Sustainable Airport Pavements

Federal Aviation Administration

Presented to: ALACPA 2016

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Outline

- **Sustainability**
- **Rating System**
- **Research & Development**
  - Warm Mix Asphalts
  - Heated Pavements
  - Nanotechnologies
  - Life Cycle Assessment
  - Extending Pavement Life

Sustainability

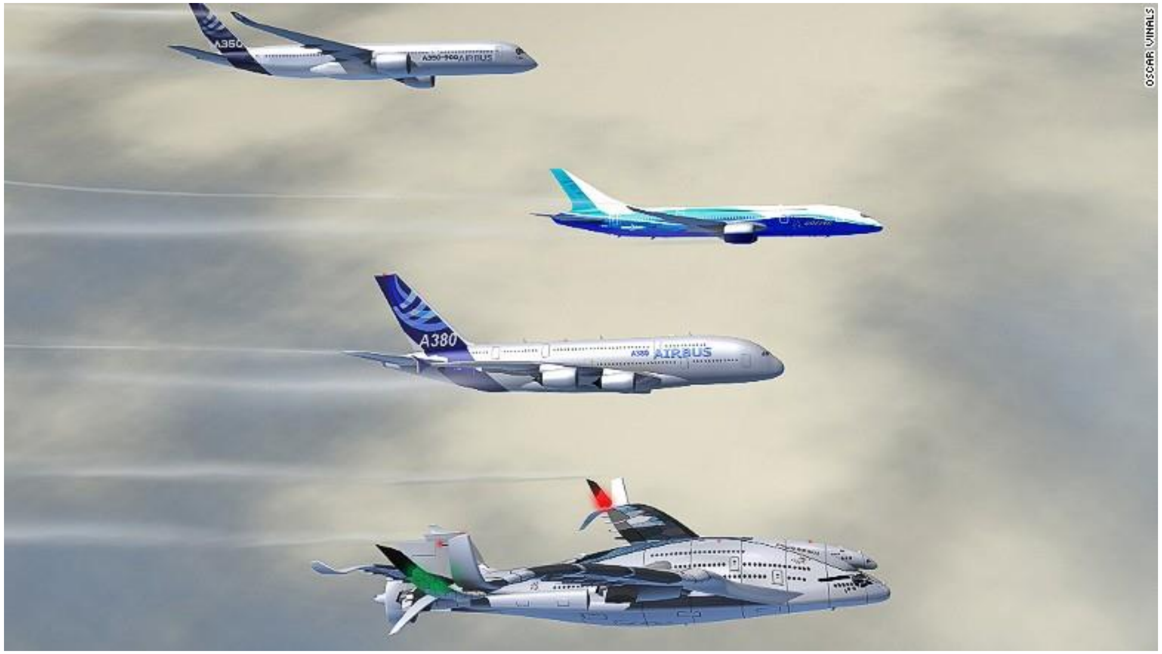
"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" - Brundtland Commission 1983

"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

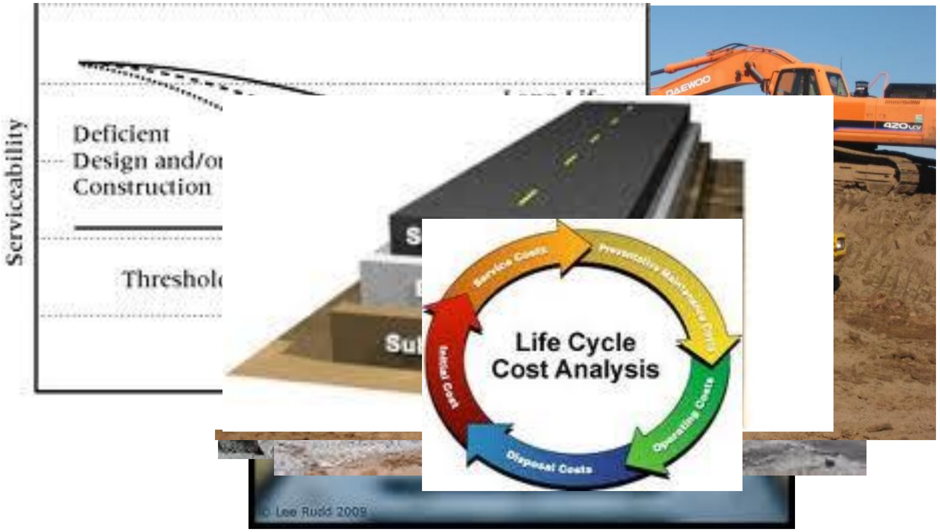
- **Benefits**
  - Reduced Operating Costs
  - Greater Utilization of Assets
  - Reduced Environmental Footprint
  - Operational Flexibility
  - Enhanced Customer Service
  - Optimization of New and Better Technologies
  - Lowering Costs of Asset Development
  - Integrated Design as a Way of Doing Business
  - 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

INSTITUTE FOR SUSTAINABLE INFRASTRUCTURE
I S I

O'Hare Modernization Program
Certificate of Recognition
Sustainable Design
Green Certification
Mount Prospect Road and Guard Post 1 Relocation

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.

Institute for Sustainable Infrastructure

FOUNDING ORGANIZATIONS

APWA ACEC ASCE

ENVISION™ CREDIT LIST

QUALITY OF LIFE
13 Credits

1 PURPOSE
QL1.1 Improve Community Quality of Life
QL1.2 Stimulate Sustainable Growth & Development
QL1.3 Develop Local Skills & Capabilities

2 WELLBEING
QL2.1 Enhance Public Health & Safety
QL2.2 Minimize Noise and Vibration
QL2.3 Minimize Light Pollution
QL2.4 Improve Community Mobility & Access
QL2.5 Encourage Alternative Modes of Transportation
QL2.6 Improve Site Accessibility, Safety & Wayfinding

3 COMMUNITY
QL3.1 Preserve Historic & Cultural Resources
QL3.2 Preserve Views & Local Character
QL3.3 Enhance Public Space

