environmental remediation; and
- 590 metres of noise barrier walls.

The project was funded by the Government of Canada, the Province of British Columbia, CN Rail, the District of North Vancouver and Kinder Morgan.

WSP Canada Inc. (WSP) provided a full array of project management, engineering design, and other technical services for the project through to the completion of the construction tender package. This work included preparing a Project Definition Report to provide a basis for project funding agreements, outline the business case, scope, permitting process, land disposition, funding, risk management plan, delivery method, budget, and stakeholder consultation approach. Subsequently, the consultation, detailed design, permitting, and the preparation of the construction tender package was also completed.

R.F. Binnie & Associates Ltd. provided project management following the detailed design through the construction phase of the project to completion. The project was guided by a steering committee consisting of all partners, with the District of North Vancouver delivering the construction phase.

The project was completed in July 2016.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-242

City of Vancouver - Green Fleet Plan

Amy Sidwell

Abstract:

In 2013 the City of Vancouver developed a Green Fleet Plan to reduce fleet asset based carbon dioxide (CO_{2e}) emissions. The objective of the plan is to reduce CO_{2e} emissions from these assets 30% below 2007 levels by 2020. This plan was developed in support of both the Greenest City 2020 Action Plan and Vancouver's internal Corporate Strategic Business Plan. Reducing CO_{2e} emissions reduces Vancouver's overall carbon dependency, enhances energy resilience, conserves energy and resources, and enhances the health of the ecosystem.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-244

Water Transfer Project from Tajikistan to Iran and Iranian Oil and Gas from Iran to Tajikistan

Shahram Yarmand

Abstract:

This case study discusses a water transfer project from Tajikistan to Iran in exchange for a transfer project of Iranian oil and gas from Iran to Tajikistan. The initial cost of the project is estimated at about 6 Billion US dollar to build a 600 km pipeline to supply water, oil, and gas. The construction of the project is estimated to take four years. Although Tajikistan and Iran have agreed to initiate the project, other countries in the Aral Sea basin did not support this project. The two main problems are the political aspects around geographical conditions of the countries around the Aral Sea basin and the business model of the international water trading. Geographically, the Aral Sea basin covers an extensive area of Central Asia, Tajikistan, Turkmenistan, Uzbekistan, Kyrgyzstan, Kazakhstan, Afghanistan, and Iran. Perlman, Veilleux, Zentner, and Wolf (2012) argue that there is a substantial risk to water security and a conflict between all basin users since the countries have been developing initiatives for agriculture and industry. However, Iran prepared a business model for water trading as well as oil and gas trading. The main idea put forward in this case study is that in addition to assessing hydropolitical vulnerability and resilience in the basin we also need to analyze the mutual benefits of trading water in exchange for oil and gas.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-245

Sharing the experience of exploring Envision: A Case Study of The North East False Creek Project

Raghav Grover
Megan Pate

Abstract:

The development of sustainable rating systems for the construction industry was initiated with Paasive House and BREEAM in the 1990s and LEED in the 2000s. The focus of these initial rating systems was vertical structures i.e. buildings, houses, hospitals, etc. Recently, there has been an increased interest in sustainable rating systems for all civil infrastructure projects. This has resulted in the development of systems such as Envision, BREEAM Infrastructure, CEEQUAL, and GreenRoads. There is limited literature available on the infrastructure rating systems and tools themselves, particularly with regard to critical analysis of outcomes and experiences related to field use (Griffiths et al, 2015). For the present, although none of the systems are recommended as a universal panacea, a study of any or all of them would help in developing an understanding of the subject (ACEC, 2014). This case study presents the City of Vancouver's experience with initial exploration of Envision, an infrastructure rating system developed in the US in 2012. The main objective of this case study is to share the processes related to decision making on selecting a rating system, training of employees and provide insights on the exploring the potential of using Envision during the design phase of the project.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

GEN-246

Achieving Organizational Quality Management: A Municipal Perspective

Maria Luisa Barroga
Dane Doleman
John Brodie

Abstract:

This case study describes the preparation that the City of Vancouver undertook to obtain the Organizational Quality Management (OQM) Certification from the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC) and the lessons learned from its implementation.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-500

Structural Dynamic Characteristics of the London Ancient Egyptian Obelisk

Mohamed Darwish
Mohamed Rashwan
Ahmed El Sayed

Abstract:

An ancient Egyptian obelisk is located in London, UK. This obelisk is one of several ancient Egyptian obelisks located in major global cities. Within this study the mechanical properties of the red Aswan granite of which the obelisk is made are experimentally studied. Following on that, the structural dynamic characteristics of that monument are studied through performing an eigenvalue modal analysis. After that a time-history dynamic analysis is performed in order to assess the response of the obelisk under a scaled historical earthquake. The obelisk is found to be safely capable of withstanding the earthquake load.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-502

Parameters Affecting the Dynamic Behavior of the Machine Foundations

Mahmoud Hassan

Abstract:

The industrial facilities like petrochemical plants, oil production facilities, power plants, etc., have a number of centrifugal and reciprocating machines. Foundation for these machines should be designed such that the dynamic forces of machines are transmitted to the soil through the foundation in such a way that harmful effects are eliminated. The analysis of machine foundations under dynamic loads is considered a very complex problem because of the interaction of the structure, the subsurface soil, and the vibrating machine. In this paper, the dynamic response of a large pump-foundation system is investigated. The study examines the effect of embedment depth, soil stiffness, soil damping, pile length, foundation mass, and pile type on the dynamic behaviour of shallow and deep block foundations. The current study would be helpful for the practising engineers to determine reasonable foundation dimensions with the minimum the number of design iteration.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-503

Different Approaches to Model Cover Cracking of RC Structures due to Corrosion

Arman Roshan
Beatriz Martin-Perez
Martin Noel

Abstract:

Corrosion is an electrochemical process in which iron, water, and oxygen are consumed to produce corrosion products that occupy a greater volume than the parent iron. This expansion leads to a buildup of pressure at the reinforcement and concrete interface. Being weak in tension, the concrete cover will eventually crack to release the expansion pressure.

This crack propagation can be modeled analytically or numerically; since cracks due to corrosion form longitudinally and parallel to the reinforcement, the cracked cover is usually represented by two-dimensional models. Although many numerical and analytical models have been proposed during the past years, they are not quite successful in the prediction of the time associated with the appearance of the first crack at the concrete surface.

In this study, two approaches were employed to model corrosion-induced crack propagation: an analytical solution based on a thick-walled cylinder analogy, and a finite-differences solution which treats cracked concrete as an orthotropic material. The first approach considers the partially cracked concrete cover as a combination of an outer un-cracked thick wall cylinder and an inner cracked concrete cylinder. Concrete is considered as a brittle material, and shear stresses are neglected. These assumptions simplify the problem enough to be solved using a closed-form solution. The second approach models concrete with strain-softening assuming smeared cracking. Smeared cracking is useful for representing concrete behaviour in tension, especially at the initial stages of corrosion when several microcracks have formed and none of the cracks are distinctly larger than the others. A program was developed using MATLAB to solve the problem numerically using finite differences.

The results obtained using each approach were compared against each other as well as against experimental results. In general, the observed trends from experimental measurements were captured by the modelling approaches used. The advantages and disadvantages of each modelling approach are discussed.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-505

Seismic Vulnerability Assessment of Pre-Code Frame Building Retrofitting Using Buckling Restrained Braces

Anas Issa
Aman Mwafy
Shahria Alam

Abstract:

A systematic seismic vulnerability assessment of a benchmark 8-story structure representing pre-seismic code frame buildings in a highly populated and seismically active area is conducted in this study. Detailed structural design and fiber-based modeling are carried out for the reference structure. Forty earthquake records are selected to represent potential earthquake scenarios in the study area. A large number of inelastic pushover analyses (IPAs) and incremental dynamic analyses (IDAs) are performed to select the performance criteria and to derive fragility relationships for the reference building. It is concluded that this category of pre-code structures is substantially vulnerable to seismic loads. The derived fragility curves for the retrofitted reference structure using Buckling Restrained Braces (BRBs) proved that such technique is efficient in reducing the seismic losses of pre-code frame structures and increasing public safety.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-506

Influence of Ti₂Ni Precipitates on Phase Transformation of Ni-Ti-Fe Shape Memory Alloy

Yulong Liang
Shuyong Jiang
Shahria Alam
Yanqiu Zhang

Abstract:

Three novel shape memory alloys (SMAs), Ti_{51.8}Ni_(45-x)Fe_{3.2}Si_x (x=0.3, 0.6, 0.9at.%), were designed in order to investigate the influence of Ti₂Ni precipitates on the phase transformation and mechanical properties of Ni-Ti-Fe-Si alloys. By adding a small amount of silicon and increasing the content of titanium, plenty of Ti₂Ni precipitates will generate in the Ni-Ti-Fe-Si alloys. The addition of varying contents of silicon has a great influence on the size and shape of Ti₂Ni precipitates. As a hard and brittle precipitate, the Ti₂Ni precipitates, which have different sizes and morphologies and were surrounded by strain fields, can affect the phase transformation behavior and mechanical properties of Ni-Ti-Fe SMAs. Results show that the phase transformation behavior of three kinds of Ni-Ti-Fe-Si alloys is almost same, while the transformation temperature exhibits a slight variation by changing the size and morphology of Ti₂Ni. Findings also revealed that the rupture strength of Ti_{51.8}Ni_{44.4}Fe_{3.2}Si_{0.6} can reach 1550 MPa due to the presence of small Ti₂Ni particles. By comparing Ti_{51.8}Ni_{44.1}Fe_{3.2}Si_{0.9} and Ti_{51.8}Ni_{44.7}Fe_{3.2}Si_{0.3}, it was observed that the yield strength can be improved at a certain size of Ti₂Ni precipitates.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-507

Seismic Vulnerability Assessment of a Long-Span Cable-Stayed Bridge Isolated by SMA Wire-Based Lead Rubber Bearings

Shuai Li
Farshad Hedayati Dezfuli
Jingquan Wang
Shahria Alam

Abstract:

The seismic performance of a newly developed smart isolation bearing, called shape memory alloy wire-based lead rubber bearing (SMA-LRB) has been studied in detail. In this regard, the efficiency of such smart isolation systems for the seismic response control of long-span cable-stayed bridges has also been verified. However, their reliability in isolating such huge structures has not been thoroughly investigated. The aim of this study is to evaluate the seismic fragility of a cable-stayed bridge isolated by SMA-LRBs. The Sutong Cable-stayed Bridge in China, with a main span of 1088 m, is taken as case study. A developed constitutive model of SMA-wire based rubber bearings was implemented in OpenSees and a 3D finite element model was generated in the same software. The pier, tower, and isolation system were chosen as 3 major vulnerable components. Results show that equipping lead rubber bearing with SMA wire increases the reliability of the bridge. The bridge system equipped with SMA-LRB undergoes damage with a smaller risk compared to LRB.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-508

Performance Evaluation of Carbon Fiber-Reinforced Elastomeric Isolators (C-FREI) through Experimental Tests

Farshad Hedayati Dezfuli
Shahria Alam

Abstract:

Recent studies showed that new elastomeric base isolation systems (rubber bearings) can be produced by using fiber fabrics as reinforcement in the place of steel shims. This type of bearings can be fabricated through a simple and cost-effective manufacturing technique called cold-vulcanization process. In this study, scaled size rectangular carbon fiber-reinforced elastomeric isolators (C-FREIs), which have been cold-bonded fabricated, are tested under vertical compression and lateral cyclic displacements. Vertical and lateral responses of C-FREIs are obtained and analyzed in order to evaluate their performance in terms of flexibility and energy dissipation capacity. Results reveal that C-FREIs possess acceptable amounts of stiffness and equivalent viscous damping compared to traditional steel-reinforced rubber bearings. As a result, these new isolation systems can be safely used instead of heavy and expensive steel-reinforced elastomeric bearings in civil applications, such as low rise residential buildings, in developing countries.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-509

Compressive Strength Enhancement of Low Strength Concrete Subjected to Freeze-Thaw Effect Using GFRP Confinement

Mosharef Hossain
Shahria Alam

Abstract:

Concrete is the most vital material for any kind of reinforced concrete structure. Very often it is likely to happen that, the specified required strength cannot be attained from the mixture because of improper mix design, inadequate compaction and several other uncertainty factors. Thus to improve the capacity of existing low strength concrete structures retrofitting is necessary with different external confining materials. An experimental investigation is made in this study to observe the effect of GFRP confinement on the compressive strength of concrete. Cylinders having GFRP confinement of different thickness are tested and improvement in their performance is observed under compression. Woven roving fiberglass as the reinforcing material and polyester resin as binding material are used to form GFRP. Cylinders subjected to freeze-thaw effect for a year and having a very low compressive strength are considered for this study. Results of the tests show that the GFRP confinement improves the compressive strength as much as 140% with the increase in the thickness of confining layer. Also the failure pattern of the concrete changes to more brittle type with increasing thickness of the GFRP layer.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-510

Cyclic Behavior of Post-Tensioned Steel Connections with Shape Memory Alloy Angles

Ahmad Rahmzadeh
Shahria Alam

Abstract:

Following the 1994 Northridge earthquake, a number of code-designed steel moment frame buildings experienced unanticipated brittle fracture in beam-column connection areas. Reinforcing beam flange and using reduced beam section were some solutions to localize damage at a predefined region. Although such configurations keep the damage away from critical areas, the residual drift after experiencing large deformations is inevitable. Post-tensioned steel connections are meant to overcome this problem. In such innovative connections, high strength steel strands are utilized and post-tensioned to provide a connection with self-centering feature. Bolted top and seat angles can be added to these systems to serve as ductile components and dissipate energy. Shape memory alloys (SMAs), with excellent superelastic property and flag-shaped hysteresis, can be used to reduce localized damages in the angles and increase the energy dissipation capacity of the post-tensioned steel connections. In this paper, three-dimensional finite element analyses are conducted to study the seismic performance of the post-tensioned steel connections with angles made of SMA material.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-511

The Dynamic Analysis of a Novel Shape Memory Alloy-Based Bracing System

Shahin Zareie
Shahria Alam
Rudolf J. Seethaler
Nadia Mohammad Mirzai

Abstract:

Shape memory alloys (SMAs) reveal unique characteristics including shape memory and superelastic effects which make them excellent candidates for civil infrastructure applications. They can have a great effect in preventing the structural damages which might occur during earthquake events. The smart system in which SMA is used can undergo a large amount of deformation and return to its initial shape after the removal of loading, and dissipate energy of loading. Due to the recovery capability (superelasticity) of SMA, the novel SMA-based bracing system is proposed to implement into building. It improves the dynamic behaviour of building by mitigation of seismic hazards and dissipate energy with re-entering capability in tension and compression mode during and after seismic events.

In order to examine the performance of suggested system, a 3-story steel frame is modeled with and without the bracing system. Dynamic analyses are conducted to investigate the effect of bracing on the response of the structure.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-516

Towards Development Length Criteria for Plain Reinforcing Bars in Tension

Lisa Feldman
Umesh Poudyal

Abstract:

Adequate bond between reinforcing bars and concrete is necessary for the optimum performance of reinforced concrete members. Many historical structures are reinforced with plain bars and these structures have reached an age where they require rehabilitation. A proper understanding of bond between plain bars and the surrounding concrete is therefore required; however, current Canadian and U.S. codes that include evaluation criteria for reinforced concrete contain no such provisions. An experimental program including approximately thirty lap splice specimens reinforced with plain round or square longitudinal bars in the top or bottom position is being conducted at the University of Saskatchewan. The focus of this work is to establish criteria for lapping and developing plain reinforcing bars in tension using a similar approach as reported for modern deformed bars. This paper will present the result of the experimental investigation and the subsequent analysis used towards establishing provisions for the evaluation of members reinforced with this historical bar type.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-518

Non-Contact Non-Destructive Infrared Thermography based Evaluation of Reinforced Concrete Structures

Harsh Rathod
Rishi Gupta
Sean Blaney
Balasubramanian Esakki

Abstract:

Periodic inspection is an integral part of Structural Health Monitoring (SHM) for the safety and reliability of civil infrastructures. Conventional SHM procedures tend to be laborious, time consuming and capital intensive. Especially in the case of large span bridges, traditional methods are not effective for rapid full field monitoring. The proposed research work uses a non-contact non-destructive evaluation technique based on infrared thermography to detect the artificial defects in reinforced concrete slabs. For this work, a total of nine 1800 mm × 460 mm reinforced concrete slabs with varying thicknesses of 100 mm, 150 mm and 200 mm have been prepared. Thermal images of each slab sample have been captured during the heating and cooling hours of the day. To better understand the thermal profile of the slabs during the heating and cooling hours, type T- thermocouples have been inserted at different locations and the temperature profiles have been correlated with the infrared images. Effect of depth, size and type of defects were investigated using infrared thermography. To validate the results obtained, slabs were modelled in Energy 2D simulation software.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-519

Cyclic Behavior of Post Tensioned Steel Beam Column Connection with Reduced Length Strands

Md Arman Chowdhury
Ahmad Rahmzadeh
Saber Moradi
Shahria Alam

Abstract:

The use of posttensioning techniques in steel beam-column connections can improve the re-centering capability and reduce permanent deformation. Reliable finite element model can be used to investigate the load carrying capacity of the post tensioned (PT) steel beam column connection under cyclic loading, which is both time and cost saving. The optimum performance of the PT connection depends on several design parameters. Reducing the length of PT strands can be an option to minimize the overall cost without compromising the performance. This study considers five different strand lengths which may affect the performance of the connection during cyclic loading. A three-dimensional finite element model is developed in ANSYS and validated with experimental results. Difficulties that may arise during the validation stage due to the complexity in connection geometry, bolt pretension, gap opening/closing and contact behavior are discussed. Finally, the cyclic response of those connections are examined in terms of stiffness, strength, energy dissipation capacity, and residual displacement.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-520

Experimental Investigation of Mechanical Properties of Rubberized Concrete Containing Recycled Coarse Aggregate

Kishoore Tamanna
Sadaf Moallemi Pour
Nemy Banthia
Shahria Alam

Abstract:

Mechanical properties, particularly compressive and flexural strength of concrete containing modified crumb rubber (CR) and recycled coarse aggregate (RCA) were investigated in this study. Surface treatment of CR was conducted using 20% solution of sodium hydroxide (NaOH) to improve the adhesion and bonding between CR and cement matrix in the concrete mix. In total 9 concrete mixes were prepared with three varying levels of volumetric replacement for both fine aggregate (FA) and natural coarse aggregates (NCA) by CR and RCA respectively. To specify, the replacement levels for FA by CR were 0%, 10% and 20% and that for NCA by RCA were 0%, 50% and 100%. Compression tests on cylindrical specimens and third-point loading flexural test on beam specimens were conducted to determine the compressive strength and flexural strength respectively for these concrete mixes. Results show that the compressive strength of the control mix decreases by 44% and 78% for 10% and 20% CR replacement respectively. Whereas, the reduction in compressive strength due to the increase of RCA replacement from 0% to 50% and 100% is 48% and 49% respectively from the control mix. Additionally, the reduction of flexural strength in the concrete mixes was found to be much lower than the reduction in compressive strength. To specify, the flexural strength of the mixes with 10% and 20% CR replacement was 28% and 57% lower respectively than that of the control mix. Whereas, for RCA replacement levels of 50% and 100% showed 28% and 33% reduction respectively in flexural strength of the control mix. However, the combination of 50% RCA and 10% CR in concrete exhibited satisfactory compressive strength and flexural strength of 33 MPa and 4 MPa with a reduction of strength 45% and 22% respectively from the control mix. In essence, 10% volumetric replacement of FA by CR.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-521

Efficacy of Concrete Constitutive Models for Bullet Impact Tests

Alok Dua
Abass Braimah

Abstract:

Structures such as defenses/ammunition bunkers in the military and elsewhere are generally constructed at remote locations where concrete structures are more convenient to construct. Such protective structures in most cases are made of plain or reinforced concrete due to inherent ease of planning, transportation and construction. The design of these structures is based on field tests which ideally is required to be done for each caliber of weapon for which the protective structure is designed. Such field tests are time consuming and are uneconomical. A cost-effective alternative to field testing is the use of high fidelity physics based numerical modelling techniques. However, constitutive modelling of concrete when subjected to high velocity projectiles is very complex due to factors like material erosion and strain-rate effects. These factors lead to a highly non-linear response, hence, high accuracy of the concrete constitutive model to be able to replicate such response is imperative to achieve accurate results. There are sizable number of concrete constitutive models available in various commercial software. This paper reviews the concrete constitutive models applicable for modelling bullet impact. Experimental results from field tests involving bullet impact on plain concrete for muzzle velocity of 900 m/s are presented and used to assess the concrete constitutive models in LS-DYNA. The importance of modelling parameters like strain-rate effects and erosion criteria have been reviewed. Furthermore, parametric studies have been presented to study the effect of MV and compressive strength of concrete.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-522

Understanding the Response of Reinforced Concrete Slabs Due to Contact Explosion of TNT

Alok Dua
Abass Braimah
Vasant Matsagar

Abstract:

Response of reinforced concrete (RC) structures to blast loads is now a matured field of research. UFC 3-340 design manual and similar manuals lay out the design practice for blast resistant structures. However, most of the design methodologies are restricted to far-field (scaled distance $> 1.18 \text{ m/kg}^{1/3}$). The semi-empirical charts and equations are not accurate in the near-field and furthermore very little research is available on contact explosions. Contact explosions are more complex than far-field events due to the spatially and temporally non-uniform overpressure. There are limited results from field tests available in the literature as many gauges do not survive the harsh near-field environment. Thus most finite element models in the near-field are validated based on post blast damage photos. This paper presents the results from field test conducted on RC slabs with embedded piezo-electric based concrete vibration sensors (CVS). A correlation has been shown between the concrete strains and the voltage recorded by the sensors. These results have further been compared to the numerical results from LS-DYNA. The contact explosion was modelled using the arbitrary-lagrangian-eulerian (ALE) element formulation. This study highlights the detonation process, shock wave propagation phenomenon and interaction with RC slab.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-523

Influence of Relative Humidity on Creep and Relaxation Behavior of Cement Paste at the Microstructure Level

Jessy Frech Baronet
Luca Sorelli
Zhao Chen

Abstract:

A recent survey has revealed that the deflection of concrete bridges increases incessantly over a period of more than 20 years and can exceed by far the predictions of current design recommendations. This work applies microindentation techniques, which allow quickly assessing the long term rate, to investigate the effect of relative humidities on both the viscous behavior of a cement paste.

A large campaign of microindentation tests was carried out at different relative humidities, loading histories, curing times, and load levels for both creep and relaxation testing. The correlations between creep rate, relaxation rate, and relative humidity were investigated. The results showed the increase of the relative humidity reduces the indentation modulus and hardness, but increases the long term creep rate of a cement paste. The effect of the relative humidity on the creep rate was possibly explained by local forces acting on Calcium-Silicate-Hydrates sheets or by microcracking drying effects.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-527

**Kinematic Model for Strain Evaluation in Dented Pipelines using
Multidimensional B-Spline Interpolation**

Chike Okoloekwe
Muntaseer Kainat
Doug Langer
Sherif Hassanien
Roger Cheng
Samer Adeeb

Abstract: Current trends in the analysis of dents in pipelines are turning the focus of pipeline dent integrity management schemes on the localized strain distribution rather than the traditional dent depth based criterion for reasons well documented in history and research. The strain based evaluation of dent severity however is limited by the available techniques for evaluating the strain distribution in affected regions of the pipeline as the existing numerical solvers used to perform nonlinear finite element analysis (FEA) are expensive and computationally demanding. On the other hand, the available closed form expressions in the codes are over simplified in assumptions. In this study a mathematical model is introduced for the strain evaluation of dented pipelines based solely on data relating the coordinates of the deformed profile. This novel approach employs the use of third order cubic spline functions to interpolate the deformed profile of the dented pipeline. The mathematical model developed discretizes the displacement components into the radial, circumferential and the longitudinal direction based on the linear elastic shell theory. The discretized displacement components create a platform that provides operators the liberty to constrain or release the strain based model from underlying assumptions and allows for flexibility in the choice of the strain measure. A good correlation is observed in the strains predicted by the mathematical models and those predicted from numerical models generated with FEA thus indicating the possibility of performing a more detailed strain analysis on dented pipelines without having to resort to FEA.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-528

Numerical Analysis of Steel Slit Dampers Under Cyclic Loading

Jayanthan Madheswaran
Solomon Tesfamariam

Abstract:

Dampers have been widely incorporated in the structure to enhance its seismic performance during earthquake action. Among those, steel slit damper, a type of “strip damper” which can dissipate energy through bending or shear deformation is considered in this study. Since, the width of these strips is same for entire height, damages are mainly concentrated at the end strips due to high stress. The aim of this study is to identify the suitable geometric configuration of damper which can perform better during structural application, in terms of strength, ductility and energy dissipation capacity. For this purpose, a conventional steel slit damper is numerically simulated using ABAQUS software subjected to reverse cyclic loading and validated with experimental result. Further, a detailed parametric study is carried out to reduce stress concentration on the width of strips to obtain the optimal shape for damper. In addition to that, the effect of parameter interaction and their influence in the final response is also studied using factorial design of experiments and with that predictive equation is developed using response surface method. Finally, structural characteristics of dampers for different configuration will be evaluated to consider best one for the use in real life structure for retrofitting.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-529

A Novel Approach for Stress-Strain Characterization of Metallic Materials Using the Product-Log (Omega) Function

Onyekachi Ndubuaku
Michael Martens
Roger Cheng
Arman Ahmed
Samer Adeeb

Abstract:

The true stress-true strain characterization of a metallic material may be established using a constitutive mathematical expression such as the Ramberg-Osgood stress-strain equation, or any of the various alternative stress-strain curve models which have been developed for the characterization of metallic materials over the full-range of the stress-strain relationship. Some common drawbacks of the existing models have however been observed as most of the earlier and simpler models tend to lose their predictive accuracy beyond a limited strain range whereas, as the precision of the models is improved, significant complexity is usually introduced in the later and more accurate models due to a requirement for an increased number of constitutive parameters. This paper therefore presents a relatively simple stress-strain curve model which is proven to be easily applicable, and capable of accurate predictions over the full range of strains. The proposed stress-strain model is defined using only two model parameters and unlike many existing stress-strain models, can be easily applied to materials with a well-defined yield plateau. To evaluate the applicability of the proposed model, curve-fitting techniques are employed for comparison to experimental stress-strain data obtained from cryogenic tensile tests of three different metallic materials; 300 series austenitic stainless steel (AISI 304L), 5000 (Al-Mg) series aluminum alloy (AA5083), and nickel steel alloy (Invar steel-FeNi36). Using the proposed model, excellent approximations of the nonlinear load-deformation behavior of the tested specimens are observed over the full-range of the true stress-true strain relationship.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-531

Compressive Behaviour of Concrete Cylinders Reinforced with Glass Fiber Reinforced Polymer Bars

Brandon Fillmore
Pedram Sadeghian

Abstract:

Current design standards ignore any contribution of glass fiber reinforced polymer (GFRP) bars in concrete in a state of compression. This paper challenged this convention by testing 30 cylinders of 36 MPa concrete to failure in pure axial compression. The testing matrix consisted of control groups of plain and steel-reinforced concrete specimens which were used to benchmark groups of concrete specimens reinforced with commercial and modified GFRP bars. Cylinders were built in 4, 6, and 8 bar arrangements with nominal diameters of 10M or 13M and with concrete cover 25 mm, cylinder diameter 150 mm and height 300 mm. The GFRP bars were found to exhibit crushing failure long after the concrete in the cylinders had been crushed. Commercial GFRP bars significantly increase the toughness of the specimens over unreinforced concrete, outperforming both steel and modified GFRP reinforcement in this metric. However, steel reinforcement proved to increase peak load the most over unreinforced concrete, with commercial and modified GFRP reinforcement increasing peak load by less than half as much as steel.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-532

Short Concrete Columns Reinforced with GFRP Rebars under Eccentric Loading

Koosha Khorramian
Pedram Sadeghian

Abstract:

In this paper, the compressive performance of short concrete columns reinforced with glass fiber-reinforced polymer (GFRP) composite rebars is evaluated. A total of fourteen 500 mm long concrete specimens with square cross-section (150×150 mm) were prepared and tested under concentric and eccentric compressive loading up to failure. Nine of the specimens were reinforced with six GFRP rebars (16 mm diameter), longitudinally. Different eccentricities, namely, 0, 10, 20, and 30 percent of the width of the specimens were considered. Strain of GFRP rebars were monitored during the tests to evaluate the usable level of strain and mode of failure of rebars. Also, a cross-sectional analytical model was developed and verified against the experimental results. It was observed that the GFRP rebars were able to withstand the peak concentric and eccentric loads without crushing and local buckling. It was concluded that the maximum usable strain of the GFRP rebars in compression was larger than the ultimate compressive strain of concrete.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-534

Large Size Superelastic SMA Bars: Heat Treatment Strategy, Mechanical Property and Seismic Application

Wei Wang

Abstract:

This research reports a comprehensive study on the mechanical performance of large size superelastic shape memory alloy (SMA) bars, with the main focus given to their potential applications for seismic-resistant connections. A series of practical issues, including heat treatment, mechanical property assessment, and connection design/evaluation, were discussed aiming to benefit both material and civil engineering communities. The study commenced with a detailed discussion on the heat treatment strategy for SMA bars and the resulting mechanical properties including strength/stiffness, self-centring ability, energy dissipation, and fractural resistance. It was observed that the mechanical performance of the bars were quite sensitive to both annealing temperature and duration, and size effect was also evident, resulting in different appropriate heat treatment procedures for the bars with varying diameters. The optimally heat-treated SMA bars were machined to the bolt form and were then used for two types of practical self-centring connections, namely, connection with all SMA bars and that with combined angles and SMA bars. Through conducting full-scale tests, both connections were shown to have stable and controllable hysteretic responses till 5% loading drift. Up to 3% drift, the self-centring performance was satisfactory for both connection types, but beyond which the presence of the angles could lead to accumulated residual rotation. Importantly, for both connections, the deformation was accommodated by the SMA bolts or angles, whereas no plastic deformation was observed at any other structural members. This confirmed the feasibility of using such connections for highly resilient structures where minimal repair work is required after earthquakes.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-536

Finite-Element Modelling of Reinforced Engineered Cementitious Composite (ECC) Structure under Seismic Loads

Wai Man Wong
Carlos Cruz-Noguez

Abstract:

This study addresses the mechanical characteristics of Engineered Cementitious Composite (ECC) under seismic load using Finite-Element Analysis (FEA) modeling approach. ECC is a type of high-performance fiber-reinforced cementitious composites (HPFRCC), which is tailored to exhibit microcracking behavior and achieve higher tensile ductility using micromechanical theory. Although extensive experimental studies and material testing of ECC has been conducted to date to demonstrate the improved energy dissipation capacity and enhanced damage tolerance of ECC, in terms of seismic resistance, large-scale testing results are scarce. An alternative is to use a robust finite-element (FE) analysis model, which verified with experimental results from material and component testing, to investigate the behaviour of large structures made with ECC numerically. In this study, a computer simulation of two reinforced-concrete (RC) frames, one made with ECC and another made with conventional concrete, is conducted using FE program OpenSEES. Dynamic analyses and static push-over are carried out and the response of the frames is presented in terms of strength, ductility, and energy dissipation. The advantages and limitations of the ECC material on the global structural response are discussed.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-537

Deterioration of Joints in Concrete Pavements: Investigation of Field Cores

A.K.M. Rakinul Islam
Ahmed Ghazy
M. T. Bassuoni

Abstract:

Signs of premature deterioration are customarily observed in areas adjacent to longitudinal and transverse joints in concrete pavements. These areas, in many cases, continue to hold water/solution (due to application of de-icing salts) long after wetting events. This solution can contribute to the deterioration process by physical (e.g. increasing the degree of saturation and subsequent damage due to frost action) or chemical (e.g. decomposition of hydration products and formation of expansive phases) mechanisms. Until now, the root causes of joint deterioration are not fully understood since a multitude of reactions and mechanisms are responsible for this deterioration (de-icing salts, freeze/thaw (F/T) cycles, wetting/drying (W/D) cycles, etc.). The goal of this study is to classify the source of this damage and identify aspects contributing to premature joint deterioration of concrete pavements in Winnipeg, Manitoba. In addition to visual inspection, this study involved analyzing concrete cores collected from both distressed and sound joint locations in concrete pavements. To characterize the quality and pore structure of these cores, absorption and mercury intrusion porosimetry (MIP) tests were performed. The alteration of microstructure in concrete was studied by scanning electron microscopy (SEM) with energy-dispersive X-ray analysis (EDX). It was noted that the microstructure of the cores collected from joints in concrete pavements directly exposed to de-icing salts had high intensity of micro-cracks and most air voids (both small and large) were filled with various levels of secondary depositions compared to the cores collected from concrete pavements not directly exposed to de-icing salts. Furthermore, the results indicated that the deterioration at joints is primarily caused by a combination of physical and chemical aspects.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-538

Electrical Resistivity Response of Young Normal Strength Concrete Mixes under Low Temperature Cycling

Douglas Tomlinson

Abstract:

There is desire within the construction industry for a simple but accurate method of estimating the strength of cast-in-place concrete during curing in real time. Knowing this strength will allow for more rapid construction since formwork removal, post-tensioning, and finishing can be performed earlier and with higher confidence than with existing prescriptive methods.

Electrical resistivity has been proposed as a means of predicting concrete strength but the resistivity of mixes subject to early-age freeze-thaw cycles is not well understood. This program presents the electrical resistivity responses of five concrete mixes used in the Ottawa area over their first 28 days. These mixes had varying water-cement ratios (0.35 to 0.60) and slag replacement values (0 to 30%). The mixes were thermally cycled at 1°C/hr from +24 to -24°C twice after one day of curing at room temperature.

For all mixes, resistivity increased according to the Arrhenius equation as temperature decreased. However, ice formation, which occurred between 0 and -10°C, caused a sudden increase in resistivity that no longer followed the Arrhenius equation. A method of using resistivity to estimate the ice formation temperature (the datum temperature) for each mix is presented that requires considerably less effort than existing experimental based techniques. The datum temperature decreases as concrete ages and also as the blended slag percentage increases.

Resistivity increased as water-cement ratio decreased and is shown to be proportional to concrete strength. However, resistivity also increased as slag percentage increased; this is attributed to the slower-reacting slag reducing ion mobility in the concrete. These results indicate that resistivity can be normalized based on temperature and slag percentage in order to predict the strength of cast-in-place concrete in real time.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-539

Stability of Extended Shear Tab Connections

Victoria Buffam
Robert Driver
Logan Callele

Abstract:

Extended shear tab connections are efficient for both fabrication and erection where a beam would otherwise need to be coped to clear the flanges of the supporting member, and are therefore used extensively in industry. Stability issues can arise as the plate becomes longer and more slender, as may be required in skewed connections or other complex geometries. Commonly, designers resolve the concern of stability failure by increasing the plate thickness or adding stiffeners to the connection, which increases the required material and cost. Previous studies at the University of Alberta have experimentally investigated the behaviour of extended shear tabs and found that nearly all tested specimens reached their full cross-sectional plastic capacity without buckling. Therefore, this research aims to determine when stability of the extended shear tab governs the behaviour and capacity of the connection as opposed to strength, considering the interaction of axial, shear, and bending stresses. A parametric study using finite element simulations is being conducted, in which the length of the extended shear tab is increased until instability of the plate is the governing failure mode. Additionally, the effect of axial compression on the connection behaviour is being investigated by applying a compressive load of either 10% or 25% of the plate's cross-sectional yield capacity. Preliminary results suggest that shallow connections require longer lengths and larger deflections for instability to occur prior to full plastification of the cross-section. Additionally, buckling tendency of the plate is exacerbated by the addition of compressive axial loading, resulting in shorter plates at the stability limit. Increased understanding of the behaviour of extended shear tabs derived from this research will be used to improve the associated design procedures by defining when instability becomes a potential design limit state in order to reduce design time, uncertainty, and unnecessary costs.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-542

Structural Behaviour of Sandwich Panels Constructed of Foam Cores and Flax FRP Facings

Dillon Betts
Pedram Sadeghian
Amir Fam

Abstract:

In this study, the flexural behaviour of sandwich panels constructed of flax fibre-reinforced polymer (FRP) facings and polyurethane foam cores was examined. A total of nine sandwich beam specimens (1200 mm long and 150 mm wide) made of 75 mm thick foam were prepared and tested under three-point bending. The parameters of the study were core density and facing thickness. Three different foam densities (32, 64, and 96 kg/m³) were used as well as three different facing thicknesses: one, two and three layers of a bidirectional flax fabric (400 gsm). A bio-based epoxy resin was used to make FRPs. Several different failure mechanisms were observed during the testing, including: delamination, shear, crushing of the top face, tensile rupture of bottom face, and several combinations of these failures. It was observed that the shear and delamination failures occurred mainly in the low-density foam specimens, delamination and crushing of the compression face occurred mainly in the medium-density foam specimens, and that tensile rupture of the bottom face occurred in the high-density foam core specimens. As the tensile rupture of the bottom face occurred, it was concluded that the flax FRP facings reached full capacity in these cases and the foam did not cause premature failure.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-543

Parametric Study on Fly Ash & Bottom Ash Based Alkali Activated Mortar and Concrete

Urmil Dave
Rishi Gupta
Yash Khandol

Abstract:

Environmental issues related to production of cement have sensitized researchers to make attempts to bring novelty in the field of the concrete technology. One of the results of this is alkali activated concrete using activation of alumino-silicate materials using alkaline solutions. The evolution of this concrete has been a major advancement towards increasing the beneficial use of industrial waste products and reducing the adverse impacts of the cement production. An attempt has been made by the researchers to develop cementless alkali activated concrete using the combination of fly ash and the bottom ash. This paper examines the effect of variation in source materials and other salient parameters on the compressive strength of alkali activated concrete. The initial work utilizes fly ash and bottom ash based alkali activated mortar. The initial and final setting time and consistency measurements have been taken. Suitable mix-proportioning for the alkali activated mortar was used to develop the alkali activated concrete. Parameters related to source materials that were varied during this study include: ratio of fly ash to bottom ash of 70:30, 50:50 and 30:70, amount of source material, alkaline liquid to source material ratio of 0.35 and 0.4; alkaline liquid ratio of 2 and 2.5; concentration of NaOH solution of 8M, 10M, 12M 14M and 16M; addition of super plasticizer of 0% and 1%; extra water content of 10% and 15% and rest period of 1 day and 2 days. Sodium based alkaline activators have been used for the activation process. The compressive strength was evaluated for alkali activated concrete mixes that were cured at ambient curing. Test results show the satisfactory strength attainment of the alkali activated concrete using substantial amount of bottom ash in addition to the fly ash as the source material at a lower concentration of NaOH solution under ambient temperature.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-544

100% RAP Mixes using a Soybean-Derived Rejuvenator

Mohamed Elkashef
R. Christopher Williams

Abstract:

Within the asphalt industry, interest in rejuvenators has grown more pronounced over the past several years. Rejuvenators are mainly used to restore aged asphalt to its original state. Thus, rejuvenators have made it possible to increase the amount of recycled asphalt pavement (RAP) in new flexible pavements. In this work, a proprietary soybean-derived rejuvenator is blended with a polymer modified PG 64-28 at a dosage of 0.75%. Complex shear modulus master curves were developed for the unaged, RTFO and PAV-aged control and modified binders, using frequency sweep DSR measurements. The results revealed that the soybean-derived rejuvenator improved low-temperature fatigue performance and lowered the complex shear modulus values at all test temperatures. The drop in the complex shear modulus was more prominent at high temperatures, accompanied by an increase in phase angles, which resulted in a decrease in rutting potential of the modified binder. The DSR results of the aging binders provided evidence of the continued performance of the soybean-derived rejuvenator even with long-term aging. The control and soybean-modified PG64-28 binders were then used to prepare dynamic modulus samples containing 100% RAP mixtures. The resulting rejuvenator dosage in the overall mixture was 0.12% of the total binder content. Dynamic modulus master curves were constructed for both the control and soybean-modified mixtures. The modified 100% RAP mixtures showed a slight reduction in dynamic modulus at high temperatures with no appreciable effect on the low temperature side, compared to the control 100% RAP mixtures.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-545

Buckling Resistance of Stainless Steel Welded I-Columns

Shameem Ahmed
Mohammad Anwar-Ul-Saadat
Mahmud Ashraf

Abstract:

Stainless steel is characterised by its nonlinear stress-strain behaviour with significant strain hardening. However, currently available design codes treat it as elastic and perfectly plastic material like carbon steel, which leads to conservative predictions. A new design approach called the Continuous Strength Method (CSM) has recently been developed for nonlinear metallic materials to exploit the beneficial effect of strain hardening and to eliminate the effective width approach. Recently a proposal was made to calculate the buckling capacity of rectangular hollow sections (RHS) and square hollow sections (SHS) combining CSM with Perry curves. In this paper, that proposal is extended for welded I-section. Using finite element technique the behaviour of welded I-section was investigated for major and minor axis buckling. It is observed that, behaviour of column buckling about major axis is different from that of minor axis buckling and required separate column curves. It is also found that, cross section slenderness has a significant effect on column capacity. The shapes of column curves are mostly affected by ρ . Hence imperfection factor as used in Perry formulations, is expressed as a sigmoidal function where coefficients of the sigmoidal function were expressed as a function of ρ . This technique yields separate column curves for different ρ values. Different functions for the coefficients are proposed for major and minor axis buckling. Performance of the proposed technique is compared with European guidelines.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-546

Experimental Fire Testing of Concealed Steel-Glulam Timber Semi-Rigid Bolted Connections

Adam Petrycki
Sam Salem

Abstract:

The outcomes of an experimental study aimed to investigate the fire behaviour of glulam beam-to-column semi-rigid connections exposed to standard fire while subjected to constant static load are presented in this paper. Each test assembly consisted of two glulam beam sections that were simply supported at their far ends and connected to an inversely-loaded glulam column in the middle using two concealed steel T-stub connectors. Two test variables: the bolt's end distance and the number of bolt rows, were investigated in four large-size glulam beam-column assemblies. The test assemblies were exposed to elevated temperatures followed the CAN/ULC-S101 standard time-temperature curve inside the large-size fire testing furnace accommodated in Lakehead University's new Fire Testing and Research Laboratory. Two draw-wire displacement sensors were installed outside the furnace then attached to the test assembly using ceramic rods to measure the vertical displacements of the left and right-side beams, as well as a third displacement sensor to measure the column vertical displacements. In addition, several thermocouples were implemented inside the glulam beam sections to capture the elevated temperatures at several locations and depths underneath the gradually-developed char layer during fire tests. Once the failure criterion, which is mainly deflection dependent, was reached, the test was terminated. Test results revealed that increasing the number of bolt rows from two to three rows, each of two bolts, resulted in an increased fire resistance time of a greater increment compared to that achieved by increasing the end distance from four to five-time bolt diameter.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-548

A Proposed Use of Concrete Cloth in the Repair Works of Concrete Beams

Ashraf Youssef
Ahmed Hussam
Sherif Alam El Din
Seif Diab
Ahmed Hamza
Eman El Nahas
Amr Fathy
Ezzat Fahmy
Mohamed Abou-Zeid

Abstract:

Concrete Cloth is an innovative material composed of a flexible aluminate cement powder-impregnated fabric that rapidly hardens upon hydration to form a thin, durable waterproof and fire-resistant concrete layer. The material is delivered in the form of rolls of various thicknesses that allows their placement without a need of any plant or mixing equipment. Their ease and rapid installation facilitates their use in a wide range of applications such as slope stability, ditch lining and fast deploying shelters to name a few. This study aims at achieving better understanding of the properties of the cloth material through particularly when used for repair. Tests including composition, microscopic analysis, chemical analysis, density, response to moisture were performed on the cloth.

Sets of precracked beams were prepared with crack length-to-depth ratio of $\frac{1}{4}$, $\frac{1}{2}$, and $\frac{3}{4}$. The cloth material were installed to fortify the beam using three different adhesion techniques, methods; Hilti anchors, epoxy resins and cementitious grout. The beams were examined for three-point flexural test while deflection was recorded. Initial results indicate that the cloth do enhance the flexural strength of the beams although special adjustment need to be introduced to justify their use in such repair works when compared to other repair techniques.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-549

Effect of GFRP Bar Splice Length on Flexural Strength of Jointed Precast Deck Slab with UHPFRC-Filled Closure Strip

Mohtady Sherif
Khaled Sennah

Abstract:

Reinforcement Corrosion in bridge decks and railings is significant factor limiting the life expectancy of bridge superstructure. In Canada, temperature fluctuations, deicing salts in winter times exaggerate the phenomena, leading to costly frequent maintenance or replacement. The use of glass fiber reinforced polymer (GFRP) bars as reinforcement is a viable option for the replacement of deteriorated concrete bridge deck slabs and railings. This research investigates the use of ribbed-surface GFRP bars in the closure strip between jointed precast deck slabs over girders. The jointed deck slabs utilizes two vertical shear keys. GFRP bars in the precast deck slabs are proposed to project with straight ends into the closure strip, which will be filled with ultra-high performance fibre-reinforced concrete (UHPFRC). The behavior of GFRP reinforcement in concrete is studied using full-scale tests of lap splices at the closure strip. Four different bar splice length were considered in this study, namely: 75, 105, 135 and 165 mm for closure strip widths of 125, 155, 185 and 215 mm, respectively. The mechanics of the anchorage behavior are observed and recorded to evaluate the manner in which the capacity of a straight-end GFRP bars is developed. Observations from these lap splice tests provide information on the mechanism of stress transfer between lapped bars. The Specimens are of 600 mm width, 2800 mm length and 200 mm thickness. Precast concrete compressive strength is taken as 35 MPa, while UHPFRC is of 160 MPa. 27 specimens were tested under four-point load to collapse. 6 sets of lap splices at the joint, namely: full-contact lap splices, non-contact lap splices with spacing equal to and half the bars spacing respectively., a A model for anchorage capacity is produced based on the bond strength of the GFRP bars on non-contact lap splices.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-552

Impact of Mixing Water Temperature on Portland Cement Concrete Performance

Ahmed Negm El Din
Fady Ziada
Magdi Madi
Maha Mazen
Norhan Refaat
Sherif Ahmed
Ahmed Hamza
Eman El Nahas
Amr Fathy
Ezzat Fahmy
Mohamed Abou-Zeid

Abstract:

Water is as an essential component in the concrete mix as it has a direct influence on the durability, workability, strength and other performance aspects of concrete. This study aims at assessing and quantifying the impact of mixing water temperature on the performance of fresh and hardened Portland cement concrete. In this work, concrete mixtures were prepared using different mixing water temperatures, 5°C, 15°C, 30°C, and 45°C. The temperature of the aggregates and the cement were controlled throughout the process, where sixteen mixes were poured at room temperature and two mixes were poured at 45°C in order to simulate hot weather conditions. Mineral and Chemical admixtures were used, in order to evaluate the impact of mixing water temperature on the properties and the functions of those admixtures. For each mix, two sets of tests were conducted: Firstly, fresh tests including measurement of temperature, unit weight, air content and slump retention. Secondly, hardened concrete tests were conducted including compressive and flexural strength tests as well as chemical durability. A separate set of tests were conducted to simultaneously monitor the heat of hydration for concrete samples with time. Results of the study highlight the strong impact of water temperature on concrete performance particularly at early ages. The results well justifies, in a quantitative manner, the need to incorporate cold/chilled water in hot weather conditions. Recommendations are provided for concrete applicators in hot weather conditions.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-554

Development of Nonlinear Analysis Models for Shear Wall Reinforced-Concrete Structures using the Finite-Element Method

Bernardo Garcia Ramirez
Carlos Cruz-Noguez

Abstract:

Although significant progress in the modeling of the nonlinear response of reinforced concrete (RC) structures at the element level has been achieved in the past decades, reliable and accurate analysis models at the system level for RC structures are scarce. Due to the complexity of elements required to model the 3D response of RC panels, nonlinear analysis of complete RC structures is avoided and instead the response of selected sub-assemblies, isolated from the rest of the structure, is examined in usual design practice. As a result, there is substantial uncertainty on the response of complete RC buildings, making it impossible to analyze global failure modes and making the design more complicated and potentially unsafe. Although simple structures can be designed and analyzed based on the response of their components with good accuracy, RC shear wall buildings with complex geometries or under extreme loading necessitate the analysis of the full structure. Recent progress in the development of efficient element formulations to simulate the nonlinear in-plane and out-of-plane response of RC panels, and the availability of experimental data on the response of full shear wall structures, offers the possibility of developing reliable and efficient analysis models for entire RC structures under static and dynamic loads.

My presentation discusses techniques to address the challenges found in the analysis of full, 3D RC shear wall structures such as the transmission of forces between beam and column elements and walls, the modeling of shear wall elements with confined boundary elements or flanges, and the performance of fiber section elements vs. multilayered shell elements. Finally, the creation of models that resemble the real behavior of several tests performed previously.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-555

Effects of Sample Preparation on the Results of the Oxygen Consumption Test Used to Evaluate Oxidation Potential of Sulfide-Bearing Aggregate

Mona El Mosallamy
Medhat Shehata

Abstract:

In the last decade, sulfide-bearing aggregate was reported to be responsible for severe deterioration in concrete elements. This deterioration takes place due to the oxidation of sulfide phases which produces sulfuric acid, leading to internal sulfate attack. Earlier research work came up with a test for quantifying the oxygen consumption of sulfide bearing aggregate using oxygen consumption cells. In this test method, the aggregate is processed to obtain materials passing 150 μ m sieve. The processed aggregate is then compacted into 100 mm layer in a cell of 200 mm height. Hence, the sample is exposed to a limited amount of air and the O₂ consumption is monitored over time. This paper examines the factors that affect the test results. It has been found that aggregate processing has a great effect on the oxidation. Processing the aggregate using the commercially available disk pulveriser with steel plates resulted in the presence of iron powder in the crushed materials. For more evaluation of this behaviour, a sand sample was crushed in iron disk pulveriser, and another sample from the same sand was crushed using ball milling with stainless steel balls. The first sample showed high oxygen consumption, while the second sample crushed using stainless steel balls showed very little or no consumption. When 5 % by mass iron powder was also added to the sand sample crushed using stainless steel balls, a high oxygen consumption was recorded and found to be close to the measured consumption of the sand crushed in the disk pulveriser. Based on the obtained results, a method to process aggregate samples was recommended and adopted for a number of different aggregates. The results are presented and analysed in this paper.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-556

Using Graphene as a Nanofiller in the Construction Industry

Cherif Khalil
Mohamed Abou-Zeid

Abstract:

This paper provides a literature review which is intended to explore and give an overview about the use of graphene as a nanofiller in the construction industry. The paper starts with providing detailed information concerning the need for adopting micro reinforcements and fibers in the ordinary Portland cement (OPC) structures. Then the paper explores the limitations of using these micro fibers compared to using engineered nanomaterials. Furthermore, the paper briefly discusses the effect of using two engineered nanomaterials currently employed in the construction industry, namely the Nano silica and carbon Nano tubes while highlighting their shortcoming. In addition, the paper discusses in details the graphene and its different forms. Moreover, the advantages of both the graphene nanoplatelets and the graphene oxide are thoroughly investigated to highlight the benefits of their adoption in the composite over the ordinary Portland cement structures. More specifically, this research shows that the incorporation of graphene in the construction industry due to its higher specific surface area and aspect ratio increases the cement hydration making the section in consideration more dense, durable, ductile, more resistant to higher compressive strength and tensile strength, more resistant to thermal cracking and to the phenomenon of freeze and thaw, and also more resistant to fire, impact and blast compared to the OPC structures. Last but not least, limitations and barriers that currently hinder the widespread adoption of the graphene in the construction industry are presented hoping that future research could tackle them because it is expected that the adoption of graphene will revolutionize the construction industry while preserving and sustaining the environment.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-558

Predicting the Shear Resistance of SFRC Beams

Michael Cohen
Stanislav Potapenko

Abstract:

This paper presents a literature review on the shear behaviour of steel fiber reinforced concrete (SFRC) and proposes equations for predicting the shear resistance of SFRC beams. First a large database of test results is used to evaluate the effect of various parameters on the shear response of SFRC beams. In addition, the paper reviews various equations proposed in the literature to predict the shear capacity of SFRC beams. The paper then presents equations which can be used to predict the shear resistance of SFRC beams. The shear resistance equations modify the general method of the 2004 CSA A23.3 Standard to account for the effect of steel fibers on shear capacity. The method proposed in this paper and equations proposed in the literature are used to predict a large database of SFRC beam test results. The results show that the method presented in the paper provides reasonably accurate predictions of shear capacity for beams having a wide range of properties.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-559

Evaluating the Potential Alkali-Silica Reactivity of Mineral Fillers: A Preliminary Study

Noura Sinno
Medhat Shehata

Abstract:

Mineral fillers have been used in concrete to achieve certain properties such as self-consolidation. Different sources of fillers are present depending on the type of original rock from which the filler is produced. The potential of mineral fillers to cause alkali-silica reaction when used in concrete is a concern. This research focuses on modifying the accelerated mortar bar test to evaluate the alkali-silica reactivity of mineral fillers. The effects of different levels of mineral fillers on workability and expansion of mortars are studied. Three different mineral fillers are tested: a calcium-carbonate filler, a carbonate filler with 27% SiO₂, and a siliceous filler produced from reactive aggregate. The gradation of mortar samples is done as specified in the accelerated mortar bar test described in the Canadian and American Standards, CSA A23.2-25A and ASTM C1260. Two types of sand are used which had different levels of expansion when tested using the accelerated mortar bar test. Two replacement methods of sand by filler are adopted where the filler is taken as a percent from the sand finest portion, or from the total graded sand. The results showed that workability of mortars decreases as the filler replacement level increases. In addition, a minor decrease in workability of samples with fillers being replaced from the total graded sand was observed compared to the samples where the filler replaced only the finest fraction of the sand. As for the expansion due to alkali-silica reaction, when a percent of the total graded non-reactive sand was replaced by the carbonate filler containing silica, samples showed a slightly lower expansion than the control. However, this was not the case for samples where the finest portion of the sand was replaced. In this case, the expansion was the same as the control.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-560

Response of Concrete to Incremental Levels of Sulfuric Acid Attack

Mohamed Hussien Mahmoud
M. T. Bassuoni

Abstract:

Concrete elements in sanitary sewer pipes, wastewater treatment plants, pumping lift stations, junction chambers, etc. are exposed to acidic environments. However, many field cases have shown that concrete elements in these environments are severely damaged due to biogenic and/or chemical sulfuric acid attack. Since high alkalinity is required for the stability of the cementitious matrix, concrete is highly prone to acidic attack, which can decalcify and disintegrate the hydrated cement paste to various levels based on exposure conditions and type of concrete. Hence, the aim of this study is to investigate the resistance of concrete incorporating different types of cement (general use or portland limestone cement [PLC]) and supplementary cementitious materials (SCMs) to progressive levels of sulfuric acid attack. The study comprised full immersion of test specimens in sulfuric acid solutions for two consecutive time intervals involving twelve weeks at a pH of 4.5 followed by ten weeks at a pH of 1.0. Physical and microstructural results reveal that surface deterioration of concrete under sulfuric acid attack was dependent on the degree of solution aggression consisting of both concentration and pH. While PLC may improve the resistance of concrete to sulfuric acid attack, the SCMs had a mixed effect on the results.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-563

Investigation on Impact Loads for Test Level 4 of Bridge Barriers

Morteza Fadaee
Khaled Sennah

Abstract:

Bridge barriers must be designed for impact loads of different crash test levels proposed in design standards. Crash tests with different load and evaluation criteria are provided in design standards such as National Cooperative Highway Research Program (NCHRP) Report 350 of 1993 which was superseded by the 2009 AASHTO Manual for Assessing Safety Hardware (MASH). Test Level 4 (TL-4) is considered for trucks with higher weight and speed impact comparing to regular vehicles. The criteria for TL-4 indicated in MASH has been changed to higher values of speed and truck weight than the values given in NCHRP Report 350. In MASH, the single-unit vehicle weight increased from 8,000 kg to 10,000 kg and the impact speed increased from 80 km/h to 90 km/h while impact angle is kept at 15° to the barrier longitudinal direction. However, impact loads used for designing corresponding bridge barriers specified in the 2014 version of the Canadian Highway Bridge Design Code are not modified for TL-4 with new criteria in MASH. This paper presents a literature of various studies on the determination of equivalent loads to vehicle impact to design TL-4 barriers, including computer modeling and full-scale crash tests with specifications similar to the new criteria of TL-4 in MASH. Based on these studies, it is concluded that the impact loads for TL-4 with new conditions are significantly increased. Therefore, new impact loads are suggested for TL-4 barrier for possible inclusion in the 2019 version of the Canadian Highway Bridge Design Code in order to meet the requirements for TL-4 bridge barrier specified in MASH. The proposed changes will be in the amount of transverse, longitudinal and vertical equivalent impact loading as well as the height of impact point.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-564

Numerical Modeling of Reinforced ECC Building Frames

Roman Melnikov
Khandaker Hossain

Abstract:

This paper is focused on the numerical modeling of reinforced concrete frame incorporating high performance concretes: self-consolidating concrete (SCC) and engineered cementitious composite (ECC). The numerical modeling SCC and ECC frames were conducted using finite element software ABAQUS Implicit. The developed three dimensional FE model was subjected to monotonic lateral loading until failure. The material input were obtained from experimental research through extensive literature survey. The method of loading was selected as displacement controlled. The FE model frame performance was evaluated based on load capacity, ductility, mode of failure and crack patterns compared to those of obtained from experimental studies. Also, ECC/SCC frames with two different reinforcement configurations (flexure controlled and shear controlled) were modeled and analyzed. The study revealed that the ECC frame, although having reduced initial stiffness compared to SCC, showed superior ductility and load carrying capacity. Furthermore, the ECC frame showed more uniform crack distribution at the critical regions, compared to those with SCC. Parametric simulations to study the effect of ECCs with varying tensile strain capacities showed that material with larger tensile strain capacity resulted in the development of more uniform stress in reinforcement in the critical regions.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-565

Prediction of Burst Load in Pressurized Pipelines using Extended Finite Element Method (XFEM)

Sylvester Agbo
Meng Lin
Arman Ahmed
Jung-June Roger Cheng
Samer Adeeb

Abstract:

Application of the principles of fracture mechanics to response of pipelines with circumferential flaw subjected to varying internal pressure and tensile load is a relatively new field. Many researchers have studied the integrity of pipelines using many methods, but no well-established methodology exists to address the biaxial loading state introduced by a combination of internal pressure and tension on pipelines. Fracture mechanics principles were applied to pipelines with circumferential flaw of different sizes subjected to varying internal pressure and tensile load. Several studies have been carried out on the integrity of pipelines, using many methods, no well-established methodology exists to address the biaxial loading condition introduced by a combination of internal pressure and eccentric tensile loading on pipelines. Eight full-scale pressurized tests were previously carried out in our laboratory on X52 grade NPS (nominal pipe size) 12inch pipe subjected to eccentric tensile load with premachined flaws close to the girth weld. This paper discusses the development of finite element models using the extended finite element method (XFEM) to predict burst load in pipes due to crack growth under the loading conditions of full-scale tests. The model results were validated using the load history obtained during the full-scale tests. The Crack Mouth Opening Displacement (CMOD) - load history of each model was analyzed to produce compliance measurements at increasing levels of internal pressure. This paper compares the numerical results including burst load predicted by XFEM models with the results of full-scale tests. This paper illustrates the potential advantage of XFEM technique, a tool easy to implement, to predict burst load in steel pipelines due to crack growth.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-566

The Introduction and Modeling of Novel Shape Memory Alloy-Based Bracing

Shahin Zareie
Shahria Alam
Rudolf J. Seethaler
Nadia Mohammad Mirzai

Abstract:

Shape memory alloys (SMAs) reveal exceptional characteristics by undergoing a large level of deformation and then recovering their predefined shape (initial state) as a result of the superelasticity and/or shape memory effect. Considering these unique property, a new SMA-based bracing system is introduced to be implemented into steel building structures. Due to a specific configuration, this smart bracing system provides an adequate damping mechanism and which can sufficiently dissipate the energy of seismic loads in compression and tension modes. The numerical model of the smart bracing system is obtained by using OpenSees, as a structural open-source computer software. After validating the model by experimental results, the numerical model is tested under quasi static and cyclic loads in order to evaluate the performance of proposed smart system and examine its accuracy.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-567

Analytical Study of Ductile Connections for Cross-Laminated Timber Structures

Asif Iqbal

Abstract:

Cross-Laminated Timber (CLT) has been gaining increased interest within the construction industry over the last two decades. It is already well accepted in Europe and has been coming into the North American market in the last few years. There are a growing number of applications for CLT around the world including regions of high seismicity. It is therefore essential to develop design guidelines and standards to reduce the risk of potential serious problems in the future, particularly in respect of jointing for seismic applications. Significant research has been completed in Europe and North America on properties, structural behavior and sustainability aspects of CLT. But the research on the seismic considerations particularly on joining of the structural members to ensure ductile performance has been limited. This paper focuses on a detailed investigation of CLT joint design. The primary focus is to develop appropriate jointing methods for CLT panels in order to provide a system that will accommodate expected loads particularly seismic forces, conforms with building code requirements and suitable for the construction environment. Experience from similar engineered wood products is drawn into the current research. A new type of with jointed ductile connections through combination of post-tensioning and energy dissipating elements has been implemented for CLT members. The post-tensioning ensures self-centering in addition to the ductility provided by additional energy dissipating elements within the connections. Extensive experimental and numerical investigation is currently underway to develop and test appropriate connections types for CLT building structures. The results confirm the behavior of the connections can be predicted with analytical and numerical work. Experimental program is planned next for validation of the models. The ultimate goal is to develop guidelines and recommendations for practical applications through further analysis and testing.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-568

Application of a Four-Bar Crank Rocker Mechanism as a Subtalar Joint Wear Testing Machine

Author(s):

Jonelle Jn Baptiste
Joseph Sabbagh
Samer Adeeb
Nadr Jomhal
Stephen Andrews
Julia Bowes
Edmond Lou

Abstract:

The subtalar joint is responsible for inversion/eversion of the foot and ankle. Replacing subtalar joints damaged by primary osteoarthritis or a sequelae of physical injuries with prostheses has not yet been studied according to literature. The standard method of treatment is subtalar joint fusion, where the joint tissues are removed and the talus and calcaneus bones are fused together to eliminate discomfort and improve the overall function of the foot and ankle. However, fusion eliminates inversion and eversion which is necessary for balancing the foot on uneven surfaces. Joint replacements have been successful in the hip, knee and ankle. Therefore, it may be possible to develop subtalar joint prostheses which maintain some degree of motion in addition to providing the benefits of fusion. The long term objective of this study is to develop and apply a testing protocol for wear of subtalar joint prostheses. No protocols exist for wear testing of ankle joints, so standards for wear testing of total hip-joint prostheses will be used as the basis for developing that of the subtalar joint. A four-bar crank rocker mechanism capable of applying a specific angular displacement to replicate eversion and inversion, +/- 10 degrees. Cyclic loading of 50-800 N was applied using a fatigue testing machine. This simulator was optimized to withstand the applied fatigue loading without failure after a minimum of 5 million cycles. Furthermore, to simulate real-world conditions, the implants will be submerged in bovine serum diluted with deionized water during initial testing. While fatigue testing machines for implants exist, they are extremely costly in comparison to this apparatus which is an add-on to a regular fatigue testing machine. As experimental studies on subtalar joint prostheses have not yet been conducted, the results of this procedure will determine how the setup can be improved and which materials will be best suited for use as implants.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-569

