INTERNATIONAL CONCRETE SUSTAINABILITY CONFERENCE
MIT CONCRETE SUSTAINABILITY HUB SHOWCASE

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ABSTRACTS

The 2014 International Concrete Sustainability Conference provides learning and networking opportunities on the latest advances, technical knowledge, continuing research, tools and solutions for sustainable concrete manufacturing, design and construction. The MIT Concrete Sustainability Hub Showcase is an opportunity to look back at the progress made over the first five years and explore the developments to come over the next five years.

Alphabetical by Presenter

Aboujrad, Haithem

Removal of Nutrients in Pervious Concrete, Haithem Aboujrad, Luis A. Mata and Nicole M. Villeneuve

Pervious Concrete Pavement Systems (PCPS) are widely accepted as a best management practice to reduce stormwater runoff. Studies have reported the potential PCPS have to remove pollutants; however, very few have focused on the removal of nutrients. The proposed manuscript describes the effectiveness of pervious concrete in removing phosphates and nitrates when iron filings and wollastonite are incorporated into mixtures. Results show that phosphate was removed at initial cycles by those mixtures containing iron filings and wollastonite. Concentrations of nitrate, however, did not show any reduction after testing.

Ahlstrom, Gina

FHWA Sustainable Pavements Program,

The INVEST self-evaluation tool, a sustainability working group, and the creation of a Sustainable Pavements Program are among the efforts underway at FHWA to help State and local agencies document and improve the sustainability of the Nation's roadways. For years, FHWA has supported research, development, and implementation efforts at the forefront of the sustainability movement. The sustainable highways initiative supports the various activities conducted across FHWA to facilitate balanced decision-making among environmental, economic, and social values—the triple bottom line of sustainability. This presentation will provide an overview of FHWA's Sustainable Pavements Program.

Akbarian, Mehdi

The Impact of Pavement Properties on Vehicle Fuel Consumption within the Pavement Infrastructure, Mehdi Akbarian, Arghavan Louhghalam and Franz-Josef Ulm

It is generally accepted that Pavement-Vehicle Interaction (PVI) is a major contributor to the environmental impact of high-volume pavements. While various empirical investigations have revealed potential fuel consumption differences between pavement types, there is high uncertainty

and variability in the evaluated impact of pavement types on vehicle fuel consumption. In this paper we develop a mechanistic model that quantifies the impact of PVI on fuel consumption and study the effect of various pavement design systems from the Long Term Pavement Performance program's General Pavement Studies (GPS) sections [2]. These sections include two types of asphalt concrete (AC) pavements; three types of composite pavements; and three types of Portland cement concrete (PCC) pavement designs. Variations in pavement design, along with changes in climatic and traffic settings, result in significant changes in pavement performance throughout the United States.

Ali, Subhan

Life Cycle Design of Polypropylene Fiber-reinforced Cement-based Composites, Subhan M. Ali and Michael D. Lepech

Fiber reinforcement has been used for concrete applications globally to reduce shrinkage and temperature cracking, control crack widths, and provide structural reinforcement. Polypropylene (PP) is a thermoplastic polymer that has found wide adoption for concrete fiber reinforcement. Its use has been for control of shrinkage and temperature cracking rather than as structural reinforcement of fiber reinforced concrete (FRC) due to its low bond strength in cementitious matrices. The hydrophobic nature of PP leads to low chemical bonding between fibers and the surrounding cementitious matrix. Polarity control through additive copolymerization shows substantive promise in modifying the hydrophobicity of PP to be more hydrophilic. Leveraging this hydrophilic nature, modified PP fibers can be used to structurally reinforce cementitious matrices through formation of a stronger bond with the surrounding cementitious matrix. This paper presents a material design methodology which leverages multi-scale modeling and experimental testing to develop a more sustainable replacement for asbestos reinforcing fibers in developing countries.

Amekuedi, Godwin

A Sustainable Approach for Returned Concrete, Godwin Q. Amekuedi and David R. Green

Each year, concrete producers generate millions of tons of residual concrete from the wash out of concrete drums. This material, regardless of its final disposition, once removed from the truck is exhausting our resources and contributing to a less sustainable future. Utilizing existing technologies for chemical admixtures and taking the opportunity to new levels of sustainable material management can significantly impact our concrete industry. Quantifying the results with a third party validated methodology brings credibility to the results reducing opportunities for "greenwashing". Developing new best practices to support sustainable development should be the approach we all consider. This presentation will provide insight into 1) the overall impact of returned concrete in North America; 2) managing returned concrete from a sustainable perspective; 3) quantifying the environmental impact of managing returned concrete; 4) the financial and environmental impact of managing returned concrete for a sustainable future; 5) a case study for North America.

Barcelo, Laurent

"Smog-eating concrete": A New Technology for Better Cities, Laurent Barcelo, Matthieu Horgnies, Isabelle Dubois-Brugger, Julie Buffenbarger and Ellis Gartner

EPA lists Nitrogen Oxides (NO and NO2, together referred to as "NOx") as one of the six common air pollutants. NOx is present in emissions from motor vehicles, power plants and other combustion process emissions. The technology used in "smog-eating" (or "de-polluting") concrete helps mitigate the effect of atmospheric NO2. Contrary to other solutions, this technology does not rely on photo-catalysis and therefore can function perfectly well in the dark. So it is especially suitable for use in confined areas prone to very high NO2 concentrations, such as tunnels or parking garages.The use of small additions of activated carbon can greatly enhance the NO2 absorption properties of many classes of concrete and also reduces the negative influence of carbonation the process.

Bienvenu, Michael

Comparison of Fuel Consumption on Rigid Versus Flexible Pavements in Florida, Michael Bienvenu and Xin Jiao

Sustainable construction and development implies investing in the needs of today without compromising the resources of future generations to meet their needs. Reducing user costs by improving fuel economy from pavement type is important to advance sustainable development. An on-going study of fuel consumption by vehicles traveling on rigid versus flexible pavements at Florida International University (FIU) Department of Civil and Environmental Engineering indicates that rigid pavements provide better fuel economy for the travelling public and commercial carriers. The FIU study along 28 miles of Interstate 95 in Brevard County indicates that travelers in passenger vehicles on rigid pavements use 3.2% less fuel compared to flexible pavements. In addition, the study shows that loaded tractor-trailers along the same corridor the rigid pavement provides 4.5% better fuel economy than the flexible pavement. While benefits are extrapolated estimates, the findings of this study indicate the potential for real sustainable benefits by increasing rigid pavement lane miles into agency work programs.

