Sustainable Airport Pavements

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Outline

• Sustainability

• Rating System

• Research & Development
  – Warm Mix Asphalts
  – Heated Pavements
  – Nanotechnologies
  – Life Cycle Assessment
  – Extending Pavement Life
Sustainability

“Development that meets the needs of the present without compromising the ability of future generations to meet their own needs” - Brundtland Commission 1983

“One that meets transportation and other needs of the present without Compromising the ability of future generations to meet their needs” - TRB 2005

“Triple Bottom Line”
Sustainability

“A holistic approach to managing an airport so as to ensure the integrity of the Economic viability, Operational efficiency, Natural resource conservation and Social responsibility (EONS) of the airport.” ACI-NA
Sustainability

• Why
  – Worldwide awareness and a global economy
  – Airline industry financial pressures
  – Rising Energy Costs
  – Green and environmental mandates
  – Resource conservation
  – Aging Infrastructure
  – Facility life cycle costs
  – Enabling technologies

• Benefits
  – Reduced Operating Costs
  – Greater Utilization of Assets
  – Reduced Environmental Footprint
  – Operational Flexibility
  – Enhanced Customer Service
  – Optimization of New and Better Technologies
  – Lowering Costs of Asset Development
  – Integrated Design as a Way of Doing Business
  – Improved Bond Rating
  – Improved Benefits to the Community
  – long-term environmental, economic benefits
Sustainability

• “Green” vs. “Sustainable”
  – “Green” – Focuses solely on Environmental Stewardship or one component of the “Triple Bottom Line”.
  – “Sustainable” – Includes the ‘Green’ aspect of a project and also integrates the other two components of Economic Growth and Social Responsibility.
Design Development

• **Factors Affecting Sustainability**
  – Cut and Fill
  – Design Life
  – Drainage
  – Thickness
  – Construction Method
  – Material Selection
  – Life Cycle Cost
Construction Development

- Factors Affecting Sustainability
  - Virgin Materials
  - Dust
  - $CO_2$
  - VOCs
  - Noise Pollution
  - Delay Times
  - Energy
  - Life Cycle Cost
Sustainability

• Rating Systems
  – US Green Building Council (USGBC) LEED® program
  – Institute for Sustainable Infrastructure
    • ENVISION
  – Airport Authorities
Sustainability – Rating Systems

• **ENVISION**

  • The Envision sustainable infrastructure rating system is a comprehensive framework of 60 sustainability criteria that address the full range of environmental, social, and economic impacts to sustainability in project design, construction, and operation.

  • These criteria—called “credits”—are arranged in five categories: Quality of Life, Leadership, Resource Allocation, Natural World, and Climate and Risk. The full Envision guidance manual detailing the credits is provided at no cost to users.

  • Envision is available for self-assessment at no cost, the third-party project verification and award program is available to recognize projects that have achieved higher levels of sustainability using Envision.

  • Envision rating: Bronze, Silver, Gold, or Platinum.
Sustainability – Rating Systems

2016

West Park Equalization Facility, Nashville, Tennessee
Ridgewood View Park Reservoir and Pump Station, Portland, Oregon
Historic Fourth Ward Park, Atlanta, Georgia
Green Build Project at San Diego International Airport, San Diego, California
Integrated Pipeline Project, Fort Worth, Texas
Holland Energy Park, Holland, Michigan
T.F. Green Airport (PVD) Runway 5 Extension, Providence, Rhode Island
Kansas City Streetcar, Kansas City, Missouri
Kunia Country Farms, Honolulu, Hawaii
Runway 4L/22R and Associated Taxiways Reconstruction, Detroit, Michigan
Middle Blue River Green Infrastructure, Kansas City, Missouri
Hardeeville Water Reclamation Facility, Town of Hardeeville, South Carolina
Sustainability

