INTERNATIONAL
# CONCRETE SUSTAINABILITY CONFERENCE
MAY 6-8, 2013 - SAN FRANCISCO

## CONFERENCE SCHEDULE* (Hotel Sofitel San Francisco Bay)

### MAY 6, 2013

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| 12:00 PM – 5:00 PM | ALCATRAZ PRISON TOUR SPONSORED BY CONCRETE INDUSTRY MANAGEMENT (CIM) PROGRAM AT CALIFORNIA STATE UNIVERSITY (CSU) CHICO (Grand Ballroom Foyer) (Additional fee required) |
| 6:00 PM – 7:00 PM | RECEPTION ( Grand Ballroom Foyer) |

### MAY 7, 2013

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| 7:30 AM – 8:30 AM | BREAKFAST (Grand Ballroom Foyer) |
| 8:30 AM – 10:00 AM | OPENING GENERAL SESSION (Champagne)<br>***Welcome to the 8th Annual International Concrete Sustainability Conference***, William Childs, President of Chaney Enterprises and Chairman of NRMCA<br>***Sustainable Concrete Infrastructure through Virtual Management Systems***, Michael Lepech, Stanford University<br>***Architecture 2030: Progress Toward Net Zero***, Francesca Desmarais, Architecture 2030<br>***Progress Toward Sustainable Highways***, Suneel Vanikar, Federal Highway Administration |
| 10:00 AM – 10:30 AM | BREAK (Grand Ballroom Foyer) |

| 10:30 AM – 12:00 PM | SESSION T1A (Champagne) | SESSION T1B (Grand Salon) | SESSION T1C (Blue Room) |
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| | GREEN CONCRETE | FUNCTIONAL RESILIENCE | LOW-IMPACT DEVELOPMENT |
| | ***Sustainable Cementless Blend for Pervious Concrete: Towards Carbon-Reduction Initiatives***, Adel Abdollahzadeh, University of Cambridge | ***Sustainable Concrete Structures Through Seismic Resilience: A Case Study***, Matthew Comber, Degenkolb Engineers | ***The Science and Engineering of Photocatalytic Pavements: Update on the 1st US 'TX Active' Highway Application***, James Alleman, Iowa State University |
| | ***Tailoring of Polypropylene Fibers for the Design of Sustainable Fiber-reinforced Cement-based Composites***, Subhan Ali, Stanford University | ***Performance-Based Assessment of Concrete Durability in Coastal Structure***, Madeleine Flint, Stanford University | ***Fabrication Techniques for Concrete Containing TiO2 Photocatalytic Particles***, Shannon Hanson, University of Utah |
| | ***Enhancing the Performance of High Volume Fly Ash Concretes Using Fine Limestone Powder***, Ahmad Ardani, Federal Highway Administration | ***Structural Performance Assessment in the Context of Seismic Sustainability***, Bora Gencturk, University of Houston | ***Cool Communities: The Benefit of Cool Pavements in CA Cities***, Dev Millstein, Lawrence Berkeley National Laboratory |

| 12:00 PM – 1:30 PM | LUNCH (Bordeaux) |
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| 1:30 PM – 3:00 PM | SESSION T2A (Champagne) | SESSION T2B (Grand Salon) | SESSION T2C (Blue Room) |
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| | GREEN CONCRETE | FUNCTIONAL RESILIENCE | LOW-IMPACT DEVELOPMENT |
| | ***Ternary Blend Concrete with Reclaimed Asphalt Pavement as an Aggregate in 2-lift Concrete Pavement by the Illinois Tollway***, Ross Bentsen, Quigg Engineering, Inc. | ***Glass-FRP Reinforced Concrete Bridge Deck: A Sustainable Approach***, Jianwei Huang, Southern Illinois University Edwardsville | ***Hydraulic Design of Pervious Concrete Highway Shoulders***, Nathan Grahl, University of Missouri- Kansas City |
| | ***Coal Ash Material Safety—A Health Risk-Based Evaluation of USGS Coal Ash Data from Five US Power Plants***, Lisa Bradley, AECOM | ***Designing Buildings to Last Many Lifetimes***, Alan Kren, Rutherford & Chekene Consulting Engineers | ***Removal of High Levels of Dissolved Zinc and Copper in Pervious Concrete***, Liv Haselbach, Washington State University |

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| | ***Controlling the Cohesion of Calcium Silicate Nanohydrates by the use of Polyelectrolytes: Towards Sustainable Cementitious Materials***, Fabrice Brunel, Laboratoire Interdisciplinaire Carnot de Bourgogne | ***Mapping a Structure's Impact on the Environment: Case Studies***, David Shook, Skidmore, Owings & Merrill LLP | ***Urban Physics: City Texture Matters***, Jacob Sobstyl, Massachusetts Institiute of Technology |
| **3:00 PM – 3:30 PM** | **BREAK (Grand Ballroom Foyer)** | | |
| **3:30 PM – 5:00 PM** | **SESSION T3A (Champagne)**<br>**GREEN CONCRETE**<br>***From Residential Applications to Iconic Concrete Structures: An Overview of Sustainable Concrete Projects Brought to Life Through Concrete Mix Optimization and Innovative Admixtures***, Mark Bury, BASF Corporation<br>***Towards the Development of a CO2 Neutral Cement***, Natalie Carr, Delft University of Technology<br>***Performance of Typical Concrete Mixtures for Transportation Structures as Influenced by Portland-Limestone Cements from Five Sources***, Tim Cost, Holcim (US) Inc. | **SESSION T3B (Grand Salon)**<br>**NEW CONCRETE TECHNOLOGY**<br>***Bond in Strain Hardening Fiber-Reinforced Cement Based Composites***, Matthew Bandelt, Stanford University<br>***A Novel Cementitious Calcium Carbonate Containing CO2 from Industrial Flue Gas***, Irvin Chen, Calera Corporation<br>***Behavior of Confined and Unconfined Rubberized Concrete***, Mohamed ElGawady, Missouri University of Science and Technology | **SESSION T3C (Blue Room)**<br>**LOW-IMPACT DEVELOPMENT**<br>***Quasi-Steady-State Equilibrium Estimation of Concrete Pavement CO2 Sequestration***, Liv Haselbach, Washington State University<br>***Pavement Albedo: Importance and Measurement***, Jessica Slater, CTLGroup<br>***Pervious Concrete: New Field Practices, Standards and Technology***, Alan Sparkman, Tennessee Concrete Association |
| **6:00 PM – 7:00 PM** | **RECEPTION (Grand Ballroom Foyer)** | | |
| **MAY 8, 2013** | | | |
| **6:30 AM – 7:30 AM** | **RMC RESEARCH & EDUCATION FOUNDATION – WALK FOR SUSTAINABILITY (Grand Ballroom Foyer) (Additional fee required)** | | |
| **7:30 AM – 8:30 AM** | **BREAKFAST (Grand Ballroom Foyer)** | | |
| **8:30 AM – 10:00 AM** | **SESSION T4A (Champagne)**<br>**GREEN CONCRETE**<br>***Is Your Sustainable Concrete Program Blue?***, Joseph Daczko, BASF Corporation<br>***Perceptions and Usage of Recycled Concrete Aggregate within Transportation Agencies in North America***, Jason Ideker, Oregon State University<br>***Rethinking Concrete Delivery Methods for Increased Sustainability***, Eric Koehler, Verifi | **SESSION T4B (Grand Salon)**<br>**NEW CONCRETE TECHNOLOGY**<br>***Use of Mutated Micro-Organisms to Produce Sustainable Mortar***, Bijoy Halder, University of Texas at El Paso<br>***Advances in Green Concrete***, Fred Kinney, CERATECH<br>***Green Concrete Without the Tradeoffs***, Jennifer Wagner, Carbon Cure Technologies | **SESSION T4C (Blue Room)**<br>**LIFE CYCLE ASSESSMENT**<br>***LCA and LCCA of Climate Resilient Buildings for the 21st Century***, Julie Buffenbarger, Lafarge<br>***Life Cycle Assessment of Buildings: A Gap Analysis of Existing Literature and Trending Tools***, Jeremy Gregory, Massachusetts Institute of Technology<br>***Life Cycle Sustainability Assessment of Pavements Under Uncertainty and Variation***, Arash Noshadravan, Massachusetts Institute of Technology |
| **10:00 AM – 10:30 AM** | **BREAK IN EXHIBIT HALL (Grand Ballroom Foyer)** | | |
| **10:30 AM – 12:00 PM** | **SESSION T5A (Champagne)**<br>**GREEN CONCRETE**<br>***Laboratory and Field Studies of "Green" Concrete Properties***, Ward Malisch, American Society of Concrete Contractors | **SESSION T5B (Grand Salon)**<br>**SUSTAINABILITY INITIATIVES**<br>***Taking Sustainability to a New Level: Facility-based Initiatives Targeting Biodiversity, Community Engagement and Stakeholder Relations***, Josiane | **SESSION T5C (Blue Room)**<br>**LIFE CYCLE ASSESSMENT**<br>***Life Cycle Assessments of Low Carbon Concrete***, Kari-Anne Lyng, Ostfold Research |

