



INTERNATIONAL
CONCRETE SUSTAINABILITY CONFERENCE
NORTH AMERICA + LATIN AMERICA
MAY 11-13, 2015 | MIAMI

SPEAKERS

Keynote Speakers (alphabetical order by last name)

Leslie Chapman-Henderson, President and CEO, Federal Alliance for Safe Homes (FLASH), USA

Resilience on the Rise: A Report on the Disaster Safety and Mitigation Movement

Session: Opening General Session, May 12, 8:00 am – 10:00 am

Ms. Chapman-Henderson has championed the disaster safety movement through the creation of FLASH (Federal Alliance for Safe Homes) and its groundbreaking awareness initiatives for homebuilders, homeowners and design professionals. Ms. Chapman-Henderson's experience and expertise span both creative and technical initiatives from delivery of the award-winning, 4-D "edu-tainment" experience, StormStruck: A Tale of Two Homes at the INNOVENTIONS Attraction at Epcot at the Walt Disney World Resort to development of Blueprint for Safety, a comprehensive education program on disaster resilience for graduate students, professionals and volunteers. She has served as co-chair of the legislatively-created My Safe Florida Home Advisory Council, as a board trustee for Florida International University–International Hurricane Research Center, an advisory council member for the Florida State University Catastrophic Storm Risk Management Center, consumer representative and chair for the Florida Hurricane Catastrophe Fund Advisory Council, guest lecturer at Florida State University and the University of Florida–School of Construction and as a Florida representative to the Federal Communications Commission WARN Committee.

Philippe Fonta, Managing Director, Business Applications, World Business Council for Sustainable Development, Switzerland

Panelist for Panel Discussion on Resilient Communities

Session: Closing General Session, May 13, 3:30 pm – 5:00 pm

Mr. Fonta has over 20 years experience with private companies, working in cooperation with international institutions, policy-making bodies and non-governmental organizations. Successively Director of Environment and Head of Sustainable Development for Airbus, one of the two major aircraft manufacturers, he also endorsed the responsibility of chairman of the environmental committee of the aerospace manufacturers' trade association, being the official observer to the UN aviation-specialized standard- and policy-making agency. He is now bringing his technical engineer's background and his experience in economic scenarios and international cooperation to the cement sector, leading since March 2011 the World Business Council for Sustainable Development's Cement Sustainability Initiative (CSI), a global effort by 22 major cement producers with operations in more than 100 countries who believe there is a strong business case for the pursuit of sustainable development. In addition, in January 2012, Philippe endorsed the responsibility of director of the Energy Efficiency in Buildings (EEB) project, another major WBCSD project. Created in 2006, the EEB project first assessed how to transform the building sector with better energy-efficient solutions and recommendations and is now focusing on triggering implementation within the building sector, through the next project phase, called EEB2.0, launched in January 2013.

Allen Hamblen, President and Chief Executive Officer, CalPortland Company, Inc. and Chairman of the NRMCA, USA

Welcoming Remarks and Progress Report on NRMCA Sustainability Initiatives

Session: Opening General Session, May 12, 8:00 am – 10:00 am

Mr. Hamblen is President and Chief Executive Officer of CalPortland Company and prior to a 2006 consolidation Mr. Hamblen was President and Chief Executive Officer of Glacier Northwest. Mr. Hamblen has been working with CalPortland and its predecessors for 29 years. He is currently serving as the Chairman of the Board of the National Ready Mixed Concrete Association. He also serves on the Board of Directors of the Portland Cement Association and is a past President of the Washington Aggregates and Concrete Association. He received a bachelor's degree and MBA from Sam Houston State University in Huntsville, Texas. He and his wife Arlene have two sons, Joshua and Jacob. They both enjoy California's weather which is great for spending time outdoors with their horses.

Dr. Natalie West Kharkongor, Associate Professor of Economics and Head, Center for Development of North Eastern Region IIM Shillong, India

Green Economics: Sustainability Funding

Session: Luncheon, May 13, 12:00 pm – 1:30 pm

Dr. Kharkongor holds a Doctorate Degree in Economics. She has twenty three years of teaching experience, twenty years of research experience, and 10 years of consultancy experience. She received the Broad Outlook Learner Teacher Award from the Prime Minister, Dr. Manmohan Singh in 2004 and the Rashtriya Gaurav Award with Certificate of Excellence in 2011 in New Delhi. She has presented and published a number of papers related to Banking and Finance, Entrepreneurship, Agriculture, Industry, Higher Education, Water Management, Women Empowerment, Health Sector, Green Economics and others. Currently, Dr. Kharkongor is the President of Meghalaya Economic Association. She is a Life Member of the Indian Economic Association and Member of Green Economics Institute, UK. Dr. Kharkongor is also an active Social Worker for the past twenty five years.

Lionel Lemay, Senior Vice President, Sustainable Development, National Ready Mixed Concrete Association, USA

Moderator for Panel Discussion on Resilient Communities

Session: Closing General Session, May 13, 3:30 pm – 5:00 pm

Mr. Lemay is Sr. Vice President, Sustainability for the National Ready Mixed Concrete Association (NRMCA). He manages programs that assist concrete producers, contractors, and design professionals transform concrete manufacturing and construction to improve overall sustainability of the concrete industry. Mr. Lemay has written numerous articles on concrete design and construction and is co-author of the McGraw-Hill book *Insulating Concrete Forms for Residential Design and Construction* and contributor for FEMA 320 *Taking Shelter From the Storm: Building a Safe Room For Your Home or Small Business*. He is a Registered Professional Engineer and Structural Engineer in the State of Illinois, a LEED Accredited Professional and ACI Fellow. Mr. Lemay holds a bachelors and masters degree in civil engineering and applied mechanics from McGill University in Montreal, Canada.

Fred Malik, FORTIFIED Programs Director, Insurance Institute for Business and Home Safety, USA

Panelist for Panel Discussion on Resilient Communities

Session: Closing General Session, May 13, 3:30 pm – 5:00 pm

Mr. Malik is responsible for overseeing the day-to-day operations of the FORTIFIED suite of programs, which seek to improve property resilience to natural disasters on a local, regional and national level. Since taking over the program in 2009, Fred has led FORTIFIED's expansion to include existing residential, new residential and light commercial building standards. Under his leadership, FORTIFIED has quickly become the national building standard for resilience. With more than 20 years of construction experience and a MBA from Virginia Tech, Fred has established himself as a recognized mitigation expert. He is a featured speaker on resilience and its value and practicality at conferences across the country. Fred is married and lives with his family in Florida.

Aris Papadopoulos, Founder, Resilience Action Fund, USA

The UN Role in Shaping the Emerging Global Resilience Movement

Session: Luncheon, May 12, 12:00 pm – 1:30 pm

Aris Papadopoulos is the retired CEO of Titan America (1994-2014). He is past chair of the Portland Cement Association, founding chair of the Concrete Joint Sustainability Initiative and recipient of ACI's Sustainability Award. He had been a member of the UN's International Strategy for Disaster Reduction (UN-ISDR) for over 5 years and served as first chair of its Private Sector Advisory Group (2011-13). He actively participated in the Sendai World Conference on Disaster Risk Reduction representing the private sector. He recently launched his first eBook titled 'Resilience – The Ultimate Sustainability: Lessons from Failing to Create a Stronger and Safer Built Environment' (available on www.buildingresilient.com). He recently founded the non-profit Resilience Action Fund to promote greater transparency, awareness and education for resilience in the built environment. Mr. Papadopoulos will present on the UN's role in shaping resilience.

Kirsten Ritchie, Director of Sustainable Design, Gensler, USA

The Growing Demand for Transparency and Corporate Social Responsibility in the Building Sector

Session: Opening General Session, May 12, 8:00 am – 10:00 am

A recognized expert in sustainability rating systems, Kirsten Ritchie has also played a pivotal role in the development of numerous building product standards including the newly released Health Product Declaration (HPD). Ms. Ritchie is a LEED® AP+ (O+M) and a licensed professional engineer. She holds a bachelor of science in civil engineering from the University of California, Berkeley and a master of science in civil engineering from California State University, San Jose. She serves on the Board of Directors and Material and Resources Technical Advisory Group (MR-TAG) of the US Green Building Council. She is also an advisor to the Ecological Building Network, the Health Product Collaborative and the Responsible Purchasing Network. Her presentation will center on the drive for information transparency by the design profession as a lever to improving health and reducing carbon in our built environment.

Steve Sunderman, President, Terrazia PC and Principal Architect at Quantum Architects

Panelist for Panel Discussion on Resilient Communities

Session: Closing General Session, May 13, 3:30 pm – 5:00 pm

Mr. Sunderman promotes sustainable building strategies that save money, improve people's lives & ensure a sustainable future. He provides high performance building design and educational programs as a means to conserve financial & natural resources for a variety of stakeholders and to create sustainable environments for current and future generations. His architectural experience includes design and management for a wide variety of building types throughout the United States and the Middle East. Sustainability, exemplified by alternative energy, conservation and equitable environmental design, has been his passion since the early 1970's.