Bradley, Lisa

Hazard, Exposure, and Risk – Why All Three Are Important for Material Ingredients Decisions, Lisa Bradley

The product disclosure and material ingredients standards in LEED v4 encourage transparency in the material ingredients used in building projects and minimization of ingredients that are considered to be harmful. While a variety of available health criteria ratings systems identify the presence or absence of a chemical in a building material, they do not generally address whether or not a user of the material will be directly or indirectly exposed to these chemicals or whether that exposure could be at a sufficient level for a sufficient length of time so as to elicit an adverse effect by the user. Simply labeling a material as hazardous by virtue of its chemical ingredients ignores the basic tenet of chemical toxicology: the dose (exposure/concentration/time) makes the poison. This talk will provide a basic introduction to toxicology and risk assessment. Materials decisions will be discussed in the context of these disciplines using elements often referred to as heavy metals as an example.

Cao, Wanlin and, Dong, Hongying

Seismic Performance of Recycled Concrete Shear Walls and Columns, Hongying Dong and Wanlin Cao

To investigate the seismic performance of low-rise recycled concrete shear walls with different percentages of recycled coarse aggregate and recycled fine aggregate, a low-frequency quasi-static cyclic loading experiment on low-rise shear walls with a shear-span ratio of 1. 0 was carried out. Based on the experimental study the load-carrying capacity, stiffness, ductility, hysteretic behavior, energy dissipation and failure phenomena of each shear wall are analyzed and the bearing capacity is calculated theoretically. To analyze the seismic performance of recycled concrete short columns, experiments on two 1 /2.5 scale concrete under cyclic loading action were conducted. One specimen was made from recycled concrete and the other was made from natural concrete in the first floor and recycled concrete in the second floor. Load-carrying capacity, stiffness and its deterioration process, hysteretic loop, displacement ductility, energy dissipation, failure patterns and failure mechanisms of the specimens are analyzed on the basis of the experiments.

Constantino, Cesar

A Journey "Under the Hood" of an Environmental Product Declaration (EPD)…The Meaning Behind the Label, Cesar Constantino and David R. Green

Environmental Product Declarations (EPDs) are quickly becoming an important component for building material requests from architects and specifiers for the construction of sustainable buildings. The ready mixed concrete (RMC) sector has been presented with the idea that EPDs can be considered equivalent to Nutrition Facts Labels for food products. This presentation was inspired by the U.S. Food and Drug Administration website entitled “How to Understand and Use the Nutrition Facts Label,” and we aim to do just that, as facts apply to concrete EPDs. Clear understanding of an EPD facilitates our ability to fully utilize the metrics. It also enables more robust scientific innovations and more sustainable solutions for concrete users. The net result is a more balanced and more sustainable RMC industry.

Cost, Tim

Extending the Use of Fly Ash and Slag Cement in Concrete Through the Use of Portland-Limestone Cement, Tim Cost, Thomas Matschei, Jay Shannon and Isaac Howard

Concrete mixtures using higher replacement of cement with byproduct supplementary cementitious materials (SCM’s) such as fly ash and slag cement are increasingly being called for in order to minimize portland cement clinker content in the interest of sustainability. This study reports research that documents the potential for extended use of SCM’s with typical Type IL Portland-limestone cements’ (PLC) as well as the hydration interactions that improve performance. Concrete and laboratory paste mixtures were used to explore the limits of OPC replacement of cement, comparing results for PLC’s and corresponding OPC’s. Presented data also includes field concrete strengths from a construction project that used each cement type in comparable high-SCM content mixtures. PLC mixtures with high replacement levels of SCM’s (both 1- and 2-SCM combinations) produced higher strengths at all ages and generally more favorable setting performance than similar OPC mixtures. Recommendations are made on using these benefits in the development of sustainable, high-performance concrete mixtures.

Crowley, Aaron

A High Volume Fly Ash Concrete Mixture for Tennessee Bridge Decks, L. K. Crouch, Aaron Crowley, Daniel Badoe, Heather P. Hall and Alan Sparkman

High Volume Fly Ash (HVFA) portland cement concrete (PCC) was developed to compete with the Tennessee Department of Transportation (TDOT) Class D PCC. HVFA PCC is PCC with at least 50 percent of portland cement (PC) replaced with Class C fly ash. The current TDOT allowable PC replacement rate is 25 percent for Class C fly ash. A higher PC replacement rate would greatly increase the use of an industrial byproduct thus making more efficient use of natural resources. However, performance and economy cannot be sacrificed for environmental concerns. This paper addresses HVFA PCC performance and not environmental benefits. The results of the research show that HVFA PCC meets or exceeds all TDOT 604.03 Class D PCC property requirements.

Culp, Michael

INVEST: The FHWA Sustainable Highways Self-Evaluation Tool,

Launched by The Federal Highway Administration (FHWA) in October 2012, INVEST (Infrastructure Voluntary Evaluation Sustainability Tool) was developed by FHWA as a practical, web-based, collection of voluntary best practices, called criteria, designed to help transportation agencies integrate sustainability into their programs (policies, processes, procedures and practices) and projects. While the use of INVEST is voluntary, it can be used by transportation agencies, such as DOTs, MPOs, Council of Governments, public works departments, and their consultants and partners, to evaluate and aid the integration of sustainability into their programs and projects. This presentation will provide background on FHWA INVEST and progress to date.

