Welcome to our Summer 2016 addition of CPATT News!

We hope all your projects have been successful to date and we wish you all continued success as the construction season progresses.

In this newsletter we highlight some of the various projects underway at CPATT including work with MEPDG, Climate Change on pavements, and Reclaimed Asphalt Pavement. Also, we highlight some events and special features from the past few months which include a seminar by Curtis Berthelot from PSI Technologies Inc., Susan Tighe’s University of New Brunswick lecture, graduate student awards and new students starting with CPATT/Norman W. McLeod Chair in Sustainable Pavement Engineering.

CPATT was very happy to be featured in the July issue of the Constas Magazine. The article was on smart carriageways and self-healing materials and features CPATT and Hassan Baaj. The article can be found here.

Please join our CPATT facebook group by clicking the icon

Should you have any questions related to our activities please do not hesitate to contact us.

Sincerely,

Susan L. Tighe, PhD., P.Eng Norman W. McLeod Professor in Sustainable Pavement Engineering Director of CPATT
Faculty Feature - Dr. Wei-Chau Xie

Dr. Wei-Chau Xie, PhD., PEng

Dr. Wei-Chau Xie received his PhD in Applied Mechanics in 1990 from the Department of Civil Engineering at the University of Waterloo. After graduation, he worked at Atomic Energy of Canada Limited (CANDU) as a Stress Analyst and Design Engineer. He returned to the University of Waterloo in 1992 and is a Professor in the Department of Civil and Environmental Engineering and the Department of Applied Mathematics. Dr. Xie has published over 100 journal papers on dynamic stability of structure, reliability and safety analysis of engineering systems, and seismic analysis and design of engineering structures.

In 2006, Dr. Xie’s monograph *Dynamic Stability of Structures* was published by the Cambridge University Press. This book represents the culmination of twenty years of research on this subject. This is the first book that gives a systematic presentation of the modern theory of Lyapunov exponents and moments Lyapunov exponents and their applications in the study of stochastic dynamic stability.

Earthquakes are one of the most destructive natural disasters. The Great East Japan Earthquake and the tsunami, occurred on March 11, 2011, caused a series of equipment failures, nuclear meltdowns, and releases of radioactive materials at the Fukushima Daiichi Nuclear Power Plant. Since several destructive earthquakes have occurred in recent decades, nuclear energy industries world-wide are launching an unprecedented and extensive re-evaluation of seismic hazards and risk to nuclear power plants (NPPs). Furthermore, nuclear energy regulators and utilities are taking a critical look at existing methods of estimating seismic risk of NPPs. A number of deficiencies have been recognized in the existing methods of seismic risk analysis.

Dr. Xie and his research team are developing a modern probabilistic framework of analysis: from seismic demand analysis, seismic fragility analysis of Structures, Systems, and Components (SSCs), to seismic risk quantification of nuclear power plants. The focus of research is on developing efficient and accurate modelling and analysis techniques, design methods, and guidelines for structural changes to ensure that SSCs in NPPs are seismic qualified in a cost-effective way. The methodologies developed provide modern tools to assess existing SSCs in refurbishment of existing NPPs and to design new SSCs in new NPPs to comply with standards for seismic safety. Dr. Xie and his co-authors are writing a research monograph/textbook on *Seismic Risk Analysis of Nuclear Power Plants*, to be published by the Cambridge University Press.

Dr. Xie devotes great efforts in teaching, advising and mentoring students. He was awarded the Teaching Excellence Award in 2001 and the Distinguished Teacher Award in 2007, the highest formal recognition given by the University of Waterloo for a superior record of continued excellence in teaching. His undergraduate textbook *Differential Equations for Engineers* was published by the Cambridge University Press in 2010. The book has been adopted in many universities worldwide.