Mark Woerner, Assistant Director for Planning, Miami-Dade Dept. of Regulatory and Economic Resources, USA

The Challenges of Climate Change and Steps Miami-Dade County is Taking to Mitigate Weather Disasters

Session: Opening General Session, May 12, 8:00 am – 10:00 am

Mr. Woerner oversees the administration, maintenance and update of the County's adopted Comprehensive Development Master Plan. The Department's Planning Division is the lead office for all land use, comprehensive planning and growth management matters, as well as, historic preservation and sustainability initiatives for Miami-Dade County. Mr. Woerner has served with Miami-Dade County for 26 years since 1987, and previously worked for five years as Sarasota County's Chief of Long Range Planning. Prior to moving to Florida in 1982, he worked for four years with the Montgomery and Greene Counties Metropolitan Planning Organization in Dayton, Ohio as a Transportation Planner. He holds Bachelor's degree in Urban Studies/ Sociology and a Master's degree in Public Administration. He is also a certified planner with the American Institute of Certified Planners. Mr. Woerner will present the challenges presented by climate change to Miami-Dade County, which encompasses the city of Miami, and how the county is working with the city and surrounding counties to address the ever increasing threat from weather related disasters.

Technical Speakers (alphabetical order by last name)

Ehssan Amir Sayyafi, Florida International University, USA

Development of a New Lightweight-wind-resistant Composite Roof System, Ehssan Amir Sayyafi, Arindam Gan Chowdhury, Amir Mirmiran and Vasant H. Surti

Session: T1A, May 12, 10:30 am - 12:00 pm

During windstorms, such as hurricanes, roofs are subjected to high wind uplift pressure, especially at the edges and corners. Such wind loading often causes damage to conventional roofing systems. Roof damage can lead to water intrusion, causing serious impairment to building interiors and contents. The objective of this research is to develop a new roof system for commercial and industrial buildings that withstands high wind pressures and resist hurricane induced damage. The proposed system includes prefabricated panels using high performance concrete and non-corrosive reinforcement and addresses the structural and architectural requirements. The effort is to improve the structural efficiency while reducing the weight of the system. The proposed roof system will make significant contributions towards enhancing the hurricane resilience of buildings in vulnerable coastal communities. It would be lightweight, wind resistant, durable, non-corrosive, and almost maintenance-free with low risk of damage from fungi and termites. The system is applicable to new construction as well as upgrading the roof of existing buildings. The estimated cost is comparable to the cost of conventional roofing systems.

Laurent Barcelo, Lafarge, Canada

Aether™ a Low CO2 Cement, Laurent Barcelo, Gunther Walenta, Ellis Gartner and Bruce Blair

Session: T3A, May 12, 3:30 pm - 5:00 pm

The manufacture of concrete accounts for over 5% of manmade CO2 emissions, but this is primarily due to the enormous global demand for such construction materials, especially in rapidly developing economies. Nevertheless, compared to most other building materials, concrete has a very low carbon footprint, and it cannot easily be substituted by anything that is more environmentally sustainable. Despite this, the cement and concrete industries continue to work on minimizing their environmental impact. The low-cost options, such as re-use of industrial by-products, are already being used to a large extent and are close to saturation. With Aether™, a belite-calcium sulfoaluminate-ferrite cement, Lafarge has patented a new category of cements that can potentially reduce specific CO2 emissions by 30% compared to Portland Cements, and can also in principle be manufactured in existing cement plants in most locations worldwide. The presentation will summarize the characteristics of Aether™ cements and provide an update on their development (performance, durability, etc...).

Mostafa Batouli, Florida International University, USA

A Simulation Framework for Assessment of Pavement Network Sustainability: Comparative Assessment of Pavement Material Types, Mostafa Batouli, Ali Mostafavi and Michael Bienvenu

Session: T4C, May 13, 8:00 am - 10:00 am

The choice of appropriate pavement materials is a critical aspect of sustainability in road infrastructure networks. Over the past few decades many research studies have investigated sustainability of pavement materials using life cycle assessment and life cycle cost analysis. While these studies are helpful in selection of sustainable pavement materials at the project level, the long-term impacts of pavement material selection on the sustainability performance of road networks is not fully understood. For a network level sustainability assessment, more holistic analysis approaches are required. In this paper, we argue that sustainability is a complex dynamic process rather than a static end state; and hence, a solution could be sustainable under a certain condition while the same solution is less desirable under different conditions. For assessment of the impacts of pavement material selection at network level, the complex interactions between the condition of assets, priorities of the agency, and user behaviors need to be considered. To address this limitation in current evaluation techniques, we present a simulation framework to simulate the performance, cost and environmental impacts of a pavement network under different conditions. The simulation framework is based on agent-based modeling that captures the dynamic behaviors at the interface of network-agency-user interactions.

Tim Cost, Holcim (US) Inc., USA

Enhanced Cementitious Efficiency in Sustainable Concrete Mixtures with PLC – Influence of the Chemical and Physical Properties of PLCs and SCMs, Tim Cost, Isaac Howard, and Jay Shannon

Session: T3A, May 12, 3:30 pm - 5:00 pm

This presentation will begin with a brief review of published work by the authors that documents the potential for increased interaction efficiency of many common supplementary cementitious materials (SCMs) when portland limestone cement (PLC) is used. The most recent focus of ongoing work by the authors has related to the specific chemical and physical properties of PLCs that drive the greatest performance synergy with SCMs as well as the specific SCM properties that maximize this performance potential. Of particular interest is the necessary fineness of PLC, since this controls the available surface area of the limestone particles, known to influence the extent of possible chemical interaction with SCMs. This also affects, to some extent, the sustainability metrics of PLC, since finer grinding requires increased energy and grinding time investments. Among new data to be presented are the results of concrete trials using aggressive SCM replacement of cement with both OPC (as a control) and PLC samples of varying fineness, from the same plant, made from similar clinker. Considering the objectives of maximizing the potential for beneficial cement-SCM interaction and overall cementitious efficiency, conclusions will be presented relative to optimal PLC fineness and other properties, as well as SCM type and general chemical and physical attributes. Example concrete mixtures that capture these benefits and result in reductions of CO2 footprint and embodied energy approaching 50% (relative to traditional mixtures with similar performance) will be presented.

Daniel Duque, Cementos Argos S.A., Colombia

Beyond EPDs: Using LCA Models and Tools to Develop More Sustainable Cements and Concretes, Daniel Duque, Renée Morin and Cashion East

Session: T5C, May 13, 10:30 am - 12:00 pm

In 2014, Argos undertook a project aiming to obtain an EPD covering 19 concrete mixes produced at 18 different concrete plants in the major metropolitan market of Dallas – Ft. Worth. This initiative was accompanied by PRé Sustainability, a leading company in LCA. As a result, Argos obtained an NRMCA certified EPD covering 342 products and various LCA models for its cement and concrete plants. While the benefits of EPDs are now well understood and will increase in the future as more and more building owners adopt LEED v4 or other sustainable construction certifications that encourage EPDs, the benefits of LCA models are still

not fully integrated into the business processes. The development of sustainable products can be more straightforward as LCA models permit testing of a wide range of hypotheses, and give the whole picture of environmental impacts. Argos and PRé are finding ways to take full advantage of the richness of data embedded in robust LCA models starting at the product design phase. Thanks to a web-based software tool developed by PRé, now it is very easy for non LCA experts at Argos to manipulate existing models, both at the cement and concrete level and quickly visualize the resulting changes in impacts. In this presentation we will share some examples of how the LCA model results help to guide the development of more sustainable products by giving visibility into the impacts of those scenarios in advance of implementation.

Jacob Ellis, Texas State University, USA

Modeling the Life-Cycle Impact (LCI) of Concrete through Comparative Life Cycle Analysis (LCA), Jacob Ellis, Jiong Hu and Vedaraman Sriraman

Session: T6C, May 13, 1:30 pm - 3:00 pm

As the concrete industry continues to move toward a more sustainable future, innovative environmentally-friendly solutions in concrete production and construction have become commonplace. With a wealth of new sustainable solutions available, the importance of weighing and comparing the life cycle impact (LCI) of concrete products through life cycle analysis (LCA) is paramount, but in many cases the amount of resources required to incorporate experimental LCA in concrete applications prohibits its widespread use. Modeling the LCI of concrete through regression analysis of LCA case studies presents a quick and cost-effective method of predicting environmental impact that can potentially be useful in construction estimation and other fields. This study constructs a predictive model for the LCI of concrete in pavement applications from current LCA research as an example that allows for the life cycle comparison of different concrete compositions with alternative supplemental cementitious materials and recycled aggregates. Through modeling environmental impact outputs with concrete mixture inputs that are widely available to users, this type of LCI analysis can be used to assist in the prediction of environmental impact for new concrete construction, as well as informing break-even analyses when traditional concrete is compared to sustainable alternatives. The benefits and limitations of a regression-model approach to assessing life-cycle impact in construction estimation are discussed, as well as opportunities for future research in applying regression analysis in the design of sustainable concrete.

