INTERNATIONAL CONCRETE SUSTAINABILITY CONFERENCE
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PRESENTATION ABSTRACTS[1]

(Alphabetical Order by Author Last Name)

FHWA Sustainable Highways Self Evaluation Tool: Pilot Version Offers Improved Accounting of Key Pavement Attributes, Abdo, F.

In January 2011, the Federal Highway Administration of the U.S. Department of Transportation launched a fully functional Beta version of the Sustainable Highways Self-Evaluation Tool (Tool). The Tool identified characteristics of sustainable highways and was developed to help stakeholders apply and integrate sustainability best practices into highway and roadway projects. After a review and comment period, FHWA elected to issue a revised and scaled back Pilot Test version of the tool. It is believed that the Tool would be embraced by many and would have significant positive impact on sustainability of highways and roadways. This presentation will examine the Tool credits and highlight important improvements made in the Pilot version. In addition, recommendations will be presented for further enhancement of the Tool in matters related to pavement materials and construction.

The FHWA Sustainable Pavements Program, Ahlstrom, G., Van Dam, T. and Smith, K.

In 2010, the Federal Highway Administration's Office of Pavement Technology created the Sustainable Pavements Program to increase the awareness, visibility, and the body of knowledge regarding sustainability in the design, construction, maintenance, and rehabilitation of pavement systems. This presentation will provide a comprehensive discussion on the composition and activities of the FHWA's program, with particular focus on the work of the Sustainable Pavement Technical Working Group. Input will be sought from the conference participants to help identify anticipated future activities and technology transfer opportunities as they relate to creating more sustainable concrete pavements.

Use Sustainable Concrete with Increased SCM Content while Shortening Curing Time with Advanced Heat Control for Hydronic Cured Concrete Directed by Laboratory Established Maturity Curves, Anderson, E.

The construction industry in geographically cold weather portions of the U.S. pushes the envelope of late season cold weather concrete construction which urged GPT to develop the Controlled Concrete Curing Management System (C3MS) as a way to more effectively manage the risk that ready mix providers and contractors take on in order to complete contracts on or ahead of schedule. Through GPT's testing of the C3MS it has proved too supply a fixed and controlled temperature in order to mirror a laboratory established "HEAT SIGNATURE" to a curing slab for a set period of time. Through research/testing of the C3MS GPT has realized that this technology can be applied to make concrete an even more sustainable and longer lifecycle product.

Energy Management and Corporate Sustainability – The Practical Approach, Bayne, C.

Titan America/Roanoke Cement has an active Energy Team which focuses on managing and reducing the company's environmental impact. This team represents a cross section of the plant's management, maintenance, engineering and operations staff. Through this process, the plant has seen overwhelming success both from an environmental and economic standpoint, resulting in a company that is more competitive in the business arena while reducing impact on the community. As a complement to this program, Titan has established their "Plant a Star program" where we offer the resources of our energy team, free of charge, to business partners to help them jump-start their energy program. We have worked with many ready mix manufacturers helping them establish the

[1] Authors, titles and abstracts are subject to change.

programs and initiatives necessary to build a successful energy program based not on capital investment and infrastructure changes but on life-style changes and conservation efforts. This presentation is designed outline a practical approach to making our core businesses sustainable and will serve to demystify the process of energy management.

A Sustainability Performance Index for Concrete, Bhattacharjee, B.

In this paper a sustainability index for concrete is defined taking account embodied energy, relative potential for CO2 emission, durability and consequent functionally among other factors. Experimentally obtained results are used to demonstrate the utility of the model and the performance index.

Achieving Differential Durability and Extended Service Life with Blended Cements, Buffenbarger, J. and Miltenberger, M.

Climate change is one of the defining issues of the 21st century as studies show greenhouse gas emissions may more than double this century. Designers face unique challenges to select and utilize low-carbon building materials to address sustainability requirements on both private and government building and infrastructure projects. Differential durability of construction materials cause significant economic impacts, and can also affect sustainability in terms of environmental degradation, resource depletion, greenhouse gas emissions, and reduction in bio-diversity. In order to effectively address durability issues, it is important to examine the service life of the components of those structures, as well as the materials that comprise those components. Concrete building materials manufactured with blended cements intrinsically offer substantial service life extension that result in an optimal balance of economic, environmental, and societal benefits while addressing the challenges of climate change, functionality, and differential durability.

Recovered Mineral Component's Impact on Lowering the Carbon Footprint of Concrete and Providing Material Resilience - Furthering Sustainability through Long-Term Durability, Bühler, E.

Environmental impact profiles of Recovered Mineral Components (RMC) have been translated into avoided CO2 emissions, water & energy savings for concrete mix design incorporation of ground granulated blast furnace slag, coal combustion fly ash, and Silica Fume, as utilized in federally funded construction projects. Three of the four primary identified RMC are frequently used in the United States ready mix industry as (SCM). Supplementary Cementitious Materials (SCM) play an increasingly important role in decreasing the overall carbon footprint of concrete. Today virtually every High Performance Concrete (HPC) design considers using SCM, if not multiple combinations of SCM, specifically when designing for high rise, transportation, marine environment and the heavy-industrial building sector. A key goal would be increased RMC usage into more mainstream conventional concrete applications, where multiple RMC in one concrete design compound benefits in both areas of continued high-priority interest: a.) less immediate and long-term environmental impact, and b.) higher quality future concrete structures, built to last.

Sustainable Concrete Practices: Using a Hydration-Controlling Admixture to Improve Your Economic and Environmental Position, Bury, M. and Ryan, R.