QL0.0 Innovate or Exceed Credit Requirements

LEADERSHIP
10 Credits

1 COLLABORATION
LD1.1 Provide Effective Leadership & Commitment
LD1.2 Establish A Sustainability Management System
LD1.3 Foster Collaboration & Teamwork
LD1.4 Provide for Stakeholder Involvement

2 MANAGEMENT
LD2.1 Pursue By-Product Synergy Opportunities
LD2.2 Improve Infrastructure Integration

3 PLANNING
LD3.1 Plan For Long-Term Monitoring & Maintenance
LD3.2 Address Conflicting Regulations & Policies
LD3.3 Extend Useful Life

LD0.0 Innovate or Exceed Credit Requirements

RESOURCE ALLOCATION
14 Credits

1 MATERIALS
RA1.1 Reduce Net Embodied Energy
RA1.2 Support Sustainable Procurement Practices
RA1.3 Use Recycled Materials
RA1.4 Use Regional Materials
RA1.5 Divert Waste From Landfills
RA1.6 Reduce Excavated Materials Taken Off Site
RA1.7 Provide For Deconstruction & Recycling

2 ENERGY
RA2.1 Reduce Energy Consumption
RA2.2 Use Renewable Energy
RA2.3 Commission & Monitor Energy Systems

3 WATER
RA3.1 Protect Fresh Water Availability
RA3.2 Reduce Potable Water Consumption
RA3.3 Monitor Water Systems

RA0.0 Innovate or Exceed Credit Requirements

NATURAL WORLD
15 Credits

1 SITING
NW1.1 Preserve Prime Habitat
NW1.2 Protect Wetlands & Surface Water
NW1.3 Preserve Prime Farmland
NW1.4 Avoid Adverse Geology
NW1.5 Preserve Floodplain Functions
NW1.6 Avoid Unsuitable Development on Steep Slopes
NW1.7 Preserve Greenfields

2 LAND+WATER
NW2.1 Manage Stormwater
NW2.2 Reduce Pesticide & Fertilizer Impacts
NW2.3 Prevent Surface & Groundwater Contamination

3 BIODIVERSITY
NW3.1 Preserve Species Biodiversity
NW3.2 Control Invasive Species
NW3.3 Restore Disturbed Soils
NW3.4 Maintain Wetland & Surface Water Functions

NW0.0 Innovate or Exceed Credit Requirements

CLIMATE AND RISK
8 Credits

1 EMISSIONS
CR1.1 Reduce Greenhouse Gas Emissions
CR1.2 Reduce Air Pollutant Emissions

2 RESILIENCE
CR2.1 Assess Climate Threat
CR2.2 Avoid Traps & Vulnerabilities
CR2.3 Prepare For Long-Term Adaptability
CR2.4 Prepare For Short-Term Hazards
CR2.5 Manage Heat Island Effects

CR0.0 Innovate or Exceed Credit Requirements

www.sustainableinfrastructure.org

Institute For Sustainable Infrastructure
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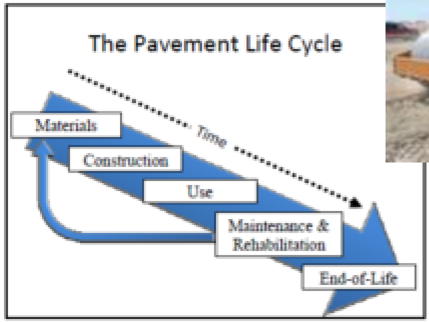
Sustainability – Rating Systems

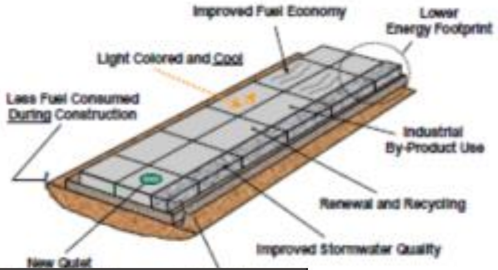
2016

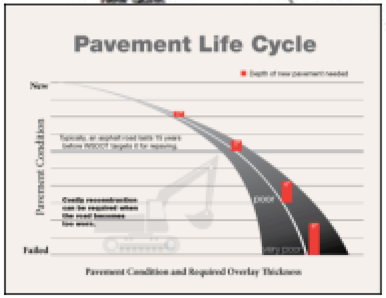
- West Park Equalization Facility, Nashville, Tennessee
- Ridgewood View Park Reservoir and Pump Station, Portland, Oregon
- Historic Fourth Ward Park, Atlanta, Georgia
- Green Build Project at San Diego International Airport, San Diego, California
- Integrated Pipeline Project, Fort Worth, Texas
- Holland 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