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| | ***Slag Cement for Sustainable Concrete Construction***, John Melander, Slag Cement Association<br>***Improving Fly Ash Utilization and Performance by Sulfate Optimization***, Mark Niemuth, Lafarge | Bonneau, Wildlife Habitat Council<br>***EPDs: An Inside Look at the Keys to Successful Implementation***, Chris Erickson, Climate Earth, Inc<br>***Designing Sustainable Concrete Pavements using the Mechanistic Empirical Pavement Design Guide***, James Mack, CEMEX | ***Embodied Energy and GHG Emissions of Five External Walls for Residential Buildings***, Anne Roenning, Ostfold Research<br>***Characterizing and Implementing Uncertainty in the Life-Cycle Cost of Pavements***, Omar Swei, Massachusetts Institute of Technology |
| **12:00 PM – 1:30 PM** | **LUNCH (Bordeaux)** | | |
| **1:30 PM – 3:00 PM** | **SESSION T6A (Champagne)**<br>**CASE STUDIES**<br>***NASA's LEED Platinum Sustainability Base***, David Johnson, William McDonough + Partners<br>***San Francisco Public Utilities Commission (SFPUC) LEED Platinum Headquarters***, Brook Mebrahtu, San Francisco Department of Public Works<br>***Fabric Formed Concrete Structures - Style and Substance***, Russ Miller-Johnson, Engineering Ventures | **SESSION T6B (Grand Salon)**<br>**SUSTAINABILITY INITIATIVES**<br>***Responsible Sourcing through CSR Reporting***, Tien Peng, NRMCA<br>***The ABCs of EPDs, LCAs, and LEED***, Nicholas Santero, PE International<br>***Navigating the Legal Obstacles on Your Road to Sustainability: Recent Developments in the Law***, Benjamin Tymann, Greenberg Traurig LLP | **SESSION T6C (Blue Room)**<br>**LIFE CYCLE ASSESSMENT**<br>***Comparative Analysis of the Life-Cycle Impact Assessment of Cement Mortar Mixes Using the GreenConcrete LCA Tool***, Arpad Horvath, University of California, Berkeley<br>***An Approach for Analyzing Cost and Energy Performance Trade-offs in Residential Building Wall Systems***, Christoph Wuestemeyer, Massachusetts Institute of Technology<br>***10 Questions LCA Can Answer about Concrete Buildings***, Frances Yang, Arup |
| **3:00 PM – 3:30 PM** | **BREAK (Grand Ballroom Foyer)** | | |
| **3:30 PM – 5:00 PM** | **CLOSING GENERAL SESSION (Champagne)**<br>**PANEL DISCUSSION**<br>***Transparency and Material Ingredient Disclosure – What Google is Doing to Keep its Buildings Healthy***<br>Caspar Wagner, Google, Inc.<br>Franz-Josef Ulm, Massachusetts Institute of Technology<br>Michael Fletcher, BASF Center for Building Excellence<br>Jeff Davis, Central Concrete<br>Ted van der Linden, DPR Construction<br>Blake Inouye, KPFF Consulting Engineers | | |

## End of Conference

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# PRESENTATION ABSTRACTS

Adel Abdollahzadeh

*Sustainable Cementless Blend for Pervious Concrete: Towards Carbon-Reduction Initiatives*, Adel Abdollahzadeh and Abir Al-Tabbaa

The production of Portland cement (PC) as the main component in concrete is dramatically increasing throughout the world and is responsible for 5 to 10% of all anthropogenic carbon dioxide emissions, encouraging research into how to reduce or eliminate carbon dioxide emissions by this sector. Reactive magnesia cement, containing MgO, PC and a pozzolan, has recently emerged as a potential, more sustainable, cementitious material compared to Portland cement. The feasibility of using this kind of material in pervious concrete, with high pore content, might enhance the cement industry's carbon-reduction initiatives. This study examines the mechanical properties of magnesia blends comprised of MgO, PC and GGBS, based on up to 90 days compressive strength, density and pH solution.

Subhan Ali

*Tailoring of Polypropylene Fibers for the Design of Sustainable Fiber-reinforced Cement-based Composites*, Subhan Ali and Michael Lepech

Fiber reinforced concrete (FRC) is a widely used building material that has found wide adoption. Asbestos fibers are a reinforcing material in FRC that have been extensively used in developing countries, but carry associated human health impacts that have been documented. Polyproplyene fibers are a viable replacement for asbestos fibers as a reinforcing material, but polypropylene is a hydrophobic material that creates a poor bond with a cementitious matrix when mixed. Therefore, polarity control can be employed in order to create a polypropylene material that is more hydrophilic. In order to measure the strength of the bond created between the modified polypropylene and the cementitious matrix, single fiber pullout testing can be employed. In this paper, experimental investigation of the pullout testing is presented. Chemical bond strength and frictional bond strength values are produced for polypropylene modified with certain additives. The increased bonding can create a higher strength polypropylene fiber reinforced cementitious composite at low crack widths thus serving as a low-cost viable replacement for asbestos FRC in developing countries.

James Alleman

*The Science and Engineering of Photocatalytic Pavements: Update on the 1st US 'TX Active' Highway Application*, James E. Alleman, Joel Sikkema, John Kevern, Peter C. Taylor, Tom Cackler, & Rangan Gopalakrishnan

This presentation will examine the current and next-generation state-of-the-art 'smog-eating' photocatalytic TX Active pavement. Both lab and full-scale testing results will be presented in order to provide the conference audience with a full overview of the involved science and engineering. Our research team has a unique, in-depth familiarity with this timely, green pavement topic given that we are currently studying the environmental performance of one such photocatalytic highway section located in St. Louis, Missouri.