The disposal of returned plastic concrete and washwater from truck drums has been an economic and environmental challenge for ready mixed concrete producers. The use of HCA technology to manage the disposal of returned plastic concrete and washwater can increase a producer’s economic position while lowering the impact on the environment. This presentation will review how the HCA technology works, describe in detail the different applications, and provide economic and environmental data to illustrate potential cost savings and environmental benefits for the ready-mixed concrete producer.

Service Life Design Guidelines for Underground Facilities, Chen, W.

With the increase of population and limited surface space in urban area, the demand of underground space utilization is an unavoidable global tendency. In addition, it is “green” to construct facilities underground to minimize surface land use and to minimize energy consumption, since temperature below ground surface is more uniform than the temperature in above ground environment. The exposure of underground facilities to adverse environment is also

much less critical than that of surface facilities. This paper will review and discuss state-of-the art service life prediction models for surface facilities and propose guidelines for service life prediction of underground facilities.

Use of CKD and Wastewater Sludge in the Manufacture of Artificial Aggregates, Colangelo, F., Cioffi, R. and Santoro, L.

This paper reports the results of an investigation on material recovery by stabilization/solidification of wastewater sludge coming from a wastewater treatment plant. Stabilization/solidification was carried out to produce artificial aggregate in a rotary plate granulator by adding hydraulic binders based on CKD, lime and coal fly ash. Different mixes were tested in which the sludge content ranged between 60 and 90%. The granules were tested to assess their suitability to be used as artificial aggregate through the measurement of the following properties: density, water absorption capacity, compressive strength and heavy metals release upon leaching. It was demonstrated that the granules can be classified as lightweight aggregate with mechanical strength strongly dependent on the type of binder. Concrete mixes were prepared with the granulated artificial aggregate and tested for in-service performance, proving to be suitable for the manufacture of standard concrete blocks in all the cases investigated.

The Sum of the Parts Equals Sustainability, Constantino, C. and Bury, M.

What parts, when added together, result in sustainability? In alignment with concepts outlined in The Sustainable Concrete Guide – Applications by the U.S. Green Concrete Council, this presentation provides an account of a special and unique concrete project in Florida. This project combined the use of 1) concrete making materials, 2) construction practices, 3) application of tools and eco-efficiency analysis methodologies, and 4) codes to provide deliverable and measurable sustainable benefits in concrete construction. This presentation will provide details on Tarmac America's development of a concrete mix that was designed to meet the desired plastic properties for ease of placement by the contractor, the hardened concrete properties to meet building codes, while reducing the mix's environmental impact. The presentation will also illustrate the use of eco-efficiency analysis methodology to quantify the environmental savings in impact areas such as energy, emissions, land use, resource consumption, risk potential, toxicity potential, and fresh water savings.

Concrete Sustainability Versus Constructability - Closing the Gap, Cost, T.

As project owners and public agencies increasingly require greater sustainability in projects and specify them using LEED and other metrics systems, a "sustainability vs. constructability" challenge must often be resolved for concrete construction. This presentation will explain these challenges and pose resolution protocols. Examples will be used to illustrate each category of issue and the related technical influences will be exposed and discussed. A simple performance testing approach for qualifying candidate materials and proportions will be presented and used to show how these issues can be understood, evaluated, and controlled. Recommendations for project-specific use of this testing approach will be made, and guidance presented on how sustainability of concrete mixtures can be maximized while appropriate performance and constructability is assured.

Sustainability Rating Systems – Why Bragging Rights Aren't Enough, Demich, G.

Defining sustainability is the easy part. Several transportation greenscale systems have been developed that are similar in concept to the U.S. Green Building Council's LEED®, but they do little to drive us toward becoming more sustainable over time. This presentation describes one system, STEED® (Sustainable Transportation Engineering & Environmental Design) that takes a different approach. Borrowing from the Plan-Do-Check-Act cycle of Continuous Improvement, it provides a method for designers and owners to track progress (or lack thereof) toward sustainability and use that information to improve their very next project. STEED® measures a project at four stages, Planning, Environmental, Design, & As-Built.

The Tenant Avenue Bridge, Built with Environmentally Friendly Concrete, Donovan, M.

The production of Portland cement, and by extension, concrete, generates a disproportionate share of carbon dioxide. The State of California, through a broad law, seeks to reduce the impact of a number of industries, including the cement and concrete industry, upon the environment. The California Department of Transportation has revised its specifications for structural and paving concretes to include the use of significantly increased amounts of supplementary cementitious materials than had been used customarily. U.S. Concrete, Inc. through its California

subsidiary, Central Concrete Supply Co., Inc., has created a series of concrete mixtures that incorporate at least 50 percent replacement of Portland cement. This article discusses the background of the law, the changes in the specifications, and the practical implications on the construction of a new bridge built in 2009 in the San Jose, California area. Detailed concrete performance results, including the carbon dioxide footprint of the revised concrete mixes, are presented in the article.

Effect of In-Boiler Additions to Coal Combustion on Composition, Compressive Strength Development and Durability of Resulting Combustion Products, Drimalas, T., Kruse, K., Bentivegna, A., Folliard, K., Brown D. and Sandberg, P.

A novel method has been developed for improving the cementitious value of coal combustion products (CCP) by the addition of post-consumer and other low cost additions to a coal fired boiler, using different addition points. This paper describes the effect of the novel method on composition and compressive strength development in mortar for cements replaced at up to 60% with the modified CCP. The results show that it is possible to significantly enhance the strength developing characteristics of the resulting CCP, thereby potentially allowing for much more aggressive cement replacement than is typical in the concrete industry.

The Effect of Wall Construction Materials on the Air Leakage of Single-Family Houses, Durschlag, H., Norford, L., Goerger, B. and Yang, E.