The Effect of Cement Type on Concrete Resistance to Sulfates

Ahmed Hamza
Abdelrahman El Aref
Adam Rafique
John Daoud
Michael Mina
Athnasious Ghaly
Amr Fathy
Mohamed Abou-Zeid

Abstract:

Concrete resistance to aggressive sulfates is of paramount importance to concrete performance in many parts of the world. This study aims at evaluating concrete performance to sulfates of various concentration. Concrete Mixes were prepared with Portland Slag Cement, Portland Sulfate Resisting Cement, Portland Limestone Cement and Ordinary Portland Cement and were subjected to an experimental study. Tests included fresh concrete properties as well as hardened concrete properties. Another set of tests were allocated to chemical resistance to sulfates for several weeks. The outcome of this study reveals that exposure characteristics are highly affected by the selection of the cement type. Recommendations are made for applicators to better select the adequate cement type when serving in sulfate environment. Ultimately, this study can be a step towards proper selection of cement type in light of the nature of sulfate concentrations encountered.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-570

A Study on Green Lightweight Concrete using Recycled Poly-Ethylene Terephthalate (PET) as Coarse Aggregate

Md Jahidul Islam
Iftekhar Alam Dipta
Md. Rahat, Islamic

Abstract:

As one of the environmental concerns in the world is the enormous number of plastic bottles made from Poly-Ethylene Terephthalate (PET) deposited in domestic wastes and landfill, it is now time for the development and implementation of sustainable recycled materials in construction to reduce the generated wastages. Furthermore, the assimilation of PET as aggregate can significantly improve certain properties of concrete, like reduced density. PET is significantly lighter than natural aggregate (NA), and therefore, its incorporation lowers the density of the resulting concrete which makes it lightweight concrete. The purpose of this study is to investigate the possibility of using recycled PET waste in concrete mixes as aggregate replacement to find a way to make low-cost lightweight concrete of effective compressive strength and also reduce the environmental effects of PET disposal. For this experiment 36 cylinders are prepared with conventional concrete materials, 108 cylinders are prepared by replacing 10%, 20% and 30%, by volume, of coarse aggregate (brick chips) with PET. Three different w/c ratios (i.e. 0.42, 0.48, and 0.57) are taken under consideration for achieving optimum workability in using PET as plastic coarse aggregate. The combination of 10% coarse aggregate replacement and 0.42 w/c showed improved result both in compressive and tensile strength test. This study also assures that reusing waste plastic as a coarse-substitution aggregate in concrete gives a good approach to reduce the cost of materials and solve some of the solid waste problems posed by plastics.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-571

Sustainable Self-Consolidating Concrete using Recycled Aggregate and Supplementary Cementitious Materials

Samer Al Martini
Ahmed Kharatbeel
Abdul Rahim Saboumi

Abstract:

Sustainability has become one of the key parameters in the construction industry in United Arab Emirates. Recently, Dubai municipality has introduced new regulations that enforced the use of green concrete in all construction projects in Dubai. The focus of these regulations is to reduce the Carbon foot print in the construction industry by greening of concrete. The current practice has been concentrating solely on the approach of replacing cement with supplementary cementitious materials (SCMs) such as grand granulated blast furnace slag (GGBS) and fly ash. However, the use of recycled aggregates also contribute to the greening of concrete and reducing the Carbon foot print of the construction industry in the UAE, where concrete is the main construction material. The current research tends to expand the current practice by replacing aggregates with recycled aggregates in the concrete mix. Recycled aggregates are obtained from a local recycled aggregate plant in Abu Dhabi. These aggregates are recycled using concrete from demolished buildings in Abu Dhabi. The natural aggregates in self-consolidating concrete mixtures (SCC) were replaced by recycled aggregates with the following percentages: 30%, 50% and 100%. Various parameters affecting the behavior of fresh and hardened concrete are investigated including slump flow, rheology, compressive strength, water absorption, permeability, and chloride penetration. The results are analyzed to arrive at pertinent conclusions, in addition to recommendations regarding the utilization of concrete with recycled



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-572

Effect of Drilled Cores on Axial Load Capacity of Reinforced Columns with Brick Aggregate Concrete

Tanvir Manzur
Ayatullah Khomeni
Md Abul Bashir Emon
Ishtiaque Ahmed

Abstract:

Determination of in-situ concrete strength using drilled cylindrical core from Reinforced Concrete (RC) structural members is an established and reliable practice. A number of available standards (i.e. ASTM C42, BS EN 12504-1, CAN/CSA-A23.2-14C-14 etc.) provide specifications and testing procedures; but literature on the effect of core drilling on load capacity of functional RC members is not very common. The tragic collapse of Rana Plaza in 2013 has triggered structural integrity assessment of existing Ready-Made Garments (RMG) factories in Bangladesh. As part of the material quality assessment, evaluation of concrete strength through core cutting from columns is being recommended for a large number of buildings at present. In these circumstances, a comprehensive study has been undertaken to investigate the effect of core extraction on capacity of RC columns. Since a large number of old factory buildings were made of brick aggregate concrete, column specimens were prepared using brick chips. A total of 27 column specimens (200mm x 200mm cross section) were made having various mix ratios. Cores were drilled from two different locations of the columns. Control columns without any core were also tested for comparison. The specimens were tested for compressive strength and the failure patterns were observed. It was reported that with core at one-third height of the column, strength reduction can be as high as 25%; whereas, for columns with core at mid-height, maximum reduction in strength was around 10%. In addition, experimental results were used to simulate behavior of full scale columns with cores using ABAQUS. In fine, the findings of the study is of utmost significance to the practicing engineers and consultants in the field of structural safety assessment and retrofitting works.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-574

Complex Load Sharing in Weak-axis Moment Connections of Industrial Steel Structures

Riley Quintin
Robert Driver
Logan Callele

Abstract:

It has become common for steel fabricators to find torsional loads included in the design documents of industrial steel structures. These loads arise at beam-to-column moment connections whenever a beam is subjected to weak-axis bending, which is transferred to the supporting column as torsion. Due to a lack of codified guidelines or relevant literature on how to design the joint to transfer the torsional moment, engineers routinely add full-depth stiffeners to the column to prevent localized distortion of the cross-section, which is both costly and time consuming. Previous research at the University of Alberta investigated the behaviour of unstiffened wide-flange members subjected to torsion applied through one flange, and this research aims to extend that work to determine the impact of column axial load on this kind of connection. A parametric study using finite element simulations has been conducted to identify the major parameters affected by the presence of axial load. The parametric study considered variations in cross-sectional geometry, axial load, and the effect of residual stresses. Preliminary results suggest that the length of an unstiffened column effective in resisting the applied torque does not change significantly with the presence of axial load. However, the bending stress at first yield is inversely related to the level of axial stress. A full-scale testing program is also being conducted using five standard W-shape sections with three test specimens each. Each specimen is subjected to a torsional moment at mid-height under a specified level of axial stress, ranging from 25% to 75% of its axial yielding capacity. Using these results, a design method will be proposed that predicts the maximum torsional moment that can be applied to an unstiffened wide-flange member before yielding occurs on the cross-section. This will improve the efficiency, constructability, and cost effectiveness of many industrial steel structures.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-575

Investigation of the Strength Development using Magnesium Alkalinization for Subgrade Soil

Nurmunira Muhammad
Sumi Siddiqua

Abstract:

The stabilization of problematic soils with chemical additives has become popular globally. The use of the magnesium chloride ($MgCl_2$) for improving weak soil properties was studied by others, but the $MgCl_2$ mixed with the alkaline solution as a chemical additive have not been investigated. This paper studied the factors that contribute to the strength development of silty sand, a typical subgrade soil in Kamloops BC, Canada, using the $MgCl_2$ with different ratios of alkalinization solution ($Na_2SiO_3/NaOH$). The total of 65 samples included the untreated sample were examined using standard compaction and the unconfined compressive strength (UCS) tests under a curing period of 7, 14, 28, and 60 days. Results revealed that the chemical additive was improving the density and the compressive strength of the silty sand. This increase in strength was subjected to the formation of the new cementitious product, which was the combination of the chemical additive that filled up voids and reinforces the particles in the soil.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-577

Fatigue Reliability of Structural Connections using Stress Concentration Information

Christian Wokem
Jishnu Subedi

Abstract:

There are mainly two types of structural connections, bolted and welded connections. These connections in many types of structures such as bridges, cranes and buildings are subjected to fatigue loading and mostly fail at stresses that are significantly less than the yield strength of the material. The failure of such connections can be amplified by the presence of stress raisers such as bolt holes and bearing of the bolts against the connection plates, which could significantly reduce the reliability of these connections in terms of their useful fatigue life. This research will focus on identification of the parameters that affect the fatigue reliability of splice bolted connection. This is done through a literature study and the finite element modeling and analysis of various geometric configurations of the connections to obtain the stress concentration, then using reliability and sensitivity techniques to obtain parameters that can adversely affect the reliability of these details. Some parameters that have been shown to affect the stress concentration, and hence the fatigue life, are the plate thickness, the bolt hole diameter, the applied load, the number of line of bolt holes, and the gage and edge distances. Ways to improve the reliability of these connections in terms of fatigue life were investigated and discussed.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-578

A Corrosion Comparison of Historical and Modern Reinforcing Bars

Bjorn Vors
Richard Evitts
Lisa Feldman

Abstract:

Ransome bars, otherwise known as twisted bars, were used as reinforcement for concrete structures and were generally made by cold twisting a plain square bar a given number of turns per length. Ransome bars are known to be one of the oldest reinforcing types used in concrete construction, dating back to 1894. The process used to fabricate Ransome bars results in aggressive cold working of the material, altering its microstructure and mechanical properties. While past studies have shown that the yield and tensile strength of the bars is increased by the cold working, it is still not clear whether the corrosion properties of Ransome bars differ from other types of steel reinforcement. An understanding of their corrosion rate is required to properly assess and plan for the rehabilitation of concrete members reinforced with these bars. This paper presents the results of an experimental program used to evaluate the corrosion potential of these bars, as compared to modern deformed reinforcement. Differences in corrosion potential and rate between modern reinforcing bar types and historical Ransome bars were measured. Both polished and sandblasted surface preparation techniques were used in two different solutions: one to simulate fresh non-carbonate concrete, and the second to simulate carbonated concrete. Potentiodynamic scans and linear polarization resistance tests were both conducted. The results show that approximately one hour after exposure to the different solutions, corrosion rates increased, peaking after twenty-four hours, before tapering down as a film of rust develops on the bars that acts as a diffusion barrier and reduces corrosion rates. After seven days of exposure the polished new plain square bar sample in the solution carbonated concrete solution had the lowest corrosion rate while the polished historical Ransome bar sample had the highest corrosion rate in the solution that simulates fresh non-carbonate concrete solution.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-580

Developing Reclaimed Concrete Cement for Structural Grade Sustainable Concretes

John Gales
Mina Li

Abstract:

The demand to consider novel sustainable material development within the concrete construction industry is growing. To consider this trend, the overarching goal of this research programme is to consider sustainable concrete development. Recognizing that the bulk of research into demolished concrete waste currently pertains to Recycling Concrete Aggregates (RCA) for conventional aggregate substitution, this study instead considers this waste stream for the development of Reclaimed Concrete Cement (RCC). Received concrete demolition waste was sieved as predominately fine RCA (less than 4.75 mm by grain size). A procedure was then developed based on a thermo-mechanical procedure to the RCA. An optimum procedure for this technique for RCC was determined. The procedure also reduced deleterious aggregates which were present within the waste stream. Bench-scale concrete cylinders were prepared according to a conventional 50 MPa concrete mix design. Trial mixes were considered with RCC replacing conventional cement by mass percentage (0, 20, 30, 50, and 100%). Results indicated that RCC substitutions of less than 20% by mass had no negative impact on mechanical properties, and structural grade concrete could be achieved with up to 50% cement substituted RCC by mass. It must be acknowledged that the thermo-mechanical procedure used in this study for developing RCC is currently challenging in conventional practice without adjoining novel cement making technologies. Despite this, the research provides a good introduction to the potential use and development of RCC in sustainable concrete mix designs in the future.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-582

An Innovative Reactive-Transport Modeling Framework for Cementitious Porous Media

Burkan Isgor
Vahid Jafari Azad

Abstract:

A reactive-transport modeling framework is being developed to connect finite element analysis (FEM) with thermodynamic modeling of cementitious systems to model reactive transport processes. The FEM module is responsible for modeling multiphysics phenomena such as mass transport, heat transfer, phase flow and kinetics, while thermodynamic module is used to model chemically complex reaction computations based on Gibbs Energy Minimization (GEM) theory. A non-iterative operator splitting technique in a time marching scheme is used for uncoupling the multiphysics phenomena from reaction equations. The framework is able to analyze complex chemical systems including processes that take place in cementitious materials. The presentation summarizes examples using the framework, its current limitations, and future work.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-583

Effectiveness of a Natural Pozzolanic Material from Southern Saskatchewan for Cement Replacement in Concrete

Shailza Sapal

Abstract:

Pozzolans are a category of supplementary cementitious materials that can be used as a partial replacement of the Portland cement when mixing concrete. Aside from their environmental benefits, pozzolans have also been found to increase the strength, reduce the permeability, and thereby increase the durability of concrete. There may also be economic benefits to their use if the pozzolan can be produced at a lower cost than Portland cement.

The first pozzolanic materials came from natural sources, as a product of volcanic eruptions. Today, pozzolans are often the by-product of industrial processes, such as coal burning for the production of electrical power (which produces fly ash as a by-product) or from the production of silicon alloys. However, naturally occurring pozzolans are still available.

In this project, General Use Portland cement and natural pozzolanic materials from deposits in Southern Saskatchewan were used to prepare concrete mixes to evaluate the effectiveness of the natural pozzolan as a replacement for cement. Specimens with replacement amounts of 10%, 20% and 30% by weight of cement were prepared and tested to measure compressive strength and permeability, along with a reference mix without pozzolan for comparison. The effect of sieving out particle sizes greater than 74 mm was investigated.

The results showed that 10% and 20% replacement amounts produced compressive strengths that did not differ significantly from that of the reference mix, as long as pozzolan particle sizes were limited to less than 74 mm. Permeability also did not differ significantly among specimens with replacement amounts of 20% and lower. The natural pozzolan is therefore considered to be an effective cement replacement material.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-584

Hysteretic Behavior of Structural Steels Under Biaxial Nonproportional Compression and Torsion

Iraj Mamaghani

Abstract:

Experimental study of the cyclic behavior of structural steel under multiaxial loading has attracted limited attention. The author has carried out a series of experiments on SS400 steel (equivalent to ASTM A36) under cyclic biaxial proportional and nonproportional torsion and compression loading. The main objective of this paper is to investigate hysteretic behavior of structural steels under biaxial loading, through conducted experiments and analytical analysis. The experimentally observed biaxial hysteretic behavior of the structural steel subjected to combined nonproportional compression and torsion is examined and discussed. Some important hysteretic behavior of steels within the yield plateau and strain-hardening region, such as reduction of the elastic range, the decrease of the yield plateau, cyclic strain hardening, fading and nonfading memory under biaxial nonproportional loading are presented. The rate of nonproportionality of loading on cyclic behavior is evaluated. The mechanism of the modified two-surface plasticity model developed by author is evaluated and discussed in light of the experimentally observed cyclic behavior of steels under biaxial nonproportional loading. Application of the developed model in cyclic large displacement analysis of cold formed steel tubular structures is verified and discussed. It is shown that the 2SM can simulate cyclic elastoplastic behavior of steel structures more accurately as compared to commercially existing material models.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-585

Modelling Cyclic Stress-Strain Behavior of Confined Concrete

Iraj Mamaghani

Abstract:

Present trend in composite construction is towards the use of concrete-filled steel tubular structures in bridge piers and high-rise buildings. Such structures exploit the best attributes of both steel and concrete, thus allowing the engineer to maintain manageable member sizes while obtaining increased stiffness, strength and ductility; particularly essential for earthquake resistance. In light of the severe structural damage caused by recent earthquakes, such as the 1994 Northridge earthquake, the 1995 Kobe Earthquake and the 1999 Taiwan Earthquake, studies are presently being conducted on the performance of various types of filled steel composite members, in an attempt to supplement efforts geared towards evolving earthquake resistant structures. In this paper the results of a research program aimed at studying the cyclic stress-strain response of concrete confined by steel tubes is presented. A confinement model for concrete confined by steel tubes has been developed and adopted in the Finite Element Analysis of concrete-filled steel tubular columns under cyclic loading. The stress-strain curve of confined concrete was determined based on the compatibility in the lateral expansion between concrete and the steel tube. The results of the predictions from the proposed confinement model showed good agreement with the experimental results of concrete filled column. The comparisons indicated that the proposed model has the potential to be used for predicting the cyclic stress-strain curve of core concrete confined by steel tubes, with sufficient accuracy.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-586

Fatigue-Life Prediction of Shear Stud Using Finite Element Analysis

Md Manik Mia
Anjan Bhowmick

Abstract:

Steel-concrete composite beams are widely used in bridges. The longitudinal shear forces developed at the interface between concrete deck and steel girder is transferred mostly by shear studs. Among different types of shear studs, headed shear stud is most commonly used in practice. In bridges, these shear studs are subjected to rapidly fluctuating stresses which may result in fatigue failure during the lifetime of the structure. Thus, the fatigue resistance of shear studs in composite beams is significant for the safe of whole structure and needs to be well investigated. The aim of this paper is to investigate the fatigue behavior of headed shear studs. A detailed nonlinear finite element model (FEM) is developed using commercial software package ABAQUS for predicting fatigue life of shear studs embedded in a solid concrete slab. Both fatigue crack initiation life and crack propagation life are estimated. The developed FE model is validated against test results and an excellent correlation is found. Finally, an extensive parametric study is performed using the validated finite element model to investigate effects of different parameters on fatigue life of headed shear stud.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-589

A Two-Surface Plasticity Constitutive Model for Soil-Structure Interfaces

Miad Saberi
Charles-Darwin Annan
Jean Marie Konrad
Ali Lashkari

Abstract:

An elasto-plastic constitutive model is proposed to simulate the behavior of interfaces between coarse granular soil media and structural materials (i.e. steel or concrete). The proposed model is formulated within the frameworks of the two-surface plasticity, critical state soil mechanics and state parameter. The interface constitutive model requires a single set of eight calibration parameters to predict both monotonic and cyclic responses of the interface behaviour under a wide range of normal stress and soil densities without a need for recalibration. The model is capable of simulating the stress path dependent behavior of granular soil-structure interface problems. All the model parameters have physical meaning and can readily be obtained from standard interface shear tests. The performance of the proposed model is evaluated by comparing the model predictions and laboratory test data.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-591

Mass Heritage Timber Performance in Fire

Arlin Otto
John Gales

Abstract:

Timber heritage structures are prevalent worldwide due to the inherent ease of their construction prior to the popularization of contemporary concrete and steel buildings. As material reuse or conservation becomes more a popular and sustainable option, the performance of these timber structures is being examined – their performance in a fire is not an exception. For this reason, there is a value to research the fire performance of existing mass heritage timbers members found in infrastructure. This study aims to address this need to provide a holistic study on the resilience of heritage timber after controlled fire exposure.

The research presented involves testing sections of heritage timber (which has seen over 100 years in service conditions) that were reclaimed from structural members in an existing adaptive reuse project in Ontario. These samples were tested using a cone calorimeter, with exposure to a severe heat flux. The authors studied the char depth and pyrolysis behaviour. The results were compared to modern engineered timber samples (LVL, glulam and conventional lumber) of equivalent moisture condition(s) that were also tested by the authors.

For heritage structures undergoing conservation efforts, such as adaptive reuse, no in-service timber structure will be the same and will be subject to a variety of moisture conditions. This study therefore provides the practitioner with a range of the moisture content analyses in relation to fire performance of the timber. The effect of common material defects of mass heritage timber (splitting cracks, knots etc.) exposed to fire was also considered. For applicability, the researchers investigated environmental conditions in various heritage timber buildings to allow relationships to be established for practical use.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-592

Engineered Graded Materials: Vibration of Doubly-Curved Nano-Panels

Hamid Akbarzadeh
Hamidreza Yazdani Sarvestani
Sara Rankohi
Armin Mirabolghasemi

Abstract:

Functionally graded materials (FGMs) as a type of engineered advanced materials are composed of the mixture of two or multiple materials or phases in a fashion that overall multiphysical properties gradually changes throughout the medium. Due to the advances in manufacturing and prototyping techniques, FGMs have found emerging interests in engineering applications from nano/micro-scale as thin films and nano/microelectromechanical systems to macro-scale as thermal shields and porous biomedical devices. Conventional plate and shell models based on the classical continuum theories, however, cannot capture the size effects occurring in nano/microstructure of FGMs due to the lack of material length scale in the formulation of classical continuum mechanics. As a result, plate and shell models based on the size-dependent continuum theories, such as couple-stress theory, have been recently revisited.

In present paper, a size-dependent modified couple-stress model is developed for moderately-thick doubly-curved panels based on the first-order shear deformation theory. The non-classical model incorporates the material length scale parameter, which incorporates the size effect in the mechanical behavior. In specific, we investigate the free vibration of FGM doubly-curved nano-panels for alternative boundary conditions. The material properties of the FGM panel vary through the thickness direction, effective properties which are estimated through a multiscale homogenization technique. The governing equations are first derived by a variational formulation using Hamilton's principle and are solved afterwards using the numerical Galerkin method. Numerical results are finally presented to study the effects of the material length scale parameter and material compositions on the free vibration behavior of FG doubly-curved nano-panels.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-593

Particle Breakage and Constitutive Modeling of Granular Soil-Structure Interface

Miad Saberi
Charles-Darwin Annan
Jean Marie Konrad

Abstract:

Particle breakage occurs in granular soil-structure interface zones in different soil-structure interaction (SSI) systems under cyclic loading, and it largely affects the performance of these structures. The effect of particle breakage on mechanical behavior of granular soil-structure interfaces should be taken into account in an interface constitutive model for accurate simulating the SSI problems with critical interfaces. In this study, the effect of particle breakage on the mechanics of granular soil-structure interface is presented. An approach is then proposed to improve an elasto-plastic interface constitutive models to be capable of simulating particle breakage under shear loads. The effectiveness of the approach is evaluated using an interface constitutive model to predict the volumetric behavior of a granular soil-structure interface under different stress path. The model predictions are then compared with experimental observations. It is illustrated that the particle breakage has significant effect on the compressibility behavior of the granular soil-structure interface, and it can be well addressed within the constitutive formulations of an interface plasticity model.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-594

An Optimal Numerical Scheme for Multi-Span Composite Laminated FRP Deck Bridges

Author(s):

Hamid Reza Naderian
Mo Shing Cheung
Elena Dragomirescu
Abdolmajid Mohammadian

Abstract:

This research suggests a very efficient numerical technique, originated from spline finite strip method, for simulating fiber reinforced polymer (FRP) deck bridges. An Integrated Finite Strip Method (IFSM) is employed in order to evaluate the bending and vibration performance of continuous multi-span composite laminated FRP bridge systems. The anisotropy nature of the FRP laminated deck is considered into the analysis by developing so-called laminate spline strip in the environment of integrated finite strip solution. So-called column strips model the piers, while the structural interactions between the FRP deck and piers are handled into the analysis by introducing transition section elements. The accuracy and efficiency of the IFSM in modelling as well as bending, and free vibration analysis of a multi-span slab-girder FRP bridge is investigated. The finite strip results will be validated against the finite element analysis. Using the proposed integrated finite strip approach, the time required for analysis dramatically reduces without affecting the degree of accuracy. This results in developing an optimal numerical scheme for composite FRP bridges. The developed IFSM solution provides the opportunity for analysis and design FRP deck bridge structures in a very efficient way where the coupling effects of the FRP laminated deck and the structural interactions of bridge components are fully handled.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-595

Detection and Characterization of Surface Cracks and Defects in Concrete Structures using Various NDTs

Pejman Azarsa
Rishi Gupta
Alireza Biparva

Abstract:

Concrete is the most versatile and durable construction material; however, due to many factors such as drying shrinkage, plastic shrinkage and service loading, cracking in concrete is inevitable. Developing cracks into the concrete matrix creates pathways for aggressive agents to initiate deterioration processes and endanger the structure service life. Thus, over the past few years, many techniques have developed to evaluate the state of various concrete structures, to detect internal voids, defects and cracks in a non-destructive way. Among these techniques, infrared thermography (IRT) is available to engineers for non-destructive testing (NDT) of concrete elements. Presence of cracks and voids in concrete affect heat flow through the material and these changes in heat flow cause localized differences in surface temperature. By measuring surface temperatures under conditions of heat flow into or out of the material, one can determine the presence and position of any subsurface anomalies. However, IRT has proved to be a convenient, and economical testing method, it is well known that IRT has certain limitations concerned with problems of the emitted radiation from the surface (emissivity), but at the same time IRT was proven useful when used in conjunction with NDT methods that enable detection of defects. Therefore, another NDT method, that utilizes surface electrical resistivity, is combined with IRT technique to quantify and locate cracks. The main goal of this work is to detect the surface temperature distribution captured by the IR camera in conjunction with resistivity readings to determine and quantify the position of the crack/voids. For experimental investigations, a range of crack widths, representing mechanical damage, has been induced into concrete cylinders under controlled laboratory conditions and also measurements have been taken from series of circular hollow-section columns in field. Combing maps of delamination/cracking using both techniques allow for an assessment of need for surface repairs.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-596

Effect of Geometric Imperfection and Residual Stress on the Capacity of Stainless Steel I-Sections Subjected to Lateral-Torsional Buckling

Mohammad Anwar-Ul-Saadat
Mahmud Ashraf

Abstract:

Stainless steel is a group of steel alloy with versatile crystal structures and material behaviours. Its characteristic nonlinear, rounded stress-strain behaviour without well-defined yield point makes it different from carbon steel. The degree of nonlinearity and roundness vary significantly from one grade of stainless steel to another which also increases the challenge to give a uniform formula for predicting the ultimate capacity of stainless steel sections of all grades. Presence of initial geometric imperfection and residual stress in structural member lead to premature yielding and loss of stiffness eventually reduces the load bearing capacity. For both structural design and finite element simulations, knowledge of their magnitude and distribution is therefore important. Recent years saw keen interest from the researchers on discovering the imperfection and residual stress pattern of stainless steel welded I-sections. Current study utilizes these findings to develop of finite element (FE) models for previously experimented stainless steel I-beams subjected to lateral-torsional buckling. In addition to that mesh sizes, boundary conditions and material nonlinearity were varied in the FE models. Capacity of the developed FE models when compared with that of the lateral-torsional buckling experiments, revealed the influence of the variables considered. Understandings from this study will help further to develop finite element models for parametric study on stainless steel I-beams, consequently leading to evaluate the performance of the international design guidelines.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-597

Performance of Cross Laminated Timber Shear Walls under Cyclic Loading

Md Shahnewaz
Shahria Alam
Thomas Tannert
Marjan Popovski

Abstract:

Cross-laminated timber (CLT) is becoming increasingly popular as a structural material for residential and non-residential buildings because of its low carbon footprint and potential cost-competitiveness compared to concrete and steel. The 2016 supplement to the 2014 edition of the Canadian Standard for Engineering Design in Wood, CSAO86, provides provisions for platform type CLT structures. The research presented in this paper investigated the seismic behavior of CLT shear walls with different connections for platform-framed construction. Finite element analyses were conducted in OpenSees with various connections including steel brackets and hold-downs. The CLT panels were modelled as orthotropic elastic material, and non-linear springs were used for the connections. The models for the hysteretic behaviour of the connections under cyclic loading and the wall assemblies were calibrated using experimental tests. A parametric study was conducted that evaluated the wall capacity and stiffness as a function of number and type of connectors. It was shown that increasing the number of the connectors from 4 to 7, the average capacity of CLT shear walls increased from 53-57% while the stiffness of the CLT shear walls increased by 33-39%.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-598

Non-Destructive, Acoustic Evaluation of Masonry Compressive Strength

James Booth
Katherine Bown
Brandon Nguyen
Chi Zhang
Bowen Song
Mark Mendoza
Sudip Talukdar
Neil Cox

Abstract:

In many developing economies, the ability to implement and to maintain standard quality assurance programs for the masonry blocks used in residential and commercial construction is beyond their current capacity. One consequence of this is that seismic events, small or large, have a disproportionate cost in lives and in infrastructure damage. An illustration of this were the two strong earthquakes of 2010: Haiti suffered a magnitude 7.0 earthquake while Chile weathered a magnitude 8.8 event. The latter released approximately 500 times more energy, but the resulting loss of life was far greater in Haiti than in Chile.

To address the need for introducing some type of quality assurance, a cross-disciplinary team at BCIT has embarked on a research program investigating a non-destructive testing (NDT) protocol for assessing the compressive strength of masonry units. This work utilizes the air-borne acoustic signals generated by striking the masonry unit. The sound is recorded, analyzed, and the characteristic vibrational frequencies, f , are correlated with the compressional strength measured through standard destructive testing, fc' . Testing on over 60 concrete cylinders, ranging in compressive strength of less than 2 MPa to over 30 MPa, has shown an excellent correlation between fc' and the velocity of the acoustic waves passing through samples, $v = 2Lf$. (Here L is the cylinder length.): $\ln(fc')$ is proportional to $(2Lf)$ with a Pearson correlation coefficient squared of 0.95. A similar trend has been observed on testing of concrete blocks.

The proposed NDT technique is very attractive as it can be implemented using low-cost technology that is found ubiquitously throughout the world, it can be quickly and easily applied by non-technical personnel, and the tested specimen is not damaged. This talk will provide an overview of the testing methods and very promising results that have been realized to date.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-599

Finite Element Modeling of Timber I-Joists with Web Holes and Flange Notches

Moein Ahmadipour
M. Shahidul Islam
Shahria Alam

Abstract:

I-joists, studied in this research, are composite beams mainly used to support floor panels. They consist of oriented strand board (OSB) webs and timber flanges. For post-construction purposes, these beams are often drilled in the web or notched through the flange in order to pass electrical/mechanical facilities through. This can result in a significantly lower load-carrying capacity for these important elements. This study presents the finite element simulation of composite timber I-joists to predict the load-carrying capacity of these members with respect to size and location of the web hole and flange cut. Challenges involved in this study are reviewed, including the web-flange connectivity, numerical model meshing, computational precision and material properties. The numerical models are validated against experimental research and the data is used to obtain the load-deflection relationship for considered beams. It has been demonstrated that the proposed finite element simulation can perfectly capture the behavior of the beams. Furthermore, it is found that the existence of web holes or flange notches has considerable impact on the stiffness and load-carrying capacities.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-600

Experimental Investigation on the Mechanical Behavior and Microstructure of Polypropylene Fiber Reinforced Concrete Subjected to Uniaxial Compression

Biao Li
Lihua Xu
Yin Chi

Abstract:

This paper concerns on the mechanical behavior and constitutive model of polypropylene fiber reinforced concrete (PFRC) under uniaxial compression. A total of 54 specimens for different fiber volume fractions and fiber aspect ratios were fabricated and tested. The microstructures and interfacial transition zone (ITZ) were investigated by using scanning electron microscope (SEM). The results show that an improvement on the mechanical behavior, especially for post-peak ductility, can be observed for PFRC due to fiber bridging effect. However, when the volume fraction excess 0.15%, the improvement is insignificant, even with the effect being negative, which indicates that the volume fraction of PF shall be under 0.15%. Moreover, PF can alter the microstructures of concrete specimen, with respect to reducing the crystallization and orientation of $\text{Ca}(\text{OH})_2$ at the aggregate-cement/fiber-cement ITZ and decreasing the micro-voids, which is owing to the multi-directional constraint network formed by the uniformly dispersed and randomly oriented fibers in the concrete matrix. Finally, based on the test results, a damage constitutive model is developed to predict the stress-strain relation of HFRC, with fiber parameters taken into consideration. The developed model is verified by the test data in open literatures, it is observed that the prediction yields a close estimation of the compressive response of PFRC with varying fiber parameters.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-604

The Effects of Adjusting Aggregate Fineness and Mix Proportions to Produce Concrete Masonry Blocks of Various Strengths

Katherine Bown
Sudip Talukdar
Svetlana Brzev
Neil Cox
James Booth
Brandon Nguyen
Chi Zhang

Abstract:

Low resource countries across the world struggle with the devastating consequences seismic events have on infrastructure. Many of the structural collapses in countries such as Nepal and Haiti seen during earthquakes can be attributed in part to weak/substandard masonry. There is often very poor adherence to standards in such countries, and they often do not have access to suitable materials testing equipment. We hope to mitigate this situation by developing a reliable, low-cost Non-Destructive Testing (NDT) device which can be integrated into the building processes of such countries to reduce the use of unacceptably weak blocks. An essential ingredient for this work is the development of concrete mix designs which can produce a wide range of strengths. Creating low compressive strength samples is important for developing an evaluation tool for identifying poorly fabricated units. This also affords us the opportunity to study the effectiveness of Canadian code equations when applied to substandard materials.

While the minimum standard for masonry compressive strength in Canada is often 10 MPa, examination of blocks from areas where structures have collapsed due to earthquakes has often indicated strengths which are less than 5 MPa. Therefore, to verify the effectiveness of the NDT equipment being developed, sets of specimens with strengths ranging from 0.2 MPa to 28 MPa needed to be cast. Suitable mix designs were developed by varying the amount, gradation and type of fine aggregates. By varying the amount of fine aggregate in the mix, and adjusting the fineness of the aggregate used, mixes of varying strength could be reliably produced. Results were validated using traditional destructive testing and the new non-destructive acoustic testing methods that we are developing. Using the data from testing these mixes, new equations are being developed to define material behavior with a particular focus on the acoustic response of lower strength mixes.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-606

Structural Performance of Engineered Cementitious Composites Subjected to Pre and Post-Fatigue Monotonic Loading

Khandaker Hossain
Shirin Ahmad

Abstract:

This paper presents the effect of d fatigue loading on the flexural performance of Engineered Cementitious Composite (ECC) prismatic beams. ECC has been designed for high ductility, durability and strain hardening capacity with multiple-cracking behavior in addition to be cost-effective and green through the replacement of cement by Class-F fly ash and the use of local aggregates (mortar sand in place of silica sand). The main variables in this study were, Class-F fly ash as cement replacement of 55% and 70%, type and size of aggregates while maintaining fatigue stress level and number of fatigue cycles constant. ECC prismatic beam samples were loaded to failure under static monotonic loading after the application of 400000 cycles of fatigue loading to study performance based of strength, deflection capacity, stiffness and energy absorbing capacity. The mortar sand based ECC specimens showed better fatigue performance in terms of higher residual strength, deflection, stiffness and energy absorbing capacities compared to their silica sand counterparts.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-607

Cyclic Behavior of Concrete Filled Fiber Reinforced Polymer Tube

Daniel Robillard
Radhouane Masmoudi
Nathalie Roy

Abstract:

Concrete-filled fiber reinforced polymer tubes (CFFT), have been mainly studied under static loading, and very limited research data is available for CFFT columns under cyclic loading. These studies showed the higher structural performance and the relevant use of CFFT for seismic design of reinforced concrete (RC) structures. Indeed, it is well known that CFFT can increase the ductility ratio which is a crucial factor in seismic design. Thus, research on cyclic behavior is essential to the development of new design guidelines using the technology of CFFT. This paper presents the results obtained from an experimental investigation to study the effects of the FRP tube thickness on the cyclic behavior of CFFT columns. Two full-scale CFFT RC columns are reinforced with FRP tube thickness of 4 mm and 8 mm. One control RC column designed according to the Canadian standards for bridges (CSA S6-06) is made for comparison purposes. The specimen setup consisted in a column-footing with the FRP tube embedded in the footing before casting of the concrete. The column is axially loaded under a constant load, while a horizontal hydraulic actuator applied a quasi-static lateral load on the head of the column. The tubes are made at the Composite Material Reinforcement Laboratory of the Sherbrooke University using the filament winding manufacturing process. Comparing the CFFT columns with the control column and also by taking into account for the difference in the concrete sections, we obtain for S0PS2V4 & V8 respectively, 44 % and 46 % more for first cracking moments; 26% and 41% for yielding moments, and 21% and 45% for the ultimate flexural moments. The ductility of CFFT columns are also better than typical RC column with the CFFT specimen reaching 11.38 % and 10.33 % compared to 8.47% for the control.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-608

Effect of Sand-Coating Bond Performance on The Flexural Capacity of Circular Concrete-Filled FRP Tubes

Radhouane Masmoudi
Ahmed Ali
M. Iqbal Khan

Abstract:

This study presents an experimental investigation to evaluate the bond performance of sand-coating between concrete core and the fiber-reinforced polymer (FRP) tubes on the flexural behaviour of circular pultruded concrete-filled FRP tubes (CFFTs). The experimental study consists of one full-scale circular CFFT cantilever 2200 mm long, 305 mm diameter, 12.7 mm tube wall thickness and the shear span from the face of the footing to the load point is 1930 mm. The tube is embedded 500 mm into a very rigid reinforced concrete footing 1200×1200 mm² and 800 mm depth. The sand coating was applied by using epoxy resin to the interior surface of the tubes and covered by coarse sand particles. The specimen was tested under quasi-static cyclic lateral load only. The lateral deformation, Axial and hoop strains of the CFFT outer surface at different heights, and slippage between concrete core and the FRP tube were measured. The results show that sand-coating can be used to prevent the slippage under service load between the concrete core and the FRP tube in the unreinforced CFFT structural members.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-609

Predicting Self-healing in Concrete Using Artificial Neural Networks

Ahmed Suleiman
Moncef Nehdi

Abstract:

Recently, several studies have explored the potential self-healing of cement based materials via incorporating specific healing agents in the cementitious matrix. In the present paper, the application of artificial neural networks (ANNs) to predict the self-healing of concrete is investigated. GA-ANN model was developed based on data retrieved from the open literature. The results showed that the proposed model is capable of predicting the self-healing in concrete with adequate accuracy.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-611

Dynamic Analysis for Modular Structures

Yingcai Han

Abstract:

Pre-fabricated steel modular structures are widely used for the large projects in energy and chemical industry, to save cost and improve safety during construction. Vibrating equipment such as compressors, turbines, pumps and motors are mounted on the sea-transported steel modules. To ensure a safe and reliable operation throughout the design life of equipment it is important to assess dynamic behavior of the supporting structure. Advanced soil-pile-structure interaction is introduced in dynamic analysis for modular structures in order to design cost-efficient foundations and structures. The dynamic analysis is divided into two stages for simplification purposes in this study. In the first stage, simplified analysis is performed to optimize piling and foundation layouts. The simplified FEM models are then validated to ensure reliability of analysis. In the second stage, a detailed superstructure model is evaluated to check for excessive local vibration within the structure.

A typical steel frame module in the scope of this study is 54 m long, 14.7 m wide and 35 m tall with a total weight of approximately 4,000 metric tons. The modules are supported on concrete piled foundation, with 15 m long 400 mm square precast concrete piles, situated in highly variable soil conditions. The radiation damping (geometric damping) of soil-pile system mainly governs the vibration of foundation and structure. Frequency dependent stiffness and damping are generated using DYNAN software. Then, impedances of the piled foundation are imported as boundary conditions for the FEM model in SAP2000 package. The dynamic response of the structure is calculated using time history analysis and steady state analysis. Different design options of piled foundation are compared in order to optimize cost and to meet the allowable machine vibration and human perception limits.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-612

In-Situ μ XCT Tests and 3D Image-based Numerical Modelling of Concrete and Fibre Reinforced Concrete

Zhenjun Yang

Abstract:

X-ray Computed Tomography (XCT) is a non-destructive technology that can accurately image the internal structures of composite and heterogeneous materials in three-dimensions (3D) with high resolution. In this study, in-situ micro XCT tests of concrete cubes under progressive compression and ultra high performance fibre reinforced concrete (UHPFRC) under wedge-splitting, respectively, are carried out. The 3D images are then segmented into different phases and directly converted into finite element models. The damage and fracture behaviour is simulated by both discrete crack models and continuum damage plasticity models, which are subsequently validated against the in-situ XCT tests by comparison of load-displacement curves and crack patterns. It is found the in-situ micro XCT tests are powerful in elucidating the fundamental 3D damage and fracture evolution in concrete and UHPFRC with unravelled clarity, and are promising for optimal design of complicated materials when combined with image-based finite element modelling.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-613

Technical and Economic Feasibility of Self-Healing Materials

Mohamed Fawzy
Mohamed Abou-Zeid

Abstract:

Concrete cracking represents a major challenge in the concrete industry. Self healing technique is an emerging technology that can minimize cracking at early stages on one hand and provide opportunity to conduct a thorough repair at a later stage on the other. This study aims at achieving better understanding of the technical and economic feasibility of self healing techniques when compared to conventional repair interventions. The study focuses primarily on developing a model that predicts the rate of crack propagation in self-healing in comparison with conventional concrete. This model covers a five year time span and induces twelve various crack geometry and characteristics. A simplified economic feasibility study is conducted taking into considerations anticipated cost of repair, type and extent of repair, cost of inspection, cost of usage disruption and the timely monetary value. For that, the cracking was studied in three scenarios: Initiating immediately after casting, five years after casting, and ten years after casting. This work reveals higher efficiency and economic merits for the self healing techniques compared to conventional repair methods particularly for small cracking situations. It is recommended to expand this work to cover wider sets of self healing techniques and cracks as well as implementing factors that can affect the healing percentages during service.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-614

Effect of Nano Silica on the Performance of Cementitious Materials

Athnasious Ghaly
Aya Attia
Habiba Mostafa
Karim Sammour
Mina Ghobrial
Amr Fathy
Mohamed Abou-Zeid

Abstract:

Nano silica is a relatively new product that has come to markets in limited parts of the world. Its production and thus characteristics vary significantly in the absence of clear specification and guides for its use. This study aims at achieving better understanding of the performance of cementitious mortar prepared using imported Nano silica when compared with mixtures made with silica fume.

The testing program included physical properties, chemical analysis as well as the compressive and flexural Strength. Another set of tests included water permeability, rapid chloride permeability, resistance of the mortar to sulphates, sulphuric acid. Results reveal that the Nano silica used enhances some of the cementitious mortar properties while substantial enhancement was not witnessed when compared to silica fume mixtures. Recommendations are provided to better utilize this innovative material and projects that are likely to make best use of its application.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-615

Detection of Progressive Deterioration of Structures Using Wavelet Transform

Peter Friesen

Ayan Sadhu

Abstract:

Condition assessment of critical structures is of paramount importance in detecting structural deterioration that could result in loss of serviceability or structural failure. Over last few decades, modal identification is shown to be an effective method in identifying structural damage. In particular, discrete damage has been widely researched. However, initial damage may progressively worsen over time causing an increasing risk of failure in a structure. The time-variant nature of progressive damage makes it difficult to detect faults using traditional methods. Several time-frequency signal processing methods have shown success in identifying progressive changes of the modal parameters. In this paper, the authors propose continuous Cauchy wavelet transforms (CCWT) for detecting progressive structural damage. The Cauchy mother wavelet is selected for its strong frequency resolution capabilities to capture subtle frequency variations in time. After analyzing the mode shape information from CCWT, the location of damage is also identified. Performance of CCWT is validated using the experiments of a building model subjected to earthquake excitations.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-616

Utilization of Red Mud as Partial Cement in Cement Mortar

Mohamed Abdel-Raheem
Bilkis Martinez
Lizeth Gomez

Abstract:

Red Mud (RM) is a hazardous waste produced during the alumina refining process. RM is very similar in its chemical composition to cement. As such, several previous studies investigated the possibility of utilizing RM as a possible partial replacement of cement in concrete and cement mortars. However, there are a lot of discrepancies in the results obtained in these studies in terms of the usefulness of the utilization of RM as a partial replacement of cement as well as the optimal replacement percentages concluded. One of the reasons for these discrepancies is the chemical composition of the RM used, which varies with respect to the type of alumina and the manufacturing process used. None of these studies were conducted using RM originated in the U.S.A. As such, it deems essential to carry out a further study to assess the performance of RM on the compressive strength of cement mortars. This paper presents the outcome of recent research conducted to assess the effect of the utilization of RM as a partial cement replacement in cement mortars. The preliminary results obtained show that the RM originated in the U.S. can be very useful if utilized in cement mortar and concrete as it improves the compressive strength.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-617

Further Experimentation on the Utilization of Gasifier Ash in Mortar

Mohamed Abdel-Raheem
Bilkis Martinez

Abstract:

Gasifier ash (GA) is classified as a hazardous material according to the U.S. Environmental Protection Agency (EPA). Although GA is chemically similar to fly ash, it has never been used in concrete before. As such, GA may have the potential of serving as a partial cement or sand replacement in concrete. Incorporating GA in mortar and concrete can have several positive outcomes. First, this method will minimize the negative effects that cement production has on the environment by partially replacing cement with GA in concrete mixes. Also, using GA in concrete serves as a more sustainable alternative for the coal industry for the disposal of GA. A recent study conducted showed that GA can be a useful material if used as a partial sand replacement in regular cement mortars up to 10%. This paper investigates the effect of alkaline activators as well as the water/cement ratio on the compressive strength of cement mortar. GA was incorporated in mortar cubes with varying percentages as both cement and sand replacement. The percentages of alkaline activators and water/cement ratio were then varied with respect to the best GA mortar mix. The results show that increasing the W/C ratio up to a certain limit can improve the compressive strength of GA mortar mix. However, the study concluded that utilization of alkaline activators as binding material has a negative effect on the compressive strength of the mortar.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-619

Experimental Study on Blast Induced Roof Loads in Building Structures

Danesh Nourzadeh
Jag Mohan Humar
Abass Braimah

Abstract:

Analysis of the response of different components of building structures to blast loading is an important step in the protective design of buildings. Included in such components are beams located on the roof and sides of the building and spanning in a direction perpendicular to the shockfront. Traditionally, in the analysis of the blast response of such beams, the blast loads are simplified as spatially-uniform, time-varying forces. This simplifying assumption makes the use of low-cost single degree of freedom models possible. However, in previous studies it has been shown that the results of response analysis based on such assumption are often quite inaccurate when compared to those obtained from a more precise analysis.

To examine the validity of the results obtained from the simplified, as well as the more accurate analyses, the response of such beams to propagating blast load is measured in a series of small-scale experiments. The experimental set-up consists of an Aluminum beam supporting a Plexiglass sheet representing the roof, resting on a rigid blast table. The assembly is subjected to a series of blast load events. During the experiments, blast pressures acting on the beam and the deflections of the beam are measured using high accuracy gauges. The test results are then compared to those obtained from numerical analyses carried out with and without using the simplified uniform load assumption. The numerical simulations are carried out in OpenSEES software using nonlinear beam elements. The comparison shows the inaccuracy and unreliability of the simplified methodologies, as well as confirming the validity of the more precise analysis based on a travelling pressure wave representation of the blast load and a finite element model of the structural assembly.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-620

Response of Multi-Story Frames and Individual Columns to Blast Loading

Danesh Nourzadeh
Jag Mohan Humar
Abass Braimah

Abstract:

Columns are critical members in maintaining the structural integrity of building structures under any types of extreme loading. This importance is even more highlighted when the buildings are subjected to blast loading, since in most cases the columns in the front face of the buildings experience high blast demands. Response of these members to blast loading is traditionally analyzed by modeling columns as isolated elements, where the boundary conditions are assumed to be some combination of fixed and pinned, but laterally restrained. Therefore, an investigation was carried out to determine how much the ends of the columns displace in reality, and how such displacement affects the response of the columns. In this regard, selected two-dimensional multi-story reinforced concrete frame was subjected to two different blast load scenarios. The response of the critical columns in the multi-story frame was compared to the response of the same columns under similar loadings modeled as isolated columns. The comparison shows that for high blast loads, the response of an isolated column was much larger than the response of the same column when it is treated as a part of the multi-story reinforced concrete frame (global model). When the blast loads are modest, so that the column remains elastic the difference between the response of an isolated column and when it is part of a multi-story frame is not large, although isolated column response is still higher. Therefore, it can be concluded that in a new design, response analysis of isolated column model would provide acceptable, but conservative results. When evaluating existing buildings however, a global analysis of the multi-story frame may be necessary to obtain realistic results, particularly when the isolated column analysis shows that the column becomes inelastic.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-623

Observation of Polymer Modified Asphalt Microstructure by ESEM

Peter Mikhailenko
Changjiang Kou
Hassan Baaj
Susan Tighe

Abstract:

The observation of asphalt binder microstructure with the Environmental Scanning Electron Microscope (ESEM) has yielded promising results. There have been findings that show the microstructure evolving with aging and certain loading applications. The goal of this study was to observe the PMA microstructure using ESEM analysis. Four PMA binders of varying PG grades were observed in ESEM, comparing them to a straight run binder. The binders were compared in terms of the fibril diameter and shape observed visually, along with the fibril structure. The initial “bee” structures before the appearance of the fibrils were also compared. It was found that the PMA binders had a denser fibril structure, corresponding to their higher PG grades indicating stiffer binders, although this varied with different PMAs. The images were also analyzed by calculating the area and length of the fibrils through an image analysis protocol. This study is a step towards the further understanding of the microstructure of PMAs.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-625

Ultimate Load Tests on a 40-m long TL-5 Bridge Barrier reinforced with GFRP bars with special profile 180

Michael Rostami
Khaled Sennah
Ahmed A.B. Mostafa

Abstract:

A recent design work conducted at Ryerson University on TL-5 bridge barrier has led to an economical glass fibre reinforced polymer (GFRP) bar detailing for sustainable construction. The proposed barrier configuration was recently crash tested to qualify its use in Canadian bridges. However, design procedure under static load equivalent to vehicle impact force is unavailable. The yield-line pattern specified in AASHTO-LRFD Specifications for the design of concrete barriers reinforced with steel bars may not be applicable to GFRP-reinforced barrier. This may be attributed to the low stiffness, bond characteristics, elastic response of the GFRP bars till failure. Moreover, the low strength under compression and shear stresses, could possibly leads to punching shear failure instead the yield line pattern presented in the AASHTO-LRFD. Therefore, full-scale GFRP-reinforced barrier wall with length of 40 m was constructed over a 360 mm cantilever deck slab. Segments of this barrier were tested for collapse to determine their structural behavior, crack pattern and ultimate load carrying capacity under simulated vehicle impact load. Two types of loading were considered at a height of 990 mm over the deck slab surface, namely: line load over 2400 mm at interior location and line load of 2400 mm at end location. Although both flexural and diagonal cracks appeared at the tapered face of the barrier during loading, the test results showed punching shear failure modes at the load location of tested barrier segments. The experimental ultimate load carrying capacities of the barriers were observed to be far greater than the factored design loads specified in AASHTO-LRFD Specifications and the Canadian Highway Bridge Design Code. Comparison between experimental and theoretical punching shear strength equations obtained from available literature was conducted.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-627

Effect of Cementitious Protection on Flexural Response of CFRP Reinforced Beams Exposed to Elevated Temperature

Reem Abou Ali
Mohamed Abou-Zeid

Abstract:

Carbon Fiber Reinforced Polymers (CFRP) has been used extensively over the past decades to strengthen and retrofit the concrete structures. They are proven to enhance the structure load carrying capacity. The externally bonded CFRP systems improve the flexural strength of the concrete structures.

This study aims at achieving better understanding of the effect of cementitious protection on flexural response of CFRP reinforced beams exposed to elevated temperature.

Beams were prepared using cementitious protection and were exposed to three different temperatures and four durations. The results of this work reveal that CFRP experienced a significant drop in flexural strength upon exposure to elevated temperature. The strength however, was restored up to 63% upon using ready-to-use mortar. It is recommended to use this protection type as means to alleviate the negative impact of elevated temperature on CFRP system.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-628

Anchorage Capacity of TL4 Concrete Bridge Barrier-Deck Junction Reinforced with GFRP Bars with Newly-Developed, Cost-Effective, 180° Hooks

Michael Rostami
Khaled Sennah

Abstract:

Corrosion of steel reinforcement due to environmental effects is a major cause of deterioration problems in bridge barriers. Glass fibre reinforced polymers (GFRP), not only addresses this durability problem but also provides exceptionally high tensile strength. A recent design work conducted at Ryerson University on TL4 bridge barrier proposed the use of 12 mm diameter GFRP bars as vertical and horizontal reinforcement. The Vertical reinforcement spaced at 300 mm spacing in the barrier front and back faces. The connection between the deck slab and the barrier wall utilized the newly developed 180° hooks GFRP bars for proper anchorage. Three actual size barrier walls of length 1000 mm each were cast and then tested to collapse under transverse line load at 790 mm from the top of the deck slab to determine their ultimate load carrying capacity with the presence of the new hook at the bottom end of the vertical GFRP bars at the front face of the barrier wall. The first barrier had vertical reinforcement at 300 mm spacing and rest over a cantilever deck slab, representing barrier segment within the bridge length. The second barrier wall was identical to the first barrier but with front vertical reinforcement at 150 mm, representing the end portion of the bridge barrier wall in practice. The third barrier wall was identical to the first barrier wall by rest over a 500 mm thick solid slab, representing non-deformable deck as the case in voided-slab or solid slab bridge cross-section. This paper presents the results from these tests in the form of crack pattern, deflection history and the ultimate load carrying capacity as compared to the design values specified in the Canadian Highway Bridge Design Code for barrier anchorage into the deck slabs.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-629

Seismic Performance Assessment and Design of Shape Memory Alloy (SMA) Cross-Wire Configured High Damping Rubber Bearing

Kaila Spencer
Farshad Hedayati Dezfuli
Shahria Alam

Abstract:

Base Isolation systems are currently one of the common methods used to maintain the general integrity of bridges and other structures from the damages caused by seismic activity. The use of these isolators can come with some complications due to their limitations with regards to aging as well as possible deformation or failure after experiencing a substantial earthquake; this results in the need to constantly maintain or replace the isolators, which can be costly and time consuming. The use of shape memory alloy (SMA) wires in high damping rubber bearings (HDRBs) helps to resolve most of the major problems associated with the commonly used isolation devices, which would allow the isolation devices to possibly experience seismic events without needing to be consistently fixed or replaced. This study evaluates the design of a new smart elastomeric isolator, called SMA-HDRB, using a cross configuration for the wires, as well as different material types of SMAs, and pre-straining effect. The hysteretic shear behavior of designed SMA-HDRBs with the cross configuration shows that the lateral flexibility and residual deformation are reduced compared to normal HDRBs. Results also demonstrate that pre-straining the wires helps to prevent the reduction of the lateral flexibility; and increasing the diameter of the wires increases the effective horizontal stiffness and total energy dissipation capacity of the base isolation system.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-631

Enabling Operational Resilience through Performance-based Fire Design

Matthew Smith
John Gales

Abstract:

Operational resilience is an increasingly important topic in today's conversations about building design, asset management, and business continuity. This is a trend that will not disappear as a changing environment and growing urbanization continue to increase the importance of designing for extreme events, whether they are malicious, accidental, or environmental in nature. The research presented herein will analyze how performance-based fire design can be used during the design of a building to enable operational resilience within it. By proactively and quantitatively determining the performance of a structural solution for a range of realistic design fires, the public can understand the implications of the fire for their tenant space and ultimately for the operation of their business.

A methodology will be proposed for developing a range of criteria, in concert with the expect users of the building, to understand the required performance of the building. This can be quantified as immediate occupancy, short-term disruption, and long-term/permanent disruption. This is a novel approach to fire safety design that varies from what is typically seen in Canadian practice where a deterministic set of design fires seek to capture the worst case structural and life safety scenario. The overall aim of this approach is to lay out specific levels of performance for ranges of design fires so that the users of the building can appropriately prepare response plans for different fire events and remain operational following a fire. This methodology will be demonstrated through a case study of a realistic Canadian building design that has performance levels quantified for a realistic design fire to feed into a business continuity plan. The end result is a more sustainable building which enables operational resilience within it, and the approach can be extrapolated to all hazards affecting infrastructure.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-635

Lateral Torsional Buckling Analysis and Design of Steel Beams with Continuous Spans

Arash Sahraei
Payam Pezeshky
Magdi Mohareb

Abstract:

Design standards do not provide provisions to account for the interaction between adjacent spans of continuous beams. In the absence of such provisions, the designer may opt for calculating the lateral torsional buckling capacity for each span separately by applying the moment gradient factors provided in standards and adopting the smallest critical moment as the one governing the design. The Salvadori hypothesis of isolating a member from the rest of the structure is assessed in the present study. The elastic lateral torsional buckling resistance for continuous beams is investigated based on finite element analysis. Comparisons are made between two types of solutions: (1) those neglecting interaction effects between adjacent spans, and (2) those considering span interaction. Also examined is the effect of presence of lateral/torsional restraints at intermediate supports of continuous beams. The results illustrate the merits of adopting the FEA solution in accounting for span interaction when determining the elastic lateral torsional buckling capacity of continuous beams.

Keywords: lateral torsional buckling, finite element analysis, interaction effects, moment gradient factors, continuous beams



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-636

Karhunen-Loève Expansion for Extreme Values of Homogeneous Gamma Fields

Arnold Yuan
Adetola Adegbola

Abstract:

Many problems encountered in engineering manifest a non-Gaussian probabilistic behavior and as such, they are best modeled as non-Gaussian stochastic processes and/or fields. In stochastic degradation modeling particularly, there is a need to characterize both spatial and temporal uncertainty. This paper presents a method of evaluating extreme value distribution of a type of non-Gaussian random fields by simulation. The Karhunen-Loeve expansion is adopted to represent a one-dimensional gamma field with exponential autocovariance function, which can be further extended to multidimensional gamma random fields. Major contributions of this paper include the numerical evaluation of extreme value distribution of gamma fields as well as properties of the fields.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-637

Effect of Bracing Height on Lateral Torsional Buckling Resistance of Steel Beams

Payam Pezeshky
Arash Sahraei
Magdi Mohareb

Abstract:

Present beam analysis techniques for determining the elastic lateral torsional buckling resistance for beams enable the modelling of intermediate lateral braces located at section mid-height. In practical design situations however, either top or bottom flange bracing may be provided. Such bracing conditions have received little attention in the literature. The present study investigates the effect of bracing height on the elastic lateral torsional buckling resistance of beams. In each case, three eigen-value buckling solutions are conducted: (1) a shell-based finite element solution, (2) a newly developed beam finite element that captures distortional buckling effects, and (3) a non-distortional Vlasov thin-walled beam buckling element modified to account for top and/or bottom flange bracing. The three models are used to investigate the elastic lateral torsional buckling for cantilevers under tip loads and simply supported beams under point loads. An assessment is then provided on the effect of various bracing scenarios and distortional effects on the predicted critical moments. Comparisons with shell analysis illustrate the versatility of the finite elements developed in comparison to existing standard procedures in quantifying the critical moments for beams with braces offset from the shear center.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-638

Site Specific Record Selection and Seismic Fragility Analysis

Yasamin Rafie Nazari

Murat Saatcioglu

Abstract:

Seismic fragility of a 5-storey regular shear wall building was assessed through nonlinear dynamic analysis and the effect of site specific record selection and direction of applied load were investigated. Two sets of twenty synthetic earthquake records compatible with western and eastern Canadian seismicity are applied to the structural model. Fragility curves of the building were developed having both spectral acceleration at the fundamental period of the structure and peak ground acceleration as seismic intensity parameters. The results indicated that fragility curves are less sensitive to record selection when spectral acceleration is chosen as the seismic intensity parameter, as this parameter provides a normalized format of hazard intensity. On the other hand, when peak ground acceleration is chosen as seismic intensity indicator, significant change is observed in fragility curves derived for sites with different seismicity characteristics. Numerical simulation of the building was further analyzed under seismic records applied at an angle of 45 degree and the results of dynamic analysis and fragility curves are compared to the case that the load is applied parallel to one of the principle directions. Based on the result, applying the load in an angle would cause a delay in entering to nonlinear range of behaviour for the structure and therefore is not a conservative approach at lower levels of seismic intensity.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-639

Seismic Vulnerability Assessment of Canadian Reinforced Concrete Shear Wall Buildings Designed in Pre-Modern Seismic Code Era

Yasamin Rafie Nazari
Murat Saatcioglu

Abstract:

This research intends to assess seismic vulnerability of existing Canadian reinforced concrete shear wall buildings. A probabilistic methodology is taken to account to quantify the likelihood of exceeding different damage states under different levels of seismic hazard intensity in the format of seismic fragility curves. The buildings considered are designed prior to the enactment of ductile design requirements in Canada. Considering 1975 as the benchmark for introduction of modern seismic design provision, pre-1975 shear wall buildings with regular plan, are simulated in PERFORM 3D software for nonlinear modelling and analysis. The buildings are subjected to Incremental Dynamic Analysis by applying time history records compatible with Canadian seismicity with increasing intensity to cover the whole range of structural behaviour. Accordingly, seismic fragility curves of the existing shear wall buildings designed in pre-seismic code era are derived considering immediate occupancy, life safety and collapse prevention as damage states. It is concluded that Canadian shear wall buildings designed in pre-seismic code era are vulnerable based on life safety objective of recent modern seismic codes. Therefore, consideration of rehabilitation strategies based on acceptable margin of safety intended may be necessary.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-640

A Review of Low-Cycle Fatigue of Corroded Steel Bars

Fangjian Chen
Arnold Yuan

Abstract:

Low-cycle fatigue (LCF) represents an important material degradation phenomenon that may compromise structural performance under strong earthquakes. A large number of studies have been performed over the past two decades to fully understand and model the LCF behaviours of steel reinforcement, including the combined effects of corrosion and buckling on LCF. This paper presents a critical review of the experimental and theoretical work to forge a converging view on the influential factors of the low-cycle fatigue behaviour with an emphasis on corroded rebars. Testing protocols, major experimental findings, and model development were reviewed. The review finds that the objective of experimental studies has been extended from the sole prediction of fatigue life to more thorough characterization of cyclic behaviours such as strength and stiffness degradation, energy dissipation, and pinching in hysteresis loops, whereas the LCF model has become a submodule of steel rebar's constitutive law under cyclic loadings. It is also found that corrosion does not only reduce the fatigue life drastically, but also significantly affects strength degradation and energy dissipation. Moreover, the presence of corrosion aggravates the synergetic effects of buckling on LCF. It is suggested that future studies should aim to establish LCF model based on measurement of pitting corrosion (e.g., pit depth), rather than that of general corrosion.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-642

A Review: The Effect of Graphene Oxide on the Properties of Cement-Based Composites

Daman Panesar
Tanvir Qureshi

Abstract:

Graphene oxide (GO) is a recently invented 2D nano-plane fiber. Graphene oxide is typically produced from the chemical oxidation and exfoliation of graphite. It contains some active functional reactive groups on the nano plane surface which play a major role during the cement hydration process. Preliminarily, it is reported in the literature that hydration properties of GO-cement composites result in a higher rate of hydration rate which affects its water demand as well as workability. Some studies also report that reinforcing the cement matrix with GO yields the formation of CSH gel in the micropores enhancing the composites mechanical properties. Markedly few studies have been reported on examination of durability properties of GO-cement based composites. This paper presents a critical review on the functionalities and influence of GO in cement-based composites ranging from its effect on hydration, workability, transport properties, evolution of mechanical properties, and durability. This review will also cover the literature reports related to life cycle cost and the carbon footprint of such a cement composite.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-643

Seismic Performance of Beam-Column Joint Reinforced with Different Shape Memory Alloy Alternatives.

