RPA P4 Advanced Materials

Need

Advancements in paving materials and technologies will conserve airport development funds and reduce the downtime of runways from construction and operation and maintenance activities.

Research Goals

- Full scale testing and laboratory testing of modern/advanced pavement technologies for use on airfields
- Lab comparison of cracking potential of polymer modified HMA and WMA at colder temperatures for use in full scale testing
- Comparison of HMA, PMA, WMA, SMA in the lab and field. (Cape May Research Taxiway and other sites)

FY 2016 Accomplishments

- Published Task 1-A Report
- Completed Task 1-B, 1-C, 1-D reports for heated pavements under the PEGASAS grants program.
- Full Scale Electrically Conductive Concrete at DSM

Heated Pavement Projects

- **Radiant Heating (Geothermal) for Airfield Pavements – Greater Binghamton Airport - (2009)**
  – Professor Bill Ziegler, University of Binghamton
- **Airport Heated Pavement – PEGASAS – Partnership to Enhance General Aviation Safety, Accessibility, & Sustainability**
  – Task 1-A: Energy and Financial Viability of Heated Pavement Systems – **2 Reports Published**
  – Task 1-B: Hybrid Heated Airport Pavements – **2 Reports**
  – Task 1-C: Potential Use of Phase Change Materials (PCM) to Store Heat in PCCP – **1 Report**
  – Task 1-D: Advanced Construction Techniques for Heated Pavement Systems – **1 Report**
  – Task 1-E: Potential Use of Phase Change Material to Store Heat in HMA
  – Task 1-F: Feasibility of Using Electrically Conductive Asphalt Cement Concrete
  – Task 1-G: Superhydrophobic and Icephobic Materials for Nano-Modified Heated Asphalt
  – Task 1-H: Full-Scale Demonstration of Heated Portland Cement Concrete Pavement
    - **Full Scale (2 Slabs) Implementation Project as DSM**
- **Conductive Concrete for Airfield Heated Pavement**
  – Dr. Christopher Tuan, University of Nebraska – Lincoln
    - Draft Report Submitted. Under FAA Review.

Greater Binghamton Airport

- **New Grant to be Awarded September 15, 2015**
  - Optimization of the System
    - Optimal Supply Line Temperature Vs. Return Line Temperature
    - Optimal buffer tank Temperature
    - Pump Cycle Efficiencies
    - Vertical Vs Horizontal Well efficiency
  - Economic Feasibility Validation
    - Establish detailed cost breakdown of construction cost
    - Validate the financial viability using the Financial Viability Study created by PEGASAS COE Iowa State
  - Establish a Data Management Structure for Raw Data

Greater Binghamton Airport

- **Financial Viability Study Report from PEGASAS (Iowa State)**

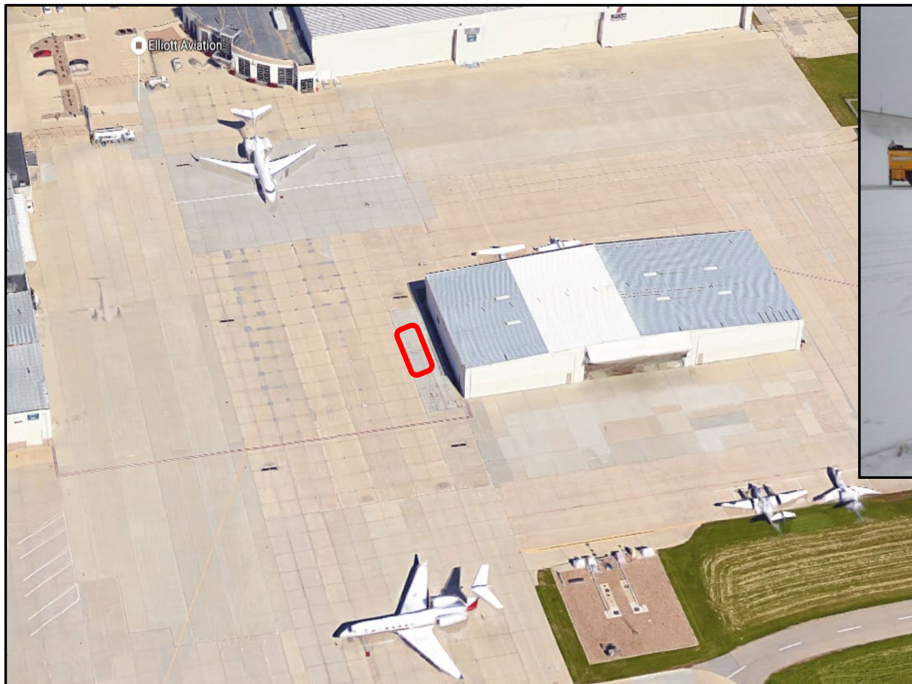
	HPS by natural gas
Analysis period	20
Capital cost	1,145,216
Operation and Maintenance (O&M) costs (annual	16,657
Benefits (annual)	169,358
Cost-benefit analysis of monetary costs and benefits for the entire analysis period	
Present value of costs	(1,321,681)
Present value of benefits	1,596,698
Net present value	275,017
Present value of cost (base case)	(7,006)
Benefit cost ratio	**1.208**
Incremental benefit cost ratio	**1.215**

- **Actual Data from GBM**
- **GBM provided comments**
  - **Cost associated with housing SRM**
  - **Terminal Cooling Savings**
  - **Utilities to Run System**