Infiltration, the amount of air entering and exiting a building through unplanned openings, has been shown to be an important factor in building heat flows energy consumption. Between 16 and 33% of energy consumption has been attributed to infiltration. In other studies, infiltration is responsible for between 7 and 46% of energy loss. Effective leakage areas (ELA) of twenty-five insulated concrete form (ICF) houses were calculated using the results of blower door testing and standard ASTM E-779 methodology. These results show that air leakage of ICF houses is at the lower end of the ranges found in the standards and in U.S. houses. However, the air leakage of ICF homes is similar to that of newer houses included in the LBNL database.

Comparative Analysis of the Embodied Energy and Carbon Footprint of Concrete and Other Construction Materials, Estrada, H. and Lee, L.

It is well understood that the main objective of infrastructure design code specifications is to protect the public's welfare, health, and safety; none of which appear to be directly related to sustainability. However, a number of jurisdictions have adopted language based on the United States Green Building Council to curtail the adverse effects of global climate change and minimize environmental impact of new construction; in some cases to improve air quality in the community and to increase the long-term viability of the local construction industry. In this paper we provide a comparative analysis of the embodied energy and carbon footprint of concrete and other construction materials; including steel, timber, masonry, and composites. We will concentrate on structural materials and discuss other peripheral uses of these materials as they relate to buildings, such as thermal and acoustic mass. It is anticipated that the results of this study will provide a first step towards detailing the environmental impacts of these materials.

Use of Limestone Fillers in Portland Cement Binders: A Study of the Potential for Thaumasite Sulfate Attack, Farrington, S.A. and Luciano, J.J.

With the increasing pressure to reduce the CO2 footprint of concrete, there is a trend among concrete producers to replace a portion of the portland cement in the binder with supplementary cementing materials. One material that has a near net-zero CO2 contribution is finely-ground limestone. ASTM C 150 allows for the use of up to 5% in portland cements. One of the reasons that the use of limestone fillers in concrete has not been embraced is concern that a specific form of sulfate attack, i.e. thaumasite sulfate attack, will occur in concrete under sulfate-exposure conditions due to the presence of the limestone filler in the concrete. This paper presents the results of a study that attempted to look at how the binder composition in concrete affects the potential for thaumasite sulfate attack to occur. The results suggest that when limestone fillers are used in the binder, the use of supplementary cementing materials and low water/powder ratios will protect the mortar from thaumasite sulfate attack.

Improving Sustainability of Concrete Construction – The Role of High Strength Concrete, Fidjestol, P.

An initial study has been performed on the ways in which the use of high strength concrete and special construction features will improve sustainability related aspects of general concrete construction. This paper will discuss the limitations and bottlenecks facing this approach, along with a look at the future in terms of opportunities to further optimize material composition when other factors influence the availability of present day volume SCM's, such as fly ash and slag, and the impact of sub-micron silica fume on strength development and other properties of the resulting ternary binders.

Update on the PCI Sustainable Plant Program for Precast Concrete Plants, Frank, D.

The Precast/Prestressed Concrete Institute (PCI) is launching a Sustainable Plants Program, which encourages and recognizes sustainable practices in precast concrete plants manufacturing operations.
This optional program is intended to provide immediate benefits giving precast concrete plants direction in making improvements in their operations that typically result in energy, material, and cost savings, while providing direction in gathering data that may be requested or required in the future. This presentation will provide information about how the program is formatted, measured metrics, and the overall concepts supporting the program.

Potential Climate Change Impacts on Stormwater Infrastructure: Grey vs. Green Approach, Ghosh, I.

The sewer infrastructure in many older cities consists of combined sewer systems, which are characterized by combined sewer overflows (CSOs) during wet weather events. These are significant point sources of pollution, especially during high intensity rainfall events. The Long Term Control Plans to mitigate CSOs for most cities have focused on mainly "grey" or traditional infrastructure solutions, which are localized, cost-intensive and have marginal water quality benefits. Green infrastructure approaches, such as rain gardens, bioretention swales and vegetated roofs that are built within the traditional infrastructure could be spread throughout the city, and in addition to reducing surface runoff and sewer overflows, have multiple sustainability benefits in terms of treating water on-site, reducing energy costs and increasing property values. The focus of this study is to compare the efficiency of the traditional and the green infrastructure approaches in relation to hydrologic model output under current and future climate scenarios for a study area in Greater Boston, Massachusetts.

Concrete Pavement Sustainability-Current Success and Future Opportunities, Grove, J., Vanikar, S. and Tayabji, S.

Sustainability is not new to concrete pavements. The use of recycled concrete in new concrete, the use of supplementary cementitious materials in concrete mixtures, and the adoption of improved surface texture techniques to reduce noise and increase safety have all positively affected the triple bottom line goals-economic, environmental, and social-of sustainability. What is not often realized is the subsequent benefits that result from these primary actions. Each of the three triple bottom line goals often realizes numerous benefits from a subsequent outgrowth benefit resulting from that initial step. This paper outlines the chain of sustainable events that results from the primary action of incorporating fly ash into a concrete mixture and offers this as an example of what results from many of these common actions.

Green Infrastructure for Stormwater Management, Hair, L.

This presentation will provide an overview of the current EPA initiative to promote green infrastructure for stormwater management, including how communities across the country are adopting this approach. Structural components in stormwater management are essential to meet society's needs while protecting water quality and meeting EPA requirements. key areas where concrete plays a role will be presented. The audience will be asked what other uses, approaches, or research need exist to increase the potential for synergy.

A Study Showing The Influence of Differing Percentage of Coarse RCA Containing Gypsum on Properties of Concrete, Hedayatnasab, A. and Limbachiya, M.

In recent years, sustainable concrete construction has had garnered world-wide attention. In this research, the influence of coarse recycled concrete aggregate (RCA) is investigated on slump, compressive strength development, modulus of elasticity, and flexural strength of the recycled concrete.