Ahmad Ardani

*Enhancing the Performance of High Volume Fly Ash Concretes Using Fine Limestone Powder*, Jussara Tanesi, Dale Bentz, and Ahmad Ardani

One of the primary approaches being explored to produce more sustainable concretes consists of replacing a significant portion of the portland cement with industrial by-products. In high volume fly ash concretes, for example, the nominal goal is to replace 50 % of the portland cement in a conventional concrete with fly ash. While these mixtures typically perform admirably in the long term, they sometimes suffer from early-age performance issues including binder/admixture incompatibilities, delayed setting times, low early-age strengths, and a heightened sensitivity to curing conditions. Recently, investigations have indicated that the replacement of a portion of the fly ash in these concrete mixtures by a suitably fine limestone powder can mitigate many of these early-age problems, specifically the undesirable delays in setting times. This presentation will present the results of a recent study that investigated the production of viable infrastructure concrete mixtures where either 40 % or 60 % of the portland cement is replaced by fly ash and limestone powder, on a volumetric basis.

Matthew Bandelt

*Bond in Strain Hardening Fiber-Reinforced Cement Based Composites*, Matthew J. Bandelt and Sarah L. Billington

High performance fiber-reinforced cement based composites (HPFRCC) are emerging materials that have increased durability, mechanical performance, and sustainability as compared to traditional cementitious materials. HPFRCC materials exhibit a pseudo strain hardening behavior which leads to multiple fine cracks when loaded in tension and a significant increase in ductility. This behavior can lead to a large reduction in longitudinal and transverse steel reinforcement in many structural elements. To date, researchers have shown that HPFRCC materials can result in increased life cycle and structural performance for a variety of applications. In order to develop modeling tools and design guidelines for these new materials, it is necessary to understand how they interact with typical steel reinforcement. On-going research on characterizing bond strength and bond-slip behavior between reinforcement and multiple HPFRCC materials will be presented. Future research on additional experiments and modeling approaches will also be discussed.

Ross Bentsen

*Ternary Blend Concrete with Reclaimed Asphalt Pavement as an Aggregate in 2-lift Concrete Pavement by the Illinois Tollway*, William R. Vavrik, Steven Gillen, Jeffery Roesler and Ross Bentsen

The Illinois Tollway, part of the $12 billion Move Illinois capital program, desires roadway construction to be 'greener' than ever before. For concrete pavements, this translates to requiring the use of industrial byproduct, recycled asphalt pavement as a coarse aggregate and allowing for the use of recycled concrete aggregate in ternary blend concrete pavement materials. To develop the standards and specifications for this "black rock" concrete mixture, the Illinois Tollway completed a laboratory and field trial program. The laboratory program investigated the replacement of virgin coarse aggregate in a ternary blend concrete mix with various levels of fractionated recycled asphalt pavement (FRAP). The results of the laboratory investigation showed that up to 50 percent FRAP may be feasible in a ternary concrete pavement mix that meets the Illinois Tollway's strength requirements. This presentation presents the impacts of the FRAP on the concrete material properties such as slump, unit weight, air content, compressive strength, split tensile strength, flexural strength, dynamic modulus, shrinkage, and freeze/thaw durability.

Josiane Bonneau

*Taking Sustainability to a New Level: Facility-based Initiatives Targeting Biodiversity, Community Engagement and Stakeholder Relations*, Josiane Bonneau

The concrete industry is a leader in providing the technology and materials for green infrastructure and sustainable construction. As interest in sustainable development grows, the ready mixed concrete industry must not only remain a crucial provider of those services, but also be able to demonstrate their own commitment to sustainable development. Facilities can successfully be encouraged to go above and beyond the regulatory framework and land management activities and implement programs promoting environmental stewardship, as demonstrated by several success stories. On-the-ground initiatives in partnerships with ENGOs can target native ecosystems restoration, control of invasive species, enhancement of pollinator habitat, water quality improvement and community engagement. By engaging employees and/or the community in education or outreach programs associated with your efforts, your company can put a 'public face" on the conservation efforts enacted by your employee volunteers, solidifying community relationships and building awareness of your sustainability initiatives. Join us to learn how companies within the concrete industry have applied these concepts at their facilities through ENGO partner programs.

Lisa Bradley

*Coal Ash Material Safety—A Health Risk-Based Evaluation of USGS Coal Ash Data from Five US Power Plants*, Lisa Bradley

Recycling of coal ash (CCPs) is one of the great environmental success stories of our time. Over 42% of the coal ash produced in the U.S. is put into beneficial use. Almost a quarter of this recycling is reuse in concrete and cement products. However, these uses are threatened by U.S. Environmental Protection Agency's (USEPA) potential regulation of coal ash as a hazardous waste, and by constant references to "toxic coal ash" by the press. Therefore, a detailed health-risk based evaluation was conducted of coal ash data released in a report by the U.S. Geological Survey. This evaluation was conducted by comparing constituent concentrations in coal ash to risk-based screening levels developed by the USEPA that are protective of a child's direct exposure to residential soils. Constituent concentrations in coal ash were also compared to background concentrations in soils in the U.S. The results indicate that, with few exceptions, constituent concentrations in coal ash are below screening levels for residential soils, and are similar in concentration to background U.S. soils.

Fabrice Brunel

*Controlling the Cohesion of Calcium Silicate Nanohydrates by the use of Polyelectrolytes: Towards Sustainable Cementitious Materials*, Fabrice Brunel, Isabelle Pochard and Christophe Labbez

Due to its excellent mechanical strength and low cost, concrete is the most used building material in the world. However, its main drawback is its very low ductility. The aim of this project is to enhance the flexural strength of cement by increasing the cohesive force range between the nanoparticles of calcium silicate hydrates (C-S-H), i.e. the cementitious matrix, through the use of cationic polyelectrolytes. The project consists of two complementary approaches, one numercial, based on molecular dynamics and Monte-Carlo simulations, the other experimental, combining various characterizations techniques: adsorption isotherms, acoustophoresis, rheometry and atomic force microscopy. Numerical models coupled with experiments on a model system allowed us to better understand the relationship between the nanoscale interactions and the mechanical properties of the final materials. Knownledge-based design of the polymer will be a huge help to further improved mechanical properties of cement/polycation hybrid materials.

Julie Buffenbarger

*LCA and LCCA of Climate Resilient Buildings for the 21st Century*, Julie Buffenbarger and Francois Thueux

The frequency and severity of natural disasters has become an inevitable consequence of climate change. Increasing resilience in response to natural and man-made disturbances is the key to assuring security, reductions in the loss of life, reductions in property damage, and enabling businesses and communities to quickly recover and suffer minimal losses. Commitment to advance building stock resilience must include concrete structures with extended service lives, functionality and adaptability, reduced operations and maintenance, environmental sustainability, and increased public health and safety. Life Cycle Analysis (LCA) and Life Cycle Costing (LCC) for a traditional three-bedroom single family dwelling, G+3 multi-family dwelling, and a G+8 office building were evaluated on a global platform. The environmental impacts (CO2, energy, water consumption, waste, etc.) as well as costs over the whole life cycle of each structure were assessed for various building elements and constructive systems. Comparisons of the LCA and LCCA for various building materials will provide beneficial tools for owners, design professionals, contractors, and other decision makers when selecting constructive systems and materials.