Above 1.0 = Cost Effective Investment

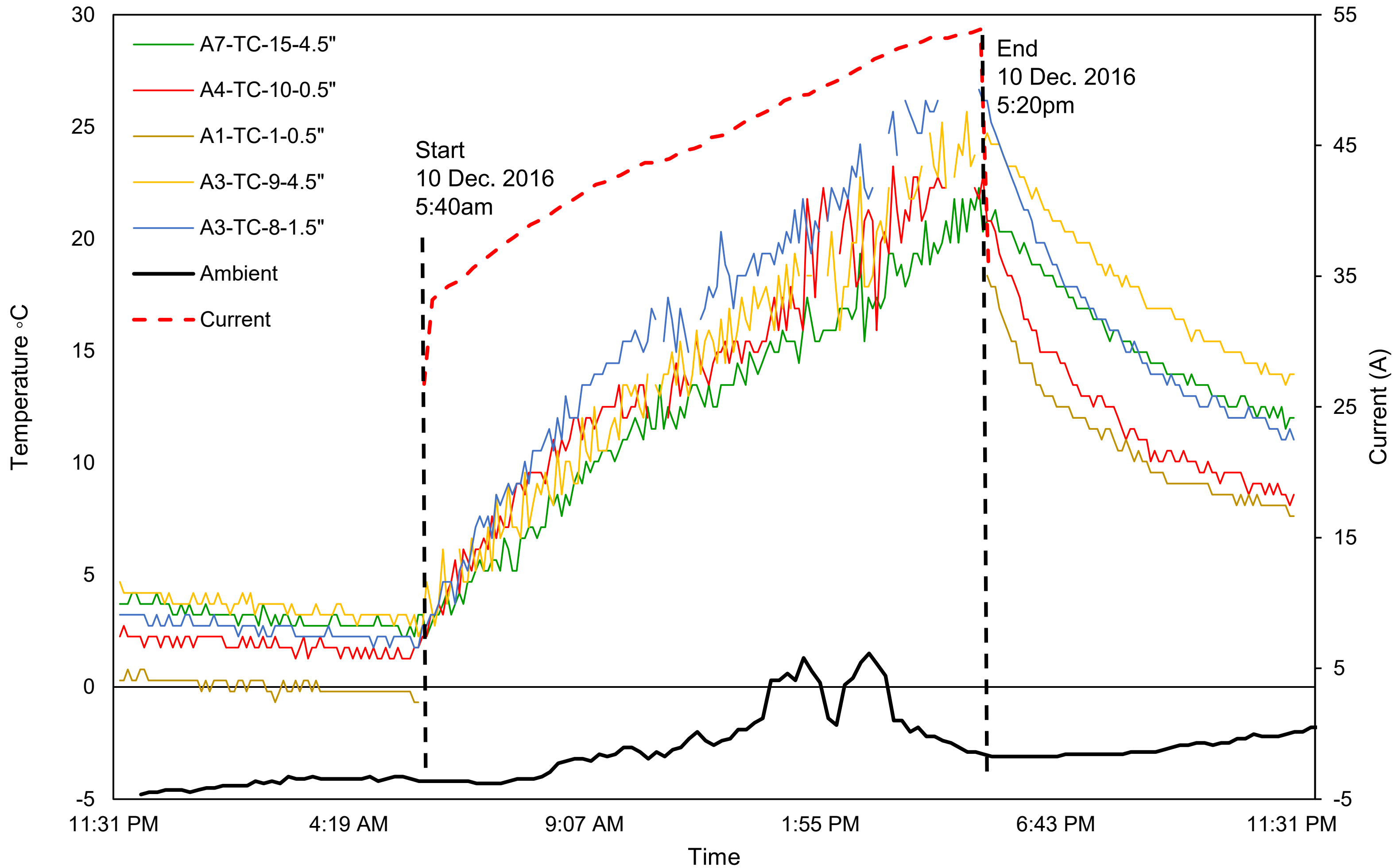
DSM Conductive Concrete

- Iowa State constructed 2 electrically conductive concrete slabs (15' x 13.5' x 7.5") at DSM airport
- Mix Design closely followed our 10-G specifications and construction was completed in November 2017



December 10, 2016:
1.0 inches of snowfall at average 25ºF
8 mph winds.
System on at 5:40AM to 5:20PM

DSM Conductive Concrete

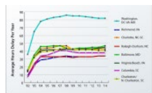


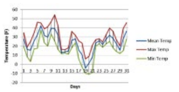
DSM Conductive Concrete

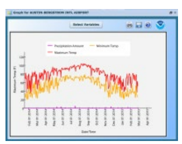
Data collection

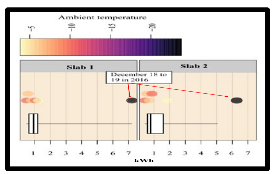
•Construction and actual operation measurements from DSM airport