Sustainable Concrete Design in the Green Revolution: A Producer's Perspective, Henkensiefken, R.and Donovan, J.M.

More owners and major developers are insisting on sustainable building designs and construction practices. This is a major reason why the sustainable market is one of the fastest growing segments in the construction industry. Fortunately, many technologies exist today to meet this demand; however, the major hindrance in today's construction environment lies in the lack of flexibility in design codes and specifications. Many specifications limit the concrete producer's ability to achieve a truly sustainable concrete by prescribing mixture proportions rather than setting performance criteria. This paper outlines the fundamental problems obstructing the concrete construction industry from progressing forward in the green revolution. Methods and solutions for breaking down these barriers are presented along with new innovative concrete design methodologies which can be used to foster growth in a sustainable world.

From Cradle to Grave: Life Cycle Assessment and Carbon Benchmarking of Buildings, Hsu, L., Love, A., Norford, L. and Ochsendorf, J.

This presentation is a discussion on efforts to benchmark the carbon emissions of buildings. There is a focus on the methods used by academics and professionals in the benchmarking process, and how these can be adopted for other organizations. Research from the Building Technology Program of the Massachusetts Institute of Technology involving Life Cycle Assessments (LCAs) of typical buildings based on 2003 Commercial Building Energy Consumption Survey data is discussed. Also discussed are the processes and tools used by various design firms to benchmark their designs, as well as tools that have been developed internally in firms and in conjunction with the American Institute of Architects to assess a firm's progress towards achievement of the carbon reduction goals established by the 2030 Challenge. The first step in achieving these aggressive goals is to benchmark current practice and real projects to better understand the carbon emissions from buildings so that opportunities and common strategies can be identified to work towards to the goal of net-zero carbon buildings.

Feasibility Study of Using Recycled-Concrete Fine Aggregate in Self Consolidation Concrete, Hu, J.

This paper presents a preliminary study in using Recycled-Concrete Fine Aggregate (RCFA) to obtain SCC with the comparable properties as such of using natural aggregate. In order to evaluate the influence of different portion of RCFA in SCC, traditional tests including slump-flow test, V-funnel test, J-ring test, L-box test, and column-segregation test were used to measure the flowability, passing ability and segregation resistance. Compressive strength test and shrinkage change rate test were used to evaluate physical properties of hardened concrete. In addition, a concrete rheometer was used to measure the rheological properties of concrete; the results were compared to traditional fresh concrete measurements in order to have a better understanding of concrete behavior.

Biodiversity at Ready Mix Concrete Plants, Ingerson, D.

In 2010, a partnership was formed between the concrete industry, through the National Ready Mix Concrete Association (NRMCA), and the Wildlife Habitat Council (WHC) to encourage participation in the programs of the industry and the council and to engage and demonstrate voluntary corporate leadership in environmental performance, including enhancement and restoration of wildlife habitat. A unique approach to biodiversity serving the specific needs and potential of ready mixed concrete production facilities was created. WHC developed a biodiversity toolkit specifically designed for the ready mixed concrete industry to engage in habitat projects and further their sustainability mission. This presentation will detail Titan America's experience with integrating biodiversity at several of their facilities for limited costs through the WHC program. Three specific case studies will be introduced. The participants can expect to leave with a detailed understanding of the biodiversity program, as well as the benefit to a company for participating in the program.

Chemical Admixtures of the Future: Opportunities and Challenges for Sustainable Concrete Production, Placement, and Service Life, Jeknavorian, A.

Chemical admixtures have long been known for the beneficial role they play in improving the engineering properties of concrete and mortar mixtures. This discussion concerns the current and future needs of the concrete industry and how both newly introduced and future admixture technologies can make a favorable impact. Special attention is paid

to new classes of chemical admixtures, which have begun to provide great value to the concrete industry such as the production and placement of self-consolidating concrete (SCC), improved concrete surfaces for dry-cast concrete, reduced labor for pervious concrete, increased use of SCMs, and placement of concrete at sub-freezing temperatures. Complimenting the introduction of new chemical admixture technologies is the need for applicable standards that both protect and guide users as well as facilitate commercialization.

EPA's Pourous Pavement Research Center in Edison, N.J., Justice, K.

The parking lot at the EPA's Edison, NJ, Environmental Center permits the investigation of a number of topics relative to the design and performance of porous pavement systems. The project is unique, not only due to the three side-by-side permeable surfaces but also because of the planned long-term monitoring, the extent of the installed instrumentation, the scale, the division of the parking rows for replicates, and the direct monitoring of volume and flow rate. Measurements are taken under controlled conditions while the lot is actively used for employee parking. The porous pavement parking lot is a demonstration site that is used as an educational tool to show how porous pavement works. The results of this study provide much needed design and performance information to the regulated community to enable better decisions associated with their stormwater management programs.

Role of Process Control in Improving the Sustainability of Concrete Production, Koehler, E. and Groh, D.

Concrete can offer numerous sustainability benefits. Concrete producers can further enhance the sustainability of concrete by increasing operational efficiency through improved process control. Use of process control technology can reduce variability and enable optimized use of materials, equipment, and fuel. This presentation describes a newly upgraded process control technology available for managing concrete in a ready mix truck and shows how this technology—and particularly the recent new enhancements—can contribute to sustainability.

Legislating and Building a Sustainable Roadway Infrastructure, Kuebler, T.

Left to their own devises, government agencies will build the cheapest, easiest and most commonly used pavement type regardless of the benefits of other more sustainable pavement systems. To change the status quo there must be a concerted effort to change the mindset of the controlling agencies. When agencies are resistant to change, appealing to legislators is the only way to put pressure on them. This presentation and paper would look to explain how an initiative of sustainable development and construction is put into action resulting in real sustainable change in how taxpayer dollars are used for the best most sustainable uses for public good.