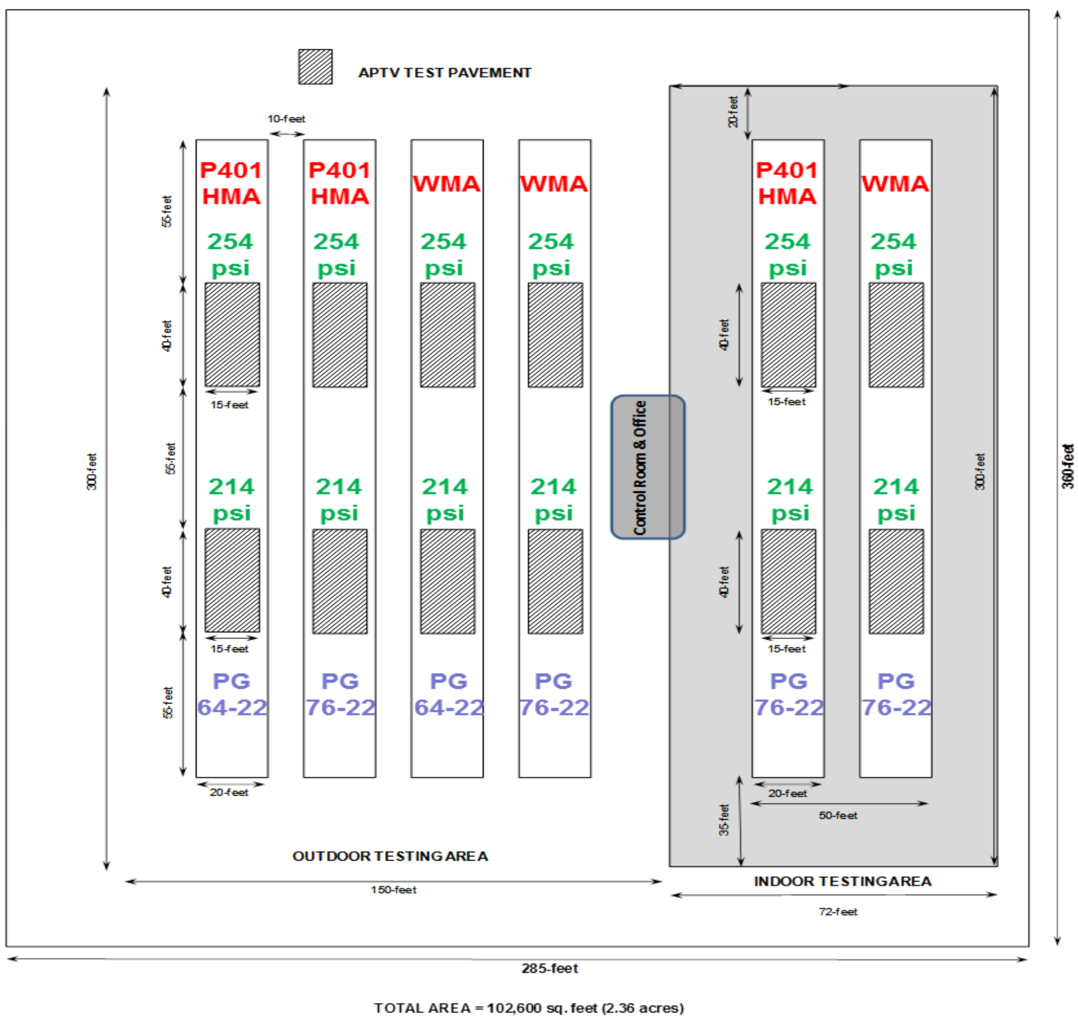
- **WMA reduces temperatures by 25° to 55° C**
  - Reducing Energy Usage
  - Reducing Emissions
  - Reducing Worker Exposure
- **Placement**
  - Longer Hauls and Lower Temperatures
- **Production**
  - Wax Like Products
    - Sasobit, Asphaltan B, Fatty Acid Amides
  - Foaming Processes
    - Aspha-min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