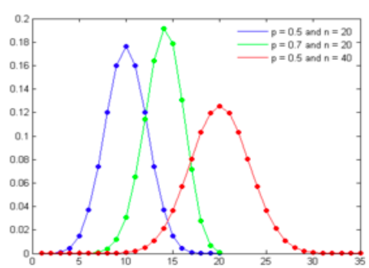
Data analysis



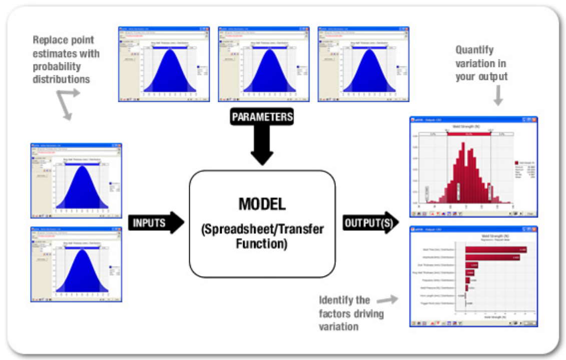




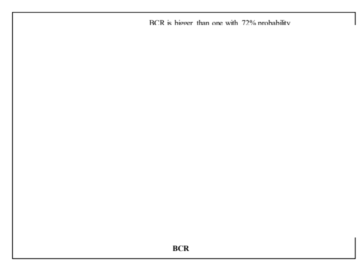




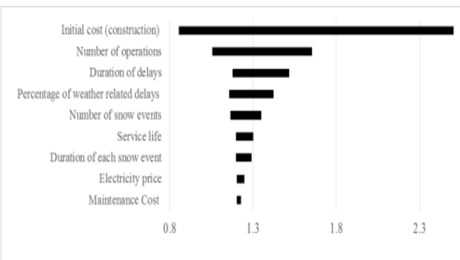
Benefit-Cost Ratio & Developing LCCA framework