Mark Bury

*From Residential Applications to Iconic Concrete Structures: An Overview of Sustainable Concrete Projects Brought to Life Through Concrete Mix Optimization and Innovative Admixtures*, Mark A. Bury, David Green and Andreas Tselebidis

Understanding the role of concrete with respect to sustainability can be simplified by segmenting the discussion into three categories; sustainable practices for producing concrete (plant and fleet operations), sustainable design (e.g., LEED), and the sustainable aspects of the concrete mix itself. To help concrete producers address these issues an advanced mix optimization program has been developed to design economical, sustainable, high performance concrete. This program combines high-level proportioning expertise, innovative admixtures, and recycled materials to redefine the performance space for concrete. What once was conceptual is now a reality with admixture innovations leading the way towards a more desirable concrete for today's demanding economic, environmental, construction and design challenges. This presentation will describe the advanced mix optimization process, highlight the innovative admixture technologies, and demonstrate an award-winning tool used to quantify the environmental impact of concrete mixtures.

Natalie Carr

*Towards the Development of a CO2 Neutral Cement*, Natalie Carr and Henk Jonkers

This paper presents the development of methodologies that will enable the production of a sustainable cement (i.e. 'BioCement'), based on ashes derived from the conversion of biomass residues. The theory behind the research is that biomass can act as a source for functional clinker minerals as well as an

energy source during the necessary biomass conversion. Within this project the two main objectives are to obtain a material comprised of hydraulic minerals from the ashes produced in the combustion of a blend of sustainable biomass and/or waste-products and to adapt the raw materials and the sintering process so that the combustion is conducted in a way that also generates energy. After thermal conversion there will be two products; the primary product being energy and the secondary product being ashes which contain functional cement minerals. The ultimate goal is that these ashes will be capable of replacing a substantial part of traditional Portland cement in typical cement-based products such as concrete.

Irvin Chen

*A Novel Cementitious Calcium Carbonate Containing CO2 from Industrial Flue Gas*, Irvin Chen, Miguel Fernandez, Patricia Lee and Martin Devenney

A novel calcium carbonate cement system made from CO2 containing flue gas is described. Calcium carbonate has three anhydrous crystalline polymorphs: vaterite, aragonite and calcite, where vaterite being the least and calcite being the most thermodynamically stable polymorph. Previous research has demonstrated that the polymorphic transformation from vaterite to aragonite through a dissolution-reprecipitation process in water exhibits some cementitious properties; however, with low strength. In this study, vaterite was produced by capturing and mineralizing CO2 from natural gas-generated flue gas in a mixed stream of calcium-rich natural brine and alkalinity. For optimum cementitious properties, the vaterite was highly engineered for particle size distribution, lattice and surface properties to control its polymorphic transformation to aragonite and the size, morphology, and bridging of the aragonite crystals formed. As a result, the final cemented material achieved a compressive strength of 33 MPa in paste, mortar, and concrete, showcasing the good binding properties of the calcium carbonate cement with inorganic substances.

Matthew Comber

*Sustainable Concrete Structures Through Seismic Resilience: A Case Study*, Matthew V. Comber, Chris Poland and K. Mark Sinclair

Current practice in life cycle assessments of buildings' embodied environmental impacts accounts for only those impacts associated with first construction. Much of the world's building inventory is subject to damage due to natural disasters such as hurricanes, wildfires, floods and earthquakes. Damage sustained in these disasters leads to rebuilding efforts that consume additional resources and result in environmental impacts that are not accounted for using the traditional first-construction LCA model. In areas prone to seismic activity, concrete structural systems can be selected and tailored to minimize lifetime environmental impacts including those due to probable damage to a building, its nonstructural components, and its contents. The authors have developed an analysis methodology that allows a more holistic approach to LCA by quantifying the environmental impacts that can be expected due to building repair efforts after seismic events. This methodology is used to present a case study on a mid-rise concrete building and examine alternative seismic design strategies to better understand how to reduce the building's total lifetime environmental impacts.

Tim Cost

*Performance of Typical Concrete Mixtures for Transportation Structures as Influenced by Portland-Limestone Cements from Five Sources*, Tim Cost, Gary Knight, Wayne Wilson, Jay Shannon and Isaac L. Howard

Provisions for portland-limestone cements (PLC's) containing from 5% to 15% limestone have recently been added to ASTM C595 and AASHTO M 240 specifications for blended cements. It is anticipated that these (PLC) cements will be used interchangeably with Type I ordinary portland cements (OPC's) as specified in ASTM C150 and AASHTO M 85. This study was undertaken to document the performance of PLC's produced at five different plants located in southeastern (AASHTO) states, as compared with that of OPC's from the same plants, in concrete mixtures representative of those used in transportation structure applications. Reported test results include characterization of all materials, fresh concrete properties, time of setting, and compressive strengths at various ages up to 56 days.Tests for length change (ASTM C157) at 7 and 28 days and chloride ion penetration (ASTM C1202) at 56 days were also conducted and reported for selected mixtures.

Joseph Daczko

*Is Your Sustainable Concrete Program Blue?*, Joseph A. Daczko

While environmental policy and sustainability are core issues within the construction industry, a growing concern within the topic of sustainability is the conservation of fresh water. Fresh water is an essential element for sustaining life and globally there is growing concern about the current and future availability of fresh water for an ever growing and geographically dispersed human population. In some regions of the United States drought is an annual reality. Not only do drought conditions limit times for watering lawns or washing cars but in some documented cases, water, for basic human consumption, has to be trucked into towns from outlying areas. This presentation proposes a new way to look at sustainability based on water conservation during the production, placement and use of concrete and concrete structures. Also presented are current opportunities for limiting fresh water use and for increasing the current and future availability of fresh water.

Mohamed ElGawady

*Behavior of Confined and Unconfined Rubberized Concrete*, Osama Youssf, Mohamed A. ElGawady, Xing Ma and Julie E. Mills

The large amount of tired finding their way into landfills or illegally dumped into waterways every year is leading to serious health issues. The challenge is how to find different way to maximize the economic benefits and minimize the environment effects of scrap tire rubber disposal. One emerging way to do so is to recycle scrap tires into concrete material as a partial substitution for mineral aggregates resulting in product called rubberized concrete. This paper presents results of an experimental study on the behavior of confined and unconfined rubberized concrete having different percentages of scrap tire rubber. Forty-five standard concrete cylinders were investigated to determine the effects of rubber content on the compressive strength at 7 and 28-days, modulus of elasticity, tensile strength. In addition, three concrete cylinders were encased into fiber reinforced polymer (FRP) tubes. The effects of the thickness of the FRP tube on the axial behavior of rubberized concrete were investigated.

Chris Erickson

*EPDs: An Inside Look at the Keys to Successful Implementation*, Chris Erickson

Environmental Product Declarations (EPDs) are a well-structured environmental product labeling approach that is becoming important to owners and

architects because they allow purchasers and specifiers to make environmental impact a factor in their decisions. Developed by the Carbon Leadership Forum at the University of Washington, the ready mixed concrete industry has a national standard for EPDs in place. Leading companies such as Central Concrete in California have already implemented EPDs and NRMCA is authorized to verify EPDs to ensure the fairness and compliance of every ready mix label. This presentation is an inside look from the implementer of Central Concrete's EPD and a founding member of the Carbon Leadership Forum at University of Washington. The presentation covers an overview of the standards and methods for developing EPDs. It also covers what you need to know about the standards and the process and what you should ask and do, to have a successful EPD program.