Warm Mix Asphalt

MATERIAL

TIRE PRESSURE

BINDER TYPE



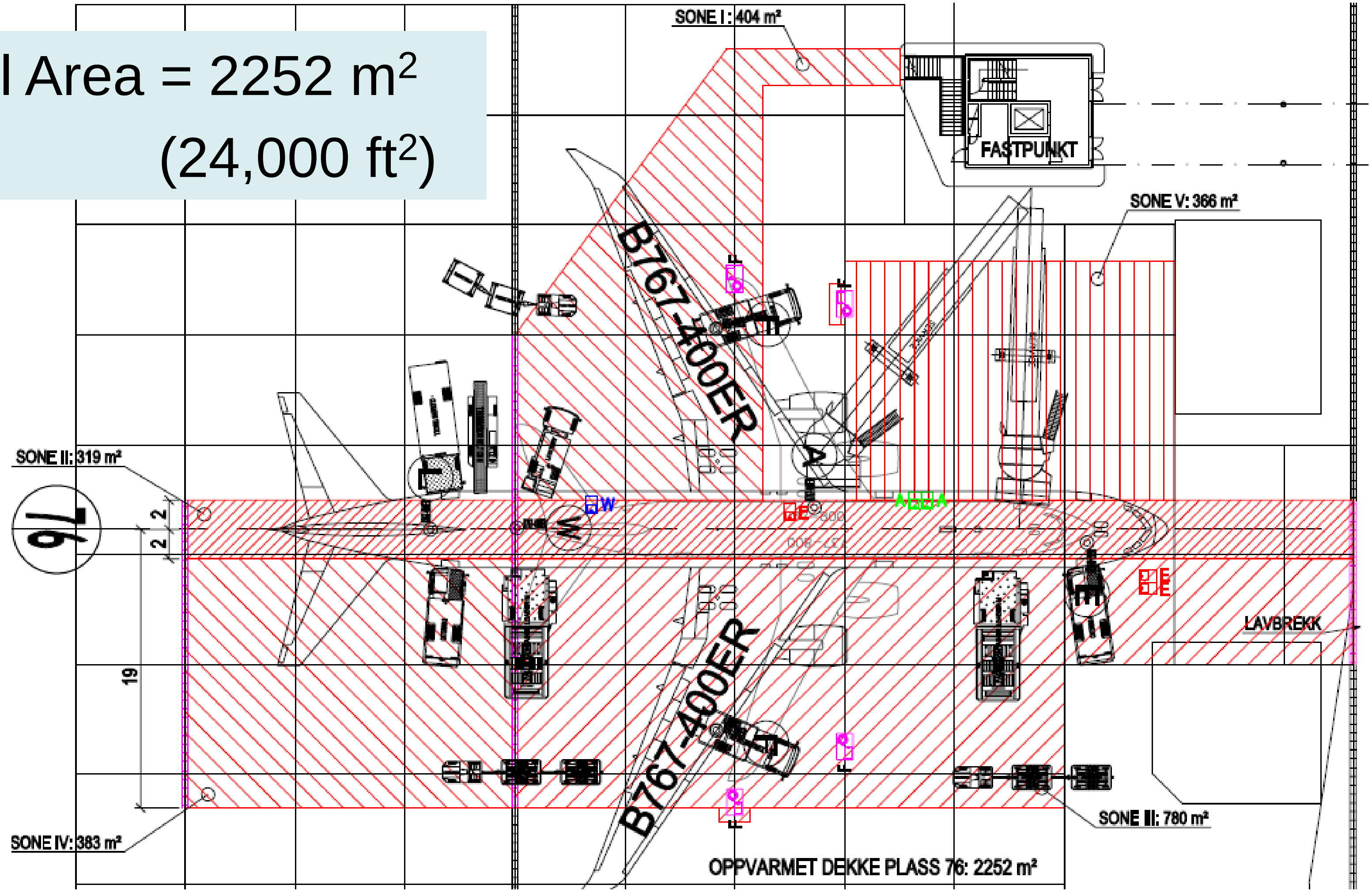
Heated Pavements

- 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

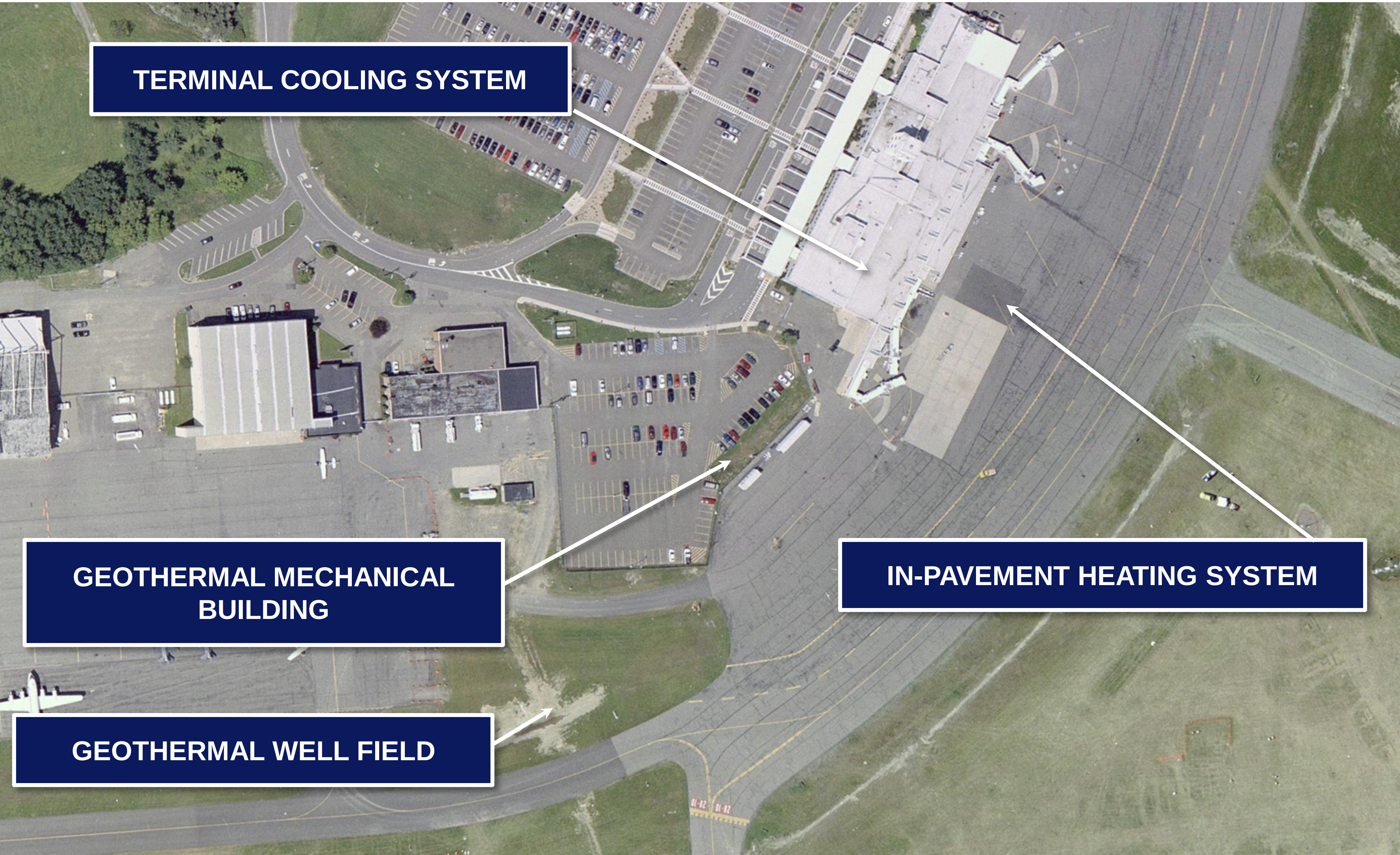
Heated pavements have been installed

- **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



Greater Binghamton Airport

COOLING

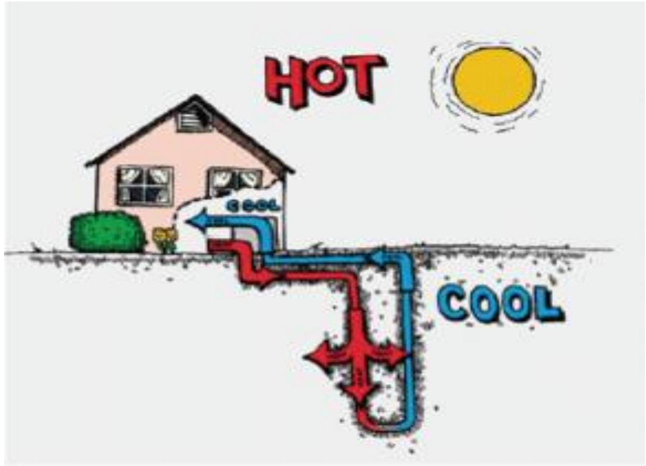
Then: In the spring and autumn, the glycol is circulated through heat pumps for further cooling and then sent pre-cooled into the terminal building to assist with air conditioning (cooling).

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 surpface 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.