Dalkie, Matt

Net Zero Energy Precast Concrete Home, Matt Dalkie and Don Zakariasen

Lafarge recognizes that the Habitat for Humanity Net Zero Energy Precast Concrete Home has become a learning vehicle to develop sustainable construction solutions that will be applied in building better communities. Some of the knowledge gained by Lafarge from this unique project has been the design and development of ultra high performance insulated precast panels used as structural element, architectural finish and energy efficient/air tight building envelope. Moreover, the interface of different trades and material suppliers through integrative process has allowed Lafarge to develop a better understanding of the challenges and the cooperation that is required to maximize the benefits of combining multiple green building concepts and solutions. This presentation is aimed at sharing the green building knowledge that has been gained through the design, development, and production of the first targeted net zero energy precast concrete homes which will be used in building better communities. The presentation will also share the initial findings of the energy studies being undertaken by MIT.

Di Maio, Francesco

Recycling End-of-Life Concrete: The C2CA Project, Francesco Di Maio, Somi Lotfi, Peter Rem, Maarten Bakker and Mingming Hu

The efficient high-grade recycling of Construction & Demolition Waste (C&DW) is of increasing interest from an ecological and economic point of view, yet it is beyond what can presently be achieved by the recycling industry. End-of-life (EoL) concrete is the main component of C&DW. Therefore the recycling of end-of-life (EoL) concrete is one of the most interesting option for reducing worldwide natural resources use and emissions associated with the building materials sector. The European FP7 Project: C2CA is developing breakthrough technologies for the liberation and production of cement and clean aggregates and fines (to be utilized as fillers) of high and consistent quality from C&DW streams, including A) the novel ADR technology, B) An ecological and economic effective thermal process technology that converts the cement paste fraction of C&DW into a cement product, and C) developing process control and quality control technology based on powerful emerging sensor technologies.

Ferrari, Giorgio

New Sustainable Technology to Recover Returned Concrete, Giorgio Ferrari

Globally, 100 to 200 million cubic meters of ready mixed concrete is returned to the concrete mixing plant yearly. A new sustainable technology to recycle returned concrete is presented, which uses specific, non-toxic, additives added directly into the drum of the truck mixer. The additives transform the returned concrete into granular materials that can be reused as aggregates for the production of new concrete, without producing any waste. The new technology, the characteristics of the new aggregates and the performance of concrete obtained by using the new aggregates are presented. Furthermore, examples of full scale application of the new technology are presented. With the new method, quarries' exploiting is reduced and natural resources are preserved. Furthermore, the new technology allows a reduction of the overall costs both for waste disposal and for aggregates supplying. Therefore, the new technology has important environmental, social and economical issues of sustainability.

Hester, Joshua

Streamlining Building LCAs in Residential Construction, Joshua Hester, Randa Ghattas, Jeremy Gregory, Elsa Olivetti and Randolph Kirchain

Focus groups with architects and designers facilitated by our research group identified a need for a tool that considers the full life cycle of a building early in the design process when few details are known. This presentation will highlight research being conducted at the MIT Concrete Sustainability Hub in order to address this gap. We are developing a Building Attribute to Impact Algorithm (BAIA) – a combination of statistical relationships between design parameters that are used by architects in early design phases and environmental effects. BAIA incorporates uncertainty, reflecting the range of effects from possible attributes that could be specified at a later phase in the design process when more

information is known. As more details are specified, the range of uncertainty shrinks, allowing the efficient comparison of a variety of conceptual designs before one is selected for further development. The BAIA approach will provide a methodology for designers to integrate environmental assessments throughout the design process, from the conceptual through construction document phases.

Hooton, R. Douglas

Durable and Sustainable Concretes with Portland-limestone Cements and SCMs, R. D. Hooton, R. Ahani and R. Fung

One of the ways of significantly increasing sustainability of concrete structures is to specify durability in order to achieve long-service life. In addition, as long as constructability and durability are not compromised, reducing the cement clinker factor of cementitious binders can also reduce embodies carbon and energy associated with concrete construction. Relative to Portland cement, Portland-limestone cements with up to 15% interground limestone have been found to provide improved early-age properties of concretes made with supplementary cementitious materials while also providing equal durability to chloride ingress, ASR, freezing and thawing and sulfate attack. This contribution will address these points.

Hooton, R. Douglas

Development and Standardization of Rapid Methods for Assessing the Fluid Penetration Resistance of Concrete, R. D. Hooton, E. Karkar and G. Charmchi

The common element in designing durable concrete in aggressive exposures is reducing the rate of ingress by fluids, such as chloride and sulfate solutions. While some tests for measuring chloride diffusion, permeability and rates of absorption have been standardized, due to the extended time for their completion, they are often only suitable for prequalification of concrete mixtures. For acceptance during construction, rapid index tests are needed. While the ASTM C1202 resistance to chloride penetration test has served this purpose for many years, it can be replaced by even more rapid and less costly test methods such as bulk resistivity and surface resistivity. This contribution will discuss these issues, review alternative test methods, and discuss adoption in standard specifications.

Jeknavorian, Ara

A Holistic Perspective on the Role of Concrete Admixtures for Sustainable Concrete Construction, Ara A. Jeknavorian

Chemical admixtures have long been known for the beneficial role they play in improving the engineering properties of concrete and mortar mixtures. Looking back over the past decades, the use of air entraining agents and superplasticizers can be considered among the major influences that have allowed extending the use of concrete for many diverse applications. Moreover, ACI 212.3R reports that chemical admixtures provide numerous benefits to concrete mixtures such as increasing compressive and flexural strengths at all ages and increasing durability through reduction in permeability. A holistic review of the numerous functions provided by chemical admixtures is used to help identify the future admixture capabilities required for the design, placeability, and increased service life of sustainable concrete construction. Performance attributes of the next generation of chemical admixtures will include allowing the acceptable use of a wider range of aggregates and supplementary cementitious materials, and enabling more predictable plastic and hardened concrete properties.

Jimma, Betiglu

Pervious Concrete: Do Ready Mix Concrete Producers Love it or Hate it?, Betiglu E. Jimma and Prasad Rangaraju

Pervious concrete, which was once limited to the warm southeastern climate, is now becoming a preferred paving material for parking lots, sidewalks and driveways all across the country, where suitable subgrade materials exist. There are some significant issues that need to be addressed. Some of these issues include problems associated with mixture proportioning, testing, construction techniques and quality control and assurance of this product. This paper shares the data collected from a survey of selected ready mixed concrete companies in North and South Carolinas. The findings from this investigation share the experience of these companies in dealing with material selection process, mixture proportioning methods, quality control and quality assurance, test methods, and various challenges associated with mixing, transporting and placing of pervious concrete. This presentation will shed light on critical aspects of pervious concrete mixtures and the need for a systematic approach to develop solutions to the problems faced by the pervious concrete industry.