Giorgio Ferrari, MAPEI SPA, Italy

Durability of Concrete with Recycled Aggregates from Returned Concrete, Giorgio Ferrari

Session: T4A, May 13, 8:00 am - 10:00 am

Recycled aggregates produced with a new technology from fresh returned concrete were used to produce new concrete, by replacing 100% of natural aggregates. The new concrete was tested for internal sulphate attack (ISA) by long-term durability testing including several weathering cycles simulating the typical conditions of exposure of concrete pavements. A reference concrete with the same dosage of cement and w/c made with natural aggregates was used as comparison. Dynamic elastic modulus (DEM) measurements indicated that no mechanical deterioration of both the concretes was observed at the end of the test. X-ray powder diffraction (XRPD) analyses confirmed that the concrete with the new aggregates and that with natural aggregates behaved similarly to ISA. Scanning electron microscope (SEM) analysis showed that the microstructure of concrete made with the new aggregates were less affected by the aging cycles at the end of the test, compared to concrete made with natural aggregates. The results of the present work confirmed that recycled aggregates produced from returned concrete with the new technology can be used to produce durable concrete.

Stephen Fleming, Prairie Materials, Canada

High Performance Concrete, Stephen Fleming

Session: T2B, May 12, 1:30 pm - 3:00 pm

This presentation provides an overview of high performance concrete in the Chicago market from the early 1960s through 2015. Characteristics of HPC are discussed along with real world examples of foundations and structural framing systems for high rise buildings in Chicago. From 6,000 psi concrete in the early 1960s to nearly 20,000 psi in recent projects, this presentation addresses opportunities and challenges of some of the world's most high profile projects including Trump Tower and the upcoming Wanda Vista tower.

Ehsan Ghafari, Missouri University of Science and Technology, USA

Admixture Compatibility of Alternative Supplementary Cementitious Materials, Ehsan Ghafari, Dimitri Feys and Kamal Khayat

Session: T4A, May 13, 8:00 am - 10:00 am

This paper aims to study the compatibility between the some natural pozzolans including flyash (FA), perlite (PL), pumice (PM) and zeolite (ZL) with one type of superplasticizer namely by means of rheological properties and hydration analysis. The results showed that the inclusion of pumice and zeolite led to an increase in yield stress and plastic viscosity with time, compared to the mixtures with perlite or fly ash, or the plain cement mixtures, regardless of temperature. The results of the calorimetry analysis revealed that the inclusion of zeolite accelerated the hydration reaction significantly and released almost the same cumulative heat compared to the plain cement paste while pumice accelerated the reaction slightly during the first 12 hours of the test. Perlite has the lowest heat flow among all SCMs which implied a slower hydration reaction. The hydration reaction was also delayed when including fly ash and pumice.

David Green, BASF Corp, USA

Gaining Value from an Environmental Product Declaration - A Simplified Approach to Develop more Sustainable Concrete Solutions, David Green

Session: T5A, May 13, 10:30 am - 12:00 pm

Environmental product declarations provide valuable information on the environmental impacts of products and processes. Is the information really beneficial to producers if the results are too difficult to understand, interpret and explain? This presentation will provide the means to compare different concrete mixes using life cycle analysis and report the environmental impacts required in a concrete EPD in simple, practical terms that are easily understood for producers, their employees, families and all customers along the value chain. Using a practical equivalent approach will support producers in defining their most sustainable concrete solutions.

Kelly Henry, Lafarge, Canada

Utilizing the Resiliency and Longevity of UHPC to Build a Sustainable World, Kelly Henry

Session: T1A, May 12, 10:30 am - 12:00 pm

Ultra-High Performance Concrete (UHPC) has been studied extensively over the last 20 years and long-term durability compared to normal concrete is a key attribute considered. The characteristics of UHPC which contribute to its resilience capabilities will be reviewed using as references studies performed by the Federal Highway Administration (FHWA) and the US Army Corps with its Marine testing facility at Treat Island, Maine. The Treat Island study, started in 1996, is the oldest running study focused on chloride penetration and freeze/thaw effects on UHPC. The FHWA's study, conducted from 2002 to 2005, was to understand the characteristics of UHPC in comparison to HPC for potential uses in the US Highway and bridge structure segment. Over the last 7 years, UHPC has proved that it is well suited for the bridge market in North America. Examples of completed projects will be used to highlight the sustainability benefits of UHPC in these types of applications. UHPC is also being utilized in the architectural realm, where its durability and high strength characteristics are benefiting buildings. The Perez Art Museum of Miami utilizes 16 foot mullions to hold into place the large panes of glass. In Victoria, British Columbia, The Atrium was designed to resist earthquake loads. Looking at the entire life cycle for structures and knowing that they will survive significantly longer than we could previously build for is what will ultimately make for a more environmentally sound solutions. Resilience and longevity is the key to protecting the rest of this earth from the stresses that occur when we build.

Joshua Hester, Massachusetts Institute of Technology, USA

Streamlining Life Cycle Assessments of Residential Construction, Joshua Hester, Carla Rodrigues, Reed Miller, Paolo Tecchio, Jeremy Gregory and Randy Kirchain

Session: T5C, May 13, 10:30 am - 12:00 pm

With today's concern about climate change and the impacts that humans have on our environment, more attention is being given to the design of buildings that produce fewer pollutants (especially greenhouse gasses) over their lifetime. Life Cycle Analysis (LCA) is an increasingly-used method for determining a product's environmental impacts but existing methods for LCA of buildings generally require a very specific design, which both adds to the burden of data collection and also limits LCAs to late stages of the design process when there is less opportunity to make significant improvements. Therefore, there is the need for effective and efficient LCA models that can be applied earlier in the design process when these models have greater potential to influence the final building. Two main methods have generally been used to streamline LCAs and make them easier to perform: limiting the scope of the analysis and using proxy or surrogate data for materials or processes when the desired information does not exist. A third option is to "underspecify" the materials or processes by grouping them into related families, performing Monte Carlo simulations by randomly sampling a material from each family, and then using statistical measures on the resulting data set to identify and select the most influential components to specify at a higher resolution. The underspecification method is used in the MIT Concrete Sustainability Hub's Building Attribute to Impact Algorithm (BAIA), which is a combination of statistical relationships between early-stage building design attributes and the environmental impacts of buildings with these attributes. Here, the authors present recent results from the current version of BAIA that demonstrate how underspecification can be used to reduce the need for detailed data collection for a LCA while still generating results similar to the fully-specified model.

David Holt, Texas State University, USA

Evaluation of the Effect of Recycled Tire Rubber as Fine Aggregate Replacement on Concrete Properties, David Holt, Michelle Londa, Matthew Snead, Michael Mullen, Philip Bateman, Jiong Hu and Reid Pierson

Session: T1B, May 12, 10:30 am - 12:00 pm

Concrete production consumes a considerable amount of natural resources that cannot be replaced or replenished. With landfills being created at an alarming rate, compounded with the increased cost of disposal, the need for recycling has reached an all-time high. Of the various solid wastes, accumulated waste tires are of particular interest because of their non-biodegradable nature. This study will analyze the feasibility of using fine recycled tire rubber, which has a particle size ranging from 1mm to 4mm, as a fine aggregate in place of natural sand in concrete. Lightweight, toughened concrete mixtures comprised of significant amounts of recycled materials should be beneficial for many applications. In this study, concrete mixtures with various recycled tire rubber replacement levels (0, 15, 35, 50 and 100% by volume) of fine aggregate and different dosages of high-range water reducing agent were prepared. Fresh concrete properties, including slump and unit weight, and mechanical properties, including compressive strength, toughness and the modulus of elasticity, will be measured. Scanning Electron Microscopy (SEM) is to be used to evaluate the interface between rubber and cement paste, and Thermal Gravimetric Analysis (TGA) is to be used to determine the amount of moisture absorption and the decomposition temperature for the rubber.

Matthieu Horgnies, Lafarge Research Center, France

An Innovative Depolluting Concrete Doped with Activated Carbon to Enhance Air Quality, Matthieu Horgnies, Isabelle Dubois-Brugger and Eric Stora

Session: T4B, May 13, 8:00 am - 10:00 am

Air pollution generated by transportation affects the health of tens of millions of persons in the world. Some of the most toxic air pollutants are composed of nitrogen oxides (especially nitrogen dioxide, NO₂) and volatile organic compounds (VOCs, such as benzene, toluene...etc.). The technology of this new de-polluting concrete, patented in 2010, does not rely on photo-catalysis and can function perfectly well in the dark, which is especially suitable for use in confined areas prone to pollution peak (tunnels or parking garages). In 2012, the Lafarge Research Center built two prototype parking garages where the walls are made of de-polluting concrete or are coated by a de-polluting mortar. The tests done using gasoline generator as a source of pollutants confirmed a significant abatement about NO₂ and certain aromatic VOCs. The de-polluting effect was confirmed all along of one year of tests and helped in scheduling future field-tests.

Jiong Hu, Texas State University, USA

Optimizing Concrete Pavement Type Selection Based on Life Cycle Cost Analysis, Jiong Hu, Evan Humphries and Ash Kotwal

Session: T4C, May 13, 8:00 am - 10:00 am

Material properties of coarse aggregate are considered to be an important factor when designing and constructing concrete pavement. In many cases, however, the cost and availability of coarse aggregate can also have a substantial influence on project outcomes. While continuously reinforced concrete pavement (CRCP) and joint concrete pavement (JCP) have both shown promising performance, study shows that the potential for severe spalling in CRCP increases substantially

with the use of coarse aggregate with high coefficient of thermal expansion. In this study, in-depth analysis was made of the life-cycle cost of the concrete pavement with coarse aggregates from various sources. A case-based cost analysis was performed to compare current cost and life cycle cost of CRCP with JCP. By comparing costs associated with the two different pavement options, it is possible to determine the optimum pavement choice for a given project based on the base-line life-cycle cost generated from the study. Proper selection of PCC pavement type based on coarse aggregate type will enhance overall PCC pavement performance, thus minimizing maintenance and repair costs.

