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SWIFT 2014

EXTENDED SERVICE LIFE FOR AIRPORT PAVEMENTS

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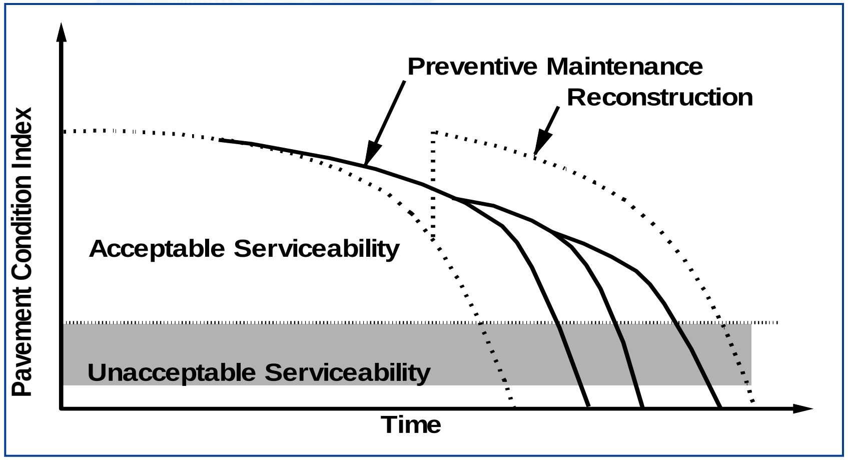
APPLIED RESEARCH ASSOCIATES, INC.
An Employee Owned Company

Objective of Presentation

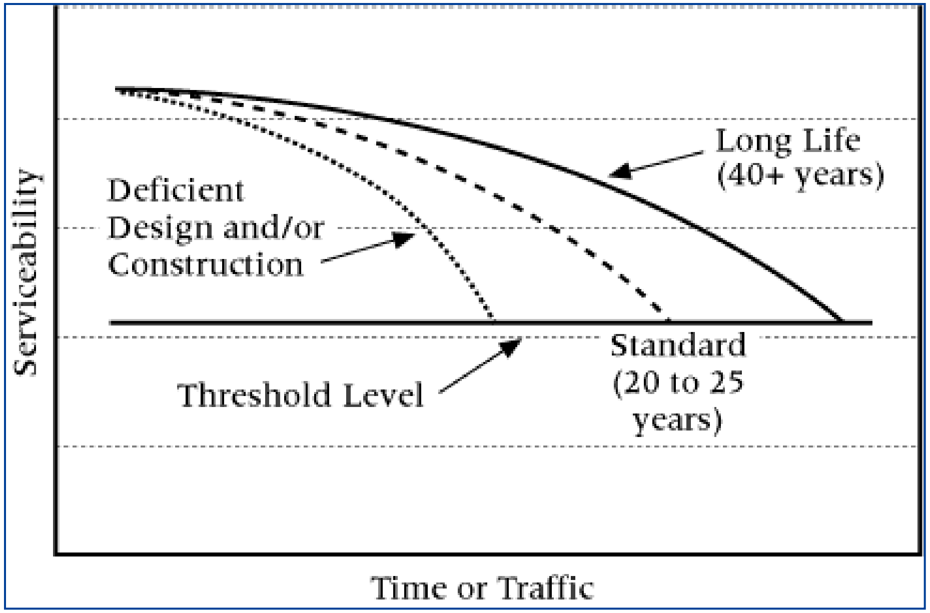
- **Discuss Issues Relating To Extended Pavement Life**
  - How can pavement service life be extended beyond the current 20-year design life?
- **Items Related to Longer Pavement Life**
  - Design Thicknesses
  - Subsurface Drainage
  - Traffic Operations
  - Climate
  - Durability (Quality of Materials)
  - Plans and Specifications
  - Construction Processes
  - Quality Control/Quality Assurance
  - Maintenance Practices

Concept of Longer Service Life



- Pavements deteriorate with time through development of a range of distresses
- Pavement life can be extended with proper maintenance
- Deterioration ultimately reaches a level of unacceptable serviceability

- Current FAA design is typically for a 20-year pavement life
- Some pavements last longer than 20 years while others fail prematurely
- What factors impact extended pavement service life?



Design Thickness

- **Structural Thickness is Key to Providing Load Support**
- **What is Adequate Thickness for 40-Year Life?**
  - Theoretical analysis with FAARFIELD
  - Performance Data from In-Service Pavements
  - May not require significant increase
- **Design Models Must Represent Performance**
- **Design Inputs Clearly and Accurately Defined**
- **Non-Uniform Conditions Produce Failures**
- **Changes Due to Climate and Traffic**

Design Thicknesses

Rigid Pavement Design Issues

- PCC Surface Layer Spreads Load Stresses
- Tensile Strength of PCC Must Be Greater Than Applied Tensile Stress
  - Subgrade Support (over life expectancy)
  - Tensile Strength of PCC
  - Traffic Load Distribution (over design life)
  - Load Transfer at Joints
  - Climatic Factors