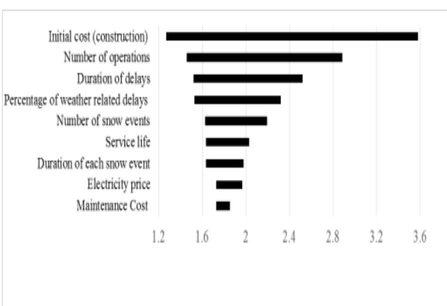


•Monte Carlo simulation based Life cycle cost analysis framework



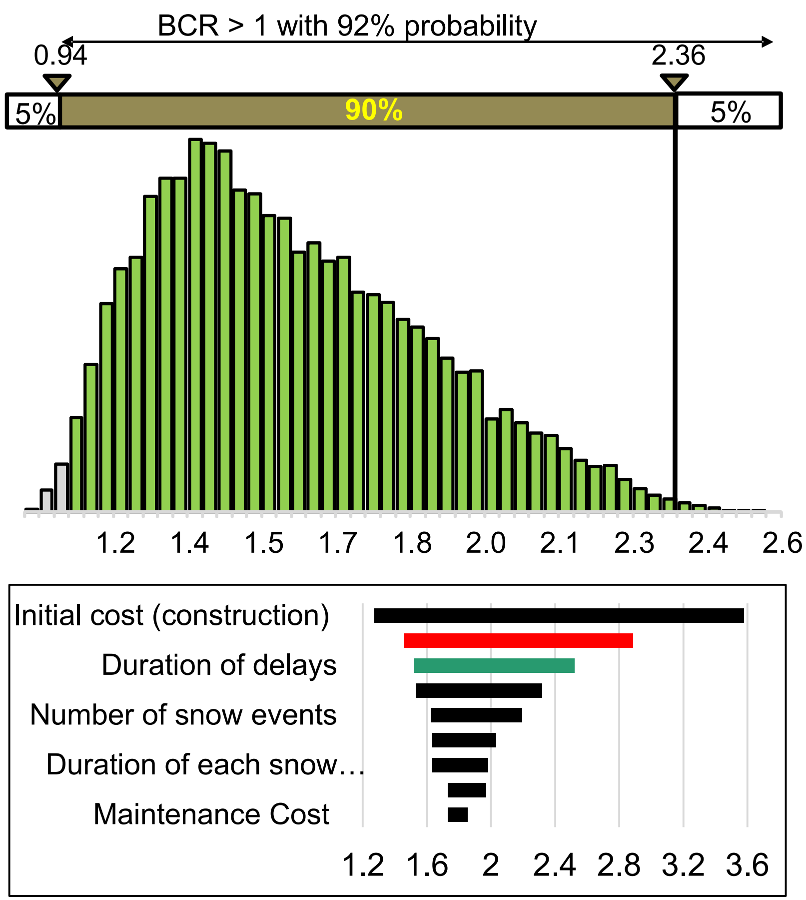
Stochastic sensitivity analysis



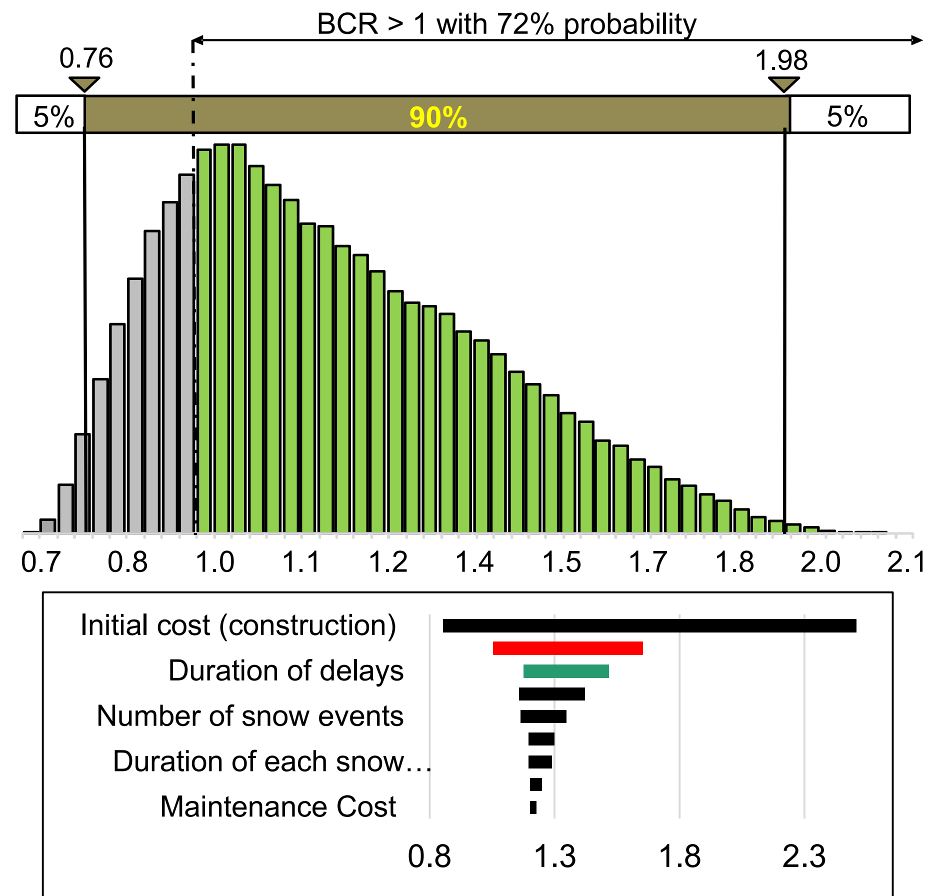


Benefit-Cost Ratio (BCR)

Large Hub - MSP



General Aviation- DSM

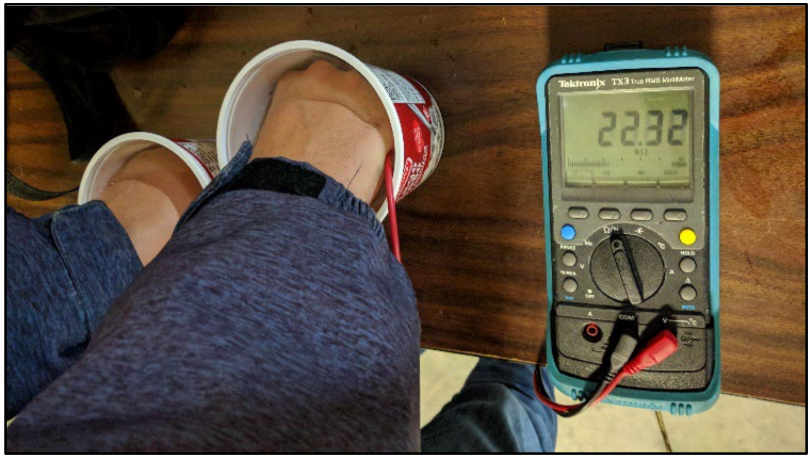


Electrical Safety Risk

Human health is at risk if 20 mA goes to the heart (the National Institute for Occupational Safety and Health)

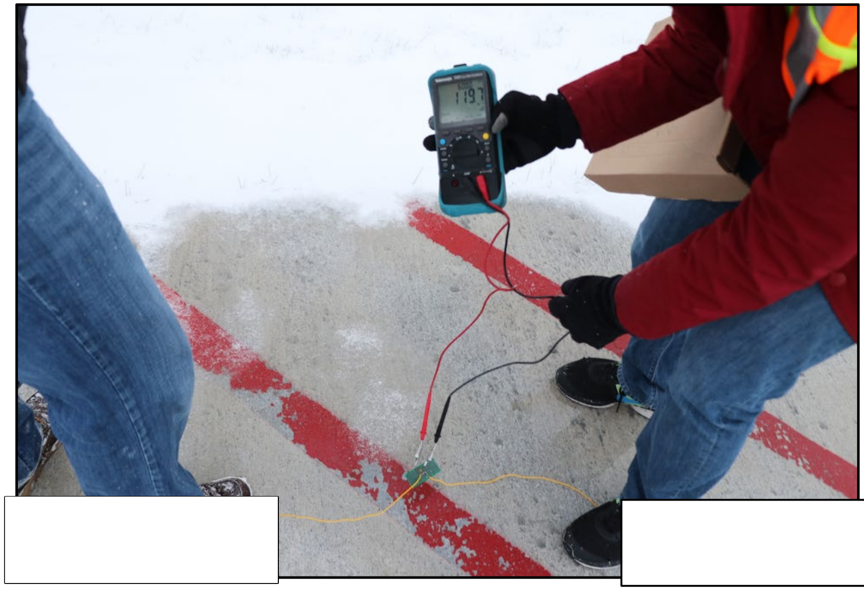
Measuring the resistance of human hands in water and salt water