Sosan Rizvi
Rashedul Kabir
Shahria Alam

Abstract:

For seismic design based on the structural performance to minimize the earthquake damage and possible seismic hazard scenarios to the structure, reinforcing the beam-column joints is crucial. Shape memory alloys are specially developed materials that exhibit the unique ability to return to their original shape after experiencing large stress deformations. Incorporation of SMA in the plastic hinge regions of beams of beam-column joints could potentially increase the ductility and reduce the residual deformation. Five various types of SMAs from the literature are being purposed as potential contenders in the SMA-Steel hybrid RC beam-column joint in this study. Numerical investigations of the beam-column joints have been carried out under reversed cyclic loading. The performance of the hybrid joints is scrutinized in terms of load-storey residual drift, moment-rotation, and energy dissipation capacity and compared to regular steel reinforced beam-column joint response. All the SMA-Steel hybrid beam-column joint proved to have adequate energy dissipation capacities with minimal residual storey drift under earthquake type loading.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-644

Application of High-strength Composite Materials for the Nuclear Waste Containers and Flasks

Faizul Mohee
Faizul Kamal

Abstract:

Nuclear Waste Management Organization (NWMO), Ontario Power Generation (OPG), Bruce Power and Canadian Nuclear Laboratories (CNL) in Canada are currently pursuing several nuclear waste management projects. For all these projects, a proper structural design of the nuclear waste containers and flasks is a crucial component. For the permanent nuclear waste disposal at the NWMO site requires the waste containers and flasks to be corrosion-proof. Consideration of the transportation or acceleration load and the fatigue load is critical component for the proper design of the nuclear waste containers. If a nuclear waste container is made of steel, it can be corroded in presence of oxygen and water at the temporary or permanent storage facility; and if it is made of aluminum, it can be corroded in presence of another metal (galvanic corrosion). Therefore, a new and innovative corrosion-free and non-magnetic composite material should also be considered for the manufacturing of these containers. Application of this high-strength and corrosion-free composite materials will also ensure a higher fatigue and transportation acceleration strength.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-645

Towards a Mechanical Anchor System for CFRP Plates

Faizul Mohee

Abstract:

For prestressed carbon fibre-reinforced-polymer (CFRP) plates, a special end-anchor is required in order to transfer the forces from the CFRP plate to the concrete beam or slab surface to avoid premature peeling-off failure in the CFRP plate. Since CFRP plate has a relatively low transverse compressive strength, the traditional anchors and clamping used for steel plates can crush CFRP at its load bearing area, leading to premature failure of the CFRP plates at the anchorage point. Without an anchor, the full tensile capacity of CFRP plates is not utilized. In order to utilize the full capacity of its ultimate tensile strength, prestressing an easy-to-install anchor is required. This article deals with the development, analysis, parametric study and experimental investigation of an innovative, easy-to-install, low cost, epoxy-free, mechanical, compact, high-strength, prestressing anchor for carbon fibre-reinforced-polymer (CFRP) plates. The anchor was developed to prestress the popular and commercially available high-strength CFRP plates. The novel CFRP plate anchor was designed and analyzed by means of finite element numerical modelling.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-646

Seismic and Wind Vulnerability Assessment for the Pattullo Bridge

AHM Muntasir Billah

Ryan Taylor

Abstract:

The Pattullo Bridge between New Westminster and Surrey in Metro Vancouver was designed and constructed in the early 1930's, a time when the effects of earthquakes on structures received little consideration. Since the bridge opened to traffic, no major seismic rehabilitation and retrofitting has been done to date. The paper presents results of a seismic and wind vulnerability assessment with the purpose to develop an advanced warning system for the Pattullo Bridge. The assessment includes the definition of design criteria, design loads, thresholds and detailed finite element model development. Based on probabilistic seismic hazard analysis, the threshold seismic event was identified. Wind analysis was carried out based on the site-specific wind loads and turbulence criteria developed using historical data. Based on the outcome of this study, it is found that the probability of exceeding a threshold event (seismic or wind) at the bridge site within the expected remaining 10 year services life is unlikely. These findings can be implemented in the warning system development.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-647

Case Study of Seismic Load Reduction Factors for Equivalent Seismic Loads for Low and Mid-Rise Buildings

Navpreet Bharaj
Ashraf El Damatty
Mahdy A. Hamada

Abstract:

The current study assesses the seismic response of a number of buildings in various seismic regions in Canada. The provisions of the 2010 National Building Code of Canada (NBCC) are strictly followed related to the loading and analysis of various buildings used in the study. The study uses different shape mid-rise buildings as case studies. The studied buildings have different plan view geometry, such as Rectangular, Semi-L Shape, L Shape, and Irregular building. The buildings are analyzed for different seismic locations in Canada including, London, Toronto, Montreal and Victoria. These locations are chosen to simulate low, moderate and high seismic areas. Three-dimensional finite element (FE) models of the buildings are developed for the buildings using the commercial finite-element software package ETABS. The lateral force resisting system of the buildings consists of concrete shear walls aligned in both principle directions. The code provisions are strictly followed. The fundamental periods obtained from 2010 NBCC equations and finite element analysis are compared. Consequently, a comparison between the seismic base shear values obtained for the different fundamental period is conducted. The study revealed that the fundamental period obtained from 2010 NBCC can be overestimated for low storey buildings when compared to periods obtained using FE analyses. In addition, the FE analyses shows that the building fundamental period differs in the principle axes while the 2010 NBCC only suggests a definite fundamental period equation to be used for the seismic analyses of a building. Such a difference in building fundamental periods leads to different base shear values along the principle axes of the building.



EMM-648

Advanced Deep Learning Based Damage Detection Using Computer Vision

Wooram Choi
Oral Buyukozturk
Young-Jin Cha

Abstract:

The prominent methods for monitoring structures to date rely on analyzing data measured from contact sensors that are physically attached to a structure. However, these approaches have the high possibility of false alarms due to noises, sensor malfunctions and complex environmental effects. It means that engineers would still have to make on-site visits to confirm that damage has occurred. To address this challenge, this paper proposes a new concrete-crack-detection using a convolutional neural network (CNN) from images taken by smartphone cameras. In order to train the CNN, required 'intact' and 'damaged' images are taken from the Faculty of Engineering buildings on the campus of the University of Manitoba. A CNN classifier, composed of 8 components including convolution, pooling, ReLU, and softmax layers, is trained on the collected image dataset. A sliding window technique which enables us to scan images of any size larger than 256X256 pixel resolutions is implemented. The trained CNN classifier recorded 98% of accuracy in its analysis of 4,000 numbers of images. In terms of computational cost, the trained network needs about 20 seconds to scan an image with a resolution of 4864x3072 pixels.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-649

Evaluation of Early Age Shrinkage Cracking Tendency of Concrete

Bruce Menu
Marc Jolin
Benoit Bissonnette
Nicolas Ginouse

Abstract:

This paper presents the experimental work carried out to investigate the early-age shrinkage cracking characteristics of concrete. Early-age shrinkage cracking is an ever-present concern in concrete technology which affects the long-term reliability and integrity of concrete structures. In this study, restrained and free ring tests were used to evaluate concrete cracking potential and creep characteristics. This study goes beyond the basic test data analysis and evaluates the rate of stress development under restrained shrinkage conditions. A test procedure addendum is also outlined to quantify the tensile creep behavior of concrete using a companion free shrinkage ring specimen. A separate study was carried out to evaluate the influence of curing on the rate of stress development under restrained conditions. Analysis of data obtained from this research project showed that the time it takes for a concrete element to crack depends more on shrinkage rate rather than the magnitude of shrinkage. This suggests that there exists a strong correlation between stress rate and the time-to-cracking of the concrete ring specimen. Furthermore, cracking resistance under restrained conditions is found to depend on the combined effect of the shrinkage stress buildup, tensile strength development and tensile creep potential of concrete.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-650

Effect of Fire Exposure on Impact Resistance of Hybrid Fiber-Reinforced Engineered Cementitious Composites

Mohamed Ali
Moncef Nehdi
Ahmed Soliman

Abstract:

The effect of fire on the impact resistance of a novel hybrid fiber-reinforced engineered cementitious composite incorporating short randomly dispersed shape memory alloy and polyvinyl alcohol fibres (HECC-SMAF) was investigated in this study. A two-parameter Weibull distribution was used to analyze variations in experimental results in terms of reliability function. Results showed that the impact resistance of the composite was generally degraded due to fire exposure. However, among the tested specimens, the composite incorporating 2% PVA and 1% SMA fibres achieved highest impact resistance. Adding more fibres beyond a threshold level led to fibre clustering, compromising impact resistance. The Weibull distribution was adequate to predict the impact failure strength of the composite, allowing to preclude additional costly experiments.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-653

Experimental Study and Parametric Analysis on the Stability Behavior of High-Strength Aluminum Alloy Angle Columns under Axial Compression

Zhongxing Wang

Abstract:

An experimental program including study has been conducted to investigate buckling behavior of 7A04 high-strength (HS) aluminum alloy columns under axial compression, in which 42 L-shaped extruded specimens were designed and tested. The specimens involved two sections and seven slenderness ratios varying from 15-100. The test results were compared with design results in accordance with American Aluminum Design Manual, GB 50429-2007 and Eurocode 9. A finite element (FE) model of the tested specimens under axial compression has been developed by using general finite element software ANSYS, and was verified by using the test results reported herein and other experimental results presented in the literature. By using this FE model, an extensive body of parametric analyses were conducted to clarify the effects of width-to-thickness ratio of angle legs, initial imperfections and material strengths on the buckling resistance of the 7A04 angle columns. Based on the test and FE analyses results, a modified design method was proposed for predicting the buckling resistance of 7A04 high-strength aluminum alloy columns more accurately.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-654

Properties of Oriented Strand Board (OSB), and Timber to Evaluate the Stiffness of Timber I-Joist

M. Shahidul Islam
Mohammad Nouroz Islam
Shahria Alam

Abstract:

Timber I-joist is an engineered building construction element produced from solid timber and Oriented Strand Board (OSB) as flange and web, respectively. In Canada, timber I-joists are commonly used for construction of residential and industrial buildings. This research study was conducted to evaluate the different mechanical properties of OSB and timber. The Ultimate strengths, Modulus of Elasticity (E), Shear Modulus of Elasticity (G), and Poisson's ratio were investigated under tension loading as per specified standard (ASTM-D1037 and ASTM-D143). Based on these mechanical properties of OSB, and timber, the combined stiffness of composite I-joist was determined and compared to the overall stiffness (K) of the tested I-joist under four points bending test. It is found that a good agreement exists between the flexural stiffness derived from the material properties and bending test. Finally, calculated stiffness and measured stiffness based on the four point bending test of I-joists were compared and it is found that the calculated values of stiffness (K_A) are very close to the experimental stiffness (K_E).



EMM-655

S-TIMBER: Integrated Timber Design by S-FRAME Software

Moein Ahmadipour
Siriwut Sasibut
Shahria Alam

Abstract:

Timber plays an essential role as a key construction material in structural engineering industry. As timber technology and fabrication quality has increased, constructing taller timber structures have been made possible and gained more attention and popularity. Thus, the design of such structures has become more complicated. This has resulted in the need for automated design means to let the engineers iterate between thousands of designs and get to the most efficient one. In a collaboration, S-FRAME Software Inc. and the University of British Columbia (UBC) at the Okanagan campus have initiated development of the product S-TIMBER to accompany S-FRAME structural analysis and design software. This product features analysis and design of timber structures and is capable of capturing the demand and capacity for sawn lumber, glued-laminated (glulam) and cross-laminated (CLT) timber elements based on CSA O86-14, Engineering Design in Wood. The product is tested using thousands of unit tests and verified against Wood Design Manual published by Canadian Wood Council. This presentation will showcase the unique and user-friendly features of this upcoming product.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-656

Using Wood Ash as Cement Replacement

Tanya Fraser
Ameeta Bhabra
Ahmad Rteil

Abstract:

The production of portland cement, a major constituent of concrete, accounts for about 5% of the total CO₂ emissions worldwide. As the world's population continues to grow and its infrastructure continues to age, cement production will increase. For this reason, researchers are trying to find new raw materials and processes that would result in greener cement.

In this paper, the use of wood ash as a partial cement replacement will be investigated. Wood ash is an abundant waste material in British Columbia that after combustion roughly 6-10% of the original mass is left as residual ash, of which 70% is usually landfilled. Depending on its combustion temperature, wood ash can demonstrate cementitious property and therefore have validity as a partial cement replacement. The research group cast standard cement mortar cubes with cement replacements of wood ash at 10, 20 and 30 percent. The cubes were tested for compressive strength at curing periods of 7 and 28 days. The combustion temperature was also varied, with samples held at 700, 850 and 1000 degrees Celsius for 4 hours in the kiln.

Results showed that wood ash treated at 1000 degrees Celsius could replace up to 20% of the cement with no effect on compressive strength.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-658

Experimental and Analytical Performance of an Innovative Pile-to-Pile Mechanical Connector

Ramon Rosales-Espinoza
Carlos Cruz-Noguez

Abstract:

Pile-to-pile mechanical connections are used if the depth of the soil layers with sufficient bearing strength exceeds the original (“leading”) pile length. The additional pile segment is termed “extension” pile. Mechanical connectors consist of an assembly of sleeve-type external couplers, pins, and other mechanical interlock devices that ensure the transmission of forces between leading and extension pile segments. However, the followed common practices when designing mechanical connectors neglect important aspects of the assembly response, such as stress concentration around pin holes, torsional stresses from the installation process, and interaction between the forces at the installation and service stages. This translates into potentially unsatisfactory designs in terms of the ultimate and service limit states, exhibiting either reduced strength or excessive deformations. In this study, the experimental response under compressive forces of a type of mechanical connector is presented, in terms of strength, deformation and failure modes. Using the results from the compressive tests, an analysis model is developed using the Finite Element (FE) method to study the interaction of forces under installation and service stages of a typical mechanical connector. The response of the analysis model is used to identify potential areas for design optimization, including size, gap between leading and extension piles, number of pin/bolts, hole sizes, and material properties. The results show that the design of mechanical connectors should consider the interaction of forces present at every stage of their life cycle, and points out the most critical zones of the mechanical connection.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-659

An Integrated Simulation Method for Performance-Based Assessment of a Structure

Xu Huang
Vahid Sadeghian
Feng Rong
Oh-Sung Kwon
Frank Vecchio

Abstract:

In current engineering practice, the performance assessment of the structures is carried out through a two-stage process. First, a system-level analysis is performed mostly based on equivalent linear elements. Then, the critical components identified from the system-level assessment are examined in more detail using either sophisticated nonlinear analysis tools or laboratory testing. Such two-stage process does not accurately capture the interaction of the critical elements with the rest of the structural system, particularly in highly nonlinear stages of the response. To overcome this limitation, an integrated simulation method is proposed to allow an explicit consideration of nonlinear behaviour of the critical elements during the system-level analysis. In this method, the potential critical components, which are initially represented with linear elements, are modelled in a detailed FE analysis tool using more sophisticated elements. The two sub-models communicate through internet network to satisfy compatibility and equilibrium requirements. By using a standardized communication routine for data exchange between the substructures, any other potential elements, either numerical or physical, can be readily integrated. In this paper, the application of the proposed method is illustrated through an integration of a commercial structural analysis and design software, S-FRAME, with a state-of-the-art analysis tool, VecTor2, for the performance assessment of a reinforced concrete high-rise building. Based on the analysis results, the procedure is found to provide a more realistic behaviour of the critical elements in the component-level and also accurately considered the influence of force redistribution between elements on the performance of the structural system.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-661

Seismic Damage Assessment of RC Building with Transfer Slab System

Mohamed Elassaly
Mohamed Nabil

Abstract:

Over the past decade, several studies investigated behavioural aspects of irregular structures and limitations of seismic code provisions for such class of buildings. This paper investigates the dynamic and seismic behaviour of buildings employing thick transfer slab between two different structural systems representing podium and upper tower. The shape of these structures is commonly dictated by either aesthetic or functional considerations that often preclude simplicity or regularity. The purpose of this paper is to assess the seismic damage potential of such structures compared to regular buildings. The seismic behaviour is examined under the effects of 14 natural ground motions. The structural damage assessment is conducted through examining drift ratios and damage indices of the overall structure as well as of the significant structural components of RC building. Other significant seismic design parameters such as base and story shear are also assessed for the varying ground motion characteristics. The evaluation and the comparison of the seismic behavior of these buildings, has great impact in attenuating the seismic structural response under various earthquake ground motions. Nonlinear dynamic analyses are performed on a 2-dimensional model of R.C. building.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-662

Application of BIM Technology in Design and Construction: A Case Study of the Pharmaceutical Industrial Base of Amino Acid Building Project

Lancine Doumbouya

Abstract:

The rapid development of information technology has brought several innovations to the field of civil engineering. BIM technology places emphasis on information integration and the establishment of database. It also aims to realize the building life-cycle management. BIM technology is exerting a significant and profound impact on the design, construction, management, operation, and maintenance of building project. In this study, the value of BIM in construction projects was analyzed, and the significant meaning about this study was elaborated on. BIM standards and data standard of IFC were discussed, and the important concepts of 4D-BIM and 5D-BIM were also presented. The key technologies like parameterization, visualization, geographic information system, building life cycle management, and clouding computing were analyzed. Furthermore, the mechanical behavior of the building was analyzed, and the value of BIM in construction was expounded. Particularly, the application of BIM in bidding, BIM virtual construction, clash detection, and refined calculation about resources as well as materials, were analyzed in this paper. Also, the construction dynamical management system of 4D-BIM was discussed. Finally, the coordination which acts as an important issue between BIM design and BIM construction were analyzed comprehensively.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-665

Design of a Two-Span Continuous CPCI Girder Bridge with Semi-Integral Abutment

Falak Naz

Abstract:

Over the past few years, the significant growth in commuters especially in major cities of Canada emphasises the need to improve and expand our transportation infrastructure. Further, traffic statistics indicate that the Greater Toronto Area (GTA) is one of the most congested areas in Canada. Hence, this project involves building a new two spans semi-integral CPCI girder bridge, which is designed to carry vehicular traffic within the GTA. The bridge has each expansion joint placed at the end of the approach slab which protects the substructure/bearings components. This simplicity and durability led to a growing interest in the significant sustainability contributed by such design concept not only in Canada but world-wide as well. To find the most cost effective and optimum design, two options of precast/prestressed concrete girders (CPCI I-Girders and CPCI Box-Girders) were investigated. Though few box-girders provide high stability against torsional failure, more I-girders, yet with much reduced weight, can still provide adequate resistance. Moreover, the moderate cost usually associated with I girders fabrication, shipping and installation economically favours the I-girder alternative. However, the overall optimum design criterion addresses other various aspects aiming towards a bridge that is structurally sound, aesthetically appealing and environmentally friendly.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-667

Recent Development and Trial of Corrosion Resistant Structural Steel

David Lai

Abstract:

The use of uncoated weathering steel for highway bridges in Ontario started in the late 1960's. By early 2000's, it has been observed that uncoated weathering steel is not performing well at certain locations, including the soffit of box girders over traffic and field splices of plate girders over rivers. The premature corrosion of weathering steel in these applications has led to major maintenance efforts and could pose a safety concern if sheets of corrosion product fall onto traffic below. There is therefore a need to identify a more corrosion resistant steel for highway bridges in order to minimize the maintenance effort, but the new steel should preferably have similar mechanical properties compared with the standard weathering steel, and could be fabricated by local fabricators using current technology. MTO has engaged the steel industry, CISC, and Surface Science Western since 2008 through a ministry and industry funded research project to develop the chemistry of a new corrosion resistant steel; several compositions have been evaluated, including the one with 5% Cr which shows promising results. At the same time, the ASTM A1010 steel with 12% Cr has been identified as a viable alternative based on the two bridges that the Oregon DOT has constructed and based on laboratory evaluation; the ministry implemented two trial projects using A1010 steel in 2015 and 2016, one for plate girders over a waterway and another for box girders over highway. This paper provides a comparison of the laboratory test results of A1010, 5% Cr, and the standard weathering steel. Lessons learned from the development of the welding procedure and fabrication of the A1010 steel is also shared. Finally, based on the cost premium of the A1010 steel in the two MTO contracts, a life-cycle cost comparison is made between the use of A1010 steel versus coated weathering steel.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

EMM-670

Capacity of Recycled Aggregate Concrete under Normal and Extreme Loading Conditions

Feng Fu

Abstract:

In this case study, strength test and impact testing of RAC have been performed which is to check the possibility of using the RAC as a formal alternative to current normal concrete. A series experimental studies were carried out to investigate the behaviour of recycled aggregate concrete (RAC) concrete members under compressive, tensile splitting test, as well as impact test. Different proportion of recycled concrete to the fresh concrete in each mix design specimen and different water to cement ratio has been chosen in the investigation. The results of the tests show by changing certain parameters of RAC, such as water cement ratios, the strength of RAC is adequate to be used for certain construction projects. Therefore, the use RAC as a substitute of Normal concrete become promising. However, it also found that RAC concrete with 100% replacement of RA exhibits less strength, and is not recommended for the construction use.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-002

Assessing the Degree of Accessibility of Sidewalks for People with Disabilities

Ayman Halabya
Khaled El-Rayes

Abstract:

Federal and state laws require state and local governments to provide and maintain accessibility on their sidewalks to prevent discrimination against people with disabilities. To comply with these laws, state and local governments are required to conduct self-evaluations to identify all non-compliant sidewalks in their right-of-way. The mandatory self-evaluation process includes assessing sidewalks' compliance with a long list of accessibility requirements. This paper presents the development of a novel model to automate the assessment of the degree of accessibility of sidewalks. The developed model enables decision makers to (i) quantify the degree of accessibility of sidewalks, (ii) calculate the overall degree of accessibility of a group of sidewalks to facilitate the ranking and prioritization of their upgrade, and (iii) determine the type of upgrade required to achieve full accessibility. A case study of a small town that includes 864 sidewalks is analyzed to evaluate the model performance and illustrate its unique and original capabilities.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-003

Strategies to Model Complex Architectural Objects Using Unmanned Aerial Systems (UAS)

Xi Wang
Gabriel Dadi

Abstract:

The use of Unmanned Aerial Systems (UAS) and photogrammetry are becoming attractive for creating three-dimensional (3D) models in many surveying applications of construction engineering. Although several researchers have introduced and evaluated UAS and photogrammetry technologies' potential in various applications such as earthwork surveying and building components modeling, there is still a lack of a comprehensive investigation of the UAS and photogrammetry applications from the perspective of practice. This paper aims at identifying and summarizing the optimal strategies of 3D mapping and modeling for existing buildings in terms of the efficiency and accuracy from field experiments at a facility in Kentucky. The strategies discussed in this paper involve the development of the UAS images acquisition plans and the selection of data processing options for point cloud model using the Pix4D software program. For a complex structure, the efficiency relates to the number of image locations needed to model the object with its geometrically complex components and the number of subprojects that will be merged together for faster processing. The accuracy is evaluated through the measurements comparisons and the effect of visualizations. The experiment results and illustrations are useful as a reference for researchers and practitioners in need of guidance to efficiently implement UAS and photogrammetry technology for their applications.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-006

Understanding What Drives Young Individuals to Pursue Craft Careers in Construction: The Theory of Planned Behavior

Farzad Minooei
Paul Goodrum
Timothy R.B. Taylor

Abstract:

Previous studies show that the construction industry is facing a skilled labor cliff. The increase of the average age of craft workers within the industry, change in workforce demographics, decline in career and technical education in North America, and the difference between motivational factors of new entrants and the current workforce indicate that the industry is facing long-term structural changes regarding the construction craft workforce. These changes demand the need for understanding the underlying factors that influence young people to choose a career as craft workers in construction.

The goal of this study is to shed light on the motivational factors that differ across different demographic groups. Based on the Theory of Planned Behavior, a survey is designed to measure a) individual's attitude (i.e. the degree to which a person has a favorable or unfavorable appraisal of working in the construction industry), b) subjective norms (i.e. the degree to which the individual's close network encourages her/him to choose a career in the construction industry), and c) perceived behavioral control (i.e. the perceived ease or difficulty of entering into construction). A national survey was conducted involving 760 completed questionnaires. The target population for this research includes young people between the ages of 15- 24 who were exposed to Career Technical Education (CTE) or participated in construction training programs. The statistical analysis shows that if young people have some work experience in construction-related jobs, it can significantly improve their attitudes and intention to choose a career in the construction industry. Also, some differences in components of attitude were found based on gender and ethnic group. Moreover, relative importance of motivational factors is described in this research.

The results of this study will help the North American construction industry to gain more insight on how to attract young people to the industry.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-007

Influence of Delay Risk Score on Allocating Float to Activities in Network Schedules

Yi Su
Gunnar Lucko
Richard C. Thompson

Abstract:

Floats and buffers can be used by project planners to cushion delays. While the former are generated by the critical path method, the latter are inserted by the planner. The challenge of fairly allocating those floats and buffers to individual activities merits serious investigation. This research expands theory by introducing the delay risk score (DRS), considers the criticality index from Monte Carlo simulation, and integrates it with existing political apportionment methods that have been adapted to perform such allocation. Its contribution to the body of knowledge is threefold: First, activities with small and large DRS values are explored regarding when they become saturated with float. Second, a new performance index is created to evaluate the trend when modifying the exponent of the allocation method. Third, schedules with different structures and DRS values are compared by their performance indices. This research helps answering the classic *who owns the float* research question.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-008

A MCDA-C Application to evaluate the Approval Sectors Management

Luana Siewert Pretto
Antônio Edésio Jungles
Romualdo França
Estacio Pereira

Abstract:

The issuance process of building permits is the subject of many complaints in City Halls, due to its length and poor quality. When these procedures are slow and bureaucratic, there is always a direct impact on the construction industry, harming businesses and directly affecting the economic development of the municipality. An analysis of the reports of these problems has shown that most of them originate from management deficiencies. The lack of standardization and transparency, communication failures and low productivity can be listed as some of the shortcomings present in most cases. In order to improve the performance of these processes, this article aims to help agencies that work with project approval by building a management model able to cover the opportunities for improvement identified through the “Multiple Criteria Decision Aiding – Constructivist Model (MCDA)”. The current situation was identified by mapping the process flow, its interface with the actors and the way they interact, observing the barriers that hinder the development of the work. The scenario for this research is the agency responsible for the approval of construction projects and the obtainment of all building permits in the City Hall of the municipality of Joinville – Brazil, and the situation analyzed was the reality of the year 2016 and the future scenario after the actions proposed by the model.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-011

Government Coordination in Providing Emergency Accommodation for Displaced Persons in an Urban Context

Miriam Hacker
Jessica Kaminsky
Kasey Faust

Abstract:

According to the UNHCR, more than two million displaced persons have fled their country of origin to seek refuge in Europe during 2015. This rapid influx of asylum-seekers migrating to other countries creates new demands for infrastructure services, and is a significant challenge for cities' built environment. From a construction standpoint, the response has required both new development projects and the repurposing or rehabilitation of existing assets. Germany hosted nearly 750,000 of these people of concern in the last year and has processed the largest volume of asylum applications in the European Union over the last five years. This paper describes the organizational approaches three German cities have used to supply expanded emergency accommodations.

In the summer of 2016, 26 semi-structured interviews were conducted with construction companies and governments in three cities and surrounding areas in Germany. Data from these interviews were qualitatively analyzed to discover the various approaches taken by each city's government. The data describe three different approaches to coordinating construction projects for emergency accommodations. These include utilizing conventional regulatory processes for public projects, forming a specific taskforce for constructing the emergency accommodations, and a hybrid approach that blends a conventional and taskforce structure. Tasks within these approaches included selecting locations for accommodations, coordinating city efforts, processing permits, and meeting regulations. In addition, respondents also identified benefits and challenges associated with each of the three approaches including communication, time management and efficient use of resources.

Results from this study contribute critical insight to the limited research regarding construction practices and organizational design of infrastructure for emergency accommodation in an urban context. Describing governments' organizational structures along with their benefits and drawbacks provides other government agencies with foresight in emergency planning and crisis response techniques, and contributes to increased infrastructure resilience in future emergency response.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-013

**Eco-Efficiency Analysis of Recycled Material Based Residential Construction -
A Case Study for Okanagan, BC**

Piyaruwan Perera
Kasun Hewage
Shahria Alam
Rehan Sadiq

Abstract:

Very high resources demand is one of major criticisms for construction industry. Furthermore, construction and demolition (C&D) waste constitutes one third of the national waste inventory. Renovation and demolishing projects generate 90% of the national C&D waste. Waste disposal is a critical issue today, especially in urban areas. Landfilling is currently the primary mode of disposal, which leads to the formation of leachate and landfill gases. Literature reveals that, the C&D waste can be turned into a resource, by producing recycled construction materials. This study compares the eco-efficiency of the use of recyclable inculcated concrete foam (ICF) blocks and recycled concrete aggregate (RCA) based concrete with conventional materials for single family detached housing (SFDH) construction. A typical Okanagan SFDH was selected as the case study. Life cycle assessment was conducted using HOT2000 and Athena Impact estimator software. Life cycle economical analysis was calculated using RSmeans database. The eco-efficiency of the use of recyclable ICF and RCA reinforced concrete is discussed. Three alternative models were used for this study on the material selection for walls. Alternative 1 used conventional wall system, Alternative 2 used conventional with ICF and RCA concrete walls, and Alternative 3 used ICF and RCA concrete wall system. The results of this study prove that conventional wall construction with ICF concrete and RCA based concrete wall systems have the highest eco-efficiency among the selected three alternatives. This research can be developed to support decision makers in planning for recycled material based residential construction in Canada.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-015

Framework for Measuring Overall Productivity in Construction Projects

Aminah Robinson Fayek
Selam Yazew Ayele

Abstract:

In construction research, the concept of productivity is generally measured as the relationship between outputs and inputs, where total factor productivity (TFP) compares outputs to all identifiable inputs, such as labour, capital, material, and energy. TFP is considered to be a meaningful measure for showing effectiveness in utilization of resources as well as overall project success. However, much of the research related to productivity measurement and analysis is limited to labour productivity, which considers only a single input (i.e., labour). The widespread use of labour productivity measures to assess operational efficiency is due in part to the relative availability of data, despite the fact that such measures exhibit substantial limitations in assessing global project productivity. Determining overall productivity on construction projects has its own challenges, which stem from project complexity and data requirements. This study will adopt a two-phase approach to introduce a method for measuring overall productivity in construction projects. The first phase of the study comprises a comprehensive analysis of productivity measurement methods, which will aid in the development of an appropriate measurement metric. The second phase of the study will focus on the development of a data collection framework that will be used as a structure to measure overall productivity in construction projects.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-016

Identifying Construction Organizational Competency Measures and Performance Indicator Metrics

Aminah Robinson Fayek
Getaneh Tiruneh

Abstract:

Understanding how to successfully identify and manage organizational competencies is critical for construction organizations, given the direct and significant influence they have on an organization's performance. Organizational competencies are combinations of knowledge, skills, abilities, and other underlying characteristics that contribute to increased organizational effectiveness, competitiveness, profitability, and performance. Research on organizational competencies has been receiving significant attention in recent years, and it is becoming increasingly more vital for construction organizations to explore new approaches to assess and enhance their competencies. Furthermore, it is important for construction organizations to adopt effective strategies and performance measurement methods if they are to improve their effectiveness and competitiveness. The variables that characterize construction organizational competencies are both quantitative and qualitative in nature, and thus require measurement methods and modeling techniques that can handle both variable types. Additionally, relating organizational competencies to performance is essential in order to identify target areas leading to improved performance. In order to address these challenges, this paper will first review literature related to organizational competencies, competency frameworks, and competency models, including both models that have been developed specifically for use within the construction domain as well as those developed for use in other disciplines. Next, this paper will provide an overview of performance measurement methods, and based on an analysis of the literature, organizational competency measures and key performance indicator metrics will be developed. Finally, a data collection approach and a model will be proposed, which will assist researchers and industry practitioners in evaluating the competencies of construction organizations.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-017

Evaluation of Heterogeneous Levels of Expertise in Expert Risk Assessment in Construction

Aminah Robinson Fayek
Natalie Monzer
Nasir Siraj

Abstract:

The construction risk assessment and management process often involves heterogeneous groups of experts with different levels of expertise who must collectively make decisions and reach a common solution. However, real-life decision making involves a great deal of uncertainty and subjectivity. To mitigate these challenges, this paper explores the application of fuzzy logic in contexts involving multi-criteria group decision making (MCGDM) problems. More specifically, the approach discussed in this paper involves the process of aggregating the opinions of a heterogeneous group of experts in order to achieve one unique, representative value. In most heterogeneous MCGDM problems, moderators arbitrarily and subjectively assign importance weights to the experts, based on each expert's importance level or level of knowledge regarding the problem. In this paper, we will conduct a review of existing literature in order to explore methods for assigning weights to expertise, based on a variety of expertise criteria such as knowledge, experience, reputation, and performance. Furthermore, this paper will identify and classify qualification criteria in order to evaluate an expert's expertise in relation to the risk management context. In the course of this study, data was collected from highly experienced experts in order to compile the most relevant criteria for assessing expertise. Moreover, a pairwise comparison was conducted in order to determine the relative importance of qualification attributes contained in the developed criteria list; as a result, a final list of criteria, complete with the respective scales of measure and metrics for assigning weights, was developed. This paper will assist researchers and practitioners investigating MCGDM problems by presenting clear and consistent criteria that can be used to rate experts' levels of expertise. In the future, this research will be extended by integrating the data on expertise weights obtained from this study into the fuzzy aggregation process.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-018

Chronographic Space Planning: A Case Study for Construction Projects

Adel Francis
Stéphane Morin Pépin

Abstract:

Scheduling construction projects without regard for the Resources and location of the work management is inefficient and may lead to a misleading schedule. The project may suffer from a lack of resource availability or from workspace congestion that will negatively affect the movement of people and materials and may reduce productivity at construction sites. Several Lean construction methods have been developed to stabilize the work on building sites. We can note, in particular, the takt planning, the Last Planner System, the standardization of tasks and the visual management. The Chronographical scheduling method belongs to this category and models the construction operations as well as their processes, logical constraints, association and organizational models that help to better illustrate the schedule information using multiple flexible approaches. The aim is to link the spatial and temporal aspects. Using a space planning model promotes an efficient use of the site and ensures optimal rotation of the workforce in the different spaces. Collaborative graphical modeling helps to involve partners in order to find better work balance to improve productivity and avoid congestion in work areas. This paper presents the results through a case study. The validation process was developed in order to compare the mental effort required to find information using this visual model versus a traditional bar chart schedule. The results demonstrated that graphical modeling helps to simplify the scheduling and monitoring processes and ensure better results.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-019

Integrated AHP - Value Engineering Decision Making Model

Ahmed Montaser
Ali Montaser

Abstract:

Value Engineering (VE) is the most reputable practice that is being used during the early phases of project development and planning to enhance the project value. VE is producing numerous alternatives for a project based on predetermined criteria to select the optimum or near optimum alternative, which best addresses the functions. Therefore, the ability to make smart decisions is very important to the accomplishment of projects. This problem may become a very challenging one when different units measure the criteria or the pertinent data are difficult to be computed. Analytical Hierarchy Process (AHP) is an effective algorithm in dealing with this kind of decision complications. This paper provides VE decision-making model to choose optimum alternative based on the assessment of several alternatives in terms of a number of criteria through applying AHP. AHP algorithm was automated through using excel spreadsheet application to assess both criteria and alternatives. The developed model had been verified through applying it to real case study project. The project is Joubal lagoon resort that is located at El Gouna, Red Sea, Egypt. The architectural block façade system was the selected item for VE study. The selected criteria for the VE study were eight criteria and VE team had defined three alternatives. The developed model, methods and algorithms augment VE application and expand upon alternatives and criteria evaluation.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-020

Framework for Selection of International Financing Instruments for Infrastructure Projects

Samer Ezeldin
Mohamed Moussa

Abstract:

The funding of large-scale high-risk infrastructure projects is always challenging. This issue is of special importance and of growing importance in the Middle East as the emerging economies of the region strive for expanding in infrastructure projects and find the optimum financing schemes. Egypt is no exception, with a portfolio to infrastructure projects for which the country is in dire need to be executed, there is a need to assess the current infrastructure financing methods and identify the associated risks with each method.

The World Bank is one of the main financing entities that support infrastructure projects in developing countries. Not only does the bank support such projects through funding, but also through technical assistance. There are three main financing tools offered by the bank, namely; Development Policy Lending, Investment Lending, and the relatively recently proposed Program-for-Results. The latter two are currently used to support an array of infrastructure projects dispersed in a variety of developing nations.

The aim of this paper is to compare between the financing schemes provided by the World Bank and to propose a framework to determine which of these tools would be suitable for any given project. Structured interviews are conducted with international professionals and experts working on World Bank financed projects in Egypt in order to identify the criteria for the optimum selection of finance methods, the risks associated with each method, and risks associated with different infrastructure projects. The outcome of the interviews and the existing literature are analyzed to develop the sought-after framework.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-021

A Decision To-Bid Model Based on Predicting the Amount of Winning Claims Using Artificial Neural Networks and Genetic Algorithms

Tarek Zaki
Cherif Khalil
Mohamed ElGindi

Abstract:

Competitive bidding is one of the most commonly used bidding strategies that Clients use to procure services from Contractors. In general, a bid price is composed of main items including direct costs, indirect costs, overhead costs, profit and risk. Contractors tend to lower their bid prices as much as possible while providing competitive technical proposals in order to win bids. Due to uncertainties and price fluctuations, some Contractors consider generating profits from the amount of generated claims during the execution of the project. Hence, contractors may minimize their bidding price if they pre-estimate the amount of resolved claims during bid preparation. In this paper, a model was developed using Artificial Neural Networks (ANN) to forecast the resolved amount of claims for a specific project based on a set of parameters that affect the generated amount of claims; including: type of client, project delivery system, type of contract and contract price. Previous case studies from literature were used to train and validate the model outcomes. Genetic Algorithm (GA) was used to minimize the prediction error of the forecasted amount of claims. Using ANN reveals a promising potential for accurately predicting the expected claimed amounts. Thus, a Contractor can pre-estimate the amount of generated profit from winning claims on a specific project prior to bidding; hence, cutting-off the bidding price to increase the chances of winning the bid.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-024

Cost Factors Affecting Decisions for Recycling and Reuse of Concrete Residuals in North Carolina

Nicholas Tymvios
Tara Cavalline
Christopher Albergo

Abstract:

Construction and rehabilitation operations such as hydrodemolition, diamond grinding and diamond grooving, performed for the North Carolina Department of Transportation (NCDOT) generate a large amount of concrete residuals. These residuals consist of wastewater, wet sand, chips and chunks of concrete, and slurry water. The North Carolina Department of Environmental Quality (NCDEQ) classifies these residuals as “Class A,” and they are therefore treated as “inert debris,” allowing them to be reused instead of disposing them in facilities such as Publicly Owned Treatment Works (POTW) and Municipal Solid Waste (MSW) sites.

The NCDOT would like to encourage beneficial reuse methods for these concrete residuals, and requested an investigation of the costs associated with the following end uses: Land Application, Water Reclamation, Beneficial Fill, Alternative Daily Cover, and Soil Modification within Roadways. The aim of the study was to provide information that could encourage contractors to opt in favor of these recycling/reuse methods, and to allow the NCDOT to better estimate costs. In this study the costs associated with these methods were identified, and data was collected and analyzed. A model was developed, using @Risk and Monte Carlo simulations, to facilitate comparison of the different disposal/reuse methods and to provide insight into the relative costs of specific options for projects within different regions of North Carolina. Ultimately, this model can be used to facilitate the decision making process for NCDOT and contractors, potentially providing cost savings to stakeholders and enabling more frequent selection of beneficial reuse options for concrete residuals.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-026

Weather Derivatives as a Risk Management Tool for Construction Projects

Mohammad Ammar Al-Zarrad

Gary Moynihan

Stephanie Vereen

Abstract:

With the increasing complexity of construction projects, the possibility for significant delays being encountered is becoming more and more frequent. When the completion of a construction project is delayed, the result is added expenses for both owner and contractor. Although there are a variety of causes for construction project late delivery, certainly the most common cause is abnormal weather such as excessive precipitation, extreme cold or extreme heat, and other atypical weather. Although it is known that using hedging as a risk management tool adds value to a financial firm, limited knowledge has been established about using weather hedging in the construction industry. The first objective of this research is to compare weather hedging contracts with regular insurance policies. The second objective is to develop a step-by-step guideline for applying weather hedging in the construction industry. The guideline presented by this research helps construction companies to reduce the risk of late project delivery due to extreme weather. The research outcomes indicate that weather hedging have many advantages over regular insurance policies. Further, the research concludes that applying weather hedging in the construction industry could reduce the cost of construction projects and should not be overlooked by construction companies.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-028

Time-Driven Activity-Based Costing to Optimize Crew Configurations of Linear Repetitive Projects

Mohammad Ammar Al-Zarrad
Gary Moynihan
Stephanie Vereen

Abstract:

Linear Repetitive Projects (LRP), such as highways and pipelines, are an important part of our infrastructure. LRP crew optimization has not been investigated in the literature. LRP depend primarily on the production rate resulting from the equipment and crew composition for each operation. Inefficient crew configuration could affect the time and cost of LRP. The objective of this research is to develop and illustrate a model for determining the optimum crew configuration assigned to complete a Linear Repetitive Project. This model will utilize Time-Driven Activity-Based Costing as a tool for tracing costs within a process back to individual activities. Monte Carlo simulation will be used to select the best crew configuration from a range of possible configurations. The research outcomes indicate that optimizing crew configurations could reduce the cost and duration of LRP and should not be overlooked. This research could help departments of transportation to reduce the cost and duration of highways and other pipeline projects.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-029

Productivity Improvement for Positioning Industrial Modules Using GPS Technology and Scheduling Data.

Amin Amini Khafri
Hosein Taghaddos
Ulrich Hermann
Simaan AbouRizk

Abstract:

Heavy industrial construction is primarily involved with construction of petrochemical or oil-and-gas related facilities. Due to cost and schedule savings, many industrial construction projects in Alberta, Canada are delivered using a modular construction approach. Modules are traditionally positioned using measuring tape, and coordinates are determined using construction site drawings. The practice of locating and positioning modules, however, is time consuming. Industrial construction projects are carried out in open fields, which is conducive to the use of GPS-based surveying equipment. Locating and positioning modules using a GPS-based approach, particularly one that incorporates automation, could result in considerable improvements to activity-level productivity. In this research study, an automation system, comprised of a GPS handheld device and an automated tool that calculates a module's coordinates from available scheduling data and yard layout, is proposed. This system allows module positions to be automatically determined and precisely located. Implementation of the proposed automation system was estimated to improve productivity by over 500% and to reduce activity duration by two-thirds.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-030

Port-Said Single Leaf Bascule Bridge

Hussein Abbas

Abstract:

Movable bridges are special structures that can change position to allow navigation across waterways. They are composed of structural, electro-mechanical, hydraulic and control systems. Bascule Bridge types constitute by far of majority of movable bridge designs. The objective of this report is to present a detailed description of a new born bascule bridge in Egypt.

The new bridge design consists of six bays each of about 22 meters span and width of 14.8 meters, with movable bascule intermediate span, providing a navigation channel with infinite vertical clearance. The fixed bays are designed as composite multi-girder steel bridge with reinforced concrete slabs above, while the movable bay has been designed as plate girder with orthotropic steel deck and a light pavement. The movable bay dimensions has a length and width of 19.2 m and 14.8 m respectively. The spacing between balance weight supporting columns is 22 meters, allowing to a maximum open angle of 70 degrees. The operating system includes the gearbox, driving unit, shafts and brakes. The stroke length for the hydraulic cylinder reaches 2.4 meters.

The project is a good example of how functional and limited budget constrains can be taken into account in a movable bridge project. These constrains were considered starting from the concept design stage and extended up to the detailed drawing stage. The project required detailed inspection of material condition and structural configuration. The motor of the bridge lifting system has to be strong enough to operate the bridge against normal and higher wind pressures.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-031

Framework for Holistic Sustainable Disaster Recovery

Mohamed Eid
Islam El-adaway

Abstract:

The recent disastrous events (Fort McMurray wildfire, Hurricane Matthews, etc.) stress the dire need for a proactive decision making framework for holistic sustainable disaster recovery. Such tool should be able to highlight the redevelopment strategies that meet the needs of the multi-sector stakeholders while decreasing the built environment vulnerability (social, economic, and environmental). This paper presents such framework through an innovative approach that involves: (1) a bottom-up multi agent-based modeling approach to capture the participating entities needs and decision actions, (2) well-established community specific vulnerability indicators to evaluate the built environment vulnerability, and (3) multi-objective evaluation approach to simultaneously meet the communities' recovery and vulnerability reduction needs. Accordingly, the proposed framework can identify the optimal redevelopment strategies at the community level. In order to evaluate its potentials, the proposed framework was implemented on the post-Katrina recovery processes in three Mississippi coastal counties in regard to the residential and economic sectors. The developed model utilized the actual recovery strategies and plans employed by the Mississippi Development Authority (MDA). As such, the model attempted to optimize the associated government agency's budget distribution over the different recovery plans to: (1) increase the welfare of the impacted stakeholders, and (2) decrease the built environment vulnerability. The framework's outcome dominated the actual budget distribution by the MDA in regard to the recovery progress of the stakeholders and the host community's vulnerability status. Such novel approach will enable the decision makers to engage their communities in the prevent-event phases to find the common shared goals that decrease the built environment vulnerability and achieve true sustainability post a disastrous event.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-032

A Bayesian Model for Improved Optimal Bid Price Estimation in Transportation Projects

Ibrahim Abotaleb
Islam El-adaway

Abstract:

Transportation projects represent 42% of the total public construction projects in the US. With such immense size, proper competitive bidding is a must to ensure appropriate utilization of the taxpayer's money. Contractors submitting high bid prices are less likely to be awarded projects. On the other hand, those submitting low bid prices are awarded but they become claim-oriented to recover losses resulting from their unrealistic bids; leading to severe quality, schedule, and cost impacts. Several models have been developed to help contractors determine balanced bid prices based on statistical analysis of competitors' history. However, the statistical integrity of such models is compromised in cases of imperfect information, where the dataset of competitors' historic bids is not complete; and dynamic behavior, where a competitor's old bidding strategies behavior contradicts its more recent ones. This paper presents an advanced model that utilizes Bayesian statistics and decision theory for optimal bid price determination. The developed model is based on a three-stepped algorithm that enables drawings sound inferences in cases of incomplete historical data and dynamic behavior of competitors. The first step is fitting the competitors' data into appropriate Bayesian prior density functions. The second step is developing the likelihood functions through the most recent historic observation(s). The third step is developing the posterior distributions from which the joint probability of winning, expected profit, and optimum bidding price can be calculated. The proposed model was applied to a case study from the literature. In such case study, the effects of the different parameters were demonstrated. The research will be beneficial to the transportation infrastructure economy by ensuring that contractors submit bids with reasonable prices; which will make them less susceptible to claim-oriented behavior and eventually lead to healthier contracting environments.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-033

Effect of Fine Material on Penetration Resistance

Abdulrahman Hamid

Abstract:

This study was aimed to evaluate the effect fine material on the penetration measurement using the dynamic cone penetration test (DCPT) for sands. The soil sample was classified as poorly graded sand (SP) according to USCS. DCPTs were performed on sand samples with the addition of different silt content (1%, 4% and 8%) and different relative densities (40%, 60% and 90%) where it was compacted in a large scale circular mold (1600 mm diameter and 1500 mm height). Test results indicated that the increase in the dry density and shear strength caused a decrease in the dynamic cone penetration index (DCPI) and the silt content has a minimum effect on the DCPT results. Furthermore, the results indicated that the DCPT is an operative tool in the assessment of the compaction during construction of sand backfills.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-034

The Comparative Experience in Multiskilling among U.S. Hispanic and non-Hispanic Construction Craft Workers

Mohammed Albattah
Paul Goodrum

Abstract:

After the latest economic recession, the U.S. construction industry has faced a shortage of craft workers, mainly among highly skilled trades, such as pipefitters and electricians. Current skilled workers are leaving the industry for other industries, such as manufacturing. As one approach to retain the current workers, multiskilling is one workforce strategy that has been traditionally proposed as a pathway to increase wages and job duration for workers. This study aims to understand the changes in multiskilling and the influence of race on multiskilling patterns through the National Craft Assessment and Certification Program (NCACP) dataset. Previous studies revealed that the Hispanic population has increased sharply in the construction industry but mainly among lower skilled construction trades. Furthermore among single skilled workers, there are significant differences in formal training between Hispanic and non-Hispanic workers. However, the findings show that there was no statistical difference between multi-skilled Hispanic and non-Hispanic construction craft workers in the rate of formal training. Further, there was no difference between Hispanic and non-Hispanic trade patterns among craft workers with dual-skills.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-035

Study on the Impact of IPD Incentive Mechanism on Project Team Performance Based on Multi-agent Simulation

Hao Lu
Guangbin Wang
Qinghong Cui

Abstract:

The use of incentives has been seen as an important way of facilitating the successful implementation of IPD. A sharing of risk and reward, as the compensation method of IPD, is used to incentivize collaboration and align the individual goals with team goals. To achieve optimal team performance and project outcome, it is still a big challenge to design an effective incentive mechanism for IPD. As for us, this study will explore the impact of the incentive mechanism on project team performance from the perspectives of incentive target setting and gain/loss sharing. The system will be modeled based on principal-agent theory and social psychology theory, and the multi-agent simulation method will be adopted. A large number of incentive measure assumptions will be put forward. The assumptions will be verified under the various conditions structured by the combinations of different risk preference of construction agents and external environment through the research on the interactions among the behavior of group, tasks outcome and the environment factors.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-037

Towards Agent-based Modeling for Operational Clash Detection through BIM

Abdelhady Hosny
Mazdak Nik-Bakht
Osama Moselhi

Abstract:

Current clash detection models view the crews as plain objects with a predefined and fixed performance. Such an assumption, though being logical in measuring the impact of certain clashes in the workspace (by maintaining the rest of the factors constant); is not entirely correct. Crews are either people or equipment controlled by workers, which are in both cases intelligent agents with variable performances. Performance of these agents can significantly affect the impact of clashes. This paper proposes a conceptual framework that models crews as intelligent agents, by defining three major decision variables: worker as a unique agent (carrying own traits); team selection strategy; and influence of the management style on the team performance. Existing models are amended to capture the three components referred to above in construction. The paper presents the starting phases of employing agent based modeling in clash detection models.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-038

Change Management in an Architecture Agency

Souha Tahrani
Forgues Daniel
Samia Ben Rajeb

Abstract:

The linear and fragmented nature of the construction process no longer meets the demands that are imposed by the growing complexity and scope of construction projects. Furthermore, it is now harder to keep up with the increasing number of stakeholders that are involved in the decision making process. Building Information Modeling (BIM) is seen as a solution in which a software-based platform has the potential to involve and connect all the project's stakeholders via a virtual platform. However, with all the specialties that are required in such a common work environment, the integration of this platform in the traditional structure poses major problems on the levels of communication, design, execution, etc. Therefore, the challenges in implementing this solution are not technological, but social. How do we re-organise the work process in order to maximise the impact of BIM in a firm? This paper presents the first results of applying a new approach that aims to assist organisational change around implementing BIM in the workflow of an architectural firm. The study has adopted the “*ShareLab*” approach, which is based on a three intervention stages: the creation of a common ground; the construction of a shared vision; and the concretization of a collective dedicated strategy. The first two stages were workshops involving several participants from the firm that represents the operational and decisional levels. The BIM maturity matrix has been used as a tool to structure the discussion in these workshops. The results of this study demonstrate the importance of a participative approach to foster the creation of a strategy for BIM implementation that addresses situations specific to the firm. The outcome of the study calls into question the role of the researcher in the process, and his/her involvement in a larger context where different actors from the industry are involved.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-040

Assessment Strategies for Building Information Modeling Skills in Problem-Based Learning Pedagogics

Rahimi A. Rahman
Steven Ayer

Abstract:

Preparing students with the knowledge of Building Information Modeling (BIM) may be critical for advancing the construction industry in the future. Educational researchers have explored various pedagogical models for teaching students about BIM. One potentially promising educational approach for BIM education is problem-based learning, as it presents BIM in a context that may effectively simulate a real-world scenario students may expect to experience in their careers. This paper explores how prior research efforts have used problem-based learning to educate students. The results will help to inform future BIM education research efforts. Specifically, this work addresses the following research questions: (1) What can be assessed from problem-based learning modules? And (2) What are the potential assessment methods for problem-based learning modules related to BIM? The results suggest that students' development, learning processes, and problem-based learning modules can be assessed for determining the benefits of adopting the module in BIM education. Additionally, rubrics, surveys, interviews, reflective journals and peer assessment are strategies for evaluating BIM skills. However, using a single strategy might not be adequate. Therefore, future work should adopt several of the strategies when determining the benefits of implementing problem-based learning in BIM education.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-041

Enhanced Benefit-Cost Analysis for Infrastructure Corridor Rehabilitation

Dina Saad
Tarek Hegazy

Abstract:

Infrastructure rehabilitation has recently been under the spotlight of governments, municipalities, and tax payers due to its severe deterioration and the large backlog of overdue maintenance. Allocating the limited infrastructure rehabilitation funds, however, is a complex problem, particularly for the assets that have physical interrelationships among them. Because roads, water/sewer pipes, bridges, and culverts are usually co-located, managing the rehabilitation of these assets requires better coordination to reduce the social costs associated with multiple disruptions. Yet, most of the existing fund-allocation methods used by municipalities deal with co-located assets in isolation, thus resulting in much inefficiency. This paper, therefore, presents an enhanced benefit-cost analysis method, as a fund allocation mechanism, to provide optimum funding for multiple co-located assets of different types. The proposed mechanism utilizes the equal marginal utility concept of consumer theory to achieve near-optimum fund-allocation decisions while maintaining equilibrium and balance among the different types of co-located assets. A real case study consisting of bridges and culverts co-located in the right-of-way of a pavement network has been used to demonstrate the proposed mechanism and its results. Using the case study data, the proposed mechanism proved to be able to arrive at optimum fund-allocation for corridor rehabilitation, and provide credible economic justification for spending the tax-payers money on infrastructure projects.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-042

Efficient Repetitive Scheduling for Scattered Rehabilitation Projects

Ehab Kamarah

Tarek Hegazy

Abstract:

Effective planning and scheduling play a major role in project delivery, particularly for repetitive construction projects. Among the three types of repetitive projects (vertical such as high-rise buildings, horizontal such as highways, and scattered such as rehabilitation sites), the latter is the most complex to schedule. This is due to the geographical separation between sites, the simultaneous presence of in-house and outside contractors, the large number of crews that need to be synchronized without interruption, and the large number of activities and construction methods. To facilitate efficient scheduling of repetitive scattered projects, this paper presents an innovative scheduling and cost optimization framework. The scheduling formulation is designed to consider the practical constraints that affect scattered projects, including: (a) site-specific productivity factors; (b) designed periods of work interruption; (c) quantity of work variations among sites; (d) crew assignment strategies; (e) order of site execution; and (f) constrained construction methods; and (g) the moving time and cost from one site to another. The proposed scheduling model utilizes the Constraint Programming (CP) optimization technology to optimally schedule the work for all the scattered sites, considering all constraints. This framework will provide large public organizations such as school boards, universities, and municipalities with an effective scheduling and control tool that is particularly designed to address the challenges facing their management teams in delivering large and scattered infrastructure maintenance and renewal programs. An example of a case study from Toronto District School Board facility management department will be used to discuss the essential components of the propose framework and its optimization benefits.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-045

Proactive Construction Claims Analysis using BIM

Mohamed Marzouk
Ahmed Othman
Mohamed Enaba
Mohamed Zaher

Abstract:

The construction industry is permeated with claims that result from change in quantities, quality, specifications and many other issues. One of the ways to minimize the effect of these claims is to try to handle them in a proactive manner; this allows the project parties to foresee the potential claims and take necessary measures to avoid them. Thus, project parties will share common goals and achieve project success. As such, BIM can provide an effective tool for claims analysis and evaluation. This research introduces a BIM-based claims analysis and evaluation model. Firstly, different BIM protocols are demonstrated and analyzed, highlighting BIM protocol critical success factors. Secondly, different claim causes and claim analysis techniques are introduced. Thirdly, a 5D BIM model is developed to forecast potential claims and these claims are assigned to their responsible parties. Afterwards, relevant claim evaluation techniques are utilized to evaluate and quantify such claims. Finally, a claim report is generated showing actual and potential claims, their causes, evaluation and recommendations to derogate their consequences.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-046

Design of Funicular Arched Truss Steel False-work

Ahmed El Sayed
Mohamed Darwish
Khaled Nassar

Abstract:

The patented steel formwork systems used in construction cost a lot, take time to be erected and reduce the space in the construction site as they prevent motion underneath the system. The proposed new system depends on developing a formwork system using the concept of the funicular arch. The proposed system costs less than the existing patented system because it incorporates fewer amounts of steel, environmental friendly because it uses less material and provides more space in the site for workers and materials to flow in the construction site. The new system also reduces the time needed for erecting the system and consequently saves time and cost.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-047

Public-Private Partnership in Egypt

Muhammad Kamel
Ali Montaser
Ibrahim Abd El-Rashid

Abstract:

While the development wheel in Egypt is in need of large and immediate investments, the funds provided by the government are not sufficient to face such a challenge. Public-Private Partnership (PPP) is a delivery/financing system that can be a solution to this problem. In this system, the private sector partners with the public sector to provide projects/services, affording the burden of finance and sharing risks. Egypt was one of the countries that witnessed some earlier and most successful (PPP) projects during the nineteenth century, more than a century before the appearance of the term (PPP) itself. This paper displays the Egyptian experience of the PPP history, modern background, and present environment including the determinant legal frame. Semi-Structure interviews were conducted among different PPP participants in order to join the puzzle pieces, which have scattered due to different perspectives and attitudes. The interviewed experts were a mix of government officials, investor representatives, project managers, and consultants. The Egyptian Government has adopted earnest measures to facilitate execution of PPP projects as a manner among others to overcome its chronic budget deficit. PPP practices have not yet achieved the anticipated contribution to the Egyptian Economy.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-048

Study on BIM Capabilities Measurement and Improvement Strategies for AEC industry in China: a survey in Shanghai

Dan Tan
Guangbin Wang
Daniel Castro-Lacouture

Abstract:

With the rapid application of Building Information Modeling (BIM) technology in the architecture, engineering and construction (AEC) industry in China during the past decade, it has been recognized that it brings many benefits. But the benefit of BIM does not meet industry expectations of the industry, which conflicts with the intent of BIM practitioners. Therefore, practitioners and researchers in this field have begun to realize that it's necessary to improve the BIM capabilities of industry professionals. The main objective of this paper is to understand the current situation of BIM capability of the firms in the AEC industry in China, and find out the critical factors influencing the BIM capabilities, such as strategy capability, technology capability and process capability, and establish the BIM capacity measurement index system. The research will establish the theoretical framework of BIM capabilities based on literature review. Then a questionnaire survey to 300 construction project stakeholders in Shanghai, e.g., owner, designer, contractor, BIM consultant, is used to explore the current situation and the measurement index for BIM capabilities. Based on the survey feedback, the strategy capability, technology capability and process capability are analyzed. Results show that if level of BIM capability maturity is at the initial stage, then firms are keen on the improvement of BIM capabilities. However, the performance is poorer than expected. To further investigate the causes of lower performance, the major barriers on BIM capabilities improvement are also analyzed. Finally, several strategies to break the barriers are discussed.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-049

Leak Detection Model for Pressurized Pipelines Using Support Vector Machines

Samer El Zahab
Tarek Zayed

Abstract:

Aging infrastructures, specifically pipelines, that were installed quite a while back and currently operating under poor conditions, are highly susceptible to the threat of leaks, which pose economic, health, and environmental threats. For example, in the year 2009, the state of Ontario lost 25% of its water supply solely due to leaks. The amount of lost water is equivalent to the volume of 131,000 Olympic swimming pools and worth 700 million Canadian dollars. Therefore, a need arises to develop an approach that allows condition monitoring and early intervention. This article proposes a model for a real-time monitoring system capable of identifying the existence of single event leaks in pressurized water pipelines. The model relies on wireless accelerometers placed within the network on the exterior of the pipelines. The vibration signal derived from each accelerometer was assessed and analyzed to identify the Monitoring Index (MI) at each sensor on the pipeline. The data collected from experimentation were analyzed by means of support vector machines (SVM) technique. A leak threshold was determined such that if the signal increased above the threshold, a leak status is identified. Experiments were performed on one inch cast iron pipelines, one inch and two inch PVC pipelines using single event leaks and the results were displayed. The developed models showed promising results with 98.25% accuracy in distinguishing between leak states and non-leak states.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-050

An Overview on Integrating Interface Management and Building Information Management Systems

Ekin Eray
Behrooz Golzarpoor
Carl T. Haas
Derek Rayside

Abstract:

Complex capital projects such as rapid transit systems, power plants, refineries and port facilities are hard to manage since those projects are generally executed by project participants who have different specializations and also who are located in geographically different places. In those type of projects, complexity of tracking the coordination between project stakeholders, controlling design and engineering processes, and monitoring project health requires project participants to use advanced project management techniques. Interface Management Systems (IMS) which are used for creating interface points and agreements among different project participants to track and solve interface related problems between them, and Building Information Modelling (BIM) which provides a digital 3D representation of the project where users can store data on the elements of a 3D model, are advanced project management systems increasingly used lately for complex projects. Although, these sophisticated new techniques are providing better visualization and coordination for project managers on complex projects, they need to be integrated with each other and with CPM systems to enable project health and engineering process measurement for more effective project management. The objective of this paper is to develop a framework for the integration of IM and BIM systems and to develop engineering progress and health metrics, in order to collect better project health and engineering process data in the project definition and design phases. In this regard, first a brief explanation of IM and BIM systems and the benefits of using these systems to the project participants is provided. Then, the proposed framework, which is based on connecting interface points and interface agreements of an IM system with related BIM elements on the 3-D model is explained. Finally, functional validation of the proposed framework is done by presenting an example project.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-052

Evaluating the Sustainable Performance of Public Infrastructure Projects

Mike Benson
Jeff Rankin

Abstract:

In an environment of increasingly scarce financial resources, asset managers and public authorities are continuously looking for methods to determine which infrastructure projects can deliver the highest return on their investments. For public authorities, where public interests are at the heart of decision-making, the definition of a return on investment can mean many different things. Most recently there has been significant emphasis placed on the sustainable development of infrastructure. This paper focuses on a unique method to determine the sustainable performance of public infrastructure investments using the Sustainable Efficiency Model (SEM). The SEM allows decision-makers to identify and prioritize projects which perform well along the sustainable criteria defined by the International Standards Organization's (ISO) technical specification 21929-2.