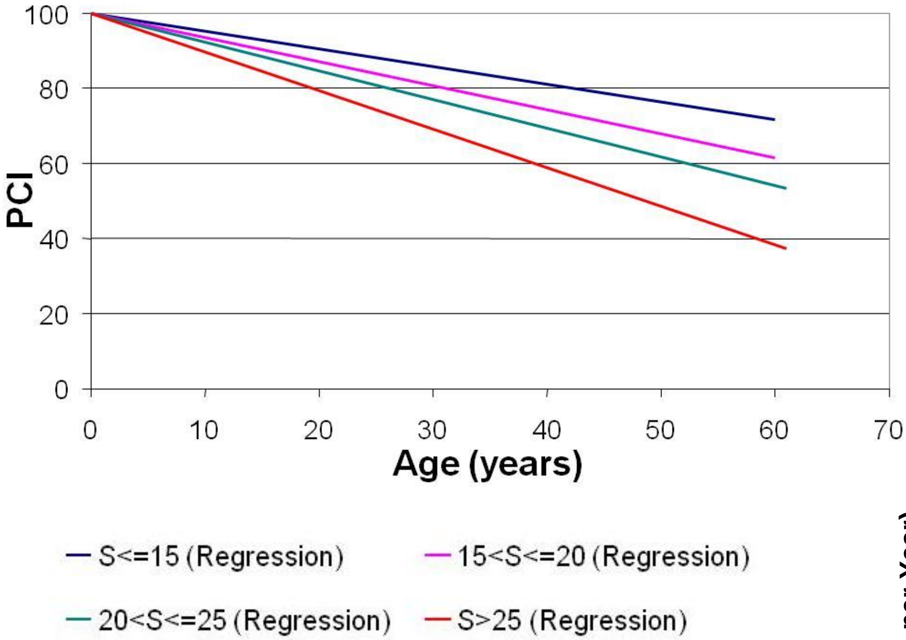
Design Thicknesses

- **Flexible Pavement Design Issues**
  - Structural Layers Distribute Load and Protect Subgrade (from shear failure)
  - Layers Consecutively Stronger from Subgrade to Pavement Surface
  - Design for Lowest Expected Subgrade Strength (soaked CBR?)
    - Subgrade Strength
    - Traffic Load Distribution (over design life)
    - Quality of Pavement Layers
    - Climatic Factors

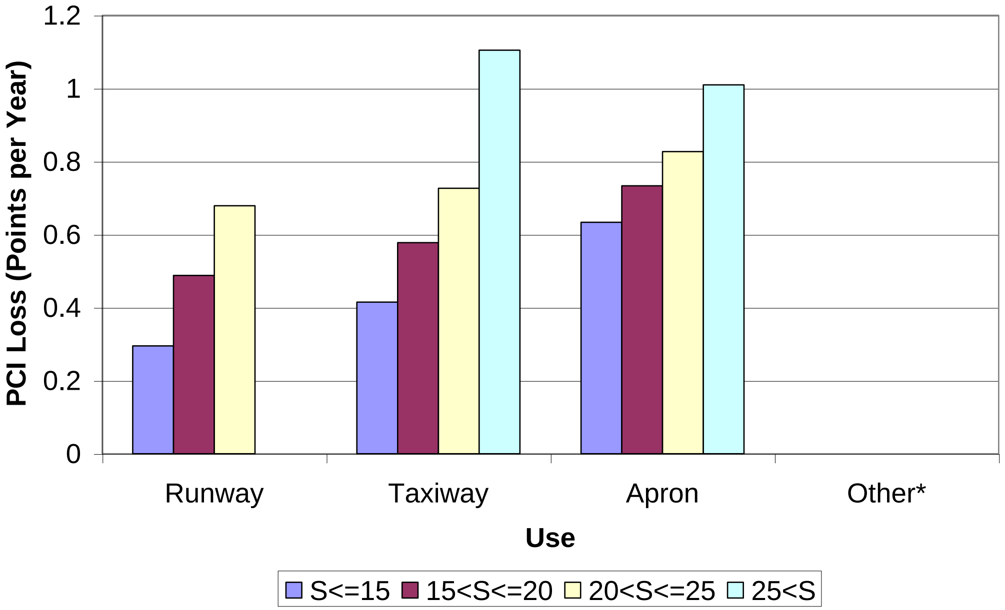
Geometrics of PCC Slabs

- **Joint Spacing Related to Cracking**
  - FAA Recommends Maximum of 20 ft Joint Spacing
  - Performance function of climate, concrete aggregate type, slab thickness
- **Warping and Curling Stress**
  - Higher on Stiffer Substrates
  - Higher Stresses on Larger Slabs
  - Affected by Climatic Locale
- **Early Age Cracking**
  - Some Effect From Slab Dimensions
  - Impacted by High Flexural Strength and Rapid Rate of Strength Gain
  - Affected By Weather Condition During Construction
  - Influenced By Type of Cementitious Materials