- Lowest resistance was approximately 22 kΩ



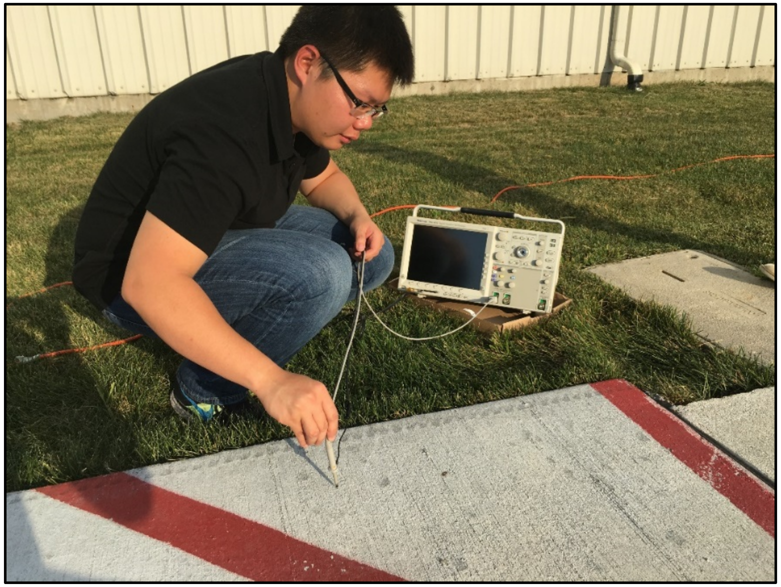
Field tests conducted on DSM HPS slabs during operation under 2 to 3 inches of snow event in December 29, 2017

- The measured current values < 20 mA of pre-set threshold
- Using a 22kΩ - 5.44 *m*A
- Using a 10kΩ - 9.72 *m*A

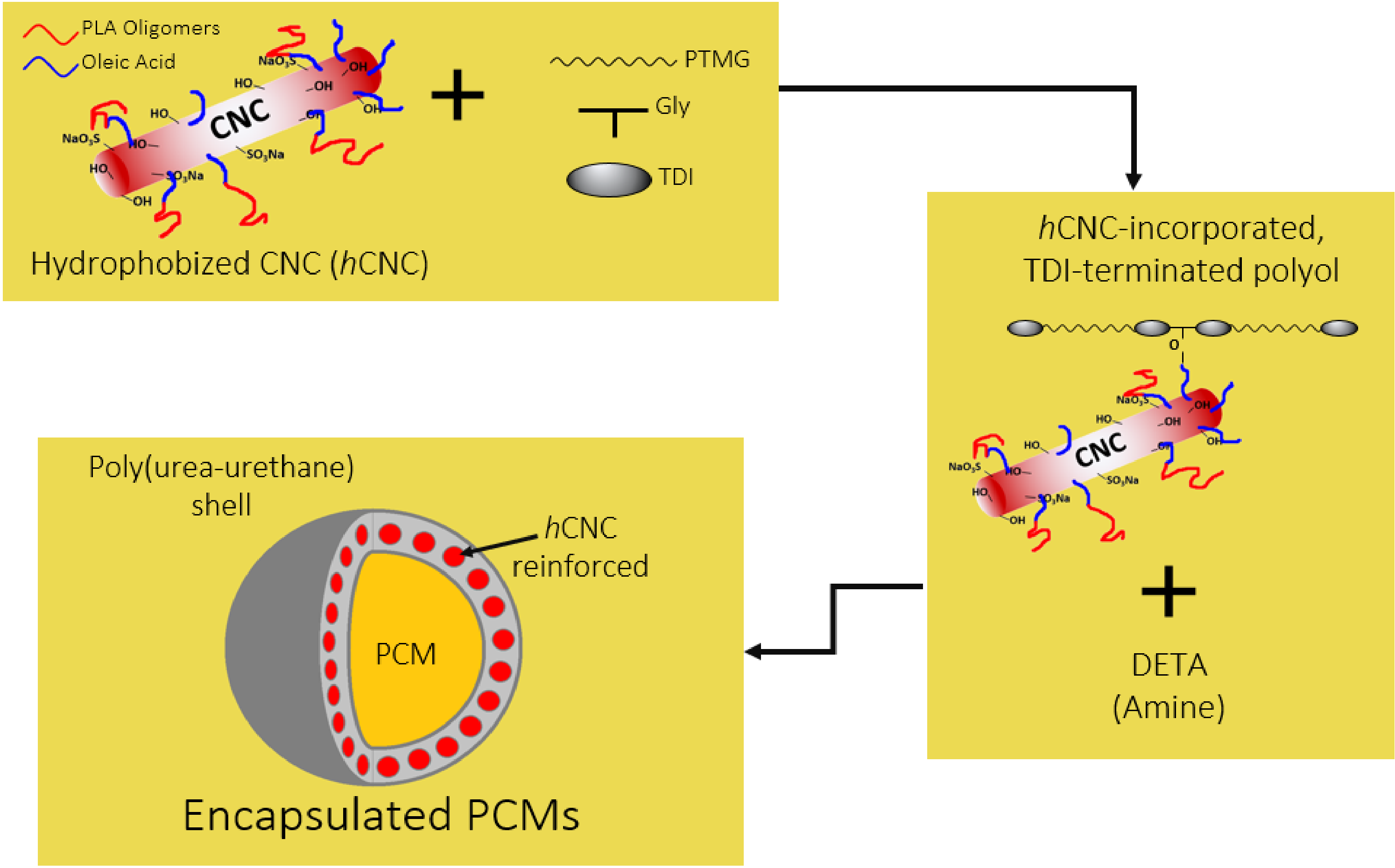


Radio Frequency Test

- Radio frequency ranges used in airports: 3 kHz to 300 GHz
- Frequencies of electrical signal produced during ECON slab operations are always lower than 60 Hz
- HPS will not create radio frequency interference