The SEM comprehensively integrates economic, environmental, and social criteria through the use cost-benefit and multi-criteria analyses. Decision-makers are able to use the model in two distinct fashions: i) comparing projects of dissimilar typologies, and ii) comparing design alternatives. To demonstrate the model in use, two case studies are presented for each potential use. Following these case studies, the SEM is post-evaluated as to its usefulness, usability, and feasibility by a key municipality decision-maker.

The first case study compares upgrades to a major traffic intersection against upgrades to a municipality's wastewater treatment system. Second, two delivery options for the construction of a hotel building in Newfoundland and Labrador are contrasted to demonstrate the potential benefits of modular and offsite construction. Initial results indicate that the major traffic intersection upgrades are a more sustainably efficient project. Additionally, it was determined that a modular and offsite construction delivery method is superior to a traditional on-site construction. Model evaluation results have been limited at the time of writing with results expected sometime in the new year.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-053

The Effects of Spatial Cognition on Individual Wayfinding Performance

Sara Al-Haddad
Antoine Verghote
Paul Goodrum

Abstract:

An experiment was conducted to analyze the effects of different information formats and spatial cognition on individual wayfinding in unknown environments. Participants were asked to memorize either a set of 2D drawings or a three-dimensional (3D) model before navigating through a series of checkpoints in an unfamiliar environment. Individual wayfinding is dependent on an individual's use of route knowledge or survey knowledge. Route knowledge was assessed from the start of the route to Checkpoint A (i.e. the first checkpoint). Meanwhile, survey knowledge was assessed from Checkpoint A to Checkpoint B. Spatial cognition of participants was measured by administering the card rotation and cube comparison tests. The research found that 3D models have a beneficial impact on the success of individual wayfinding. Furthermore, the success rate of the participants with low spatial cognition improved significantly when using a 3D model rather than a set of 2D drawings. However, the success rates of participants with high spatial cognition was not affected by the information format. This research will aid in understanding the relationship of cognitive spatial abilities, task performance, and information displays on people with demanding and stressful jobs, such as first responders. Further research, with a larger sample size and longer route, is required to confirm the results concluded in the study. Additionally, research suggests that realistic rendering and color might have a beneficial effect on decreasing workload memory when navigating through a space.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-055

Analysis of Bottlenecks in BIM-based Building Design Coordination Process and Benchmarking State of the Art BIM Tools

Sarmad Mehrbod
Sheryl Staub
Yunpiao Bai

Abstract:

Design coordination and conflict detection with BIM are of the most frequent and valued uses of BIM in the construction sector. However, through prior studies and our own observations of design coordination meetings, we have found that even when BIM tools are readily available. Practitioners frequently revert back to 2D digital and paper drawings and rarely interact with BIM tools on their own without the help of a BIM navigator, and many coordination issues are resolved on construction sites, knowledge regarding the design issues often get lost throughout coordination process. Having rigorously analyzed existing literature, we proposed a set of functionalities to address these challenges, and analyzed widely used state of the art BIM tools to benchmark their capabilities and functionalities. We conducted interviews with practitioners to assess priority of each function. We found Solibri followed by BIM 360 Glue as most, and Autodesk Revit and Tekla BIMSight, as least compatible platforms. The best-supported functionalities were zooming, panning, and commenting, and the least supported were multi-model format and design issue documentation across all platforms. We believe the results of this research are useful for the AEC industry researchers and professionals, as well as the BIM software development community.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-056

Construction Safety Perception Analysis using Affecting Sensing Technology and Virtual Reality

Nipesh Pradhananga
Hazal Ergun

Abstract:

Virtual Reality (VR) is widely used in conception, planning and design phases of a project, mainly for communication and collaboration. During the construction phase, safety demands major attention at any active construction site. Iterating among alternative safety plans in real world conditions can be dangerous, expensive, resource intensive and often not feasible. Safety is not only governed by what regulations are at place, the perception of the workers towards site safety conditions is also equally important. In other words, in addition to imposing safety rules, it is also equally important that the workers feel safe in their working environment. This paper explores the potential of leveraging VR to investigate on perceptual response of workers on site safety conditions. A VR environment is created based on real-time geometric (laser scan) and location (GPS) data collected from moving equipment and workers at an active construction site. Hazards are introduced into the VR scenes in a systematic and controlled manner. Subjects are exposed to the scenes through a head-mounted VR system. The experience of the subjects in different hazardous scenarios are recorded through Affective Sensing devices and a questionnaire. Affective sensing technology can track human physiological responses in real-time. The goal of this research is to leverage VR environment to (i) test the feasibility of using affective sensing devices for tracking human responses to hazardous situations, (ii) study the potential of exposing construction workers to virtual hazards for training purposes. The results from this study will give a better understanding of potential of VR in construction safety training and management.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-057

Intelligent Supply Chain Visibility for Risk Management in Pipe Spool Manufacturing

Hani Ahmed
Carl T. Haas
Tarek Hegazy

Abstract:

Stockpiles of material are a regular sight on construction projects, especially on large industrial projects, where substantial quantities of material are accumulated prior to construction in vast laydown yards and warehouses. The additional costs incurred by a project to accumulate and maintain these stockpiles can be enormous. On the other hand, in construction projects, the late arrival of materials often leads to delays that cause substantial overruns, thereby shrinking or eliminating project profit margins. The many risks that influence the progress of the supply chain become problematic when the probability of the occurrence of these factors is not well defined. Much of the uncertainty, however, arises out of a lack of readily available and accurate information concerning the status of material at different stages within the construction supply network (lack of supply chain visibility). The use of an automatic update system within the construction supply network presents a solution to this problem. This article presents an intelligent framework for supply chain visibility that facilitates efficient risk management in pipe spool supply. Because the probability of the occurrence of risk factors continue to change throughout the duration of a project, later recognition of these changes creates more severe effects that are more difficult and costlier to manage. For this reason, the proposed framework has been designed to incorporate a variety of tracking technologies that provide timely updates on work productivity and the probability of the occurrence of risk factors during the early stages of a project. Pipe spool supply was chosen as a critical activity in most industrial construction projects. More importantly, it is a segment of the construction industry that suffers from the effects of uncertainty in the supply network. An example is provided to show the framework components and the benefits of supply chain visibility on the efficient management of construction schedules.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-059

**Financial Incentives For Green Residential Buildings in Canada:
A Review From A Regulatory Lens**

Anber Rana
Rehan Sadiq
Kasun Hewage
Shahria Alam

Abstract:

Green building construction is a rapidly evolving industry in Canada. The growth in sustainable buildings construction is driven by market conditions and benefits acquired during buildings operational stage. However, adoption of green practice in residential buildings is negatively impacted by the high initial investments required for green products. Financial incentives provided by the federal, provincial, and local governments may encourage residential building developers, owners and users to adopt greener construction products and technologies. In this paper, a critical regulatory review is carried out for different types of financial incentives for green residential buildings in Canada. An investigation is performed to determine variations in local government incentives for different types of residential buildings. As a case study, different types of financial incentives available for residential buildings in provinces of British Columbia and Ontario are compared. The findings of this study can be used to identify the regions where green building communities are plausible to be developed in future. The results will also help local authorities to further develop and improve their financial incentive policies for green residential sector.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-060

**Sustainability Performance Assessment:
A Life Cycle Based Framework for Modular Buildings**

Mohammad Kamali
Kasun Hewage

Abstract:

Appropriate methods of construction can significantly contribute to achieving the goals of sustainability. In this regard, sustainability performance assessment of a building in its full life cycle is needed to select most sustainable construction methods. In this paper, a life cycle based performance assessment framework is proposed for modular buildings. The proposed framework follows a step-by-step approach to identify and select appropriate sustainability indicators (and sub-indicators) for modular buildings, quantify the selected indicators, and develop the least/most desirable performance values. Subsequently, the proposed framework provides a methodology to calculate the overall sustainability performance index of a given building as well as individual sustainability performance indices for each of the sustainability categories, i.e., environmental, economic, and social. In addition, under each sustainability category, different sustainability performance sub-indices associated with the building's life cycle phases are derived separately. The calculated sustainability indices will help decision makers to make informed decisions on the most appropriate construction methods (i.e., modular vs. conventional) on a given project. The outcomes can also be used to address the low sustainability performing areas over the life cycle of a building, even if the decision on the construction method has already been made.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-061

Early Involvement of Facilities Management towards Efficient Utilization

Mohamed El Deeb
Ali Montaser
Ibrahim Abd El-Rashid
Walid Abdelal

Abstract:

Investors are keen on ensuring long-term investments by avoiding deterioration of valuable assets. Accordingly, Facilities Management (FM) has been a crucial management approach. Involving FM earlier in the engineering and construction phases of the desalination plants, would lead to significant savings and optimized reliability. In light of the future global water crisis, desalination plants are considered a major capital investment for Real Estate mega projects nowadays. The purpose of this paper is showing the importance of this practice through actual case studies of two Sea Water Reverse Osmosis (SWRO) desalination plants. Both SWRO desalination plants have same to similar parameters. A failure trend analysis was conducted to reflect the production reliability of both cases, taking into consideration the timing of FM involvement. Afterwards, a cross-comparison was carried out between the data sets of the two case studies to render tangible results of 27% improvement in reliability when FM is involved early. The results signifies the better utilization of the asset when FM is involved in an early stage in the project. The early involvement of FM team achieves better utilization of the desalination plant, ensuring an added value to the investment, as well as the overall assets useful lifetime and efficiency.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-062

Quantifying the Impact of Architectural Design Features on Building Cost and Performance in Hot Weather Regions

Abdullah Al-Saggaf
Hassan Nasir, King
Tarek Hegazy

Abstract:

Architectural design decisions are subjective in nature, yet have an enormous impact on the esthetics, performance, and the life-cycle cost of projects. This research identifies and evaluates seven key Architectural Design Variables (ADVs) that can mitigate the negative impact of hot weather, while providing esthetics and good performance. To quantify the impact of any combination of ADVs, a decision support system has been developed to efficiently evaluate a building design in terms of: (1) space functionality; (2) construction performance; (3) operations performance; and (4) esthetics. The system easily allows the decision maker to simply and subjectively specify the degree (low, medium, high) by which each ADV adds to, or reduces from, the performance of each performance criterion. Compilation of all inputs is then used to calculate the weight of each criterion, the comparative impact of each ADV, and the impact of any combination of ADVs. Experimenting with the developed decision support system on a case study with three alternative building designs proved that the system is capable of estimating how clients value each design. Afterwards, using sensitivity analysis, the system is capable of arriving at the optimum set of ADVs that can best match the client requirements with the lowest life-cycle performance. This research is expected to assist designers in understanding the cost implication of the key ADVs, and presents a scientific decision-making approach to quantify the design alternatives that contain subjective features.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-063

Evaluating Stage Construction Approach as an Efficient Tool for Reducing Environmental Impacts of Highway Projects

Mohammad Reza Heidari
Gholamreza Heravi
Asghar Nezhadpour Esmaeeli

Abstract:

Roadway construction has an important role in the development of each country. Paying attention to “sustainable development”, highway management organizations should consider long-term environmental effects on the in their design strategies and apply the procedures with lowest possible destructive effects on the environment. Stage construction is a reasoning approach can be utilized in highway construction. Economic advantages of this approach are well clarified. Among them are: deferral in investing a portion of initial construction costs results in decreased life cycle rehabilitation costs; and reaching more suitable surface and thereupon lower vehicle operating costs. In addition to such benefits, stage construction is environmentally feasible. In this paper, a quantitative life-cycle assessment method is used to evaluate the environmental effects of stage construction. As a case study, stage construction approach and traditional construction approach are compared in a highway project in Iran. It is expected that life-cycle environmental effects of pavement construction are considerably decreased due to probable future technology improvements during the pavement life-cycle. Also, the excess fuel consumption of vehicles due to surface quality decline is lowered since having a better surface in stage construction.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-065

Fuzzy Life-Cycle Assessment Approach for Quantifying Environmental Impacts of Highway Projects under Uncertainty

Mohammad Reza Heidari
Gholamreza Heravi
Asghar Nezhadpour Esmaeeli

Abstract:

Sustainable development is a challenging issue which has been heavily concerned during recent decades. A considerable investment of general budget of each country is annually allocated to highway projects. Therefore, a minor improvement in this section can lead to major efficiencies in the way of sustainable development. A number of research has been conducted to evaluate the environmental effects of highway projects in a long-term horizon. Existing methods often model the projects in a deterministic approach. But considering uncertainty associated with every project compels using non-deterministic methods. Fuzzy method as a potent tool for uncertainty-based assessment, not only covers the uncertainties, but also addresses shortcomings of probabilistic methods like Mont-Carlo simulation (MCS). In the MCS, large number of iterations should be used for having reliable results, also some other disadvantages of MCS are computational burden, sensitivity to uncertainty about input distribution shapes, and the need to assume correlation among all inputs. The method presented in this paper considers the uncertainties associated with traffic demand and pavement performance by fuzzy set theory and provides a tool to compare different strategy alternatives for performing pavement project by an innovative life-cycle assessment (LCA) method. The presented LCA tool quantifies environmental effects of each construction alternative in two terms of “Global Warming” and “Energy Consumption”. Finally, the presented approach is implemented in a highway project, as a case study. The results indicate that the significant effect of pavement performance on global warming impacts and energy consumption, emphasizing that pavement performance should be taken into consideration in the evaluation of different pavement construction strategies.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-066

Integrating Bridge Information Modeling (BrIM), Bridge Sustainability Rating System (BrSRS), Bridge Environmental Performance Strategy Mapping (EPSM) and Cost Estimating at the Conceptual Design Stage

Aly Elgayar
Ahmad Jade

Abstract:

Bridges are crucial infrastructure for urban development as cities rely heavily on various modes of transportation for access and mobility. In an effort to fill the gap in the knowledge and methodology used in sustainable bridges construction, a model was developed using the concept of BrIM to provide capabilities to develop bridges at the conceptual design stage, which offers ample versatility to influence stakeholders' decisions towards sustainable bridge design. The model is comprised of a knowledge-based decision support system and 4 modules namely, BrIM module, the first ever Bridge Sustainability Rating System (BrSRS) module, the first ever Bridge Environmental Performance Strategy Map (EPSM) module and a conceptual cost estimating module. The model takes fundamental data input and processes it through the knowledge-base system established based on MTO's Highway Geometric Design and the Navigational Waterways Clearance guidelines. The sustainability capabilities of the model are broken into two sub-modules; in the first a BrSRS was developed by using the amalgamation of various existent Highway and Road SRS and the introduction of bridge design considerations. The system mimics the style of LEED as users can select from a list of weighted sustainable construction activities and materials options to accumulate credits towards a sustainability classification. The second includes an EPSM that forecasts footprints levels of bridge projects based on 5 footprint indicators namely, carbon, water, energy, emissions and work environment with data obtained from Statistics Canada pertaining to each footprint illustrated on a web graph. The third module takes the knowledge-base output and presents it in 3D mode via AutoCAD allowing users to alter the drawing's dimensions and the model then reiterates the calculations based on the changes done on CAD. The final module computes an approximate cost estimate of the conceptually designed bridge, which is ideal for the feasibility study of the project.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-068

Annotation of Heavy Construction Videos Using Object Detection and Bayesian Networks

Ehsan Rezazadeh Azar

Abstract:

Emergence of low-cost videotaping devices and storage systems, including hardware and cloud-based, have resulted in rapid increase of the recorded construction videos. In return, several vision-based systems were developed to detect and track resources in videos to extract productivity and safety metrics. There are, however, limited efforts to semantically annotate and retrieve videos of the interest from the construction video archives. This paper introduces a semantic annotation framework which uses object recognition to locate objects, and then applies Bayesian Belief networks to annotate the objects and their actions. Finally, it employs fuzzy logic to retrieve the indexed videos. The developed system was evaluated using videos from various sources, such as a video hosting website, which provided promising performance in retrieval of the videos and also highlighted the areas for the future improvements.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-069

Lean Scheduling of Low Income Housing using Cold Formed Steel

Dina Saad
Mohammed Masoud
Hesham Osman

Abstract:

Construction of low-income housing is a tremendous challenge for governments to meet the increasing demand especially in developing countries. Thus, a fast and cost-effective construction process is required. To meet this challenging demand, light (cold-formed) steel (CFS) framing systems have been used as a more affordable and faster alternative to traditional systems. Construction of a CFS building is often a repetitive process of erecting CFS walls and slabs, and cladding using ferro-cement boards. Moreover, low-income housing projects usually consists of typical residential units spaced close to each other. The construction of such units, therefore, is a repetitive process that requires linear scheduling to facilitate continuous flow of resources and reduce idle time. For a project that consists of large number of residential units, traditional linear scheduling of the whole project as one big batch would lead to large work-in-progress inventory, potential delay due to discovered defects, and waste of time due to the waiting time between trades to finish the whole batch. In order to accelerate delivering repetitive low-income residential units to meet demand and reduce cost, this paper discusses the application of the batching concept of lean construction in the repetitive scheduling of low-income housing projects. A case study of 200 residential units, each consists of a basement and 5 floors, has been used to examine the impact of batching on reducing the total project duration and cost; work-in-progress inventory; and the impact of defects. Using this case study, it has been noticed that scheduling the project using 10 batches has reduced the work-in-progress inventory and achieved less duration as opposed to scheduling using a single batch of 200 units. As such, this research demonstrates benefits of applying lean construction principles in the construction of low-cost repetitive residential units.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-070

Framework for Measuring Process Interoperability in Construction Management

Seouyoung Kang
Carl T. Haas
Behrooz Golzarpoor

Abstract:

Organizations are required to collaborate in capital projects. While each organization has its own role and responsibility for a project, process interoperability between these organizations is necessary to deliver successful projects. However, compared to discussions on general enterprise interoperability, process interoperability in construction management is in its early stage. This is because enterprise interoperability has broader meaning than process interoperability in most industries. On the other hand, capital projects emphasize processes that connect multiple enterprises involved in a project. In this paper, process interoperability in construction management is defined as management-level workflow connection between organizations in a construction sector. In order to improve process interoperability in the construction field, a prior step would be to develop a framework for measurement of process interoperability. Thus, this study proposes a foundation for measuring process interoperability in the construction management field. The measuring method consists of three levels: project, organization and process-level. These approaches are explained in the paper, and examples using case studies are presented for initial validation. This methodology avoids self-reported and subjective responses on questionnaires. Moreover, this method can be used for consulting to understand the status of projects, organizations, and processes in terms of process interoperability.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-072

Defining a Resilience Framework for Project Delivery

Fei Han
Susan M. Bogus

Abstract:

Resilience has been studied in diverse disciplines, including structures, transportation, and construction. The essence of resilience is commonly described as an ability to bounce back from some form of adversity, disruption, or change. Unlike the idea of risk-control that tends to fend off these “unwanted” activities, resilience embraces such disruptions and allows a transition from resisting to recharging before and after the disruptions kick in. This feature makes resilience truly desirable for construction project delivery where the disruptions in terms of risks and changes are ubiquitous. Overall project performance is still vulnerable to disruptions like design, budget, and political issues. Pre-planning alone is insufficient to address the risks that are inevitable or unpredictable. Instead, we need to build resilience into the project when the risk is looming, especially for project development as a whole. This research aims to fill a gap by defining resilience in project delivery and resilience measures for the project delivery process. Based on key properties found in the literature and through a case study, a resilience framework is defined in the context of construction project delivery. Resilience works in different modes – resistance and recovery – at different project stages which are accounted for in the framework. In addition, there are different dimensions of resilience that are specified according to the concerns at each project stage. Lastly, the framework attempts to create measures to assess the level of resilience at each project stage. The conceptual framework shows how resilience is incorporated within a typical project delivery process, including the resilience mode, the dimensions of resilience, and potential measures of resilience. The proposed framework is expected guide future research into the resilience assessment criteria that enable more resilient construction project delivery.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-074

Assessment of Construction Projects' Impact on Internal Communication of Primary Stakeholders in Complex Projects

Shirin Kamalirad
Sharareh Kermanshachi
Jennifer Shane
Stuart Anderson

Abstract:

In construction projects, multiple parties are involved and communication becomes critical as project complexity increases. Effective internal communication can be an element of contributing to project success, however, there are limited number of studies in the field of construction which focus on the internal communication of primary stakeholders. Therefore, the objective of this paper is to assess the internal communication of primary stakeholders including owners, designers, and contractors in the construction industry and their related variables/parameters. In this paper, based on the literature, potential project-based communication variables are identified and categorized. Then, a survey focusing on project-based communication variables was developed and distributed among construction project participants active in the construction industry. Forty-four responses were collected. Through a statistical analysis, including two-sample *t*-test, Chi Squared Test, and Analysis Of Variance (ANOVA), researchers were able to determine significant project characteristics affecting the effectiveness of communication between the primary stakeholders, owners, designers, and contractors. The results of the statistical tests indicate that "the number of design/engineering organizations involved in the project", "number of financial approval authority thresholds", and "clarity of the project scope" have a significant impact on internal communication of the primary project stakeholders. The findings of this research will help construction managers to improve internal communication of primary stakeholders and as a result reduce the risk of failure in terms of miscommunication specifically in complex projects.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-079

Utility Company Practices to Expedite Utility Adjustments on Highway Projects

Ernest-John Ignacio

Khaled El-Rayes

Abstract:

The relocation and adjustment of utilities have been reported to cause delays to the completion of roadway projects and increase their total costs. In recent years, departments and ministries of transportation have implemented a number of Best Management Practices (BMPs) and incentives in an effort to mitigate these delays and their associated costs. This paper presents the findings of a recent study that evaluated the performance of utility adjustment Best Management Practices and incentives. The study conducted a comprehensive survey of utility company representatives to gather and analyze their experiences in implementing 45 BMPs in utility adjustment projects. A total of 90 utility company representatives participated in the survey representing all types of utilities, including water, gas, electricity, telecommunications, cable television, sewer, petroleum, high pressure pipelines, hazardous liquids, fiber optics, government entities and internet service providers. The survey was designed to evaluate the performance of these 45 BMPs and incentives including the frequency of their use, their effectiveness in accelerating utility adjustment, and problems and challenges encountered as a result of their implementation. The findings of this study should prove useful to researchers and decision makers in transportation authorities and will contribute to improving the selection and use of the BMPs in an effort to mitigate utility adjustment delays and accelerate utility adjustment projects.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-080

Exploring and Assessing the Utilization of Best Practices for Achieving Excellence in Construction Projects

Elnaz Safapour
Sharareh Kermanshachi
Jennifer Shane
Stuart Anderson

Abstract:

Many construction projects face cost overruns and schedule delays. To reduce the unintended outcomes of these challenges, CII (Construction Industry Institute) has developed 14 construction Best Practices (BPs). Although implementing all BPs would be profitable for construction projects, it may not be a practical approach. Therefore, based on the project's physical and managerial characteristics, Project Managers (PMs) should make a decision of which BPs will be more valuable to select. The aim of this paper is to provide a constructive approach and develop a decision-making tool to assist PMs with the selection and implementation process of CII BPs in construction projects. For this reason, a structured survey was developed to collect information on project physical and managerial characteristics as well as the impact of the implemented BPs on these projects. Forty-four responses were collected. Through statistical analysis including the two-sample *t*-Test, Kruskal-Wallis test, and Chi-squared test, the researchers were able to determine the significant project physical and managerial characteristics which are the main drivers of selecting and implementing construction BPs. The results of the analysis indicate that "interfaces among project participants", "project resources", and "stakeholder management" are the three primary determinants in the decision-making process of BPs' selection and implementation. The findings of this research will help PMs to invest in BPs which have the greatest impact in the optimization process of project development and execution in the construction industry.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-081

Public Perceptions Toward the Impact of Displaced Persons in Germany on Water and Wastewater Systems

Felipe Araya
Kasey Faust
Jessica Kaminsky

Abstract:

The United Nations High Commissioner for Refugees approximates that 12.4 million people have been forcibly displaced due to conflict or persecution in 2015; a migration that has continued into 2016 and 2017 due to instability in the Middle East. Many of these displaced persons have been hosted in developed countries, particularly Germany accepting approximately 750,000 refugees and asylum seekers in 2015 alone. This study aims to evaluate public perceptions of hosting communities towards the impact of displaced persons on German water and wastewater systems. Data was collected in August 2016 via a survey deployed to the general public in Germany. Questions of interest include whether additional population from displaced persons is temporary or permanent and the impact of displaced persons on water and wastewater systems to understand if the perceived impacts are thought to be short or long term. Statistical modeling is used to estimate demographic (e.g., income, education) and geographic parameters (i.e., specific states) that affect the perceptions of the hosting communities. Informed incorporation of local perceptions may contribute to minimizing potential opposition during the integration of displaced persons into hosting communities.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-083

Perception of Industry Professionals about Mixed Reality for Electrical Prefabrication

Jad Chalhoub
Steven K. Ayer

Abstract:

The use of Building Information Modeling (BIM) has been steadily increasing in the building industry. This increase has led many project teams to assess design and constructability for projects in a 3D, BIM-based, environment. Despite this increased use, many projects still use traditional 2D documentation to communicate design concepts to various project participants. Mixed Reality (MR) can technically be used to visualize 3D design content without the need for 2D paper communication, but in practice it is not clear how users would feel about replacing traditional 2D drawings with 3D MR. This research investigates the perceptions of industry professionals about replacing paper construction documents with a 3D MR based model. To evaluate behavioral and ideological changes, 18 electrical construction industry practitioners built two different conduit models using the same prefabricated pieces. In one iteration, they were provided with design communication through a MR visualization interface. In the other iteration, they used traditional paper plans. A pre-activity questionnaire was given to capture their ideas about a new technology being introduced and a post-activity questionnaire helped to evaluate their thoughts after using the technology. During the conduit assembly activity, participants were video/audio recorded to capture any verbal comments related to their perception of the activity. The results will help to illustrate some common perceptions among industry members about using MR to replace paper drawings. Furthermore, the results will also help to illustrate whether there are shifts in perception about this type of visualization environment after using both design communication approaches. The findings may help to guide future researchers and practitioners when attempting to integrate MR technology in the field.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-086

An Enhanced Framework for Dynamic Segmentation of Pavement Sections

Ahmed Abdelaty

H. David Jeong

Abstract:

Over the past decades, highway agencies used automated and semi-automated data collection methods such as laser scanning and ultrasonic waves, which resulted in the collection of an enormous amount of high density pavement condition data. Agencies are now able to quantify the level of extent and severity of different distresses for extremely short segments. Hence, finding and aggregating homogenous pavement segments based on the condition data is needed to accurately represent the overall network performance as well as making maintenance and rehabilitation decisions. This paper reviews the current methodologies for delineating pavement condition data and summarizes their limitations and challenges. Then, the study proposes a new segmentation framework for pavement sections that finds homogenous segments by considering multiple pavement distresses for performance evaluation and treatment selection purposes using the affinity propagation clustering technique and heuristic rules. The affinity propagation clustering technique finds the similarity between pavement sections based on the distress data. However, the clustering technique does not respect the spatial nature of pavement assets. As such, heuristic rules are formulated to overcome this limitation and identify homogenous pavement segments. A case study is conducted to illustrate the capabilities and applications of the proposed segmentation framework. The proposed segmentation framework will improve the a) representation of pavement condition data, b) formulation of pavement maintenance and rehabilitation strategies, and c) pavement performance evaluation.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-087

Radar Chart Tool for Evaluating the Performance of Pavement Rehabilitation Treatments

Ahmed Abdelaty
H. David Jeong
Omar Smadi

Abstract:

The transportation network of the United States has reached a mature state where maintenance and rehabilitation are more important than new construction activities. Hence, highway agencies are directing the available funds more towards maintenance and rehabilitation rather than expanding the existing network. Additionally, decision makers strive to achieve the maximum return on maintenance and rehabilitation investment decisions to effectively justify their judgment to the public. Moreover, agencies are required and sometimes federally mandated to make maintenance and rehabilitation decisions based on sound performance measures. As such, the study aims at evaluating the performance of three major rehabilitation treatments including hot mix asphalt resurfacing, cold-in-place recycling, and hot mix asphalt resurfacing with milling by using one state highway agency entire historical pavement condition data and rehabilitation records. First, heterogeneous databases are integrated in spatial environment to create one integrated master database. Second, the performance of the major rehabilitation treatments is evaluated by statistically analyzing the pavement condition in terms of ride quality before and after the treatment application. Finally, the study presents a summary of the performance evaluation results which are expected to help agencies and practitioners in evaluating future investment decisions.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-088

Strategies for Maximizing OpEx at K-12 Educational Facilities

Michael Beauregard

Steven K. Ayer

Abstract:

Every year approximately \$50B is spent nationally to maintain the facility operations of primary and secondary educational buildings across the United States. An expanding body of academic research has conclusively linked the performance of building systems and the standard of care of educational environments to scholastic performance. Furthermore, Strategic capital and operational expense (CapEx / OpEx) improvements to educational facilities are shown to have a positive influence on student academic performance, teacher retention, and standardized test scores. Despite this knowledge and the ongoing financial expense, America's educational infrastructure by many accounts is underfunded and failing. Currently, there is not a thorough understanding of the managerial philosophy and method of prioritizing spending in support of plant maintenance and operations spending at K-12 educational facilities. This research utilizes a mixed-method approach of qualitative structured interviews in combination with quantifiable data on annual spending and student academic performance targeting a representative sample of academic school districts in the state of Arizona. The outcome of the research will document existing asset management strategies while proposing a revised decision support structure prioritizing student outcomes. More specifically the research explores the extent to which current asset management strategies consider student scholastic achievement when prioritizing spending. The findings from this work will help to guide future research to develop a structured decision support tool to enable K-12 administrators to prioritize spending to enable the greatest benefits to student learning for the money spent.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-091

Optimal Nearest Neighbour Calculation for Automated Retrieval of Construction Elements from Cluttered Point Clouds

Mohamad-Mahdi Sharif
Nicolas Jeanclos
Caroline Kwiatek
Mohammad Nahangi
Carl T. Haas
Jeffrey West

Abstract:

3D point cloud data can be used for visual and quantitative dimensional control of an object of interest but requires a robust post-processing algorithm to isolate the object being considered from the clutter in the point cloud. Finding an object in a scene is a crucial task that has been investigated extensively in literature. Once the object is found it must be isolated using a clutter removal methodology. One such methodology used the KNN algorithm. This paper presents a case study on finding the optimal threshold value of the K value in the KNN algorithm. Tests have been carried out on a cylindrical pipe spool assembly. Two criteria for measuring the success of clutter removal have been defined as: (1) Number of points erroneously remaining in the point cloud. (2) Number of points erroneously removed. These two criteria have been measured under different scenarios by changing the quality of the assembly, the number of points in the scene point cloud, and the number of points in the model point cloud. The contribution of this paper is providing a mathematical solution for selecting an optimal threshold value for the K value in the KNN algorithm to ensure that only excessive points are removed from the scene point cloud once the object of interest is identified.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-092

An Investigation of the Distribution of Mobile Crane Loads for Construction Projects

Meng Lin
Lijun Deng
Ulrich Hermann
Zhen Lei
Travis Zubick
Samer Adeeb
Nguyet Duong

Abstract:

In the Canadian construction industry, mobile cranes, such as rough terrain cranes and crawler cranes are employed to perform lifting for construction projects. Over the years, the ground preparation below load-spreading mats supporting the mobile crane has been mainly designed based on crude assumptions or using rules of thumb, due to the lack of reference data regarding the actual loads transferred to the ground. This paper aims to obtain the actual reactions beneath the outrigger supports for a rough terrain crane based on the collections of adequate numbers of experimental data. The load data were recorded from the earth pressure cells buried vertically in the ground at two different depths at three critical boom positions with three working radii during the lifting operations. The experimental data were compared with others obtained from currently common used methods, such as the 2:1 approximation method, Boussinesq equations and the software predictions provided by crane manufacture. In addition, the soil-mat interaction was simulated with a two-dimensional (2D) axisymmetric model using the finite element analysis (FEA). This study indicates that the prediction of ground bearing pressure (GBP) beneath outrigger supports from the crane software is reliable but should be increased by 10%.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON- 093

Engineering Competencies Developed through Construction Management Education: Student Perceptions

Mihai Robu
Farnaz Sadeghpour

Abstract:

To respond to the need for educating well-rounded engineers, a group of international researchers have formed the Conceive-Design-Implement-Operate (CDIO) initiative for engineering education. The goal of the CDIO initiative is to provide post-secondary engineering educational institutions with a framework for their undergraduate programs that incorporates 104 technical, personal, professional and interpersonal competencies that are desired of a well-rounded engineering graduate. The intention is that through various courses in a program, engineering students should gain proficiency in CDIO competencies. This study explores which areas of the CDIO syllabus are addressed in a typical Construction/Project Management course offered in an accredited Canadian Civil Engineering undergraduate program. This paper focuses on the perception of students as one of the stakeholders in post-secondary education. A questionnaire was developed based on the CDIO list of engineering competencies. Students taking a Construction/Project Management course were asked to identify the competencies that, to their perception, are addressed in the course. They were also asked to self-assess their proficiency level on each competency. The questionnaire was administered twice, once at the beginning, and once at the end of the course. Descriptive statistics are used to portray student perceptions on which competencies were addressed in the course. Inferential statistical techniques such as McNemar's test and dependent samples *t*-tests were used to study the difference between the perceptions at the beginning and the end of the course. While students' ratings of their proficiency increased for many competencies, interestingly, it was observed that their self-assessment decreased for one of the competencies from the beginning to the end of the course. The nature of changes in student perceptions of their proficiencies in CDIO competencies, as well as the potential impact of Construction/Project Management courses in developing engineering competencies in a Civil Engineering program will be further discussed in the paper.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-094

Dimensions of Construction Safety Climate

Wael Alruqi
Matthew Hallowell

Abstract:

Safety climate has been recognized as a proactive safety metric that can be used to predict safety performance. In recent years, researchers have measured dimensions of organizational safety climate across a variety of sectors and work types. However, at present there is no consensus about the dimensions that define safety climate. Additionally, despite the volume of literature, there is limited analysis of the various dimensions modeled across studies. The paper addresses this limitation by reviewing the research on construction's safety climate in an effort to: (1) identify the salient dimensions of safety climate; (2) establish a consistent definition of each safety climate dimension; (3) review the questionnaires used to measure safety climate dimensions; and (4) model the trends of safety climate research in the last 16 years. All of the 114 construction safety climate studies published in peer-reviewed journals since the year 2000 were reviewed and analyzed. The results indicate that the rate of construction safety climate papers has increased rapidly. In fact, 60% of the identified studies were published after 2012. Fifteen percent of these studies modeled the relationship between safety climate dimensions and safety performance. When measuring safety climate, researchers most often use Likert-scale questionnaires; however, there is very little commonality in the dimensions of climate used across studies. Of the dimensions, management commitment, supervisory safety response, safety procedures and rule, and 15 other dimensions were the most common. The findings from this review can be used to direct future work, establish a unified method of measuring safety climate, and act as a catalyst for the first meta-analysis of the relationship between safety climate and performance.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-095

Improved Data Storage for Better Safety Analysis and Decision Making in Large Construction Management Firms

Megan Coffland
Amy Kim
Hessam Sadatsafavi
Mindy Uber

Abstract:

Skanska USA Building Inc. has the goal of utilizing past safety data to reduce the number of fatalities, injuries, illnesses and near misses on construction sites in keeping with their Injury Free Environment (IFE) initiative. To this end, following any safety incident, data is collected and stored following a full incident review that exceeds OSHA reporting requirements. This data, along with information on the use of Building Information Modeling on projects, and accounting from the Seattle, WA office from 2006 thru April of 2016 has been made available for investigation. This data represents 556 projects with 1953 separate data points, each representing a total of up to 20 separate pieces of information, including building type, project budget, duration, year of completion; along with injury type and incident classifications. This data was kept in separate locations and spread over multiple years, often with overlapping items. This was understandable given that most decentralized business units and departments uses data in different ways. However, the objective of this study is to discuss the lessons learned to move to a centralized system to support data-driven business operations. More specifically, the study evaluates the data storage, file structures and limited integration for ways to improve data mining for safety assessment. Centralized data will lower the cost and time threshold for future data analysis. The results will be invaluable to not just to this firm, but to construction management companies across all locals in guiding data collection and storage to facilitate future analysis.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-096

Towards Deeper Understanding of Future Craft Shortages in The Construction Industry: Supply and Demand Sides

Farzad Minooei
Mohammed Albattah
Paul Goodrum
Timothy R.B. Taylor

Abstract:

Craft labor shortages are a recurring problem of the construction industry over the past several decades. These shortages occur when the supply of craft labor is less than the demand for craft labor. The current work examines the supply and demand of craft labor across different trades to better understand the magnitude of craft labor shortages. The craft worker supply and demand is quantified based on the prediction of real demand from future industrial construction projects by using Construction Labor Market Analyzer (CLMA) data. The results of our analysis show that the workforce shortage affects specific trades (e.g. electricians, pipefitters, and welders) in specific geographic regions (e.g. the Southwest and Southeast). Understanding potential new inputs into the craft labor supply is examined through a survey to measure young people's attitude towards working in the construction industry. More than 650 completed questionnaires were collected from participants at the SkillsUSA 2016 national championship competitions across different trades. Most of the survey respondents were between the ages of 15- 24 and who are potentially interested a career in construction. The statistical analysis shows that young people across different trades perceive the construction industry in different ways especially in areas such as job opportunities, challenges in work-life balance, and learning opportunities. Another interesting result is that although the industry desperately needs welders, the future welders have a relatively pessimistic attitude towards working in the construction industry. The results of this study will help the US construction industry to understand how young people across different trades view the construction industry and what aspects should be emphasized to attract them to a construction craft career.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-098

The New Generation of UHPC bridges in Canada

Philip Loh
Yen Lei Jackie Voo
Jackson Lee

Abstract:

In a world constantly on the move, the path towards more sustainable infrastructure is one well worth the investment. To support the visionary of sustainable construction, the evolving technology of the Ultra High Performance Concrete (UHPC) is constantly tapped.

The UHPC technology is considered as one of the biggest breakthrough in the 21st century in the building material and construction industry. With 4 to 6 times stronger in compressive strength and at least 100 times more durable than conventional concrete, the use of high quality UHPC bridge components that has superior durability and prolonged service life, can also help reduce embodied energy, CO₂ emissions and global warming potential (GWP).

To-date, there are 3 UHPC bridges constructed in Canada, all pedestrian bridges, in Sherbrooke , Quebec (1997) and Calgary, Alberta (2007, 2008). Also, more than 50 bridges in Canada have utilized UHPC in closure strips between precast bridge elements made of conventional concrete, but such applications generally require relatively low quantities of UHPC. Reasons for not being able to promote the widespread use of UHPC in infrastructure construction in Canada are lack of design standards and high cost.

A process was developed to produce a new generation of UHPC which is more price-competitive and provides substantial added value added to projects. We will show the research and development of this UHPC product, including full-scale testing and its application in more than 90 bridges (pedestrian and vehicular), including post-tensioned precast segmental UHPC girders in bridges up to 100m single span and 420m 10-span structure.

As a result of a technology transfer agreement, the production of this new generation of UHPC is produced in Canada with local Canadian raw material. We will also present the tests completed to-date in Canada, with the objective to implement this material in the Next Generation of Canadian UHPC bridges.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-100

**Study on the Dynamic Safety Risk of Struck-By-Equipment Hazard:
Risk Analysis, Prediction and Safety Performance Evaluation**

Jun Wang
Saiedeh Razavi
Ioannis Brilakis

Abstract:

Having a system that can proactively identify risks on sites is the key to the success of hazard identification and prevention in the dynamic and hazardous construction environment. Safety performance evaluation also is a primary means to enhance construction safety. Leading indicators are aspects reflecting safe practices or observations that can be used to strengthen safety performance prior to the occurrence of an undesirable consequence. Thus this paper employs a network-based model and a probabilistic method with two safety leading indicators to investigate the dynamic struck-by-equipment risk. In the network-based model, entities' dynamics and the interactions among them are monitored, quantified, and analyzed to identify risk and their risk-related behaviors. Degree centrality and algebraic connectivity are employed as the leading indicators to measure the struck-by-equipment risk at the entity and network levels. Meanwhile, a probabilistic method with Monte Carlo simulation is applied to predict the risk at the two levels. Thus, real-time, posterior, and prospective safety performance evaluation can be conducted. The implementation and assessment of the network-based model and the probabilistic method for risk analysis, prediction and safety performance evaluation were conducted by using two simulated examples. The safety performance of entities (i.e., workers-on-foot and equipment) and job sites pertinent to struck-by-equipment hazard was evaluated. Accordingly, safety managers can gain a full understanding of workforce behaviors and job sites in terms of safety, to proactively eliminate unsafe actions and practices. The results also provide insight into the development of safety training strategies and programs.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-102

Cost Schedule Forecasting Model for Nuclear Power Plant Projects

Samer Alsharif
Aslihan Karatas

Abstract:

Reliable cost and schedule forecasting are one of the major project management challenges for nuclear power plant projects due to their unique characteristics (e.g., variability of projects portfolio, security and safety requirements). Inaccurate forecasting may bring along schedule delay and cost overrun, and accordingly termination of nuclear power plant's operating license. To overcome these challenges, this study develops a cost schedule forecasting model that is capable of improving the accuracy of cost and schedule estimation for nuclear power plant projects. The forecasting model is designed in two steps: (i) identifying the causal factors of delay for nuclear power plant projects; and (ii) investigating the impacts of identified factors on projects' cost schedule performance by using artificial neural network modelling. The model is also validated by project management portfolio of a nuclear power plant in Michigan, US. The initial analysis and results are presented and discussed in this study.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-105

Objectively Assessing Fatigue Levels among Construction Workers

Ulises Techera
Matthew Hallowell
Ray Littlejohn

Abstract:

The upsurge in commitment to safety from industry leaders and the implementation of better equipment and training have generated a 67% decline in recordable incident rates during the past two decades. Fatalities, however, have plateaued for the last decade and, in the past three years, have increased for the first time. Current research indicates that human factors like fatigue play a major role in accident causation and fatality occurrence. Under the effects of fatigue, the human body experiences a marked reduction in cognitive and physical abilities that inhibit normal thinking and motor processes. Unfortunately, at present, there is no method of measuring or predicting fatigue that does not rely on expensive technology, intrusive tests, or subjective questionnaires. Our hypothesis was that fatigue levels can be predicted based on activity variables. Activity variables are defined as the characteristics of the work environmental conditions, shift design, and personal habits (e.g., commute time). An activity variable questionnaire was created based on past literature and was delivered to a diverse sample of 160 US construction workers. Following this questionnaire, each worker completed a Psychomotor Vigilant Test (PVT) to objectively measure their actual levels of fatigue. The results indicate a correlation between the level of fatigue of an individual, the type of work that he/she performs and the amount of sleep obtained during the previous 24 hours. These findings inform the research community about specific ways that fatigue can be quickly and objectively measured without the intrusive and often expensive use of technology. Future research should focus on further revealing the effect that each specific trade has on fatigue.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-106

Evaluation of Computer Vision- and 4D BIM-based Construction Progress Tracking on a UAV Platform

Hesam Hamledari
Brenda McCabe
Shakiba Davari
Arash Shahi
Ehsan Rezazadeh Azar
Forest Flager

Abstract:

The application of image-based progress tracking and object detection techniques has recently been extended to dynamic automated data collection and image capture platforms such as unmanned aerial vehicles (UAV). The use of UAVs has a great potential to eliminate tedious, labor-intensive, costly, and manual image capture processes. It can also provide a clearer and more informative view of construction work due to the UAVs' high agility and maneuverability. However, it is also of utmost importance to analyze the effect of UAVs' highly dynamic behavior on the accuracy of image-based solutions. UAV-captured images are subject to motion blur which not only can jeopardizes the object and progress recognition accuracy, but also the quality and reliability of resulting as-built 4D building information models (BIM). This study evaluates the performance of a 4D BIM- and computer vision-based construction progress detection method on images captured by an unmanned aerial vehicle. In this research, the components of indoor partitions such as studs, insulation, electrical outlets, and state of drywall work are automatically detected, and the 4D BIM is updated with schedule and progress information. In a series of experiments, the accuracy of this solution is analyzed with respect to the UAV's velocity and photo capture configuration. This analysis can benefit UAV-based progress tracking systems and facilitate reliable UAV-based data collection at construction sites.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-108

Assessment of Strain Capacities of Post-Disaster Critical Infrastructure with respect to Functional and Structural Stress

Juyeong Choi
Makarand Hastak

Abstract:

Critical infrastructures are essential to the effective recovery of disaster-affected communities. Adequate infrastructure services enable the communities to sustain and restore their livelihoods. However, disasters are likely to impact critical infrastructure so the infrastructure cannot maintain design capacities to support post-disaster communities. On the other hand, communities' recovery demands often increase exponentially as a consequence of disaster impacts. Therefore, critical infrastructure become susceptible to excessive stress and cannot fulfill the required function during post-disaster recovery. To successfully operate infrastructure services, critical infrastructure should have sufficient capacities to not only serve communities as designed, but also as expected. For example, in a post-disaster situation, a hospital requires certain amount of electricity, water and steam to operate building facilities and medical equipment so that it can treat as many patients as they can. But, it also needs to have redundant resources to expand its capacities so as to accommodate ex-post demand surge in the case of mass casualty events. This research utilizes a stress-strain capacity analysis to evaluate strain capacities of critical infrastructure with respect to post-disaster stress. This research evaluates strain capacities of an infrastructure with respect to both structural and functional stress and proposes a framework to develop capacity building strategies to address them. With simulation capability, we investigate the post-disaster operation of a hypothetical hospital to demonstrate how to develop capacity building strategies to mitigate functional and structural stress.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-110

Key Factors of Prioritizing Energy Resource Conservation Measures in a Portfolio of Buildings: A Literature Review

Lysandra Medal
Amy Kim

Abstract:

Prioritizing energy efficiency retrofit efforts in buildings is ideally based on the rational objective of generating trade-offs between maximum benefit and minimum cost. However, current practices have demonstrated stakeholders' tendency to inconsistently adopt mental shortcuts that are built upon personal intuition, limited empirical studies, or heuristic decision-making strategies to prioritize energy efficiency retrofit projects. Thus, there is a need to understand the behavioral anomalies that influence energy efficiency investment decisions beyond economic considerations. This crucial step is usually ignored when developing prioritization models for energy conservation measures. The goal of the study is to synthesize the current practices of how facility resource conservation managers and other relevant decision makers systematically perceive and proceed with retrofits of large building portfolios. The study entails reviewing recent literature relevant to the prioritization strategies of energy conservation in buildings. The literature assessment revealed a systematic evaluation of factors that influence the retrofit decision-making process in buildings. The primary factors identified are upgrade costs, energy savings, and environmental benefit. However, other factors indicate the application of heuristic rules, which include project practicality, expert skills, team collaboration, occupant comfort, and social rewards. The conceptual representation that links both factors and processes is synthesized into causal-loop diagrams. Based on the obtained findings, challenges faced by the decision makers were explored when prioritizing energy conservation measures in a complex environment. The study results lead to diagnosing the interrelatedness of common and hidden decision factors to improve the organization management of energy conservation measures.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-111

Exploring Agent-Based Modeling Approaches for Human-Centered Energy Consumption Prediction

Yewande Abraham
Zhidan Zhao
Somayeh Asadi
Chimay Anumba

Abstract:

In buildings, occupants take different actions to meet their comfort needs and improve their satisfaction indoors. Studies have highlighted the importance of taking into account the behavior of occupants for energy consumption estimation while ensuring their needs are met. Human behavior is dynamic and modeling behavior is quite challenging. Existing energy simulation tools to predict energy consumption mostly assume occupants are static and do not adequately capture the impact of occupants and their preferences indoors. Agent-based modeling approaches have been used to model human behavior in different contexts, they have also been used in relation to energy consumption prediction. This study explores how agent-based approaches can be used to better model not only human behavior but also look into how human values (for instance thermal comfort, visual comfort, indoor air quality, perceived health and personal productivity) and indoor environmental preferences can be maintained while improving energy savings. Following a review of the available literature, we highlight the gaps and present recommendations to better account for occupant preferences and behavior. Occupant behavior based on actual feedback data from building occupants is used to highlight behavior that takes place in an operational case study office building. The behavior explored include change in clothing levels of the occupants, use of portable heating and cooling devices, adjusting thermostats, adjusting lighting levels, and the use of shading devices which can be assigned to the agents. Rather than relying solely on traditional simulation methods, we explore how agent-based modeling can be implemented for the analysis of human-centered energy use prediction in buildings to improve occupant satisfaction and realize energy savings in buildings.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-112

Operationalizing Performance in Publicly Listed AECFirms: The Dominant Dimensions

Yousif AlHosani
Sabah Al Kass
Constantine Katsanis

Abstract:

Organization performance is one of the most important constructs in management research, whereas determination of organization performance is essential for gaining robust results. Many organizations are investing considerable amount of resource implementing measures that reflect all dimensions of their performance. It is reported in the literature that consideration is being given to what should be measured today, but little attention is being paid to the question of what should be measured tomorrow. Despite numerous topics that have been demonstrated in the literature on performance, limited attention is paid to its measurement in empirical studies. The operationalization of organization performance provides rich implications for both researchers and practitioners. This issue is becoming more prominent in construction industry (AEC firms: Architect, Engineers and General Contractors), where the industry processes are typically prone to risks, which ultimately affects organizations' performance. The main objective of the paper is to explore various factors contributing to the performance of construction firms, making it more predictable, rather than measuring a single-item indicator. The article is capturing the different operationalization aspects of performance in construction industry. It presents an extension to the work done by one of the co-authors on Dominant Dimensions of Performance. Furthermore, the paper addresses two issues in the proposed performance operationalization, (1) the dimension, establishing which measures are appropriate to the research context: and (2) selection and combination of measures, establishing which measures can be usefully combined. Therefore, an overall concept rather than narrow, strictly economic criteria will be presented.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-113

Construction Project Control and Monitoring with the Integration of Unmanned Aerial Systems with Virtual Design and Construction Models

Azzeddine Oudjehane
Shahab Moeini
Tareq Baker

Abstract:

This paper introduces the process of integrating the use of Unmanned Aerial Systems and BIM models in construction project management control.

A case study application was conducted on a recreation and sports facility construction site for progress monitoring and reporting. Data and information was first captured using UAS. UAS/BIM interrelated systems were then used for construction progress monitoring and constant comparison between the “As planned” and the actual state of the project “As-build”. This comparison which represents a critical task in project control should enable construction project managers (CPM) to keep projects on track. By contrast, most typical progress and inspection reports on construction sites are based on human or manual observations at each and every phase of the project. The latter process while mandatory has a direct impact on project costs, schedule and progress.

The value impacts of the integrated approach of unmanned aerial systems and BIM models, on the project management control is finally demonstrated.

The key learning objectives:

- Identify the process of implementing UAS in construction project management
- Demonstrate how to integrate BIM models with UAS
- Measure the impacts and value of integrated innovative systems UAS-BIM on construction management project

An interactive action learning discussion will be planned for the presentation.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-115

Identification and Classification of the Resilient Structural Dimensions and Contingency Factors of Project-Based Organizations in Construction Industry

Ardalan Hosseini Naveh
Gholamreza Heravi

Abstract:

Resilience is one of the strategic and tactical aspects of organizations that help them recover from crises. A resilient organization absorbs shocks and copes positively with unexpected situations. Although the idea of resilience is becoming increasingly popular, there is only a few number of articles about resilience of organizations, particularly in the field of construction industry. Thus, resilience is an essential component of organizations in construction industry, which enables them to respond to extreme events. Observe the features that describe specific organizational design traits, is the first step for understanding resilience of organizations. Structural dimensions and contingency factors are two types of interacting features of organizations, which describe organizations in much the same way that personality and physical traits describe people. Structural dimensions describe the internal characteristics of an organization, and contingency factors describe the organizational setting that influences and shapes the structural dimensions. This paper intends to describe various types of factors affecting the resilience of the organizational structures used in the different types of construction organizations. Initially, this research employs theoretical methods such as terminology analysis, logical analysis, and synthesis to study and analyze the concept of organizations' resilience. In the next step, the resilient organizations' key features were identified and the factors affecting resilience were mentioned. This research illustrates that among major factors, which increase the resilience of construction industry organizations, are reducing bureaucracy, professionalism and technical competence, downsizing, managerial tools and techniques, environment, and organization's culture. All of the factors have been classified into structural dimensions and contingency factors. Finally, a number of factors have been split into subfactors. To achieve resilient organizations, organizational resiliency factors shall be brought into attention. It is also believed that resilience organizations, which have resilient crisis response and recovery, will boost the reliability of organizations.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-116

Finite Element Method based Jerk-Energy for damage localization of dynamic response

Mohamed Bouyahi

Abstract:

A new method is proposed to identify the damages of locations based on two Jerk Energy (JE) methods. Proposed for test with pulse excitation, firstly a reduced discretized analytical model is derived from active acceleration. Then, the experimental model is implemented based on knowledge measurement data under stationary and random excitations are developed using pseudo excitation method. To verify the analytical prediction an experimental test is used with different stiffness's levels of damage cases to verify the two JE methods to uses in real-time damage detection. Finally, the finite element model (FEM) updating method is adopted for quantifying the damages of structure from the experimental measured. Three degrees of freedom (DOF) coupled model are investigated in this paper to analyze the acceleration sensor outputs



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-118

Web-Based Integrated Progress Monitoring and Reporting

Ahmed Montaser
Ali Montaser

Abstract:

Web-based progress reporting systems are powerful tool in the pursuit of improving efficiency and enhancing the flow of information within construction projects. Executive management of real estate developers needs an easy manner and a near-real-time project information that describes project status to take immediate corrective actions as well as to know the exact overall status of corporation projects. This paper presents an integrated web-based progress monitoring and reporting system for real estate developers. It utilizes Primavera P6 as a scheduling tool while progress visualization capabilities are achieved through project progress photos. The application main development tool is ORACLE Business Intelligence Enterprise (BIE). Specially designed relational database was used to be the main repository for scheduling and progress captured photos beside its customized web-based application. The developed application and methods constitute a practical integration between time reporting and progress visualization. The application has been tested and applied to actual case study to demonstrate and verify its ease of use and capabilities. The case study project is a residential community composed of villas, building and supporting infrastructure works in addition to community building in the Kingdom of Saudi Arabia with 53,800 m² land area and a 39,526 m² built up area. The analyzed case study demonstrates how the developed system can assist real estate developers in taking corrective actions based on the near-real-time actual data captured and processed to enhance project controls and progress reporting in construction industry.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-119

Industry Foundation Processes (IFP) – A Unique Approach to Improve Process Conformance and Interoperability

Behrooz Golzarpoor
Carl T. Haas
Joel Gray
Derek Rayside
Seokyoung Kang

Abstract:

Process conformance and interoperability are long sought after goals in capital facility engineering and construction project management. Processes are defined within corporate operating standards by the most sophisticated firms, but research studies confirm that they are not implemented consistently from project to project. It is well established from statistical analysis of hundreds of projects that improved process conformance and improved interoperability are correlated with substantial improvements in project performance in terms of cost, schedule, and productivity.

Process conformance in many industry sectors such as health care, manufacturing, and banking has been radically improved with automation and integration of processes via workflow engines. In the construction industry, data interoperability has substantially been improved over the years with employment of data modeling techniques and standards. Process interoperability which enables inter-organizational communication between project stakeholders in large-scale construction projects is relatively less developed.

This paper introduces the concept of Industry Foundation Processes (IFP), and discusses its development and applications. IFP is a unique process modeling system that facilitates integration of core processes of known best practices in the construction industry into workflow management systems, and improves process conformance and interoperability. IFP processes are defined as structured workflow processes based on known best practices in the construction industry, with specific features and properties that comprise the IFP ontology: version, scope, core structure, abstraction level, data structures, recommended practices, workflow inheritance, conformance, and interoperability.