Outside of the classroom, Dr. Xie’s interests are as vast and varied as his professional experiences have been. He is a casual bodybuilder, a hobby he developed sixteen years ago with one of his students who was once a stunt-double for Jacky Chan. Best known for his perfect circles, he has many creative endeavours, an antithesis to his work in mechanics and mathematics. Dr. Xie enjoys painting, as can be seen by the landscape he painted which hangs in his office. To relax, Dr. Xie likes to watch police procedurals with a bowl of his famous 28-bean soup.
Student Feature - Gulfam Jannat

Meet Gulfam Jannat

Gulfam Jannat is a Doctor of Philosophy candidate in the Civil and Environmental Engineering department at the University of Waterloo. She received her B.Sc (Civil Engineering) and MASc from Bangladesh University of Engineering and Technology (BUET). Her research interest is pavement distress prediction models and deterioration models, performance based cost effective pavement maintenance schedule, application of Mechanistic-Empirical Pavement Design Guide (MEPDG) in to pavement management systems.

Gulfam has more than 8 years engineering work experience in the field of pavement engineering and transportation infrastructure management. She worked in the Asian Development Bank (ADB), where she was involved in managing a number of transportation infrastructure projects. Prior to joining the ADB, she also worked in the World Bank as a highway engineer. She started her PhD under the supervision of Professor Susan Tighe in 2013.

Developing Cost-Effective Pavement Maintenance and Rehabilitation Schedules: Application of MEPDG Based Distress Models and New Key Performance Index (KPI)

The Ministry of Transportation Ontario (MTO) partially funded this research project through the Highway Infrastructure Innovations Funding Program (HIIFP), conducted by CPATT at the University of Waterloo. The objective of the MTO project is to develop engineering criteria and standards for the key performance indicators (KPIs) used in pavement management systems.

The overall objective of the research is to develop a cost-effective pavement maintenance and rehabilitation (M&R) schedule by incorporating (a) Mechanistic-empirical approach into overall condition index, and (b) estimation of KPI models by considering the factors affecting pavement performance. The findings of the research is expected to incorporate the MEPDG approach in an integrated way into pavement performance as KPI and pavement M&R schedules. It is expected that with the realistic and precise prediction of the distresses and overall condition of pavement, development of the M&R strategy will be practical and cost-effective.
Meet Donghui Lu

Donghui Lu is a PhD student in the department of Civil and Environmental Engineering at the University of Waterloo, under the supervision of Dr. Susan Tighe and Dr. Wei-Chau Xie. Donghui was born in Jilin, China. She received her B.Sc. and PhD degree in 2009 and 2014, respectively from China Agricultural University, Beijing, China. In 2013 she joined the University of Saskatchewan as an exchange student for one year. She has research experiences in Life Cycle Assessment studies, Biomass Fuel Densification, and Forage Mechanization Systems. Donghui has always had a curious mind and strong desire to learn. She is very interested in sustainable pavement engineering and so began her second PhD with Drs. Tighe and Xie in the Winter of 2016.

Risk of Climate Change on Pavement Performance and Adaptation Strategies using Big Data

Pavement deterioration is a dynamic process influenced by changing environmental conditions, traffic, construction and maintenance characteristics. It is estimated that by 2050, the average temperature will increase 2 to 3 degree C in southern Ontario, which means more extreme weather and flooding will occur in the future and the effect along with traffic load could make the pavement degradation quicker. Climate change would impact how roads are planned, designed, constructed, operated and maintained. Considering climate change related hazards such as flood occurrence and rapid weather, change is crucial for promoting pavement performance prediction and pavement management. This research proposal was submitted to the MTO under the HIIFP program. Recently, the research in progress is “performance based fragility analysis of pavement considering flood hazard”. Flooding events occur more frequently under the changing climate, quantifying the effect of flooding on the pavement deterioration trend before and after, and the vulnerability of pavement could potentially promote pavement management decision making and reduce the pavement flood risk in the future.