Madeleine Flint

*Performance-Based Assessment of Concrete Durability in Coastal Structure*, Madeleine Flint and Sarah Billington

The lifetime costs and greenhouse gas emissions of conventional and green reinforced concretes in coastal construction have been compared using a modular probabilistic framework. The performance-based durability engineering (PBDE) framework is designed to produce quantitative metrics for assessing the economic, environmental, and social impacts related to structural durability. By combining uncertainty in exposure, deterioration, repair, and impacts, the framework yields robust estimates of structural sustainability. The assessment presented studies an archetypal reinforced concrete structure located near the ocean in Hilo, Hawaii. Results are presented as probabilistic distributions of lifetime costs and emissions, which may be translated into a variety of decision-making metrics, such as average impacts or probability of exceeding an unacceptable value of impact. Benefits of the PBDE approach include generality, flexibility, and the ability to assess the sensitivity of results to models and assumptions.

Bora Gencturk

*Structural Performance Assessment in the Context of Seismic Sustainability*, Bora Gencturk and Kazi Ashfaq Hossain

The main objective of sustainable design is to reduce the total cost and environmental impact of a structure or system without compromising its safety. Therefore, sustainability assessment typically comprises evaluation of economic, social and environmental factors throughout the service life of the structure. Life-Cycle Assessment (LCA) has become a widely accepted technique as a measure of sustainability. Recently, the authors have developed a framework for evaluating sustainability through comprehensive LCA taking into consideration its three main components: life-cycle cost assessment (LCCA), life-cycle environmental impact assessment (LCEIA) and life-cycle structural performance assessment (LCSPA). This study discusses the LCSPA component of the framework. Structural performance is assessed in terms of structural damages that the structure might experience from future earthquakes.

Nathan Grahl

*Hydraulic Design of Pervious Concrete Highway Shoulders*, Nathan Grahl, John T. Kevern and Jerry Richardson

This paper discusses preliminary research on the hydraulic response of pervious concrete pavements exposed to sheet flowing water. Pervious concrete samples were placed at several different void contents for testing. The pervious samples were placed in a hydraulic flume and the effects of sheet flowing water, across the sample, were tested at a range of discharges and slopes. Results show the infiltrate rate of permeable pavements exposed to sheet flowing water is significantly lower than the measured infiltration rate. Pavement infiltration rate is also reduced as the slope of the pavement is increased. Preliminary discussion of a design methodology is included.

Jeremy Gregory

*Life Cycle Assessment of Buildings: A Gap Analysis of Existing Literature and Trending Tools*, Randa Pierre Ghattas , Suzanne Greene, Jeremy Gregory, Travis Reed Miller and Elsa Olivetti

It is widely reported that buildings contribute one-third of global greenhouse gas (GHG) emissions and more than 40% of global energy use. As population growth and migration to urban areas continue to necessitate the construction of new housing, the Building Sector is an easy target for mitigation through GHG policy initiatives. In fact, the United Nations Intergovernmental Panel on Climate Change identified the Building Sector as the area with the most potential to deliver long-term and cost-effective GHG reduction. One method for quantifying real and potential reductions in GHG emissions is life cycle assessment (LCA). This paper will review different approaches to building LCA in an effort to identify overarching trends, as well as identify gaps or inconsistencies ripe for refinement. An alternative approach will be discussed that provides a scalable platform for multi-dimensional impact analysis of buildings that targets the life cycle impacts that are the most significant. Further, the approach attempts to quantify, and reduce, uncertainty, allowing practitioners and the general public to understand the credibility of the results.

Bijoy Halder

*Use of Mutated Micro-Organisms to Produce Sustainable Mortar*, Bijoy Krishna Halder, Vivek Tandon, Ramana V. Chintalapalle, Anthony Tarquin and Debarshi Roy

Although Portland cement is a commonly used civil infrastructure material, its production requires a significant amount of energy. To minimize the carbon footprint, fly ash or other supplementing cementing materials have been utilized over the years to create a stronger and durable cement matrix. Recent studies have identified that the use of micro-organisms have the potential of enhancing the strength as well as the durability of mortar. To evaluate the influence of micro-organisms, mutated Bacillus Pasteuri bacteria (or wild bacteria) were used in this study. Since fly ash creates an optimum environment for bacterial growth by lowering the pH of the matrix, 5% of cement content was replaced with fly ash. Thus, mutated bacteria, wild type bacteria and fly ash were used to prepare mortar specimens which were evaluated to identify the influence of micro-organisms on strength and durability.

Shannon Hanson

*Fabrication Techniques for Concrete Containing TiO2 Photocatalytic Particles*, Shannon Hanson and Paul Tikalsky

Recent developments have shown the pollution reduction capabilities of photocatalytic TiO2 on tropospheric NOx gases. Tropospheric NOx gases affect the diurnal rise and fall of low level ozone. Concrete has shown to be a possible durable media in which photocatalytic TiO2 can be distributed on a large scale. A research program was undertaken to investigate fabrication techniques to find an efficient and cost effective method of distributing the TiO2 onto the

surface of the concrete so it can react with NOx gases in the atmosphere. The effects of the curing regiments were also considered. Finally, typical finishing methods such as media blasting, acid etching, and surface tining were addressed to see their effect the concretes surface's NOx reducing efficiency.

Liv Haselbach

*Removal of High Levels of Dissolved Zinc and Copper in Pervious Concrete*, Liv Haselbach, Cara Poor and Jerin Tilson

Pervious concrete systems can be effective low impact development best management practices. In addition to their stormwater quantity benefits, they can also improve water quality by filtration and other methods. Due to the chemistry associated with the pH, carbonate species, and hydroxide species of ordinary portland cement concrete, the pervious concrete layer in a pervious concrete system has the additional potential for dissolved metal sorption. 13 mm (0.5 in) of simulated dissolved zinc and copper stormwater solutions with approximately five times typical roadway stormwater levels were applied to laboratory made pervious concrete cylinders at a rate of +76 mm/hr (3 in/hr) and the exfiltrate analyzed. The application was repeated ten times over a period of several weeks. Removal rates for these conditions repeatedly exceeded 85%.

Liv Haselbach

*Quasi-Steady-State Equilibrium Estimation of Concrete Pavement CO2 Sequestration*, Liv Haselbach, Robby Borden and Mylene Gueneron

Ordinary portland cement (OPC) concrete pavements can sequester a significant portion of the CO2 released during the manufacture of OPC. Thermogravimetric analyses were conducted to determine interior carbon sequestration levels on one inch (25.4 mm) deep laboratory prepared cement specimens that had been aged only a few years, and also on older concrete pavement samples collected from actual applications The results of the testing correlate well with a quasi-steady-state equilibrium partitioning model for interior sequestration based on material and chemical characteristics. Interior stoichiometric carbon dioxide sequestration levels from 20 to 25% were found in OPC specimens with even higher sequestration levels when specimens are made with supplementary cementitious material.

Arpad Horvath

*Comparative Analysis of the Life-Cycle Impact Assessment of Cement Mortar Mixes Using the GreenConcrete LCA Tool*, Petek Gursel, Cagla Meral, Paulo Monteiro and Arpad Horvath

Concrete manufacturing accounts for more than five percent of anthropogenic CO2 emissions annually, mostly attributable to the production of portland cement clinker, the active ingredient in concrete. One of the sustainable solutions is partial substitution of portland cement clinker with supplementary cementitious materials (SCMs). This presentation covers a systematic approach to compare OPC mortars with blended cement mortars with SCMs (fly ash, silica fume, and slag) in terms of their environmental impacts and engineering (strength) properties. The authors applied a recently developed concrete life-cycle assessment (LCA) tool, named "GreenConcrete LCA" within a cradle-to-gate system boundary.