In addition, this paper offers an implementation framework for the IFP system, and describes how IFP processes can be customized to more detailed processes suitable to particular types of projects, and then to specific projects, and how the IFP ontology facilitates improved process conformance and interoperability in the domain of the construction industry.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-120

Forecasting Construction Staffing Needs for State Transportation Agencies

Ying Li
Timothy R.B. Taylor
Paul Goodrum

Abstract:

State Transportation Agencies across the country continue to face many challenges to repair and enhance highway infrastructure to meet rapidly increasing transportation needs. One of these challenges is maintaining an adequate and efficient agency staff to execute construction projects. In order to effectively plan for future staffing levels, State Transportation Agencies need a method for forecasting long term construction staffing requirements. However, current methods in use cannot function without well-defined projects therefore making long term forecasts is difficult. This work develops a dynamic model which captures the feedback mechanisms within the system that determines highway staffing requirements. The system dynamics modeling methodology was used to build the forecasting model. The formal model was based on dynamic hypotheses derived from literature review and interviews with transportation experts. Both qualitative and quantitative data from literature and federal and state databases were used to support the values and equations in the model. The model integrates State Transportation Agencies' strategic plans, funding situations and staffing strategies while determining future staffing levels, and will hopefully fill the absence of long-term forecasting tools at State Transportation Agencies. The model was tested using standard system dynamics validation procedures, after which the model was calibrated using input data specific to the Kentucky Transportation Cabinet to simulate an expected retirement wave and search for solutions to address temporary staffing shortages.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-122

Critical Analysis of Alternate Design/Alternate Bid Contracting for Highway Pavement Types

Ilker Karaca
Ashley Buss
Douglas Gransberg

Abstract:

Alternate Design/Alternate Bid (ADAB) allows the pavement-type selection decision to be made as part of the procurement process by permitting contractors to bid their preferred alternative using real-time market pricing for the paving materials. The primary source of information was a survey of US Departments of Transportation which resulted in 40 responses, an 80% response rate. The paper provides a critical analysis of the results of ADAB projects in the US as well as the Canadian province of Ontario. The paper found that many ADAB projects documented an increased number of bidders on a given paving project by allowing both the asphalt and concrete paving industries to compete, as well as a trend of overall bid price reduction for both pavement types. One surprising finding was that when the agency competed asphalt and concrete pavement types on a head-to-head basis without a life cycle cost adjustment factor that concrete won 67% of the time. The paper concludes that head-to-head competition of the two pavement types not only eliminates the industry-based controversy of how to properly compute a rational life cycle adjustment factor but also simplifies the procurement process by allowing current market pricing to determine the pavement type based on hard facts rather than tenuous academic assumptions.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-123

Development and Validation of a Methodology to Evaluate Indoor Environmental Quality in Green Residential Buildings

Joshua Akom
Mohamed Issa
Abdul-Manan Sadick
Marten Duhoux
M Shokry Rashwan

Abstract:

Despite the abundance of literature on buildings' indoor environmental quality (IEQ) in general and their impact on occupants given the time people spend indoors, there is limited empirical evidence on residential buildings' IEQ in particular and their effects on occupants. This paper reports on an ongoing research study aiming to develop and validate a methodology to evaluate IEQ in green homes built to the Leadership in Energy and Environmental Design (LEED) rating system in the city of Brandon, Manitoba. The methodology relies on four main data collection instruments: 1) a comprehensive physical measurement protocol to evaluate various parameters related to thermal comfort, indoor air quality, lighting and acoustics using various sensors, 2) a questionnaire survey to evaluate indoor conditions and occupant satisfaction with them, 3) interviews with these homes' architects and facility managers and 4) a field observation form to record the physical conditions of these homes. The methodology was applied in a first phase to four of these homes with the aim of validating and refining it. When complete, the results should help designers and facility managers identify IEQ aspects and parameters in need of improvement, physical conditions that can help improve these aspects and parameters, and the effects of improving them on home occupants. They should also help develop best practices that can be used in the long-term to substantiate and improve existing relevant guidance. They can also spur further studies on homes and residential buildings that address the limited literature in the field and relevant knowledge gaps.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-124

Evaluation of Tall Building Construction Permitting Process in Toronto

Kamellia Shahi
Brenda McCabe
Arash Shahi
Paul De Berardis
Richard Lyall

Abstract:

With continuous population growth, the City of Toronto is one of the fastest growing municipalities in North America, attracting many developers to invest in its physical growth. As the major employment centre and surrounded by the contiguous cities that comprise the Greater Toronto area, downtown Toronto has no option to grow except upwards in the form of mixed-use tall buildings. The rapid increase in construction of tall buildings all over the city raises concerns among city planners, architects, engineers, and citizens about the way in which the city grows. To prevent undesirable or incompatible developments in the city, there have been numerous policies and regulations imposed on construction of tall buildings. These, coupled with complex processing practices, have resulted in significant and increasing delays in the processing of new applications for the construction of tall buildings. These delays have slowed the supply of new units to the market and resulted in enormous opportunity costs for the City. In this research, detailed information for 162 towers in the city of Toronto are collected and their permitting process evaluated. A number of challenges with the current system are identified and recommendations for improvement are provided. Finally, a Bayesian Network is developed to assess the probability of a new building proposal being rejected at the City Council and having to appeal to Ontario Municipal Board for approval, based on a number of proposal characteristics.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-125

Window Wall vs Curtain Wall: An Objective Review

Patrick Marquis
Seyedfarid Mirahadi
Hiba Ali
Arash Shahi
Brenda McCabe

Abstract:

The enclosure designs for modern tall buildings in Canada often incorporate highly glazed cladding systems such as the window wall and the curtain wall. Simply put, the main difference between the systems is that the window wall structurally sits between the slabs and the curtain wall is hung off the slabs by anchors. However, there are many more intricacies that differentiate the systems. The aesthetically slick and more expensive curtain wall is most often used in commercial buildings, while the highly customizable and constructible window wall is mostly used in residential construction. Further, curtain walls are structurally engineered and must be installed from the outside via crane or rig while the window wall relies on the existing structure and can be installed from inside. A comprehensive comparison of the two systems is performed. Thermal performance, water penetration, air leakage and moisture control are the metrics for the system's overall performance. A comparison is also made for the two system's constructability, life cycle cost and maintainability. Recommendations are outlined for the best use of each system, and improvements to their standard builds are defined. Overall, the window wall and curtain wall are very similar systems that can both be improved significantly from their typical designs. Both systems have their uses, but prove to be useful alternatives to each other with careful design.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-126

A Knowledge Map Based on Network Analysis to Support Energy Decisions on the Construction Phase

Rodrigo Aragao
Tamer El-Diraby

Abstract:

This study presents a framework to obtain a knowledge map (K-map) to support the decision-making (DM) process of energy estimates of the construction phase of oil and gas projects. The K-map comprises the most impacting construction activities in Brazil and the respective parameters, such as physical systems, design, site characteristics and resource features. The proposed K-map relies on the network representations of three case studies and expert surveys. In addition, the K-map can be updated with knowledge collected from a pilot social network interface, used by specialists and contractors to discuss a real oil and gas project. The K-map can provide the DM with useful correlations, which are concealed in the context of previous projects of the organization and its experts. As part of a larger life cycle energy assessment (LCEA), the proposed K-map can be expanded in the future to improve the DM process of infrastructure facilities in the early stages of the project, by providing more evident scenarios of energy savings during the construction phase and the corresponding trade-offs in the life cycle. The current research is not an energy calculator of the construction phase, but a collaborative tool to allow project team to debate and co-investigate the best means to improve energy consumption.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-128

Advancing Construction Students' Sustainability Competencies Using Online Tools

Caroline Clevenger
Moatassem Abdallah
Melissa Beauregard

Abstract:

Sustainability is an important component of engineering design and construction, however, research has shown that engineering education remains inefficient in teaching students basic principles of sustainable development. This research documents one year of using online tools to promote learning of sustainability principles in construction education. Autodesk's Building Performance Analysis (BPA) online modules were assigned in a sustainable construction class. Over the course of a semester, students were required to complete tutorials and earn the BPA Certificate. Student feedback and assessments were collected after each module was assigned, as well as after final group presentations. Overall, students concurred that the modules enhanced their learning experience both in regard to specific course material and sustainability. Findings suggest that the online training material enhanced sustainable competencies in both systems thinking and change-agents skills. Findings also suggest, however, that field trips may provide more time efficient learning enhancements. As a control, opinions regarding the effectiveness of BPA training and delivery were compared to students' who completed another online training to earn Procore's Fundamentals Certificate. Comparison suggests that Autodesk's BPA is a more effective teaching mechanism than Procore's program, but students perceive they are more likely to use Procore's project management concepts and software in industry.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-130

Work Structuring Principles, Strategies and Tools: A Review of the Literature

Kawalpreet Kaur
Panagiotis Mitropoulos

Abstract:

In the construction context, Work Structuring refers to the decomposition of the project's scope of work into manageable work packages and the allocation of these work packages to the project participants. Work Structuring determines the scope and complexity of each work package, as well as the dependencies between work packages and the need for coordination between the project participants assigned the different work packages. Work Structuring establishes the organizational structure of the project. As a result, it can influence the contractor's ability to win a project, and has significant implications for project performance. The long term goal of this research is to develop ways to improve the Work Structuring of construction project organizations. Towards this goal, this study investigates the principles, strategies and tools/methods used for structuring the work in different disciplines with emphasis on construction, manufacturing and software development. The study reviews the literature with a focus on the following questions: (1) How is work structuring currently performed—what are the principles, strategies and criteria and tools that guide work structuring; and (2) What are the implications for performance, and how are these implications evaluated—what factors, metrics, and indicators are used to evaluate work structuring.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-131

Uncertainty Analysis of Procurement Phase Performance Indicators Using Extreme Bounds Analysis (EBA)

Sharareh Kermanshachi
Bac Dao
Jennifer Shane
Stuart Anderson

Abstract:

The procurement phase (PP) is one of the major phases of construction projects which has a significant impact on the ultimate success of projects. Although some studies focused on identifying the PP cost and schedule performance leading indicators, however, the robustness/fragility of these variables have rarely been studied. An analysis of these indicators allow project managers to focus on the primary contributors, and the more robust indicators should receive higher priority when allocating scarce project resources as they are more likely to positively impact project performance. Therefore, the aim of this research is to differentiate between the robust and fragile PP cost overrun and schedule delay indicators. For this reason, this study used the two previously developed regression models which predict the PP cost and schedule performances. Extreme Bounds Analysis (EBA) was used to study the robustness or fragility of the identified PP indicators. In this study, both Leamer's and Sala-i-Martin EBA methods were used. Since Leamer's method only focuses on the extreme bounds of the indicator's distribution while Sala-i-Martin considers the entire indicator's distribution, the final conclusions were made based on the Sala-i-Martin method. Findings which were presented in both numerical and graphical forms, indicate that "bulk material quality issues", "company's degree of familiarity with technologies to be utilized in the construction phase" and "number of design/engineering organizations" are the three robust PP cost performance indicators. Results of the analysis also reveal that "percentage of design completed prior to the start of construction", "number of execution locations", and "number of supplier organizations" are the robust schedule delay indicators in the PP. The findings of this research will guide project managers in allocating limited human and machinery resources more effectively and efficiently.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-135

Rainwater Supplied Concrete Laboratory – An Interdisciplinary Approach to Sustainability Education

Heta Kosonen
Amy Kim

Abstract:

Rainwater collection is an environmentally sustainable way to reduce the demand on public water supplies and to mitigate the impacts of storm water runoff. While untreated and treated rainwater is used for a number of purposes ranging from garden irrigation to toilet flushing, a more extensive use of rainwater resources is currently hindered by the lack of uniform regulations. Considering that many regions suffer from droughts and that water scarcity is becoming one of the main environmental issues in the United States, a change in regulations, as well as in sustainable water design practices, is needed. University of Washington's (UW) Civil and Environmental Engineering (CEE) department is aiming to facilitate this change by educating a new generation of engineers to become familiar with the economic and ecological advantages of rainwater harvesting, know how to design and operate rainwater treatment systems and have a holistic understanding of sustainable water management practices in urban areas. In spring 2015, the UW Campus Sustainability Fund (CSF) grant awarded the construction of a rainwater collection and purification system in and adjacent to the construction materials laboratory space in the CEE department. The goal of the project was to provide the laboratory with a supplementary source of water for various uses, and serve as a campus wide educational tool for innovative, sustainable water management practices. The student-designed and built rainwater collection & purification system was brought online in March 2017. This presentation summarizes the lessons learned from implementing the interdisciplinary student project and discusses the experience from both students' and project lead's perspective.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-137

Using the DACUM Process to Develop an Industry-Directed Construction Education Curriculum

Parya Nickbeen
Vanessa Valentin
Susan M. Bogus
Amy Ballard

Abstract:

The need for sustainable development and demand for green buildings requires an expansion of education and training in green construction technologies. Currently, construction education often focuses on traditional skills, such as scheduling and cost estimating. This creates a mismatch between industry needs in the area of green construction and students' academic skills. To bridge the gap between job market needs and academic programs, there is a need for industry-directed curriculum design enabling graduates to quickly transition into positions in green construction. The purpose of this paper is to present a process for developing a curriculum that takes into account industry needs and expectations. DACUM (Developing a Curriculum) is an occupational analysis process that is used to link industry with academia. In one case study, the DACUM process was used over a two-day meeting with green construction professionals from different sectors and companies around Albuquerque, New Mexico, USA. Duties and skills of a "green construction technologist" were identified through interaction and cooperation of the professionals during a structured brainstorming process. Six main duties were identified including: performing pre-construction activities, performing construction activities, performing post construction activities, participating in professional development activities, and perform administrative tasks. For each of these main duties, seven to twenty tasks were identified during the DACUM process. To validate the results, a survey was conducted of professionals across the construction and related industries. The results of which will be used to develop a green construction technology certificate program at a local community college.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-139

Developing a BIM model for FM from handover documentation: A case study

Soojung Kim
Sheryl Staub
Erik Poirier

Abstract:

BIM is increasingly being used for design and construction (D&C) due to its emerging benefits. As the use of BIM for facility management (FM) remains limited in Canada, however, the D&C models end up losing their value post-construction. As the benefits of BIM for FM become better known through increasing research, there is a push to develop and extend the use of BIM for FM. However, there are still potential barriers of utilizing BIM for FM, which makes the owner hesitant about adopting BIM. To address these barriers, a detailed case study is done on a museum project which is initiated by a large public organization. A part of the existing BIM model of the project was developed into an operational model by populating the model data with handover documentation. This paper focuses on the information retrieval process and addresses the challenges of the process. The challenges include the massive amount of documents, unorganized templates, and the use of inconsistent units and terminologies by different suppliers. These problems caused the delay of information retrieval process. The paper informs the owners of the importance of handover documentation quality control to utilize BIM for FM purposes.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-140

Ontology-Based Data Integration for Supporting Big Bridge Data Analytics

Kaijian Liu
Nora El-Gohary

Abstract:

The deterioration of bridges is dependent on complex interactions of multiple factors. Existing research efforts focused on predicting bridge deterioration using indicators that consider a limited set of factors and ignore the interactions between them. On the other hand, a big size of bridge data is being generated and opens opportunities to big bridge data analytics for improved bridge deterioration prediction. The big bridge data include: (1) National Bridge Inventory (NBI) and National Bridge Elements (NBE) data, (2) traffic, weather, climate, and natural hazard data, and (3) data from bridge inspection reports. There is, thus, a need for data integration methods to integrate the big bridge data from distributed sources and in heterogeneous formats. To address this need, this paper proposes an ontology-based data integration methodology. Ontology aims to facilitate the integration based on content and domain-specific meaning. The proposed methodology includes two primary components: (1) ontology-based data linking: identifying the links among data from different sources, and (2) ontology-based data fusion: resolving conflicts between the linked data and fusing them. This paper focuses on presenting the proposed ontology-based data linking methodology and its experimental results. Data linking is defined as a multi-class classification problem – classifying data links into multiple types, including “is-type-of”, “is-supertype-of”, “is-part-of”, “is-parent-of”, “is-related”, “equivalent”, and “non-match”. In developing the methodology, several comparison functions for comparing attribute value similarities and machine learning algorithms for classification were implemented and evaluated based on accuracy. The experimental results show that the proposed data linking methodology achieved an accuracy of 98.7%.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-142

Spatial Interpolation of Weather Data for Occupational Health and Safety Research in Construction

Wonil Lee
Ken-Yu Lin

Abstract:

Weather data help inform the sustainable management of construction workforce. Weather data can be used to predict the level of heat stress faced by workers and inform job rotation. Oftentimes, researchers struggle to obtain authorization from project owners or contractors when it comes to installing on-site weather station for collecting desirable data. Thus, researchers look to alternative data sources. This paper studies two alternative data sources: the weather stations validated by the world meteorological organization (WMO) and those provided by weather underground (WU), an online platform from The Weather Company, LLC. Specifically, we selected a project site in Seattle and estimated weather data for the site location on a geographical information system using inverse distance weighted interpolation. Weather data collected from 35 weather stations within a 200-km radius from the project site through WU. We seek to understand: 1) through the spatial interpolation and for the locations which house the WMO stations, are the weather data derived from localized personal weather stations comparable to those measured by the WMO stations? 2) if they are comparable, for the location which houses the selected project site, are the weather data derived from localized personal weather stations areas comparable to those measured by the WMO stations?, and 3) if they are not comparable, how big is the difference when it is translated into the scale of heat stress? Eventually, our study hopes to develop a robust method to monitor construction workers' level of heat stress at specific project locations through localized weather data.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-143

How Pre-Disaster Construction Capacity Affects Post-Disaster Rebuilding Of Residential Housing

Erin Arneson
Matthew Hallowell
Amy Javernick-Will

Abstract:

The existing U.S. residential housing stock is increasingly exposed to storm surge and coastal flooding. For example, over 650,000 single-family residential homes were damaged or destroyed following Hurricane Sandy in 2012. The construction industry must meet post-disaster demand for construction services to facilitate post-disaster repair and reconstruction of residential homes. Construction capacity, defined here as the maximum building volume a construction industry can supply with available resources, determines how efficiently residential housing is rebuilt following a disaster. To better prepare for post-disaster reconstruction, this study addresses the question: how do we measure pre-disaster construction capacity at the state-level, and how does it compare to post-disaster reconstruction? We analyzed this question for single-family residential housing in the states of New Jersey and New York following Hurricane Sandy. Building on literature from construction supply chain management theory, we: (a) identified construction wholesale trade (material) and residential contractor (labor) establishments within New Jersey and New York; (b) measured state-level pre-disaster construction capacity as the net value of residential construction that can be performed in a given year; (c) calculated post-disaster losses for single-family residential housing based on FEMA damage inspections; and (d) compared pre-disaster construction capacity and single-family residential housing unit counts to post-disaster housing reconstruction progress, using a cross case comparison. Results highlight the extent to which construction resources within New Jersey and New York were capable of meeting post-disaster demand for residential construction. Furthermore, the novel methodology developed and employed can be used to assess whether construction capacity can meet demand following a disaster in other regions.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-145

A Belief Network Model of Resilient Safety Climate in the Construction Industry

Yuting Chen
Brenda McCabe
Douglas Hyatt

Abstract:

Resilience has been proposed to be a proactive approach to safety management for the next generation. Qualitative studies on defining resilience and using resilience rules to interpret safety practices have been widely conducted; however, relatively few quantitative studies have been done to measure resilience. Further, no empirical studies have investigated the interactions between resilience factors and safety outcomes. This paper aims to identify the interactions among resilience factors, and their impact on individual safety performance on construction sites. In this paper, a belief network was built based on 431 self-administered surveys from 68 sites in Ontario, Canada. This paper leads to several conclusions. First, management commitment is the key promoting a strong safety culture, and safety awareness is the most important individual factor affecting the safety performance of construction workers. Second, support from team members, especially coworkers, has a significant positive impact on improving the safety awareness of construction workers. The contributions to the Body of Knowledge are twofold. The relationship between construction safety outcomes and organizational resilience is quantified for the first time, and the pivotal role that management has in the safety performance of works is demonstrated. Secondly, this is the first empirical study.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-146

Trends, Benefits and Challenges in Utilizing Building Information Modeling Technology for Building Operation and Maintenance

Ahmed Atef
David Bristow

Abstract:

This paper discusses the evolution of Building Information Modeling (BIM). BIM is a suite of technologies for representing buildings in semantic and geometric descriptions. It enables, through a variety of tools, various analyses of the underlying architectural, structural, mechanical, electrical and plumbing systems. An extensive literature review is carried out on current practices of utilizing BIM to design, construct and manage building operations through its expected lifecycle. The literature review starts by highlighting current practices and the benefits in using BIM technology. Subsequently, the paper addresses existing challenges in using BIM in assessing and understanding the operation and maintenance of buildings. Efforts made thus far to address these challenges are discussed as well. Our work shows that there is a substantial need for more holistic approaches to managing the lifecycle of buildings that considers not only interdependencies among core systems but also interdependencies with other interrelated civil infrastructure networks. These integrated holistic approaches will equip stakeholders of any building with mechanisms to secure a delicate balance between; 1) retained operational risks of building systems, 2) anticipated demands of their customers and 3) desired and competing objectives for both internal and external stakeholders. The paper concludes that current BIM practices pay negligible consideration to the interdependencies among building systems and components which can be a key in hindering effective implementation of sustainable operation and maintenance plans.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-147

Modeling Spatial and Operational Interdependencies among Building Systems using Building Information Modeling

Ahmed Atef
David Bristow

Abstract:

Over the last decade, building information modeling (BIM) has been utilized as a standardized approach to represent and analyze the complex, diverse and rich design of architectural, structural, mechanical, electrical and plumbing systems. The current state of the art, however, focuses on deploying BIM for applications limited to optimizing the design and construction process of buildings in general. Minor emphasis is being directed to using BIM to operate and maintain buildings against the many risks they face. A difficulty in doing so is that there is no means to adequately trace the effect of hazards across the systems and components of the building. The objective of this paper is the development of a framework for extracting interdependencies among building systems and components in order to understand how can any hazard affect the resilience of building systems and components. The proposed framework is developed inside the Revit environment and is composed of two models; 1) a spatial model and 2) an operational model. The spatial model divides a building into spaces and then extracts all of the building elements in each space. The extracted elements are grouped into five domain specific groups; architectural, structural, mechanical, electrical and plumbing systems. The operational model is a processed version of the spatial model that allows for the assessment of the propagation of consequence through the building's operation. It provides novel visualization and understanding of a building's operational risks against all hazards. The proposed framework expands over the existing functionalities available in the Revit Application Program Interface (API) using the C# language. A case study using a multi-story office building is used to demonstrate the proposed framework application with discussion for its results and potential improvements.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-151

Modeling Food Desert Disruptors: An Object Oriented Programming Approach

Kelsey Abel
Kasey Faust

Abstract:

Urban food deserts (FDs) are any bounded geographic area in which over 30% of residents live more than one mile from stores supplying healthy, affordable foods. FDs affect 23.5 million people in the US. Previous FD models primarily focus on determining the extent of FDs based on either temporal food availability (when people access grocery stores) or geographic food availability (radial distance to grocery stores). However, food access also depends on regional mobility, resident behavior, and resident demographics. The study proposes a hybrid agent based model and GIS framework to more holistically capture FDs, coupling temporal and geographic food availability, while incorporating mobility and resident demographics. Data from publically available sources are used to determine demographics specific to residents within the FD (e.g., employment rate and car ownership), capture residential behaviors (e.g., method of transportation for grocery trips), and store locations. This framework is demonstrated through introducing disruptions, such as resident's willingness to walk and placement of new grocery stores, convenience stores, or restaurants at two different locations to assess the change in the current level of food access. A FD in Austin, Texas, which is home to approximately 6,500 individuals with a median income of \$31,994, is used as the case study. Food access was improved by 0.5% to 39.3% depending on the distance each resident is willing to walk. Results may inform methods that may increase food access through built environment disruptors that shift (and improve) the status quo of food access.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-152

BIM and PLM: Investigation on the Different Possibilities of Deploying a PLM Platform in the AEC industry

Estelle Grialou
Forgues Daniel
Iordanova Ivanka

Abstract:

Le Building Information Modeling (BIM) et le Product LifeCycle Management (PLM) ont tous deux des objectifs communs en termes de coordination, de travail collaboratif et de contrôle de l'information. Cependant, l'implantation du BIM dans les projets de construction implique de nouvelles méthodes de travail et présente des limitations dues à une mauvaise gestion de l'information dans le secteur, volet encore peu exploré en construction. Les solutions PLM, mises en œuvre depuis plus longtemps, facilitent l'accès à l'information et permettent d'en préserver l'intégrité tout au long du cycle de vie, d'où l'intérêt d'investiguer le potentiel de dériver ou déployer des pratiques ou technologies PLM en construction.

Cet article présente une investigation sur les possibilités de déploiement d'une plateforme PLM en construction à travers deux études de cas. Les résultats permettront de déterminer dans quelle mesure une plateforme peut être utilisée comme fil conducteur de l'information dans les projets de construction.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-154

Multi-Attribute Utility Theory Approach to Value-based Infrastructure Asset Management

Zaid Alyami
Susan Tighe

Abstract:

Several government regulatory bodies mandate agencies to report their Capital Tangible Assets' (CTA) values within their annual statement. For example, the Canadian Public Sector Accounting Board (PSAB), the Governmental Accounting Standard Board (GASB) and the New Zealand International Financial Reporting Standards (NZ IFRS) to name a few. Using asset valuation financial/ accounting methods alone in reporting asset values may result in underestimating asset values. If the underestimated asset values are used as the basis of annual fund allocation, it may result in insufficient funding to preserve assets and therefore impact the overall network performance. Therefore, it is essential to integrate asset value in asset management systems to effectively manage assets while maintaining or enhancing the value of these assets. This paper introduces a Multi-Attribute Utility-Theory and optimization methodology that integrates asset value as a performance measure in infrastructure network-level asset management decision making. A case study using data from Ministry of Transportation Pavement Management System (PMS2) is used to illustrate the proposed methodology.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-155

Quantifying the Risk of Pavement related Foreign Object Damage

Kamran Rafiei
Gary St Michel
Zachary Berglund

Abstract:

Traditional airfield pavement management has its roots with the US Army Construction Engineering Research Laboratories work beginning in the early 1970's that effort being the basis for M.Y. Shahin's 1994 treatise and subsequent development of the MicroPAVER pavement management software. The MicroPAVER methodology does not use quantified measures of user costs as part of its' project selection process. Other asset management techniques are economics based whereby projects are selected based on their economic benefits to users such as the World Bank developed Highway Development and Management (HDM) transport economics based analysis or the US Army Corps of Engineering's "Risk and Reliability Engineering for Major Rehabilitation Studies" risk quantification technique.

The authors have developed a technique whereby the MicroPAVER methodology is used as the airfield pavement capital project identification tool which is then augmented by a quantification of the risk associated with failing to undertake the project. In this case the risk is identified as the probability that a distressed pavement surface will cause Foreign Object Debris Damage (FOD) to aircraft and the cost to air carriers of dealing with this damage. The probability is established based on the number and type of aircraft movements on the project pavement, the size of the surface and the current and predicted FOD index. The probability is calculated under the two alternative courses of action; fund and undertake the pavement rehabilitation project or not. This comparative analysis is conducted for all pavement projects generated by the MicroPAVER process and used to justify capital funding and prioritize the projects.

This paper first discusses the inputs required and the MicroPAVER project selection process. It goes on to describe and apply the risk quantification and project prioritization and selection procedure based on a real life example as implemented at Saskatoon International Airport



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-156

The Impact of Limited Resources on Asset Management and Infrastructure Resilience

Kristal Metro
Susan M. Bogus,
Heather Himmelberger

Abstract:

A lack of resiliency in our aging infrastructure is a problem throughout the United States. For example, the American Society of Civil Engineers grades both water and wastewater infrastructure at a D (poor). In the United States, waterline breaks occur on average of 240,000 times per year; sanitary sewers experience up to 75,000 overflows in the same time frame. Current funding levels are not keeping up with the needs for managing these aging infrastructure assets. This study identifies factors contributing to this lack of infrastructure resiliency, focusing on water and wastewater systems. The contributing factors are ranked and evaluated for recommended improvement. Communities analyzed in this report were previously selected for participation in a U.S. Environmental Protection Agency (EPA) funded program titled Water Community Assistance for Resiliency and Excellence in Drinking Water and Wastewater (WaterCARE). The communities selected for WaterCARE needed assistance developing long term strategies for asset management of their water infrastructure while continuing to provide clean drinking water and wastewater treatment to their residents. To evaluate resilience, Likert-scale questionnaires were distributed to community experts in the WaterCARE communities. Their responses were analyzed using the relative importance index method. Based on the responses received, the factors and groups contributing most to reducing infrastructure resiliency are presented and discussed, and recommendations are made to increase resiliency of aging infrastructure in these communities.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-157

Human-Infrastructure Interactions: Statistical Modeling of Bottled and Filtered Water Use in U.S. Shrinking Cities

Euijin Yang
Kasey Faust

Abstract:

The recent water crisis in Flint, Michigan, has focused a great deal of attention, nationwide, on communities' water infrastructure. The Flint crisis, along with other water infrastructure issues, has impacted how people interact with their water infrastructure—whether they consume water, for example, from the tap or from a bottle. In June 2016, a survey was deployed to the general public to assess public views toward their city's water infrastructure and describe their interactions with it. Individuals surveyed were from 21 shrinking U.S. cities—cities that have experienced chronic urban decline and operate underutilized water infrastructures supported by increased per capita costs. Six survey questions of interest pertain to whether the respondent drank bottled/filtered water, how frequently they did so, and whether they used such water for purposes other than drinking. Results indicate that 75% of respondents drank bottled water and 51% did so frequently. Approximately, 65% drank filtered water, with 42% doing so frequently. For purposes other than drinking—e.g., hair washing, teeth brushing, pet care—29% used bottled water and 32% used filtered water. In explaining their water use behaviors, respondents cited cost, convenience, and water quality concerns. To understand the drivers of these human-infrastructure interactions, the survey questions were statistically modeled to identify geographic and demographic parameters that increased/decreased the likelihood of bottled/filtered water use. Insights that this study provides into the water use behavior of end-users can help decision makers implement sustainable strategies that continually evaluate and incorporate human-water infrastructure interactions.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-161

Measuring the Embodied Energy of Construction Materials through Building Information Modelling

Ahmad Odeh
Ahmad Jrade

Abstract:

Today, researchers are concerned about the calculations of energy at the operational stage, mainly due to its larger environmental contribution, but the fact remains, embodied energies represent a substantial contributor unaccounted for in the overall energy computation method. The calculation of materials' embodied energy during the construction stage is complicated. This is due to the various factors involved. The equipment used, fuel needed, and electricity required for each type of materials varies with location and thus the embodied energy will differ for each project. Moreover, the method used in manufacturing, transporting and putting in place will have significant influence on the materials' embodied energy. This anomaly has made it difficult to calculate or even benchmark the usage of such energies. This paper presents a model aimed at calculating embodied energies based on such variabilities. It presents a systematic approach that uses an efficient method of calculation to provide a new insight for the selection of construction materials. The model is developed in a BIM environment. The quantification of materials' energy is determined over the three main stages of their lifecycle: manufacturing, transporting and placing. The model uses three major databases each of which contains a set of the construction materials that are most commonly used. The first dataset holds information about the energy required to manufacture any type of materials, the second includes information about the energy required for transporting the materials while the third stores information about the energy required by machinery to place the materials in their intended location. Through geospatial data analysis, the model automatically calculates the distances and then uses dataset information for energy computations. The computational sum of all the energies is automatically calculated and then the model provides designers with a list of available construction materials along with their associated embodied energies.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-163

Deep Learning for Building Energy Consumption Prediction

Kadir Amasyali
Nora El-Gohary

Abstract:

In recent years, building energy consumption prediction gained a lot of research attention due to its importance in energy efficiency-related decision making. With the advancements in data analytics and machine learning, there has been numerous studies on developing data-driven building energy consumption prediction models based on support vector machines (SVM), artificial neural networks (ANN), and other statistical regression algorithms. These studies showed that each algorithm has its own advantages and disadvantages for different cases and that, therefore, the algorithms should be selected based on the specific application. However, none of the existing research efforts tested the effectiveness of deep learning – which is shown to outperform other machine learning algorithms in many other fields – in building energy consumption prediction. To address this gap, this paper (1) presents a deep learning-based model to predict cooling energy consumption of a building based on outdoor weather conditions (e.g., outdoor temperature), and (2) compares the prediction performance and computational efficiency of the deep learning-based model against other machine learning and statistical regression-based benchmark models. In order to generate a labelled dataset for training the models, a building was modelled and simulated by EnergyPlus in five locations. The models – the deep learning model as well as the other benchmark models – were trained using the simulation-generated data and the performance was evaluated in terms of accuracy and computational efficiency. The testing results showed that deep learning can be successfully applied to the field of building energy consumption prediction.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-164

Representation and Management of Project's Knowledge – A Linked Data Approach

Pouya Zangeneh
Brenda McCabe
Murray Pearson, Hatch
Nick Mason, Hatch

Abstract:

Engineering companies often have abundance of project data in the forms of reports and tables. As well, they possess valuable expert knowledge that is mainly tacit and suffering from “Expert Retirement”. These valuable resources are not captured, handled, or took advantage from, properly. The advances in computer sciences have significantly changed our interaction with data. More devices getting connected the internet each day. “Sematic Web” has raised as a solution to increase machine readability and interoperability of data using “Linked Data” format and graph data structures. This as well, provided a great environment to capture knowledge with certain branches of ontology engineering and logic. Overall, these concepts made it possible to create powerful and efficient knowledge bases. This paper presents our latest efforts to create a knowledge management and representation system for industrial projects, using ontology engineering, linked data and semantic web concepts.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-165

Comparative Study of University Courses on Construction Safety at Undergraduate Level

Zia Din
Rahimi A. Rahman
G. Edward Gibson

Abstract:

Worker safety is a critical success factor in today's construction projects. Workplace safety plays an important role in the on-time delivery of projects, and it also translates into whether the project participants will earn a profit on investment. More often than not, the majority of today's construction projects encounter events that compromise workers' safety. A key to creating and maintaining a safe workplace is providing effective safety education or training to workers including to those who are responsible for making decisions on a project such as safety managers, construction managers, and supervisors. Despite the emphasis on safety education of workers, safety performance in the construction industry is far from satisfactory. Therefore, there is a need to analyze the content of the safety courses to evaluate their relevance to the major safety challenges faced by the construction industry. In determining what recommendations might be reasonable in establishing construction safety course contents, one area to be examined is what construction safety content is being taught in universities. In this examination, the authors approached the question in two ways. First, they analyze construction safety syllabi from universities in the United States. Second, they set the baseline using the most frequently cited serious violations data over the period of five years as well as Focus Four hazards in construction. Then the content of the safety courses was compared with baseline data. While examining construction safety courses offered at the undergraduate level in construction programs, we found that the contents of the courses were inconsistent. In light of these differences, a growing need has emerged for guidelines for construction safety education, a common foundation from which construction safety education syllabi is enriched. Data obtained from the study provided a basis for recommendations to academia about potential changes which would bridge the gap between construction.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-168

Managing Wastewater During Refugee Crisis - Comparing the Lessons Learned from Finland and Jordan

Heta Kosonen
Heidi Gough
Amy Kim

Abstract:

The civil war in Syria has caused the displacement of an estimated 11.7 million people, of which over 5 million are seeking asylum or protection abroad. While the large-scale movement has been mainly directed towards the bordering countries, such as Jordan, Lebanon and Turkey, in summer 2015, the number of people seeking for asylum in the EU exploded unexpectedly. This presentation discusses the wastewater infrastructure management challenges associated with large-scale population displacement. Technical challenges are derived from first-responder experiences in two different countries hosting refugee populations. The discussed data consists of 19 expert interviews and field observations that were conducted in Jordan and Finland in 2016. All interviewees were directly involved in wastewater treatment plant re-construction and operation. Preliminary research findings showed that understanding of steady-state practices in wastewater management did not prepare stakeholders for emergency response activities. Refugee response was effective when stakeholders felt comfortable providing improvised solutions, stakeholder role division was clear, and decision makers were personally motivated to solve problems related to environmental protection and humanitarian aid provision.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-169

A Data Analytics Solution for Predicting the Pavement Condition Index of Roads using the Most Affordable Attributes

Sayed Madeh Pirayonesi
Tamer El-Diraby

Abstract:

The process of road condition assessment is costly and laborious. Many small municipalities have no sufficient financial resources to collect the distress data for their road network. On the other hand, larger municipalities cannot collect distress data for their entire road network due to the gigantic size of networks and limited budgets. Data analytics could be an efficient solution to this problem. Most municipalities already have collected some data as a part of their asset management program. This data could be utilized to learn models for predicting the condition of roads in the future. In this paper a decision tree is learned to predict the variations in the pavement condition index (PCI) of asphalt roads under no maintenance. The predictive attributes which were selected for model learning are as follows. The current condition of road, annual freeze index, total annual precipitation, annual average of minimum temperature, the functional class of road, pavement type, annual average of maximum temperature and the age of road. These attributes were chosen after interviewing asset management experts and also reviewing the asset management plans of ten small municipalities in Ontario and their data. The cost of data collection was one of the main considerations for selecting these predictive attributes. The machine learning model was learned based on the data retrieved from the Long-Term Pavement Performance (LTPP) database. The developed model successfully predicted the deterioration in the PCI of asphalt roads after three years.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-171

Barriers and Incentives for Affordable Green Building Construction in California

Ali Arabshahi
Reza Akhavian
Cristian Gaedicke

Abstract:

Concerns over the energy consumption and environmental impact of the built environment have been growing recently more than ever. The State of California and its local government and agencies make every effort to set rules and regulations to curtail depletion of resources and promote efficient construction and facility management. Policy efforts to deal with these issues have mainly focused on sustainable design, green technologies, renewable energy, and increased efficiency in energy and water use. Previous studies that focus on the State of California green building policies have used empirical data and information extracted from secondary sources such as comparison of conventional and green building approaches, barriers to green building, utilities savings per square foot, and incentives. This paper discusses the barriers and incentives that affect affordable green housing construction in California. An online survey consisting of 12 questions was sent to a broad range of subject matter experts such as architects, civil engineers, project managers, contractors, faculty members, interior designers, and real estate agents. Out of the 75 respondents, 76% have more than 10 and 17.3% have between 5 to 10 years of experience. Also, 76% have been engaged in planning or construction of green buildings. Analysis of results encompassing different answering methods (e.g. multiple choice and Likert scale) presents strong indicators about the barriers and enablers of green building in California. For example, the majority of respondents believe that lack of interests from clients and higher investment costs are the main barriers to the rapid growth of the green building. Also, tax incentives and fee subsidization are identified as the most important enablers. Considering the fact that California is in the frontline of sustainability and energy efficiency policy development, results of this study are valuable to researchers and decision makers in other states and scalable to the federal level.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-173

Decision Making for the Construction of Cycling Infrastructure through Predicting Usage

Siroos Shahriari
Farnaz Sadeghpour

Abstract:

Cycling has gained an increasing attention among both researchers and municipalities in the last two decades as a sustainable alternative to car-based transportation. However, when it comes to decision making, there is a debate on whether investing on cycling infrastructure would be cost beneficial. This debate is particularly pronounced in cities with cold climate such as most Canadian cities since it is assumed that the cycling infrastructure will remain unused for the main part of the year. Furthermore, when deciding to build or extend cycling infrastructure, the question of where to build to get the most usage rises. This paper presents a portion of a larger study the overall goal of which is to predict usage for a proposed cycling infrastructure in cities with cold climate. Studies have shown that several factors such as Cyclists' Demographics, Attitudes toward Cycling, Built Environment, Infrastructure Quality and Weather Condition affect cycling frequency. This paper focuses on a subset of variables from the first two factors, referred to as Cyclist Characteristics, on cycling frequency. The objective of this paper is to identify the characteristics that impact the frequency of cycling and infrastructure usage, and to determine the magnitude of their impact. An intercept survey with a purposive sample of winter cyclists in Calgary is used. A regression model is developed to identify the characteristics with statistically significant impact on cycling frequency. Eventually, it is examined to what extent the examined Cyclist Characteristics are accountable for predicting cycling frequency. The findings of the study presented in this paper will be used in developing a complete model that incorporates all variables affecting cycling frequency. When developed, the complete model can help planners and decision makers in municipalities to identify the best locations for constructing and expanding on cycling infrastructure within a city with cold climate.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-175

Risk Assessment in Fast-Track Construction Projects: A Conceptual Model

Claudia Garrido Martins
Vanessa Valentin
Susan M. Bogus

Abstract:

Construction projects play a major role in the economy of a country and they are also recognized as the most exposed to risks and uncertainty. Despite the complexity of engineering problems in a construction project, a constant pressure is placed on managing the duration of the projects while meeting regulatory obligations, emergency/disaster recovery, and time-to-market limitations. Under this scenario, traditional construction schedules can be compressed through schedule crashing or activity overlapping. Projects that apply activity overlapping are called fast-track projects. However, risks resulting from activity overlapping can affect the project duration and compromise the fast-track strategy. In this study, we analyze the overall duration of a fast-track construction project subjected to various risks arising from different levels of overlapping. A conceptual computer model was developed using a Monte Carlo simulation to apply different levels of overlapping for each activity in a sample schedule. The simulation includes risk factors defined as risk probability and schedule impact for each level of overlapping. The output of the model includes: the probability of attaining the desired fast-track project duration under different risk scenarios, the most probable duration of the project, the optimal level of overlapping for each activity, the most significant risks, and the activities most affected by the risks. The results can assist decision-makers with information to understand how overlapping levels and project risks affect the expected project duration and what risks must be mitigated to avoid the threat of delays to the project duration.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-177

Automated Construction Materials Data Acquisition using Digital Imaging and RFID

Farzaneh Golkhoo
Osama Moselhi

Abstract:

Recent researches in the construction materials management demonstrates an obvious negligence towards the interconnectivity of real-time data acquisition technologies and measuring material consumption rate on daily basis. This research aims to calculate the real-time consumption rate of materials using digital imaging and RFID technologies. Construction materials are classified in “Tagged materials and Bulk materials”, then based on materials nature, ease of use, related expenses, and applicability, digital imaging and RFID technologies are applied to measure the consumption rate of bulk and tagged materials respectively. Change detection method in 2D images and also in 3D structure of an under-constructing element from multi-view images captured by a camera at consecutive days is applied to calculate the bulk material consumption. Calculation the amount of installed tagged materials is addressed using RFID as a novel activity-based progress tracking method. The results shows that the proposed method can be applied practically in the construction projects and influence positively not only on the efficiency of construction materials management but also on the construction project cost and schedule, claim settlement and ease of project progress tracking.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-178

Cross-Asset Management for Transportation Infrastructure Systems

Zaid Alyami
Seyedata Nahidi
Cristina Torres-Machi
Susan Tighe

Abstract:

Transportation Infrastructure Systems are pillars for society development and growth. The challenge of fund limitation, aging and deteriorating infrastructure, higher loading demand, increases the mandate for implementing effective asset management to manage transportation infrastructure assets cost effectively at acceptable levels of service. Pavement Management System (PMS), Bridge Management System (BIM) have existed for several years. However, these systems are often operated separately. Agencies are faced with the challenge of fund allocation and the trade-off between assets; for example, allocating funds for bridge rehabilitation or pavement rehabilitation while deferring the other. Therefore, there is a need for a decision support system that cost-effectively optimizes the trade- of between systems' components. On the other hand, there is a unique advantage in cross-asset optimization in that cost saving can be generated through bundling of asset components by location for maintenance and rehabilitation. In essence, cross-asset management provides opportunities to reduce procurement cost, user delay, and interruption. This paper presents a cross-asset management methodology using hazard and survival model. A case study is presented to demonstrate the proposed methodology.



CON-181

Smart Disaster Management System for Tall Buildings

Seyedfarid Mirahadi
Brenda McCabe
Arash Shahi

Abstract:

The recent trend of movement and impetus towards realization of smart cities and smart multi-purpose complexes calls for more efficient and safer disaster management systems. Elevator, as the main tool of vertical transportation in high-rise buildings, can potentially propel the advancements towards more competent disaster management systems. Dispatch algorithm of the elevator is the dominant factor that determines how smart and efficient the elevator could perform. With recent innovative research on checking the possibility of elevator use for emergency evacuation, the importance of having an expert control system, which would provide a faster and a safer evacuation program, has been observed. In this paper, first the importance and feasibility of using Occupant Evacuation Elevators (OEEs) are reviewed. Then, a Smart Disaster Management System (SDMS) is proposed. The main purpose of this system is to simulate all the possible scenarios of emergency in the building and then, through the decision-making capability of the system, select the fastest and safest strategy of egress. To this end, an Agent-Based Modeling (ABM) unit is connected to an Artificial Intelligent (AI) unit to build a thinking engine for the proposed model. Overall, the paper shows how recent technologic advancements can be incorporated in order to form a smart disaster management system.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-182

A Framework for an Integrated BIM-GIS Decision Support Model for Site Layout Planning

Ahmad Alsaggaf
Ahmad Jrade

Abstract:

Site layout planning (SLP) is an essential step for an efficient and safe construction environment. A well-designed construction site helps in increasing the productivity and safety of construction operations and in reducing the project's cost and duration. The main purpose of SLP is to manage available spaces on the construction site and to select appropriate locations for the temporary facilities (TF) by considering all the constraints between TFs and PFs (permanent facilities). Previously developed models vary in their scopes, objectives and approaches in order to provide efficient solutions to the existing problems due to the complexity that is included in the SLP process. This paper proposes a framework to develop a model for site layout planning that integrates Building information modeling (BIM) and Geographic information system (GIS). The proposed model will assist practitioners in planning and design a safer and conflict-free construction site in an attempt to provide comprehensive, flexible, and practical solutions that are not covered in the existing models. The model consists of five modules: a 3D modeling module that links BIM and GIS tools; a scheduling module that automatically calculates the durations of the TFs based on project's activities; a temporary facility library (TFL) pertaining the physical and functional attributes and constraints in a geodatabase; a 4D modeling module that shows the progress of construction and of placing the TFs; and a time-space conflict (TSC) module that uses detection tool to forecast conflicts and clashes so that the layout of the site is adjusted accordingly until no conflict is detected. The successful development of the model would partially fill the needs of the AEC industry to achieve more accurate and reliable solutions to the SLP issues.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-185

Effectiveness of Applying a Behavior-Based Safety Program in Industrial Modular Construction.

Estacio Pereira
Xingzhou Guo
Meimanat Soleimanifar
Ming Fung Francis Siu
Vawn Jeddryr
Simaan AbouRizk

Abstract:

Behavior-based safety (BBS) management programs aim to reduce the occurrence of accidents by preventing unsafe behaviors through observation and intervention. Although these programs are supported throughout safety management literature and are commonly applied in industry, the impact of implementing BBS programs on industrial modular construction worksites remains relatively unexplored. This research proposes a data-driven framework that can be used by companies to determine if the (i) implementation of a BBS program improves company safety performance, (ii) adoption rate of a safety program correlates with safety performance, and (iii) information collected by a safety program can identify proactive indicators of accident prevention. The proposed method was used to examine the effect of BBS implementation on safety performance at a case company. A BBS program, requiring workers to complete daily, anonymous risk reviews of their peers, was implemented at an industrial-construction company in Alberta, Canada. Data, collected from BBS cards and incident reports, were extracted, queried, and cleaned from the company's safety management systems. Implementation of the BBS management program significantly reduced incident rates, the filling rate of BBS cards was found to inversely correlate with total incident rates, and certain safety categories in the BBS cards were identified as proactive indicators of safety performance. Altogether, these results suggest that—to maintain low accident rates and to improve BBS program effectiveness—the present company should emphasize the completion of BBS cards and the assessment of certain proactive safety indicators prior to the delivery of certain industrial operations.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-186

Comparative Study of Unifomat and Masterformat for Construction Cost Estimating

Ming Lu
Tarequl Hasan
Monjurul Hasan

Abstract:

Cost estimating is the core functionality of project planning pertaining to all the stakeholders in developing a project. UniFormat (UF) and MasterFormat (MF) are two commonly used project breakdown standards for guiding construction cost estimating throughout different stages of the project lifecycle. This study aims to develop a systematic framework to assist in applying UF and MF in estimating processes starting from conceptual planning to detailed estimating the framework defines the application spaces of UF and MF and establishes the correlation between these two systems, which is conducive to estimating project costs without tediously building and altering project work breakdown structures (WBS). The framework's central concept is to take advantage of the WBS embedded in UF and the structured RS Means data to formalize the project preliminary WBS, thereby easing the search for MF items; at the same time minimal changes are required to develop the final project WBS. A simple garage project is used as a demonstration case to apply the proposed framework.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-188

Risk Reduction in Transportation Public-Private-Partnership (P3) Project Delivery through Integrated Quality Management

Venkata Vemana
Smitha Koduru

Abstract:

P3 project model has gained wide acceptance for transportation infrastructure projects, such as bridges, highways, light rail and airports. In Canada, public sector has encouraged P3 model due to the ability to transfer the risk of asset life-cycle costs to the private sector. The essential feature of P3 model is that the project specifications are defined by the public sector entity in terms of the performance objectives over the life cycle of the asset. With this model, the risk due to design, construction, financing and operations is typically assumed by the private sector partner. Shortcomings in design and construction phases result in a greater risk transfer to the operations phase of the project.

As the specifications in a P3 model are performance-based, the success of the project is highly dependent on demonstrating that the performance objectives have been met. The Quality Management System (QMS) established within the project determines the forms of the evidence to be produced during design, construction, and operational stages of the project to ensure that the project specifications have been met throughout the life-cycle of the asset. A well-designed QMS will ensure mitigation of hidden risk transfer between different project phases and project partners, and efficiency gains in cost and schedule.

This paper provides a framework for an integrated quality management system that ensures risk reduction during design and construction phases in P3 projects. The implementation of this system and the efficiencies gained due to the process are demonstrated through the case study of North-East Anthony Henday Drive (NEAHD) Project in Edmonton. NEAHD Project consisted of 27-kilometer highway construction and 47 bridge structures with the total cost of up to two billion dollars. This paper describes the effectiveness of the QMS in reducing the long-term risks and maintaining quality while minimizing the schedule impact.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-190

Investigating BIM's Potential to Proactively Address Project Delivery Issues

Achintya S. Bhat
Erik Poirier
Sheryl Staub

Abstract:

BIM has yet to be widely accepted by all stakeholders in Architecture, Engineering Construction and Operations industry, even though, there has been increasing investigation of its benefits. Amongst other project performance indicators, prior research has found that the use of BIM leads to a reduction of construction related issues which is measured by a reduction of project related communications, such as requests for information (RFI), change order and site instructions, as one of the significant benefits of BIM. While this may be true, there still lacks an understanding as to what types of issues are being addressed through BIM and to a certain extent, whether or not that the number of construction related communications is actually a valid measure of successful BIM use. The objective of this paper is to investigate the nature and types of issues that arise and are documented during the design and construction phases of a project in order to better understand the impact of BIM on project delivery. The research project involved the case study of a large institutional building project and entailed the analysis of more than 1400 construction communication documents. A theoretical framework was first developed to characterize the issues and to relate them back to BIM. The reasons underlying each of these issues were then characterized to explore the various possibilities of how BIM could have been implemented differently to better serve the project delivery team. Analysis based on the developed framework, uncovered that the most prevalent root cause of issues on the project studied was location, i.e., position or orientation of a component in the model which led to design revisions. Potential enhancements to how BIM could have been used to curtail these project delivery issues were then identified.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-193

Storage Tank Foundation Reinforcement During Construction

Jason Warners
Geoff Ballard

Abstract:

Aging infrastructure and requirements for additional capacity required an existing 30 m diameter tank be replaced with a 55 m diameter tank in an area of Regina with significant foundation design challenges. The tank was to be founded on high plastic clay ranging in thickness from 6 m to 12 m, underlain by a silt and sand aquifer with local restrictions limiting the depth of development to 6 m below surface. Based on these restrictions it was proposed to support the tank on a gravel ringwall foundation. Foundation plans and records were not available for the existing tank; during demolition, it was discovered that the existing tank was founded on piles. The piles were cut-off 3.5 m below surface and backfilled with material from stockpiles within the terminal. The material had questionable properties for support of the tank due to construction debris and variable moisture contents and densities of the material. Due to concerns regarding the ability of these soils to support the original design, a cone penetration testing (CPT) program was completed to gather additional information and compare the properties of undisturbed material and the material within the foundation backfill zone. Proof-rolling was also completed to identify localized soft spots.

The design team needed to ensure that the tank foundation performed as originally designed with minimal changes to the overall design. A cellular confinement system and layers of geogrid were added into the design of the ringwall to increase the bearing resistance and reduce the potential for significant differential settlements. The addition of reinforcement within the foundation and underlying soils allowed the overall design to perform as originally proposed – verified with hydrostatic testing settlements correlating with original design predictions – and construction to progress with minimal removal of the pile backfill material.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-194

A Major Transportation Project: A Case Study on the Implementation of a Sustainable Rating System for a Vancouver Municipality

Tiffany Kirk
Thomas Froese
Cheryl Nelms
Jimmy Zammar

Abstract:

In the past decade, numerous sustainable rating systems have been developed for large infrastructure projects. These systems facilitate the incorporation of sustainable practices throughout the entirety of a project and are commonly utilized in the execution of projects globally. Despite the systems prevalence in international projects, there is only one large infrastructure project in the Greater Vancouver Regional District (GVRD) that has achieved a full rating system certification. This paper aims to establish what went well and what did not during the inclusion of the rating system, Envision, for a specific project. The main objectives are to conduct a case study detailing the inclusion of Envision for a transportation project and highlight the challenges and success in the decision-making process. The methods adopted in this case study first involve a literature review of decision-method frameworks and lesson learned case studies for the inclusion of Envision. The second method involves a series of interviews with key project personnel to determine challenges in selecting a rating system certification. The deliverables are presented in a rating system comparison table and a summary of lessons learned table based on the Project Management Book of Knowledge (PMBOK) knowledge management areas. The results are validated by municipal officials who critiqued the lessons learned usability for future discussions about the inclusion Envision at the Request for Qualifications (RFQ) stage the project. Future Project Teams can use the concluded lessons learned to develop potential risk registers for using Envision for other municipal projects.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-195

Simulation-Based Contingency Estimating for Helical Pile Installation

Chaojue Yi
Baocheng Li
Chaoyu Zheng
Ming Lu

Abstract:

An Excel based simulation tool was developed to guide the preparation of bid proposals on helical pile foundation projects featuring a high degree of uncertainty. This simulation tool was designed based on a systematic methodology which integrates project information generally available at the bidding stage, i.e. engineering design, subsurface conditions and site layout plans; and synchronizes takeoff, estimating, scheduling and risk analysis. The methodology behind the simulation tool is described in this paper, which effectively decomposes the whole helical pile installation project into sufficient installation work packages. The tool automatically generates cumulative distribution function graphs indicating the estimated ranges of total project duration and total bid price. The simulation report presents the anticipated bid price and project schedule, plus the contingency estimate at a certain confidence level. The proposed methodology is effective to lend direct decision support for helical pile contractors in preparing bidding proposal and estimating contingency.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-198

Locational and Demographic Drivers of Perceived Water Conservation Efforts in Austin, Texas

Khalid Osman
Kasey Faust

Abstract:

In response to the number of droughts increasing with frequency and severity, Texas cities have attempted to reduce water consumption. These efforts include placing water restrictions, such as restaurants serving tap water without customer request and incentivizing decreased household consumption. Many conservation habits are self-imposed (e.g., using low-flow appliances) in addition to citywide restrictions (e.g., limiting outdoor water use). This study seeks to assess the drivers leading to perceived conservation efforts in Austin, Texas. In August 2016, a survey was deployed to the general public to understand water use behavior and perceptions towards water infrastructure. Of interest to this study are questions pertaining to (1) individual water conservation efforts and (2) methods used to conserve water. Survey results from over 400 respondents indicate that 86% of respondents stated that they actively attempt to conserve water. Statistical modeling was used to identify the locational and demographic parameters that increase or decrease the likelihood of perceiving if one conserves water. Modeling the zip codes as locational parameters provides insight into the geographic variability of perceived water use behavior and the identification of possible local influences. Accompanying the statistical analysis is a qualitative analysis of how individuals attempt to conserve water. Study results may inform water providers with influential parameters that are more likely to affect perceived water use behaviors and methods adopted to conserve within the household scale. Furthermore, this information may allow for tailoring outreach efforts that encourage conservation.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-199

Examination of Transportation Program Delivery: Preliminary Analysis

Anushree Upare
Dan Tran

Abstract:

Transportation programming is a process of developing and improving transit facilities using innovation and technology. Transportation programs are often developed with a vision that these facilities sustain and serve for a longer period. Delivering projects on time and within budget, distributing funding effectively, and managing resources are typical driving forces for program delivery. While a number of project delivery options are available for transportation agencies to choose to deliver their transportation projects, there is a lack of research that documents how to implement a variety of project delivery methods including design-bid-build (DBB), design-build (DB) and construction manager/general contractor (CM/GC) for a transportation program. Each delivery method has certain performance opportunities in terms of cost, schedule, quality, risk management, and other performance metrics. Developing an effective strategic plan by incorporating these diverse delivery options is critical to the success of program delivery. This paper documents the state of practice in strategic program delivery based on a rigorous literature review, survey questionnaires, and a content analysis of research reports, guidelines, and manual relevant to program delivery from 13 experienced highway agencies in the United States. The results show that the most significant benefits of the strategic approach to transportation program delivery are accelerated delivery, flexibility in innovation, and flexibility in reassessing and reassigning risk. The major challenges of using a strategic approach to program delivery include staffing capacities, cultural barriers, and required organizational changes. The results of this study will provide for practitioners and professionals with proactive measures and guidance on successfully delivering their transportation programs.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-202

Experimental Field Study on Energy Comparison of Three Space Heating Systems

Alula Assefa
Fitsum Tariku

Abstract:

The energy consumption of indoor conditioning systems such as space heating systems directly affects building performance. However, there are various systems available that provide space heating; there are limited comparative studies about their relative energy consumption. That is one of the necessary information needed in making system selection to achieve a high-performance building. This research compares the energy performance of three major space heating systems including a heat pump, forced air heating, and electrical radiator heater. Two full-scale experimental test buildings were used to conduct the research in which two of the space heating systems simultaneously run at a time. The result indicates that heat pump outperforms both electrical radiator heater and forced air system by consuming less energy around 25% and 90% respectively. Whereas, the Forced air system consumes over 70% energy than electrical radiator heater. The outcome of this study presents the relative performance of the heating system, which in turn could be useful for industry in the process of system selection.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-203

Local Wind Model in New York City

Elham Azimi
Fletcher Griffis

Abstract:

According to insurance companies, 70–80 % of economic losses due to natural disasters in the world are caused by extreme winds and related water hazards. Wind behavior assessment in vulnerable areas can mitigate the following damages due to the wind. This study introduces a methodology to specify local wind pattern as a function of location in New York City. A variety of methods can be used to obtain localized wind. These include codes of practice, full-scale, wind tunnel or Computational Fluid Dynamics (CFD) studies. Each of these has their advantages and disadvantages.

Due to the considerable numbers of buildings under-study, codes evaluation was selected. The methodology for determining regional wind speeds and wind multipliers from major wind loading standards, focusing on Minimum Design Loads for Buildings and Other Structures from the American Society of Civil Engineers/ Structural Engineering Institute (7-10) and the Australian Wind Loading Standard AS/NZS 1170.2 (2011) is discussed in this research. Finally, it provides the wind pattern for New York City calculated using the different wind multipliers.

Wind multipliers/coefficients can be considered the basis of local wind determination; without them, the local wind would be meaningless. They convert the national scale wind to the local level by incorporating the effects of direction, height and terrain, topography and shielding. Combining these effects can describe the site wind speed in any location.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-205

A Comparative Life Cycle Assessment of Tall Buildings with Alternative Structural Systems: Wood vs. Concrete

Maryam Abolghassem Tehrani
Thomas Froese

Abstract:

Life cycle assessment (LCA) has been a useful decision making tool in sustainable building design, construction and building material selection. One of the main benefits of using LCA in early stages of any construction project is that it allows to quantify and compare the environmental impacts of the building using two different material alternatives. This comparison can facilitate decision makers to identify the most suitable material for their project. The objective of this paper is to make a comparison between two different construction technologies, wood and concrete through Life Cycle Assessment methods to understand the environmental benefits and drawbacks of each technology in terms of 9 impact categories. Two 18 storey residential buildings in Vancouver, Canada were considered for this study; a traditional cast in place concrete frame building and a mass timber hybrid design using glulam and CLT. The scope of this study was limited to assessment of foundations, structures, floors, columns, beams, and roofs. Floor plans, elevation views and material quantities were obtained from construction drawings and inputted into an LCA software (Athena's Impact Estimator) to obtain the two building's cradle to grave life cycle assessment. The results will indicate in each of the 9 impact categories which building has lower environmental impacts and in which stage of its life cycle the impact corresponds to most significantly. This study along with future project life cycle costing analysis will help decision makers in making tradeoff decisions between a project's environmental impact and cost.



CON-207

Geotechnical Risk Management in Design-Build Infrastructure Projects - A Case Study on Seismic Risks

Ziyad A. Elkhatib
Ricardo M. Tapia-Pereira
Ghada Gad
Douglas Gransberg

Abstract:

The Design-Build project delivery method has proven to speed the construction process of infrastructure projects since it permits construction to commence prior to the full completion of the design. Among the many risks entailed on DB projects, geotechnical risks play one of the major roles. This is because geotechnical engineers manage risks at a time when Design Builders are expected to speed the project delivery. A common issue in the planning stage in DB projects is the amount of subsurface exploration and laboratory testing the owner needs to perform before issuance of the Request for Proposal (RFP). Therefore, there is a need to identify the current effective practices being employed to deliver DB projects while managing geotechnical risks. The objective of this study is to present how geotechnical risks (specifically seismic risks) are assessed and managed in DB infrastructure projects prior to contract award; providing recommendations for agencies to best manage seismic geotechnical risks. To achieve this objective, the methodology adopted involved three steps: (1) a review of literature of how geotechnical risks are handled in DB projects, (2) a case study of two projects subject to high seismic geotechnical risks (the California Department of Transportation “I-15/I-215 Interchange Improvements-Devore” Project and the South Carolina Department of Transportation “Port Access Road” Project), and (3) a comparison between the two projects, including suggested recommendations. The case studies incorporated semi-structured interviews with each project’s team, job site visits, and content analysis of the both projects’ documents. Based on the data collected, the study recommends specific risk mitigation measures to be conducted by agencies prior to issuance of the RFP, including increasing the amount of preliminary subsurface exploration and studies by the owner, specifically pertinent to seismic risks.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-209

Influence of Geographical Location on the Optimum Insulation Thickness

Christopher Palimaka
Thomas Froese
Belgin Terim Cavka

Abstract:

The commercial and residential buildings are largely responsible for emission of greenhouse gases, which greatly promotes the global warming. Sustainable construction seems to be a partial solution to this problem, as insulated building envelope can save up to 77% of consumed energy, hence limiting GHG emission. However, to make a real difference, sustainable construction have to become more affordable, thus more attractive to the general public. Therefore, finding optimum between the initial and operational cost of the building can be beneficial not only for the environment but also one's finances. The objective of this project is to determine the trade-off between insulation cost and life cycle energy cost for the building situated in three different provinces of Canada. This study will utilize the 3D BIM model of single family house constructed by AYO Smart Home Inc. on Vancouver campus of the University of British Columbia. Revit and Green Building Studio will be used to run the energy simulation. Simulations will be done for the AYO smart home insulated with expanded polystyrene (EPS) ranging in thickness between 3 5/8" to 11 3/8" and located in British Columbia, Alberta and Yukon. Obtained life cycle energy cost for each building location and insulation cost will be used to create the trade-off graphs and to determine the optimal insulation thickness. The eventual aim of this study is to enable AYO Smart Home Inc. with results that will aid decision making regarding design of their building envelope in different regions of Canada.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-213

How Are We Evaluating Building Performance? A Review of Up-To-Date Practices for the iiSBE Level II Protocol

Author(s):

Francisco Calderon

Thomas Froese

Abstract:

Building Performance Evaluation (BPE) is critical in order to validate the development of green and sustainable buildings. In recognition of this, iiSBE Canada, part of an international group committed to advancing the sustainable building agenda across the globe, has initiated a project to develop a BPE Protocol for Post Occupancy Evaluations. Problematically, the development of a BPE Protocol has recognized challenges and the industry is still in an iterative process of testing, learning, and improving. Furthermore, the use of inadequate metrics and procedures can hinder the evaluation process, limiting the potential benefits to society and stakeholders. This paper's objective is to present up-to-date practices of BPE, with a central focus on the collected data. For this purpose, the paper identifies, examines, and compares three tested protocols, with similar objectives and scope to the new iiSBE Protocol. It also reviews case studies that employ these protocols. The main contribution of this paper is the presentation and discussion of eight tables, each one summarizing data collected to describe and evaluate buildings in a different category: building description and characteristics, occupancy and schedules, energy use, water use, thermal comfort, indoor air quality, lighting, and acoustics. The aim of this paper is to assist in the development of the iiSBE Protocol and other BPE efforts, an area where consensus has not been reached and there is still opportunity for improvement.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-214

Severe Weather Preparedness

Cody Bradley
Lloyd Waugh
Jared McGinn

Abstract:

Infrastructure that was built in the 1970s is now approaching the end of its service life and significant investments will be required to avoid service disruptions. Age-based deterioration, combined with an increase in the frequency of severe weather events, has caused numerous culvert washouts in rural Atlantic Canada, leaving residents isolated from essential services. The magnitude of damage caused by severe weather events in the past five years is exacerbated by the scarcity of human resources within the New Brunswick Department of Transportation and Infrastructure (DTI).

The University of New Brunswick Construction and Engineering Management Group (UNB) assessed the capacity of DTI to respond to severe weather events. A framework for assessing capacity was developed from the National Institute of Standards and Technology, and the American Planning Association disaster preparedness guides. The framework includes the identification of people and processes that should be in place prior to a severe weather event. These form a “vision” of a severe weather response scenario.

The “vision” was refined during twelve interviews with key DTI representatives. Opportunities for improvement in capacity were generated by comparing the “vision” to the people and processes that are currently in place for severe weather response. The comparison also identified policies and protocols that the DTI either has in place or would benefit from implementing. Seventeen recommendations were made to improve the DTI's efficiency in responding to severe weather events. The common characteristic of the recommendations is the lack of formality in the DTI's current response to severe weather events.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-215

Sustainable Safety in Labor-Intensive Operations: An Innovative Perspective

Nipesh Pradhananga
Nirajan Mani
Sudip Subedi

Abstract:

Maximizing safety often means operating a construction site at its highest sustainable level of safety. This sustainable level of safety is of major interest for safety managers because knowledge of such level can help them identify areas and opportunities of enhancing safety on the jobsites. Safety strategies and plans are made by the managers based on their perception of such sustainable safety. No formalized method exists to determine such level of safety for a particular construction site. OSHA regulations provide a general guideline but do not consider specific site conditions. The regulations also do not provide insight on what can be done beyond the mandatory requirements to maximize the level of safety and what level of safety can actually be attained and sustained on a site. To address this problem, this paper proposes a novel framework to identify the sustainable level of safety for a given condition at site. The method builds upon a two-way approach in which a theoretical maximum level of safety and observed level of safety govern the sustainable safety at site. The method also intends to explore the inefficiencies at the jobsite and help identify the areas of improvement. The scope of the paper is limited to labor-intensive lifting operation and relies on skeletal data collected by Kinect camera for illustration purposes. The paper outlines the method and the components of the framework and provides an illustration through a lab-based experiment. The method can potentially help the safety managers to improve their strategies based on real data collected from the actual site and set realistic goals for safety management on construction sites. The method can also be implemented to automatically analyze safety and make recommendations based on real-time data collected from the site.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-217

Implementing Intelligent Planning Unit (IPU) Concept for Optimized Electricity Demand Management in the Complex Built Environment

Sayanti Mukhopadhyay
Soojin Yoon
Makarand Hastak

Abstract:

Intelligent Planning Unit (IPU) is a recently developed novel concept that renders the complex built environment system to be more intelligent, helps to standardize the complex physical entities and processes at a modular scale as well as aids in the information collection at different levels of complexity for IPU refinement and control. Such a planning unit can be used to provide accurate and timely information to the responsible decision-makers for better decision-making. In this research, we propose an application to implement the IPU concept for optimizing an intelligent electricity demand management system in a built environment. The built environment related to electricity demand consists of four different categories of end-use consumers: residential, commercial, industrial and transportation. In this context, the individual components that constitute the energy systems in the built environment, e.g., the smart meters, sensors, electric appliances, energy storage equipment, water heating systems, transportation signals, etc., are considered as IPUs. These IPUs can be replicated as well as combined to have composite IPUs that will build up the upper hierarchy of the IPU network. Standardizing the energy system using the IPU strategy within the residential, commercial, industrial and transportation units will ultimately lead to several benefits such as, (a) reduced loss in energy use and optimum energy use; (b) accurate information and better understanding of electricity demand patterns; (c) better electricity adequacy planning; and (d) informed decision making at different levels of the complex built environment system.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-218

Finite Element Model Based on Subspace Fitting Displacement with Damage Localization

Mohamed Bouyahi

Abstract:

A new method is proposed to identify locations and severities of structural damages based on the subspace fitting (SF). Firstly, a reduced discretized analytical model is derived from active displacement. Then, the experimental model is implemented based on knowledge measurement data under stationary and random excitations are developed using pseudo excitation method. To verify the analytical prediction, experiments without feedback control are conducted. Control force based on outputs of sensors. Finally, the Finite Element Model (FEM) updating method is adopted to localize the structural damage which minimizes the difference between analytical and experimental model. Two degrees of freedom (DOF) coupled model are investigated in this paper to analyze the displacement sensor outputs



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-220

Optimizing Construction Productivity and Resources in Building Projects under Uncertainty

Charinee Limsawasd
Nathee Athigakunagorn

Abstract:

Construction duration is always one of a very crucial unknown that every party involved in construction projects attempts to determine. However, with a resource limitation and construction uncertainty, it is intimately impossible to have the least construction duration and have an accurate estimate of construction activities' durations. This leads to an inefficient resource allocation that has a significant impact on a project success. To this end, there is a need of a novel and innovative approach that is able to support an estimation of a construction duration under uncertainty, as well as an optimization of construction productivity and available resources to obtain highest benefits.