Daniel Hussey, Manhattan College, USA

Mechanical Properties of Concrete Mixed with Recycled Shredded Tires and High Percentage of Polypropylene Fibers, Goli Nossoni and Daniel Hussey

Session: T1B, May 12, 10:30 am - 12:00 pm

The goal of this research was to reduce the elastic modulus of cement paste to match that of the tire chips and yield a new "Rubcrete" that has high ductility and relatively low strength for specific applications such as Jersey barriers. To reach this goal, a high percentage of polypropylene fibers was added to the concrete mix. This is a promising approach for alleviating stress concentrations in the cement paste due to incompatibility of deformation between cement paste and rubber aggregate under applied load. Concrete was produced replacing 0%, 25%, 50%, 75%, and 100% of coarse aggregate with shredded tires. All concrete batches were mixed using 1% polypropylene fibers. Both load-deflection and stress-strain curves were obtained for each mix. The results showed that as the percentage of the shredded tire chips in the concrete mix increased, the ductility of the concrete increased. A maximum strain of 0.08-0.1 and a maximum deformation of 0.3 inch was obtained for 100% replacement. This modified Rubcrete is a very ductile and relatively inexpensive concrete compared to Engineered Cementitious Composite (ECC) and can be used for different applications where high strength is not needed, but high ductility is desired.

Xin Jiao, Florida International University, USA

Effect of Pavement-vehicle Interaction on Fuel Consumption by Field Measurement in Florida - Phase II, Michael Bienvenu and Xin Jiao

Session: T2C, May 12, 1:30 pm - 3:00 pm

Fuel consumption is measured by operating a passenger car and a tractor-trailer on two interstate roadway sites in Florida. Each roadway site contains both asphalt pavement and concrete pavement with similar roughness, traffic and environmental conditions. Comparison reveals that the average fuel consumption differences between vehicles operating on asphalt pavement and concrete pavement at given test conditions are 4.04% for tractor-trailer and 2.50% for passenger car, with a fuel saving on concrete pavement. The fuel consumption differences are found statistically significant at 95% confidence level for both vehicle types. Test data are also used to calibrate the Highway Development and Management IV (HDM-4) fuel consumption model and model coefficients are obtained for four sets of observations. Field measurement and prediction by calibrated model shows generally good agreement. Finally, the effect of wind speed and direction on vehicle fuel consumption is investigated and modified equations are recommended for HDM-based aerodynamic resistance calculation with Florida's condition.

Scott Jones, National Institute of Standards and Technology, USA

Service Life Modeling of Reinforced High Volume Flyash (HVFA) Concrete Structures Containing Cracks, Scott Jones, Dale Bentz, Kenneth Snyder and Nicos Martys

Session: T3B, May 12, 3:30 pm - 5:00 pm

The ingress of chloride ions is a major issue relating to the durability and sustainability of reinforced concrete structures. Chloride ions, resulting from the application of de-icing salts or exposure to marine environments, travel through the concrete matrix by diffusion in connected pore network. Cracks present in the concrete facilitate chloride movement by allowing ions to bypass the concrete matrix and travel directly to reinforcing bars. Modeling this phenomenon is important to predict the service life of reinforced concrete structures. In this paper, the diffusivity and chloride binding capacity of high volume flyash (HVFA) concrete mixes, created in the laboratory, are measured. These results are incorporated into a modeling scheme where the chloride ion concentration in a reinforced concrete slab is computed given an assumed chloride ion exposure condition. The model is expanded by incorporating the effects of cracking and crack repair procedures commonly used in industry. The output of the model is the service life, defined to be the time required for the chloride concentration to reach a threshold level determined by the type of reinforcement. Simulation results suggest that the HVFA concretes are capable of achieving equivalent service life to ordinary Portland cement (OPC) concretes.

Mahsa Kamali, University of Miami, USA

Sustainable Construction Concrete Using Recycled Glass, Mahsa Kamali and Ali Ghahremaninezhad

Session: T1B, May 12, 10:30 am - 12:00 pm

Research on finding ways to incorporate waste glass in construction materials has been motivated by environmental concerns over the limited capacity of available landfill sites as well as greenhouse gas emissions generated during the production of construction materials. In 2010, only 23% of waste glass was recycled in the United States. This research study aims to investigate the feasibility of incorporating recycled glass in concrete construction materials thereby increasing sustainability in construction and reducing the greenhouse gas emissions. In this study, the effect of recycled glass powder as a replacement of cement on structural properties and durability behavior of concrete was investigated. The results indicated that concrete containing glass powder exhibits comparable strength as concrete without glass powder. The incorporation of glass powder in concrete decreases chloride permeability thereby improving the corrosion resistance in steel reinforced concrete. In addition, glass powder was shown to be effective in mitigating alkali-silica-reaction cracking in concrete. It is concluded that, recycled glass powder with an average size of below 50 micron can be used as a replacement of cement up to 20 percent in construction concrete.

Dirk Kestner, Walter P Moore, USA

Concrete Specifications and Whole Building LCA in LEED V4 – A Case Study, Dirk Kestner

Session: T5C, May 13, 10:30 am - 12:00 pm

Capitol Tower, a 35 story, 750,00 GSF Class A office building in downtown Houston is one of three Platinum Pre-Certified projects in the LEED V4 Beta program. As one of the first projects in the nation to pursue LEED V4, it is one of, if not the, first project to pursue the new LEED V4 Whole Building Lifecycle Assessment

credit in LEED. This paper and presentation will be a case study of this project's pursuit of the LCA credit, with a specific focus on the role of the concrete specification, and the significant contribution it made to the credit. The presentation will discuss the options currently available in commercial LCA software, the hurdles the design team faced, and how NRMCA EPD's and Industry Benchmarks were used by the project team.

Brian Killingsworth, National Ready Mixed Concrete Association, USA

Producing Roller Compacted Concrete With Sustainability as a Goal, Brian Killingsworth

Recent industry surveys show that the use of roller compacted concrete pavement has grown more in the last 3 to 4 years than in the previous decade. Along with this expansion, innovative solutions for mixing and producing RCC through ready mix plants has been introduced that allows concrete producers to participate in the RCC market. Additionally, material component modifications like utilizing recycled aggregates, replacing cement with supplementary cementitious materials, and using fibers and admixtures have made RCC pavement a more sustainable option while maintaining the strength and durability that makes RCC unique. This presentation will discuss how the ready mix producer can participate in the RCC market and produce more sustainable RCC.

Ash Kotwal, Texas State University, USA

An Investigation of Blended Cements with High Volume Intergrind Limestone, Ash Kotwal, Rusty Winters and John Schemmel

Session: T2B, May 12, 1:30 pm - 3:00 pm

The production of portland cement is one of the largest sources of energy consumption and carbon dioxide emissions in the world. Although cement is critical to the development of most infrastructure, regulations and permitting make it extremely cumbersome to increase production capacity. By intergrinding limestone with clinker, cement manufacturers can increase overall production volume and decrease material costs. The present research takes advantage of these benefits through the development of two to four innovative and sustainable blended cements with limestone content up to 25%. However, to determine their feasibility in concrete applications, it is crucial to evaluate the characteristics of the materials and their effect on fresh and hardened properties. An experimental program was performed to support the development of portland limestone cement. Preliminary results indicate a slight decrease in compressive strength due to higher limestone content, although drying shrinkage appears to be unaffected. Additional mechanical and durability testing is being performed, and recommendations will be provided for applications in the construction industry.

Lionel Lemay, National Ready Mixed Concrete Association, USA

Using the NRMCA Industry Average EPD to Lower the Impact of Concrete and Concrete Buildings, Lionel Lemay

Session: T6A, May 13, 1:30 pm - 3:00 pm

NRMCA sponsored a project to help NRMCA member producers meet the requirements of LEED v4 by providing producers with an industry-wide EPD in accordance with LEED v4. A cradle to gate Life Cycle Assessment (LCA) for ready mixed concrete was conducted and an industry wide (average) EPD was produced. The LCA and EPD encompassed concrete for a variety of applications, strengths, durability classes and slumps (or slump flows), and regions so that a producer can use the industry wide EPD during the submittal process for a project requiring an EPD. The EPD represents concrete typically used on a variety of projects including residential, commercial and public construction in different climate zones and in different markets. Using data collected in developing the Industry-Wide EPD for concrete, a set of industry benchmarks (industry averages) for key environmental impacts was developed for the national level and eight NRMCA regions. The benchmarks represent the environmental impacts of products with varying strengths for different applications and exposure conditions. Concrete producers can use these benchmarks to compare their environmental impacts to those of the industry baselines to determine if theirs are lower. This presentation provides guidance on how these documents help meet the LEED v4 requirements and actually reduces the environmental impacts of concrete and concrete buildings.