Kazmierowski, Tom

Comparative Metrics of Two Sustainability Rating Systems Developed in Canada, Susanne Chan, Stephen Lee, Michael Navarra and Tom Kazmierowski

Sustainability is an increasingly important consideration in road building across North America. Pavement sustainability can be evaluated using several different methods or tools, including life cycle assessment, life cycle cost analysis, performance assessment, and sustainability rating systems (SRS). A SRS is basically a list of sustainability best practices with a related measure, usually a point score, which quantifies each best

practice in a common unit. In an effort to bring awareness of and promote “green” initiatives to designers, both the Ontario Ministry of Transportation (MTO) and Golder Associates created user-friendly SRS to promote sustainable pavement technologies for the design, construction, rehabilitation, reconstruction, and preservation of roads. This paper describes the development and implementation of these two SRS and compares their analysis through a case study of a highway with 20+ years of documented performance using numerous innovative concrete pavement preservation and rehabilitation techniques.

Keiper, Hank

The Future of Fly Ash is Under Our Feet, Hank Keiper and William Fedorka

This paper discusses the dwindling availability of coal fly ash suitable for use as supplementary cementitious material in the US due to environmental regulations and market factors. To ensure a future supply of high-quality, Class F fly ash, The SEFA Group has modified its proprietary thermal beneficiation process to accept fly ash reclaimed from disposal sites including both landfills and settling ponds. The STAR®, or Staged Turbulent Air Reactor process, and its product, STAR Refined Pozzolan®, are described. The modified STAR® plant can accept fly ash directly from a coal utility, as well as prepare reclaimed fly ash for STAR treatment without substantial additional energy inputs. Beneficiating reclaimed fly ash has been successfully accomplished through an existing STAR® facility and the results of concrete and laboratory testing are described.

Kestner, Dirk

Embodied Energy and Carbon Impacts of Light Weight Concrete for Steel-framed Commercial Buildings, Dirk M. Kestner and Kelly L. Roberts

Lightweight concrete is frequently used in the composite floor slabs of steel framed commercial buildings. The production of lightweight aggregate requires energy inputs which increase the embodied energy and CO2 per functional unit of material as compared to conventional aggregates. However, the thermal and mechanical properties of the light weight concrete facilitate material savings in other aspects of the structure. This presentation discusses the results of an embodied energy and CO2 study that compared the embodied energy in the structural system of steel framed building with lightweight concrete floor slabs to those framed with normal-weight concrete.

Krekeler, Paul

GreenLITES: A Transportation Environmental Sustainability Rating Program,

The New York State Department of Transportation (NYSDOT) is committed to improving the quality of transportation infrastructure in ways that minimize impacts to the environment, including the depletion of irreplaceable resources. To recognize transportation project designs, operations and maintenance practices that incorporate a high level of environmental sustainability, NYSDOT is implementing “greenlites (Green Leadership In Transportation Environmental Sustainability),” a transportation environmental sustainability rating program. This presentation will provide on overview of NYSDOT's experiences to date.

Lenngren, Carl

Different Pavement Types and Rolling Resistance, Carl A. Lenngren

Falling Weight Deflectometer data has been used to analyze pavement bearing capacity since the 1980s. It complements the mechanistic-empirical design methods that are becoming common throughout the world. As sustainability is affecting many decisions about road construction, it is equally important to assess the rolling resistance different pavement types incur. As rigid pavements are stiffer than flexible pavements, the pavement deflection is usually less from any wheel load. The analysis of dynamic field tests shows that concrete pavements reduce truck fuel consumption. This paper deals with assessing pavement hysteresis by evaluating falling weight deflectometer time histories. By plotting load and deformation as the test progresses a hysteresis curve is formed and the energy losses can be estimated. In the paper flexible, semi-rigid and rigid pavements are compared. Attention is also given to the curling of plain jointed cement concrete pavements, and the thickness of the asphalt concrete layer in semi-rigid pavements.

Liu, Rui

Comparison of LCCA to Environmental LCA for Highway Pavement, Rui Liu, Brooke Smartz and Barry Descheneaux

A good estimation on project level life cycle costs, benefits, and environmental impacts is one of the important steps in the highway investment decision-making process. “RealCost” LCCA software with a user manual has been provided by Federal Highway Administration, but use of this software is at the discretion of each state. Research indicates LCCA is implemented in over 80% of the states, but environmental LCA has not been implemented during this process. Both LCCA and LCA are performed for a highway reconstruction project in Colorado with portland cement concrete pavement (PCCP) and hot mixed asphalt (HMA) alternative. The vehicle fuel consumption is not included in the current LCCA employed

by CDOT as well as user cost due to crashes and nonuser costs. These should be considered in the future pavement LCCA.

Mahgoub, Mohamed

Concrete Industry Information Management Systems Innovative Concept for Construction and Infrastructure Maintenance, M. Mahgoub, J. Miima, A. Orama and L. Potts

The quality of concrete used in construction projects is always field tested for compliance to specifications. Traditional concrete field-testing involves manual measurement of on-site slump that may have inherent loopholes for compromised test results. Furthermore, consistency of concrete mixtures from various concrete ready-mix vendors is a key to very large building projects. To mitigate several ambiguities related to the current field and laboratory recording procedures, the use of a sustainable process (digital technology) is proposed. An automated Concrete Industry Information Management System (CIIMS) supported by automated data capture technology such as Radio Frequency IDentification (RFID) and imaging technology mitigate human-induce errors. The benefit of such a CIIMS is digital archiving of sample tests for comparison with on-going infrastructure maintenance and management of civil structures such as concrete structure of transportation systems, pipeline in conveyance systems, and waterborne structures such as piers and wharfs.