This paper aims to present a new application of discrete-event simulation in enhancing a work productivity of a construction activity. The construction process in a high-rise building was selected as an example to demonstrate the proposed framework and its capabilities in efficiently allocating construction resources to reduce an activity duration under uncertainty. The final result is expected to be able to identify the possibility of receiving an anticipated construction activity's productivity under different resource allocation strategies. Moreover, the analysis is expected to illustrate a tradeoff relationship between a construction productivity and allocated resources. This study should prove useful to contractors in applying the concept of discrete-event simulation to support their decision making during resource acquisition and allocation processes.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-227

A Modified Ant Colony Optimization Method for Solving the Single Tower Crane Allocation Problem

Mohamed Abdel-Raheem
Carlos Trevino

Abstract:

Tower cranes are critical equipment in major construction project due to the high dependence on them for material handling, and the high cost associated with their operation. As such, it is very desirable to maximize the efficiency of utilizing tower cranes in different construction operations. To achieve this goal, the problem is formulated as an optimization model with the objective of minimizing the tower crane travel time between supply and demand points. Minimizing the total travel time will in turn lead to reduction in the costs incurred due to transportation of materials. Previous models attempted to optimize the tower crane location using different approaches such as mathematical techniques and evolutionary algorithms (EAs). However, none of the previous studies considered ant colony (ACO) as an optimization tool despite its notable performance in solving the non-linear quadratic assignment problem. This paper presents a modified ant colony optimization (MAC) method and its application to the tower crane allocation problem. A comparison conducted between the performance of EAs used in previous methods, ACO, and MAC in solving the tower crane allocation problem. The results show that MAC outperforms ACO as well as other EAs, and offers significant computing capabilities that can also be used for other optimization problems.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-229

Methodology for Improving the Net Environmental Impacts of New Buildings through Product Recovery Management

Benjamin Sanchez Andrade
Carl Haas

Abstract:

Buildings contribute significantly to the global environmental load caused by human activities. From a life cycle perspective, the building industry is responsible for about 30 per cent of global annual Greenhouse Gas (GHG) emissions and 40 per cent of energy consumption. Several studies have recognized the importance of the End-of-Life (EoL) stage in buildings, and the opportunity of their adaptive reuse as a superior alternative to new buildings in terms of sustainability. Adaptive reuse, identified as a process to improve the financial, environmental and social performance of buildings, involves restoring and in some cases changing the use of existing buildings that are obsolete or are nearing their disuse stage. The aim of this study is to add a Life Cycle Assessment (LCA) perspective to the decision-making methodology for adaptive reuse in buildings. LCA accounts for the materials and energy involved in a product and then measures the associated environmental impacts along all of its life stages. The proposed methodology focuses on the LCA of the subsystems of a building and on specific classes of assets relevant to the construction industry in North America. Through a case study named “Region of Waterloo County Courthouse Renovations”, the environmental savings due to adaptive reuse per subsystem is demonstrated. A detailed consequential substitution LCA was performed in order to quantitatively demonstrate the relevance of each building component, as well as their influence on the net environmental impact due to adaptive reuse. In the end, some of the environmental savings were monetized and evaluated with respect to the natural resources of the emplacement of the building.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-230

Adoption of Computer Aided Facilities Management (CAFM) to Improve Service Quality

Mohamed El Deeb
Ali Montaser
Ibrahim Abd El-Rashid
Walid Abdelal

Abstract:

The complexities of service delivery in Facilities Management (FM) necessitates efficient tools to be up to the challenge. One of the significant elements in evaluating FM service quality is the Service Response Time (SRT), as improving it leads to better customer relationship. This requires integrating Computer-Aided Facilities Management (CAFM) tools to facilitate processing and data logging, which minimizes the SRT. This paper presents a model for measuring the improvement in SRT due to applying a CAFM system. The model calculates the average SRT from CAFM system's logs using request's start time and close time. Then, it uses the request priority as the criteria for grouping requests, after which the average SRT was calculated and compared to the average SRT before applying a CAFM system. A case study was utilized as the model's data source with two main data sets and each data set contains requests' priorities, start time and close time. One set is the log of year 2013 before implementing the CAFM system with 1,464 sample points. While the other is for year 2014 after utilizing a CAFM system with 3,134 sample points. The results obtained quantify the improvement in service delivery for the year 2014 after adopting a CAFM system.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-233

Analysis of Utility Coordination Impact on Projects Delivered Using Alternative Contracting Methods

Douglas Gransberg
Dominique Pittenger
Gary Chambers

Abstract:

Third party issues are known to create both cost and schedule risk on urban transportation projects where public rights of way are shared by utilities and other stakeholders. The potential negative impact of those risks on project performance increases as public agencies attempt to accelerate delivery schedules using alternative contracting methods (ACM) like Design-build (DB), Construction Management/General Contractor (CMGC), Alternative Technical Concepts (ATC) and Public Private Partnerships (P3). This paper reports the result of a survey of 30 US state departments of transportation aimed at benchmarking the state-of-the-practice of utility coordination on ACM projects, and a content analysis of 77 ACM project solicitation documents worth more than \$17 billion from 27 states. The paper uses Important Index Theory to objectively determine the relationship between utility coordination tasks and their effectiveness in the four previously mentioned ACMs. It finds that there is a strong correlation between specific utility coordination tasks and specific ACMs. For example, a requirement to implement subsurface utility engineering (SUE) to locate utilities is found to be most successful when applied with CMGC project delivery. The paper's contribution is twofold. First, an objective ranking of ACM project utility coordination tasks is determined that can be used as a checklist for planning the utility coordination aspects of ACM project, and secondly, a set of recommended guidelines for selecting the appropriate ACM based on specific project utility requirements is proposed.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-235

Energy Storage and Microgrid Construction Education

David Riley
Parhum Delgoshaei

Abstract:

Energy storage and microgrid (ESM) systems introduce capabilities to dramatically improve the resiliency and efficiency of electrical grids as well as enable the introduction of renewable energy systems to new and existing power distribution infrastructure. Multiple market forces have converged to enable the feasibility of ESM construction in many regions of the world. These forces include dramatic drops in the cost of solar photovoltaics and energy storage; regional shifts in the availability of low-cost natural gas; increased interest in resiliency among utilities and facility owners; and emerging capabilities among developers, builders, and finance professionals to conceive, design, finance, build, and operate ESM systems. The development and construction of ESM projects require significant levels of innovation, endurance, and responsiveness to project specific conditions. Collaborative and integrative methods have emerged as critical process management methods that facilitate the planning, construction, and operation of energy storage and microgrid projects. These unique challenges of ESM project also require specialty skills and capabilities across project developers, managers, engineers, and skilled workforce. This paper presents the patterns emerging from multiple microgrid development projects and an integrative approach to building capacity to pursue and execute ESM projects among utility professionals, development teams, and electrical construction project managers. Lessons learned in the design, construction, and operation of a living laboratory for ESM system research and education are presented. Experiences gained through the development of a hybrid microgrid system including combined heat and power, solar photovoltaics, and multiple types of battery energy storage systems are also included. The implications of ESM system growth on a global scale are also discussed, including the need for integrative research and education programs at regional levels to support the growth of ESM markets and system deployment.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-240

Proposed Framework for the use of Energy Simulation Tools in an Integrated Design Process

Alexandre Daoust
Forgues Daniel
Danielle Monfet

Abstract:

Le processus de conception intégrée (PCI) est une approche reconnue supportant la conception de bâtiments visant une meilleure performance énergétique. Ce processus bonifie la collaboration au sein de l'équipe de conception et favorise l'élaboration de stratégies énergétiques complexes. Néanmoins, il est observé dans la pratique québécoise que les outils de simulation énergétique sont peu utilisés, et ce de façon tardive dans le processus de conception. Dès les phases initiales du PCI, des extrants quantifiables issus de la simulation énergétique devraient permettre la comparaison de scénarios afin d'élaborer des stratégies énergétiques. Il n'existe pas de recherche proposant un cadre appliqué au PCI et qui intègre l'utilisation d'outils de simulation au cours du processus. Cet article a pour objectif de proposer un cadre qui définit l'utilisation d'outils de simulation énergétique des bâtiments au sein d'un PCI. Ce cadre s'appuie à la fois sur des pratiques documentées dans la littérature et d'observations réalisées sur des projets réels en PCI. Il y est décrit un processus facilitant la prise de décisions collaboratives par l'utilisation de scénarios de comparaisons issues de la simulation énergétique au sein d'un PCI. Une étape d'itération et de validation a été effectuée par une expérimentation du cadre proposé au sein d'un groupe académique. La mise en application de ce cadre pourrait avoir comme retombées des choix plus judicieux dans l'analyse des options pour améliorer la performance énergétique des bâtiments.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-242

Wind Safety Assessment during High Rise Building Construction

Kimberley Adamek
Abiy Melaku
Girma Bitsuamlak
Farnaz Sadeghpour

Abstract:

The interactions between buildings and wind not only affect the comfort and safety of individuals at street or balcony levels after a building has been constructed, but also affect the construction workers during the construction process. As the workers move further from the ground and the floors change from being open to enclosed by the addition of cladding, the wind field, as well as the safety and comfort parameters, change. Typically, the effects of this interaction are not considered prior to the completion of construction. The assessment of the interaction of wind with a building at various stages of construction can help to identify areas of safety concern and aid in the development of mitigation measures accordingly. The Dominion Towers (TD Bank and TD North) located in the Financial District in Toronto, have been selected for the case study, as dense development of the area over the last 70 years has fostered increasingly noticeable high winds. The stages of construction of the Dominion towers have been divided into four significant construction periods: prior to construction, a quarter complete, half complete with partial cladding in place, and fully constructed. The changes in the wind effects and the corresponding changes in safety at these stages have been assessed with the use of CFD models that utilize LES turbulence models. This study highlights the complex relationships between the construction of a building, the wind and the comfort of workers. The purpose is to assess how the changing form of a building and its surroundings alter the wind field responsible for creating changes in the comfort and safety of workers.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-246

The Philosophy of Performance Measurement Research in Construction Management: a Philosophical Framework for Designing Performance Measures

Saad Bin Saleem Ahmad
Amin Haddadi
Hyeon Yong Park
Nils Olsson
Olav Torp
Amund Bruland

Abstract:

Construction Performance Measurement (CPM) is an applied methodology to create new knowledge, solve practical problems, and help organizations succeed. The general aim of this study is to develop a philosophical framework for the design of performance measures. To achieve this objective, this study classifies the philosophical positions in Performance Measurement (PM) research based on Creswell's philosophical worldviews. The paper reviews the ten most cited articles in eight peer-reviewed journals and categorizes the literature with the philosophical coordinates of the authors. Among the selected journals, four are construction management specific and four reflect on PM from a managerial and interdisciplinary perspective. The findings reveal that CPM research is governed by post-positivist and pragmatic research philosophies and lacks on participatory/action research. The paper then maps the philosophical shifts of Andy D Neely through his publications in the domain of PM to scheme a philosophical framework for designing performance measures, and advocates that it is necessary to hold different philosophical worldviews in CPM research as indicated by the general PM literature.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-247

Cost Overruns in Public Infrastructure Projects: Re-evaluating Procurement in an Era of Digitization

Peter Love
James Smith
Michael Regan

Abstract:

The cost performance of a wide range of infrastructure projects (n=67) completed between 2011 to 2014 by a contractor are analyzed and discussed to illustrate the prevailing problem that confronts the public sector when it opts to use traditional (design-bid-construct) procurement methods or variants thereof to deliver their assets. The mean cost overrun was found to be 23.84%, which materialized due to change orders; the contractor's mean margin at contract award 9.38%, but significantly increased due to changes orders. No significant differences between the size of the project, its procurement method and location were found to vary with cost overruns and margin. The research provides much needed empirical evidence for the public sector to re-consider the processes that are used to deliver their infrastructure assets so as to reduce the propensity of cost overruns occurring. It is suggested that in an age of digitization that the public sector needs to 'openly' embrace technological and process innovations so that it can ensure that assets are both resilient to unexpected events and adaptable to changing needs, uses or capacities.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-252

Human Factors Considerations of First Person View (FPV) Operation of Unmanned Aircraft Systems (UAS) in Infrastructure Construction and Inspection Environments

Daniel Paes
Sungjin Kim
Javier Irizarry

Abstract:

This paper aims to discuss the most critical human factors and usability implications from the adoption of First Person View (FPV) operation of Unmanned Aircraft Systems (UAS) in infrastructure construction and inspection environments. The paper starts with the discussion of usability and safety issues, addressing how and to what extent FPV devices enable UAS control beyond visual line of sight (VLOS). *Title 14 CFR PART 107* of Federal Aviation Administration (FAA) requires UAS Pilot in Command (PIC) and Visual Observer (VO) to maintain VLOS in their operations. Therefore, there are also legal implications, i.e., whether and under what circumstances FAA's regulations would allow UAS operations beyond VLOS when coupled with FPV displays. The second part of the paper discusses the extent to which FPV devices are able to provide optical and perceptual enhancements. The implications on human factors are understood from the standpoint of situation awareness. Situation Awareness (SA) plays a critical role in construction inspection tasks, that is, having access to relevant and sufficient information is critical to decision-making in the inspection process. Hence, improving SA can lead to better decision-making and better inspection processes. Whether First Person View operation of Unmanned Aircraft Systems would improve this process of capturing and processing of relevant information is the bedrock of this discussion. At the end, this paper presents a framework for investigating the mentioned implications through an experimental approach.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-253

Analysis of Construction Accidents Using Fault Trees

Ingrid Arocho
Rebecca Yang

Abstract:

Construction is one of the most hazardous industries in the United States accounting for 20% of all the labor related deaths in the country. Heavy civil construction, including transportation infrastructure projects, account for 20% of the fatalities in the construction industry. The objective of the present study is to identify the most frequent and severe types of accidents in transportation infrastructure projects by using fault tree analysis. This methodology will allow the study of the causes for each accident and the interaction between causes.

The data used for this study was collected from the OSHA's Integrated Management Information System that includes the Fatality and Catastrophe Investigation Summaries. Accidents summaries were collected from transportation construction projects located in Oregon, Idaho, Alaska, and Washington. The methodology used included the creation of fault trees using the causes identified from the summaries and performing root cause analysis.

The results from this study show that the most frequent type of accidents were struck by/against, caught in/between, falls, and electric shock. The fault tree analysis showed that some of the causes were common to all the accident types. The most common causes of accidents were misjudgment, inappropriate procedures, insufficient training, and miscommunication. The results from this study could support construction professionals on transportation infrastructure projects to improve safety on the construction site. A better understanding of the most common accident types and the events that caused them can offer safety managers the opportunity to prioritize their efforts. Training and supervising activities can be improved to pay particular attention to reduce common and frequent accidents.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-255

Framework of Automated As-built Photo Contents and Context Retrieval using 4D BIM

Jaehyun Park
Hubo Cai

Abstract:

Daily as-built photography has been considered an efficient means of capturing construction progress status in a timely manner. During the construction phase, many as-built photos are taken; however, the contents and context of each photo is manually grasped. Thus, this practice tends to be time-consuming and prone to error. A promising alternative to the current practice is four-dimensional (4D) building information modeling (BIM) (3D BIM plus time), a powerful tool used to visualize construction plans and milestones. The potential use of 4D (BIM) is suggested to support progress monitoring and tracking when daily construction progress is reflected in the 4D BIM model every day. Thus, the 4D BIM model is the best source for describing as-built photos from a particular day. This paper presents a framework of automated as-built photo contents and context retrieval using 4D BIM. Content-based image retrieval (CBIR) technology is introduced and tested for the framework.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-257

A Case Study of Site Layout Planning within an Operational Airport

Andrew Leonard
Farnaz Sadeghpour

Abstract:

Studies suggest that site layout planning can improve cost overruns in construction projects by saving the travel and material handling time. There is a large body of literature on site layout modeling and processes. These studies commonly use small examples, as a proof of concept, to demonstrate the capabilities of the proposed process or model. However, a case study that can be used to measure the impact of site layout on an actual construction project is rare. The objective of this study is twofold. First, a formal case study of an actual construction project is created that can be used to demonstrate and compare the capabilities of different models on the same basis; and second, possible cost savings through site layout planning is demonstrated using the developed case study. The study is built based on the expansion project of the Calgary Airport. The close proximity between passengers and airport operations to the construction operations in an operational airport imposes a number of extra constraints on site layout planning including safety and security of the aviation operation as well as that of passengers. The case study was developed through direct observations on the site over the course of four months. In order to accurately monitor site logistics, a CAD model was created to reflect worker travel routes, construction spaces, site objects, and track the changes over the period of four months. It was demonstrated that with simple changes cost savings could be achieved. These savings can be achieved despite the strict restrictions on access, and as a result, on the layout of the site in an operational airport. The cost savings achieved by simple changes is of interest to all stakeholders of a project including the owner, the contractor, and construction manager team.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-258

Identifying Factors that Influence People's Attitude toward Public Private Partnership (PPP) Projects

Deepak Sharma
Vandit Shah

Abstract:

Over the last twenty-five years many infrastructure projects have been successfully pursued through the Public-Private Partnership (PPP) approach across the United States (US). While the PPP project delivery model remains same in principle, the PPP acceptance rate across the different States in the US has been significantly different. Literature review shows that researchers have identified factors that influence PPP projects at program and project level but the factors that influence end users' point of view towards PPPs are not yet identified. The knowledge gap leaves Federal Agencies with minimal information to adequately plan for PPP success. The main objective of this research is to identify factors that influence people's acceptance. Through logical reasoning we selected several demographic and road use factors that could influence end users' PPP acceptance. The data for all such factors was obtained from several government sources for California, Florida and Texas. Using SPSS, we conducted Principal Component Analysis (PCA) to identify the most influential factors. Results show that Regional Development, Congestion, and Vehicle Miles Travelled were the most influential factors affecting PPP acceptance.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-259

Identifying End Users' Expectations from Public Private Partnerships

Deepak Sharma
Sathya Kondapalli

Abstract:

Public Private Partnerships (PPPs) have been used successfully a variety of projects in several countries. As per World Bank, use of infrastructure PPPs has been gradually increasing throughout the world. PPPs being investment intensive government agencies put significant efforts to ensure PPPs do not fail and harness all the expected benefits. In the past some PPP projects failed to attract sufficient end users leading only to a partial achievement of goals. One of the probable reasons for such a failure is the difference between public sector and people's expectations from PPP projects. Agencies have used traditional statistical methods to analyze and interpret end-user's concerns but such methods cannot extract all the necessary information. The limited understanding about end users' expectations could be one of the reasons that the agencies' are not able to design projects that people would readily accept.

Understanding peoples' concerns will greatly help the agencies to plan for PPP success. If people's opinion is captured accurately, the government can focus on addressing those concerns. This will also reduce people's skepticism and increase confidence in public agencies' decision making capabilities. This research presents the study of extracting valuable information for PPP projects using Kano Analysis (KA). Traditionally KA has been used in the manufacturing industry for product design but through this work we have extended its application to PPPs. Results show that KA can be conveniently used for selecting the best project delivery option while meeting people's expectations. KA results will also enable agencies to strategically design outreach programs to educate people wherever needed.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-260

Exploring Innovation Influencing Factors in Construction Projects

Ahmad Alhomadi
George Jergeas

Abstract:

Innovation is essential to maintaining competitiveness, improving performance, increasing national economic growth, and contributing to a knowledge-based economy. Competitive success is dependent upon the innovation process and factors that relate to its successful management. Different factors, internal or external to the organization, can influence the innovation process. The construction industry is mainly project-based, and project level innovation plays a key role in enhancing the innovation performance of project-based companies. Therefore, further studies are needed to investigate project level innovation, considering that innovation is often hidden and co-developed by different participants. This research explores the factors that influence innovation in construction projects by holistically taking into consideration the multi-party environment. Semi-structured interviews were conducted with industry professionals and experts in construction project management. Data analysis identified 8 drivers, 5 inputs, 22 barriers, and 11 enablers towards innovation. Understanding these identified factors and their role in influencing innovation will allow industry professionals to be aware of how innovation can be enhanced in construction projects.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-262

Mutual Effect of Building Sections on Energy Retrofit Planning

Farnaz Khaghani
Farrokh Jazizadeh

Abstract:

Several research efforts have been made towards energy efficiency improvement in buildings. Conventionally, these efforts look at a building as a whole and propose retrofitting solutions such as efficient building systems and isolation improvement that apply to a building as a whole. In this paper, we seek to look at the problem from a different perspective and identify the units in a multi-family building with most potential for energy saving. The purpose of this research is to apply the mutual effect of buildings at a smaller level (in a single apartment). Through simulation studies, we evaluate the effect of various retrofitting scenarios on a multi-family residential model and investigate whether the same retrofitting scenario on the similar apartment with a different location at building does not result in same energy saving. We are hypothesizing that there will be a difference due to the mutual interaction of building sections. We will replicate the analysis for two other cases in other elevations to confirm the reliability of the results. We also conduct our analysis for various heating and cooling systems in addition to changes in the material characteristics of the building. The results demonstrate that HVAC modification of one apartment can impact the behavior of adjacent ones. The paper will conclude by answering whether some sections of a building have more potential on improving energy saving and non-uniform retrofit planning is a viable solution. Designers and urban planners could benefit from the findings of this paper and apply them to their evaluation of energy performance of buildings to assess the most cost-effective retrofitting plan.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-263

A Framework to Evaluate Urban Underground Utility Complexity Index Using the Delphi Method and Analytic Hierarchy Process

Dilipkumar Arvindkumar Patel
Sardar Vallabhabhai
Shantwna Dixit

Abstract:

Urbanization is rapidly increasing for a few years. Worldwide rapid and unplanned urban growth has threatened sustainable development as basic infrastructure facilities are unable to cope up with the rising urbanisation. Modern cities depend on complex network of utilities. The complex underground utility networks leads to delaying of new infrastructure projects and create hygiene problems. Underground utility network complexity evaluation is a critical task in subsurface utility engineering because of its dynamicity. The dynamicity is due to the rising urbanism, demanding infrastructure facilities thereby creating a web of cables and pipes under the ground. Therefore, a lot of complexity arise and exist in an excavated pit particularly in urban area. However, the complexity level cannot be easily measured due to its qualitative nature and it varies from one pit to another. In this connection, this study presents a framework of prioritizing, analysing and evaluating the urban underground utility complexity index (UUUCI) using analytic hierarchy process (AHP) and weighted sum method (WSM). The casual and its categorical factors are selected based on the literature review and finalized by using the Delphi method. To validate this study, 40 pit samples have been collected and their UUUCI are computed. The values of UUUCIs follow the normal distribution curve. Thus UUUCI is able to represent the complexity level of a pit. The UUUCI will be useful to measure and differentiate the complexity level of pits. The impact of complexity level of a pit on traffic flow, environment and other managerial aspects can be studied by correlating the UUUCI.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-265

Financing of Public Private Partnerships: Six Australian Motorway Case Study Projects

James Smith
Peter Love
Michael Regan

Abstract:

In the past fifteen years, Public Private Partnerships (PPPs) have emerged as the preferred procurement method for toll road construction and management in developed economies. In Australia, seven of eight new toll roads implemented since 2003 were commissioned as PPP projects. Unlike traditional procurement methods, PPPs involve higher levels of risk for private firms, who rely on bank loans for up to 85% of development funding. This study undertakes a comparative review of the financing of six of these projects of which two were financed after the global financial crisis of 2008.

This paper seeks to identify differences between the projects and the bearing that these differences may have had on project outcomes. The review considers matters such as capital formation and structure, risk allocation, loan tenors, and the organisation of equity. Common characteristics are also identified including the use of short-term bank debt, reform of State PPP policy, forecasting error and the financial failure of projects, and changes in risk allocation over the 10 years of the survey. With one exception, projects were delivered on, or ahead of budget, and on time. However, two projects experienced financial failure and substantial loss of asset value. Moreover, a further project traded for nine years before it was sold at less than half of its original construction cost. Lessons learnt from recent toll road experience in Australia and recent policy reforms particularly in the area of risk allocation are examined.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-271

Simulation-Based Constructability Analysis of RCC Dams

Hosein Taghaddos
Mohammad Saleh Dashti

Abstract:

Designing and planning construction operations is a challenging part of construction due to their highly complex dynamic nature. Simulation is a powerful approach, which has the ability to quantitatively, logically, and visually represent the construction process, its resources, and surrounding environment. Therefore it can improve the design and plan of construction operations. This paper presents a simulation-based approach to model a major milestone of construction process of a roller compacted concrete (RCC) dam. Several what-if construction scenarios have been modeled for the milestone, based on different combinations of the resources. A time-cost trade-off analysis has been used to select the optimum construction scenario for the milestone. The results of the study demonstrate the capabilities of the simulation based approach in designing and planning of RCC dam construction projects, based on a time-cost tradeoff framework.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-272

BIM Implementation in Facilities Management: an Analysis of Implementation Processes

Saratu Terreno
Chimay Anumba
Somayeh Asadi

Abstract:

The potential of Building Information Modeling (BIM) to add value to Facilities Management (FM) has long been recognized. The usefulness of BIM in asset management, including operations and maintenance has been described by numerous authors. Crucial to its implementation is the integration of information, which increases efficiency and productivity on the job and, in turn, positively impacts the primary organization's mission and goals. In view of the potential of BIM to add value to FM which in turn can boost the mission of organizations, there is a potential to study the experiences of early adopters, map out patterns and differences and to record lessons learned. This research aims to investigate how BIM is implemented in operations, how value can be derived and what the critical success factors are. What are the areas of process waste and consequent loss of value within the lifecycle phases of facilities? To this effect, case studies of three tertiary educational institutions are undertaken, mapping the processes of information flow from BIM conception through handover and into the lifecycle management of projects. Value stream mapping of organizational processes will identify areas of potential waste or non-value-adding activities, and also areas of potential value-adding opportunities. By studying BIM value through the lifecycle value chain, and identifying best practices and challenges in light of the more subjective nature of value delivery in FM, more impactful outcomes should be derived.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-273

Complex Network Analysis of Municipal Water Main System Incorporating the Reliability of Individual Pipe

Hieu Chi Phan
Ashutosh Dhar
Rehan Sadiq

Abstract:

Complex network analysis (CNA) is commonly used to predict well-connectedness of the water main system using a deterministic technique. In this technique, pipeline network is idealized as nodes and links. A number of parameters are then defined based on the nodes and links to quantify the network connectivity. Pipeline system is, however, deteriorated with time due to various causes including corrosion, which may affect the connectivity of the network. The effect of pipeline deterioration on the network connectivity has not been well-investigated till to date. In this paper, water distribution network connectivity is evaluated using the CNA considering the pipeline deterioration. The effect of deterioration of individual pipes is expressed in terms of reliability of the pipe to incorporate in the CNA. The resulting time-dependent complex system parameters would be useful for maintenance planning of water main components. The proposed method has been demonstrated using a water distribution system of City of Mount Pearl in the province of Newfoundland and Labrador.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-274

Case Application of Pavenext to Achieve Sustainable Pavement Design

Author(s):

Qingbin Cui
David Choy
Xiaoyu Liu

Abstract:

Pavement covers 45% of the land in urban regions of the U.S. and produces over 17 million metric tons of greenhouse gases every year. While technology exists to curb emissions, unfortunately, government agencies and private businesses are slow to change business as usual for short-term stability and profits. This paper presents a web-service application, namely PaveNext, to optimize pavement design and construction under the consideration of performance requirement and economical benefit. In particular, the application incorporates the carbon credits created through VCS standard. The framework, approach and process of the application are discussed and demonstrated using the I-64 project. The case project shows both environmental and financial benefits after optimizing pavement design and material selection. By replacing HMA with FSB, the new design saves 3700 tons of carbon emissions and creates \$8500 credits. The pros and cons of the PaveNext-based pavement design optimization are also discussed.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-278

Data-Driven Scenario Generation for Enhanced Realism of Heavy Equipment Training Simulators

Faridaddin Vahdatikhaki
Amin Hammad
Leon olde Scholtenhuis
Seirgei Miller
Denis Makarov

Abstract:

Improving the training of heavy equipment operators can make a significant contribution to improving the safety of construction sites. In recent years, Virtual Reality (VR)-based simulators have gained increased popularity for the use in equipment training programs. While VR training simulators for heavy equipment are less mature than those used in the aviation industry, these simulators are gradually carving their way into the training programs for construction equipment operators as well. Presently, the majority of the existing VR scenes are based on hypothetical scenarios and more focused on developing motor skills. However, on real construction sites, the decisions an operator makes to operate the equipment safely and efficiently depend on the decisions made by other operators or workers in addition to the type and location of the work. In the current situation, the training simulators do not capture the dynamism of the construction site and the uncertainties involved in the project as a result of human factors. One way to address this issue is to generate realistic training simulators based on the actual construction operations. In these VR scenes, the data from actual equipment will be used to generate a scene where the trainee is supposed to operate the equipment in face of the movements of many other pieces of surrounding equipment. For this purpose, sensor data needs to be integrated with a multi-agent system to capture the behaviour of many equipment and workers. Nonetheless, the first step towards the generation of such a scene is to reconstruct the actual construction site in the VR environment. This research builds upon the previous work of the authors and the advancements in geo-informatics to propose a method for the reconstruction of actual sites using GIS and cadastral data. Two different approaches for the generation of these scenes are compared and a prototype is developed to show how sensor data can be integrated with the VR scene for the construction of the realistic training simulators. The feasibility of the approach is demonstrated by means of a case study where GPS data from an actual construction project is replayed in the VR model of the site where the project took place.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-279

A Framework for Risk-augmented 4-D Visualisation of Construction Projects

Faridaddin Vahdatikhaki
Mohammed Mawlana

Abstract:

Along with the advent of Building Information Modeling (BIM) came the rising popularity of visualizing not only the product of a project but also the underlying activities leading to such products. For this purpose, the schedule of a project is coupled with its 3D model to visualize how different components of a project are placed during the construction, creating what is known as a 4D model. Through enabling a detailed visualization of the construction processes, 4D models allow the scrutiny of a chosen construction method or schedule for the feasibility in view of the space required for the execution of different tasks. Nevertheless, while there exist several methods to generate a stochastic schedule of a construction project, the de facto practice in the generation and application of 4D models is based on the application of deterministic schedules. Accordingly, the current 4D models cannot represent the uncertainties associated with the start and end time of various construction activities. As a result, any decisions made about the constructability of a project on account of the existing 4D models ignores the risks of delays in the completion of activities and the ensued potential constructability conflicts. This research aims to develop a framework to effectively visualize the risk of constructability conflicts associated with the construction projects. In other words, using the stochastic scheduling paradigm, the proposed framework enables augmenting the existing 4D models with information about the probability of each elements being under construction at any given time. A case study is developed to integrate the stochastic schedules coming from the discrete-event simulation tool with the 3D model of the building and further visualize the scheduling uncertainty in the 4D visualization. It is shown that the proposed method has a strong potential to provide inputs for more precise constructability analysis.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-281

Estimating Contract Times for Transportation Projects: Creating a Statistical Model to Estimate Times Using Bid Quantities

Guillermo Nevett
Paul Goodrum

Abstract:

Developing the time requirements for highway transportation projects has always been a big challenge due to the differences in project scope, location, goals and size. It's not uncommon for state transportation agencies (STAs) to produce inaccurate estimates of project durations, which leads to contractors not investing their maximum effort in a project. Several previous attempts have been made to make more accurate estimations by using different methods. The objective of this research is to find a new method able to produce accurate estimates by using historical data. This paper describes the preliminary steps of developing a tool with sample data from Montana's Department of Transportation (MDT; DOT). The data provided by MDT consists of bid tabulations, budget estimates, and project type. This paper is part of an ongoing investigation so this model might not be the most accurate by the end of the project, mostly because of the details included in other databases recently received. Nevertheless, the paper will provide an overview of the approach used to conduct such investigation. The paper provides readers with an idea of which bid items are more significant on project durations and shows how a statistical model can estimate a project duration during the design phase of a project.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-284

Adaptation of a BIM Policy Actions Model for Industry Associations

Vincent Carignan
Forgues Daniel
Sylvain Kubicki

Abstract:

Building information modelling (BIM) is not a simple straightforward set of technologies. Comprised of many processes, technology and policy components, its inherent complexity and disruptiveness are seen as major hindrances to its take-off in the architecture, engineering and construction (AEC) sector. As industry associations (IAs) have played a central part in the diffusion of other complex technologies such as electronic data interchange in the grocery sector, this article focuses on their role in BIM diffusion. This first part of an ongoing research project involving two laboratories from Europe and Canada proposes a model classifying the BIM diffusion actions of IAs as a way to help assess their role in BIM diffusion on a market.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-285

Leveraging the Benefits of Lean Integrated Project Delivery for Public Projects

Shelly Switzer
Arthur Winslow
David Dow
Brian Watkinson

Abstract:

Lean Integrated Project Delivery (IPD) is a collaborative model defined by a multi-party agreement between the owner, the designer and the constructor, who agree to share the project risks as well as the rewards. This sharing of risk and reward may be the most significant factor that separates IPD from other project delivery models. IPD uses established lean principals and building information modelling (BIM) to reduce waste, to increase value to the owner and to maximize efficiency. Lean IPD provides cost and schedule certainty for the entire team. Its contract structure is set up to change behaviors and incentivize the team to put project outcomes ahead of individual member's interests. IPD aligns their interests such that team members benefit from driving down cost while maintaining quality, program and schedule; the better the project does, the better the team members do. The full project team (consultants, sub-consultants, contractors, subcontractors, suppliers) is on boarded early in the design stage and works together to develop an efficient, constructible design. By bringing in the trades and suppliers at an early stage, the team is ensured that they are developing a design that can be built within the established budget (one of the tenets of IPD is to design to budget, not budget a design). The Lean IPD model has proven to be successful in the United States, delivering hundreds of projects on time, within scope and on budget. Oakville's Trafalgar Park Revitalization project is the first Lean IPD project in a Canadian municipality; the team has adapted the model to suit the unique public procurement and accountability demands of Canadian municipalities. Learn from the leaders of the IPD Team how this revolutionary approach to delivering capital projects has been adapted to the unique needs and constraints of municipal projects.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

CON-286

Nanaimo Memory Care: A Case Study of a Multi-Residential Construction Project

Sara Rankohi

Abstract:

Nanaimo Memory Care (NMC) is a 4-stories (79-suite) Memory Care residence situated on the Long Lake in Nanaimo, British Columbia (Figure 1). The Residence is the first stand-alone Memory Care facility available to seniors living with dementia on the Vancouver Island with a gross floor area of 48,541 sq. ft. The owner, Sussex Retirement Living, awarded CANAM group to supply and erect the project super structure including structural steel columns, beams, load bearing steel stud walls, Hambro joists and forms, open web steel joists, and steel decking. Project constraints were delivery distance, transportation means, compressed schedule, and environmental conditions. Steel components were supplied and fabricated in different locations. D500 Hambro Joists were fabricated in St. Gédéon, QC; Deck and conventional joists were fabricated in Calgary; structural steel was supplied from the islands BC; steel studs were supplied from Spokane, WA; and load bearing stud walls were assembled near construction site in BC. The longest delivery distance was 4,921 km from St-Gédéon, QC, to Nanaimo, BC, passing through United-States, which includes 2.5 hours ferry ride to the site.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-701

Debris Entrainment Dynamics in Extreme Hydrodynamic Conditions

Jacob Stolle
Ioan Nistor
Nils Goseberg
Emil Petriu

Abstract:

As a result of climate change induced sea-level rise and the urban intensification of coastal areas worldwide, the risks associated with extreme hydrodynamic events continued to increase. Events, such as the 2005 Hurricane Katrina, the 2011 Tohoku Tsunami, and the 2016 Hurricane Matthew, caused widespread damage to coastal communities as well as to critical infrastructure. As a result, emphasis has been placed on the design of communities not only for the evacuation and safety of the residents but also for the resilience of the infrastructure to withstand the associated extreme loads. The focus of the research in this field has centered around the hydraulic loads associated with these events. However, field studies of these events have indicated that debris entrained within the flow must be considered in the design of resilient structures, especially considering that the dynamics of the impulse loads associated with debris impacts are different than the sustained hydraulic loads. The study presented here aimed to assess debris dynamics in extreme hydrodynamic conditions, particularly focusing on the entrainment and propagation of multiple debris within the flow. The quantification of debris dynamics in extreme hydrodynamic conditions will allow for accurate estimations of high-risk areas for debris impact. Additionally, the assessment of debris dynamics could help in the recovery of high-value objects in the aftermath of these events. The paper will present results of a study performed by the authors in the new tsunami basin at Waseda University (Tokyo, Japan). The study assessed the propagation of debris both individually and as an agglomeration to determine the effect of debris concentration on the displacement and velocity of the debris, while also developing an analytic model to estimate these properties.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-703

Optimizing Municipal Drainage Infrastructure Design by Implementing Environment-Based Design Methodology: A Case Study

Fayi Zhou
Allen Xu

Abstract:

This paper shows how to use a design methodology-Environment Based Design (EBD) to optimizing municipal drainage infrastructure design through a case study. EBD is a generic design methodology supporting innovative product design. EBD consists of three activities: environment analysis, conflict identification and solution generation. The advantage of using EBD to support engineering design is that it relies less on individual expertise and has sufficient results because of its implied prescribed analysis on the whole project environment. Thus, we can provide a more complete analysis with less individual experience. This paper will introduce a conceptual design using EBD for improving the hydraulic performance of the Whitemud Creek Crossing storm trunk as a case study. In the case study, EBD starts from analyzing the objective of the project to get a comprehensive list of environment components and a clear understanding of the whole project. Then conflicts between environment components will be analyzed and several solutions will be generated based on solving the conflicts. The information generated by EBD can be used as a guidance to improve the efficiency of design option selection in the value engineering phase of the design process.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-704

Field Investigation and Numerical Modeling of the Flow Hydrodynamics around the Bequia Island Coastline in Saint-Vincent and the Grenadines

Philippe April LeQuéré
Ioan Nistor
Ronald Townsend

Abstract:

In order to accommodate an increasing number of tourists visiting Bequia, the largest island of Saint-Vincent and the Grenadines, the local government constructed an airport, through a major coastline land-reclamation project. However, due to the prevailing ocean current patterns in the area, an inlet created on the East side of the new airport is prone to trapping significant amounts of ocean-borne debris. This litter accumulation creates a health risk to local fishermen who clean their daily catch using water from the inlet. To address this problem, the authors proposed to install a rock-fill groyne structure on the eastward side of the new inlet. The utilisation of a coastline groyne in this case is somewhat unorthodox, as the latter is normally employed to mitigate against coastal erosion.

The goal of this study is to optimise the groyne design with the assistance of a 3D numerical model. The 'Delft3D' open-source model (WAVE and FLOW modules) was selected to examine the effects of different orientations and lengths of the proposed groyne on the movements of floating debris. An initial field campaign for data collection was undertaken using an acoustic Doppler current profiler to measure bathymetry and collect velocity data to be used in the calibration and validation of the Delft 3D model. As historical tide-induced current data for this remote island is scarce, this presents a challenge for a numerical-modeling approach. This lack of information is adding variables to the calibration of the model. Hence, in order to isolate the tide-induced current component from the bottom roughness, the calibration exercise is separated in two using two different sets of local data. This paper will report the preliminary results of this study.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-705

3D Physical Modelling of Wind and Wave Overtopping at the Billy Bishop Airport Revetment

Scott Baker
Andrew Cornett
Chris Glodowski

Abstract:

As part of a planned development for Billy Bishop Toronto City Airport, new land reclamation and related marine works are required to extend both ends of the main runway. Wave conditions at the eastern end of the runway are relatively mild, as the site is sheltered inside Toronto Harbour. However, the western runway extension will be directly exposed to strong winds, energetic wave conditions, high water levels, and winter ice conditions on Lake Ontario. An engineered revetment is required to prevent erosion, preserve stability, and protect the exposed western reclamation from attack by waves and ice. The design challenge was compounded by the requirement to minimize the frequency and extent of wave run-up and overtopping during storms as much as possible in order to avoid frequent inundation of the runway. At the same time, the crest elevation of the perimeter revetment was limited by the elevation of the existing runway and various other requirements for safe operations at the airport.

A large-scale 3D physical modelling study was crucial to develop, test, and optimize the design of the perimeter revetment and for costing the marine works. In order to accommodate the stringent design requirements, several innovative revetment design concepts (featuring lower crest elevations, milder slopes, thicker filter layers, and thicker armour layers than normally seen in conventional designs) were tested in a wide range of harsh wave, wind, and water level conditions.

Once the development is approved, the longer runway will allow for expanded operations from Billy Bishop Airport, with the ability to reach destinations anywhere across North America. This will greatly benefit the citizens of Toronto and boost the local economy. The longer runway will also improve safety by reducing the risk of a runway excursion.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-706

Simulation of Negatively Buoyant Fountains using Data Mining Methodology

Amir H. Azimi
Niyousha Mohammadidani

Abstract:

Data mining and boundary visualization techniques were employed to model the hydrodynamics of negatively buoyant fountains. Experimental results of two different fountain types of axisymmetric and plain fountains were selected for simulation. Fountain characteristics such as penetration height y_m , fountain width x_w , and the thickness of temperature layer y_t were considered. Experimental studies in the literature indicated that the fountain characteristics can be correlated with non-dimensional parameters such as Froude, Reynolds, and Prandtl numbers. All proposed empirical models from the literature are nonlinear functions of Froude and Reynolds numbers. This nonlinearity causes a considerable prediction error. The M5P model tree was used for prediction of fountain characteristics such as penetration height and penetration width of negatively buoyant fountains. The selected model restructures non-linear correlations into a tree of linear models. It was found that all model trees accurately predict fountain parameters with maximum 3% error. Different fountain shapes were formed based on variations of Froude and Reynolds numbers. Regime classification was performed using boundary visualization. Different classifiers in Weka software were tested for boundary visualization to define regime boundaries. It was found that the Logistic classifier can properly define the boundary of different fountain flow regimes.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-707

Sediment Transport and Shoreline Changes due to Dredging of Shipping Channels in Bermuda

Sundar Premasiri
Shelton Liu
Sam Salley
Sheldon Smith

Abstract:

The Government of Bermuda plans to widen and dredge the existing three shipping channels to accommodate navigation of larger cruise ships. Located between the North and South Channels, there exist the most pristine and extensive Bermuda coral and sea grass systems. A hydrodynamic and sediment transport modeling was conducted to delineate the suspended sediment plume during the dredging period in support of environmental impact assessment. The hydrodynamic model was calibrated using the field metocean data collected for this study. Dredging production rate, thickness of dredge cuts, dredging equipment type and method of dredging operations were considered in the sediment transport modeling. The sediment transport simulation was conducted under environmental forcings of astronomical tides, storm winds and waves. The sediment plume delineation and suspended sediment concentrations at various sensitive locations were estimated to assess the potential effects on aquatic system. The shoreline impacts due to the wake waves generated by larger cruise ships were also assessed. Shoreline erosion potential were classified as very low, low, moderate, high and very high based on wave energy, shoreline type and vegetation conditions. Based on these assessments, mitigation measures were recommended during the dredging and operation of ships to reduce the impacts.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-708

Developing Debris-Flood Mitigation Concepts to Address Complex Flooding in Mountain Communities Located on Alluvial Fans

Gaven Tang
Ron Kitagawa

Abstract:

The June 2013 flood in the Hamlet of Exshaw occurred over the course of a three-day rainfall event. The recurrence interval of the rainfall event was estimated to be approximately 300 years. This resulted in flooding at both Exshaw Creek and Jura Creek with recurrence intervals of 500 years and 350 years, respectively. The Hamlet of Exshaw was affected by four sources of flooding including: debris-floods on Exshaw Creek and Jura Creek; local catchment runoff; and flooding of the Bow River. In November 2015, the MD of Bighorn No.8 retained Golder Associates to provide debris-flood mitigation solutions for Exshaw Creek and Jura Creek. Golder Associates completed the following scope of work in 2016: Phase 1 – Concept Development and Validation; Phase 2 – Preliminary Design; and Phase 3 – Detailed Design. The focus of this paper will be the work that was completed at the concept development stage, Phase 1. This included the development of flood risk reduction concepts for both Exshaw Creek and Jura Creek based on design criteria that were developed by the previous consultant (BGC Engineering Inc.), who performed debris-flood hazard assessments for both Exshaw Creek and Jura Creek. At the conclusion of Phase 1, four (4) design concepts were developed for Exshaw Creek, and five (5) design concepts were developed for Jura Creek. These design concepts were presented to all stakeholders to garner feedback, and all issues (feasibility, cost, environmental impacts, and regulatory constraints) were tabulated before Golder Associates formulated recommendations for the MD of Bighorn No.8 in proceeding to Phase 2.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-709

Tunnel Replacement Project: Morphodynamic Modelling of Trench Migration

Daniel Robb
Matt Gellis
Jose Vasquez
Edwin Wang

Abstract:

A highway traffic tunnel passing under the main channel of the Fraser River in southwestern British Columbia, Canada is nearing the end of its useful life. Replacement with a new bridge has been proposed. The project includes decommissioning and removing the in-river segments of the tunnel. Preliminary plans do not propose backfilling after tunnel removal; this would result in a trench feature in the river bed approximately 630 m long, 95 m wide and 8 m deep. The tunnel is located in a tidally-influenced reach of the river 5 km upstream from the sea. Because of the complex tidal conditions at the site, it was not possible to assess the fate of the trench using analytical methods, especially the possibility that the trench could migrate upstream. In this paper, we use a three-dimensional hydrodynamic-morphodynamic model to investigate the alluvial channel response to the removal of the tunnel. The model used in the present study accounts for non-equilibrium effects (i.e. the sediment concentration profile in the vertical direction does not adapt instantaneously to spatial and temporal changes in the flow) that can influence the morphological evolution of a dredged trench. To validate the model, numerical results were first compared to existing experimental data from flume experiments on the morphodynamic development of dredged trenches. The numerical results agreed well with the experimental data over a range of initial trench dimensions. The model was then used to predict the morphological evolution of the trench resulting from the removal of the tunnel under tidal flow conditions. The model results suggest that, assuming it is not backfilled after tunnel removal, the trench will migrate downstream and fill in within one or two freshet seasons.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-710

CCDP: GIS-Based Data Portal for Climate Change Impact Assessment

Xiuquan Wang
Gordon Huang

Abstract:

While mitigating climate change would require substantial and sustained reductions in greenhouse gas emissions through worldwide consensus and collaborations, adapting to climate change has become a major focus of local policy makers and development practitioners. Sound decisions rely on impact-based modeling, but the coarse-resolution outputs of global climate models (GCMs) are unsuitable for driving impact models, which usually require finer resolution projections at both spatial and temporal scales. Effective downscaling of GCMs projections is thus required, but it is practically difficult due to the lack of computational resources and/or long-term reference data. Such difficulty has become a major barrier preventing informed climate change adaptation planning at regional scales. To address this challenge, a web-based and user-friendly public data portal with integration of advanced geographic information system (GIS) technology, named Ontario Climate Change Data Portal (CCDP, <http://ontarioccdp.ca>), has been established to allow intuitive and open access to high-resolution regional climate scenarios for Ontario, Canada. Ontario CCDP offers functions of visual representation through geospatial maps and data downloading for a variety of climate variables (e.g., temperature, precipitation, relative humidity, solar radiation, and wind) at multiple temporal resolutions (i.e., annual, seasonal, monthly, daily, and hourly). The vast amount of information this portal encompasses can provide a crucial basis for assessing impacts of climate change on local communities and ecosystems and for supporting better decision making under a changing climate.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-712

Automatic Discretization and Parameterization of Watersheds using a Digital Elevation Model

Karen Finney
Robert James
Tiehong Xaio
Nandana Perera

Abstract:

Characterization of both overland and channelized flow is crucial for understanding the sources and fate of catchment runoff. It is essential that care is taken when delineating catchments to ensure that these two types of flow are distinguished from one another. Unfortunately due to the level of complexity associated with large watersheds, obtaining complete and detailed watershed data necessary to characterize the hydrological process is not always possible. To represent stream response in a watershed the sheet flow, channelized flow, flow path slope and contributing area must first be taken into account.

This paper examines the SWMM hydrology setup and parameterization for the Toronto and Region Conservation Authority's Don River flood forecasting model using an automatic watershed delineation, parameterization and discretization tool developed in PCSWMM. In addition, two scenarios, with varying parameterization and hydrologic and hydraulic resolutions, will be compared using observed rainfall and flow data.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-717

2DH Lagrangian Discrete Parcel Numerical Modelling of Ice Dynamics in Thames River, ON

Ali Oveysy
Spyros Beltaos
Erik de Goede

Abstract:

In cold regions, the majority of rivers experience seasonal freeze up and ice breakup events. In breakup events, the highly dynamic transport of ice parcels could result in ice jam formation. During an ice jam, the water level increases significantly, resulting in inundation of nearby communities. Therefore, advanced numerical models are important tools for the study of hydrodynamics and ice dynamics in such rivers. Due to the highly dynamic nature of ice breakup events, here we present a river ice dynamic model using a Lagrangian Moving Particle Semi-Implicit Method (MPS) with viscoplastic ice rheology. The model is two-way coupled with Delft3D, a widely used 3D hydrodynamic and transport model for the hydrodynamic component.

We set up the model to study the ice jam formation in Thames River, ON, Canada. In January 1986, a thaw and rain event resulted in an ice breakup and jamming condition in Lower Thames River. The ice jam was stabilized by the cold weather shortly after that and provided conditions for safe measurement of the jam characteristics by Beltaos (1988). After refinement and calibration, the modelled ice thickness and the water level variation through the ice jam profile followed the measurements reasonably well. Ice jam thickness reaches to ~2.7 m at the toe of the jam and sharply decreases downstream of the toe. After formation of the ice jam, the water surface elevation difference between downstream and upstream reaches amounted to ~6 m, while this difference is only ~ 3.5 m for open water conditions. The 2.5 m increase in water level due to the ice jam could result in significant flood threat. The successful application to Thames River emphasizes the proposed model functionality and applicability for simulation of ice dynamics in real cases.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-721

Modelling the Generation and Propagation of Landslide-Generated Waves

Jose Vasquez

Abstract:

Sub-aerial landslides in water bodies such as bays, fjords, lakes and reservoirs can generate water waves tens or even hundreds of meters high, with potentially devastating effects on infrastructure and human safety. British Columbia has experienced several historic landslide-generated wave events, such as the 20-m high Haney slide wave in the Fraser River (1880); the 25-m high Attachie slide wave in the Peace River (1973) and the recent 35-m high Chehalis Lake wave event (2007). Using the Telemac-2D hydrodynamic model, it is demonstrated that wave propagation results are very sensitive to the mesh resolution and numerical scheme applied to solve the flow equations, typically resulting in excessive wave dissipation (i.e. amplitude under-prediction). It is also shown that correct modelling of these waves requires reproducing the solid slide impacting the water body at high velocity, which is possible using the computational fluid dynamics (CFD) model Flow-3D. It was found in Flow-3D that for accurate of modelling wave propagation over distances larger than 10 times the water depth away from the wave generation region, the use of a second order numerical scheme to solve the momentum advection equations became necessary.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-722

Effect of Longterm Navigation Channel Lowering on Scour and Degradation Processes on Lower Fraser River

Andrew Nelson
Ilana Klinghoffer
Matt Gellis
David McLean

Abstract:

The Fraser River, which is the largest river on the west coast of Canada, terminates in a large sand-bedded and tidally-influenced delta that extends from New Westminster to the Straight of Georgia. This lower reach of the river has been extensively modified over the last century to provide flood protection for surrounding areas and adequate draft for navigation of ocean-going vessels. Sediment removal by dredging the navigation channel below New Westminster, in combination with river training, bank hardening, and scour protection, has significantly altered the channel hydraulics, sediment transport characteristics, and morphology of the river. This paper uses the extensive historical record of bathymetric surveys that date back to the early 20th century to characterize the complex channel response that has occurred over time. The resulting bed lowering and degradation extend well beyond the limits of the localized navigation channel improvements. Importantly, bed lowering has led to increasing exposure of non-alluvial channel boundary material including riprap structures that were installed previously as scour protection measures, as well as cohesive delta foreset beds and less erodible Pleistocene deposits such as till and outwash. These hard points generate additional turbulence and plunging flow that have induced additional local scour, effectively amplifying the effect of the initial degradation. Consequently, deep local scour (over 20 m) has developed at some sections of the river.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-725

Frequency Analysis and Plotting Positions

Bertrand Massé

Abstract:

Various formulas have been proposed for estimating the probabilities of occurrence or return periods of the various elements comprised in a sample of historic hydrological data ranked in decreasing or increasing order. Most of these formulas are based on the equation $P = (m-a)/(N+1-2a)$, in which m is the rank of the element; N is the number of elements in the sample; and a is a parameter whose value has been a subject of dispute among hydrologists for several decades. Proposed values of a vary between 0 and 1 and, presumably, depends on the probability distribution considered. A visual representation of the return period of the most extreme value in a ranked series is proposed, which shows that the most appropriate value of the parameter a is $a = 0.30$ and that it can be applied to any probability distribution.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-726

A Simple River Meandering Model

Bertrand Massé

Abstract:

Principles of mechanics are used to derive a mathematical formulation of river meandering. In its most simple formulation the model generates symmetrical meander loops whose shapes approach those produced by the sine-generated curve. For the more general case the model generates regular upstream-skewed meander loops like those commonly observed in nature. The model proposes explicit equations for evaluating meander characteristics such as loop length or wave length, based on commonly used floodplain and river parameters like the Froude number, transverse slope and the river width.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-727

The Devil is in the Details: Assumptions and Reality Collide in Urban Dike Breach Modelling

David Roche

Abstract:

Two-dimensional modelling has become a preferred tool for simulating complex outflow from dike breaches in urban areas. As always, it is up to the engineers planning, executing, and reviewing the model to ensure that results are based on an appropriate suite of assumptions and processes. Having too much detail increases engineering costs. However, having too little detail can lead to misleading model results and inefficient risk mitigation decisions. The costs of inefficient risk mitigation decisions can exceed the modelling budget by orders of magnitude as the risk management strategy is implemented.

As part of the District of Squamish Integrated Flood Hazard Management Plan (IFHMP), KWL constructed a detailed dike breach model of the Squamish River floodplain. The model considers the interdependence between architecture and preferential flow pathways as well as alternative representations of floodplain structures, compatibility of climate change and development assumptions, the iterative nature of floodproofing and flood risk, and the potential for breaches to occur at any location along the nearly 20 km perimeter of the developed floodplain.

Flood risks for Squamish are further complicated by the overlap of sea level rise planning area and river dike breach zone within the downtown core, which has extensive at-grade development. The IFHMP explores options for a sea dike, then examines the effects of intentionally breaching the proposed sea dike to reduce floodplain inundation during a river dike breach.

Model results highlight some significant (and occasionally surprising) changes from the previous 1D modelling completed in 1994. Squamish faced difficult decisions about long-term floodplain land use, capital-intensive upgrades to the dike system, and managing development in flood risk areas. The detailed modelling completed for the IFHMP ultimately supported the adoption of new structural, non-structural and policy measures to manage flood risk as part of a sustainable community plan.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-728

Field Observations and Analysis of Total Dissolved Gas Generation on the Lower Columbia River Downstream of the Hugh L. Keenleyside Dam

Graeme Billay
David Zhu
James Bruce
Alf Leake
James Crossman

Abstract:

One of the many environmental concerns that have arisen as a consequence of dam spillway operations is the increase of total dissolved gases (TDG) by the entrainment of air into the stilling basin. When the level of dissolved gases in the river reach beyond 100% saturation with the atmosphere, fish may experience gas bubble disease (GBD). This disease occurs when fish have equilibrated to higher dissolved gas pressure and are subsequently exposed to regions of lower gas pressure, allowing the gas to form bubbles in the soft tissue. This can be detrimental to the survival of affected fish species. In an effort to improve both the understanding of the mechanisms responsible for the generation and dissipation of TDG and the methods of dam spilling operations, field work was carried out during the summer of 2016 on the Columbia River to gather TDG data during a variety of dam operational scenarios. Of particular interest to the current study is the Hugh L. Keenleyside (HLK) dam near Castlegar, BC. During this field work campaign, six scenarios were conducted corresponding to the different spillway and low-level operating gate combinations. TDG levels were measured at different transects along a 20km reach of the lower Columbia River. The measurements were taken using continuously monitoring Point-4 TDG probes and spot measurements were taken across the width of the river from a boat using a similar TDG probe. The results of the field work suggest that the southern operating gates at HLK are a larger contributor to TDG generation than originally believed. Making the resulting TDG generation at least as significant as compared to the spillway operations. The northern operating gates contributed less to the TDG increase, however, the geometry of the stilling basin may account for this discrepancy.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-729

Numerical Modelling of Rock-Weir Type Nature-Like Fishpasses

Abul Basar Baki
David Zhu
Andrew Harwood
Adam Lewis
Katie Healey

Abstract:

In recent years many migration barriers have been replaced by nature-like fishpasses to mitigate the effects of human development and habitat fragmentation on fish. This research study numerically investigated the complex flow characteristics in rock-weir type nature-like fishpasses for different structure geometries and channel characteristics to optimize design. Initially, the numerical model was validated with physical model results and good agreement was achieved. As part of this research, the study described herein examined the flow characteristics of rock-weir fishpasses with and without passage slots/notches. We investigated physical characteristics within rock-weirs with and without notches to determine how they affect the hydraulics within the structures, focusing on water surface profiles, local velocity fields, volumetric energy dissipation rates, fish resting zones, and fish passage performance. It is hoped that the results of this study will advance our knowledge on flow in a rock-weir fishpass and be useful to fishpass designers and fish biologists.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-731

Testing Evolutionary Algorithms for Optimization of Water Distribution Networks

Naser Moosavian
Barbara Jean Lence

Abstract:

Water distribution networks (WDNs) are one of the most important elements in the urban infrastructure system and require large investment for construction. Design of such networks is classified as a large combinatorial discrete non-linear optimization problem. The main concerns associated with optimization of water distribution networks are related to the nonlinearity of the discharge-head loss relationships for pipes and the discrete nature of pipe sizes. This paper compares different techniques, all based on evolutionary algorithms (EAs), which yield optimal solutions for design of water distribution networks. The fundamental concept of EAs is that they search for the global optimum with populations of solutions, rather than by improving a single solution, as in Newton-based and other search methods. EAs start with an initial population and use different operators on these populations to change their composition and improve their performance over repeated iterations, or generations. In this paper, six EAs are applied for design of two benchmark pipe networks, the Two-Loop and Hanoi networks, and one real water distribution system for the City of Farhadgerd, Iran. Results show that as the size of the network increases, the soccer league competition algorithm increasingly becomes the most efficient among these algorithms, and consistently converges to the global optimum.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-732

Assessment of Debris Issues Impacting Design of a Flood Diversion Project in a Large Scale Physical Model

Paul Knox

Abstract:

The Elbow River flows through southwest Calgary and is susceptible to flooding with catastrophic results. During the flooding event of June 2013, peak flow rates of the Elbow River reached approximately 1240 m³/s while the natural capacity of the river is less than 200 m³/s, and the losses experienced during the flood were valued in excess of \$5B. The Springbank Off-stream Storage Project was conceived to divert and store the flows of the Elbow River during floods. Some of the main structural components of the project include a diversion structure that intersects the Elbow River, a diversion channel and an off-stream storage reservoir.

A large scale physical model study was subsequently commissioned to assist in assessing and improving the initial design for the diversion structure to ensure good performance under a range of flood conditions. The main objectives for the physical model study were to:

- determine the hydraulic performance of various key elements of the new diversion structure for a range of operational and extreme flow conditions;
- assess the behaviour of sediments and woody debris within and around the diversion structure; and
- help refine the proposed designs to improve conveyance, reduce the risk of erosion and sedimentation, reduce the risk of blockage by debris, improve constructability, and reduce costs where possible.