Rui Liu, Kent State University, USA

Performance Based Concrete Specifications – Solution for Sustainable Concrete?, Rui Liu

Session: T6B, May 13, 1:30 pm - 3:00 pm

Most State Departments of Transportation in U.S. have prescriptive concrete specifications governed by minimum cementitious material contents and maximum water-to-cementitious material (w/cm) ratios for certain types of concrete, mixed with some performance requirements e.g. slump, air content, and compressive strength. Many requirements were developed before advanced concrete technologies were applied in the concrete industry. Colorado Department of Transportation (CDOT) is one of the state transportation agencies that is developing performance based concrete criteria. The durability of concrete mixtures designed according to the proposed performance based criteria is examined in this study. The fresh concrete properties, compressive strength, permeability, and freeze/thaw durability were tested in the lab for one group of CDOT Class P rubberized concrete mixtures for pavement applications, and another group of CDOT Class D fly ash concrete mixtures for structural purposes. The mixture with 10% (by volume of coarse aggregate) tire chips and the one with 50% (by weight of cementitious material) fly ash had the best performance by considering the concrete strength, durability, environmental and economic impacts. Performance based specification shows a promise as the solution for sustainable concrete.

Colin Lobo, National Ready Mixed Concrete Association, USA

A Reality Check on the Evolution to Performance Specifications, Colin Lobo

Session: T3B, May 12, 3:30 pm - 5:00 pm

An important step in the evolution to performance specifications is to identify prescriptive requirements that are intended as a surrogate for performance and to evaluate the reasoning behind them. From a long list of prescriptive provisions, the NRMCA Research Engineering and Standards Committee rated the top 5 items that prevent the ability to optimize concrete mixtures and support sustainability initiatives. A survey of 100 actual specifications identified the frequency of these provisions. This presentation will discuss these provisions, their implied basis, identify problems caused by these requirements, and suggest alternatives to achieve the desired performance.

James Mack, CEMEX, USA

Developing Robust Rehabilitation Scenario Profiles for Life Cycle Assessment using Decision Tree Analysis, James Mack, Xin Xu, Jeremy Gregory and Randolph Kirchain

Session: T1C, May 12, 10:30 am - 12:00 pm

A primary input into any life cycle assessment (LCA) for pavements is the set of rehabilitation activities that are used to maintain the system over the analysis period. For the LCA to be meaningful and reliable, the analysis must reflect the most likely activities for each alternative over that analysis period. Currently, most state highway agencies (SHA) apply a single standard rehabilitation scenario to all pavements, which may or may not be representative of the actual set of activities that will be done. This paper shows how SHAs can use probability and decision tree analysis to evaluate different rehabilitation scenarios in order to determine the range of LCA results as well as an expected value LCA result. This information helps quantify the underlying risk assumptions that the rehabilitation selection has on the LCA results so that a more informed decision can be made when comparing the LCA results of pavement designs. A case study based on alternative designs and rehabilitation scenarios used by a SHA demonstrates the extent to which the decision tree analysis could affect the outcome of an LCA.

Mohamed Mahgoub, New Jersey Institute of Technology, USA

Integrated Multi-sensor Monitoring Systems for Sustainable Concrete-based Infrastructure Assets, M. Mahgoub, L. Potts, D. Washington and J. Miima

Session: T2C, May 12, 1:30 pm - 3:00 pm

This paper provides a framework for developing predictive intervention schedules of concrete-based assets using integrated multi-sensor monitoring systems (IMSMS). In most cases monitoring of civil infrastructure and assets involves a multitude of sensors to gather information in order to anticipate maintenance needs and to identify safety concerns. Multi-sensor technologies include geotechnical, geodetic, geosensing, and low-coherence deformation sensors that overcome the limitation of low spatial resolution of conventional monitoring methods. The quantitative methods include optimizing sensor network configurations that can best capture structural vulnerabilities and unexpected stress-induced damages well in advance of structural compromise or catastrophic failure. Predictive models based on fracture mechanics, deformation and failure modes, and dynamic deformation are investigated in this study and will be ranked based on performance criteria. Output of this IMSMS offers stronger support to decision making on sustainability because preventive maintenance scheduling is based on quantitative analytical methods to avoid high cost associated with rehabilitation due to limitations in knowledge of structural adjustment that would occur.

Mohamed Mahgoub, New Jersey Institute of Technology, USA

Hybrid OR/MS and GIS to Optimize Ready-mix Concrete Deliveries, L. Potts, M. Mahgoub, J. Miima and D. Washington

Session: T4A, May 13, 8:00 am - 10:00 am

Companies in the concrete industry are facing the following scheduling problem on a daily basis: concrete produced at several plants has to be delivered at customers' construction sites using a heterogeneous fleet of vehicles in a timely, but cost-effective manner. The distribution of ready-mixed concrete (RMC) is a highly complex problem in logistics and combinatorial optimization. The optimization theory and Microsoft Excel's Solver is used to create the standard optimization tools since it is an efficient and user friendly program. This paper demonstrates case studies using excel Solver application to 1) capture the complexities of the real-world and 2) use simple programming to support decision making. The problem statement is formulated with objective function to minimize cost and the total time needed subject to constraints on order size, route restrictions, and time to pour. The methodology developed to solve this problem draws on operations research and information technology, merging integer programming, network optimization models, and a geographical information system (GIS) for visualization. Analytical models in transportation are based on the supply chain management theory in order to achieve the lowest cost. This hybrid approach combines quantitative aspects of analytical mixed-integer linear programming with human reasoning stimulated by graphical inputs from Geographical Information System (GIS) visualization capabilities. The case study demonstrates issues on the main themes a) data preparation, b) metrics for systems performance, and c) model validation.

Jamie Meil, Athena Institute, Canada

Athena Impact Estimator for Highways – A Web-enabled Environmental Life Cycle Assessment Software for Assessing Regional Materials Manufacturing, Roadway Construction, Use and Rehabilitation Life Cycle Stages, Jamie Meil

Session: T4C, May 13, 8:00 am - 10:00 am

Life Cycle Assessment (LCA) is acknowledged as the most comprehensive way to evaluate the environmental impact of a Roadway over its lifetime. The Impact Estimator for Highways with its intuitive user interface puts the power of LCA in the hands of designers and policy analysts so they can better weigh the environmental implications of alternative roadway designs. Loaded with a large material and construction equipment database and the flexibility to specify unique pavements and rehabilitation schedules, the software allows for quick and easy comparison of multiple alternative roadway design options. It is also the first commercial software capable of modeling pavement vehicle interactions (PVI), so designers can optionally consider roadway roughness and deflection on predicted roadway traffic fuel consumption. This presentation will highlight the latest software developments including the web-enabled version, support for U.S. locations, the integration of PVI, and an illustrative comparison of two alternative pavement designs in two different U.S. locations.

Jamie Meil, Athena Institute, Canada

Industry Average Slag Cement EPD – A Tool to Document How Use of Slag Cement Can Reduce the Environmental Footprint of Concrete Mixtures, Jamie Meil and John Melander

Session: T5A, May 13, 10:30 am - 12:00 pm

Life Cycle Assessment (LCA) is a more comprehensive way to look at the environmental impact of a product over its lifetime. Now there's a new industry format called an EPD, or Environmental Product Declaration, that conveniently documents this information in a standardized format that makes the job of the product specifier much easier. This presentation will trace the development of an industry average Environmental Product Declaration (EPD) for N. American slag cement based on recently developed Product Category Rules (PCR) and a Life Cycle Assessment (LCA) study. Since slag cement is a recovered material that puts to beneficial use what might otherwise be wasted, the use of slag cement to replace a portion of the portland cement in concrete mixtures provides a significant reduction in the environmental footprint of concrete. This EPD simplifies the documentation of that reduction in environmental impact. The presentation will draw on the Institute's ongoing experience in conducting LCA studies on concrete mixtures and in working with the Canadian and US slag cement industry and its EPD Program Operator to highlight the process.

Katherine Michaud, Queen's University, Canada

Environmental impact of concrete containing RCA and PLC, Katherine Michaud, Neil Hoult, Abdurahman Lotfy, Paul Lum

Session: T6C, May 13, 1:30 pm - 3:00 pm

The need for more sustainable structural materials is of increasing interest around the world driven by issues such as climate change and consumption of non-renewable resources. Recycled concrete aggregate (RCA) and Portland limestone cement (PLC) are two commercially available products that can help reduce the construction industry's impact on the environment. RCA is regularly used in low risk applications such as road-base, parking/driveway pavements, and drainage fill but has not been accepted for use in higher risk structural applications such as deep beams and floor slabs. The goal of this research is to assess whether concrete containing RCA and PLC has a significant beneficial impact on the environment. The material and structural performance of five (5) mixes containing PLC and various levels of RCA were investigated. The first phase of the investigation involved a full materials testing program and found that the fresh and hardened properties were comparable to conventional concrete for all 5 of the RCA replacement levels. The second phase of testing evaluated the structural performance of the mixes. The initial results of the structural tests showed that 4 out of 5 of the RCA mixes performed at the same level as the benchmark mix. Since the experimental results showed that the RCA mixes have the potential to replace conventional aggregate, a life cycle analysis (LCA) was used to evaluate the environmental impact of structures made with PLC and RCA concrete against similar structures made with conventional concrete. Quantitative results for the environmental impact of each scenario are given based on life-time green house emissions and carbon footprints. Conclusions on the best use of PLC and RCA concrete are also given.