Joint Spacing Impacts Performance



- **Large Slabs May Result in Cracks That Impact Performance**

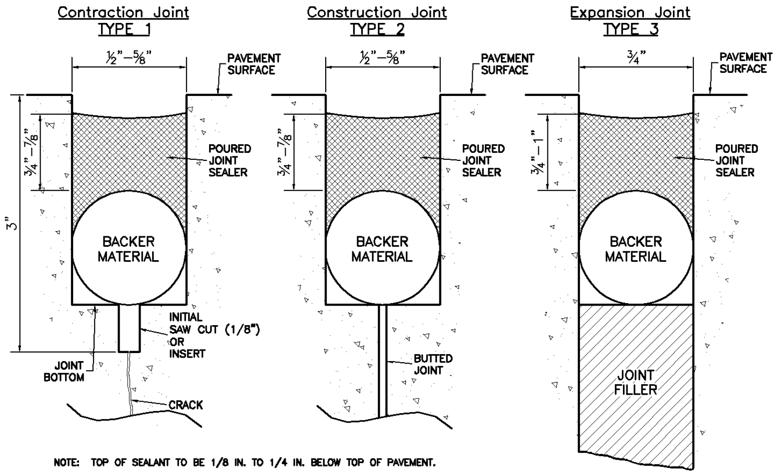


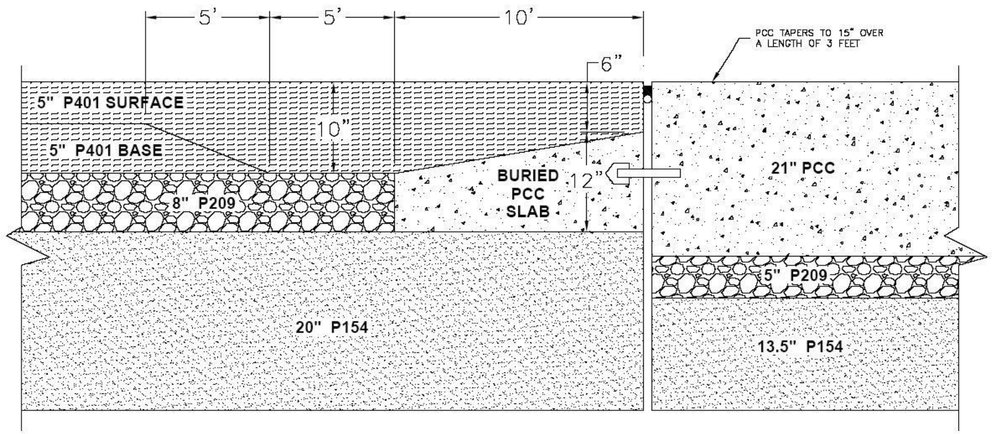
Joint Design and Load Transfer

- **Joint Design Determines Load Transfer**
  - Design typically assumes 75% load transfer
  - Aggregate Interlock Reduced When Slabs Shrink (curing and cold weather)
  - Shorter Joint Spacing Ensures Higher Load Transfer
- **Joint Types**
  - Construction Joints – Typically Doweled
  - Contraction Joints – Doweled or Undoweled
  - Expansion (Isolation) Joints
- **Doweled Joints – both directions?**
  - Military Airfields Dowel Only Longitudinal Joints on Runways and Taxiways
  - Aggregate Interlock Adequate for Transverse Joints on Taxiways and Runways?

Joint Design and Load Transfer

- **Beveled Edges**
  - Prevents Minor Edge Spalling (Sliver Spalls)
  - Improves Joint Performance
- **Joint Sealant Selection**
  - Hot Poured
  - Cold Poured
  - Preformed
  - Correct W/D Ratio for Sealant
- **Junctures Between AC and PCC**



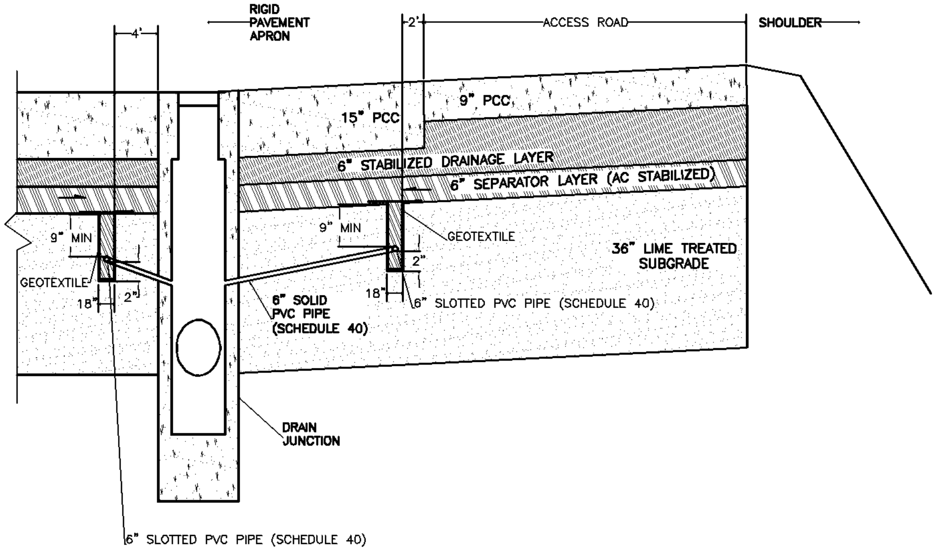


Subsurface Drainage

- The old adage "water, water, and water" (Harry Cedergren)
- Subgrades naturally increase in moisture
  - Reach approximately 85 to 90 percent saturation after 3 years
  - Equilibrium moisture tends to be near Plastic Limit
  - Free water can reduce subgrade support (to 100% saturation)
  - Loss of subgrade support leads to structural distresses