Makul, Natt

Utilization of Unprocessed High-volume Coal Fly Ash Combined with Biomass Rice Husk Ash in Cost Effective Self-Consolidating Concrete, Natt Makul and Grisada Sue-iam

The effect of unprocessed high–volume coal fly ash and biomass rice husk ash from electrical power plants on the properties of self-consolidating concrete is investigated. This paper describes a study undertaken to explore the use of a high volume of coal fly ash as a replacement for Type 1 Portland cement and a high volume of biomass rice husk as a replacement for fine aggregate in the production of self-consolidating concrete (SCC). The admixtures were designed based on a slump flow diameter of 70 ± 2.5 cm. In addition, the workability properties and the hardened properties of SCC were determined, and a blocking assessment performed. The results indicate that increasing the admixture content beyond a certain level reduces the strength and increases the water requirements of the SCC mixtures. The partial replacement of cement by coal fly ash and fine aggregate by biomass rice husk can result in substantial cost savings and alleviated environmental problems.

Maraghechi, Hamed

Investigation of Using Alkali Activation to Enhance the Pozzolanic Performance of Recycled Glass Powder, Hamed Maraghechi, Mahsa Maraghechi and Farshad Rajabipour

Utilization of recycled glass powder (GP) as a supplementary cementitious material can provide environmental, economical and technological benefits towards production of green concrete. In this study, application of alkaline solutions to accelerate the pozzolanic performance of GP is investigated in two research phases 1) dissolution of glass -which is the initial step in the pozzolanic reaction - is quantified by mass loss measurement of glass slides exposed to various concentrations of NaOH solutions; 2) the rate and stoichiometry of the pozzolanic reaction between calcium hydroxide (CH) and GP are investigated. Effect of using alkaline solution to enhance compressive strength of CH-GP mortars is also highlighted.

Mata, Luis

Frost Resistance of Pervious Concrete in Realistic Freezing and Thawing Cycles, Luis A. Mata

The proposed manuscript describes the effects on frost resistance of realistic freezing and thawing rates in pervious concrete specimens. Pervious concrete disk specimens were used in a unique and innovative test that considers realistic, slow freezing rates of partially saturated pervious concrete disk specimens. Tests were performed using a deicing salt solution to simulate frost exposure conditions in a pavement similar to the exposure described in ASTM C672. Dynamic elastic modulus and loss of mass were determined at 10, 20, 30 and 40 cycles. Air void evaluation was also performed by microscopic examination on selected specimens to assess the content of air in the paste. Results confirmed previously published reports that sand must be included in the mixture to be frost resistant when concrete is saturated or normally saturated, regardless of the addition of air entraining admixture (AEA).

Mesa, Debora

Supraextructures: New Opportunities for Prestressed Concrete Technology in Architecture and Urban Planning, Anton Garcia-Abril and Debora Mesa

The POPlab (Prototypes of Prefabrication laboratory) at MIT, founded by Ensamble Studio architecture office, is a new research lab at MIT born to innovate the design and construction of architectural and urban environments, bridging the gap between art and science. As one of the main focuses of its agenda, it explores the opportunities of prestressed concrete technology at multiple scales, from the material, to the building and

the city; developing different typologies and assembly methods. Hemeroscopium House (completed in 2008) is the beginning of a research process that explores both the mechanical and aesthetical possibilities of precast concrete in architecture as well as its capacity to provide new qualities to space. Through this research, a new concept in architecture and urban planning is developed: SUPRAEXTRUCTURE. The various projects developed show how this prefabrication technology offers the opportunity to create spaces and systems intelligently thought, engineered and built.

Minkara, Rafic

Fly Ash Sustainability: How is the Industry Responding to Regulatory and Other Shifts Affecting Ash Resources?, Rafic Minkara

There is a recent concern in the engineering and construction industries about the long-term sustainability of fly ash for use in concrete. This perceived concern is the result of regulatory actions and shifts in the U.S. energy portfolio toward natural gas. Past regulatory actions affecting coal-fired generation, such as NOx emission reduction, have forced the utilities to install low NOx burners and SCR/SNCR's that resulted in fly ash quality degradation. The ash industry adapted to that reality by introducing innovative solutions to mitigate the impact of these regulatory actions. Carbon in ash treatment, carbon burn-out, and electrostatic separation are examples of deployed mitigation technologies. More recent regulations targeting mercury and other emissions will further impact the fly ash resources. Headwaters Resources Inc. has a new technology initiative in the implementation stage that has been specifically developed to address the presence of activated carbon in ash. Other industry initiatives are also underway to lessen the impact of mercury emission control on ash quality.

Monkman, Sean

Carbon Dioxide Utilization in Fresh Industrially Produced Ready Mixed Concrete, Sean Monkman

A novel approach to beneficially using carbon dioxide to produce ready mixed concrete was investigated during two pilot demonstrations during the summer of 2013. Gaseous carbon dioxide was introduced into industrially produced ready mixed concrete during mixing. The carbon dioxide was thereby absorbed into the concrete to form thermodynamically stable carbonate reaction products distributed throughout the concrete matrix. The effects of the absorbed carbon dioxide on the concrete temperature, slump, slump life, heat evolution, compressive strength, flexural strength, and rapid chloride permeability test performance were examined.

Naugle, Matthew

Buildings Instead of Landfills: Recycled Plastic Waste in Concrete Structures, Wolfgang Werner, Jennifer Marmon and Matthew Naugle

Can we find ways to design concrete structures that contain substantial amounts of recycled plastics without causing an overall increased environmental footprint compared to conventional alternatives? In an attempt to answer this question, we explored design strategies that leverage the lightweight nature of different plastics and their ability to reduce the overall weight of the structure. If a meaningful degree in total weight reduction is possible for the superstructure, then we can include some amount of the more EE/EC-intensive plastics into the design without causing an overall increase in EE/EC intensity. To study this hypothesis three lightweight reinforced concrete slab systems were investigated, each with a different type of recycled plastic embedded within the makeup of the slab.