Jianwei Huang

*Glass-FRP Reinforced Concrete Bridge Deck: A Sustainable Approach*, Jianwei Huang

Chloride is a hazard to steel reinforcement in reinforced concrete (RC) structures because it induces the corrosion of steel which is exacerbated by the heavy use of de-icing salts to remove snow/ice, especially on steel RC bridge decks. Steel corrosion has resulted in (1) reduced rideability (2) structural deficiency and (3) increased life-cycle cost. Glass fiber reinforced polymers (GFRP) do not corrode as the way steel does. To date, significant research works have been conducted to explore the possibility of using GFRP bars as a substitute to steel reinforcement. Several GFRP RC decks have been constructed as demonstration projects in North America. This paper presents a newly developed model for the prediction of GFRP bar long-term performance in real RC structures.

Jason Ideker

*Perceptions and Usage of Recycled Concrete Aggregate within Transportation Agencies in North America*, Jason H. Ideker and Matthew P. Adams

The use of recycled concrete aggregate (RCA) in new construction is a known method of reducing the amount of construction and demolition waste sent to landfills, as well as reducing the amount of natural aggregates that need to be mined from the earth. Use of the material is still limited, however. A survey of transportation agencies in North America asking about the agencies' perceptions and usage of RCA, as well as concerns limiting increased RCA usage are presented. Responses from 26 agencies, including U.S. State Departments of Transportation, the Federal Highway Administration, and Ministries of Transportation in Canada, were received. Agencies were also asked to rank the barriers to the use of RCA, potential durability concerns, and what attributes are most important to know about the RCA source before considering its use in new construction. The outcomes of this survey provided valuable insight on what data transportation agencies would like to know about RCA performance before they will consider its use.

David Johnson

*NASA's LEED Platinum Sustainability Base*, David Johnson

The U.S. Green Building Council (USGBC) awarded the new ultragreen federal facility, named Sustainability Base, located at NASA Ames Research Center, Moffett Field, Calif., the highest level of Leadership in Energy and Environmental Design (LEED) certification, LEED Platinum, in 2012. Unlike any other government building ever constructed, this new facility's performance includes repurposed NASA aerospace technologies. Highly intelligent, even intuitive, this building is designed to optimize its performance automatically, in real time, and in response to internal and external changes. NASA's new, environmentally-friendly building was named in honor of the first humans to walk on the surface of the moon more than 40 years ago. The landing site for the Apollo 11 spacecraft was named Tranquility Base. Sustainability Base is a site where NASA technologies can be repurposed for application on Earth.

Fred Kinney

*Advances in Green Concrete*, Fred Kinney

This presentation discusses use of flyash in concrete from intial use to modern day 100% flyash based concrete. Discussion topics include the increasing

amounts of flyash used in mixes, specifiers desire to specify more and more carbon neutral alternatives to traditional concrete mixes and solutions available today. Specific projects with varying amounts of flyash will be cited with slag included as a portion of the discussion. Use in commercial, transportation and industrial markets will be explored.

Eric Koehler

*Rethinking Concrete Delivery Methods for Increased Sustainability*, Eric Koehler and Sue Priest

Regardless of how well concrete is batched at the plant, variation is introduced during transit and at the jobsite. Historically, many of these sources of variation were beyond the control of the ready mix concrete producer and were addressed by over-designing concrete and by making manual adjustments during delivery. Specifications, mixture designs, and standard operating procedures were developed based on limited measurement and automation during delivery. However, new technology is available for automatically measuring, managing, and recording concrete slump, temperature, mixing, load size, and water and admixture additions on board the truck during delivery. This technology enables concrete producers, engineers, contractors, and owners to completely rethink the concrete delivery process, resulting in increased sustainability, among other benefits. Changes to the delivery process are essential to achieving the full sustainability benefits or this new technology. This paper will describe this new technology and recommend specific changes to concrete delivery practices. This paper will also address ways specifications can be re-written and inspection practices updated to enable more sustainable concrete delivery processes.

Alan Kren

*Designing Buildings to Last Many Lifetimes*, Alan Kren

First cost almost always drives building design, even buildings that include sustainability as a key design criterion. How would our designs change if we instead designed for longevity, and shouldn't we consider longevity in judging a building's sustainability? First opened in 1984 and expanded in 1990, the Monterey Bay Aquarium includes longevity as a top priority in their building design. The adjacent ocean and interior sea water exhibits together comprise an aggressive environment that coupled with changing exhibitry and heavy live loads require specific design strategies to provide for longevity. Concrete is used as the primary construction material to address this aggressive environment. Reinforcing steel has ample cover, mix designs include high percentages of fly ash, placement is carefully executed, and concrete is well cured. Tests from nine and sixteen year old in-place concrete show minimal ingress of chloride ions and low permeability.

Kari-Anne Lyng

*Life Cycle Assessments of Low Carbon Concrete*, Kari-Anne Lyng, Mie Vold and Anne Ronning

Cement is of particular interest for climate change because of the large amount of climate gas emissions released in the manufacturing process, about 2,6% of the total Norwegian GHG emissions (2008). The emissions from the industry are partly related to process related emissions and partly energy related emission. The process-related CO2 emissions from cement manufacturing result primarily from the conversion of raw limestone feedstock into clinker, an intermediate product which is then blended with several other additives to produce cement. The cement and concrete industry in Norway has introduced life cycle assessments (LCA) as a method to document the environmental properties and reduce the emissions of climate gas emissions. This presentation shows the results from a case study of three different types of concrete using LCA as a method. The study has shown that the most important measures to reduce the carbon foot print are to reduce the total amount of clinker in the concrete products through use of substitutes, either in cement or concrete prescriptions directly.

James Mack

*Designing Sustainable Concrete Pavements using the Mechanistic Empirical Pavement Design Guide*, James W. Mack, Mehdi Akbarian, Franz-Josef Ulm, Jeremy Gregory, Randolph E Kirchain and Margaret Wildnauer

Increasing the sustainability of our infrastructure is accomplished in ways other than just developing better materials and more efficient processes: it is also about employing the right designs. For concrete pavements, overdesign causes excess materials to be used during construction, leading to higher economic costs and environmental impacts. Optimizing pavement designs for prescribed service lives, climates, and traffic conditions allows pavement engineers to create structures that have low initial costs and low initial CO2 emissions as well as low life cycle costs and low lifetime CO2 emissions. This paper will show how design optimization can lower costs and CO2 emissions by balancing the initial costs and CO2 emissions of a pavement, which are primarily a function of the thickness and specific design features used, and the rehabilitation costs and CO2 emissions, which are a function of the pavement's estimated service life and required rehabilitation activities.