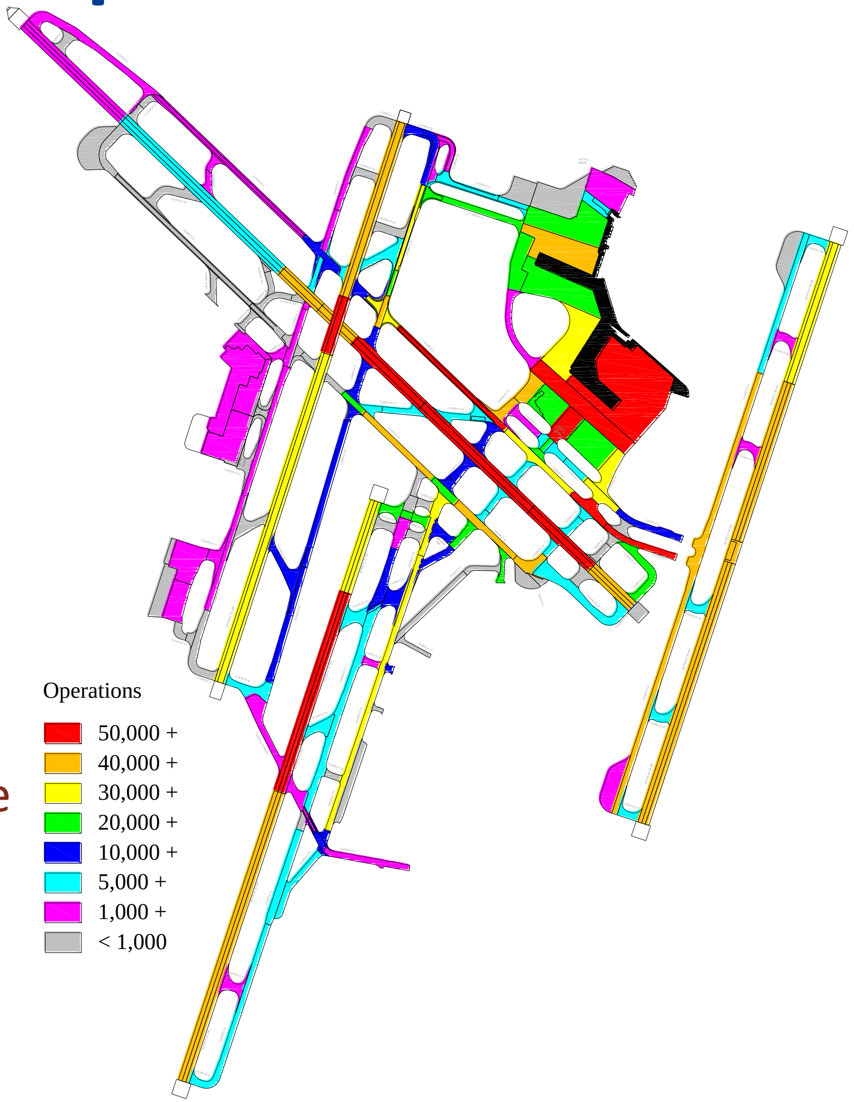
Subsurface Drainage

- **Subsurface drainage systems remove free water**
  - Water infiltrates into pavement structure
  - Design for permeability of 1,000 fpd
  - Typical Design to Remove 85% Free Water in 24 Hours
  - Separation Layer Prevents Migration of Subgrade Fines Into Drainage Layer
- **No official FAA guidance on subsurface drainage**



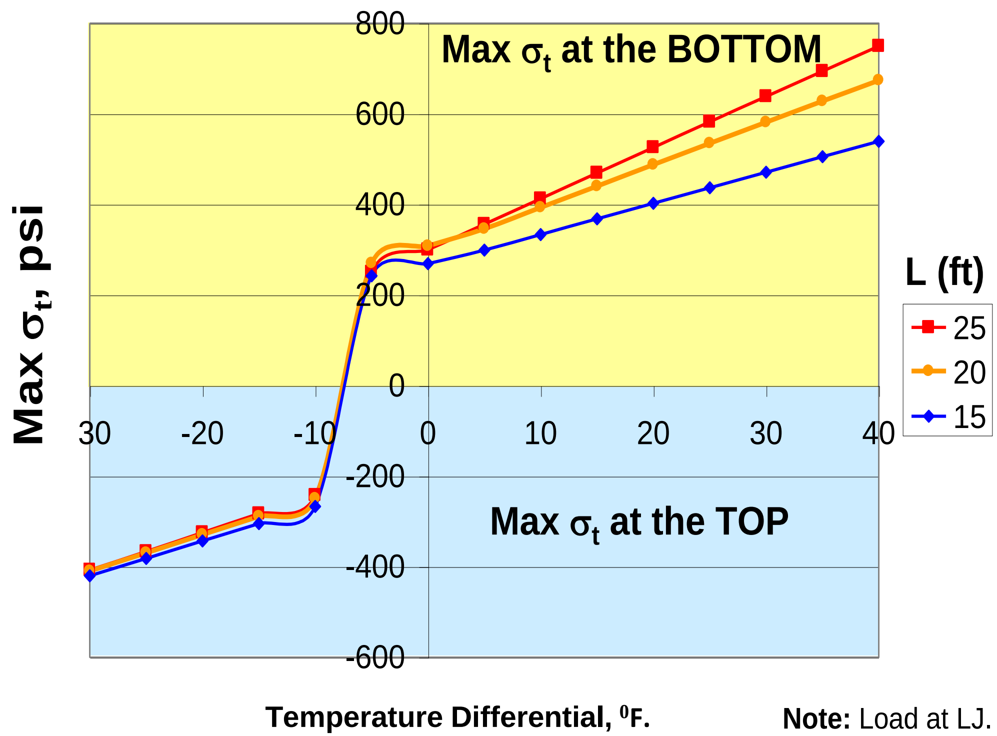
Traffic Impacts

- **Aircraft Variables**
  - Aircraft Types
  - Gross or Operating Loads
  - Annual Operations
- **Traffic Distribution**
  - Operations on Each Airfield Feature
  - Take-off and Landing Directions
- **Lateral Wander**
  - Based on studies in 1970's
- **Design for Actual Traffic**
  - Expected Traffic Over Life of Feature
  - What Traffic after 20 Years?



Climate Impacts

- **Climatic Zones**
  - Wet Freeze
  - Wet No-Freeze
  - Dry Freeze
  - Dry No-Freeze
- **Design for Freeze-Thaw (not well understood)**
- **Design Methodology Should Consider Impacts of Climate**
  - Daily Temperature Differentials
    - Large Differentials Produce High Warping Stresses
  - Seasonal Variations in Structural Support
  - High Moisture During Spring Thaw



Durability of Materials and Mixes

- **Durability Related to Quality of Materials**
  - Likely Biggest Issue for Long-Term Performance
  - Specifications Must Address Material Quality
- **Mix Designs**
  - Quality Mixes (PCC, AC, Stabilized Materials) Critical to Long-Term Performance
  - Responsibility of Contractor versus Owner Developed Mix Design
  - PG Grades and Polymer modified asphalts improve temperature susceptibility and increase shear strength of Asphalt Mixes
  - Concrete Mix Designs for Workability and Coarseness
  - Must Consider Alkali Silica Reaction and other Detrimental Reactions
- **Aggregate Sources versus Specifications**
  - Quarry with History of Quality Aggregate Production
  - Quality Sand
  - Limit Sand in Asphalt Mixes
  - Coarse Aggregate Impacts Performance

Plans and Specifications

- Plans Must Reflect the Design
- Plans Show Contractor What is to be Constructed
  - Details and Dimensions Important for Clear Understanding
- Specifications Describe Requirements and Processes for All Aspects of Construction
- Plans and Specifications Must be Coordinated (not contradictory)