Phase Change Materials



CNC-Reinforced PCM-Core Microcapsules

Phase Change Materials

Sample Preparation and Measurements	Status
Hydrophobize CNCs	Done
Fabricated 620 grams of PCM microcapsules	Done
Mechanical properties of the microcapsules	Partially Done
Thermal properties of the microcapsules (DSC and TGA)	Partially Done
Prepare PCM/asphalt samples with 0, 2.5, 5 and 7.5 wt% conc.	
Rotational viscometry	
Dynamic Shear rheometer	
Rolling thin-film oven	
Pressure aging vessel	
Bending beam rheometer	
Marshall testing	
Low guarded comparative calorimetry (LGCC)	

Future Heated Pavement Projects

- **Continue to Monitor Financial Viability of Heated Pavements Systems**
- **Perform Full Scale Implementation of Phase Change Materials**
- **Electrically Conductive Asphalt Concrete for Heated Airfield Pavements**
  - Snow and ice removal from electrical heating. Health monitoring from sensing capacity and self healing from induction heating
- **Superhyrophobic and 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)
- **Focus on Full scale airport heated pavement testing at <u>Airports.</u>**
  - PCM Concrete slabs at Purdue University Airport.
  - Superhydrophobic coatings at DSM Airport.
  - Full economic and sustainability analysis of construction, maintenance and operation costs would be performed.
- **Advisory Circular 150/5370-17 Update**
  - Larger scale partnerships to construct Heated Pavement systems

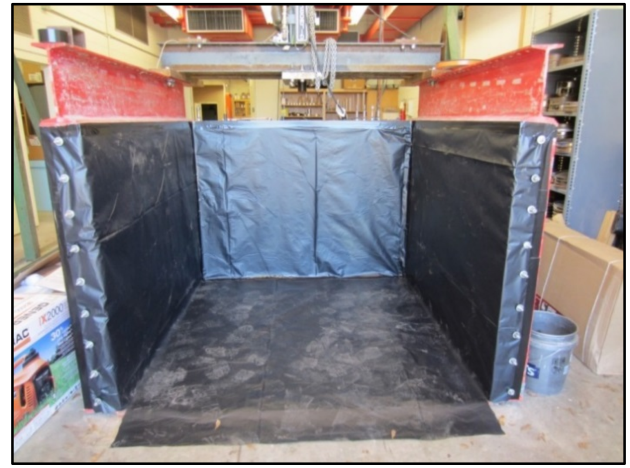
Geosynthetics

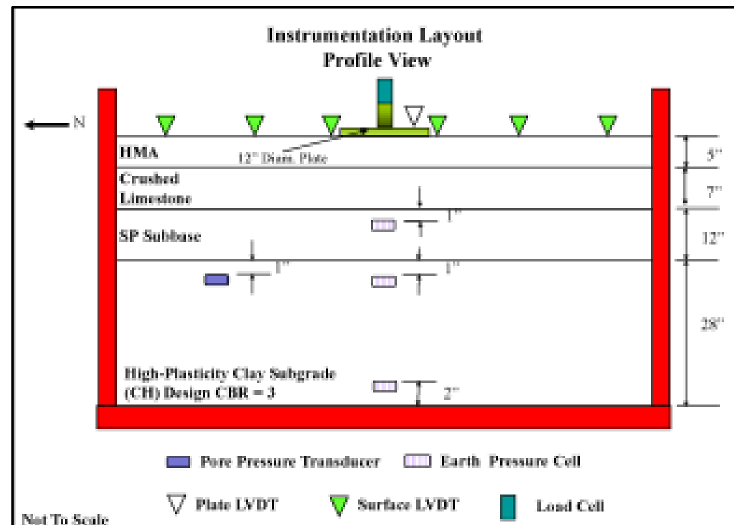
U.S. Army Corps of Engineers at Vicksburg

- **Completed Phase 1 Cyclic Plate Load tests**
  - Final draft is under review for publication
- **Awarded Phase 2 Cyclic Plate Testing of Geosynthetics**
  - 24-month period of performance
  - Geotextiles positioned at subgrade/subbase interface
- **Materials Selected**
  - Tensar BX1200
  - Tensar TX 140
  - Huesker Fornit 40/40
  - Tencate RS580i
- **Quantify Benefit of Material**
  - Traffic Benefit Ratio:

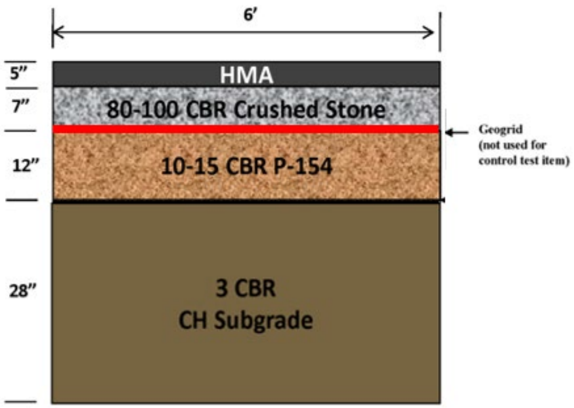
$$TBR = \frac{Cycles\ to\ failure\ of\ reinforced}{Cycles\ to\ failure\ of\ unreinforced}$$