Flooded Pavement
Flood Flow Modeling at Grand River around Waterloo

Floodplain and Road Map

Example of Fragility Curve of Pavement with the occurrence of flood
Lab Work Focus

Improving Durability of Asphalt Mixes Produced with Reclaimed Asphalt Pavement (RAP) by Enhancing Binder Blending

Reclaimed Asphalt Pavement (RAP) has been favoured over virgin materials in the light of the unstable cost of virgin asphalt binders, shortage of quality aggregates, and compelling need to preserve the environment and natural resources.

The main objectives of this research are: to examine the kinematics of blending of aged and virgin binders by considering the time-temperature effect during mixing and silo storage, and assess the thermo-mechanical behaviour of Hot Mix Asphalt (HMA) containing RAP at different blending states.

Miller Group and Steed and Evans are the suppliers of the mixtures from their Dratch, Drum, and Batch asphalt plants. HMA will be produced by the suppliers with RAP using Marshall™ mix design procedures: HL3 and HL8. HMA mixture with different percentages of RAP ranging from 15% to 40% will be considered in this study. For comparison purposes, control mixtures without any RAP will also be produced. Samples will be collected right after production and at several time intervals of silo-storage (i.e. 1, 2, 4, 6, and 24 hours). To understand the blending phenomena and its effect on the performance of the pavement, a multi-scale investigation is proposed. The Environmental Scanning Electron Microscope (ESEM) has been validated as a tool for the observation of the binder microstructure.

ESEM sample preparation

Blending zone, virgin, and oxidized binder could be clearly differentiated by ESEM images as shown in the Figure below.

ESEM Images of 58-28 binder (left), blending zone (middle), oxidized binder (right)

The performance of HMA containing RAP will be examined using dynamic modulus testing, thermal stress restrained specimen testing, rutting testing, and flexural beam fatigue testing. The collected experimental evidence will help the scientific community to better understand the complex blending phenomenon.

Moreover, the proposed project will unveil correlations between time-temperature effects and mixture performance. Consequently, it will deliver a synthesis document that provides practical recommendations to the professionals of the Canadian asphalt industry for a better use of RAP in more economic, sustainable and environmentally friendly asphalt mixes.
Highlights, Awards and Recognition

Susan Tighe Guest Lectures

Recently, Susan Tighe was invited to Western University and the University of New Brunswick Transportation Group Seminars as a guest lecturer. Her lectures were on resilient pavement for the sustainable future.

A key aspect to determining if a pavement design can be effectively used in Canada is that it must be resistant to harsh environmental and traffic loads. Currently, public agencies are also investigating the feasibility of incorporating sustainability and climate change impacts into transportation asset management. The potential benefits are diverse and of strategic importance as they encompass improvements to virgin material usage, alternative material usage, pavement in-service monitoring and management, noise, air quality, water quality and energy usage.

The lecture provided a framework for formally evaluating new materials and designs into pavement engineering. An evaluation of the concept of a solar road and the advanced application of SEM and CT scanning tools for evaluating and predicting performance of asphalt materials for usage on Canadian pavements was presented. Engineering tools such as Finite Element for more sustainable and climate factors into asset management programming at the network level work was also presented.

Awards and Recognition

**2016/2017 Ontario Graduate Scholarship - Dan Pickel** - Awarded for excellence in the graduate program

**2016/2017 President’s Graduate Scholarship - Dan Pickel** - Awarded to graduate students who hold major federally and provincially funded competition-based scholarships

Upcoming Events


September 25-28, 2016 - [Transportation Association of Canada Conference and Exhibition](http://www.tacconference.com) - Toronto, ON

November 13-16, 2016 - [Canadian Technical Asphalt Association](http://www.ctaa.ca) - Banff, AB
On May 27, 2016, CPATT and the Norman W. McLeod Chair hosted a seminar with Dr. Curtis Berthelot as the guest speaker. Dr. Berthelot’s presentation reviewed the application of applied mechanics. The application of applied engineering mechanics has grown significantly over the past decade with the development of improved materials characterization methods as well as advanced 3D numerical modeling techniques. These capabilities now enable engineers to provide their clients with more optimized design solutions that result in cost-effective life cycle investment in infrastructure. The presentation showed how PSI Technologies has turned the application of engineering mechanics into a successful growing business venture in road and mining engineering.