WELL FIELDS

Nanotechnology

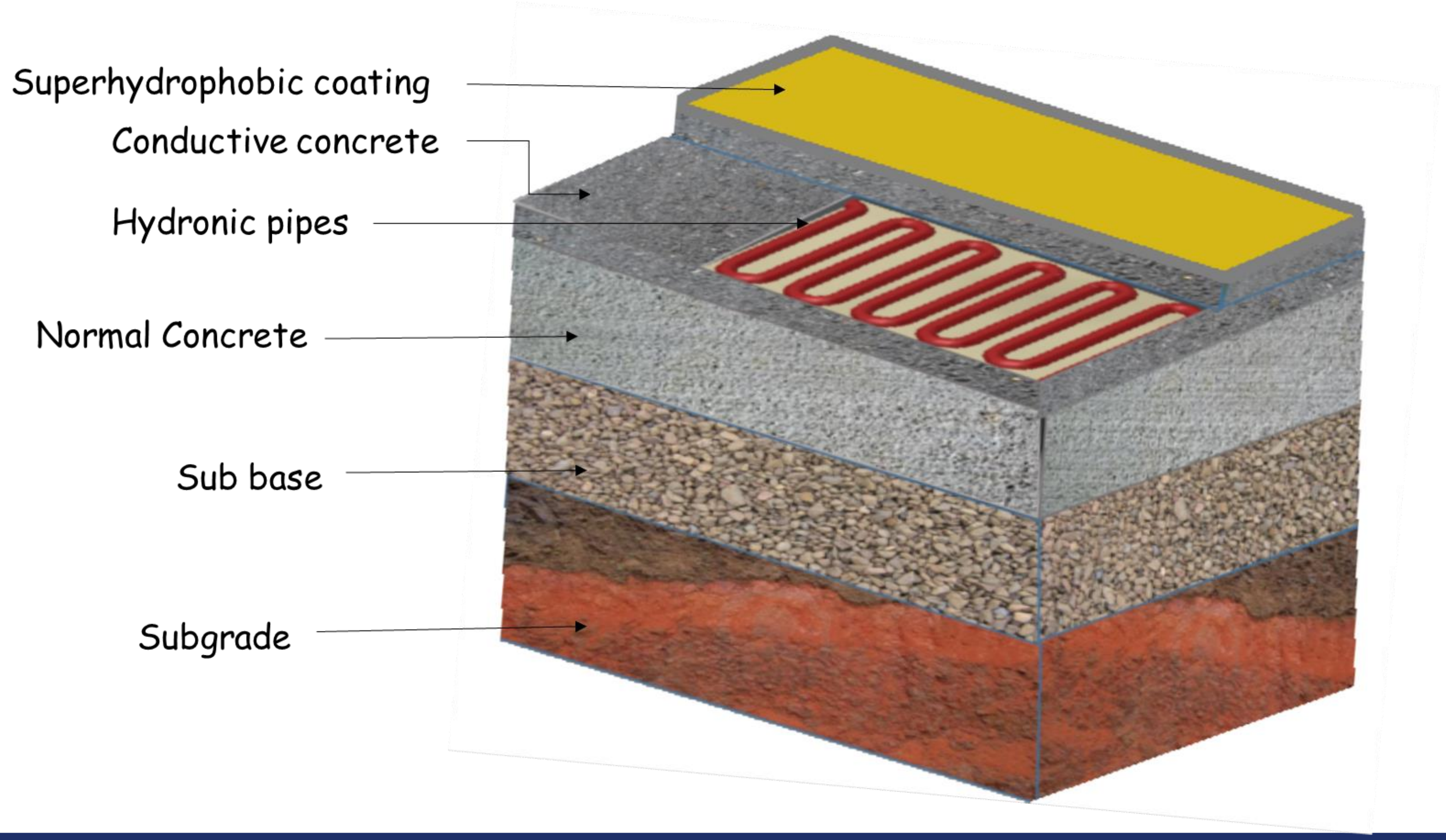
- Nano-Structured Superhydrophobic Pavement Surfaces
- Phase Change Materials for PCC Pavements
- Phase Change Materials for HMA Pavements
- Nano-Engineered Smart Tarmacs

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, CeO_2 & TiO_2) 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)

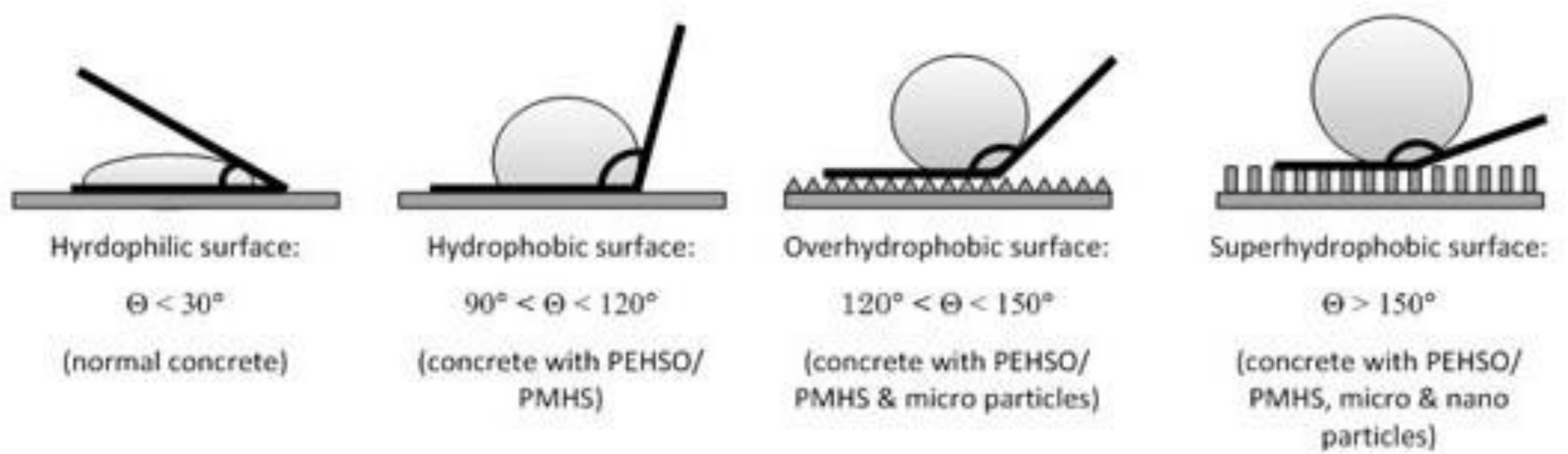
Nano Structured Superhydrophobic Coatings