- **Predictive Models**
- **Recommend Specification**



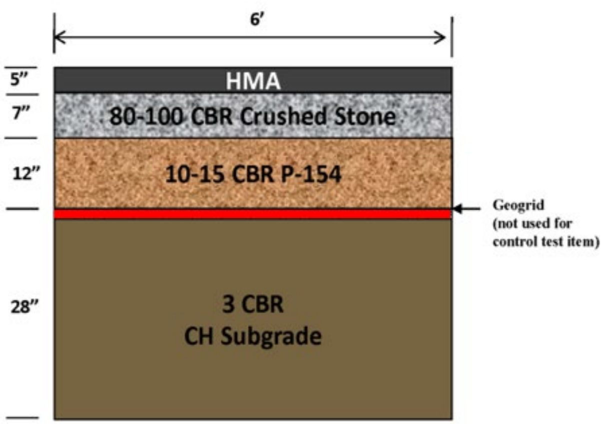


Geosynthetics



Phase I – Base/Subbase

Phase 1	Test Item	Cycles @ 1" Deformation	Cycles @ 2" Deformation	TBR @1" Deformation	TBR @2" Deformation
Geosynthetic on subbase	*Control w/Sand*	304	1,278	1	1
	BX1200	6,322	25,960	20.8	20.3
	TX140	1,000	4,304	3.3	3.4
	Fornit 30	9,024	34,901	29.7	27.3