Ward Malisch

*Laboratory and Field Studies of "Green" Concrete Properties*, J. Michael Donovan, Ryan Henkensiefken, Ward R. Malisch and Bruce A. Suprenant

Much of our knowledge about concrete properties has resulted from tests on straight portland cement concrete, or binary mixtures using fly ash or slag cement. Now ternary and quatenary mixtures with portland cement contents as low as 200 lb/cu yd and specified strengths as high as 8000 psi are being used as owners, engineers, and architects seek to limit greenhouse gas production by limiting portland cement content. But are the established rough relationships of 7 vs. 28 day strengths and strengths of standard-cured cylinders vs. drilled cores from structure still valid? Can we adequately predict commonly specified 56-, 90-, or 120-day strengths based on 7- or 28-day standard-cure cylinder strengths? And when very low water-cementitious materials ratios are needed to achieve high strengths in these "green" mixtures, is there enough water under normal curing conditions to ensure that the hydration reactions are complete enough to provide the desired properties? These questions and more were studied in a combination laboratory and field study.

Brook Mebrahtu

*San Francisco Public Utilities Commission (SFPUC) LEED Platinum Headquarters*, Brook Mebrahtu

The San Francisco Department of Public Works (DPW) managed the design and construction of a new 13-story office building that serves as the new headquarters for the San Francisco Public Utilities Commission (SFPUC). The new 277,000-square-foot building located at 525 Golden Gate Avenue is

slated to achieve a LEED Platinum rating from the United States Green Building Council (USGBC). Key sustainability features include on-site clean energy generation through photo voltaic; 100 percent of waste water treated on site; use of lowflow toilets; 45 percent daylight harvesting; and the consumption of 55 percent less energy and a 32 percent less electricity demand from the main power grid. The building will utilize an innovative structural system with post tensioned (flexural) cores that will provide the highest asset preservation for the building.

John Melander

*Slag Cement for Sustainable Concrete Construction*, Peter Bohme and John Melander

Developments in binary, ternary, and quaternary blends using slag cement with portland cement, fly ash, and silica fume have fundamentally changed available concrete technology. These developments provide broader options for engineering the properties of concrete, and designing for durability, sustainability, and economy. They have also led to the need to update concrete design approaches, applicable test methods, and construction specifications. The impetus for these new cementitious systems is the growing interest in "greener" cements that have a lower carbon footprint. This presentation provides data from a Life Cycle Inventory (LCI) analysis of slag cement concrete.

Russ Miller-Johnson

*Fabric Formed Concrete Structures - Style and Substance*, Russell B. (Russ) Miller-Johnson

Case studies of two residences and one public use stair and observation structure using fabric as the concrete formwork material will be presented. The studies will focus on the combined structural and aesthetic features of fabric forming that allow for reduced construction material, waste and energy use; for increased durability from enhanced surface properties; and for fabric reuse. In addition, it will be shown that for design oriented exposed concrete the construction method can be economically competitive.

Dev Millstein

*Cool Communities: The Benefit of Cool Pavements in CA Cities*, Dev Millstein

Lawrence Berkeley National Laboratory's Heat Island Group researches the benefits of cool community strategies – cool roofs, cool pavements, urban vegetation – to save energy, reduce urban ambient air temperatures and improve air quality and health. Specifically, the group has analyzed potential temperature reductions due to the adoption of cool pavements in Bakersfield, CA. Potential temperature reductions from cool pavement deployment were compared to potential temperature reductions from cool residential and commercial roof deployment. To achieve detailed comparisons, high-resolution aerial imagery was analyzed to create detailed estimates of urban density and roof area across the Bakersfield city limits. A state of the art meteorological model was used to estimate the temperature reductions expected throughout the year given various levels of cool pavement and roof deployment.

Mark Niemuth

*Improving Fly Ash Utilization and Performance by Sulfate Optimization*, Mark Niemuth, Jason Weiss and Laurent Barcelo

The sustainability and performance benefits of fly ash as a replacement for Portland cement in concrete have long been known. However, there can be some performance limitations to the amount and ability to use fly ash as a replacement for Portland cement that mainly revolve around lower early strength development. Fly ash replacement of ordinary Portland cement (OPC) decreases early strength, some of which is due to non-optimum sulfate levels. By designing the system for optimum sulfate early strengths, a significant limitation to increased use of fly ash can be improved. The pros and cons of various mix scenarios are discussed, including limitations of infrastructure, specifications, and liability.

Arash Noshadravan

*Life Cycle Sustainability Assessment of Pavements Under Uncertainty and Variation*, Arash Noshadravan, Jeremy Gregory and Randolph Kirchain

There is a growing interest in incorporating sustainability considerations into civil infrastructure system decisions, including pavements, because such systems can be significant contributors to energy consumption and environmental impact. Life cycle assessment (LCA) is a tool that can be used to quantify the environmental impact of pavements. An LCA model for pavements depends on a variety of input parameters creating uncertainty. A probabilistic approach is beneficial to accommodate uncertainty and scenario variation in the comparative life cycle assessment in order to draw a more credible conclusion on the superiority of different alternatives. In this study we present a systematic approach for incorporating uncertainty and variation into a comparative life cycle assessment of pavements. The approach will be demonstrated using several case studies involving functionally equivalent pavement designs in different locations in the US. These cases will illuminate how the results of this work can help decision-makers make more informed assessments by quantifying the level of confidence in the environmental superiority of different pavement designs.

Tien Peng

*Responsible Sourcing through CSR Reporting*, Tien Peng

Expectations on the building materials industries are rising. The US Green Building Council's LEED v4 Rating System will likely adopt Corporate Social Responsibility (CSR) Reporting as a means to achieve the Materials and Resources: Sourcing of Raw Materials Credit. For those companies seeking improvements in social and environmental performance, the CSR report can identify key areas of concern or models of best practice. Corporate managers can benchmark their progress against their own internal goals and the records of their peers. Customers can identify companies with positive social and environmental records. Some of the larger materials companies – Titan, Lafarge, Cemex – already issue CSR reports as a matter of course. But is it a good idea for everyone? With increased focus on resource transparency, the materials industry would benefit from a standard approach to stakeholder communications. Using The Global Reporting Initiative (GRI) framework can help start the process. The GRI Guidelines is the world's most widely used framework for CSRs. Understanding the GRI's guidelines allows organizations to create a CSR report in accordance with international standards that will support the effective communication of their sustainability efforts.

Anne Roenning

*Embodied Energy and GHG Emissions of Five External Walls for Residential Buildings*, Anne Roenning and Mie Vold

For more than a decade Life Cycle Assessment (LCA) has been developed as a tool for assessing environmental aspects of different building products and buildings during its lifetime – cradle to gate. There are several LCA-studies that compare building materials, such as wood against concrete or steel. Many of the studies exclude phases or activities throughout the life cycle of the building. Environmental aspects related to maintenance or consequence of changes in user's needs or requirements are often excluded. The LCA-project presented in this paper focus on how to calculate greenhouse gas emissions and embodied energy from five different external walls for residential buildings. The aim of the project was threefold: to document the GHG (Green House Gas) emissions and embodied energy from the life cycles of five external walls; to clarify challenges in how to develop calculation procedures when changing focus from building materials or products (cradle to gate) to building elements or parts and identify critical factors which influence the LCA and to make a draft PCR (Product Category Rules) for external walls in accordance with and as an input to the EN 15804 standard.

Nicholas Santero

*The ABCs of EPDs, LCAs, and LEED*, Nicholas Santero

Transparency has become a focal point in LEED. New credits in the rating system will allow concrete manufacturers to contribute simply by stating the impact of their products using Environmental Product Declarations (EPDs). What are these documents and how can the concrete industry capitalize on this opportunity? What LEED credits are at stake? What are the costs and how can we bring them down? This presentation will provide insights into using Life Cycle Assessment (LCA) to put the concrete industry at a strategic advantage in the marketplace. The discussion will cover the most current LEED v4 credits, the science behind EPDs, an overview of the recently approved Product Category Rule (PCR) for concrete, and offer recommendations for moving forward with a successful EPD program.