Identify Overall System-Level Requirements



Nano Structured Superhydrophobic Coatings

- **Defining Superhydrophobicity and Hydrophobicity**



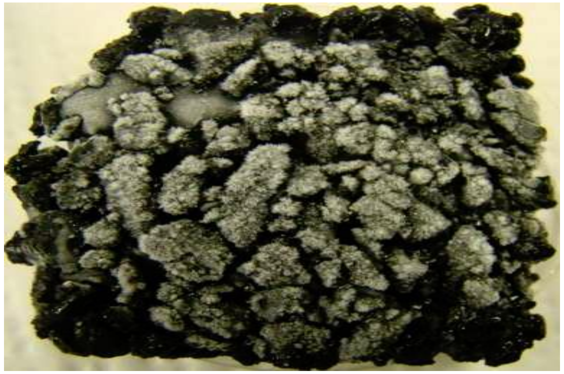
Nano Structured Superhydrophobic Coatings

Polytetrafluoroethylene (PTFE) coatings on concrete

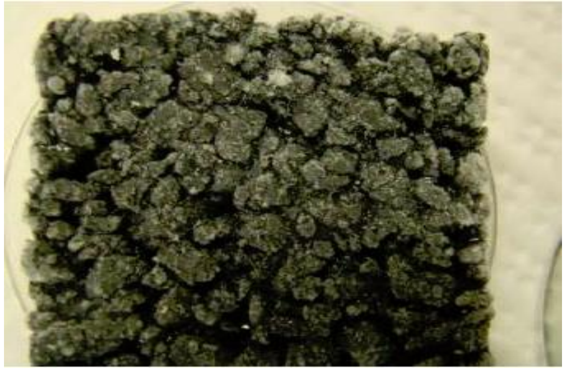
From left to right: control, 2% PTFE, and 5% PTFE modified mortar specimens

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

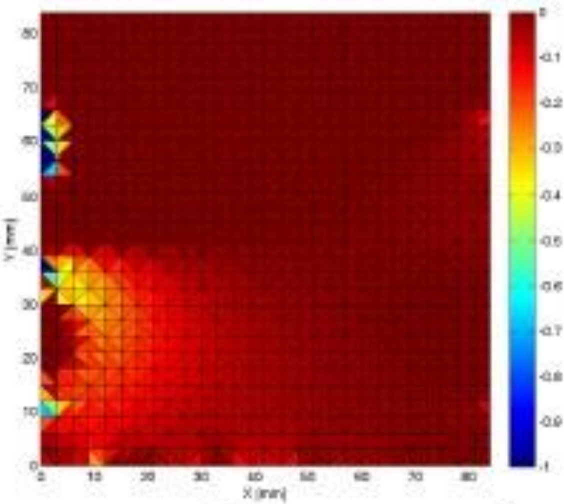
Nanotechnologies

- 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.

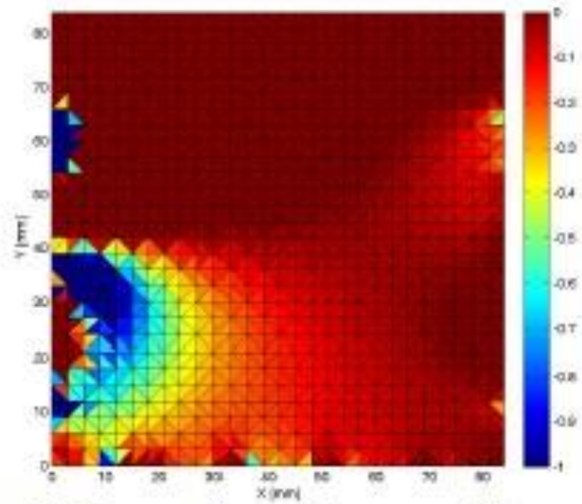
- NEST will eliminate the need for tedious, and expensive conventional methods currently being used.

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



EIT image of smart tarmac with a partially drilled hole

Smart tarmac with a partially drilled hole



EIT image of smart tarmac with a hole drilled through the specimen

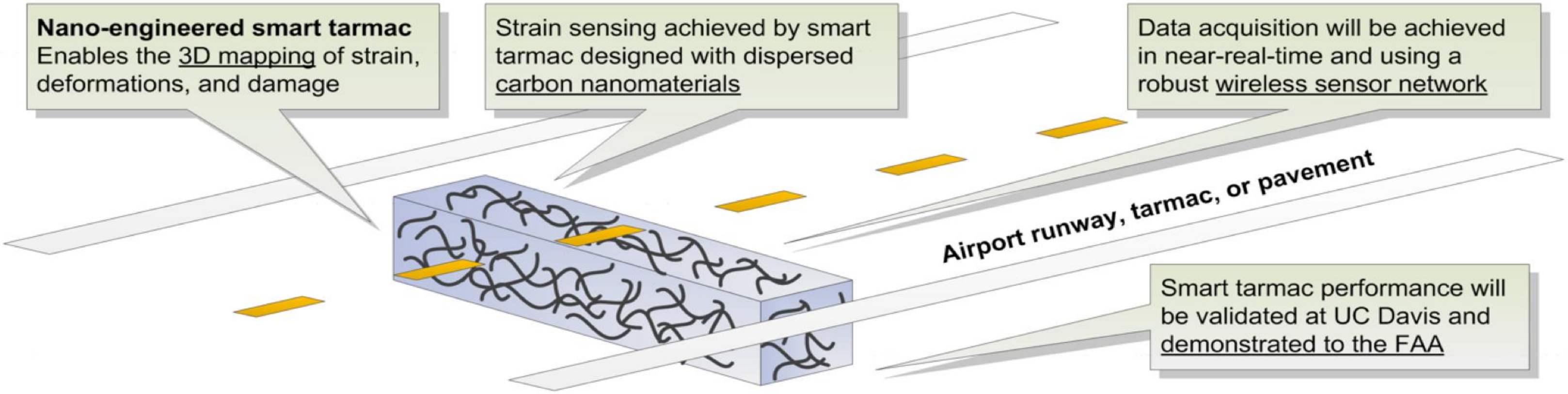
•Nano-Engineering and Smart Structures Technologies (NESST) Laboratory at UC Davis