Construction

- Poor Construction Practices Major Cause of Early Distresses
- Variability versus Uniformity
  - Subgrade
  - Material Quality
  - PC and AC Mixes
- Poor Practices (Workmanship)
  - Hand finishing PCC Resulting in Scaling
  - Segregation of Asphalt Mixes
  - And the list goes on ………..
- Inadequate Equipment
  - Mixing Plant Operations
  - Laydown and Placement
  - Finishing
  - Vibrators
  - Rollers
  - And the list goes on…………
- Improved Specifications
- Warranties on Work

Quality Control/Quality Assurance

- **Contractor Responsible for Quality Control of Construction**
  - Contractor Quality Control (CQC) Plan
  - Qualified QC Staff
  - Qualified CQC laboratory
  - Daily Reports on Production Quality
- **Owner Responsible for Quality Assurance**
  - Full-Time Inspection by Qualified Independent Source
  - Sampling and Testing to Ensure Compliance with Specifications
  - Survey Checks (Dimensions, locations, offsets, grade, etc)
  - Coordination with Owner and Contractor

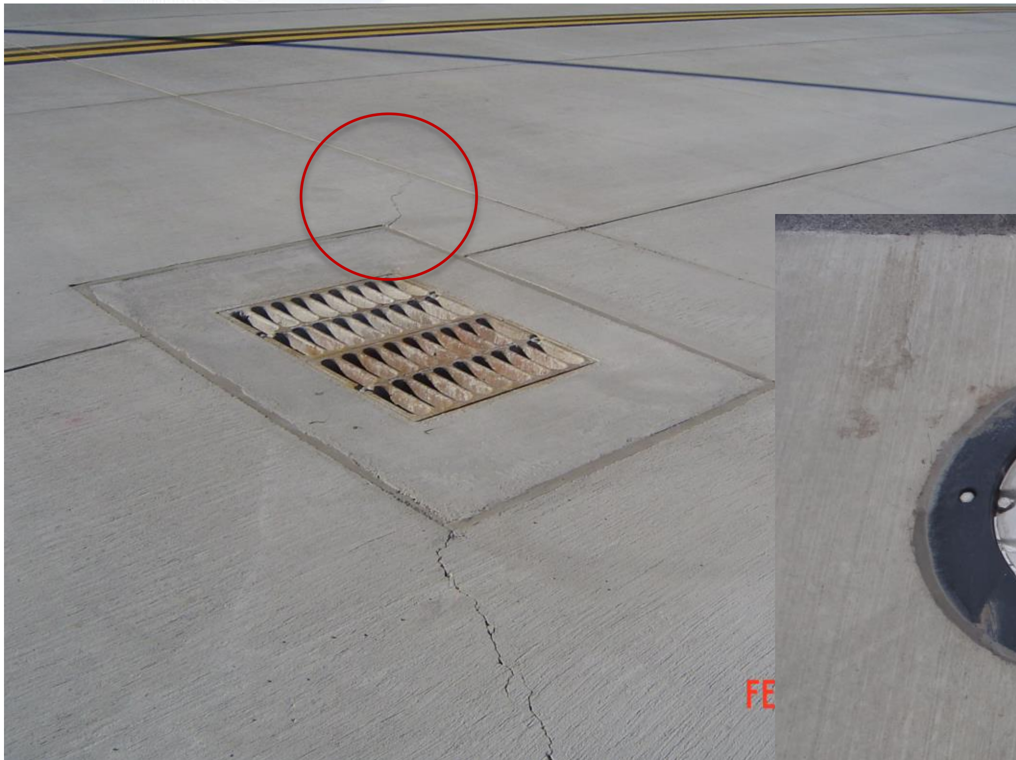
Improper Dowel Alignment/Spacing

Contractor Boo -Boos

Construction of Asphalt Pavement

- Mix Properties Critical
- Poor Compaction of Longitudinal Joints Results in Raveling & Cracking

Light Fixtures and Drainage Structures



Effective Maintenance

- Timely Maintenance Retards Rate of Deterioration
- Rigid Pavements
  - Timely Spall Repairs
  - Effective Patching Materials
  - Crack Sealing
  - Joint Resealing
  - Slab Replacements
- Flexible Pavements
  - Crack Seals
  - Patches
  - Mill and Overlay
- Surface Characteristics
  - Friction – Rubber Removal, Polishing Aggregates
  - Grooving
  - Roughness