An undistorted three-dimensional physical model of the Elbow River floodplain and proposed diversion and spillway structures was constructed at a length scale of 1:16, and operated to meet these objectives. The full paper will provide a detailed description of the physical model with a focus on the tests in which the impacts of woody debris were studied and assessed. The physical model proved to be a very useful tool for assessing and refining the design of the new flood control structures to mitigate adverse impacts due to water-borne woody debris.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-733

Modeling of Hydraulic and Water Quality Performance of Bioretention Cells

Jianxun He
Jian Huang
Angus Chu
Caterina Valeo

Abstract:

The use of Low Impact Development (LID) technologies for managing urban stormwater runoff has shown promise in reducing or eliminating the need for traditional stormwater infrastructure. Bioretention cells, also called rain gardens, are one type of LID that collect, store and treat stormwater runoff on site. To date, few models are available for simulating the behavior of bioretention cells. Therefore, this paper proposes an event-based model for predicting hydraulic and water quality performance of bioretention cells. The model was developed using the data collected from a field-scale bioretention cell located in the City of Calgary, Alberta. A total of 10 storm events were used for model calibration and validation. The performance of the model was assessed in terms of both hydraulic parameters including time to peak, peak flow, and volume of retained runoff, and water quality parameters including the removal efficiency of total suspended solids (TSS). The results demonstrate that the proposed model is capable of simulating outflow hydrographs with the coefficient of determination (R^2) ranging from 0.683 to 0.852 and the normalized root-mean-square deviation (NRMSD) ranging from 12.50% to 20.13%. The differences (in percentage) between measured and modeled time to peak, peak flow, retained runoff volume, and TSS removal efficiency have a maximum value of 18%. In addition, the comparison between the proposed model and SWMM based model (PCSWMM) indicates that in general, the proposed model yields equivalent modeling results, but more accurately predicts the hydraulic parameters in intensive storm events when compared to PCSWMM. As a result, the proposed model has great potential as a practical modeling tool for designing bioretention cells and assessing their performance.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-734

Automated Feature Selection for Fuzzy Neural Networks: An Application for Urban Flood Prediction

Usman Khan

Abstract:

Urban floods are one of the most devastating natural disasters globally and improved flood prediction is essential for better flood management. Today, high resolution real-time datasets for flood-related variables (such as streamflow and precipitation) are widely available. This data can be used to create data-driven models for improved real-time flood prediction and risk analysis. However, data collected for extreme observations have large uncertainty which must be accounted for in the models. In addition to this, typically the selection of input features for data-driven models has been subjective. Addressing these concerns will improve flood prediction and will provide more accurate flood risk assessments. In this research, a new type of fuzzy neural network is proposed to predict peak flow in an urban river. The network uses fuzzy inputs, outputs, and model parameters. A probability-to-possibility transformation is used to convert observations to fuzzy numbers. These numbers better represent the uncertainty seen in this data as compared to probability based methods. A combination of an entropy minimizing technique and possibility theory based intervals are used to train the network. An existing method, the Automated Neural Pathway Strength Feature Selection (ANPSFS) method is then used to select the input features. The ANPSFS method uses the magnitude of the weights of the network to select the features, and is adapted to use fuzzy inputs. A number of different inputs are considered, including lagged precipitation and mean daily flow rate. The impact of this approach is that network training does not follow the typical ad hoc approach, but is based on objective criteria. Ten years of data for the Bow and Elbow Rivers in Calgary (including two major floods) are used to train and test the network. Model performance using different input selection is calculated and compared to demonstrate the effectiveness of using the ANPSFS approach.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-735

Field Study on the Decay of Supersaturated Total Dissolved Gases in the Lower Columbia River downstream of Hugh L. Keenleyside Dam

Rajib Kamal
David Zhu
Alf Leake
James Crossman

Abstract:

Reliable prediction of the decay of supersaturated total dissolved gases (TDGs) produced by hydropower operations is crucial to evaluating potential hydro-environmental-ecological impacts downstream of facilities. For quantitative prediction of TDG decay under different gate operation scenarios, detailed measurements of TDG and river hydraulics were collected in the Lower Columbia River downstream of Hugh L. Keenleyside Dam near Castlegar, British Columbia. The measured data in conjunction with an analytical approach was utilized to estimate the mixing and decay rates for four different operational conditions of low level outlet gates. For dimensionless mixing coefficients of 0.6 and 0.2 for the two sub-reaches of the river, the average decay rate was 0.017 hr^{-1} . Comparison with available decay equations and some widely used reaeration models indicated that further investigation would be useful to assess their applicability in the case of supersaturated TDGs and develop a predictive tool to estimate decay.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-737

Developing a Diurnal Pattern of Sewage Flow at Inlet Nodes Using Limited Measured Nodes – A Case Study of Greater Tehran Sewer System

Arash Karimzadeh
Sahere Kaykhosravi
Omidreza Shoghli

Abstract:

Dynamic hydraulic modeling is used for purposes such as Real-Time Control (RTC) or assessment of existing sewer system, in which determining the hydraulic status of the system is of high importance (EPA, 2006). Dynamic procedures are capable of modeling non-uniform and unsteady flows. Also, backwater, surcharge, and flooding can be calculated by such procedures. Since sewage flow through the system alters during the time, information such as inflow diurnal variation, specifically at inlet nodes, is essential. This information, which is derived from direct measurements of the system, is used as the variation of loads in a hydraulic model. In some cases, directly measured data are not available, particularly at inlet nodes, thus diurnal variation of sewage flow at inlets can be generated using recorded flow values at other locations. In this study, an algorithm is proposed for developing a diurnal variation of sewage inflow of Tehran sewer system by using measured flow data of four points across the system. In this case, majority of flow measurements had been accomplished in entrance of wastewater treatment plants (WWTP) instead of inlet nodes. In spite of insufficient recorded flow data, diurnal variation of inlet flows was generated using existing measured flow values. Then, it was used as inlet loads in hydraulic model of the sewer system. Finally, comparing the hydraulic model results with recorded data revealed significant similarity.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-738

Implementation of Bioretention as a Low Impact Development Option for Stormwater Management in Communities: A Barrier Analysis

Caterina Valeo
Jianxun He
Bernie Amell
Angus Chu

Abstract:

In September of 2015, researchers at the University of Calgary and the University of Victoria engaged the community in a one day workshop to determine the barriers to widespread implementation of bioretention in local communities. Over 20 people from industry, local government, and NGOs attended the workshop ranging in expertise from landscape architecture to ecology to municipal engineering. The workshop updated the invitees on current research in bioretention in cold and temperate climates in western Canada; introduced a pilot study applied multiscale bioretention (that is, implemented at the micro, meso and macrocosm scale) in the Town of Okotoks to demonstrate that bioretention can be used to effectively manage stormwater in a community of 25,000 people; and conducted a barrier analysis to determine what the barriers are to implementing bioretention as a low impact development option in communities in western Canada. The barrier analysis began with the question, “How might we make bioretention technology a pervasive standard for stormwater infrastructure in our communities?” The discussion and input in the 3 hour workshop resulted in a barrier tree with over 50 different gaps or tasks that need to be overcome before one can make bioretention technology a pervasive standard. These 50 tasks ranged from research gaps, to community engagement, to policy development. This paper provides the barrier tree with a prioritization of the tasks involved and provides starting tasks that engineers, researchers and the community must undertake to achieve widespread implementation of this low impact development option.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-739

Hybrid Absorbable Landscapes: Treatment Trains for Urban Stormwater Management – Monitoring, Modelling, Design and Implementation

Caterina Valeo
Rishi Gupta

Abstract:

The Hybrid Absorbable Landscape Project at the University of Victoria is a field scale development to test treatment trains for stormwater mitigation and sustainable urban development. Permeable pavements and bioretention cells are the two Low Impact Development options implemented in combination to create a test site that determines the efficacy of three different permeable pavements paired with three different bioretention cells (a fourth for control) to create stormwater treatment trains testable at the field scale. Permeable asphalt, Porous Pave® and interlocking pavers are the current permeable surfaces installed and each can be tested alone and as part of the inflow to bioretention cells. Current vegetation of the cells include poplar trees, Kentucky blue grass and drought resistant shrubs but all with the same soil media composition (which can also be changed) to 0.5 metre of depth. The field site is designed to allow determination of where, when and how stormwater pollutants are removed, maintenance requirements, temporal and spatial changes in hydraulic conductivity, and optimization of these hybrid systems to achieve the most cost-effective and practical low impact development design. This presentation will provide results on monitoring methods relevant for a variety of small and large scale parameters related to performance (surface infiltration rate, bioretention hydraulic conductivity, biological treatment), modeling water flow and pollutants through the treatment train using physically-based models and statistical methods, the most relevant design parameters including retention capacity within a hybrid system versus a single system, and implementation considerations in a community.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-740

SCS Storm Type Selection for Estimating Design Flows in Canada

Rob Millar

Abstract:

The US Soil Conservation Service (SCS) methodology for estimating design peak flows in small watersheds is widely used for design of water management infrastructure and has been incorporated in the HEC-HMS computer software. A key component of the methodology is selection of the appropriate design storm. Four synthetic 24-hour rainfall temporal distributions, or storm types (Type 1, 1A, 2 and 3) have been developed and are options within HEC-HMS. Within the USA, the geographical boundaries of the four storm types have been determined and the appropriate storm type can be readily selected. However, there is no established methodology for determining the appropriate storm type for projects located outside the USA, or whether these storm types are even applicable.

A methodology is presented that allows for a rational approach to determining the appropriate SCS storm type for a project that is located outside of the USA. The approach requires depth-duration-frequency (DDF) table values. An example of the methodology is presented for the Stewart A climate station, in British Columbia, which is located adjacent to the border with Alaska. The Type 1 storm is recommended for Alaska; however, the DDF data from Stewart (Figure 1) demonstrate that none of the standard storm types are appropriate, and the Stewart short-duration design rainfall intensities are generally lower than the standard storms. Therefore, adopting the Type 1 storm for Stewart would significantly overestimate the design peak flows. The Stewart DDF data and examples from other stations in BC are used to develop equivalent site-specific design storms to provide user-defined hyetographs for input to HEC-HMS.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-742

Effects of Climate Change on Stream Erosion in a Small Watershed

Colin Brennan
Parna Parsapour-Moghaddam
Colin Rennie
Ousmane Seidou

Abstract:

The effects of climate change on stream erosion are evaluated in Watts Creek basin, located in Ottawa, Ontario, Canada. The subwatershed has a drainage area of 21 km² with land use split between urban development (68%), forest (12%) and agricultural lands (20%). The SWMHYMO platform was used to develop a lumped hydrologic model of the area. The model was calibrated using field data collected between May and August 2015 and May and October 2016. Precipitation time series simulated by the Canadian Regional Climate Model 4 (CanRCM4) regional climate model ran under Representative Concentration Pathway (RCP) 85 for the 2041-2080 period at the MacDonal Cartier International Airport were downscaled using quantile matching and then used as input to the hydrologic model. A cumulative effective work index in response to reach-averaged shear stress was calculated in a reach of Watts Creek for both the historic (1967 – 2007) and projected future (2041-2080) flows. Results suggest an increase of 240% in the work index compared to historic conditions for the average measured bed material critical shear stress for entrainment of 3.7 Pa. The increased work is shown to occur in fewer, relatively more intense events, suggesting a significant change to the flow and erosion regime in Watts Creek.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-743

Modelling Supercritical Flows-Induced Scour around Structures

Sanaz Mehrzad
Colin Rennie
Ioan Nistor

Abstract:

During post-tsunami forensic engineering surveys carried out in Indonesia and Thailand following the 2004 Great Sumatra Andaman Tsunami, researchers were able to document local scour occurrences not only at buildings located close to shore, but also hundreds of meters inland (Nistor et al., 2005, Ghaobarah et al., 2006). The investigation of local scour caused by tsunami inundation around a structure has been investigated in previous studies. Laboratory waves employed in those studies were either solitary waves or long waves. At present, general scientific consensus indicates that solitary waves tend to be less representative of actual tsunamis due to their short period. This is particularly important for studies focusing on scour, where flow duration becomes important. The use of hydraulic bores generated from dam break waves have been shown to better replicate the temporal features of tsunami-induced flooding (Chanson, 2006). Hence, a similar approach was used in the present study which investigates the scour mechanism and vortex structure around the square structure due to inland-propagating tsunami bores on a dry and flooded horizontal bed. A series of hydraulic bores were simulated using the dam-break waves generated by the release of water impounded behind a rapidly-opening swing gate. It was found that the short duration and very turbulent nature of the bores induced a rapid scouring process. Significant scour depths were reached at the front of structure while repetitive sediment deposition pattern has been observed at the back of structure. The influence of bed condition (fixed versus mobile) and (dry versus wet) on bore characteristics, and how they might affect the scouring process will be presented and discussed.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-744

Modelling Ice Dynamics in the Upper Saguenay Fjord

Andrew Cornett
David Watson
Hossein Babaei
Mohamed Sayed

Abstract:

The Saguenay Fjord is notable for its complex and strongly stratified flows, with freshwater at the surface flowing over denser seawater at lower depths. During winter a stable ice cover forms over the upper part of the fjord, and commercial ships accessing port facilities in Chicoutimi and Port Alfred are escorted by ice breaking vessels operated by the Canadian Coast Guard. Ice breaking vessels are normally deployed in early- to mid-March to initiate the Spring break-up and assist with ice clearing operations.

A numerical model of ice dynamics previously developed at the National Research Council Canada has been setup and applied to support the planning and siting of future port facilities in the upper part of the fjord. The model predicts the deformation of an ice cover over time and space due to forcing by wind and surface current. The wind and current forcing can be steady and uniform or unsteady and spatially varying. Initial conditions are specified by prescribing the initial ice concentration and initial ice thickness throughout the computational domain. In this study the ice dynamics model was used to predict the temporal and spatial evolution of ice concentration, ice thickness and ice pressure throughout the region for various hypothetical scenarios, each comprised of an initial ice condition combined with assumed wind and current forcings. The current forcing was obtained from a 3D numerical model of hydrodynamics in the fjord, while the wind forcing was either derived from analysis of historical wind measurements or obtained from a numerical wind model.

The setup and application of the ice dynamics model will be described in the full paper. The sensitivity of the ice cover dynamics in the upper fjord to variations in initial ice concentration, initial ice thickness, wind direction and wind speed will also be described and discussed.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-745

Statistical Modeling of Extreme Rainfall Processes (SMExRain): A Decision Support Tool for Constructing Intensity-Duration-Frequency Relations for Urban Water Infrastructure Design

Truong-Huy Nguyen
Van-Thanh-Van Nguyen

Abstract:

In recent years, it has been recognized that society has become more vulnerable to extreme storm events. Many studies have been carried out to investigate the variation of these extreme storms. Of particular interest for urban water infrastructure design is the investigation of the probability of occurrence of the extreme rainfalls using frequency analysis method. Many probability distributions have been proposed to model the extreme rainfall processes. However, there is no general agreement as to which distribution should be used. Therefore, in practice, a number of popular distributions are often selected and their descriptive and predictive abilities are then investigated and compared. This task requires a significant investment of time due to the availability of an excessive amount of observed data from numerous sites and of different temporal scales and record lengths. This paper presents the development of a decision-support tool for statistical modeling of extreme rainfall processes (SMExRain). The proposed tool can be used in assisting stakeholders and decision-makers to identify the most suitable distribution(s) that could provide accurate extreme rainfall estimates. More specifically, the proposed tool can be utilized to evaluate the descriptive and predictive abilities of ten commonly-used probability models, Beta-K, Beta-P, Generalized Extreme Value, Generalized Logistic, Generalized Normal, Generalized Pareto, Gumbel, Log-Pearson Type III, Pearson Type III, and Wakeby, for their accuracy and robustness in the estimation of annual maximum rainfalls. SMExRain was tested using numerous daily and sub-daily extreme rainfall data available from a wide-range raingage network located in Quebec, Ontario, and British Columbia provinces of Canada.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-746

Modelling Stratified Flows in the Saguenay Fjord with Telemac-3D

Andrew Cornett
Abolghasem Pilechi
Julien Cousineau

Abstract:

The Saguenay Fjord extends for 110 km between the communities of Chicoutimi, where the fjord transitions to the Saguenay River, and Tadoussac, where the fjord meets the St Lawrence Estuary. The fjord is notable for its complex and strongly stratified flows, with freshwater at the surface flowing over denser seawater at lower depths.

A three-dimensional numerical model of the hydrodynamics in the Saguenay Fjord has been developed to support the siting and planning of future port facilities and improved navigation safety. In particular, surface currents predicted by the hydrodynamic model were used to force an ice dynamics model that in turn gave predictions of ice concentration, ice thickness and ice pressure throughout the region for a range of hypothetical scenarios.

The hydrodynamic model is based on the TELEMAC-3D solver, which employs finite-element methods to solve the Navier-Stokes equations, in either the hydrostatic or non-hydrostatic form, over a computational domain subject to initial conditions and time-varying boundary conditions. In two-dimensions (plan) the computational domain is represented by an unstructured mesh of triangular elements. Discretization in the third dimension (depth) is achieved by defining a constant number of sigma layers, whose thickness can vary with space and time depending on the local water depth. In its final iteration the entire 110 km long fjord was discretized into 21 sigma layers, with 12,500 nodes and 23,000 triangular elements in each layer.

The development, calibration, validation and application of the 3D hydrodynamic model will be described in the full paper. The influences of freshwater inflow and tidal forcing on the hydrodynamics in the upper part of the fjord will also be described and discussed.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-747

A Stochastic Approach to Downscaling of Multisite Daily Temperature Series in the Context of Climate Change

Van-Thanh-Van Nguyen
Mahzabeen Rahman

Abstract:

Climate change has been recognized as having a profound impact on the hydrologic cycle and many studies have been carried out to investigate this impact using outputs from Global Climate Models (GCMs). However, the coarse resolution of these GCM outputs is not adequate for assessing the climate change effects on hydrologic processes at the regional or local scale. Downscaling techniques have thus been proposed to resolve this problem. In particular, statistical downscaling (SD) methods are widely used because of their simplicity of implementation. However, most SD methods were developed for a single site without considering the observed spatial dependence of the hydrologic processes at different locations; this could significantly affect the accuracy of impact study results at the catchment scale. Therefore, in the present study an improved multivariate multisite SD approach was proposed for downscaling daily temperature series at many sites concurrently. This approach is based on multiple regression models for describing the linkages between large scale atmospheric predictors and local scale daily maximum and minimum temperatures, and on the use of the Singular Value Decomposition technique and multivariate autoregressive model (SVD-MAR) for capturing the observed statistical properties of the stochastic components of these regression models. The feasibility of the proposed approach has been assessed using the available NCEP/NCAR re-analysis data and the daily extreme temperature data available in two regions with different climatic conditions: the southern Quebec-Ontario region in Canada and the Bangladesh region. Results of this illustrative application have indicated the ability of the proposed multivariate multisite SD to reproduce accurately the observed statistical properties of the daily extreme temperature series, and the temporal and spatial dependence of the underlying temperature processes at different locations.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-748

Sourcing and Channeling Information Flows for Hydrological Prediction

Steven Weijs
Hossein Foroozand
Akhil Kumar
Luis Galindo

Abstract:

Hydrological engineering and science is tasked with providing predictions of the behaviour of various components of the hydrological cycle on various time scales. Since hydrological systems are vastly more complex than the amount of data we can practically collect could capture, we are stuck in the situation of predicting from partial knowledge, and uncertainty is inevitable. Choices and trade-offs have to be constantly made between different options for monitoring network layouts (variables, locations, times, scales), as well as choices between model approaches and different model complexities (data-driven/physically based, lumped / distributed).

In this presentation, we will give an overview of some recent work on the intersection of information theory and hydrology, done in the "hydro-info-theory" research group at UBC. The overarching aim of the research is to investigate approaches to increase the amount of useful information that our water management decisions are based on. Examples of elements that contribute to this aim are 1) better quantification of uncertainties (example on discharge); 2) sourcing hydrological information in more economic ways, that trade accuracy for spatial coverage (example on snow cover); 3) improving uptake of information into models by using an information-based approach to calibration and complexity control.

We argue that elements 1 and 3, where the raw data (and thus its information content) is fixed, are questions of channeling information and should be lead by purely information-based and epistemic considerations, while element 2, which represents the choice of what information to collect, is a question of sourcing information, and should be guided by utility-based and economic considerations.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-750

Deterministic Lake and Stream Temperature Modelling: Maintaining Optimal Water Temperatures for Kokanee and Rainbow Trout through Informed Design

Alana Shewan
Anna Akkerman
Violeta Martin

Abstract:

Stream temperature is an important indicator of habitat quality for fish of all life stages. However, stream temperature is often overlooked when designing mitigation systems, with the focus being on the effects of development on stream depth and velocity. A number of simple deterministic water temperature models exist for lakes, channels, and pipelines that can be utilized to optimize key design parameters for mitigation systems.

Knight Piésold Ltd. (KP) used water temperature modelling to support the preliminary design of a water supply system for a proposed mine in BC. The water supply system will augment flows to an existing stream to support kokanee and rainbow trout populations. The proposed water supply system includes an intake in a nearby existing lake, a pump and pipeline conveyance system, and a small reservoir with low level and surface outlets. KP modeled the water temperatures throughout the supply system and in the receiving stream using three models: a one dimensional Fresh Water Lake model (FLake), a heat transfer pipeline model, and the Stream Segment Temperature model (SSTEMP). Baseline models of the existing lake and stream were completed to assess model suitability and to calibrate model parameters. Operation models were then developed using long-term site specific climate inputs for the project. The models were run with various design considerations to maintain stream temperatures within optimal ranges to support various life stages of the kokanee and rainbow trout populations. Modelling identified the periods in which conditions similar to baseline could not be achieved and additional mitigation measures were required.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-752

Quantitative Assessment of River Ice Generation Using Shore-Based Photogrammetric Techniques

Saber Ansari
Colin Rennie
Ousmane Seidou
Jarrod Malenchak
Soheil Ghareh Aghaji Zare

Abstract:

Ice cover has great influence on hydraulics and morphology of rivers in high latitude areas of the northern hemisphere. Ice generation rate dictates the ice cover behavior and propagation during the river freeze-up. However, our understanding of the process is limited, due to insufficient observation data sets. The collection of reliable hydraulic data under the ice cover conditions is difficult, dangerous, or even impossible using traditional methods. In this study, a time series of images captured by a digital time-lapse camera was used to estimate the ice generation rate at two locations along the Lower Nelson River (LNR), an open water patch and on a border ice leading edge. It was observed that ice periodically formed and was advected out of the persistent open water patch. The image time series were geo-rectified and then ice generation in the patch was estimated based on observed changes in ice volume. The volume of thermal ice generation in the open water patch and on the shores of an island was estimated using the automated image analysis algorithm. Application of this algorithm in similar studies and acquiring more comprehensive data will lead us to more precise equations for estimation of river ice production.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-753

CFD Study of the Air-Entrainment Characteristics of a Submerged Hydraulic Jump

Vimaldoss Jesudhas
Vesselina Roussinova
Ram Balachandar
Ronald Barron
Priscilla Williams

Abstract:

Hydraulic jumps are associated with strong turbulence, free-surface fluctuations, air entrainment and energy dissipation. Over the last century, several researchers have attempted to study these characteristics experimentally. However, due to limitations of conventional measuring techniques in the air-water flow of the hydraulic jump, they were only partially successful. This paper presents the results of a three-dimensional, unsteady, detached eddy simulation of a submerged hydraulic jump with an inlet Froude number 8.2 and a submergence factor of 0.24. Volume of fluid (VOF) multiphase model is used for capturing the free-surface and the air-entrainment characteristics. The results of the simulations are validated with experimental results. The flow features of the submerged hydraulic jump captured by the simulation is presented with pertinent discussions. Since the submergence factor of the submerged hydraulic jump is low, a considerable amount of air was entrained into the flow. The mechanism of air entrainment in a submerged hydraulic jump is also analyzed.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-756

A Study of Factors Influencing the Sediment Accumulation Rates in Stormwater Management Ponds

Darko Joksimovic
Sidra Siddiqui

Abstract:

Stormwater Management (SWM) ponds have been the most commonly used Best Management Practice (BMP) for controlling stormwater runoff in North America. The rate of accumulation of sediments and pollutants is uncertain, and highly dependent upon pond design, catchment characteristics and precipitation patterns. A wide range of sediment accumulation rates is reported in literature, ranging from 0.2-5.8 m³/ha/year to 36.2 m³/ha/year. Sediment removal from SWM ponds is costly and sometimes neglected by municipalities. Predicting the rate of accumulation, to aid municipalities in prioritizing their maintenance priorities and capital planning, relies on regular pond surveys. The long-term objective of the current project is to develop a data-driven modelling approach for forecasting of sediment accumulation rates in SWM ponds, based on data collected from a large number of surveyed ponds in Southern Ontario. This paper presents the methodology employed to collect the necessary information, consisting of 1) a literature review to determine the potential influencing factors, 2) a survey of relevant information availability in Ontario municipalities, 3) interviews with municipal staff, and 4) collection, organization and analyses of provided data. The results of analyses of collected information point to inconsistencies in availability and format of relevant data. A preliminary investigation of accumulation rates indicates lower values than those reported in similar studies in the past, although pointing to the same trend of decreasing performance of SWM ponds over time.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-757

Modelling Streamflow and Sediment and Nutrient Export in Pothole-Dominated, Cold-Climate Prairie Watersheds using the Soil and Water Assessment Tool (SWAT)

Kerry Mazurek
Balew Admas Mekonnen
Gordon Putz

Abstract:

The landscape in the prairie region of Canada is dominated by millions of depressions, or potholes that have a significant impact on streamflow generation in the region. It has been difficult to incorporate the dynamic storage, or “fill and spill”, processes in hydrologic models of the region. Additionally, the region is located in a cold-climate, where snowmelt and soil thaw processes impact the generation of streamflow, sediment export, and non-point source pollutants from watersheds. This paper discusses an attempt to improve the hydrological model SWAT, the Soil and Water Assessment Tool, for modelling streamflow, sediment export, and water quality assessment for two pothole-dominated prairie watersheds in Southern Saskatchewan: the Assiniboine watershed; and the Qu’Appelle watershed. The Pond module of SWAT was modified to incorporate dynamic storage in the potholes in the watershed using a probability distribution to assess how much of the storage would be spilling and therefore contributing to streamflow on a daily basis. Soil erodibility coefficients were adjusted seasonally to improve estimates of sediment export in the watersheds. Using both SWAT modifications, the ability of SWAT to predict streamflow and sediment and nutrient (nitrogen and phosphorus) export was assessed. Improved performance for simulating streamflow was seen over the existing SWAT Pond module for simulating landscape storage and for sediment export over modelling that used annual sediment erodibility coefficients. Both sets of simulations were considered good using both graphical and statistical assessments of model performance. It was found that the modified SWAT model gave satisfactory performance for nutrient export, which is greatly improved over previous studies that used SWAT to simulate water quality in similar watersheds.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-759

Optical Remote Sensing Technique for the Generation of Meandering River Channel Topography and Sediment Grain Size

Sho Harada
S. Samuel Li
Michel Lapointe

Abstract:

Traditional cross-section survey techniques are costly, time-consuming, and difficult to implement, particularly in inaccessible areas. Practical limitation in the spacing and frequency of survey points restricts ground-based survey to reach scale. This paper demonstrates the potential of sizing bed materials within complex shallow channels, using high-resolution multispectral and stereo images. The demonstration uses a 13-km long reach of meandering, alluvial river (the Goulais River in Ontario). Fluvial remote sensing provides complimentary alternative to field survey, in which a watershed-scale, synoptic view of the river may be acquired. The presented technique generates a river topography model (RTM) by combining water depth map (bed to free surface) and the dry surface elevation map (free surface and above). The former is generated from the depth-to-brightness ratio that is empirically estimated by correlating available field survey points to the digital numbers of the image (excluding the bed elevation, z). The latter is generated through a photogrammetric analysis of stereo images. A challenge arises in combining the maps when the image used to derive the dry surface elevation is at a higher stage than the image used to derive the water depth. This is overcome by applying constant vertical displacement. The resulting RTM is a continuous digital terrain that encompasses the channel bed, floodplains, and the dry terrain features. Qualitative observations of the RTM indicate a correct placement of geomorphic features (pool-riffle system, point bars) for the river. The RTM is used as a model domain for depth-averaged simulations to estimate the bed shear stress corresponding to the formative discharge. The bed material sizes derived from the simulations compare well with field observations. The method presented offers a promising complimentary tool for river analysis.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-764

Experiences in Jet Erodibility Testing of Cohesive Soils

Kerry Mazurek
Mahmud Amin
Daniel Cossette

Abstract:

This paper discusses issues the many issues encountered over many years of testing for soil erodibility using the jet erodibility test, which has been used in Canada and extensively internationally, of both natural and manufactured cohesive soils. The test uses a submerged circular turbulent impinging jet, set at a large impingement height, to create scour in a soil sample and the time development of the depth of scour along the jet centerline is measured. The scouring rate and estimation of the equilibrium depth of scour then can be related respectively to the erodibility coefficient for the soil, which is a coefficient used in the relationship between erosion rate and excess shear stress on the soil, and the soil's critical shear stress. There have been issues with the diameter of depth of the test sample, fissures and rocks in the samples, vegetation, setting the appropriate jet velocity, and ultimately the underlying theory of the test. For the underlying theory of the test, it has been seen that original analysis of the test significantly underestimates the equilibrium depth of scour and therefore underpredicts the critical shear stress of the soil. Further, the analysis procedures assumed a linear relationship between the erosion rates of the soil and the excess shear stress on the soil, which appears not to be an appropriate assumption. It also appears that the shape of the scour hole can impact results although indicators of the scour hole shape are typically not included in the analysis procedures for the test nor measured during the test. Some results for the soil erodibility parameters using the original analysis procedures of Hanson and Cook (2004) are compared to those of a new erosion model by Walder (2015).



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-765

Simulation of Ice and Sediment Processes in an Alluvial Stream

Soheil Ghareh Aghaji Zare
Ousmane Seidou
Joe Groeneveld
Colin Rennie
Rajib Ahsan
Jarrod Malenchak
Sandy Melindy

Abstract:

The flow regime of streams in the northern hemisphere can be largely affected by ice formation during the winter period. The ice cover can affect not only the river hydraulics of a particular reach, but can also influence important sedimentation processes. Although the effects that an ice cover may have on flow hydraulics are reasonably well understood, our understanding of its impact on sedimentation processes is much less developed. The sparse availability of continuous and comprehensive information on fluvial behavior during the winter period has contributed to this lack of understanding. Numerical models are one means by which to bridge this knowledge gap, and improve our understanding of the complex interaction between ice covers, river hydraulics and sediment transport. Several ice simulation models have been developed and applied over the years. Of these, ICESIM has been widely (and successfully) applied in studies of several hydroelectric projects across Canada. The robust algorithms of the model have been successfully calibrated and utilized to simulate the river hydraulic characteristics and ice cover formation. The ICESIM model was originally developed by Acres International Limited (now Hatch) in 1973 for studies of the Nelson River hydroelectric plants and since then it has been continuously advanced and improved. In a recent series of improvements, the model was converted (from Fortran) to run on a Matlab platform, and a sediment transport simulation module was also added. The resulting model, ICESIMAT, is a one-dimensional, steady-state model capable of the simulation of ice cover formation and sediment transport in a river. In a recent study, ICESIMAT was applied to simulate ice cover formation and sediment transport in the Lower Nelson River, in northern Manitoba, Canada. The results of the numerical simulations were validated by in-situ measurements performed during several field campaigns at the study site.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-767

TDG Prediction Using a CFD Model

Nikou Jalayeri
Joe Groeneveld

Abstract:

The Boundary Dam is located on the Pend d'Oreille River in northeastern Washington. The project consists of a 340 ft high concrete arch dam, seven low level sluiceway outlets, two high level overflow spillways, and a 660 MW powerhouse.

Spillway and sluiceway discharges at the Boundary Hydroelectric Development have been shown to produce high total dissolved gas (TDG) concentrations in the tailwater of the spillway and the river reach downstream. Studies were commissioned to determine modifications to the project's spillway structures to help mitigate this gas production. Resolution of many of the hydraulic design issues for the study relied heavily on the results of numerical hydraulic models. These modifications were constructed and tested in the field.

The CFD model that was developed in support of these studies was used to simulate flows through a number of the project's seven sluice gates and two overflow spillways. This model was also used to simulate the entry and movement of these flows through the project's downstream plunge pool and powerhouse area. The model was setup to track the pressure- and time-histories of representative air bubbles within the plunge pool and tailrace. These data were then used as input to a TDG predictive tool to help predict total dissolved gas production in the tailrace. The overall predictive performance was successfully calibrated and validated to actual prototype (field) TDG data.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-770

Investigation of Spatial and Temporal Seasonal Rainfall Patterns Over Sinai Peninsula

Mohamed Elsanabary
Hadeer Khafagy
Sherif Abdellah
Mohamed Ibrahim

Abstract:

Heavy rainfall events are one of the essential tough climate events especially in steep and mountainous regions with small drainage area such as Sinai Peninsula, Egypt, which can lead to devastating flash water causing massive damages to life and infrastructure. The main goal of this paper is to investigate rainfall spatial and temporal patterns over Sinai Peninsula for 1981 – 2015 and its teleconnection to El Niño region. This study employed the wavelet analysis and wavelet principal component analysis (WPCA) to analyze the seasonal rainfall gridded data over Sinai Peninsula. The paper focused on two seasons: from January to March (JFM) and the other from October to December (OND). Results showed that Sinai rainfall can be delineated into three zones: northern zone of Sinai bounded by the Mediterranean Sea and Suez Canal, the central plateau and the southern triangular zone between Suez and Aqaba gulfs. The study revealed that the dominant frequency of seasonal rainfall ranged between 2-4 years for both seasons. For (JFM) season, northern Sinai suffered from a serious decrease in rainfall from 1991 to 2005, whereas, the peaks of rainfall occurred during the periods 1981-1991 and 2005-2012. For (OND) season, southern Sinai witnessed rainfall decrease within the period 1981-1992, rainfall increase within the period 1993-2015. Moreover, the whole Peninsula was exposed to an abundance of rainfall in the period 1981-1992 and rainfall decrease from 1993-2015. Finally, the study found a strong teleconnection between El Niño region and the northern zone of Sinai, represented by El Arish city rainfall.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-771

Risk Assessment of Waste Water Projects in Egypt

Mohamed Elsanabary
Amira Saleam
Ehab Tolba
Hassan Ibrahim

Abstract:

Waste water projects are dynamic sector which affect human's life and should meet the basic needs of individuals. Through the last decade, Egyptian Government has increased its intention to support waste water projects. One of the challenges facing waste water projects in Egypt is how to assess risks that affecting this kind of projects. These risks cause losses and consequently lead to an increase in cost, time delays and lack of project quality. The purpose of this paper is to identify risk factors that affect waste water projects in Egypt and assess the impacts of such factors in the project's cost and time. The research study area was taken in Damietta, Egypt through five years' time frame from 2011 to 2015. Eight major risk factors were identified to study their impact on the cost and time of waste water projects. The study claims that cost and time related risks are most likely to occur and have the major influence on replacement and renovation of waste water projects. Furthermore, waste water projects that are totally constructed, new in nature, have low risk impact score. Defective design risk is ranked as the first of the 8 major risk factors and affecting 50% of the waste water projects. The study divided risks in waste water projects into two main categories; technical risks such as defective design and managerial risks such as permits and information unavailability. Finally, in waste water projects, the study concluded that the technical risks are more frequent than managerial risks.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-772

Harvie Passage on Bow River: Using a Physical Model to Evaluate Post-Flood Rehabilitation Options

Ali Habibzadeh
Darren Shepherd
Chuck Slack
Brian Hughes
Carl Wirzba

Abstract:

Harvie Passage is situated on the Bow River in Calgary, Alberta and is bounded by Pearce Estate Park on the right (south) bank and Deerfoot Trail on the left bank. Harvie Passage is comprised of a High Water Channel (HWC) on river left and a Low Water Channel (LWC) along right bank. The unprecedented flood of June 2013 resulted in the 1:100-year flood discharge being conveyed through Harvie Passage, which caused major infilling of the LWC, some damage to the HWC drop structures, and lower river levels downstream of HWC Drop #4. Rehabilitation measures currently underway include repairing damaged areas, eliminating unsafe hydraulic conditions, re-establishing fish passage, and construction of a new LWC.

A 1:14 scale physical model was utilized over a range of river discharges to: (i) evaluate post-flood hydraulic conditions at HWC Drop #4; and (ii) develop modifications that re-established upstream fish passage and eliminated the safety hazard that resulted from tailwater reductions. Furthermore, the physical model was also used to evaluate modifications that improved recreational hydraulic performance and boater safety at HWC Drops #3L and #3R.

Based on the model test results, recommended design modifications to HWC Drop #4 included extending the high-flow channels (i.e., upper-tier sections of the drop structure), adding sub-plates below the drop exit, and removing a large boulder that was originally embedded within the right shoulder of the drop. Recreational hydraulic performance at HWC Drops #3L and #3R was improved by reducing the longitudinal slope of the existing low-flow channels (i.e., central section of the drop structure) and by installing sub-plates and a submerged sill below the drop exit.

This paper describes how the physical model served as an important tool in evaluating rehabilitation options at Harvie Passage that addressed boater safety concerns, re-established upstream fish passage, and improved recreational hydraulic performance.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-773

Examination of Pooled Flood Frequency Analysis for Canadian Catchments

Shabnam Mostofi Zadeh
Donald Burn

Abstract:

Floods are known as one of the most damaging forms of natural hazards with devastating influence on people and the environment. Accurately estimating flood frequencies is essential for effective design of flood mitigation systems, reservoir management, and pollution control. Estimation of these frequencies is difficult since extreme events are by definition rare and the length of recorded data is often short. In such situations, extreme flow information from a number of similar sites is combined (pooled) to augment the available at-site information. Pooled flood frequency analysis is a well-known approach used to improve the estimation of extreme flow quantiles at sites with short data records. Identification of pooling groups that will effectively transfer extreme flow information is thus important. This paper aims to explore approaches for obtaining improved flood quantile estimates based on pooled frequency analysis for extreme flow events. This study focuses on the region of influence (ROI) approach among different regionalization techniques to identify homogeneous pooling groups. The ROI is a site focused pooling approach that identifies a potential set of stations for each catchment that constitutes the region for that catchment. Instead of using either catchment characteristics or flood statistics, this study will explore several statistics representing the timing and variability of peak flow events. These flood seasonality measures will be employed in the definition of similarity/dissimilarity between sites. The dissimilarities are defined as a single numeric that represents the separation of two catchments in seasonality space. Different distance metrics will be considered to describe the closeness of each catchment to every other catchment. The discussed pooling techniques were employed for a collection of catchments in the Canadian prairies. The effectiveness of these techniques in identifying extreme flow quantiles was explored for the catchments under study.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-774

Assessing the Benefits of Various Levels of Flood Mitigation in a Highly Developed Setting

Nadeer Lalji
Andrew Forsyth

Abstract:

As demonstrated during the 2013 Flood, Calgary is at risk of overland flooding from the Bow and Elbow Rivers. The City of Calgary (City) mitigates this risk through emergency response measures that include deployment of temporary barriers in anticipation of a flood event. However, the City has limited time to respond as flood events develop and propagate quickly within the steep, mountainous upstream topography. In addition, the variability in which rainfall occurs in the Rocky Mountains also makes it difficult to accurately predict whether upstream events will impact Calgary. To reduce response efforts during an emergency, The City has considered implementing permanent flood barriers for communities at greatest risk. As much of Calgary's floodplain is developed and densely populated, constructing permanent flood protection within the City is a challenging task, with little room to construct barriers.

As such, the City retained Associated Engineering to assess the benefits and costs of constructing overland and groundwater flood protection for vulnerable areas in Calgary, and to identify the optimal protection level for various locations. This analysis was performed for events between the 1:20 year and 1:1000 year return periods, considering economic, social and environmental impacts as part of a Triple Bottom Line analysis.

In summary, the process included:

- Creating groundwater inundation mapping.
- Assessing overland and groundwater inundation mapping to identify areas requiring protection.
- Proposing conceptual level flood mitigation designs and developing high-level cost estimates.
- Estimating the damages associated with overland and groundwater flooding
- Estimating the damages averted by implementing flood mitigation, representing the benefits of flood mitigation.
- Comparing the benefits and costs of flood mitigation, identifying whether a project is cost-beneficial and the optimal protection level based on the maximum benefit-cost ratio and maximum net benefit.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-775

Scour in Complex Bridge Piers: Fraser and Padma Rivers

Jose Vasquez
Matt Gellis
Andre Zimmermann

Abstract:

The construction of complex bridge piers in large sand-bed rivers has become increasingly common. These piers are made by driving or boring a group of piles deep into the riverbed and then connecting them by a pile cap on top, over which the stem of the pier supporting the deck is located. In contrast with conventional footings, the pile cap is located high above the riverbed and close to the water surface, functioning also as protection against ship collision. The combination of several piles, pile cap and stem above the riverbed gives the pier a complex geometry, which does not easily fit with the simple geometry commonly assumed by most scour prediction equations; hence the need for mobile-bed physical modelling in order to determine scour depths for design purposes. We report the results of several complex piers scour experiments carried out at Northwest Hydraulic Consultants' laboratory including the Golden Ears Bridge, Port Mann Bridge and Pattullo Bridge in the Fraser River, British Columbia and the Padma River Bridge in Bangladesh. These pier tests encompass a wide range of conditions such as vertical and inclined piles (diameters from 1.8 to 3.0 m), rectangular, octagonal and dumbbell-shaped pile caps (pile cap lengths between 18 and 60 m), and flow discharges ranging from 2-year to 100-year floods. Maximum observed local scour depths varied between 14 and 22 m.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-776

Water Oscillations in Vertical Tubes for Application of Drainage Systems

Harry Edmar Schulz
David Zhu
Yiyi Ma

Abstract:

Vertical tubes are usual components of water distribution systems and of drainage systems. Drainage systems may be subjected to flooding events, which generate water columns with free surfaces in the vertical tubes. The water level corresponds, in these cases, to the hydraulic head where the vertical tube is located. Depending on the conditions of the flow in the system, pressure pulses may induce oscillations of the water level in the vertical tubes, eventually also generating phenomena like geysering.

Oscillations may subject the buried structures to efforts not necessarily considered in the design phase. Eventual checking thus needs the periods of the oscillations. The amplitude of the oscillations may imply in spilling of water from the top section of the tube, or a momentary ejection above the outer ground level. The study of the conditions of possible spilling events is necessary to allow preventive measures.

This study considers the dynamics of oscillating flows in vertical tubes. The governing equation for the flow is presented having the pressure imposed by the hydraulic head as the main impulsive factor of the movement. The resistive factors are taken into account through local and distributed losses. The equation is presented in normalized form, and predictions are compared with proper experimental data.

Results obtained in adequate experimental devices, for different diameters of the vertical tube, were analyzed together. Conclusions about the different measured periods and the damping of fluctuations are presented.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-777

Development and Field Application of the RCC Jack Jetty for River Training

Kerry Mazurek
Anupama Nayak
Nayan Sharma

Abstract:

Jack Jetties were river training structures used for bank protection and creating sediment deposition in the United States in the 1920's. The structures looked like the jacks that children had played with earlier in that century. The jacks were made of steel and were strung together to form lines much like groynes are used today. The structures were shown to be reasonably effective, but design procedures were ad hoc; ultimately their use in North America did not continue because of their potential for disrupting navigation. A study of the potential efficacy of the Jack Jetty was conducted for the purposes of determining their potential to create sediment deposition in large rivers in India. Laboratory tests of single jacks and jack jetty fields were conducted in the laboratory to examine the flow field behind a jack, using an Acoustic Doppler Velocimeter, and to get a sense of how to optimize sediment deposition with a jack field. One jack jetty field configuration was constructed in the River Ganga in India, one of the largest rivers in the world, to assess the effectiveness of the field at creating sediment deposition at a site where there was concern about erosion. The current jacks were not made of steel but instead of reinforced concrete to reduce costs. The laboratory tests showed that the jacks were effective at slowing the flow and causing deposition of sediment. Suggestions were made at optimum configuration for sediment deposition. The field test showed that the jetty field did indeed cause sediment deposition with a significant decrease in width of the channel through the field.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-779

Laboratory and Field Measurements of Turbulence Using an Acoustic Doppler Current Profiler

Navid Kimiaghalam
Shawn Clark

Abstract:

Acoustic Doppler current profilers (ADCPs) have been used widely in river engineering applications, in particular for measuring discharge and bathymetry along open channels. Reduced measurement time and simple deployment techniques are among the advantages of such devices compared to Acoustic Doppler Velocimeters (ADV). While the measurement accuracy of ADCP discharge measurements has been proven in several studies, there are few studies that have focused on using ADCP data to calculate turbulent flow characteristics within open channels, which is the focus of this paper. A four-beam M9 Sontek ADCP was used to measure and calculate stationary velocity profiles, turbulent kinetic energy (TKE), and Reynolds stress (RS) in a flume in the Hydraulics Research & Testing Facility at the University of Manitoba and within the Assiniboine River in the City of Winnipeg. Vertical profiles of velocity, TKE, and RS as well as depth-averaged values of these parameters were calculated under different flow conditions using measured ADCP data. Laboratory and field results were evaluated and compared with corresponding measurements using a Sontek MicroADV under the same flow conditions. Results showed that a four-beam ADCP can be used to calculate turbulent flow characteristics with a reasonable accuracy in a very short period of time compared to ADVs. It is anticipated that these field-based measurements of river turbulence will be helpful in predicting the type of river ice that may occur during freeze-up on rivers in cold regions.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-781

Experimental and Numerical Modeling of Hydrodynamic Loading on Pipelines due to Extreme Hydrodynamic Conditions

Behnaz Ghodoosipour
Ioan Nistor
Abdolmajid Mohammadian

Abstract:

Pipelines in coastal areas are used for gas and oil transportation, as well as for disposal of wastewater to water bodies. Installation of pipelines in coastal areas is of great importance, and requires consideration of different engineering design criteria. A new topic in pipeline design has emerged lately due to the recent extreme hydrodynamic events such as tsunami and storm surges. Therefore, the primary objective of this study was to investigate the hydrodynamic forces induced on pipelines during such extreme waves. A comprehensive program of physical model experiments were conducted in the Hydraulic Flume at the University of Ottawa. The tests attempted to measure the hydrodynamic forces exerted on pipe due to tsunami-like bores replicated using dam break flow. Different pipe placement configurations using different gap ratios (e/D), (e being distance to bottom and D pipe's Diameter), were tested under various flow conditions in wet and dry bed. For the case of dry bed conditions, experimental results show that only for $e/D = 0.3$, two peaks are noticeable in force time-history, whereas, for other relative gap ratios, no distinct peak was noticed. The main reason for such behavior when using small e/D ratios is the suppression of the vortex shedding which forms around the pipe. For the case of wet bed conditions, the time-history of the drag force shows no change even when drastically changing the relative gap ratio. The 1-D shallow water equations were also used to study the dam break flow over the flat flume bed and its impact with the circular cylinder downstream of the flow. The drag coefficient was then derived using experimental and numerical results and showed relatively good agreement between the two. Results from this study will be used for the assessment of the current design recommendations with the ultimate goal of improving them.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-783

Local Inflow Calculation for a Cascade Reservoir

Faheem Sadeque

John Taylor

Abstract:

Local inflows from ungauged tributaries of a cascade reservoir are often calculated as the residual from the hydraulic balance for the reservoir due to discharges from the upstream and downstream facilities. Level pool reservoir routing is commonly used for its simplicity of application. However, the accuracy of level pool reservoir routing principle has been found questionable in many cases, especially during peak facility discharges. The slope of the water surface increases as the discharge through the reservoir increases. Therefore, the storage volume estimated based on the measured reservoir elevation at the downstream end is no longer accurate. The change of reservoir volume in each time-step is under-estimated during the spill ramp-up period. This generates significant negative local inflows as output of the hydraulic balance equation. The additional storage volume under the sloping reservoir surface does not change if the spill discharges from the upstream and downstream facilities remain steady. As a result, the hydraulic balance equation provides reasonable output for local inflows during steady spill periods. Again, as the spill discharges ramp-down the slope of the reservoir surface diminishes releasing the additional volume of water. This unaccounted change of storage volume generates significant positive local inflows as output of the hydraulic balance equation. Hydrodynamic modeling was carried out for a cascade hydropower reservoir to demonstrate the inaccuracies of level pool reservoir routing calculations. The model results showed that the inaccuracies in storage volume estimates appear to be insignificant ($< 1\%$), but the calculated local inflows could be significantly erroneous. Some simple solutions were proposed to eliminate significant errors in local inflow calculations using hydraulic balance equation.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-784

Mesh-Free Two-Phase Modelling of Highly-Dynamic Sediment Transport

Ahmad Shakibaeinia
Ehsan Jafari-Nodoushan

Abstract:

Traditional approaches for the simulation of sediment transport are based on single-phase modelling, where a combination of flow equations, advection-diffusion equation, and (semi-) empirical relations are solved. Although these methods have proven their effectiveness in some of sediment transport studies, they are not suitable for highly dynamic movement of sediments as they are incapable of describing the underlying physics in detail. Such conditions are commonly initiated by highly-erosive flows or under powerful outer forces. Two-phase models have recently proven their potential for such sediment flow problems. These methods either describe the sediment material as a collection of discrete grains or as a body of the continuum. While discrete description provides in-depth results they are computationally intensive. The continuum description is computationally affordable; however, the conventional continuum-based methods rely on a mesh system, therefore they have issues in dealing with the deformation and fragmentation of sediment/water interface. A newer generation of methods, the mesh-free particle methods, combines the power of both discrete- and continuum-based methods. This study, introduces a multiphase mesh-free particle models for two-phase flow of water and sediments. The sediment material is treated as a continuum (a visco-plastic fluid) whose behaviour is predicted using a stress-dependent rheological model. The model is validated and applied for highly dynamic movement of dry and submerged sediments in cases such as submarine landslide and sediment scouring. The results of this study, evaluate the capabilities of mesh-free particle methods for complex sediment transport problems and provide a more thorough understanding of their complex mechanism and processes.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-785

Debris Flood Hazard Management in North Vancouver

Fiona Dercole
Kris Holm
Stephen Bridger

Abstract:

The District of North Vancouver (DNV) has a long history of managing geohazards. Starting in the 1990s, and updated approximately every 10 years, DNV has retained geotechnical and geoscientist consultants to assess debris geohazard (i.e., debris floods and debris flows) risks and make recommendations for reducing risk to tolerable levels. In 2015-2016, we completed comprehensive flood, debris flood- and debris-flow risk assessments for 35 steep creeks within the District using a variety of custom-tailored methods described in this contribution. While most creeks' headwaters are in forested and largely undeveloped terrain, the lower reaches flow through municipal areas containing over 20,000 buildings and a network of roads, utilities, and drainage infrastructure. The objectives of the assessment were to assess debris geohazards including their frequency, magnitude, extent, and potential to result in blockage and overflow of DNV drainage infrastructure; estimate the risk posed by these hazards to buildings and persons within buildings, prioritize locations for risk reduction planning; and develop risk control options and costs. Based on the results of the assessment, DNV staff are developing a 10-year work plan that will be integrated with the District's asset management, GIS-based inspection program, climate change adaptation and hazard mitigation plans. The work presented herein is an example of a pro-active science-based creek management program aiming to optimize funds for public safety and economic risk reduction.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-787

Reconstruction of Area-Capacity Curves for Alberta Lakes

Zahidul Islam
Michael Seneka

Abstract:

Area-Capacity curves represent the relationship of surface area and volume of a lake or reservoir to elevation. Area-Capacity curves are essential to the development of water balance models for lakes; more specifically, they provide science-based information on surface water availability at any given time. This information can be vital to the execution of informed management decisions, such as the permitting of water withdrawals from lakes in such a way as to protect ecosystems while supporting reliable, quality water supplies that contribute to a sustainable economy. Currently, there are three major sources of area/capacity information in Alberta: the Atlas of Alberta Lakes; Alberta Environment and Parks (AEP) archived files on lakes area/capacity calculation; and digital lake bathymetry from the Alberta Geological Survey (AGS). The Atlas of Alberta Lakes provides Area-Capacity curves for about 80 lakes in Alberta. However, these curves are only available in digital image format and are not usable unless digitized to retrieve the area/capacity information at various elevations. The AEP archived files contain manual calculations of area/capacity of lakes based on original bathymetry surveys for about 60 lakes and are not immediately accessible to the public. AGS data provide lakes bathymetry, but not the actual information on area/capacity. In the current study, an attempt has been made to combine these sources and reconstruct Area-Capacity curves for numerous Alberta lakes. Digital images of Area-Capacity curves from the Atlas of Alberta Lakes were manually digitized, and higher order polynomial equations were fitted to develop Area-Capacity curves. Lakes for which area/capacity calculations are not available but digital bathymetry data could be acquired through the AGS, an ArcGIS based tool was developed to construct Area-Capacity curves. A mathematical extrapolation technique was applied to extend the Area-Capacity curves beyond the original surveyed water level.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

HYD-788

The Importance of Fluvial Geomorphology in Hydraulic Engineering and the Contribution of Rolf Kellerhals

David McLean

Abstract: Dr. Rolf Kellerhals was an inspiration to young engineers and geomorphologists in western Canada during his career that spanned over four decades. As a specialist in River Engineering, he emphasized the importance of utilizing the tools of the geomorphologist to improve our understanding of river processes and to improve our predictions on how rivers would respond to engineering works. Much of his work related to assessing the effects of hydro power projects and diversions on river stability and morphology and emphasized the use of interpretative methods to provide independent checks on predictions from standard hydraulic engineering methods such as hydraulic modelling. This paper reviews the contribution made by Dr. Kellerhals using case histories and examples from past projects. It also shows that his message is still very relevant today, where so much emphasis is on the use of complex morphodynamic models that often have limited validation testing over the long time scales that are required to assess project impacts.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-800

Scale-up Factors When Applying Bioventing Results to the Field

Richard Zytner
Maryam Eyvazi
Michael Mosco
Alamgir Khan

Abstract:

Bioventing is an important technology used to remediate Brownfields contaminated with petroleum hydrocarbons. It is a low cost non-destructive in-situ method that uses natural occurring microbiology to degrade the contaminants. One challenge for bioventing is evaluating the correct degradation rate for application in the field. Literature shows limited research with large scale bioventing reactors, so a 80 kg reactor was developed to test soils contaminated with synthetic gasoline when subjected to bioventing conditions. Two soils were tested, with the first-order degradation rates compared to the degradation rates determined with a 200 g respirometer and 4 kg reactor to allow estimation of the scale-up factors.

Results from the 80 kg study show that a first-order two-stage degradation process exists. A similar phenomenon was found for the 4 kg reactor, but a first-order single stage degradation trend was found for the respirometer studies. In the 80 kg reactor, the sandy loam soil had a second stage degradation rate of 0.12 d^{-1} , while the silt loam soil had a degradation rate of 0.075 d^{-1} . Comparing these degradation results to the respirometer studies gave scale-up factors of 2.7 and 1.9 respectively. Comparing the 80 kg rates to the 4 kg reactor degradation rates, showed no statistical difference between the degradation rates, with similar scale-up factors. This indicates that there is no significant advantage in completing bioventing experiments at the larger 80 kg scale. As expected, when comparing the degradation rates for the two different soil types, there was a statistical difference between the degradation rates. When the soils tested was expanded to seven for the 4 kg reactor and 200 g respirometer, further differences in degradation rates between soils was found, with an average overall scale-up factor of 1.8 ± 0.5 . The use of the scale-up factor will be discussed in the presentation.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-802

Enhanced Electrochemical and Biological Phosphorus Removal in a Sole Reactor

Adam Abdelmajeed
Maria Elektorowicz

Abstract:

Excessive phosphorus levels in aquatic environments create toxic algal bloom resulting and eutrophication. To control this undesirable phenomenon, phosphorus removal from municipal wastewater treatment plants (WWTPs) is essentially required. The removal of nutrients requires constructing various operation units to provide different conditions (i.e. anaerobic, anoxic, and aerobic) intended to promote removal efficiency of each single nutrient compound. Such designs have high energy consumption and a big footprint. In this work, the possibility of simultaneous biological and electrochemical phosphorus removal mechanisms in a sole reactor was investigated. Electro-bioreactor was fed with synthetic wastewater containing phosphorus in range of 2 - 8 mg/L $\text{PO}_4^{3-}\text{-P}$. At steady state condition, the removal efficiency of phosphorus (as $\text{PO}_4^{3-}\text{-P}$) reached up to about 99%. This high percentage of phosphorus removal was due to both electrocoagulation process and polyphosphate-accumulating organisms (PAOs) growth in the reactor. Such single reactor (submerged membrane electro-bioreactor, SMEBR) is capable to create anoxic and aerobic conditions suitable for biological phosphorus removal by supplying adequate direct current density (CD) and dissolved oxygen (DO). Furthermore, the coagulation agent (Al^{3+}) is *in situ* generated due to the electrolytic dissolution of aluminum anode, which led to higher electrochemical phosphorus removal in the system and hence reduced chemical relevant-costs. The innovated technology has also shown its high potential to meet the principles of sustainability and flexibility of design including a small treatment system for individual homes.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-803

**Oil Sands Process-Affected Water (OSPW) Management Using Basal
Depressurization Water (BDW) in Forward Osmosis (FO)**

Shu Zhu

Mohamed Gamal El-Din

Mingyu Li

Abstract:

Large volumes of oil sands process-affected water (OSPW) containing high concentrations of organic and inorganic compounds like silts, salts, aromatic compounds and naphthenic acids (NAs) are produced during the oil sands mining processes. Currently, tailing ponds cover an area of 180 square kilometers and the surface is increasing yearly as new ponds are being developed. Due to the large quantities of stored OSPW, its safely discharge and recycle become an urgent need. The nature of forward osmosis (FO) demonstrates the capability of treating two wastewaters simultaneously. In the current study, to reduce the cost and energy input, FO was proposed to desalinate OSPW, using on-site waste basal depressurization water (BDW) as the draw solution. Short-term desalination experiment indicated that water flux obtained in PRO mode was higher than that in FO mode and also, increasing crossflow velocities accelerated the water flux regardless of membrane orientation. Although the evidence of calcium bicarbonate precipitation was observed on OSPW-oriented side in both orientations, the results of long-term desalination experiments did not provide a clear difference between FO and PRO modes on membrane fouling because of the comparatively low water flux. Membrane cleaning research indicated that osmotic backwash using clean water efficiently recovered the initial water flux. High rejection rate (> 90%) of inorganic and organic species was achieved, especially, the rejection of naphthenic acids (NAs) reached above 94%. Meanwhile, the volume of OSPW was decreased >40%, corresponding to 1.4 times dilution of BDW in 24 hours. The obtained high rejection rates realized the potential of safe discharge and/or reuse the diluted BDW after a sufficient processing period.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-804

Comparison of UV/hydrogen Peroxide, Ferrate(VI), and Ozone in Oxidizing Oil Sands Process-Affected Water (OSPW)

Chengjin Wang
Nikolaus Klammerth
Selamawit Ashagre Messele
Arvinder Singh
Mike Belosevic
Mohamed Gamal El-Din

Abstract:

The high concentration and low biodegradability of the organic matters in OSPW prompted extensive chemical oxidation research in OSPW treatment. However, a well-defined performance comparison among these different oxidation processes, especially between selective oxidation and unselective oxidation, is currently not available, mainly due to varying raw OSPW quality among different studies and different experimental designs. To fill this gap, this research compared the oxidation performance by UV/H₂O₂, potassium ferrate(VI), and ozone (with and without hydroxyl radical (\cdot OH) scavenger tert-butyl alcohol (TBA)).

In this project, the removal of aromatics and naphthenic acids (NAs) was explored by synchronous fluorescence spectra (SFS), ion mobility spectra (IMS), proton and carbon nuclear magnetic resonance (¹H and ¹³C NMR), and ultra-performance liquid chromatography time-of-flight mass spectrometry (UPLC TOF-MS). UV/H₂O₂ oxidation occurred through radical reaction and photolysis, transforming one-ring, two-ring, and three-ring fluorescing aromatics simultaneously and achieving 42.4% of classical NA removal at 2.0 mM H₂O₂ and 950 mJ/cm² UV dose. Ferrate(VI) oxidation exhibited high selectivity, preferentially removing two-ring and three-ring fluorescing aromatics, sulfur-containing NAs (NAs+S), and NAs with high carbon and high hydrogen deficiency. At 2.0 mM Fe(VI), 46.7% of classical NAs was removed. Ozonation achieved almost complete removal of fluorescing aromatics, NAs+S, and classical NAs (NAs with two oxygen atoms, 97.1% removal) at the dose of 2.0 mM O₃. Both molecular ozone reaction and OH reaction were important pathways in transforming the organics in OSPW as supported by ozonation performance with and without TBA. ¹H NMR analyses further confirmed the removal of aromatics and NAs both qualitatively and quantitatively. All the three oxidation processes reduced the acute toxicity towards *Vibrio scheri* and on goldfish primary kidney macrophages (PKMs), with ozonation being the most efficient. Based on both the performance and the economic consideration, we recommend ozonation for OSPW treatment.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-805

Biotransformation of Aromatic Compounds in Oil Sands Process-Affected Water by Pseudomonads

Yanyan Zhang

Jinkai Xue

Mohamed Gamal El-Din

Abstract:

Aromatic naphthenic acids (NAs) in oil sands process-affected water (OSPW) had been demonstrated to cause more toxicity than classical NAs. Therefore, appropriate approaches are required to reduce their toxicity for safety discharge. In this study, *P. fluorescens* and *P. putida* were used to evaluate the potential biotransformation of aromatic compounds in OSPW. The effect of external carbon and iron on biotransformation was also explored. The results showed with external carbon source both *P. fluorescens* and *P. putida* have the capability of biotransforming aromatic compounds in OSPW. Although no significant classical NA removal was observed during this process, toxicity reduction of 49.3% was achieved under optimal condition of biotransformation. The external carbon source played an important role in ring cleavage and the additional ferric chloride could accelerate the bacterial growth and toxicity reduction. Tests for ring-cleavage enzyme activities showed that Pseudomonads growing in OSPW had an active catechol 1,2-dioxygenase with specific activities ranging from 264.7 to 382.7 U/g protein, whereas no activity of 2,3-dioxygenase was observed, suggesting that the orthoring cleavage is the major pathway of aromatic degradation in OSPW. Gene expressions of functional PAH-ring hydroxylating dioxygenase (PAH-RHD) were determined through reverse transcription real-time PCR, suggesting the degradation of aromatic compounds in OSPW. Toxicity of OSPW was eliminated completely when this biotransformation approach was coupled with ozonation at a dose of 80 mg/L, indicating it is a promising OSPW treatment approach for the safe discharge of treated OSPW to the aquatic environment.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-806

When Membrane Bioreactor Meets Ozonation: A Possible Solution to the Oil Sands Process-Affected Water (OSPW) Issue

Jinkai Xue
Yanyan Zhang
Yang Liu
Mohamed Gamal El-Din

Abstract:

Concerns are widely raised about the impacts of enormous volumes of oil sands process-affected water (OSPW) on the regional environment in Alberta, Canada. In OSPW, naphthenic acids (NAs) are regarded as the most problematic organic compound group as they have acute toxicity to aquatic organisms. NAs are aliphatic or alicyclic carboxylic acids naturally existing in petroleum. It is estimated that the OSPW NAs' *in situ* biodegradation half-lives could be as long as 13 years. The current study was focused on the biodegradation of classical and oxidized NAs and membrane fouling in two identical membrane bioreactors (MBRs) operated in parallel, which received raw and ozonated OSPWs, respectively. It was found that the MBRs are effective in degrading both classical and oxidized NAs indigenous to raw and ozonated OSPWs. The low-dose ozone pretreatment not only substantially enhanced the MBR's NA biodegradation performance, but also significantly alleviated the system's membrane fouling. The MBR coupled with ozone pretreatment successfully removed 94.0% of NAs from OSPW within 12 hours under the optimized operating condition, and experienced severe fouling (transmembrane pressure exceeded -35 kPa) only once during the 742 days of continuous operation. Statistically analysis indicated that certain microorganisms are closely correlated with the biodegradation of NAs with particular molecular structures. For instance, *Rhodocyclales* demonstrated strong positive correlations to the removal of NAs with 12 – 17 carbon atoms and 3 – 4 rings. Moreover, it was found that the ozone pretreatment remarkably affected the microbial community structures in the MBR by repressing the growth of bacteria (e.g., *Rhodocyclales* and *Burkholderiales*) known for facilitating biofilm (biofouling) formation. The combination of low-dose ozone pretreatment (i.e., 30 mg O₃/L) and MBR is a competent candidate for OSPW treatment on a large scale in the future.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-807

Application of Electro-oxidation for Naphthenic Acids (NAs) Degradation

Abdallatif Abdalrhman
Mohamed Gamal El-Din

Abstract:

As a result of the currently used processes for bitumen extraction from oil sands and subsequent froth treatment, large volumes of Oil Sands Process-Affected Water (OSPW) are generated. It has been confirmed by different researchers that OSPW is acutely, sub-chronically and chronically toxic to a variety of aquatic organisms. The treatment of OSPW is considered a great challenge facing the oil sands industry today. Among the different constituents in OSPW, a group of aliphatic and alicyclic carboxylic acids known as naphthenic acids (NAs) are believed to be responsible for the toxicity of OSPW. NAs are highly toxic, recalcitrant and persist in the environment for many years.