Sustainable Pavement Design and Construction Practices in Ontario, Canada, Lane, B.

Sustainability was defined in the UN Bruntland Report (1987) as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. We can address sustainability in pavement design and construction practices by increasing durability of infrastructure, extending service life of pavements, optimizing designs, using fewer non renewable natural resources, adhering to the 3Rs: reuse, reduce, recycle, consuming less energy and reducing greenhouse gas emissions. This presentation highlights sustainable pavement design and construction practices in Ontario, Canada and introduces a rating system developed as a tool to promote sustainable choices in pavement design and construction.

Measuring Sustainable Concrete Production Practices, Lemay, L.

As interest in sustainable development grows, the ready mixed concrete industry must be able to support sustainable development, balancing economic prosperity, social equity, and environmental responsibility. Moving towards a sustainable, environmentally conscious production model not only reduces environmental burdens, but also increases efficiency and places ready mixed concrete plants in a position of industry leadership in the growing green movement. When effectively communicated to consumers, a progressive stance on sustainability will allow the concrete industry and its constituents to remain responsibly competitive. This presentation will discuss the NRMCA Sustainable Concrete Plant Certification (Certification) program and how it provides a quantitative, performance-based metric, to allow ready mixed concrete producers to demonstrate excellence in sustainable development. The Certification provides ready mixed concrete plant personnel with specific guidance to assess their production practices and implement sustainability strategies that will ultimately lower their overall footprint.

Design of Sustainable Reinforced Concrete Infrastructure Using Probabilistic Life Cycle Assessment and Durability Methods, Lepech, M. , Geiker, M. and Stang, H.

The construction and operation of reinforced concrete infrastructure, in particular transportation infrastructure, lies at the nexus of two major sources of our global sustainability challenge; large amounts of emissions from transportation activities and construction materials production. Therefore, significant opportunities exist in the reduction of environmental impacts associated with concrete infrastructure construction and use. Within this paper, the application of existing and newly developed probabilistic service life models for analytically determining the time-to-repair or time-to-failure of reinforced concrete infrastructure are discussed. When combined with policy-derived targets for reductions in mid-point environmental indicators, the framework can be used to rationally consider the sustainability benefits of innovative plain and reinforced concrete materials, construction methods, and structural designs in engineering planning and design decisions.

Role of Performance Based Specifications in Sustainable Development, Lobo, C.

Performance based specifications can substantially help in sustainable development. Minimal cement content requirements is one well known popular prescription that increases the environmental footprint of concrete. Likewise there are at least 20 other requirements that are not so well known. This presentation will outline all of those and clarify how concrete performance can be maintained while removing those requirements. The resulting specification can help attain concrete with the desired performance and a lower environmental footprint.

Thermal Performance of Concrete Facades, Love, A. and Norford, L.

According to the U.S. Energy Information Agency's 2003 Commercial Building Energy Consumption Survey, 70% of energy usage in office buildings is from the lighting and HVAC systems, both of which are directly related to the architectural decisions made in the building form and materials. One area that can have a large impact on energy usage is in the envelope of the building. Over the last few years, increasingly stringent energy codes have increased the requirements for building insulation and glazing performance. However, there is a limit to the cost effectiveness of increasing the amount of insulation required without looking at the wall assembly as a whole. There is a currently a push by policy and codes and within practice to develop market-viable net-zero buildings within the next 15-20 years. Better performing building envelopes will be one of the components that will help realize these goals, but to achieve better performance we need to look at the thermal performance of an assembly, rather than just the R-value of the insulation. This presentation will look at the thermal bridging and performance of different details for concrete facade systems for commercial office buildings.

Obtaining High Strength Concrete Using Recycled Aggregate Concrete by Matching Its Gradation with Normal Aggregate Concrete Power Gradation Curve, Mahgoub, M. and Bassiouny, M.

The use of Recycled Aggregate Concrete (RAC) in the last few years has been of a great importance. As the rate of construction increased all over the world, it has been observed that the earth natural resources are consumed at a very high rate. The solution for that problem is to start using the aggregates produced from demolitions of old structures in the production of new concrete which can be used in building new structures. It has been known that recycled aggregate have low strength compared to natural aggregates which lead to some restrictions in the use of recycled aggregates. In this study, the influence of recycled aggregates on the mechanical properties of RAC was studied. Recycled aggregates were used to replace natural aggregates at level of 100%. The slump, compressive strength and modulus of elasticity were tested.

Full Depth Reclamation with Cement – A Sustainable Solution to Reconstructing Failed Asphalt Roads, Martin, J.R.

Full-depth reclamation with cement (FDR with Cement) is a process where an existing asphalt or gravel roadway is recycled/reconstructed in place. A predetermined percentage of cement is added to create a new stabilized base. A new concrete or asphalt surface is applied to complete the reconstruction. FDR with Cement typically saves up to 50% of the cost of total reconstruction and is a much more sustainable approach. The article/presentation will describe how the FDR with Cement process contributes to the sustainability of streets and local roads. It will also explain the process of identifying candidate roads, preconstruction testing procedures and the basic FDR with Cement construction process.

The Evaluation and Selection of Natural Supplementary Cementitious Materials for Blended Cements, Morrical, S., Laker, T. and Descheneaux, B.

One method to reduce the carbon footprint of cement and thus concrete is through the use of blended cements that use supplementary materials such as slag, fly ash or natural pozzolans as a portion of their constituents. Due to the availability of natural pozzolan sources and the varying chemical and physical make up of each source, a rapid and accurate screening process and standard concrete testing matrix are needed to determine the feasibility of a given pozzolan source for its use in a blended cement. There are defined steps in the screening process to determine potential cementitious characteristics for a large scale industrial grind. Once a pozzolan passes through the screening process basic concrete testing and applicable durability testing can be initialed. This paper looks at the potential of a blended cement to reduce the environmental impact of its production while meeting performance requirements of specifications and environmental conditions. Involved with this is a process of identifying and qualifying a natural pozzolan source.