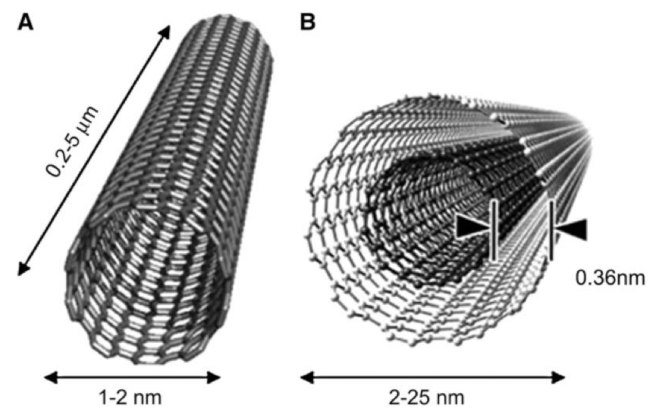
•Northern California Nanotechnology Center (NC2) at UC Davis

•Structural Engineering Research Laboratory (SERL) at UC Davis

•Laboratory for Intelligent Structural Technology (LIST) at University of Michigan

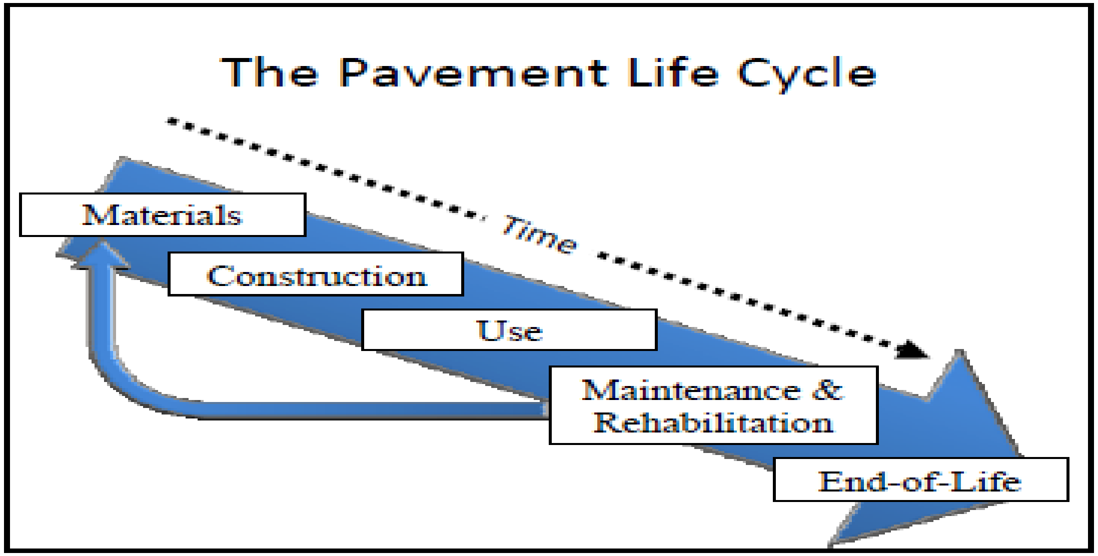
Nano-Engineered Smart Tarmacs (NEST) for Detecting Distributed Surface and Subsurface Pavement Damage





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



Life Cycle Assessment (LCA)

DOT/FAA/AR-xx/xx

Air Traffic Organization
Operations Planning
Office of Aviation Research
and Development
Washington, DC 20591

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 Services (NTIS), Springfield, Virginia 22161.

U.S. Department of Transportation
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15. Supplementary Notes

16. Abstract
This document provides guidelines for the conduct of life cycle assessment (LCA) studies for airfields. The scope is limited to airside civil infrastructure. The guidelines include recommendations for all phases of LCA, including goal and scope definition, life cycle inventory development, impact assessment, interpretation and critical review, and reporting. It is expected that these guidelines will be updated as experience is gained with LCA studies for airfields.

17. Key Words	18. Distribution Statement
Pavement, life-cycle assessment, LCA, airfield, guidelines, framework	This document is available to the U.S. public through the National Technical Information Service (NTIS), Springfield, Virginia 22161.