• “New” Technologies/Materials
  – Warm Mix Asphalt
  – Half-Warm Mix Asphalt
  – Increased amount of recycled materials
  – Concrete admixtures
  – Supplementary Cementing Materials (SCM)
  – Life Cycle Assessment (LCA)
  – Design Beyond Fatigue Cycles
  – Increase Pavement Design Life (20 to 40 years)
Warm Mix Asphalt

- **WMA reduces temperatures by 25° to 55° C**
  - Reducing Energy Usage
  - Reducing Emissions
  - Reducing Worker Exposure
- **Placement**
  - Longer Hauls and Lower Temperatures
- **Production**
  - Wax Like Products
    - Sasobit, Asphaltan B, Fatty Acid Amides
  - Foaming Processes
    - Aspha-min Zeolite, Low Energy Asphalt, WAM Foam
  - Emulsion Base
    - Evotherm
  - Other Additional Technologies
Warm Mix Asphalt

MATERIAL

TIRE PRESSURE

BINDER TYPE

OUTDOOR TESTING AREA

INDOOR TESTING AREA

Control Room & Office

TOTAL AREA = 102,900 sq. feet (2.36 acres)
Heated Pavements

• Oslo-Gardermoen Int’l Airport (Norway)
• Stockholm–Arlanda Int’l Airport (Sweden)
• Helsinki-Vantaa Int’l Airport (Finland)
New Heated Pavements Areas

Total Area = 2252 m$^2$ (24,000 ft$^2$)
Heated Pavement Installations

Heated pavements have been installed
• to reduce CO$_2$ emissions
• to reduce deicing chemicals into the environment
• for safety reasons
• Economic reasons for the installation have not been performed
Heated Pavement Projects

- Greater Binghamton Airport – Pilot Project
- Develop current economic analysis of heated pavements
- Advanced Construction Techniques for Heated Pavements
- Conductive Concrete for Airfield Heated Pavement
Greater Binghamton Airport

TERMINAL COOLING SYSTEM

GEOTHERMAL MECHANICAL BUILDING

IN-PAVEMENT HEATING SYSTEM

GEOTHERMAL WELL FIELD
Greater Binghamton Airport

**COOLING**

Then: In the spring and autumn, the glycol is circulated through heat pumps for further cooling and then sent pre-cooled into the terminal building to assist with air conditioning (cooling).

**First:** Glycol, better known as antifreeze, is pumped through tubing deep under the surface of the earth in the well fields where it arrives back at the earth’s surface at a constant 55 degrees.

**HEATING**

Then: In winter, the glycol is circulated through heat pumps for further heating, and then used to heat a separate set of glycol-filled tubing which is circulated under the concrete to prevent freezing at the surface.
Nanotechnology

• Nano-Structured Superhydrophobic Pavement Surfaces
• Phase Change Materials for PCC Pavements
• Phase Change Materials for HMA Pavements
• Nano-Engineered Smart Tarmacs
Nano Structured Superhydrophobic Coatings

1. Repel water to inhibit ice formation through a combination of roughness tailoring and material hydrophobicity

2. Investigate different materials (Silica, CeO2 & TiO2) and particle sizes for pavement coatings

3. Determine effectiveness as a stand alone treatment or in combination with conductive pavement

4. Determine physical properties of resulting concrete (compressive strength, friction coefficient, and roughness)
Nano Structured Superhydrophobic Coatings

Identify Overall System-Level Requirements

- Superhydrophobic coating
- Conductive concrete
- Hydronic pipes
- Normal Concrete
- Sub base
- Subgrade
Nano Structured Superhydrophobic Coatings

• Defining Superhydrophobicity and Hydrophobicity
Nano Structured Superhydrophobic Coatings

Polytetrafluoroethylene (PTFE) coatings on concrete

From left to right: control, 2% PTFE, and 5% PTFE modified mortar specimens
Nanotechnologies

- **Icephobic Materials for Nano-Modified Heated HMA Pavements**
  - Mitigate formation of ice crystals by being water-repellent
  - Self cleaning of asphalt surface layer
  - Mitigate HMA moisture damage (e.g. stripping)
  - Similar to current research on PCC, but with different challenges

*Without treatment*  
*With treatment*
Nanotechnologies

• Nano-Engineered Smart Tarmacs (NEST) for Detecting Distributed Surface and Subsurface Pavement Damage

• Objective:
  • To develop nano-engineered smart tarmacs (NEST) that can nondestructively detect the severity and location of airport pavement damage.