Electro-oxidation has emerged as promising process for wastewater treatment. It involves the application of direct current (DC) voltage by using suitable type of electrodes and an external electricity source. In electro-oxidation, pollutants can be oxidized either directly by exchanging electrons with the anode surface, or by indirectly through the mediation of some electroactive species generated at the electrodes. It has been applied successfully for the degradation of a variety of recalcitrant organic pollutants. The objective of this research is to investigate the effectiveness of applying electro-oxidation for the degradation of NAs. The study will focus on evaluating the performance of electro-oxidation under low current (energy) operating conditions for degrading NAs and reducing their toxicity, in addition to understanding the involved mechanisms and reaction pathways. The preliminary results from this study have indicated positive performance for electro-oxidation in degrading model NAs such as cyclohexanecarboxylic acid (CHA) and commercial mixture of NAs. Applying a low current density of 0.5 A/m^2 by using cheap electrodes material such as graphite has resulted in removal rates of 67.0% and 83.1% for CHA and commercial NA mixture, respectively.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-808

Remediation of Oil Sands Process-Affected Water (OSPW) by Indigenous Microorganisms Based Biofiltration

Lei Zhang
Yanyan Zhang
Mohamed Gamal El-Din

Abstract:

Biofiltration has been considered as one of the most important biodegradation processes for the removal of organic pollutants from wastewater. The main objective of this research was to investigate the efficiency of indigenous microorganisms based fixed bed biofilm reactor to treat OSPW using sand as media. The growth of the bacteria on the media and the development of indigenous microorganisms based biofilm were investigated by using qPCR and Z stack technology from confocal microscope. Under steady state condition, the number of total bacteria on the biofilter media was 10^9 copies per gram of sand media and the thickness of the biofilm on the sand filter was 36.3 μ m. The OSPW treatment efficiency was assessed under different conditions, including no recycling (allowed to reach initial steady-state) and different circulation times. Treated water samples from different circulating times were used for naphthenic acids (NAs) analysis. Through the 12 times of circulation on the biofilter, classical NAs from raw OSPW were removed by 39.05%. Microtox® bioassay was used for the toxicity analysis, and it was found that the toxicity of the OSPW toward *Vibrio fischeri* decreased from 27.27% to 20.33% (5 min) and from 31.22% to 24.06% (15 min) after 12 times of circulation on the biofilter. Next generation sequencing technique was used for the mega genomic sequencing analysis of the microorganisms on the biofilter. The microbial community structure investigation showed that *Rhodococcus spp* was the dominating bacterial species on the biofilter, which indicated that *Rhodococcus spp* played a critical role during the biodegradation of NAs. With clear advantages of harmless to ecosystem and low energy demand, the indigenous microorganisms based biofiltration process shows high possibility to be scaled up and used for OSPW treatment *in situ*.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-809

Comparison of Nitrilotriacetic Acid and [S,S]-Ethylenediamine-N,N'-disuccinic Acid in UV-Fenton for the Treatment of Oil Sands Process-Affected Water at Natural pH

Ying Zhang
Nikolaus Klamerth
Pamela Chelme-Ayala
Mohamed Gamal El-Din

Abstract:

The increasing amount of oil sands process-affected water (OSPW) in Alberta, Canada, its high toxicity towards aquatic organisms due to naphthenic acids (NAs) and other organics, and the zero discharge practice of the oil sands industry urge researchers to seek effective approaches for its treatment. The application of UV-Fenton processes as a common advanced oxidation process with two chelating agents, nitrilotriacetic acid (NTA) and [S,S]-ethylenediamine-N,N'-disuccinic acid ([S,S]-EDDS), for the treatment of OSPW at natural pH was investigated. The half-wave potentials of Fe(III/II)NTA and Fe(III/II)EDDS and the UV photolysis of the complexes in MilliQ water and OSPW were compared. Under optimum conditions, UV-NTA-Fenton exhibited higher efficiency than UV-EDDS-Fenton in the removal of acid extractable organic fraction (66.8% for the former and 50.0% for the latter) and aromatics (93.5% for the former and 74.2% for the latter). NA removals in the UV-NTA-Fenton process (98.4%, 86.0%, and 81.0% for classical NAs, NAs + O (oxidized NAs with one additional oxygen atom), and NAs + 2O (oxidized NAs with two additional oxygen atoms), respectively) under the experimental conditions were much higher than those in the UV-H₂O₂ (88.9%, 48.7%, and 54.6%, correspondingly) and NTA-Fenton (69.6%, 35.3%, and 44.2%, correspondingly) processes. Both UV-NTA-Fenton and UV-EDDS-Fenton processes presented promoting effect on the acute toxicity of OSPW towards *Vibrio fischeri*. No significant change of the NTA toxicity occurred during the photolysis of Fe(III)NTA; however, the acute toxicity of EDDS increased as the photolysis of Fe(III)EDDS proceeded. NTA is a much better agent than EDDS for the application of UV-Fenton process in the treatment of OSPW. This is the first application of the UV-chelate-modified Fenton on the OSPW remediation. The findings obtained in this study have significant impact for the further development of this process and OSPW remediation.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-810

Removal of a Model Naphthenic Acid -Trans-4- Pentylcyclohexane Carboxylic Acid Using Mesoporous Carbon Xerogel Adsorbent

Mohamed Ibrahim
Selamawit Ashagre Messele
Mohamed Gamal El-Din

Abstract: Oil sands process-affected water (OSPW) is a by-product of the bitumen extraction process from the oil sands surface mines. OSPW is stored onsite in huge quantities due to Alberta zero-charge policy and the OSPW toxic constituents such as Naphthenic acids (NAs), and heavy metals. Xerogel is a mesoporous carbon based adsorbent that can be used to remove the NAs from the OSPW for safe discharge of the treated water to the environment. In this study, two carbon xerogel adsorbents (i.e., XG-5.5 and XG-6.9), having different textural properties were prepared by the polycondensation of resorcinol and formaldehyde using two different solution pH values. Both adsorbents were characterized for surface morphology, surface functional groups, and surface area using SEM, XPS and BET surface area analyser, respectively. Trans-4-Pentylcyclohexane (TPCA) model compound was used to evaluate the effectiveness of the two adsorbents in removing the NAs from aqueous solutions. TPCA stock solution was prepared in pH 8 phosphate buffer to simulate the OSPW water matrix. As a positive control, commercially available granular activated carbon (GAC) was used to assess the removal of TPCA from the water. Characterization result reveals that the GAC has the highest surface area followed by XG-5.5 then XG-6.9. The TPCA isotherm was developed using all of the three adsorbents. The kinetics of the removal were investigated for each of the adsorbents. Preliminary results show that the XG-5.5 removal percentage is slightly higher than that of the AC for concentrations up to 60 mg/L. The results highlight that the mesoporous XG 5.5 can be a good alternative to the commercially available GAC in removing the NAs.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-812

Enhancement of Primary Treatment of Combined Sewer Overflow (CSO) by Using Ferrate (VI)

Abdulrahim Alumairi
Mohamed Gamal El-Din

Abstract:

Ferrate (Fe(VI)) is a dual-function chemical that has been used as an oxidant and coagulant in different water and wastewater treatment applications. In this study, Fe(VI) has been applied to enhance the primary sedimentation process for the treatment of CSOs. In particular, jar tests have been conducted on CSO samples to optimize the dose of Fe(VI) with and without cationic polymer for the removal of common regulated parameters, including total organic carbon (TOC), dissolved organic carbon (DOC), chemical oxygen demand (COD), total suspended solids (TSS), volatile suspended solids (VSS), phosphate, UV_{254} , nitrite, nitrate, alkalinity, total coliform, and fecal coliform. Moreover, the impact of the water matrix on the removal efficiency has also been investigated. Powder form of the ferrate (76% purity) has been used to avoid any competing process, with doses ranging from 0.5 mg/L to 15 mg/L. Our preliminary results showed that the pH of the treated samples ranged from 6.5 to 7.5 without any further pH adjustment. Our data also showed that 0.5 mg/L of Fe(VI) with 1.25 mg/L cationic polymer (1.25 mg/L) removed 83% of TSS, 62% COD and 54 % of turbidity, while the same dose of Fe(VI) without cationic polymer removed only 70% of TSS and almost same removal for COD and turbidity. The highest turbidity removal (58%) was achieved using 2.5 mg/L of Fe(VI), while the maximum COD removal (65%) was obtained by using 1 mg/L of Fe(VI) with cationic polymer. In general, the preliminary results of our study are promising; however, additional optimization tests are warranted.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-813

Ozonation of Synthetic Combined Sewer Overflow: Impact on the Fate of Silver Nanoparticles

Mirna Alameddine
Selamawit Ashagre Messele
Abdul Mohammed
Mohamed Gamal El-Din

Abstract:

In Edmonton, the only city in Alberta with a combined sewer system, there is a growing interest in the enhancement of Combined Sewer Overflow (CSO) treatment to maximize the removal efficiency of common regulated parameters, microorganisms, micropollutants and nanoparticles before the final discharge. All efforts converge to reduce the emission of any potentially toxic material into the North Saskatchewan River, and ultimately protect the environment and public health.

Nanoparticles have been increasingly used in manufactured goods, with silver nanoparticles (AgNPs) being the most prevalent. In fact, AgNPs are often applied to cleaning and personal care products due to their antimicrobial properties and high surface area, a feature of their nano-scale size. After consumption, they eventually end up in the wastewater stream. Given their characteristics and demonstrated toxicity to aquatic environments, the efficient removal of AgNPs from CSO prior to the final effluent release evolves into a real challenge.

While most studies have addressed the physical removal of AgNPs from wastewater through sorption during secondary treatment, in our research, chemical removal by ozonation is proposed as a step following coagulation/flocculation/settling, to primarily oxidize AgNPs in the CSO. Our preliminary experiments have revealed that an applied ozone dose of 21.5 mg/L can chemically transform around 28% of synthesised AgNPs into silver oxide, in a MilliQ water matrix, under uncontrolled conditions.

This study will explore, through bench scale experiments, the fate of AgNPs in CSO upon ozone addition. Ozonation will follow a jar test operated under optimum conditions with samples of primary influent diluted with deionized water as deemed necessary to simulate real CSO. The outcomes will be directly relevant to the Canadian water resources as they will provide a robust CSO treatment process designed with simultaneous oxidation and disinfection to improve the overall quality of discharged effluents to aquatic environments.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-816

Assessment the Presence of Heavy Metal (HM) Concentration in River Water and Fish Species and Associated Human Health Hazard due to the Fish Consumption of Turag River in Bangladesh

Sk Abdur Rashid
Afia Siddika
Tauhidur Rahman

Abstract:

Dhaka city, the capital of Bangladesh is one of the densely populated in the world with more than nine million people living in 300 square km area. One of the main rivers around Dhaka city is Turag River which is highly polluted. Wastes and effluents generated from industries and houses are directly discharged into this river without any treatment. Fishes eat wastes and deposit in their tissues as a form of Heavy Metal (HM) and through food chain HM transforms to human body and create health hazard. This study focuses on assessment of concentration of HM and potential human health hazards due to consumption of two fish species namely Banded Snakehead (*Channa striata*) and Stinging Catfish (*Heteropneustes fossilis*). Concentration of four HM i.e. chromium (Cr), cadmium (Cd), lead (Pb) and arsenic (As) in river water and two fish species of this river was measured by atomic absorption spectrophotometer and presence were further confirmed by Scanning Electron Microscopy. The average concentration of HM in river water varied in descending order: Cr(16.67-20.07)>As(8.84-116.2)>Pb(6.4-8.56)>Cd(0.42-0.84) µg/L, respectively. Both non-carcinogenic risk (NCR) and carcinogenic risk (CR) were calculated to examine effects on human health due to HM. It is found that both total target hazard quotients (TTHQ) and total hazard index (THI) exceeds the limiting value for both female and children consumers reflecting higher potential of developing NCR. Though for male, both THI and TTHQ are below limiting value indicating below unacceptable risk, but is not considered safe to consume as their hazard index (i.e. THI and TTHQ) are approaching to limiting values. Again, considering CR, arsenic indicated potential risk particularly to female and children. Therefore, to consume these fish species from this river is not safe for human health. To remove/minimize HM from river, phytoremediation process is being used and further study is under process.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-817

Biomass Waste-Derived Adsorbents for the Removal of Organic Pollutants from Water

Chunjiang An
Gordon Huang
Xiujuan Chen
Yarong Shi
Wenxia Wang

Abstract:

Many physical, chemical and biological approaches, such as coagulation/flocculation, advanced oxidation and membrane filtration have been used in the removal of pollutants from wastewater. Adsorption is an effective alternative for wastewater treatment and it has been widely employed to remove hazardous inorganic and organic pollutants present in the effluent. It is featured with some advantages such as simple design and toxic tolerance. A number of adsorbents including activated carbon, diatomite, clay, and adsorptive resin have been used for the treatment of wastewater. Biomass adsorbents derived from biomass wastes such as orange peel, rice husks, peanut husk, corn cobs and wheat straw are also applied in pollution control. This study investigated the removal of organic pollutants from water using biomass-derived adsorbents such as flax and biochar. The surface of biomass-derived adsorbents was characterized by infrared and SEM analysis. Both equilibrium and kinetic adsorption studies were conducted and the effects of aqueous chemistry on adsorption performance were explored. Different mechanisms contributed to the pollutant removal process. The results of this study have important implications for the future application of biomass-derived adsorbents in pollution control and prevention.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-818

Treatment of Oily Wastewater Using Ultrafiltration Membranes Modified by Nano Particles

Xiujuan Chen
Gordon Huang
Chunjiang An

Abstract:

Oil is one of the most important hydrocarbon products in the modern world. It can cause environmental pollution when released into the environment without appropriate treatment. The development of membrane filtration provides a promising alternative for oily wastewater treatment. Membrane fouling is a critical issue that affects treatment efficiency and service life of membrane. Membrane surface modification is a viable approach to improve its antifouling ability. In this study, PVDF membrane was grafted with poly(acrylic acid) (PAA) by cold plasma induced graft copolymerization. It provided sufficient carboxyl groups as anchor sites for further binding of nano-TiO₂. The nano-TiO₂ binding was achieved through an effective self-assembled technique. The composition of modified membrane surface is analyzed by X-ray photoelectron spectroscopy and Fourier Transform Infrared Spectroscopy. The concentration distribution of nano-TiO₂ on membrane surface was investigated X-ray fluorescence spectroscopy. The results indicated that both the PAA layer and nano-TiO₂ were uniformly and strongly attached onto the membrane surface. The surface hydrophilicity of modified membrane was significantly improved, which was proved by the decreased water contact angle. The irreversibly binding of super hydrophilic nano-TiO₂ endows the membranes with strong antifouling performance, which has been investigated and verified by treating oily wastewater. The results present the potential of using proposed technique of membrane surface modification in various membrane separation applications.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-819

Aklavik, Northwest Territories - Solid Waste Planning Study

Kenneth Johnson

Jamie Davignon

Abstract:

The Hamlet of Aklavik is a 100 year old community within the Mackenzie Delta region of the Northwest Territories, and was originally established as a fur trading post. The community's solid waste disposal facility has been experiencing operational problems in the recent years, related to the river floods in the spring, and drainage issues. In response to these issues, the Hamlet initiated a study to identify a new solid waste site. A scoping study identified 15 potential waste sites within 16 kilometers of the community, all situated along a seasonal access road. Waste generation for the community was estimated to be 200,000 m³ for a 40 year horizon. This volume, with a 3 to 1 compaction ratio, produced a 66,000 m³ volume requirement, and which was rationalized to a 66,000 m² area requirement, which was applied to the screening analysis of the 15 sites. Of the 15 original sites from the scoping study, 9 had sufficient area, which included a 50 m site buffer from the operating area to the adjacent pond areas. The estimated Capital Cost to develop these sites range from \$11.7 million to \$25.2 million based upon a substantially long site access road, and the site development features. Based upon the planning analysis it was recommended to investigate 2 of the 9 sites further. Along with the planning analysis, a review of the existing site was completed and it was recommended that the redevelopment of the existing site is a reasonable consideration to obtain additional operating capacity for the facility, and achieve additional time for the planning, engineering, and construction of a new site.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-820

Assessment of Microbial Denitrifying Capacity in Vegetated Bioreactors Treating Greenhouse Effluent

Soheil Fatehi Pouladi
Bruce Anderson
Brent Wootton
Lloyd Rozema
Kela Weber
Sonja Bissegger

Abstract:

The discharges from food production greenhouses (greenhouse effluent) contain very high nutrient concentrations, which can have adverse effects on the environment. Wood-chip bioreactors are increasingly popular passive treatment systems favoured for their economical denitrification in treating agricultural field tile drainage. However, little is known about the maturation of microbial communities in wood-chip bioreactors treating greenhouse effluents. Multiple subsurface flow wood-chip bioreactors, each vegetated with a different plant species, together with an unplanted unit, received synthetic greenhouse effluent with elevated nitrate concentrations. The hybrid bioreactors were operated for over 2 years, during which water samples were collected from the inlet, outlet and within the reactors. The high denitrification rate (up to 99%) developed in the bioreactor planted with *Typha angustifolia* (narrowleaf cattail) over a 14-month period was shown to follow the reactor's temporal trend of increasing microbial activity, measured by the average well colour development (AWCD) in Biolog EcoPlates. Similarly, the reactor's metabolic richness (the number of carbon sources utilised) increased over time, revealing a maximum of 81% utilised carbon sources associated with plant root exudates. The largest fold-change of the denitrifying gene, NirS, (determined by quantitative polymerase chain reaction, qPCR), was a 1,732-times increase in the *T. angustifolia* reactor, while NirK changes were negligible. The large increase of NirS genes after 17 months of operation, accompanied by the near-complete reduction of nitrate concentrations after 14 months suggested that an acclimation period of at least one year can be expected in unseeded wood-chip bioreactors planted with *T. angustifolia*. The great increase of NirS genes in the unplanted bioreactor, followed by high denitrification rates after almost 21 months indicated the need for a longer acclimation time in bioreactors without vegetation. These results are important for the designers and operators of wood-chip bioreactors, which are expected to be more commonly applied in future.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-821

Effect of a Novel Biochar Supported Nanoscale Iron Sulfide Composite on *Corynebacterium Variable HRJ4* and a Chem-Bio Hybrid Process for Trichloroethylene Degradation

Honghong Lyu
Hang Zhao
Catherine Mulligan
Jingchun Tang

Abstract:

Microbial degradation of trichloroethylene (TCE) is mainly hindered by the halogen substituents and their hyper-toxicity. A sequential chem-bio hybrid process with a novel biochar (BC) supported nanoscale iron sulfide (FeS) (CMC-FeS@BC) as chemical remover and *Corynebacterium variable HRJ4* as biocatalyst for TCE degradation and the impacts of CMC-FeS@BC on TCE biodegradation by *HRJ4* were investigated. Strain *HRJ4* grew well in the presence of CMC-FeS@BC up to 0.25 g/L in medium with TCE as carbon source, which is higher than the CMC-FeS@BC dosage for TCE chemical removal (0.18 g/L). The CMC-FeS@BC composite displayed an enhanced TCE removal capacity of 77.8 mg/g compared to 59.7 mg/g for CMC-FeS, 26.8 mg/g for bare FeS, and 56.5 mg/g for BC. At the equilibrium TCE concentration of 3.4 mg/L, 40.4% of TCE removal was due to reduction, and 59.6% was ascribed to sorption. The dechlorination pathway was proposed based on the results of GC-MS and XPS. 10 mg/L of TCE was dechlorinated to *cis*-1,2-dichloroethene (*cis*-DCE), vinyl chloride (VC), and acetylene within 12 h by 0.18 g/L CMC-FeS@BC. Addition of *HRJ4* strain into the reactor effectively degraded the *cis*-DCE and VC to ethylene and acetylene. XPS analysis suggested that sorption, reduction and biodegradation were dominant mechanisms for TCE removal. Results from this study forecast the potential of CMC-FeS@BC/*HRJ4* chem-bio hybrid treatment in TCE degradation.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-826

Foaming in an Innovative Anaerobic Membrane Bioreactor Treating High Solids Wastewater

Joshua Snowdon
Kripa Singh

Abstract:

An innovative anaerobic membrane bioreactor (AnMBR) using an external tubular nanofiltration membrane module is being operated under mesophilic conditions for the treatment of a high-solids wastewater (influent total suspended solids (TSS) of 5658 mg/L (\pm 1771 mg/L) and a chemical oxygen demand (COD) of 84,156 mg/L (\pm 4570 mg/L)) to determine operational conditions required to achieve good system stability while minimizing the reactor foaming propensity. The system configuration consists of a 1000 L continuous stir tank reactor (CSTR) equipped with an external tubular membrane. Thus far, operation at organic loading rates (OLR) in the range of 0.8 – 8.2 kg/m³d, and a concentration of mixed-liquor suspended solids (MLSS) in the range of 13.6 – 33.9 g/L, have been studied. Throughout the duration of the study five events of excessive foaming were recorded. Excessive foaming events were defined as events where both the primary and back-up gas traps were filled with foam, and additional foam poured down the sides of the reactor through gaps between the CSTR cover and wall created during these instances of excessive foaming. Increases (shock) in OLR, temperature, reactor ammonia nitrogen and total alkalinity concentrations, and the accumulation of colloidal materials within the reactor have all been known to impact reactor foaming propensity. This research project found shock increases in OLR, and its associated accumulation of colloidal materials, to be the most influential factor affecting reactor foaming propensity. Following an analysis of the causation of each excessive foaming event, a mitigation plan was developed to prevent future foaming events.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-827

Evaluation and Optimization of Multiple Advanced Oxidation Processes for the Removal of Venlafaxine in Water and Wastewater

Jordan Hollman
John Albino Dominic
Gopal Achari
Cooper H. Langford

Abstract:

This study presents a comprehensive evaluation of multiple advanced oxidation processes (AOPs) for degradation of venlafaxine (VEN) in water and wastewater (WW). VEN is an antidepressant, frequently detected in aquatic environments around the world and is a contaminant of emerging concern due to its endocrine disrupting effects. AOPs such as O_3 , UVC/ H_2O_2 , UVC/ O_3 and UVC/ O_3/H_2O_2 were tested to degrade VEN in aqueous solutions. Experiments were conducted in both spiked water and secondary-treated WW with VEN at an initial concentration of 10 ppm.

Degradation of VEN followed pseudo first-order kinetics in all cases and demonstrated a positive correlation between removal rate and the dosage of UVC, O_3 and/or H_2O_2 . As the UVC dosage increased from 735 W/m^3 to 3619 W/m^3 the pseudo first-order rate constant increased from 0.0046 min^{-1} to 0.026 min^{-1} for spiked water. Addition of 10 ppm H_2O_2 further enhanced the degradation rate to 0.84 min^{-1} . Ozone alone was also effective in degrading VEN, with a pseudo first-order rate constant of 0.65 min^{-1} in the best case with only O_3 . Adding UVC with O_3 increased the degradation rate to 1.1 min^{-1} with 3619 W/m^3 of UVC irradiation. The most effective AOPs were found to be UVC/ H_2O_2 and UVC/ O_3 dependent on reagent dosage, demonstrating similar removal rates. Selection of the ideal method for a given application would therefore be determined by design/cost considerations and availability of chemical reagents for a specific project. It is noteworthy that VEN removal rate showed diminished returns per oxidant dosage as dose increased, highlighting the importance of holistic design to minimize reagent costs. The detailed analysis of AOPs for the removal of VEN presented in this study brings design engineers closer to the full knowledge needed to apply AOPs on a large scale to treat emerging and recalcitrant contaminants.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-829

An Evaluation Mode for Demolition Waste in the Residential Context

Azzeddine Oudjehane
Christopher Raghubar

Abstract:

The waste generated during the demolition of residential homes consumes large volumes of limited space in municipal landfills. Unreserved disposal of demolition materials into landfills can be minimized through more methodical deconstruction methods. Sorted materials can then be reused or recycled whereas unsorted material can only be sent to a landfill.

To create an incentive for individuals and companies to spend the additional time and money to sort waste, policies must be created by regional municipality. In Calgary for example, the incentive to approach demolition with an emphasis on future use of material is seen in the form of varying disposal rates; higher rate reserved for unsorted material and lower rates for materials that can be recycled.

To understand how these different disposal rates affect the total demolition project cost for a typical Calgary home, the model and approach herein presented investigates the relationship between cost savings at disposal and labour investment during demolition. The ultimate goal of this study is to determine if there is substantial merit to the current City of Calgary tipping fees in terms of encouraging selective deconstruction of residential homes.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-831

Novel Advanced Oxidation Process(AOPs) Based on Pre-Magnetization Fe⁰ for Wastewater Treatment

Zhou Minghua
Pan Yuwei
Li Xiang

Abstract:

Novel advanced oxidation processes (AOPs) based on pre-magnetization Fe⁰ was employed to enhance the degradation of organic pollutants and reduce reagents dosage. Compared with AOPs(e.g., pre-magnetization Fe⁰/H₂O₂, pre-magnetization Fe⁰/K₂S₂O₈) based on conventional Fe⁰, AOPs based on pre-magnetization Fe⁰ could have 2.4–52.1 folds enhancement in the degradation rate of other different pollutants. Meanwhile, the feasibility of pre-magnetization Fe⁰/PS was better in wastewater including different cations and anions and pre-magnetization Fe⁰/H₂O₂ was better in high-salt wastewater. AOPs based on pre-magnetization Fe⁰ is more promising and highly efficient processes since it does not require any change of the present water and wastewater treatment processes, and does not need an extra energy source and complex equipment.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-832

Evaluation of Electrocoagulation as a Method of Pretreatment for Highly Concentrated Brewery Wastewater

Nawrin Anwar
Sharmin Sultana
Saifur Rahaman
Oluchi Okoro

Abstract:

This study intends to investigate different aspects of electrocoagulation as a method of pretreatment for brewery wastewater. The performance of a batch electrocoagulation reactor with four electrode plates was explored with respect to turbidity and chemical oxygen demand (COD) removal, electrical energy and electrode consumption, and sludge production. A parallel connection mode was used to connect the electrodes of the sacrificial materials, Fe and Al. All experiments were conducted at a current density of 150 A/m² and initial pH of 5 and 7 for the Fe and Al electrodes, respectively. Variations (Fe/Fe, Al/Al, Fe/Al and Al/Fe (anode/cathode configuration)) of the two electrode materials were investigated in regards to the electrode material and operating time. At the current density applied and initial pH used for the respective electrode materials, the optimum operating time was found to be 10 minutes and respective turbidity removal was 99%, 98.5%, 97%, and 99% for Fe/Fe, Al/Al, Fe/Al and Al/Fe (anode/cathode configuration) electrodes. Both materials showed analogous characteristics in turbidity removal and, therefore, other parameters were considered to base the selection of an optimum electrode configuration. Aluminum electrodes consumed lower electrode materials yet required higher electrical potential. Experiments with the Fe/Al configuration produced lower volumes of sludge volume and required lower potential as compared to others, and therefore were chosen as the optimum electrode configuration. The COD removal efficiency was examined using this configuration and showed an almost 60% removal rate. The effluent from the optimized electrocoagulation reactor would substantially reduce the wastewater load for a post-treatment setup such as anodic oxidation or electro-Fenton.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-833

Optimization of Combined Sewer Overflow (CSO) Enhanced Primary Treatment by Using Different Coagulants

Mohammed Zakee Shaikh
Abdul Mohammed
Mohamed Gamal El-Din

Abstract:

Aluminium sulfate (Alum), ferric chloride (FeCl_3) and Polyaluminium Chloride (PACl) are chemical coagulants that are currently used in the treatment of different water and wastewater. In this study, all three coagulants have been applied to enhance the primary sedimentation process for the treatment of CSOs. A two level factorial design has been implemented using jar tests for CSO samples in order to determine the most effective coagulant as well as optimum mixing conditions for the most effective removal of contaminants. All jars included a 1.25 mg/L dose of cationic polymer. The parameters monitored included common regulated parameters, such as biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), total volatile suspended solids (TVSS), phosphate, UV254 absorption, nitrite, nitrate, alkalinity, total coliform and E. Coli. The coagulant dosages ranged 50 – 125 mg/L Alum, 10 – 100 mg/L FeCl_3 , and 13.5 – 81 mg/L Al equivalent PACl. The mixing speed ranged from 150 – 300 RPM for rapid mixing and 15 – 30 RPM for slow mixing. The mixing times were varied from 1 – 3 minute for rapid mixing and 10 – 20 minutes for slow mixing. Preliminary results showed that applying 13.5 mg/L PACl with 1.25 mg/L cationic polymer at 150 RPM for 1 min, with 30 RPM for 20 min achieved the highest removal efficiencies for both turbidity and TSS. Applying 13.5 mg/L PACl with 1.25 mg/L cationic polymer at 150 RPM for 1 min, and 15 RPM for 10 min achieved the highest COD removal efficiencies. Among all three coagulants tested so far, PACl seems to be the best because of its impact on TSS, turbidity and COD. Our preliminary results indicate that PACl is the most effective coagulant. Additional tests are needed before mixing conditions can be optimized.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-835

Memorial University of Newfoundland Campus Cycling Study

Cynthia Coles
Kashif Rasheed

Abstract:

To adopt more climate and biodiversity friendly lifestyles and develop more sustainably one may look to countries such as The Netherlands and Denmark that have an advanced cycling culture. Cycling is one of the best modes of transportation because it is healthy, low cost, low pollution emitting, and low greenhouse gas emitting. Though governments have been taking steps to grow the awareness of and improve conditions for cycling, and approximately two thirds of Canadians are keen to cycle if the circumstances are favorable, there is still much work to do. Insufficient bike lanes and showers, and especially the lack of secure bike parking facilities are major barriers for people who want to adopt cycling as a mode of transportation. The largest proportion of the Memorial University community that bicycle appear to be connected with the Engineering Faculty though overall the numbers are still low. One of the objectives of this study is to determine how students and employees at Memorial University could be encouraged to bicycle in greater numbers and this will be undertaken by interviewing and surveying members of the university community and reviewing the literature on how other universities have become more bicycle friendly and what conditions contributed to this. The other main objective is to search for possible locations on campus where secure, indoor bicycling facilities could be located and determine how they could be constructed by modifying existing structures, keeping costs low to the university, and carrying out the construction in the most sustainable manner.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-836

Potential Land and Air Quality Impacts due to Hydraulic Fracturing in Western Newfoundland

Shareef Mohammed Mujtaba

Abstract:

Hydraulic Fracturing (HF) is a process of transmitting pressure by fluid to cracks or open existing cracks in hydrocarbon-bearing rock. It involves pumping a mixture of water, sand, and chemicals into shale at a high pressure to create fissures or fractures in a tight rock formation. Due to presence of potential HF reserves in Western Newfoundland, there has been an increased interest in exploring these reserves. However, due to the environmental concerns associated with HF a study was undertaken to identify the socio-economic and environmental implications of HF in Western Newfoundland. This paper presents environmental impacts particularly on air quality and land, corresponding mitigation measures and relevant best management practices in Western Newfoundland.

Several studies have recognized that fracturing activities may lead to increase in type of air pollutants generally found at conventional operations, including those other pollutants specific to fracturing, such as silica sand, fracturing chemicals, and flowback wastewater. Emissions of pollutants were estimated based on EPA emission factors and other criteria and using these emissions, a preliminary air dispersion study of selected criterial pollutants were conducted in two domains in Western Newfoundland. Modelling exercise revealed that peak concentrations of NO₂ were relatively high while other pollutants were predicted low. Relative high concentrations of NO₂ is cause of concern due to its health impact as well as its role in formation of tropospheric Ozone. Land requirement for HF drilling pad and supporting facilities is not large; however, constructing an access road might necessitate the reclamation of a considerable area of land. Land clearance and gravel quarrying generally destroy the existing vegetation and disturb regional fauna. Impact on flora results from an increase in soil erosion, sedimentation, and habitat fragmentation. Many areas in Western Newfoundland are rich in flora and fauna and HF might impact them adversely.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-837

Modeling Struvite Crystallization in a Batch Reactor Using Population Balance Module Coupled with 3-D CFD Model

Seyyed Ebrahim Mousavi
Saifur Rahaman

Abstract:

Discharge of significant amounts of phosphate from nutrient-rich wastewater is a problematic issue considering the potential contamination of groundwater and eutrophication of recipient water bodies. On the other hand, phosphorus is also a limited, non-renewable resource with reserves that may be depleted in the near future. As a result, phosphorus recovery is receiving due attention as an environmental concern. The recovery of phosphorus using a crystallization technique is one proven solution for this issue. In this work, crystallization of Magnesium Ammonium Phosphate (Struvite) as an alternative method for the recovery of phosphorus is modeled in a batch stirred tank reactor. The aim of this work is to link Computational Fluid Dynamics (CFD) with Population Balance Modeling (PBM) to develop a 3-D CFD model which could predict Crystal Size Distribution (CSD) of struvite. In the simulation, the CFD flow field was solved through a Eulerian multiphase approach and RNG $k-\epsilon$ turbulence model, using a commercial CFD package, ANSYS Fluent 17.1. The population balance equation was solved using the discrete method, implementing 25 different size classes. The size-independent growth rate as a function of the supersaturation index (SI) was employed in the model through User Defined Function (UDF). A series of experiments were conducted utilizing synthetic wastewater in a stirred tank reactor agitated with a Rushton impeller to confirm the simulation results. The model successfully predicted the variation of crystal size distribution as well as SI values with experiment time.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-838

Different Electrical Regimes to Demulsify Oil Sludge – Wettability Indicator

Esmaeel Kariminezhad
Maria Elektorowicz

Abstract:

Extraction and refinery of oil by oil-producing industries result in the production of a huge amount of oily sludge which disposal might present a threat to the environment. The oil sludge treatment is challenging due to its physical and chemical properties. Among these properties, a stable emulsion is one of the main obstacles to an effective treatment. Adsorption of asphaltenes and resins on the surface of solids drastically increases the hydrophobicity of the solid particles and produces meta-stable water-in-oil emulsions. In this study, an electrokinetic approach was employed to decrease the double layer thickness and destabilize emulsions to facilitate the separation of water from the oil phase. Four different types of electrical fields were applied to test their impact on the stability of water-in-oil emulsions. They included: constant direct current (CDC), pulsed DC (PDC), incremental DC (IDC) and decremental DC (DDC). Furthermore, the effectiveness of DDC and IDC methods remarkably improved compared to the sequential solvent extracted oily sludge with toluene and tetrahydrofuran. Wettability alternation analyses showed an increment in the population of fine solids in aqueous part following electrokinetic treatment which in turn leads to the higher hydrophilicity of the solids. The applied DDC and IDC fields enhanced the wettability towards water-wet solids and were better than the other tested configurations can result in better solid-oil phase separation.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-839

Design and Operation of Actively-Aerated Field-Scale Methane Biofilters

Samadhi Gunasekera
Patrick Hettiaratchi
Eranda Bartholameuz
Eamonn Irvine

Abstract:

Methane is the second most prevalent contributor to global warming after CO₂, with a global warming potential 34 times higher than CO₂. 60% of global methane emissions are a result of human activities such as the oil and gas industry, livestock farming, and landfilling. In the oil and gas industry, excess or unwanted flammable gases are often disposed by flaring or venting. However, if the emission flowrates are too low or intermittent, or the heating value of gas is too low to sustain combustion, it is not economically feasible to burn surplus gases in a stable method. In such instances, these gases are vented directly to the atmosphere. Methane biofiltration is an economically feasible, low maintenance, biological method that can remediate such low volume point source methane emissions from sources such as oil wells, and landfills. An active aeration closed methane biofilter (MBF) was designed, constructed and installed at a single well battery site in Hannah, AB during the summer of 2016. The MBF was packed with 100% compost into a 4m³ conical frustum shaped tank at a density of 800kg/m³. The source methane supply consists of 98% CH₄ and 2% impurities such as salt water and crude oil and the inlet CH₄ flowrate is maintained at 25m³/day. Heated air will be mixed with methane at an air to methane ratio of 8:1 and injected into the bottom of the MBF to diffuse uniformly across the MBF. Inlet and outlet methane flowrate, air flowrate, inlet temperature and the temperature inside different locations of the MBF will be monitored throughout the lifetime of the MBF. The efficiency of the MBF will be calculated using this information, and will determine the carbon offsets achieved. This paper presents preliminary results during the operation of the MBF and the study of the temperature profiles.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-841

An Innovative Approach to Treat Ammonia-Rich Wastewater by Partial Nitrification/ANAMMOX in BioCAST Reactor

Nayereh Saborimanesh
Catherine Mulligan

Abstract:

The release of untreated or improperly treated ammonium-rich wastewater to the environment has deleteriously impacted human health and aquatic life. Biologically-based technologies are extensively used to transform nitrogenous pollutants to non-polluting forms (e.g. N₂). These technologies have proven to be effective, but obtaining an efficient removal of nitrogenous pollutants in a one-vessel treatment system that can simultaneously provide a balance in the environmental conditions (e.g. dissolved oxygen) for the nitrifiers and anaerobic ammonia oxidizers (“Anammox”), that require aerobic and anaerobic conditions, is extremely challenging. The main objectives of this study were to investigate the potential application of a biological reactor (BioCAST) for the treatment of an ammonium-rich wastewater under the nitrite-limited feeding conditions (NO₂: 0 mg-N/L) through providing the favorable conditions for both nitrifying and anammox communities in a single bioreactor and to identify the anammox communities developed in the system. The bioreactor was initially seeded with a sludge containing nitrifiers and anammox bacteria and was fed with an ammonium-rich synthetic wastewater (NH₃-N: 350 mg/L) and operated at a hydraulic retention time of 2 days at 35°C. The results showed that under favorable conditions, nearly 80% and 98% of total nitrogen (TN) and NH₃-N were removed, respectively. Sequencing analyses revealed that *Candidatus brocadia* genus was the most abundant in the bioreactor. High ammonium removal and existence of anammox bacteria imply that the optimum conditions for the activity of nitrifying and anammox communities were provided in this system.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-842

Advanced Oxidative Processes for Degradation of Carbamazepine in Wastewater Effluents

Purnima Somathilake
John Albino Dominic
Gopal Achari
Cooper H. Langford
Joo-Hwa Tay

Abstract:

This paper presents a comprehensive evaluation of advanced oxidation based treatment processes for degradation of carbamazepine (CBZ) in wastewater effluents. CBZ is as commonly prescribed antiepileptic drug and is one of the most frequently detected pharmaceutical in water bodies including surface water, groundwater, sewage and drinking water. Wastewater treatment plants (WWTPs) are considered to be the gate ways of CBZ into the environment as CBZ is resistant to biodegradation and mostly remains unaltered during the conventional treatment processes. Advanced Oxidation Processes such as ozonation, H₂O₂/UV and TiO₂/UV individually or in combinations have indicated possibility for degrading CBZ. In this study, various AOPs including ultraviolet C (UVC-254 nm), ultraviolet A (UVA-365 nm), UVC/H₂O₂, UVA/H₂O₂, Ozonation (O₃), and photocatalysis (TiO₂/UV) were evaluated for ability to degrade CBZ. Experiments were conducted in spiked pure water and postsecondary treated wastewater by varying doses of H₂O₂, TiO₂ and O₃. Among all the tested methods, fastest degradation of CBZ was observed in both, O₃ (14.4 mg/h) and UV/H₂O₂ (100 mg/L), with a half-life period of 35 sec. Rate of degradation of CBZ in wastewater followed zero-order and first-order for O₃ and UV/H₂O₂ with rate constants of 4.3 mgL⁻¹min⁻¹ and 1.2 min⁻¹ respectively. UV/H₂O₂ was deduced to be most suitable method for degradation of CBZ as highest degree of mineralization with a total organic carbon reduction of 87% was observed after a reaction time of 8 hours while O₃ resulted with less than 10% for the same reaction time. These results indicate that degradation of CBZ in existing WWTPs could be enhanced by adding small amounts H₂O₂ to UV disinfection units.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-843

Co-Combustion of Municipal Sewage Sludge with Caster Seed Shell in Bubbling Fluidized Bed Combustor under Oxygen-Enriched Condition: Experimental Investigation

Ravi Inder Singh

Rajesh Kumar

Abstract:

In India, municipal sewage sludge (MSS) disposal is one of the most complex environmental problems. Incineration is one of the promising technique to undertake this problem which utilized the heating value of the MSS to produce energy and reduced the sludge volume to small-stabilized ash. Generally, MSS having low calorific value and high moisture contents. The co-incarnation of MSS with coal or other fuels overcome the problem of burning low calorific MSS. Oxy-fuel fluidized bed combustion technology provides the most favourable environments for the combustion of solid fuels having the moisture content up to 60%, which results in maximum amount of carbon dioxide, which is easy to control. Co-combustion with oxy-fuel fluidized bed has potential for negative CO₂ emission level for power generation. Co-combustion of municipal sewage sludge (MSS) with caster seeds shell (CSS) has been investigated in oxygen-enriched bubbling fluidized bed (BFB) combustor. The tests are performed with two different ratio of MSS/CSS is 25 %/75% and 50%/50%. This work extensively investigate the temperature profile, flue gas emission, properties of fly ash, bottom ash and the performance of co-combustion MSS with CSS under air-fired and oxy-enriched condition. The short fluidized bed combustor of 1.8 m in length is made from financial grant obtained from DST New Delhi India.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-844

Optimization of Solar Powered Reverse Osmosis Water Treatment Systems

Marina Freire-Gormaly

Amy Bilton

Abstract:

According to the World Health Organization, 663 million people lack access to clean water. Solar photovoltaic reverse osmosis (PVRO) systems are a stand-alone water purification technology that can help alleviate this need. PVRO systems can be designed using modular design approaches from commercially available components for to achieve the lowest water cost to meet the requirements of a community. An example of such a system design using such a tool was installed through a joint-collaborative project between MIT, W.K. Kellogg Foundation, and PVPure Inc. in La Mancalona, Mexico. The community required one cubic meter per day of clean drinking water from a brackish well (high saline and high mineral content). This system was designed to be operated intermittently to limit the need for batteries. However, this type of operation is thought to cause premature membrane degradation and fouling.

This work incorporates the effects of this type of fouling into the design process. Using models developed based on experimental characterization of membrane fouling under intermittent operation, operational parameters, such as the type of anti-scalant addition, rinsing procedures, and rates of membrane replacement, are optimized. The goal is to provide the community with clean drinking water at the lowest system operational cost. It is shown that the system operates at the lowest water cost when permeate rinsing and anti-scalants are employed. In the future, this approach will be expanded to incorporate the uncertainty in membrane fouling. In addition, this approach can be merged with other models to enable optimization of the full PVRO system along with operational parameters based on community specific conditions. The goal is to make this technology accessible in environments where there is the greatest need.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-845

Geotextile Filtration for Improving Surface Water Quality of Eutrophic Lakes

Catherine Mulligan

Abstract:

Eutrophication and impaired surface water quality are challenging problems due to the restriction in using many lakes and ponds for drinking and public recreational purposes. Lake Caron, located in the municipality of Sainte-Anne-des Lacs in Quebec, is one such lake hit by algal blooms every year. This *on-site* study investigates the use of a floatable geotextile filtration unit for removing suspended particles, nutrients and algae to improve the lake water quality. Different combinations of three non-woven geotextiles (GTX-300, GTN-300, and GTN-350A), differing in apparent opening sizes, were tested with lake water and monitored real time for surface water quality parameters with the help of a YSI EXO2 probe. Water quality was assessed by considering parameters such as suspended solids (SS), turbidity, total phosphorus (TP) and nitrogen (TN), and chlorophyll and blue green algae-phycocyanin (BGA-PC) concentrations in the lake water. Effective removal of SS by filtration resulted lowering TP concentration in the lake water, close to the Quebec provincial norms set for the protection of aquatic life. Overall, the filtration tests resulted in 85-98% turbidity, 89-99% SS, 60-84% TP, 25-50% (TN), 71-78% chlorophyll and 93-97% BGA-PC removals.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-850

A Review of Historical Extreme Wind Speeds in a Changing Climate at some Major Canadian Cities

Sihan Li
Peter Irwin
Mike Gibbons
Valerie Sifton
John Kilpatrick

Abstract:

Some efforts have been made to consider the probable impacts of climate change on design wind speeds in tropical cyclone prone regions, such as Australia and the east coastal line of the United States. However, in Canada, the extreme wind speeds are mostly dominated by non-hurricane wind events. One recent study based on historical ground observations and re-analysis data indicates that stations over the Gulf of St. Lawrence of Canada mostly have no clear trend in terms of annual maximum wind speeds, but with increasing variability. A similar study shows that the historical monthly mean wind speed for the same region is decreasing. A recent study applies several weather forecast models for some possible future climate scenarios at various sites in Ontario, indicating an increase in frequency of gust wind speeds between 28 km/h and 70 km/h. These studies point to three main tasks that need more advanced research, including a better understanding of any possible trends in historical data, the use of finer spatial scale regional climate model to predict future climate scenarios, and the development of more appropriate downscaling methods to relate predicted upper level wind speeds to those at ground level. The first task is critical to set up the basis of measuring the quality of the future climate modeling and to better understand how the current wind climate may translate to a probable future wind climate. From this perspective, this study explores the historical wind speed data in some major Canadian cities. Historical extreme wind observations are investigated in terms of the frequency of extreme wind events, seasonality and directionality. The probable impact on design wind speeds is discussed.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-852

Power Generation Potential from Cyanidized Water Using Osmotic Processes

Luis Vives

Abstract:

Substances such as sodium cyanide, are highly toxic, and are indiscriminately dumped into rivers and watersheds by the craft and mining industries, exposing communities to a high level of environmental risk. Looking for alternatives to mitigate the impact, draw on cyanide contaminated water and provide opportunities for power generation, the objective of this research was to estimate the variation of the electric power in a power generator, according to the osmotic pressure, using lab scale polymeric membranes and *synthetic* water for different concentrations of cyanide. During the estimation process of the electric potential, 60 assays were performed in total, 30 within the membrane reactor with vertical configuration and the other 30 within the reactor with horizontal configuration. Following a filling process under the phenomenon of counterflow of fluids, the tests were conducted between August and December 2015 in the laboratories of Chemical Modeling at the University of Ryerson and Sanitation of Cartagena University, where concentrations of sodium cyanide were modified in the solution of (25, 50, 100, 200, 500 and 700 mg/l). By using the solution of 700 mg/l, higher concentration and representative of the tailings in the South of Bolivar, the GE Osmonics SE membrane allowed to develop a power density of represented this potential in a head of water of 1.9 cm in the reactor with the vertical configuration, considered to be most significant. Tests with seawater were also performed in the same configuration. Seawater tests were conducted with concentrations hundred times the concentration of cyanide, at 71 g/l, a power density of and a head pressure of only 3.3 cm, All this leads us to conclude that there is a potential to generate electricity, cyanide water have a higher potential than seawater and vertical configuration is the most suitable to be implemented in delayed osmosis processes.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-853

Field Evaluation of Sulfolane Degradation in Groundwater Using UV/H₂O₂

Linlong Yu
Sobhan Iranmanesh
Gopal Achari
Cooper H. Langford

Abstract:

Sulfolane, an anthropogenic chemical, is extensively used in the Shell Sulfinol process to remove H₂S and other polar compounds from natural gas. Inappropriate sulfolane waste disposal practices, leaks and spills during sulfolane production, storage, transportation and processes have led to widespread groundwater contamination. The impact of sulfolane pollution is felt more as it is highly soluble in water transporting to further distances beyond the original source. A recognition of this problem combined with the attention by regulators has pushed the sulfolane contamination issues to the forefront.

Advanced oxidation processes (AOPs) have been shown as an effective way to treat sulfolane contaminated water in laboratory studies. The fundamentals of AOPs is based on the generation of hydroxyl radicals or other oxidant equivalents. Among different AOPs reported, UV/H₂O₂ has been determined as one of the most feasible solutions. However, no field studies have been conducted on sulfolane degradation using UV/H₂O₂.

In this research, a field scale UV/H₂O₂ system was tested in a sulfolane contaminated site. The purpose of this field testing is to make UV/H₂O₂ technology one step closer to full scale application in treating sulfolane. The performance of UV/H₂O₂ system was evaluated with different ground waters. The experiments were conducted in both recirculation mode and single-pass mode. Furthermore, different operational parameters such as water flow rates and hydrogen peroxide dosage were investigated.

Our field testing results show that sulfolane in different groundwater can be successfully treated by using UV/H₂O₂. The optimal H₂O₂ concentration was determined to be 40 ppm. The required electrical energy per order (EEO) for treating sulfolane with optimal H₂O₂ dosage is calculated to be 2.3 KWH. The success of this field investigation has provided useful and practical information for system scale-up and full application of the technology.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-854

Evapotranspiration Landfill Biocover to Control Atmospheric Release of Landfill Methane

Eranda Bartholameuz
Patrick Hettiaratchi
Matthew Steele
Tanaji More
Samadhi Gunasekera

Abstract:

There is considerable interest in quantifying and deploying cost-effective methods to control landfill emissions of methane (CH₄), which is a key greenhouse gas (GHG). Recent studies by University of Calgary and others indicate one of the most promising options is biological oxidation of CH₄ in a passive system known as Landfill Biocap (LBC). The LBC utilizes a permeable granular medium placed over a landfill as a final cover, which allows the landfill gases (LFGs) to “breathe out”. The LBC also supports the growth of methanotrophs, which are capable of converting the CH₄ into CO₂. Although, successful LBC projects have been developed, there is a risk that the permeable LBC encouraging water percolation into the waste matrix, increasing landfill leachate production and potentially contaminating groundwater. A novel approach could be used that integrates components of the Evapotranspiration (ET) cover into the LBC design. The ET-LBC is a novel, hybrid landfill cover design that utilizes a granular medium to promote the growth of methanotrophs and to store water to facilitate evapotranspiration by plants.

Number of issues prevent ET-LBCs adoption in Canada. A major barrier is the inability to accurately assess emission credits associated with ET-LBC projects. A research conducted in Leduc, Alberta currently demonstrates and is being used as a model to develop protocols to assess emission credits.

Other ongoing research in this technology includes: determination of the most suitable medium and thickness for maximum CH₄ oxidation; identification and adaptation of a compatible ET configuration for LBC and minimization of water percolation; and assessment and identification of robust and cost-effective method(s) to determine emissions from landfills and the CH₄ oxidation capacity of the ET-LBC system throughout the year. Accurate assessment of emission credits will be possible with the help of increased understanding of the functioning of ET-LBC system.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-857

Cigarette Butt Waste Management and Smoking Policy on Campus

Kelvin T. W. Ng
Amy Richter

Abstract:

Indoor smoking-free policies for educational institutions and universities have been widely adopted in Canada. However, illegal littering of cigarette butts is frequently observed at campus building entrances, benches, bus stops, and other open areas beside designated smoking areas. Discarded cigarette butts are largely non-biodegradable, and the environmental impacts associated with these toxic wastes are not fully understood by the research community and the policy makers. Previous research focuses largely on people's attitudes towards littered cigarette butt wastes, but studies on the actual amount of cigarette butts littered on campus is very limited. The objectives of this study are to develop methods to quantify littered cigarette butts at the University of Regina main campus, and to examine smokers' behaviors and their potential impacts on University smoking policies. A total of seventeen hotspots on campus were identified, and the numbers of cigarette butts were estimated using three square reference frames with different sizes (0.5m×0.5m, 0.75m×0.75m, and 1m×1m). Preliminary trials suggested the mid-sized frame (0.563m²) was more appropriate, and was adopted for subsequent data collection. Field data was collected from Regina main campus from May to August 2016. It is estimated that there were about 20,500 littered cigarette butts on campus at any given time. Using provincial statistics, the daily generation rates was estimated to be 4,200 CB/d. This study provides some of the first cigarette butt waste field data at a Canadian campus. Such data and analyses likely provide a solid framework for updating our current smoking policy. A total of fifteen hotspots on campus were identified, and the numbers of cigarette butts were estimated using three square reference frames with different sizes (0.5m×0.5m, 0.75m×0.75m, and 1m×1m). Preliminary trials suggested the mid-sized frame (0.563m²) was more appropriate, and was adopted for subsequent data collection. Field data was collected from Regina main campus



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-858

Cross-Correlating Landfill Gas Quality with Climatic Factors at the City of Regina Landfill

Kelvin T. W. Ng

Abstract:

Landfill gas is a by-product of the anaerobic decomposition of organic waste, and consists mainly of CH₄ (methane) and CO₂ (carbon dioxide), both of which are important when considering discussions on climate change and global warming. Five years of landfill gas data at the Regina landfill was collected to study the impacts of selected climatic factors on landfill gas collection using cross-correlation analysis. Cross-correlation is used to estimate the degree of correlation between two sets of time-series data, and returns the lag, or delay, between each series. Cross-correlation has been used successfully in a number of different fields, including seismic refraction, finance, and climate; however, its use in the field of solid waste management is extremely limited. The objective of this paper is to examine five different climatic factors (rainfall, snow cover, temperature, pressure and relative humidity) on landfill gas quality (CH₄:CO₂) and residuals (the gas collected that is not CH₄ or CO₂). Surprisingly, a consistent lag time was not observed at the Regina landfill during the study period. Results suggested that a number of reasons could be behind this phenomenon. Understanding the impact that these climatic factors may have on landfill gas collection could help to increase efficiency of collection, especially in harsh climates. As well, information on the relationships in between climatic events and increases or decreases in landfill gas quality may help landfill designers and operators to optimize the landfill system and improve environmental compliance at the landfill.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-860

Optimization of Aeration in a Single-Stage Biological Aerated Filter for the Treatment of Municipal Wastewater

Rajan Ray
Rajesh Seth
Paul Henshaw
Nihar Biswas

Abstract:

Lou Romano Water Reclamation Plant (LRWRP) treats the wastewater produced from the city of Windsor, Ontario by chemically enhanced phosphorus treatment (CEPT) followed by secondary treatment using a single-stage biological aerated filter (BAF). The plant has an effluent target of 10 mg/L 5-day Carbonaceous biochemical oxygen demand (CBOD₅) and 0.08 mg/L unionized ammonia nitrogen (NH₃-N), which it constantly achieves. Since BAF is in operation, the plant used a fixed process airflow of 2.26 m³/h/ m³ per cell. A previous study revealed that the BAF effluent wastewater has a higher than normal dissolved oxygen (DO) concentration (?5 mg/L) and the target NH₃-N level is achieved within the lower 50% of the cell height at 1.55 m³/h/m³ aeration rate.

In the current study, two years data of influent and effluent BOD loading, DO, pH, NH₃-N, and the temperature was recorded for various air flow rate to understand the seasonal variable requirements of airflow to achieve the target limits of NH₃-N and CBOD₅. The results show that aeration can be varied and further reduced between 1.07 m³/h/m³ to 1.55 m³/h/m³ per cell in response to various influent CBOD₅ and temperature without affecting effluent limit. It was found that the nitrification is still completed within 75% of the cell height and BAF effluent DO concentration is ?2 mg/L with the proposed variable aeration rate. Effluent CBOD₅ and NH₃ varies between 3-6 mg/L and 3.2- 4.6 mg/L respectively.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-861

Remediation in Challenging Environments: Preliminary Numerical Simulation and Measurement of Unfrozen Water Content for an Outdoor Pilot-Scale Biopile in Cold Climate

Wonjae Chang
Jihun Kim

Abstract:

Cold-adapted bacteria are able to remain metabolically active in petroleum hydrocarbon-contaminated soils at low temperatures, and thus have been the basis for bioremediation efforts at cold-region sites. Recent studies have consistently reported significant microbial activity in partially frozen and frozen habitats, including in soils, sea ice cores and even at the interface between ice and water. Unfrozen liquid water in freezing and frozen soils is likely prerequisite for extended microbial activity. Predicting the presence and retention of unfrozen liquid water in cold site soils can be useful for planning, managing and implementing bioremediation for petroleum-contaminated soils at remote northern sites. However, available numerical simulation tools for predicting soil water content have not been extensively considered in bioremediation research for cold sites. For this research, a preliminary study was performed to calibrate a TEMP/W model for predicting soil temperatures and unfrozen water content in field-aged, petroleum-contaminated, clayey soils from outdoor pilot-scale biopiles exposed to winter temperatures of Saskatoon, Saskatchewan (Canada). The simulation of unfrozen water content in the biopiles subjected to representative winter temperatures was conducted using TEMP/W. The preliminary study predicted that significant quantities of unfrozen water remain available in the biopile during the seasonal transitional and winter periods. By comparing the simulated and measured unfrozen water data for the site soils, this study conservatively predicted an abundance of unfrozen water in the site soils during the winter season.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-862

Toxicity and Biodegradability Study on Enhanced Photocatalytic Oxidation of Polycyclic Aromatic Hydrocarbons in Offshore Produced Water

Bo Liu
Bing Chen
Baiyu (Helen) Zhang
Jisi Zheng
Liang Jing

Abstract: Photocatalysis has showed excellent performance in oxidizing and mineralizing polycyclic aromatic hydrocarbons (PAHs). However, the efficacy of the sole technology could be significantly diminished in offshore produced water (OPW) due to its complicated composition. The prolonged retention time might not meet the requirements in the field because of the daily heavy discharge of OPW. It may further lead to the incomplete degradation of organics and the generation of intermediates with higher toxicity and persistence. Photocatalysis coupling with ozonation was proved to be a better solution in treating vary types of wastewater. Therefore, the integrated approach was applied in the treatment of PAHs in OPW. Glass slides coated with immobilized TiO₂ was used as catalysts in the process. The Microtox® toxicity and biodegradability of untreated, ozone treated and integrated process treated OPW effluents were evaluated. Results indicated that a significant enhancement was achieved: almost all the PAHs were removed by the integrated process within 1 hour. The toxicity results suggested that the depletion of PAHs was positive to the reduction of toxicity whereas the halogenic byproducts generated by ozonation has a negative effect. The treated effluent by the integrated process has the lowest toxicity because of the effective degradation of both PAHs (~100% of removal) and halogenic byproducts (91.7% of removal). It also further enhanced the biodegradability of treated OPW. Comparing with other processes, the integrated one led to the highest biodegradation rate in 9 days, during which the dissolved organic carbon has decreased from 180 mg/L to 50 mg/L. In this study, the integrated process showed a great potential in the effective treatment of OPW, the reduction of toxicity and the enhancement of biodegradability.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-865

Anaerobic Sulfate Reduction and Metal Precipitation in Upflow Hybrid Reactor: Comparison of Single and Two-Stage Processes

Shahrokh Shahsavari

Rajesh Seth

Nihar Biswas

Abstract:

Biological anaerobic sulfate reduction to sulfide by sulfate reducing bacteria (SRB) is an effective and economically attractive option for the removal of metal from acid mine drainage (AMD); an acidic and sulfate-rich waste stream produced by the mining industry. The process can be performed in a single-stage reactor in which the biological sulfate reduction to sulfide and metal precipitation occur simultaneously, or in two-stage reactors where the two follow sequentially. The single stage process may be expected to be more cost-effective and simpler to operate. However, studies conducted in suspended growth cultures by this group and others suggest that beyond a certain level of metal loading, the process of sulfate reduction and the corresponding metal precipitation by the sulfide generated is adversely affected.

In the current study, the efficacy of an upflow anaerobic hybrid reactors (UAHR) in reducing or overcoming the inhibition of sulfate reducing bacteria (SRB) by the metal precipitate was examined. Two identical UAHRs were operated on a simulated wastewater with sulfate concentration of 3040 mg/L and COD/sulfate ratio of 1. One UAHR was used to represent the single-stage process, and the influent was modified to include metal (copper) in the feed. The other UAHR was operated to represent the first stage of the two-stage process. The performance of the two processes was compared over varying hydraulic, organic, and sulfate loading rates by varying the HRT between 40 and 2.5 days at a temperature of $33\pm 3^{\circ}\text{C}$. The results show that both sulfate reduction and copper precipitation in the single stage process were similar to or better than the two-stage process over the entire duration of the study. These findings suggest that the UAHR configuration used in the present study was successful in overcoming the inhibition of SRB by the metal precipitate formed.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-866

Design Waste Generators in Construction Projects

Mohamed Osmani

Abstract:

The construction industry in the UK is by far the greatest waste producer among all industries, being responsible for 32% of total waste generated, which equates to three times the combined waste produced by all households. Consequently, the last few years saw the development of several government-driven waste related regulations, policies and consultation documents to reduce construction waste production and increase reuse and recycling rates. Equally, global research on construction waste has been conducted over the last decade ranging from 'soft' onsite waste management tools to 'hard' material and recycling technologies. However, there is an insufficient effort and no structured approach to examine the underlying generators of design waste. Hence, this research engaged the top 100 UK contractors and architectural practices through a questionnaire survey and 24 follow up interviews to investigate the direct and indirect root origins and causes of construction waste across all stages of the building design process that culminated in the development of a set of design waste maps. Respondents reported that designing out waste has never been a priority in the design process. Moreover, results reveal that design waste is affected by a wide practice of not embedding waste reduction in briefing, no waste reduction target setting, and lack of designers' understanding of design waste causes; hindered by incoherent coordination and communication between project members; and impeded by time constraints.



Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ENV-868

Exploration of Parameters Effecting Energy Performance of Building

Tofigh Tabesh

Abstract:

The reduction of the effects of global warming has become a priority all over the world. This resulted in the need for reducing the greenhouse gas emissions. As the building sector has the major amount, precautions must be taken in the existing and new building. This paper based on literature review tries to highlight significant factors which effect building energy consumption and to find a proper way in order to increase energy efficiency of the building, reduce running costs and environmental effects. It is considerably achieved that high levels of energy-saving usually can be achieved by optimal combination of several measures, such as exterior heating, ventilation and air condition system, walls, windows, roofs, thermal insulation, and lighting system. The most effective strategies contributing in energy-saving of building design, however, are those applied before construction. As a result, it can be concluded that these strategies can be useful for both the refurbishment of existing buildings and the decision making during the preliminary design stage of new buildings. Thus, it is expected that outcomes of this study would help decision makers and building designer important parameters which effects building energy conservation and environmental concern specifically in early design stages.