David Shook

*Mapping a Structure's Impact on the Environment: Case Studies*, Mark Sarkisian and David Shook

Current sustainable design practices do not holistically address the impact of structural systems on the environment. Approaches which not only consider the embodied carbon of the material used, but specifically account for key details such as travel distances and construction processes are needed. In regions of high seismicity, probable seismic damage must be considered as part of the life-cycle environmental impact of a building. Resilient structures which mitigate potential damages are needed and their benefits quantified for design designs at early phases of design. To address these needs, designers at Skidmore, Owings & Merrill LLP have developed the Environmental Analysis Tool™ for the calculation of carbon dioxide equivalents of structural systems considering cradle-to-grave life-cycle environmental impacts including probable seismic damage.

Jessica Slater

*Pavement Albedo: Importance and Measurement*, Jessica Slater, Tom Van Dam and Margot Yapp

In major metropolitan areas, the Urban Heat Island (UHI) effect is becoming an increasing concern as hotter urban environments result in poorer health for occupants and increased energy consumption required for cooling. This concern has led various municipalities to adopt cool pavement technologies, and recently California Governor Jerry Brown signed Assembly Bill 296, which in part requires the statewide adoption of cool pavement technologies. A key method to mitigate the UHI in urban areas is to increase the albedo, the percentage of solar energy reflected by a surface, of roadways, sidewalks, and other flat surfaces. The aim of this presentation is to discuss the importance ofpavement albedos and techniques for measurement. The albedo of different materials will be introduced as well as the influence of material characteristics including color, texture, and composition. The data from measured pavements, including the strategy to improve albedo, will be presented.

Jacob Sobstyl

*Urban Physics: City Texture Matters*, Jacob Michael Sobstyl, Mohammad Javad Abdolhosseini Qomi, Benoit Coasne, Roland Pellenq and Franz-Josef Ulm

With more than 50% of the world's population (85% in the US) living in urban areas and linear projections for urbanization, one of the major societal challenges is efficient energy management of cites. Although city planners consider many parameters, their qualitative approach is not sufficient enough to fully understand the sheer complexity of the relationship between inter-building interactions, city texture and atmosphere. To address this, an approach of quantifying complexity inspired by the structure of atoms and molecules is proposed. It suffices to consider the effect of solar radiation and its implications for thermal mass management of cities.

Alan Sparkman

*Pervious Concrete: New Field Practices, Standards and Technology*, Alan Sparkman

The market for pervious concrete continues to grow as the construction market puts more emphasis on building sustainable solutions, and the regulatory environment increasingly demands such solutions. Pervious concrete is becoming a more robust material thanks to progress in placement and installation methods, new ASTM standards for testing and continuing advances in mix designs and materials. This presentation will present a brief overview of developments in each of these areas.

Omar Swei

*Characterizing and Implementing Uncertainty in the Life-Cycle Cost of Pavements*, Omar Swei, Arash Noshadravan, Jeremy Gregory and Randolph Kirchain

Life Cycle Cost Analysis (LCCA) evaluates the economic performance of alternative pavement investments. Currently, practitioners treat input parameters as static, deterministic values, which although computationally simpler, will hide the implicit uncertainty underlying the analysis. Over the past decade, an emphasis has been placed upon accounting for uncertainty by treating input parameters as probabilistic, rather than deterministic, values. This research builds upon existing pavement LCCA work by probabilistically characterizing uncertainty both in the short-term and long-term. Having characterized short-

term and long-term uncertainties, the probabilistically defined input parameters have been implemented in a series of case studies located in four different geographical regions, with each location analyzed for three different traffic volumes, in addition to various possible initial design life values. The results from the case studies have provided insight regarding which parameters are driving the results of the analysis, and helps draws conclusions as to what types of designs tend to be more economically favorable in the long-term depending upon location, traffic volume, and design life.

Benjamin Tymann

*Navigating the Legal Obstacles on Your Road to Sustainability: Recent Developments in the Law*, H. Hamilton Hackney and Benjamin B. Tymann

Sustainability principles and standards continue to rapidly make their way into law and regulations. From the FTC Green Guides to SEC mineral extraction and conflict mineral reporting rules to US and international emissions disclosure rules, companies' decision-making on sustainability initiatives must increasingly be informed not just by business objectives but by a growing array of laws and regulations. Moreover, undertaking voluntary sustainability initiatives can present various less-than-obvious legal and business risks. This seminar will survey recent developments in the law relating to sustainability and how best to minimize risk while maximizing the effectiveness of your sustainability program.

Jennifer Wagner

*Green Concrete Without the Tradeoffs*, Jennifer Wagner

CarbonCure Technologies, Inc. is an emerging science-based leader in concrete technology for the LEED building sector, making CO2 sequestration profitable to concrete producers. A pioneer in mineral carbonation engineering, CarbonCure&#8208 enabled products create cost-effective material specifications for architects, engineers and contractors (AEC's). CarbonCure&#8208 enabled products represent an evolutionary milestone in concrete production. Inspired by biomimicry and 'systems design' engineering, CarbonCure's service delivers captured CO2 into "live cement", marrying Ca+ ions with CO2, and creating rock in the form of calcium carbonates (limestone). Through precision delivery of waste carbon into a concrete mix design, CarbonCure's technology speeds up set time and densifies concrete products, requiring less cement, creating high early-strength gain, and chemically sequestering CO2. CarbonCure's first products are masonry products, with an application to ready-mix concrete expected to be available in early 2013. The presentation will outline the CarbonCure process, and how it can be used to manufacture low-carbon concrete.

Christoph Wuestemeyer

*An Approach for Analyzing Cost and Energy Performance Trade-offs in Residential Building Wall Systems*, Randa Pierre Ghattas, Jeremy Gregory and Christoph Wuestemeyer

In 2009, the UN identified the building sector as the area with the most potential for greenhouse gas reduction. Approximately 30% of residential homes are built by large-scale production builders, with a focus on economies of scale. This presents a significant opportunity in a sector fragmented among many players; builders want to minimize initial construction costs while meeting increasing requirements and expectations on energy performance. There are numerous residential building structural materials, designs, and construction methods available to homebuilders. This research seeks to understand the economic and energy performance trade-offs among these different building alternatives and applies this within a life cycle cost analysis framework. The research will help us understand the relative cost competitiveness of different wall systems in residential construction, the factors driving the cost differences between products and how those differences would change over time due to changes in construction technologies or market demand.

Frances Yang

*10 Questions LCA Can Answer about Concrete Buildings*, Frances Yang

The LCA Working Group of the SEI Sustainability Committee has amassed the first ever Top 10 list of questions most commonly asked about LCA and how it pertains to structural engineering. The answers, authored by our member experts, come from focused literature review of over 20 different case studies based on life-cycle assessment, with current and geographically-specific applicability. This presentation offers a sampling of answers that relate particularly to concrete construction, the embodied energy and greenhouse gas emissions of concrete products, and benefits it offers to whole life building performance. More importantly, attendees are provided an avenue to continue the dialogue, as engagement of all parties in the supply-chain is essential to making our largely concrete, built environment more sustainable.