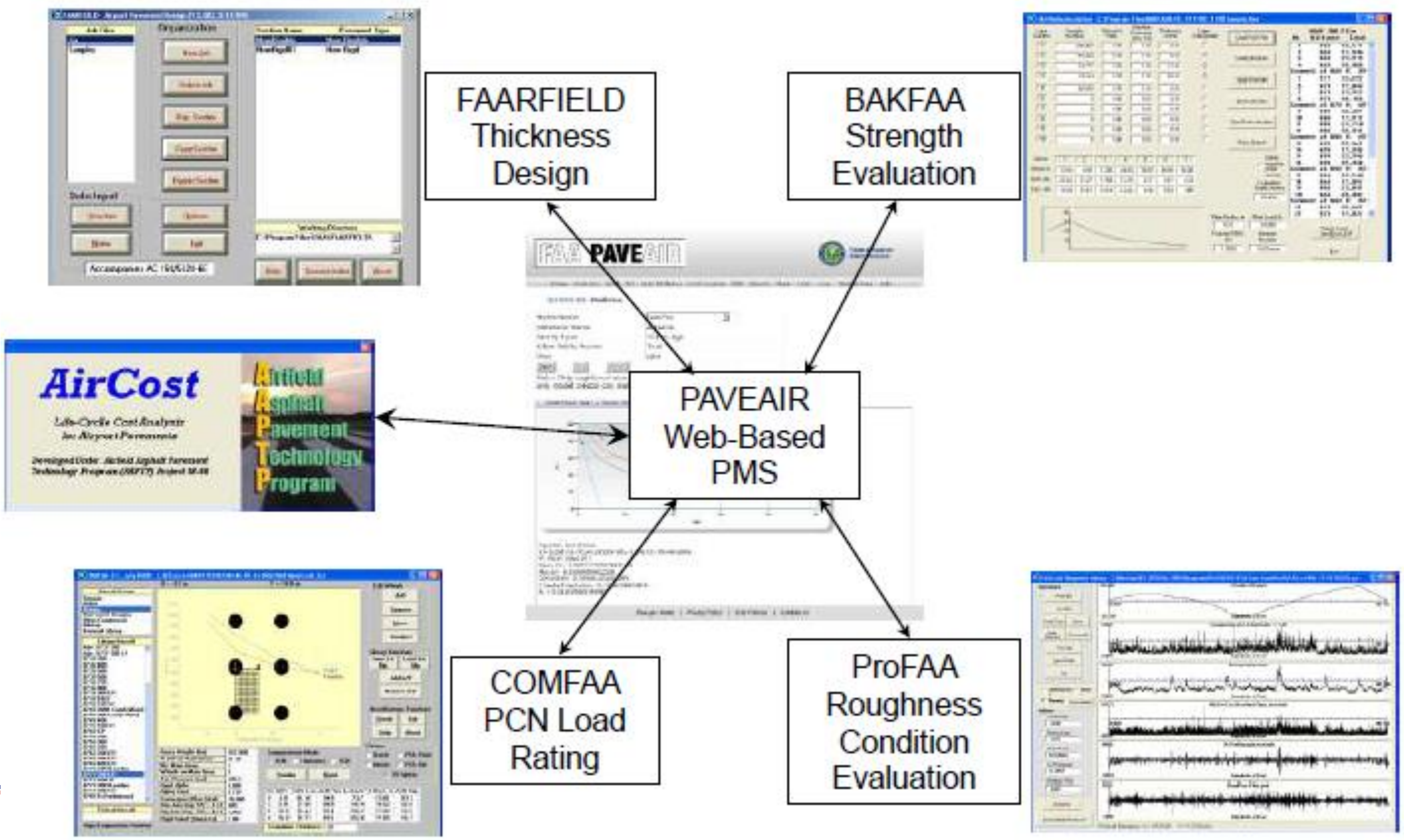
FAA PAVEMENT DESIGN STUDY

- **FAA is committing $35 million to improve pavement design procedures over the next 10 years**
- **Planned study projects include:**
  - Extending Design Life to 40 Years for Airport Pavement
  - Semi-Accelerated Full-Scale Rigid Pavement Test
  - Validated Reflection Cracking Model for HMA Overlay Design
  - Failure Criteria for Top-Down Cracking in Rigid Airport Pavement
  - FAARFIELD-Based ACN/PCN Methodology
  - New LCCA Integrated Design Procedures

FAA 40-YEAR DESIGN STUDY

OBJECTIVE OF RESEARCH

- Extend Design Life from current 20-years to 40-years
- Research to improve pavement performance at large hub airports



FAA 40-YEAR DESIGN STUDY

APPROACH

- Select runways for performance data collection
  - < 3 years of age; PCC and AC
  - > 20 years of age; PCC and AC
  - New runways for future performance monitoring
- Runways for historical data only
- Runways for both historical data and new field/laboratory testing
- Use the data to improve life cycle models

AC RUNWAYS SELECTED FOR DATA COLLECTION

Airport Code	Airport Name	Runway	Pavement Type	Pavement Age, yrs	Field Tests
CMH	Port Columbus International	10L-28R	Flexible	>20	Yes
BOS	General Edward Lawrence Logan	04L-22R	Flexible	>20	Yes
CMH	Port Columbus International	10R-28L	Flexible	<3	Yes
GSO	Piedmont Triad International	5L-23R	Flexible	3	Yes
BWI	Baltimore–Washington	10-28	Flexible	>20	Yes
SFO	San Francisco International	10L & 10R	Flexible	>50	No
TUS	Tucson International	11L-29R	Flexible	>20	No
TUS	Tucson International	03-21	Flexible	<3	No
LGA	LaGuardia	4-22	Flexible	>20	No

PCC RUNWAYS SELECTED FOR DATA COLLECTION

Airport Code	Airport Name	Runway	Pavement Type	Pavement Age, yrs	Field Tests
IAD	Washington Dulles	01R-19L	Rigid	>20	Yes
IND	Indianapolis International	5R-23L	Rigid	23	Yes
SEA	Seattle-Tacoma International	16R-34L	Rigid	<3	Yes
ORD	Chicago O'Hare International	10C-28C	Rigid	<1	Yes
IAD	Washington Dulles	01C-19C	Rigid	<3	No
IAH	Houston Intercontinental	9-27	Rigid	<3	No
SEA	Seattle-Tacoma International	16C-34C	Rigid	>20	No
LAX	Los Angeles International	6R-24L	Rigid	26	No
MCO	Orlando International	17R	Rigid	24	No