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Extending Pavement Life

40 Year Design Life

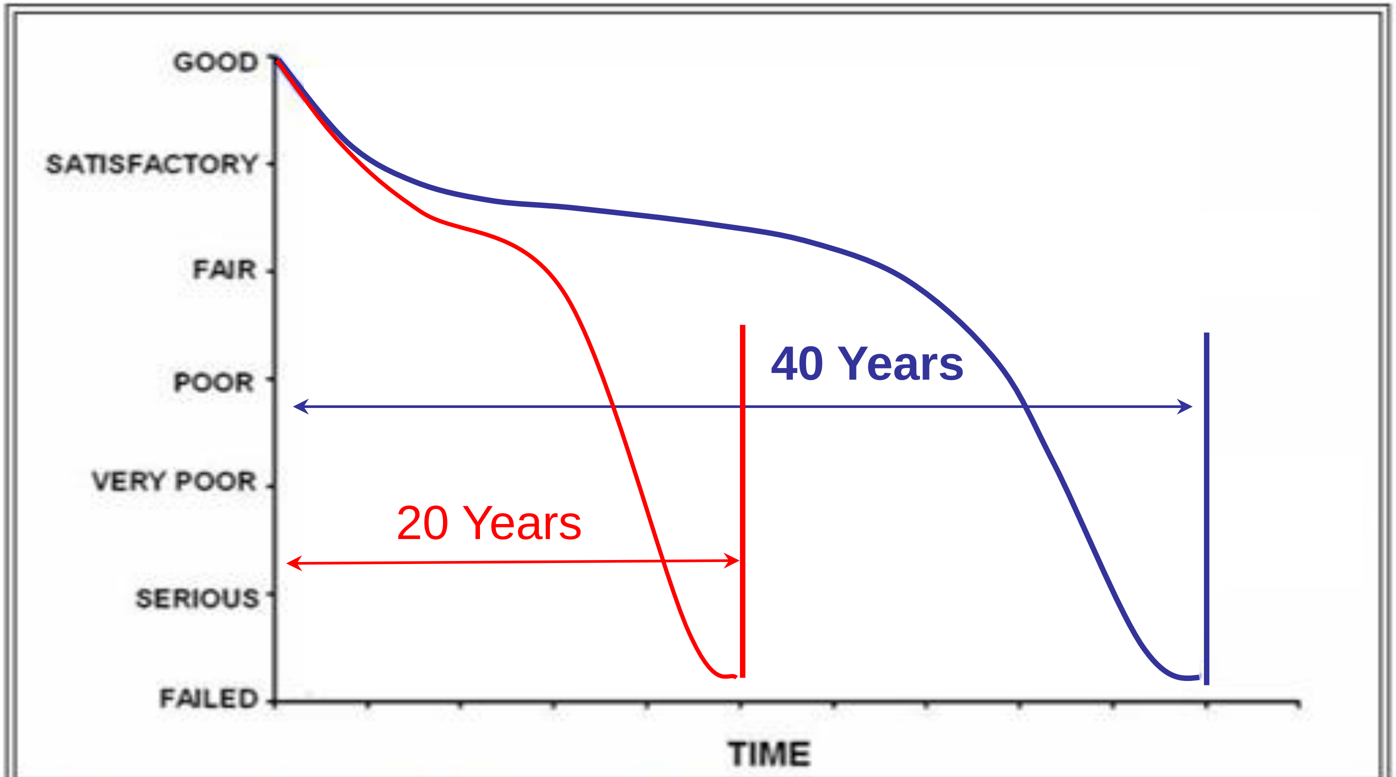


FIGURE 1- TYPICAL PAVEMENT LIFE CYCLE CURVE

Developing New Performance Models

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

<u>Current Design Procedures</u>:

- **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

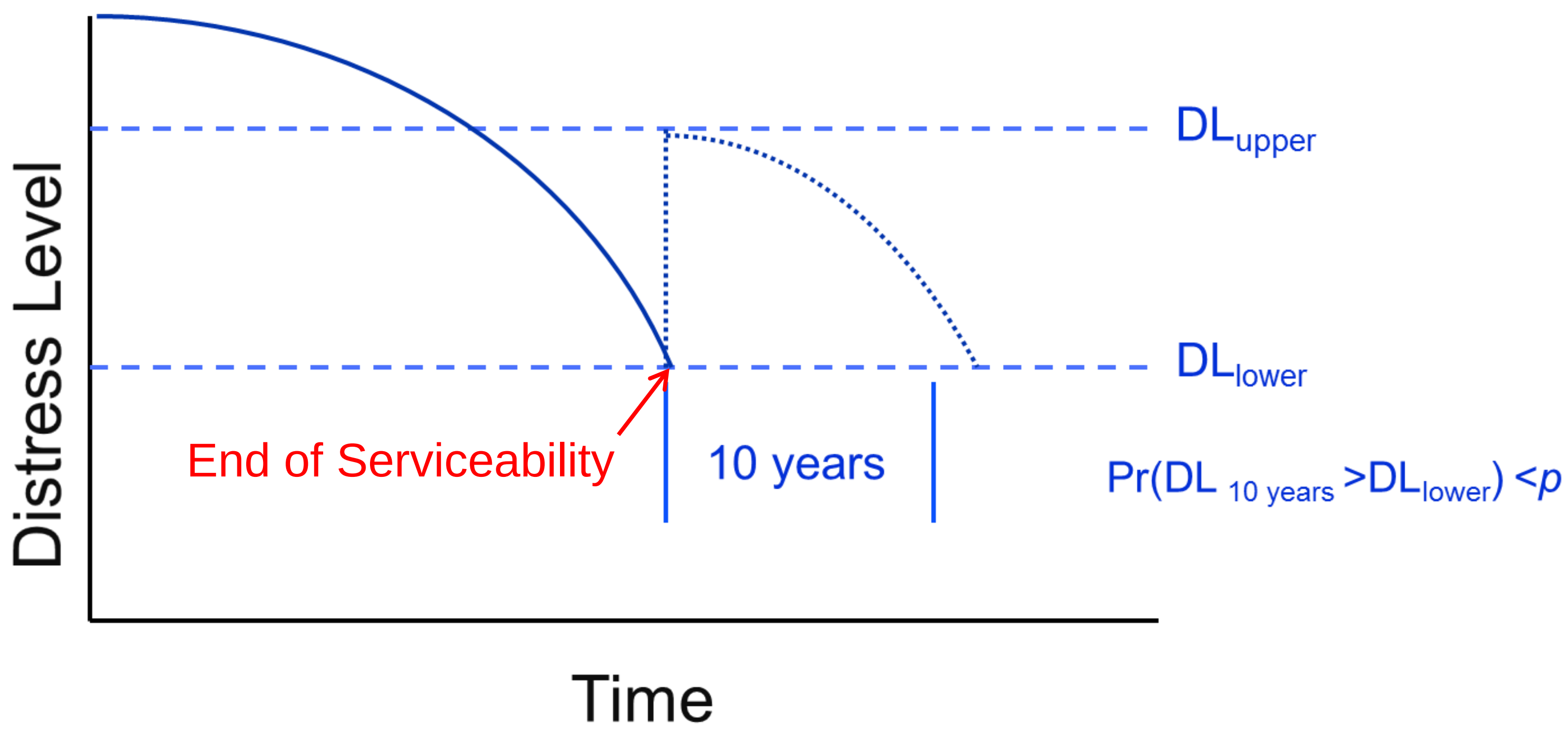
<u>40-Year Design</u>:

- **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.
  - **<u>If complete reconstruction is optimum according to LCCA, end of serviceability is the end of life.</u>**

Pavement Life Definition
Graphical Representation



THANK YOU