Greenroads in Concrete Shoes: How a Roadway Rating System Can Help the Sustainable Concrete Cause, Muench, S.

This presentation provides an overview of the Greenroads rating system including credit descriptions, program components and scoring. The presentation discusses what the Greenroads rating systems can and cannot do and how to use them properly. Observations from the first four years of implementation will be discussed and It will describe where concrete scores points in Greenroads.

Making Concrete with a Lower Environmental Footprint, Obla, K.

The choice of concrete as a building material can help reduce the life cycle environmental footprint of a structure substantially. However there will be continued demands for lowering the environmental footprint of a cubic yard of concrete as produced. The NRMCA sustainability initiatives document has s set of targets to 2020, and 2030 for embodied energy, carbon footprint, potable water use, waste reduction, and increased use of recycled materials. This presentation will address how concrete producers attain those targets while maintaining concrete performance. Specifically the increased use of fly ash, slag, recycled aggregates, and was water from concrete production operations will be covered.

Laboratory Evaluation of Coal Combustion By-Products on Raveling Potential of Pervious Concrete, Offenberg, M.

With the increased focus on sustainable and low-impact development initiatives and the recognition of benefits provided by pervious concrete pavements for stormwater management, the desire to construct pervious concrete pavements has been growing in the past few years for site designers, developers, regulators, and the concrete industry. As this market continues to grow, it is becoming more technologically advanced, in both construction techniques and mixture proportioning, including the use of supplementary cementitious materials like coal combustion by products (CCBP's). Maximizing the use of CCBP's in pervious concrete has the potential to address two critical needs: protecting water quality while reducing waste CCBP volumes. For this study, mixtures of pervious concrete will be proportioned with varying contents of fly ash and bottom ash. After the specified curing period, paired samples will be tested separately for water quality improvement and surface durability potential.

Mechanical Behavior of Concrete Made from Marginal Aggregates, Patrick, B., Tia, M. and Shoucair, J.

Most state Department of Transportation's (DOTs) have stringent requirements for the use of aggregates in their various concrete work applications. However, the availability of good quality natural aggregates is a problem in many states and they are often imported from other states or countries over long distances. The solution to such a problem requires a multifaceted approach depending on the state. This study evaluates different marginal aggregate produced in Florida and their potential in the production of concrete for both structural and non-structural application. The objective of this study is to determine the effects of the various aggregate property parameters on the performance of concrete. The aggregate properties evaluated include Gradation, Specific Gravities, Absorption, Los Angeles Abrasion Loss, Micro-Deval Loss and Soundness Loss. It also evaluates the mechanical behavior of concrete made from these aggregates. The properties of the concrete evaluated include Compressive Strength, Split Tensile

Strength, Flexural Strength, Modulus of Elasticity and Toughness. The possible performance of concrete made from these aggregate are also determined.

The Use of Sustainable, High-Performance Concrete in New York City, Pirozzi, M.

The Port Authority of NY & NJ is a leader in sustainable concrete construction in New York City. The new World Trade Center Site, when completed, will include roughly 900,000 cubic yards of concrete meeting sustainability and performance based specifications. Another project which illustrates the Port Authority's success in using sustainable, high performance concrete is the rehabilitation of the Bay Runway at JFK, the fourth largest runway in the U.S. A sustainable concrete mix was developed with maximum total cementious and cement factors below FAA requirements. This mix has out-performed traditional pavement concrete mixes. The project has been so successful that there are now plans to convert other asphalt runways to concrete at the Port Authority's Airports. Sustainability is important to the mission of the Port Authority, as a commitment to the environment is a significant part of its larger commitment to the public.

Performance Based Concrete in Ontario, Schell H. C. and Konecny, J.

Ontario Ministry of Transportation has been moving towards performance oriented specifications since the early 1980's. As performance-related indicators were introduced the ministry removed prescriptive requirements such as minimum cement contents and specified slumps, and allowed contractors to select their target slump and plastic air contents. The current approach is a mix of performance requirements with some residual prescriptive requirements. Where there are performance indicators, concrete is tested and accepted based on quality assurance testing carried out by the Ministry through third party laboratories and service providers. Contractors are expected to carry out their own quality control testing, but specific quality control activities are no longer specified. The paper discusses issues related to the move towards performance specifications, key elements of current ministry specifications, and future challenges.

Performance of Slag-Cement Concrete Subject to Early Carbonation Curing, Shao, Y., Monkman, S. and He, Z.

Early age carbonation-curing of slag cement concrete was investigated to assess the feasibility of recycling CO2 in slag cement building products while improving their short-term and long-term performance. Portland cement concretes with 0, 15, 25 and 50% of GGBF slag were compared. A two hour carbonation-curing treatment allowed concretes to uptake 8-10% CO2 by mass of cement and attain as much as 82% of the 24-hour hydration strength. The subsequent strength development of carbonated concrete was slower in the first 24 hours possibly due to the carbonate build-up, but was comparable to the conventionally hydrated concrete after 28 days. The carbonated concrete was shown to have a fracture toughness comparable to that of the hydrated concrete. The freeze/thaw durability of the concrete in deicing salt solution was vastly improved by the carbonation treatment. The pH of the carbonated concrete was reduced but was still above the threshold level required for the passivation of iron. The use of slag in carbonation-curing is beneficial to strength gain, shrinkage reduction and deicing salt resistance and will enhance the net emission reduction for cement industry by consuming less Portland cement and recycling more carbon dioxide into concrete.