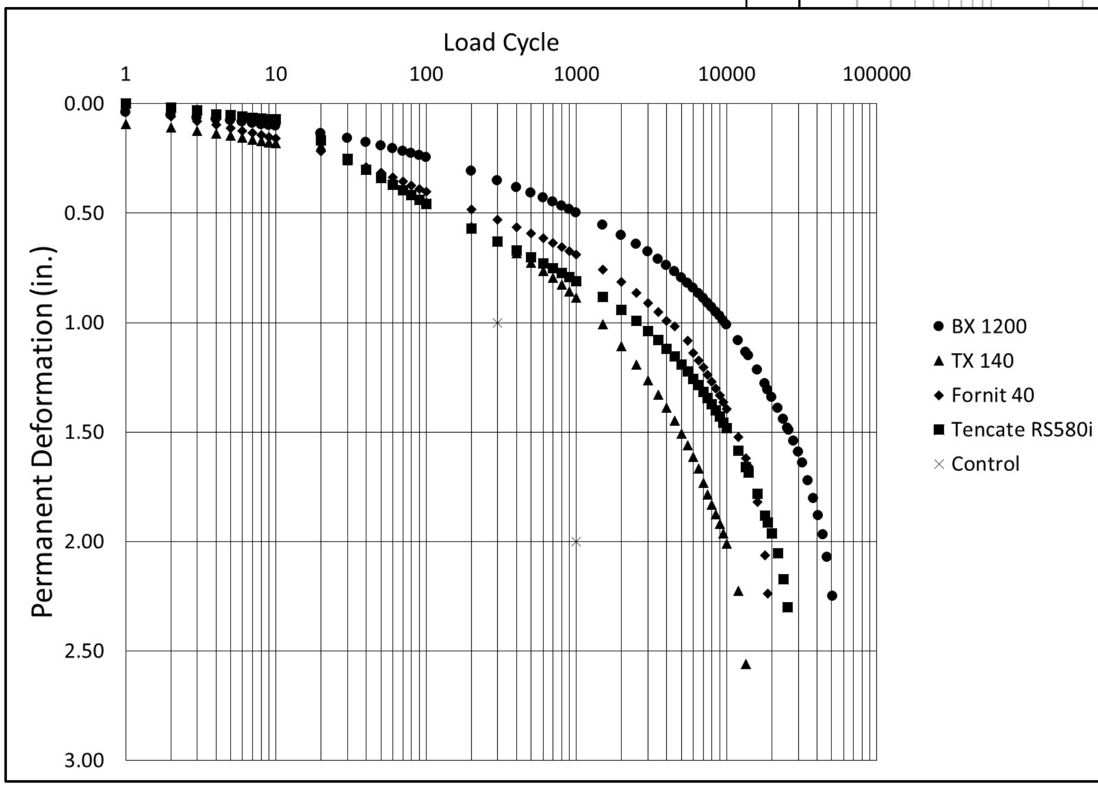


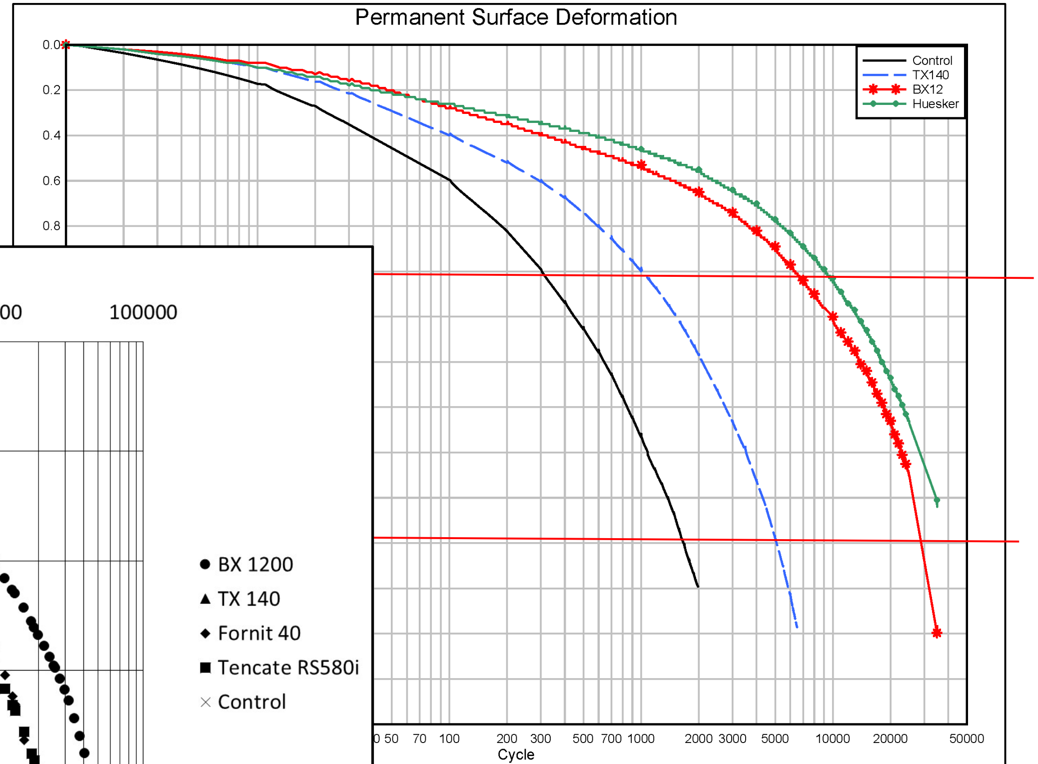
Phase II – Subbase/Subgrade

Phase 2	Test Item	Cycles @ 1" Deformation	Cycles @ 2" Deformation	TBR @1" Deformation	TBR @2" Deformation
Geosynthetic on subgrade	*Control w/Sand*	304	1,278	1	1
	Control w/LMS	150,720			
	BX1200	9,720	44,960	32.0	35.2
	TX140	1,460	9,890	4.8	7.7
	Fornit 40	4,100	17,600	13.5	13.8
	RS580i	2,575	20,830	8.5	16.3

Geosynthetics

Phase II – Subbase/Subgrade



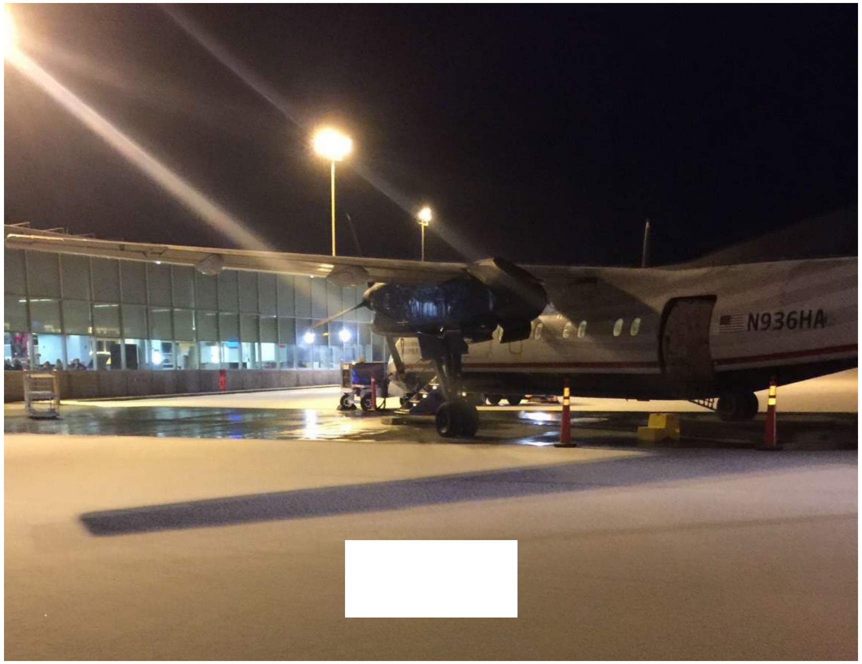


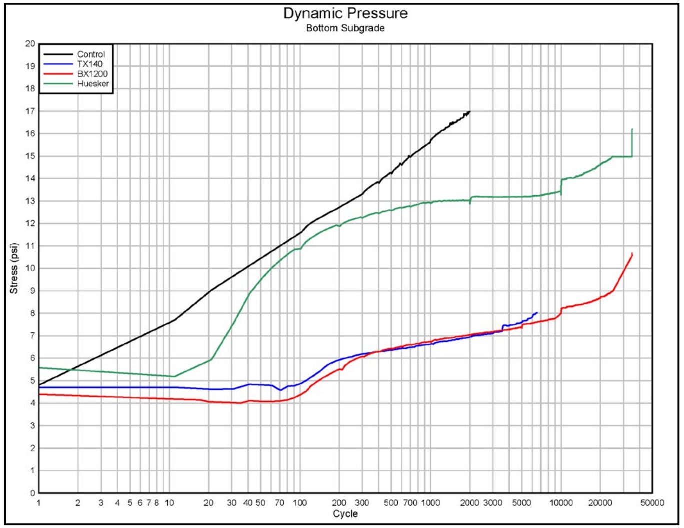
Phase I – Base/Subbase

Geosynthetics

- **Geosynthetics Materials Association (GMA) – Overview**
  - Literature Review
    - current industry research on applications of Geosynthetics
      - Soil Stabilization
      - Unbound Aggregate Layer Reinforcement
    - Presentation of Literature Review to FAA October 6, 2016
  - Establish draft specification for use of Geosynthetics
    - Goal - Incorporate into AC 150/5370-10H Update
  - Obtain/Analyze data through full scale testing
    - Current CC9 design includes two cross-sections with Geotextile/Geogrids
  - Modify Specifications for Pavement Design/Construction based on full scale testing results.
    - Goal – Include geotextile/geogrid material properties into design software

Your Feedback is Encouraged





Questions