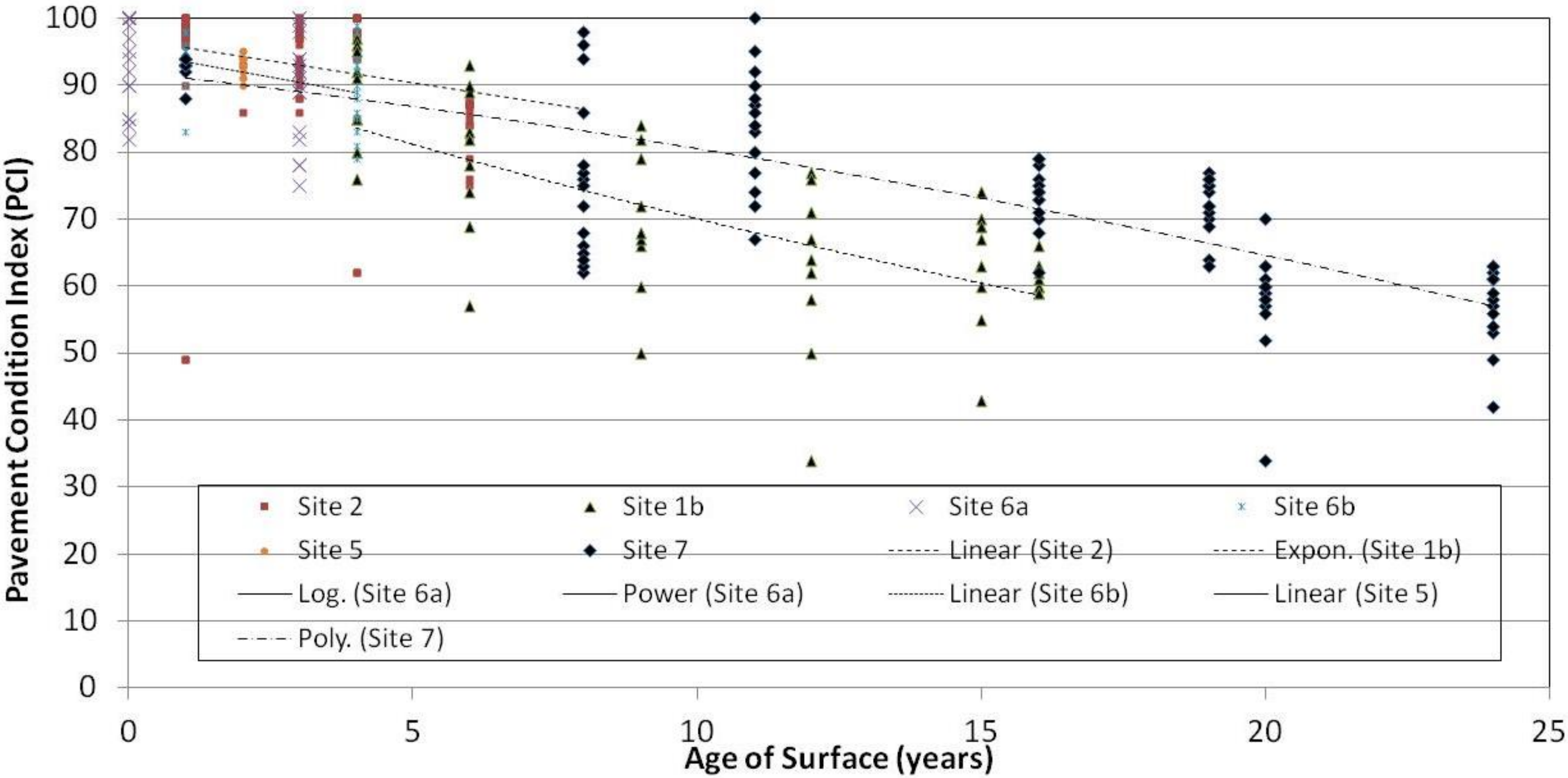
HISTORICAL DATA COLLECTION

- **ORIGINAL DESIGN DATA**
  - Design Reports
  - Geotechnical Investigation Reports
  - Plans and Specifications Design
- **CONSTRUCTION DATA**
  - Quality Control Test Data
  - Mix Designs
  - Material Types and Properties
  - Subgrade Type and Strength
- **TRAFFIC DATA**
  - Aircraft Used in Original Design
  - Current Aircraft - Aircraft Types and Weights, Number of Operations, Take-off and Landing Directions
- **PAVEMENT MANAGEMENT/EVALUATION STUDIES AND DATABASES**
  - MicroPAVER Databases Converted To PaveAir
  - Structural Evaluations
  - Friction Measurements
- **MAINTENANCE RECORDS AND COSTS**
  - Maintenance activities, timing of maintenance, triggers for maintenance
- **WEATHER/CLIMATE DATA**