T. Reed Miller, Massachusetts Institute of Technology, USA

Life Cycle Cost Implications of Hazard Resistance and Energy Use in Residential Buildings, Arash Noshadran, Jeremy Gregory and Randolph Kirchain

Session: T1A, May 12, 10:30 am - 12:00 pm

Cost is a major factor in assessing the effectiveness of strategies in improving the performance of buildings with respect to different metrics. In particular the use-phase energy consumption and hazard-induced damage cost can have significant economic implications over the life-time of buildings and are directly linked to the building performance. The robustness of decision regarding the potential value of investment in improving building performance demand a full life cycle perspective that takes into account the major sources of cost over its long life span. In this paper we address this challenge by incorporating a life cycle perspective into comparative cost assessment of residential buildings. We study the sensitivity of the comparative cost assessment to different scenarios regarding the locations, life-span, future values and other economic measures of comparison.

T. Reed Miller, Massachusetts Institute of Technology, USA

Evaluating the Environmental Impact of Pavement-vehicle Interaction (PVI) using Life Cycle Assessment (LCA), Xin Xu, Arghavan Louhghalam, Mehdi Akbarian, Franz-Josef Ulm, Jeremy Gregory and Randolph Kirchain

Session: T4C, May 13, 8:00 am - 10:00 am

Road transportation contributes significantly to the economic growth as well as the green house gas (GHG) emissions in the U.S. Due to the long service life of pavements. Pavement-vehicle interaction (PVI) describes the effect of pavement properties on vehicle fuel consumption. Three predominant mechanisms of PVI have been identified as roughness, deflection and texture. While various mechanistic models have been developed to quantify the excess fuel consumptions associated with the changes in those three pavement properties, no one has compared the relative magnitudes of their impacts in a real-world context. This presentation aims to address this by incorporating the PVI models into the life cycle assessment under a set of scenario analyses. The impact of roughness on vehicle fuel consumption is estimated using the improved HDM-4 model that has been calibrated for different vehicle types and speeds. The new generation of the MIT deflection model (Gen II) is implemented for the first time in real scenarios to quantify the fuel consumption due to deflection. Texture-induced PVI effect is roughly estimated based on HDM-4 model. The magnitudes of the three PVI effects are calculated and compared in different contexts. In addition, vehicle speed, temporal effect as well as some contextual factors are considered and discussed in the results. Finally, the engineering justifications for the evolution of PVI will be explored in each context.

Rafic Minkara, Headwaters, USA

Fly Ash Sustainability: Technologies to Mitigate the Impact of Sorbent Injection on Product Quality, Rafic Minkara

Session: T4B, May 13, 8:00 am - 10:00 am

Concrete is essentially a sustainable building material. Its basic ingredients are abundantly available and its life cycle assessment compares favorably to competing materials such as asphalt, steel and wood. The sustainability of concrete is further enhanced by using recovered industrial material, such as fly ash, to substitute for a portion of portland cement thereby reducing the environmental footprint of concrete and improving its life cycle performance. The beneficial use of fly ash as construction materials provides substantial environmental, commercial and economic benefits. The RestoreAir® technology developed by Headwaters has been effectively deployed to treat fly ash at the power plant prior to delivery to customers. The technology uses a low dosage of liquid reagent to passivate the carbon surfaces and reduce their ability to adsorb air entraining agents in concrete. Carbon is not removed, but its effect on air entrainment is neutralized. The technology also includes a novel sensor that determines the chemisorption characteristic of activated carbon/ash at very low activated carbon concentrations. Unlike the traditional foam index test, this new diagnostic test is not subjective and can be automated to provide real-time on-line measurements of ash activity.

Sean Monkman, CarbonCure Technologies, Canada

Using Carbon Dioxide as a Beneficial Admixture in Ready-Mixed Concrete, Sean Monkman, Mark MacDonald and Doug Hooton

Session: T4B, May 13, 8:00 am - 10:00 am

Industry awareness of CO₂ emissions from cement production has prompted research into the use of carbon dioxide as a feedstock in the production of concrete. Industrial trials have examined the use of CO₂ in ready-mix production. A CO₂ injection system delivered carbon dioxide into a ready-mix truck during batching and mixing of concrete. The carbon dioxide was thereby absorbed into the concrete and formed stable, finely distributed nano-scale carbonate reaction products. The impacts of carbon dioxide dose, injection method and time of injection were examined. The concrete slump and temperature was measured. Compressive strength and resistivity were measured at ages from 24 hours to 58 days. Strength improvements up to 14% at 24 hours and 26% at 58 days were observed. The resistivity was not affected by the carbonation treatment. The strength increase is attributable to the reaction of carbon dioxide with the cement very early after

hydration started. A combination of isothermal calorimetry and microstructural analysis suggests that the carbonates seed the hydration and contribute to the development of a stronger microstructure. The use of waste carbon dioxide in the process offers a means to upcycle the CO₂ as a beneficial additive to concrete that could be widely employed throughout the built environment.

Antonio Nanni, University of Miami, USA

Sustainable Concrete Without Chloride Limits, Antonio Nanni

Session: T6B, May 13, 1:30 pm - 3:00 pm

A recent article in the Boston Globe titled "For concrete, climate change may mean a shorter lifespan" pointed out to the general public some pessimistic, but still worth noting, predictions that collapse of reinforced concrete structures due to steel reinforcement corrosion could be the most immediate vulnerability resulting from climate change. Very little can be done for the existing constructed facilities, but new concrete construction can adopt, whenever it makes sense, non-corrosive reinforcement in the form of composites of stainless steel to avoid this risk. This paper is intended to present preliminary results on concrete without chloride limits that can use salt-water as mixing and curing water as well as aggregates such as recycled concrete aggregate (RCA) that may already be chloride-contaminated. If successful, this "greener" concrete would also allow the use of cement without chloride restriction; thus, giving cement manufacturers the opportunity to use solid waste as kiln fuel (co-generation) as well as adding kiln dust (byproduct that currently requires disposal) back to the clinker.

Michael Niemann and C. R. Herro, HercuTech Inc. and Meritage Homes, USA

New Category in Building Science Creates Innovative Above-Grade Concrete Application without Vertical Rebar, Michael Niemann and C. R. Herro

Session: T1C, May 12, 10:30 am - 12:00 pm

A technologically advanced panelized wall construction system, HercuWall® combines concrete, steel, and foam insulation into a unique wall building system. HercuWall® delivers incontestable improvements in strength, sustainability, and cost efficiency over traditional wall construction methods. Although a direct competitor to concrete block, HercuWall® more importantly directly competes with wood frame construction, delivering superior results as the green alternative builders seek, finally at price points that make sense for immediate implementation. PCA, MIT, and leading global cement producers observe concrete's opportunity to finally seize above-grade market share with HercuWall®. Industry observers have declared HercuWall® a "disruptive innovation" dramatically improving construction practice and building science worldwide. Produced in a controlled factory environment, it is fabricated to match the specifications of each project. HercuWall® is delivered to the job site as a kit of numbered panels ready to install. Cycle time is reduced, job site labor is minimized, and many conventional-construction steps are eliminated. For the homeowner, HercuWall® provides a more durable, safer home, with a quieter interior, lower utilities, and minimal maintenance that lasts 100 years. This changes everything.

Andres Nunez, Argos, Colombia

Development of a High-Performance Fiber-Reinforced Cement Composite - HPFRCC From Lab Scale to Industrial Scale and Applications, Andres Nuñez and Wilmar Echeverri

Session: T2B, May 12, 1:30 pm - 3:00 pm

The industrial uptake of High Performance Fiber Reinforced Cement Composites (HPFRCC) still faces hurdles derived from the singularities of their design and processing. A comprehensive approach adopted to develop HPFRCC mixes for large scale processing using local available materials is presented in this paper. A preliminary material inventory and characterization as well as rheometric studies enabled the identification of synergies and interactions. A basic HPFRCC mix formulation was tailored considering the singularities of the local available materials. The HPFRCC exhibited consistent strain hardening behavior accompanied by multiple micro cracking. Subsequently, a step-by-step upscaling process was implemented to assess the viability of large scale production of the HPFRCC. The material was successfully processed using common in field mixing equipment as well as plant mixer and concrete trucks for large batches. Further validation was undertaken by designing and building a solution for urban park furniture.

Karthikeyan Obla, National Ready Mixed Concrete Association, USA

Performance Criteria for Concrete Resistant to Chloride Penetration, Karthik Obla

Session: T3B, May 12, 3:30 pm - 5:00 pm

Concrete, especially for improved durability, is typically specified with prescriptive provisions. More recently there has been increasing interest in evolving towards performance-based specifications, both within state highway agencies and industry. One of the challenges in successfully implementing performance-based specifications is using test methods and criteria for concrete durability that can reliably provide the expected service life. The National Ready Mixed Concrete Association has been engaged in a state pooled fund research project to propose performance criteria for concrete that will be resistant to penetration of chlorides, cycles of freezing and thawing, and sulfate attack. This presentation summarizes results pertaining to penetration of chlorides.