• NEST will measure deformation and damage directly and will identify (in near-real-time and wirelessly) the location and size of surface and subsurface damage.

• NEST will eliminate the need for tedious, and expensive conventional methods currently being used.
Nano-Engineered Smart Tarmacs (NEST) for Detecting Distributed Surface and Subsurface Pavement Damage

- Nano-Engineering and Smart Structures Technologies (NESST) Laboratory at UC Davis
- Northern California Nanotechnology Center (NC2) at UC Davis
- Structural Engineering Research Laboratory (SERL) at UC Davis
- Laboratory for Intelligent Structural Technology (LIST) at University of Michigan
Nano-Engineered Smart Tarmacs (NEST) for Detecting Distributed Surface and Subsurface Pavement Damage

Nano-engineered smart tarmac
Enables the 3D mapping of strain, deformations, and damage

Strain sensing achieved by smart tarmac designed with dispersed carbon nanomaterials

Data acquisition will be achieved in near-real-time and using a robust wireless sensor network

Airport runway, tarmac, or pavement

Smart tarmac performance will be validated at UC Davis and demonstrated to the FAA

Nano-Engineered Smart Tarmacs

A

0.24 μm

1-2 nm

B

0.36 nm

2-25 nm
Life Cycle Assessment (LCA)

• “Cradle-to-grave” Concept
• ISO 14040 Series of Standards
• Involves a cumulative analysis of impacts throughout all stages of the life cycle
Guidelines for Life-Cycle Assessment of Airfield Pavements and Other Airside Features

August 22, 2016
Final Report

This document is available to the U.S. public through the National Technical Information Service (NTIS), Springfield, Virginia 22161.

U.S. Department of Transportation
Federal Aviation Administration

Life Cycle Assessment (LCA)
Extending Pavement Life

40 Year Design Life

FIGURE 1: TYPICAL PAVEMENT LIFE CYCLE CURVE
Developing New Performance Models

New performance models will relate design inputs to a future distress index ($DL$) incorporating structural and non-structural elements.

**Current Design Procedures:**

- **Inputs**
  - Structural Layers
  - CBR or $k$-value
  - Aircraft Traffic
  - Concrete Strength (rigid)

- **Output**
  - Passes to structural failure*

*defined as 2.5 cm upheaval for flexible pavements or 50% of slabs cracked for rigid pavements

**40-Year Design:**

- **Inputs**
  - Everything to the left, plus …
  - Age, Climatic Data
  - Soil/Material Properties
  - Maintenance Data
  - Airport Feature (runway, apron, etc.)

- **Outputs**
  - Passes to structural failure, plus …
  - Roughness index prediction
  - Surface friction prediction
  - Other functional indexes
Distress Level, End of Life, and LCCA

- $DL$ should contain enough information for LCCA.
- $DL_{lower}$ indicates pavement is no longer serviceable and maintenance is required.
- Multiple treatments are considered for pavement at $DL_{lower}$ during an iterative LCCA.
  - Treatments that cannot raise $DL$ to at least $DL_{upper}$ are discarded.
  - Treatments that cannot maintain $DL$ above $DL_{lower}$ reliably for 10 years or more are discarded.
  - If complete reconstruction is optimum according to LCCA, end of serviceability is the end of life.
Pavement Life Definition
Graphical Representation

End of Serviceability

10 years

Pr(DL_{10\ years} > DL_{lower}) < p
THANK YOU