Ni, Bo

Performance Evaluation of Municipal Concrete Sidewalks using Coarse and Fine Recycled Concrete Aggregate, Bo Ni, Riad Rajab, Anto Sucic, Abdurrahmaan Lotfy, Dave Morris and Paul Lum

This paper summarizes the results of an experimental study on Class C2-32 concrete pavements (as specified by the Canadian Standards Association in CSA A.23.1) for an air-entrained sidewalk mixture. Results are reported with respect to mechanical properties and durability aspects of recycled aggregate concrete, compared to its conventional virgin aggregate equivalent. The impacts of replacing virgin aggregate with Recycled Concrete Aggregate (RCA) are discussed. Mixes were evaluated with replacements of coarse aggregate up to 30% (by volume) and with 20% replacement of both fine and coarse aggregate. It was found that overall performance of recycled coarse aggregate in new concrete is equivalent to that of conventional concrete. Further durability analysis was performed to monitor salt scaling, freeze-thaw resistance, rapid chloride permeability, hardened air-void system, and linear drying shrinkage.

Niemuth, Mark

Internal Curing with Lightweight Aggregate for Durable and Sustainable Concrete, Mark Niemuth, Wesley Jones, Jason Weiss, George Zima and Laurent Barcelo

The use of fine pre-wetted lightweight aggregates can improve the durability of concrete structures through the benefits of internal curing. Internal curing, which is particularly effective at reducing autogenous shrinkage, allows for lower w/c mixtures. Typically the lower the w/c mixture the more durable the concrete with the exception of any autogenous shrinkage induced cracking. Internal curing mitigates this cracking effect

allowing for significant increases in durability by reducing the need to replace and repair concrete structures whose failure is sped up by cracking structures. In turn, the energy, raw materials and money needed to replace and repair the structures can be conserved. This work demonstrates how a specific lightweight aggregate, expanded slag, decreases shrinkage and cracking potential. Models are then proposed to link this reduction in cracking to service life.

Noshadravan, Arash

Analyzing Cost and Hazard Resistance Trade-offs in Residential Construction, Arash Noshadravan, Randa Ghattas, Jeremy Gregory and Randolph Kirchain

One of the challenges in developing a comprehensive Life cycle cost assessment (LCCA) framework for residential buildings is how to quantify and incorporate different building performance metrics into the process of comparative cost assessment. One of the performance metrics that needs to be accounted for is the resilience of the built system - the structural resistance to hazards as a quantitative descriptor of the resilience in the level of individual buildings. In this research we present a probabilistic risk-based framework for analyzing cost and hazard resistance trade-offs in alternative residential building systems. Specifically, we focus on characterizing the life cycle cost due to mitigation strategies and repairs in residential buildings subjected to earthquake. The presented framework includes probabilistic hazard modeling, fragility modeling, and damage estimation. A case study is presented to demonstrate the methodology for conducting cost-performance trade-off analysis of alternative building systems.

Nossoni, Goli

Use of Recycled Shredded Tires with Special Surface Treatment as Coarse and Fine Aggregate in Concrete, Goli Nossoni and Peter Panagopoulos

A major environmental challenge around the world is the disposal of used automobile tires. The large volume of used tires generated places a significant economic and environmental burden on disposal sites and recycling offers the most promising solution. One application that has been investigated is the use of recycled tire chips and crumbs as coarse and fine aggregate in concrete, respectively (Rubcrete). Unfortunately, this application was not as successful as researchers hoped because waste tire modified concrete has significantly lower compressive strength and stiffness compared to normal concrete. The research described in this paper addresses the adhesion and mechanical bond between cement paste and shredded tire chips in the so-called interfacial transition zone (ITZ) which has been shown to be significantly worse than that between cement and normal aggregate, since cement paste and rubber cannot react chemically to form a bond and the ITZ is the weakest link in "Rubcrete."

Omran, Ahmed

Long-Term Performance of Glass-Powder Concrete in Field Applications, Ahmed Omran, Etienne Morin and Arezki Tagnit-Hamou

Many associations of standardization, including the Canadian Association of Standardizations (CSA), have standardized a number of industrial by-products (supplementary-cementitious materials, SCM) to partially replace the Portland cement. However, these SCM are not always available in all regions. Therefore, the development of local alternative SCM is paramount. Valorization of mixed glass when grounded to same fineness of Portland cement can be used as an alternative SCM in concrete. The glass powder (GP) demonstrates pozzolanic behavior: the amorphous silica (SiO2) in the GP reacts with portlandite [Ca(OH)2] generated during cement hydration to form gels of calcium-silicate hydrate (CSH). The studies conducted at the University of Sherbrooke showed that the incorporation of 10% to 30% of GP in concrete gives increased workability, good mechanical characteristics and enhances durability. This study provides the overall performance of GP concrete after long-time service by taking core samples from the construction sites and testing in laboratory.

Ouellet-Plamondon, Claudiane

LCA of Alternative Concrete: How Do We Do?, Claudiane Ouellet-Plamondon and Guillaume Habert

In this study we carry out a detailed environmental evaluation of geopolymer and calcium sulpho-aluminate (CSA) concrete production using the Life Cycle Assessment methodology. After a literature review, previous works have been adapted to follow a similar methodology where we can accurately assess the paste quality and compare it with an amount of Ordinary Portland Cement (OPC) equivalent. With this method, we confirm that the production of most standard types of alternative concrete has a slightly lower impact on global warming than standard OPC concrete. However, the difference between published results with methods that did not pay attention to paste quality assessment and our method can induce a 20% difference. When the production of fly ashes and granulated blast furnace slags is taken into account during the life cycle assessment, it appears that geopolymer concrete has a similar impact on global warming as standard concrete.

Papatzani, Styliani

The Effect of the Addition of Nanoparticles of Silica on the Strength and Microstructure of Blended Portland Cement Pastes, Styliani Papatzani, Kevin Paine and Juliana Calabria-Holley

The complex behaviour of concrete depends on the properties and response of the cement hydration product, which is nanosized. Nanotechnology offers an opportunity to modify and observe this matter at the nanolevel. In the research described in this paper the addition of silica nanoparticles to blended cement formulations was investigated with the aim of enhancing durability and lowering environmental impact. The influence on hydration products, microstructure and compressive strength of the fresh and hardened cement paste were determined and correlated. Quaternary cement combinations were produced with Portland cement, limestone, fly ash and silica nanoparticles. The research reported was part of a much broader research project supported by the EU to investigate nanotechnology enhanced cements. The outputs of this work will contribute to knowledge that aims to determine the capability and limitations to the use of silica nanoparticles in blended cements and how silica nanoparticles may be best used to achieve high peformance nanoengineered concretes.