Claudiane Ouellet-Plamondon, Ecole de Technologie Superieure, Canada

Earth Concrete as a Promising Building Material, Claudiane Ouellet-Plamondon

Session: T6B, May 13, 1:30 pm - 3:00 pm

Earth construction has lots of potential in region where conventional building materials are less available and there is also a growing interest in the developed world for natural building materials. Earth has an improved energy, ecological and carbon footprints. However, the material needs to be engineered to be able to meet the demand. Technology transfer from the cement industry is expected to increase the use of earth by the construction industry. Cement increases the resistance against weathering of the earth and can increase the strength, but cement interfere with the binding forces of clay. Calcium sulfoaluminate (CSA) or calcium aluminat (CA) cement are foreseen to be compatible with an earth concrete. The earth concrete was made with a plastering earth mixed with 5% cement, 1% superplasticizer dosed on the fine content and an initial water to binder ratio of 0.25. The methodology included mineralogical and physical characterization, hydration of cement and thermogravimetric analysis, rheology at the fresh state, mechanical and thermal properties. These novel earth materials can improve construction time, cost efficiency and reduce the workforce, which are required to increase the use of earth in construction.

Larry Rowland, Lehigh Hanson, USA

Resilience Matters, Larry Rowland

Session: T2A, May 12, 1:30 pm - 3:00 pm

Resilience is the point where sustainability and the superior durability, longevity and strength of concrete meet. The resilience movement endorses building applications that favor our products. Ours is the building material of choice in coastal communities and beyond to make homes offices and schools safer, more resistant to damage and a better investment. This session will highlight how the concrete industry is engaging with the organizations that drive building code adoption to provide safer more secure buildings and infrastructure. This session explains why we must continue to reach out through the NCMA, the PCA, the CJSI and the like to engage with organizations such as FLASH and FEMA who are key influencers of local building code adoption. It will give concrete examples how and where our products are recommended by FEMA and others to save lives and protect property. It will show examples of inroads made by competing products and the unintended consequences recent code changes have had that undermine the use of concrete and the safety of the built environment. Attendees of this session will learn how to be more engaged in the building code process and how to leverage the resilience of concrete to promote code and code plus construction in their home regions.

James Shilstone and Chris Erickson, Command Alkon, Inc. and Climate Earth, USA

Real World Implementation of an On-demand System for Creation and Delivery of Environmental Product Declarations, Chris Erickson and James Shilstone

Session: T5A, May 13, 10:30 am - 12:00 pm

Environmental Product Declarations (EPDs) are increasingly being requested by building owners. Development of an EPD requires a life cycle assessment (LCA) which results in an LCA report and EPDs for the mixes submitted to the EPD developer. In the past, the concrete producer would submit mix designs and production data to the EPD developer who would prepare the LCA and EPDs which would then be submitted to the Program Operator for verification. The result was a process that could take weeks or months to produce new verified EPDs. In addition, producing new EPDs for new mixes would have to go through the same process. Clearly this process was not aligned with the dynamic mix design and bid-submittal process that exists today. A new process is being created that will allow for the creation of new EPDs in a matter of minutes. Under the new paradigm when a concrete producer wants to create EPDs for concrete mixes the producer will submit initial information to the EPD developer as before but instead of verifying the resulting EPDs, the program operator will verify the EPD software model that is created for the concrete producer. Then the producer's quality control software will be able to send concrete mix design information including material supplier data to the EPD model, which will then return the EPD to the QC software. The new process could result in a verified EPDs being produced in minutes instead of weeks.

Jake Sobstyl, Massachusetts Institute of Technology, USA

Urban Heat Island: City Texture Matters, Jacob Sobstyl, Mohammad Javad Abdolhosseini Qomi, Roland Pellenq and Franz-Josef Ulm

Session: T6C, May 13, 1:30 pm - 3:00 pm

Cities cover a mere 2% of the world's land, but they are home to over 50% of the population and contribute to over 70% of greenhouse gas emissions. They also intensify air and surface temperatures when compared to their rural surroundings. This effect, known as urban heat island (UHI), amplifies air pollution and increases cooling energy usage while imperiling human health and comfort, and therefore poses one of the major societal climate challenges. Although city managers are aware of these issues when devising mitigation strategies for UHI, a limiting factor remains how to quantitatively address the complexity of cities - here defined by a network of hundreds of thousands of buildings - under operational and extreme conditions when evaluating mitigation strategies. The striking resemblance between urban environments and molecular structure of materials allows us to leverage common methods from statistical physics to establish a novel means of classification of cities based on ordering of buildings. Crystals (i.e. Chicago, New York) present distinct periodic geometries, while liquids (i.e. Boston, Los Angeles) offer more sporadic and chaotic distributions. While different non-urban climatic influences cannot be excluded, we herein suggest that a polynomial form considering order parameter can significantly improve the current urban equation, which puts the city density as the antecedent of UHI. Moreover, we conclude that for a constant density, a highly ordered city experiences UHI twice as great as a city with highly discorded structure of local buildings.

Alan Sparkman, Tennessee Concrete Association, USA

Going Net Zero using Concrete Wall Systems: A Case Study, Alan Sparkman

Session: T1C, May 12, 10:30 am - 12:00 pm

This presentation will briefly cover the design and construction of a Net Zero structure built by the Tennessee Concrete Association on their campus in Nashville, TN. The project was a collaborative effort involving local architects, engineers and others in the design process. The structure is currently being monitored for temperature, humidity, and air flow and the presentation will cover the results of that monitoring over approximately a 9 month period.

Alan Sparkman, Tennessee Concrete Association, USA

Maintaining and Cleaning Pervious Concrete Pavements: Experiences from the Field, Alan Sparkman

Session: T2C, May 12, 1:30 pm - 3:00 pm

This presentation will cover actual cleaning of existing pervious concrete pavements and talk about results, effectiveness, estimated costs of cleaning, types of cleaning and other issues experienced with the cleaning and maintenance of pervious concrete projects in the Tennessee area.

Steve Sunderman, Terrazia PC, USA

What Is A Resilient Passive Concrete Building?, Steve Sunderman

Session: T2A, May 12, 1:30 pm - 3:00 pm

We typically think about resilience as it relates to how well our buildings and infrastructure can resist or withstand the initial impact of severe weather events, accidents, or even intentional terrorism. However, equally important, is resilience in the aftermath of a disruptive event. Not only do tornadoes, hurricanes, ice storms, blizzards, wildfires, and other severe natural and man-made disasters have an immediate impact on our facilities, but they often have a long-term impact on the building occupants, usually through extended power outages and interruptions in heating fuels. Fortunately there is a strategy to create resilient buildings

that can resist disruptive events, both initially and long-term. It is all about creating high-performance building envelopes, such as championed by the Passive House Institute US, combined with durable concrete building systems.

Steve Sunderman, Terrazia PC, USA

Paving the Way to Stormwater Management, Steve Sunderman and Amanda Hult

Session: T3C, May 12, 3:30 pm - 5:00 pm

In a natural woodland or meadow, very little rainfall runs off. During development, natural vegetation is usually removed and replaced with hard impervious surfaces such as roads, buildings and parking areas. This land surface change decreases infiltration, groundwater recharge and evapotranspiration; increases runoff and carries excess nutrients, sediment and other contaminants into our streams, rivers and lakes. It is imperative that we protect our natural resources and especially our fresh water. As a means to comply with new regulatory mandates, many local jurisdictions are imposing stormwater utility fees based on existing or proposed impervious surface areas of properties. Often such fees and life cycle costs can be reduced or averted if on-site Low Impact Development (LID) Best Management Practices (BMP) are properly implemented. This presentation illustrates new stormwater regulations and various best management practices (BMP); describes how permeable paving can be an extremely effective LID BMP; and explains how pervious paving BMP projects can achieve the triple bottom line by saving money, improving people's lives and ensuring a sustainable future.

Arezki Tagnit-Hamou, Sherbrooke University, Canada

New Generation of Ultra-High Performance Glass-Concrete, A.Tagnit-Hamou and N. Soliman

Session: T3A, May 12, 3:30 pm - 5:00 pm

Ultra High Performance Concrete (UHPC) is a type of concrete recognized as a revolutionary material that can provide combination of ultra-high strength, high ductility, and excellent durability characteristics. However, the typical materials used to manufacture UHPC, such as high volumes of portland cement and silica fume, are expensive and often have limited supply. An extensive experimental program at Sherbrooke University demonstrates that glass powder could provide a lower cost, high performance alternative for UHPC that can help lower environmental footprint. In 2011, only 20% of glass in the United States was recycled. In Canada, bottles of wine are imported and there is no market for glass recycling. This experimental program concludes that non-absorptive glass improves the rheology of UHPC. High compressive strength and elastic modulus of glass particles improve the strength of the cement paste resulting in decreases the amount of silica fume needed to fill the voids. Glass powder lowers the carbon footprint of concrete.