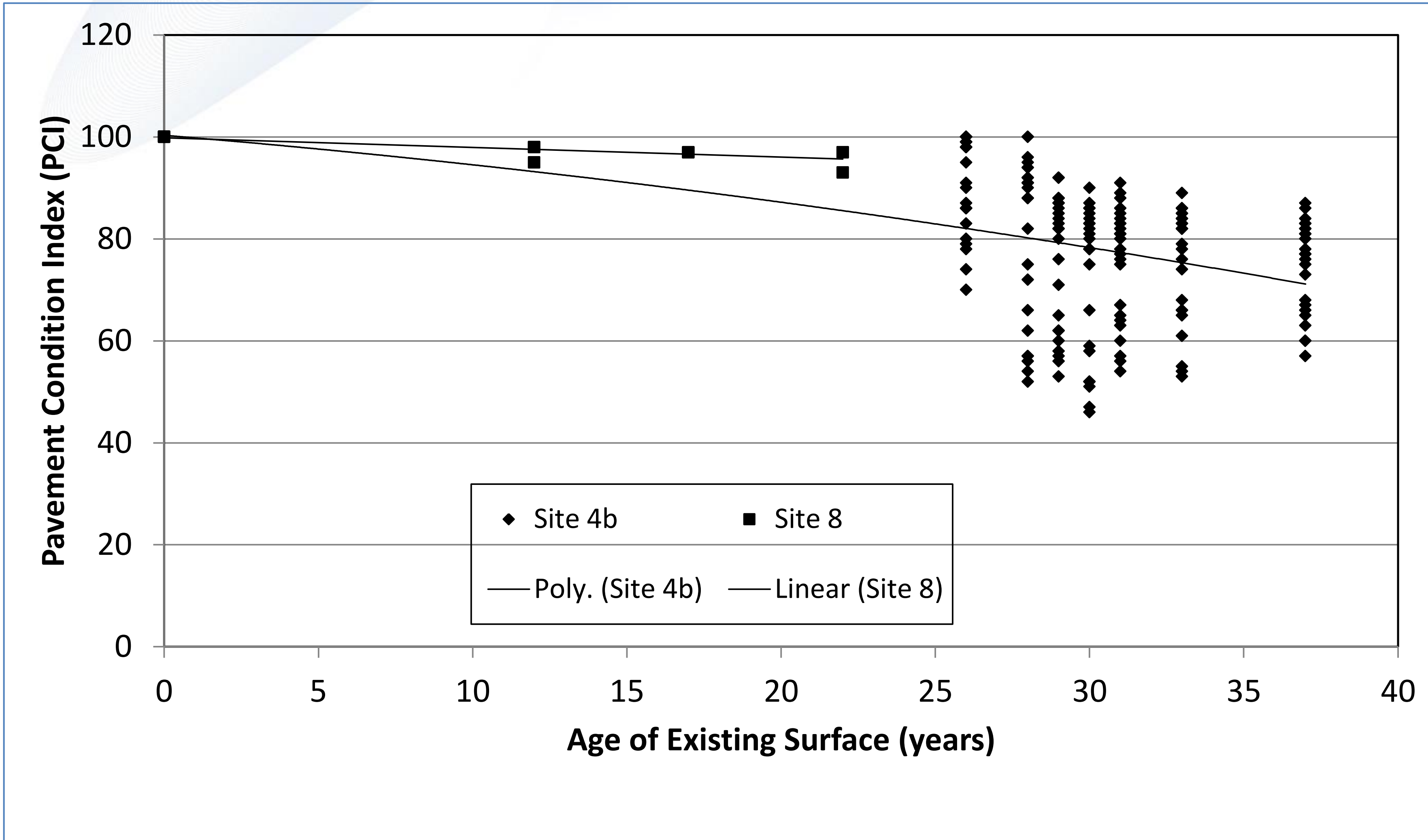
FIELD TESTING

- **DISTRESS SURVEYS**
- **CORE SAMPLING**
  - 24 cores on AC pavement
  - 20 cores (6-inch) on PCC pavement
  - Beam samples of PCC Pavements (where feasible)
- **HWD DEFLECTION TESTS**
  - HWD Loads of 15,000, 30,000, and 45,000 lbs
  - Four Lines Along Runways at 20 ft and 50 ft (or 1st and 3rd slabs) each side of centerline
  - Joint Tests at Transverse and Longitudinal Joints on PCC Pavement
- **PROFILE/ROUGHNESS**
  - SurPro device
    - 5 Profile Lines - Centerline and 10 ft and 17 ft Each Side
  - FAA Pavement Profiler (for groove data)

COMBINED DATA FOR ASPHALT PAVEMENTS



COMBINED DATA FOR CONCRETE PAVEMENTS



LABORATORY TESTING

- **Tests in FAA Research Laboratory (and elsewhere)**
  - **AC Samples**
    - Mixture Properties
      - ✓ Asphalt binder content
      - ✓ Aggregate Gradation
    - Indirect Tensile Dynamic Modulus
    - Indirect Tensile Strength
    - Flow Test Number
    - Asphalt Pavement Analyzer (APA)
    - Hamburg Wheel Track
  - **PCC Samples**
    - Direct Tensile Strength
    - Compressive Strength
    - Flexural Beam Strength (where feasible)
    - Coefficient of Thermal Expansion
    - Petrographic Examination

MAINTENACE DATA

- **PAVEMENT MAINTENANCE ON RUNWAYS**
  - Types of Maintenance Activities
  - Frequency of Maintenance
  - Annual Cost of Maintenance
  - Trigger Factors for Maintenance Execution

- **RUBBER REMOVAL**
  - Friction Tests
  - Type of Rubber Removal Methods Used
  - Costs of Rubber Removal

PRELIMINARY CONCLUSIONS

- **BASED ON LIMITED DATA PRESENTED:**
  - Major Hubs maintain runways pavements at PCI levels of 65 to 85
  - Maintenance records not readily available; particularly for older runways
  - Asphalt runways reach PCI of 70 in 12 to 15 years
  - Concrete runways reach PCI of 70 in 30 to 40 years
  - Asphalt pavements deteriorate at rate of 1.5 to 2.5 PCI points per year
  - Concrete pavements deteriorate at rate of 0.5 to 1.2 PCI points per year
  - Most distresses are materials and climate related

- **MORE DATA NEEDED TO DEVELOP SPECIFIC CONCLUSIONS**

STATUS OF PROJECT

- **PHASES I AND II DATA COLLECTION AND FIELD TESTS COMPLETE**
- **PHASE III UNDERWAY (8 additional runways)**
- **PRELIMINARY ANALYSIS OF DATA COLLECTED**
- **FURTHER DATA COLLECTION AND FIELD TESTS PLANNED**
  - Complete Matrix Of Performance Variables
  - Climate, Traffic, Surface Condition, Concrete, Asphalt, Overlays, etc.
  - Groove Performance, Rubber Removal, Joint Spacing

Analysis

- Define failure
- Identify key factors related to extended life

SUMMARY

- Extended Service Life Can Be Achieved
- Identify and Understand Critical Performance Parameters
  - Design Aspects – Thickness, Joints. and other Details
  - Traffic Demands – Current and Future
  - Durability – Material Quality, Mixes, Uniformity
  - Climatic Impacts
  - Quality Construction – QC/QA
- Long-Life Airfield Pavements Require "Best Practices" in All Aspects of Design, Materials Selection, Formulation of Mixes, and Construction
- FAA Initiative for 40-Year Life Studying Performance Parameters from Runways Across the US
- FAA intends to modify design criteria to allow 40-year design of large hub airport runways