Pinneke, Andrew

Sustainable Benefits of Ultra-High Performance Concrete, Andrew Pinneke and Kelly Henry

This paper will demonstrate how the properties of ultra-high performance concrete have been developed specifically to address the core design values of high-performance buildings. Examples of how innovation in manufacturing and ingenuity in design have helped ultra-high performance concrete evolve in stride with the sustainable building industry will be given. The specific attributes that will be illuminated are resilience, durability, versatility, efficiencies in production, reduction of virgin material and labor, plus the health and safety related characteristics of ultra-high performance concrete. Also, critical to most projects is the aesthetics of the finished product. The wide range of aesthetically pleasing applications of ultra-high performance concrete will be shown in various projects from around the world. The framework for the discussion will be that of life-cycle analysis. This paper will provide important information on how utilizing performance enhancing systems that feature ultra-high performance concrete lead to better overall building energy performance and life-cycle impact.

Ritchie, Kirsten

Information Transparency: A Roadmap to Improving Health and Reducing Carbon in our Built Environment, Kirsten Ritchie

This session will present Gensler's approach to addressing health and environmental issues related to building construction. As a global architecture and design firm Gensler has played a pivotal role in the development of numerous building product standards including the newly released Health Product Declaration (HPD). They were actively involved in the development and implementation of sustainability standards and guidelines at the organizational level, focused on improving the environmental performance and occupant well-being of global real estate portfolios and large mixed use developments. This presentation will share insights into the future of Environmental Product Declarations (EPDs) and Health Product Declarations (HPDs) and their specific impact on the construction and concrete industries.

Santero, Nicholas

Understanding Health Product Declarations and LEED, Nicholas Santero

What are the health impacts of your concrete mix? Architects and owners are asking this question as part of a general movement towards increased product transparency. The new LEED v4 supports this movement, designating an entire credit (Materials and Resources: Building product disclosure and optimization—material ingredients) to health disclosure and performance of building products. Health product declarations (HPDs) are emerging as a preferred approach to meet LEED and market requirements. Similar to the way that environmental product declarations (EPDs) disclose potential environmental impacts, HPDs provide a systematic method of identifying and reporting the health hazards associated with building products. This presentation provides an overview of the new LEED v4 health credit, evaluates the various methods of meeting this credit, and explores the effects and relevance for the concrete industry.

Shilstone, James M.

The Environmental Impact of Overly Restrictive Prescriptive Specifications, James M. Shilstone

For decades concrete producers have complained about mismatched prescriptive specifications, such as where maximum water-cementious ratios are at odds with design strengths, or when air-entrained concrete is required for areas not exposed to freezing and thawing. For the first time an industry-wide survey examines the use of prescriptive specifications and analyzes the cost, both financially and environmentally, of the improper use of prescriptive specifications. This presentation will combine NRMCA survey data with an independent survey to determine the impact on the U.S. economy and CO2 emissions.

Siddiqui, Md

A Rational, Sustainable Approach to Pavement Concrete Mixture Design, Md Sarwar Siddiqui and David W. Fowler

There is an increasing need to use manufactured sands in pavement concrete in areas where sources of natural sand are not available or are being depleted. However, manufactured sands usually do not meet the ASTM C33 gradation requirements and have high micro fine contents, poor shape, and poor texture. A logical method of concrete mixture design has been developed based on the previous work done by the International Center for Aggregates Research (ICAR). Laboratory results have shown that the proposed mixture design can save up to 150 lb/yd3 of cement compared to mixtures designed by ACI 211 without compromising strength or durability. Therefore, this proposed mixture design has the potential to produce less expensive and sustainable concrete without sacrificing performance.

Swei, Omar

Characterization of Principal Drivers of Variation in the Life-Cycle Cost Analysis of Pavements via a Scenario Space Analysis, Omar Swei, Jeremy Gregory and Randolph Kirchain

Life Cycle Cost Analysis (LCCA) is an analytical framework to assess the most economically prudent investment from a set of alternatives over their respective lifetimes. Despite its merits, a recent survey prepared for the Federal Highway Administration (FHWA) highlighted that highway officials prioritize structural and functional conditions as well as initial costs over life-cycle costs. The goal of this research, is to identify which parameters are of key importance when conducting a probabilistic LCCA across a range of possible scenario. A detailed model is developed model is developed and applied to a range of scenarios which vary in terms of location, traffic conditions, design life, analysis period, and maintenance schedule to characterize their implication to the problem at hand and identify which parameters are consistently the drivers of variation across the explored scenario space.

Szecsy, Rich

Local Specification Changes to Produce Statewide Impact, Rich Szecsy

The State of Texas is one of the largest producers of ready mixed concrete in the U.S. As such, it is also one of the largest consumers of concrete raw materials of aggregates, cementitious materials, and water. With a projected population increase of 20M people over the next 25 years, there is going to be a tremendous strain on those resources. A case example of the City of Austin will be profiled to show how changes to standard municipal concrete specifications can be used to impact the consumption rate of concrete raw materials as the demand for concrete continues to increase. Examples and data projections will be used to illustrate the need for instituting the changes to these types of specifications.

Szoke, Stephen

Making the Case for Enhanced Resiliency, Stephen S. Szoke

The most widely accepted green features of buildings are limited to energy, water and resource conservation; interior environmental quality; and site selection and development. These are all important aspects for the design and construction of sustainable buildings. However, programs, codes and standards developed in the United States allow these features, which often have higher initial costs, to be incorporated into buildings where the building cores and shells are designed and constructed to only satisfy the minimum building code requirements. Adding such “green” features without adequate consideration of criteria that enhance durability, robustness, serviceability, and disaster resistance of the building is contrary to be basic premises of sustainability. A review of negative societal, economic, and environmental impacts based on current construction standards of practice are provided. The implications related to criteria requiring enhanced resiliency for sustainable and disaster prone buildings are viewed for various levels ranging from the building to the community and beyond.