Concrete Carbon Footprints: Developing rigorous and applicable standards, Simonen, K.

As policymakers explore methods to evaluate and reduce the environmental impacts "embodied" in the materials and products used in construction, industry leadership is critical to ensure that emerging methods are relevant to practice, practical to apply and technically effective. Carbon is a clear and understood metric by which to measure one aspect of environmental impact, and policy makers and the public are increasingly interested in mitigating the pressing challenge of climate change by reducing carbon emissions. Standards are emerging for use in creating Environmental Product Declarations (EPD)-akin to an environmental 'nutrition' label for materials and products. These standards are being designed to be general enough to apply to all products from clothing, to computers to curtain-wall. Building industry specific 'rules' (Product Category Rules/PCRs) are required to refine global standards to address unique manufacturing, use and end of life conditions. This session outlines policy drivers that are motivating the development of EPDs and PCRs and how these directly impact the concrete industry. In progress work developing a draft PCR for concrete will be presented and the unique issues applying global standards to the concrete industry will be addressed.

Use of Performance Cements in Colorado and Utah: Laboratory Durability Testing and Case Studies, Smartz, B., Laker, T. and Van Dam, T.

Sustainability has become an increasingly important element in the design and construction of commercial, residential, and infrastructure projects. Concrete, as the most commonly used construction material on the planet, has a significant environmental impact. Although portland cement is a relatively minor constituent by volume, its presence is responsible for the majority of CO2 associated with concrete. Therefore the key to reducing the carbon footprint of concrete is to reduce the amount of traditional portland cement used. One way to accomplish this is by using alternative cement binders including Portland Limestone cements meeting ASTM C1157 performance cement specifications. This paper will discuss the environmental impacts of concrete and use case studies to show that concrete building projects made with Portland Limestone cements and supplementary cementitious systems are readily constructible and can easily achieve specified strength and durability requirements at a significantly lower environmental impact.

Durability of Ternary Cementitious Blends Containing Precipitated Calcium Carbonates Manufactured from Sequestered CO_2, Stone, G., Patterson, J. and Clodic, L.

Traditional cement clinker manufacturing is widely recognized as an unsustainable practice in the cement and construction industries due to the high carbon dioxide emissions from calcination and fuel burning. A common practice for reducing the carbon footprint of concrete mix designs is to replace ordinary portland cement with high volumes of supplementary cementitious materials (SCMs). This paper will introduce the concept of further reducing the carbon footprint of concrete mix designs and enhancing the properties of ternary blends through the use of highly engineered calcium carbonates made through a precipitation process that contain sequestered CO2 in conjunction with traditional SCMs. Sustainable concrete mixes will increase the competitiveness of concrete construction. This paper offers guidance on the proportioning of engineered precipitated calcium carbonates containing sequestered CO2 in conjunction with high volumes of SCMs obtained from both laboratory research and demonstration projects. Additionally, insight and direction on the required chemical composition of cements and SCMs to beneficially react with the calcium carbonates is provided.

When Worlds Collide: Project Specifications vs. Sustainable Initiatives, Szecsy, R.

The changes being brought about by sustainable materials and construction methods can be timed with a stopwatch. While changes to building codes and standard specifications are often done at a glacial, or even geologic pace. The resulting conflict often means that the successful use of sustainable construction materials such as concrete are never implemented, not because of an actual material failure, but more in a failure to frame and define why the change is necessary, in spite of what the current code may require or standard specification may recommend. This paper and presentation will explore the nature as to how we as an industry should correctly frame the discussion regarding the use of concrete as a sustainable choice for construction and where some of the counter points of resistance can be overcome, not just through the use of scientific data, but rational arguments as well.

Hydraulic Cement Specifications: Enhancing Concrete Sustainability, Tennis P. and Melander, J.

The primary objective of this presentation is to review modifications to hydraulic cement specifications over the last few years. ASTM C150 and AASHTO M 85 both have provisions for use of limestone in portland cements as well as refinement of provisions for inorganic processing additions. Ternary blended cements can now be readily specified by reference to ASTM C595 or AASHTO M240. ASTM C1157 was extensively revised in 2008 to make the standard more user-, producer-, and consumer-friendly. In addition, on-going efforts will be reviewed to develop provisions within ASTM and AASHTO blended cement specifications for a new type of cement, portland-limestone cement containing up to 15% limestone. This will provide another tool to enhance the sustainability of concrete. This technology that has a proven track record in Europe and Canada and can reduce GHG emissions by 10% to 12%, conserve energy and natural resources, and provide desired concrete performance.

Use of Pitchstone Fine as a Partial Replacement of Portland Cement for Sustainable Concrete, Tuladhar, R., Smith, M., Raj Pandey, G. and Joyce, P.

In Australia, pitchstone deposits found near the town Chillagoe in North Queensland has high pozzolanic properties. The mining site has the potential to provide in excess of 100 million tonnes of high quality pitchstone. With the

growing environmental concerns, government will scrutinize and put pressure on the concrete industry to reduce its environmental impact. The main focus of this research is to investigate the potential of pitchstone fine (PF) as a partial replacement of Portland cement. The study showed that while use of pitchstone fine as a partial replacement does not provide the initial high early strengths, remarkable high strength can be achieved over longer curing period. Partial replacement of Portland cement with up to 20% PF provided optimum results in compressive and flexural strength while ensuring good workability. The study confirmed the potential use of pitchstone fine as a partial replacement of Portland cement.