Dr. Berthelot is the president, owner, and chief technical officer of PSI Technologies and provides overall technical leadership, as well as operations management for the company. As a professional engineer, Dr. Berthelot has over 25 years of experience in research, design, construction, and project management related to roadway construction, road recycling, material stabilization, transportation infrastructure management, intelligent transportation systems, and the trucking industry. He served as an assistant professor in the Department of Civil and Geological Engineering at the University of Saskatchewan from 1998 to 2009 and a tenured professor from 2009 to 2014.

Dr. Berthelot specializes in mechanistic material analysis and has dedicated his career to developing pragmatic mechanistic based materials testing procedures and equipment in inelastic materials including asphalt concrete, asphalt cement, aggregate and soils, soil cements and other additives, and saltcrete backfill systems. Dr. Berthelot’s extensive knowledge of mechanistic-based materials science and non-destructive structural asset management has made him a pioneer in this area of expertise.

A leader in innovation, Dr. Berthelot piloted the way for road recycling and road materials stabilization across the province of Saskatchewan. Dr. Berthelot’s firsthand knowledge of Saskatchewan materials and climatic conditions has led to his expertise in pavement structure performance and recycled materials for road construction and civil engineering uses.

Dr. Berthelot’s presentation can be found [here](#).
Norman W. McLeod Chair Update

New Students

Meet Eskedil Melese

Eskedil joined CPATT in January 2016 as a PhD candidate under the supervision of Professors Tighe and Baaj. He received his Bachelor of Science degree in Civil Engineering in 2005 from Arba Minch University (Ethiopia) and Master of Science degree in Road and Transportation Engineering in 2014 from Addis Ababa University (Ethiopia). Eskedil started his career as a Graduate Assistant at Arba Minch University and then worked for ten years as a Pavement/ Materials Engineer. His current research focuses on the use of Hydraulic Road Binders in Full Depth Reclamation of gravel roads and flexible pavements at the end of their service life.

The Canadian road network consists of more than one million kilometers of paved and unpaved roads, which is the world’s seventh biggest road network. Among these, at least 800,000 km are low-volume roads (LVRs). For these roads, maintenance, rehabilitation, and reconstruction will be required earlier than in the design life. One of the key challenges of pavement engineers will be the long-term performance of the LVRs using a cost-effective solution. The main research objective of Eskedil’s PhD work is to find a cost-effective but innovative solution for LVRs by addressing long-term performance under the Canadian environment. His work will focus on Full Depth Reclamation (FDR) using Hydraulic Road Binders (HRBs) which is a technique that allows using existing materials making this technique a more economic, sustainable and environmentally friendly solution.

Meet Andy Zhong

Andy Zhong joined CPATT in September 2015 as a MASc candidate under the supervision of Prof. Tighe. He obtained his Bachelor degree in 1991 and his Master’s degree in 1997 from Chang’an University, in Highway and Urban Road Engineering. He has been serving as the deputy chief engineer at FHCC (CCCC First Highway Consultants Co.). During his work for FHCC, his work included engineering feasibility studies, design and consulting work for pavement and highway projects both in China and other countries (Chad, DPR, Korea, Burma).

Andy’s research focuses on the local calibration of the MEPDG prediction models using field measurements. Great efforts have been invested in calibrating the MEPDG for its implementation in pavement design in Ontario. Several projects have been carried out for the local calibration over the past few years. However, due to the inherent challenges of the work, the current local calibration study in Ontario has achieved only limited success. The proposed research aims to enhance the current local calibration results by using more accurate field measurements and forensic investigations. Andy’s research aims to refine and validate the MEPDG distress and performance models on rigid pavements recorded in pavement management systems in Ontario. The research will not only help the design practice using MEPDG in Ontario but also the management by incorporating the prediction capacity of MEPDG into the empirical degradation modeling module of the current pavement management system.
Norman W. McLeod Chair
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