Tecchio, Paolo

Using Probabilistic Underspecification for Streamlining Building Life Cycle Assessments, Paolo Tecchio, Jeremy Gregory, Randa P. Ghattas, Elsa A. Olivetti and Randolph Kirchain

In spite of the fact that buildings accounted for 40% of the U.S. primary energy consumption in 2012, the use of Life Cycle Assessment (LCAs) to support building design decisions is limited. Multiple barriers exist including the separation of the use phase tools and embodied and end of life tools, burdensome data inputs, tools that don’t integrate well with design process, a lack of clear, consistent environmental metrics and goals and a lack of demand for life cycle considerations. This paper will introduce an alternative approach to streamline LCA in order to 1) reduce the effort required in data collection for LCA model building; 2) provide architects, builders and designers with a decision making methodology that can be used to assess the environmental burden of a building throughout the design process; and 3) include the uncertainty associated with LCA results across the different phases of the design process.

Vázquez, Natalia

Optimization by Response Surface Methodology of Pervious Concrete Containing Fly Ash and Engineered Iron Oxide Nanoparticles, Natalia Vázquez, Linoshka Soto, Rene Santiago and Sangchul Hwang

Pervious concrete (PC) usage has increased due to its potential to reduce storm water runoff and related pollution. Partial Portland cement substitution by fly ash in concrete production has the advantages of reducing cost, carbon dioxide production associated with Portland cement and burdens of solid waste management. In this regard, a PC mixture was optimized by Response Surface Methodology. A two-level central composite factorial design was used to investigate the effects of water to powder ratio (W/P, 0.34 - 0.40), percentage of cement substitution by fly ash (FA/C, 0.1 - 0.4) and engineered iron oxide nanoparticles to powder ratio (ENP/P, 0.03 - 0.05) on compressive strength, permeability, void content and hardened density of PC. W/P and FA/C had significant impacts on all the properties of PC studied, whereas ENP/P produced significance for only the PC's compressive strength.

Wildnauer, Maggie

Full Building Life-cycle Assessment in Tally™, Maggie Wildnauer

With the passage of LEED v4, there is an increased motivation for incorporating life cycle assessment (LCA) into building design through two additions to the Materials and Resources credit category. MRc1 awards points for conducting a full building LCA of the structure and enclosure. To make full building LCAs more accessible and achievable, the Tally™ tool was created through collaboration between KieranTimberlake, PE INTERNATIONAL, and Autodesk. Tally™ is an add-in to the Revit BIM software (Autodesk) that allows architects and engineers to evaluate and report the environmental impacts of their building design. Aside from helping to achieve LEED credits, Tally™ lets users quickly understand the benefits from structure or mix design changes in the context of the entire building. This is an invaluable option for designers, allowing real-time decision making that will lead to direct reductions in a building's environmental footprint.

Wright, Joseph

The Effect of Adding PAAm Crystals to the Strength Characteristics of Concrete, Jason Charalambids and Joseph Wright

This paper involves an experimental procedure to determine if concrete would be stronger if you have a substance mixed in the concrete that is able to release water as the concrete cures. Based on our current knowledge that concrete strength is partially dependent on water content and curing time, it may be surmised that mixing in polyacrylamide (PAAm) crystals that retain water and release it back slowly will significantly alter the curing process and have a profound impact on the final strength characteristics of concrete cylinders. A preliminary investigation has been preformed that indicates that this is so. In this study various topics relating to the properties of PAAm crystals and factors that affect concrete strength have been reviewed and concrete cylinders within which PAAm crystals were incorporated in varying amounts and for a range of water/cement ratios have been tested. The results were reviewed and analyzed to determine any differences in final characteristics.

Xu, Xin

A Probabilistic Approach to Comparative Life-Cycle Assessment of Pavements: Sensitivity and Scenario Analysis, Xin Xu, Arash Noshadravan, Jeremy Gregory and Randolph Kirchain

Improving the sustainability of road infrastructure requires a thorough evaluation of the environmental impacts of pavements during all phases of their life. We have developed a probabilistic LCA methodology that incorporates different sources of uncertainties. The scope of the LCA consists of all aspects of a pavement life cycle from materials extraction to initial construction, use, maintenance and rehabilitation, and end-of-life. In particular, use phase impacts including the albedo effect, pavement-vehicle interaction (PVI), carbonation, and lighting are quantified in the approach. The methodology accounts for the range of possible outcomes from alternative designs and uses a comparison indicator to represent the relative difference in a statistical sense. We have conducted a scenario analysis as a means of testing the methodology and gaining insight on the key drivers of the outcomes and will share these results in this presentation.

Yang, Frances

LEEDv4: Sorting out HPDs vs EPDs, Frances Yang

LEEDv4 presents several new concepts to the building products supply chain, the greatest change occurring in the Materials and Resources category. This presentation will offer a simplified way of differentiating the concepts by comparing several of them to our more familiar nutrition label. Attendees will have a clearer understanding of the intention of each new credit, the differing levels of requirements within them, and how they work together. They will also likely realize there is more to our nutrition label than they thought! Examples of how different parties in the concrete industry have participated in the various mechanisms offered will also be highlighted.

Yurdakul, Ezgi

A Comparative Analysis of Prescriptive and Performance-Based Specifications for Sustainability, Ezgi Yurdakul, Peter Taylor and Halil Ceylan

With the recent advancements in concrete technology, design and production of “green concrete” has become desirable. Although, the production of structures that are entirely sustainable is still challenging, industry has shown progress by motivating alternative solutions to conventional concrete such as using recycled aggregates, binary and ternary mixes with high level of supplementary cementitious materials, and alternative binders with different chemistry causing lower carbon footprint than portland cement. However, mix proportioning guidelines for performance-based specifications have fallen behind these advancements. Despite the well known relation between cement production and carbon dioxide emission, prescriptive-based specifications which set minimum cement content requirement are still commonly used, thereby dramatically impacting sustainability. This paper presents the effect of specifications on sustainability by comparing the corresponding carbon footprint of cementitious materials required according to the prescriptive and performance-based specifications.