Precast Prestressed Concrete Pavements for Long-Life, Low-Cost, and Sustainable Pavement Rehabilitation, Tyson, S., Tayabji, S. and D. Merritt

The last ten years has seen a significant increase in the application of precast concrete panels for pavement rehabilitation. This paper provides a framework for considering the life cycle costs for precast prestressed concrete pavements based on based on immediate tangible benefits such as construction costs as well as the benefits accrued from reduced lane closures and longer low-maintenance service life. The recently constructed precast prestressed concrete pavement on a section of Interstate Route 66 in Fairfax County, Virginia, is used as a case study. Factors associated with life cycle assessment will be discussed as they relate to the use of precast prestressed concrete pavements.

From Surface to Microstructure: Investigating the Causes of In-Service Pervious Concrete Raveling Distresses, Vancura, M., MacDonald, K. and Khazanovich, L.

Pervious concrete pavements have been used extensively for stormwater management in the warm regions of United States since the 1970s but have been introduced in northern states in the last decade where pervious concrete pavements have not been consistently durable. In a recent study sponsored by the Ready Mix Concrete Research and Education Foundation, the durability of 22 pervious concrete pavement sites in a wet, hard freeze region of the United States were assessed. As part of the study, 33 cores were taken for microscopic and thin section analysis. The visual assessments resulted in identification of typical pervious concrete pavement surface distresses including impermeability, surface raveling, deep raveling, and joint raveling. Optical microscopy of the pervious concrete cores identified subsurface cracking patterns through paste, aggregates, and the paste/aggregate interface. Thin section analysis of distressed and non-distressed in-service pervious concrete samples revealed that the paste of the non-durable pervious concrete samples was extensively carbonated while only a thin layer of cement paste was carbonated around the voids in the durable samples. The information gathered from these observations indicated that the durability of pervious concrete is highly affected by the degree of hydration of the cement paste which is influenced by environment, construction, and curing.

Consideration of Economic and Environmental Factors Over the Concrete Pavement Life Cycle – A Michigan Study, Van Dam, T., Meijer, J., Ram, P., Smith, K.and Belcher, J.

The Michigan Department of Transportation (MDOT) has considerable experience on the use of recycled and industrial byproduct materials (RIBMs) in concrete pavements. Most of the work in this area has included laboratory and field investigations, with virtually no attempt to quantify the benefits and costs (both economic and environmental) of using RIBMs in concrete pavement applications. In this paper, life-cycle cost analysis (LCCA) and environmental life-cycle assessment (ELCA) techniques are used to quantify the economic and environmental impacts for a selected number of MDOT concrete pavement projects. Pavements studied include those made with and without supplementary cementitious materials (SCMs), with and without crushed concrete aggregate (CCA), and with and without air-cooled blast furnace slag coarse aggregate (ACBFS), all of which were evaluated over a range of traffic categories. The economic indicators considered include agency and user costs, whereas the environmental indicators included energy use, carbon footprint based on global warming equivalents, eutrophication and acidification to assess the impact on water, volume of secondary materials, and transportation intensity.

Mechanical and Durability Properties of Concretes Made with Different Levels of Recycled Concrete as Coarse Aggregates, Verian, K., Jain, J., Whiting, N. and Olek, J.

The use of recycled concrete (RCA) as coarse aggregates in concrete is a sustainable, cost-effective alternative to disposing the old concrete pavements. Previous studies have shown that concretes containing up to 30% of RCA as replacement for the virgin coarse aggregate can achieve good freeze thaw (F/T) resistance and mechanical

properties comparable to those of the ordinary concretes. In this paper, RCA reclaimed from an old concrete pavement was used as replacement for quarried (virgin) limestone coarse aggregates at four different replacement levels in both plain and fly ash (20% replacement of cement) concretes. The aggregate replacement levels were chosen based on previous studies by other researchers. Tests performed on all aggregates included absorption and specific gravity (as per ASTM C127) and resistance to degradation by LA abrasion test as per ASTM C131 and test results satisfied ASTM standard limits. The results of mechanical and durability testing will be used to determine the optimal replacement levels of virgin aggregates with RCA. The test results obtained to date indicate that although higher levels of replacement of virgin aggregates with RCA generally lead to reduced strength and durability, the resulting concretes still satisfied INDOT's specifications for pavement materials.

Recycled Concrete Aggregates for Use in New Concrete – European Experiences, Vestergaard Nielsen, C.

The lack of specifications and unclear regulations on the reuse and recycling of construction and demolition waste seems provide a hindrance towards the use of recycled aggregates into the production of new concrete. Since the mid 1990ies RILEM has explored the application of recycled aggregates into concrete. The European concrete standard EN 206-1 has existed for 8 years and it is currently being revised. Part of the revision includes applications of recycled aggregates and a task group was formed to implement this. The outcome of the task group is presented. The subjects of the presentation will be allowable constituents of recycled concrete aggregates, rules for application, important material properties, etc.

Minimizing Cementitious Content for Performance and Sustainability in Rigid Pavements, Yurdakul, E., Taylor, P., Ceylan, H. and Bektas, F.

The main purpose of this research is to investigate the minimum cementitious content required with an appropriate water to cementitious ratio (w/cm) to meet given workability, strength, and durability requirements in a rigid pavement; and so to reduce carbon dioxide emissions, energy consumption, and costs. This paper will present an experimental program that was conducted on 32 concrete mixtures. Sixteen mixtures were prepared using ASTM Type I ordinary portland cement and 16 contained ASTM C618 class C fly ash at 20% of portland cement replacement level. The test results showed that strength is a function of w/cm and independent of the cementitious content after the required cementitious content is reached, for a given w/cm. Based on the findings, for the aggregate system used in this work, it is possible to reduce the cementitious content without sacrificing the desired strength and durability of rigid pavements, for a given w/cm.

National Ready Mixed Concrete Association
900 Spring Street
Silver Spring, MD 20910
(301) 587-1400
www.nrmca.org