Napaporn Tangtinthai, Newcastle University, United Kingdom

Extraction, Use and Disposal of Construction Materials in Europe and Southeast Asia: Case Studies in Great Britain and Thailand, Napaporn Tangtinthai, David Manning and Oliver Heidrich

Session: T3C, May 12, 3:30 pm - 5:00 pm

In the new global economy and a period of rapid urbanisation, construction growth has become a causal factor of economic competitiveness. Consequently upstream businesses, cement and concrete manufacture, also expand. The overarching paradigm of sustainability balances economic, environmental and societal issues and although this philosophy is realized in European nations, there seems to be less awareness amongst the 10 countries that form the Association of Southeast Asian Nations (ASEAN). Great Britain (which experiences one of the highest recycled aggregates among European countries at the rate of 25% of input aggregates) and Thailand are used as case studies. This paper investigates and compares for both countries. It analyses the construction industry, in particular the housing sectors, and the associated material flows from the raw material extraction to disposal. It considers the local and national cement industry calculating the raw materials needed for cement and its calcination process. Moreover, it also identifies and evaluates key mineral-based components of construction materials, including cement products, aggregates and concrete, and considers the waste chains, using government and manufacturing data in 2012 for material flow analysis (MFA) and presenting the results using Sankey diagrams.

Oscar Tavares, Alpena Community College, USA

Carbon Sequestration and the Impact on Concrete Performance, Don MacMaster and Oscar Tavares

Session: T3C, May 12, 3:30 pm - 5:00 pm

Early-age carbonation curing of concrete products result in improved strength, increased surface hardness, and reduced surface permeability to water, as well as the potential reduction for efflorescence. Carbonation reaction between carbon dioxide and calcium compounds result in permanent fixture of the carbon dioxide in thermodynamic stable calcium carbonate. The moisture content, relative humidity, temperature profile of the hydrated system has considerable and important influence on the rate and ultimate extent of carbonation. Carbon sequestration reduced water requirements by 20% for optimum strength profile. Test results of a dynamic pressurized carbon sequestrations curing and normal atmospheric CO₂ at various concentrations levels are compared to the traditional kiln curing procedures are discussed.. Early compressive strengths profile for 30% CO₂ cured CMU's are equivalent to 100% CO₂ cured CMU's and exceed the traditional curing compressive strengths.

Matthew Trussoni, University of Miami, USA

Sustainable Reinforcement Alternative: Glass Fiber Reinforced Polymer (GFRP) for Reinforced Concrete Balconies in Coastal Environments, Matthew Trussoni, Josh Jordan, Antonio Nanni and Ronald Zollo

Session: T2A, May 12, 1:30 pm - 3:00 pm

Structural damage caused by the corrosion of steel in reinforced concrete in coastal environments is a well-known trigger of costly repairs. The application of Glass Fiber Reinforced Polymers (GFRP) reinforcement offers a sustainable alternative to traditional steel reinforcement because its life cycle is not reduced by corrosion problems. Furthermore, there is a sound theoretical foundation for the safe and serviceable design based on the physical and mechanical properties of GRFP materials as a component of reinforced concrete. This research reports on an experimental program to investigate 4 and 6 inch (100 and 150mm) concrete slabs designed as exterior balconies with GFRP reinforcement. The GFRP slab specimens were experimentally load tested according to ACI 437.1R-07. Test results show that the cantilever slab balconies can be designed to meet service load deflection and ultimate strength perforce criteria similarly applied to steel reinforced RC designs.

Rabin Tuladhar, James Cook University, Australia

Development and Application of Recycled Plastic Fibres to Reinforce Concrete, Rabin Tuladhar and Shi Yin

Session: T5B, May 13, 10:30 am - 12:00 pm

Due to the sheer volume of concrete poured every year around the world it is very important to consider sustainability aspects of concrete. On the other hand, increase in production and consumption of plastics has resulted in significant increase in plastic pollution in the last few decades. This paper researches the development and application of recycled polypropylene fibres produced from industrial waste to reinforce concrete elements. Virgin plastic fibres are increasingly used to replace steel in concrete elements; however, the use of recycled plastic fibres has not been widely accepted by the concrete industry. With the modified melt spinning and hot drawing process it was possible to produce recycled plastic fibres with enough strength to replace virgin plastic fibres or reinforcing steel mesh in concrete elements such as footpaths, precast concrete elements like drainage pits, culverts and sleepers. Round determinate panel tests and Crack Mouth Opening Tests conducted on concrete reinforced with recycled plastic fibres showed comparable results to the specimen reinforced with virgin plastic fibres. Life cycle assessment of the recycled plastic fibres also showed 90% less environmental impact compared to the steel mesh.

Cise Unluer, Nanyang Technological University, Singapore

Development of Novel Cements with Optimized Carbon Capture Capabilities, Cise Unluer

Session: T4B, May 13, 8:00 am - 10:00 am

Currently produced at a rate of >3 Bt/year, Portland cement (PC) is the most widely used construction material in the world. It is responsible for 5-7% of anthropogenic CO₂ emissions, due to a combination of the decomposition of limestone and high calcination temperatures used for the process (1450°C). Therefore, there are major global pressures on the cement industry to reduce its emissions. Mineral CO₂ sequestration, combining alkaline earth metals (i.e. Mg) with CO₂ to form stable carbonates, is a safe and rapid approach for reducing industrial CO₂ emissions. Reactive magnesia (MgO) cements have received significant attention in the technical press due to their technical and sustainability credentials over PC including their lower manufacturing temperatures (~700°C); ability to sequester significant quantities of CO₂, becoming carbon neutral and leading to high strengths; significant durability advantages; and complete recyclability when used alone. The presented work focuses on the use of reactive MgO in porous applications, where it carbonates by absorbing CO₂ and gains strength accordingly. The main goal involves maximizing the amount of CO₂ absorbed within construction products, thereby reducing the overall impact of the construction industry.

Stefan van Uffelen, Concrete Sustainability Council, USA

Success in the New Social Economy with the Concrete Sustainability Council (CSC) Certification, Tien Peng and Stefan van Uffelen

Session: T6A, May 13, 1:30 pm - 3:00 pm

Today the consumer is not only demanding sustainable products but also organizations that have sustainability integrated into their core strategy. Companies that do good are rewarded with tangible benefits – such as high performing brands, reduced waste – and intangibles - such as higher productivity, greater retention, and strengthened customer engagement. With the launch of LEED v4, all building products are now rewarded for reporting through an approved responsible sourcing certification system. The new Concrete Sustainability Council (CSC) certification system allows concrete enterprises the opportunity to demonstrate leadership in the sourcing of raw materials and expand their market. This standard seeks to protect labor rights, manage the fair flow of capital, add value to products, ensure equitable use and sharing of benefits on the organization and its stakeholders. This session outlines the CSC certification and how organizations can use it to evaluate, benchmark and report their performance at a regional level. Constructive lessons from pilots of the program from manufacturer will also be shared.

Frances Yang, Arup, USA

Guide to Material Ingredient Disclosure and Optimization for Ready Mixed Concrete, Frances Yang

Session: T6A, May 13, 1:30 pm - 3:00 pm

LEED v4 has new provisions for reporting product material ingredients and their impacts on human health. The criteria and framework for reporting is confusing and extensive. This presentation provides the details of the new Guide to Material Ingredient Disclosure and Optimization for Ready Mixed Concrete in LEED v4. Health Product Declarations (HPDs), Cradle to Cradle and Green Screen frameworks are discussed and the most economical and expedient approaches to meeting the LEED v4 Material Ingredient credits are presented. Details of the newly launched HPD version 2 are presented, which will likely make the process of reporting easier for product manufacturers.

Ardavan Yazdanbakhsh, City College of New York, USA

Environmental Impacts of Replacing Natural Aggregates with Recycled Demolition Waste for Use in Concrete in New York City Area, Ardavan Yazdanbakhsh, Lawrence Bank, Thomas Baez, Sandy Rampaul, Ali Hamidi and Iddo Wernick

Session: T5B, May 13, 10:30 am - 12:00 pm

The use of coarse recycled aggregates (RAs) obtained from crushing and grading construction and demolition waste (CDW) in concrete has been widely studied and commercialized in several countries. In the US, over 300 million tons of construction and demolition waste is produced yearly, only a smaller portion of which is recycled and mainly used as road-base, fill and drainage materials. Only a small portion of U.S. RA is used in structural concrete pavements. To make a compelling case for the use of these recycled materials in concrete, in addition to mechanical performance and durability of RA concrete, the environmental impacts of replacing coarse natural aggregates (NAs) with RA need to be investigated. These impacts are highly dependent on local conditions, local recycled material sources, aggregate production methods, transportation distances, and concrete mix proportions. The presented study focuses on the local conditions of New York City metropolitan area and utilizes Life Cycle Assessment (LCA) to compare the environmental impacts and energy costs of using either natural or recycled aggregates in structural concrete.

Ardavan Yazdanbakhsh, City College of New York, USA

Can Structural Design Strategies be Used to Offset the Lower Strength of Recycled Aggregate Concrete?, Ardavan Yazdanbakhsh, Lawrence Bank, Ali Hamidi, Stefanie Reichman, Minhui Weng and Chen Chen

Session: T5B, May 13, 10:30 am - 12:00 pm

The use of recycled aggregates (RAs) obtained from crushing and grading construction and demolition waste in concrete has been widely studied and commercialized in several countries as a sustainable alternative to natural aggregates. One disadvantage of replacing natural aggregates with RAs is the reduced strength of concrete. However, it is possible to use design strategies to produce reinforced concrete members so that their ultimate load-carrying capacity is not significantly affected by the lower strength of RA concrete. This work presents two design strategies, validated by experimentation, that serve this purpose for flexural members. One of the strategies involves using low reinforcement ratios and the other incorporates external strengthening of reinforced concrete members with fiber reinforced polymers.

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