



Presented September 15, 2010
SWIFT Conference
M. Main

CBR Index Measurements For Gravel Runway Assessment



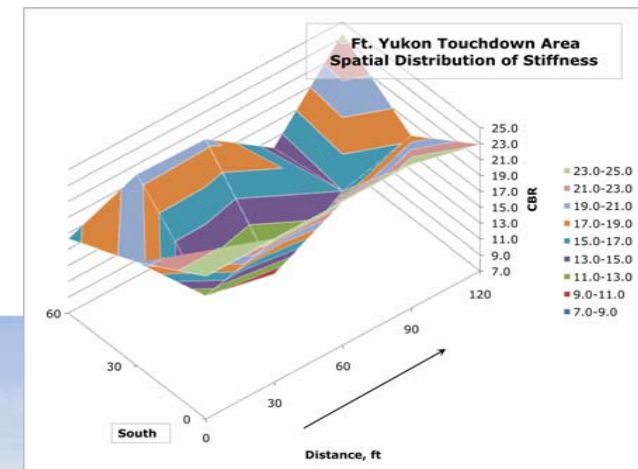
Problem: Questionable Gravel Runway Surface Integrity

- Sufficient Strength?
 - Is the surface safe for aircraft operations?
- Durability?
 - Will the surface hold together?
- Sufficient Support?
 - Will the surface fail from below?
- Life Cycle
 - How long will the surface perform?
 - What's the cost of sustaining performance?
 - How can maintenance be anticipated and planned?



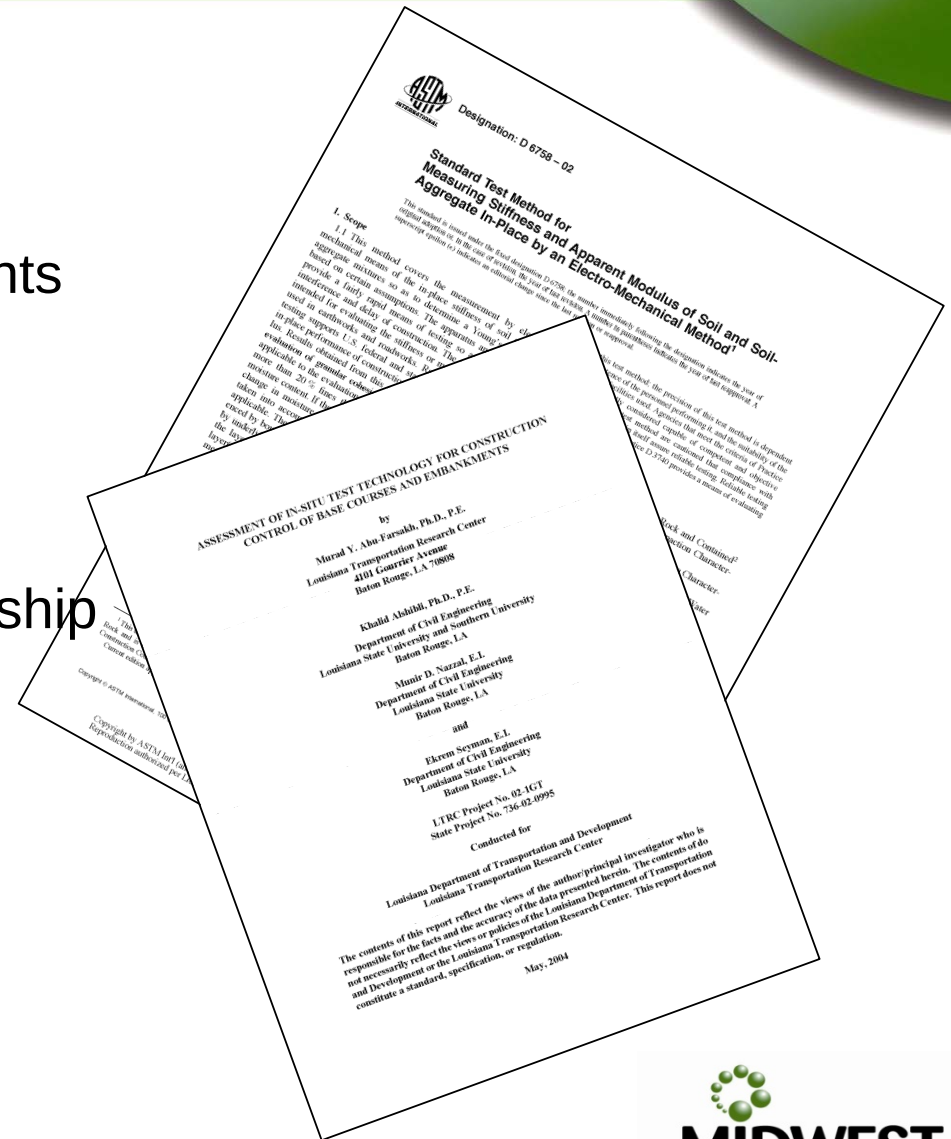
Objective: Simple Monitoring of Integrity

- Simple, rapid, noninvasive & accurate surface CBR index measurement
 - Quality control
 - Condition assessment
 - Health monitoring
 - Data
 - Estimate life
 - Anticipate maintenance



Approach: Surface Stiffness Indexed to CBR

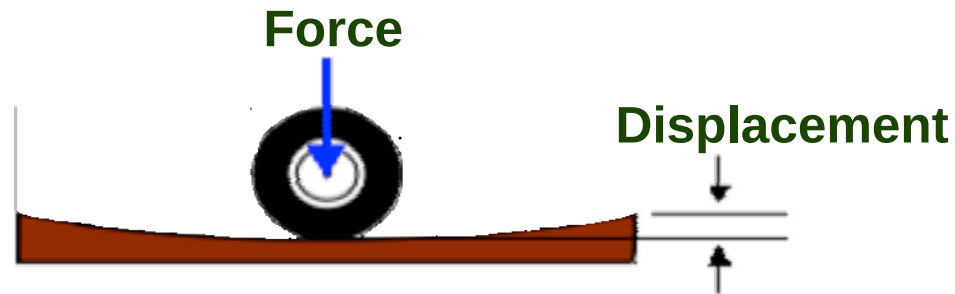
- ASTM D6758 stiffness measurements
 - Humboldt GeoGauge
 - Non-invasive
 - Simple & quick
 - Established precision & bias
- GeoGauge stiffness – CBR relationship
 - LTRC (LADOTD & LSU)
 - 0.84 correlation (R^2)



What Is Stiffness?

A Primary Measure of Ground Behavior

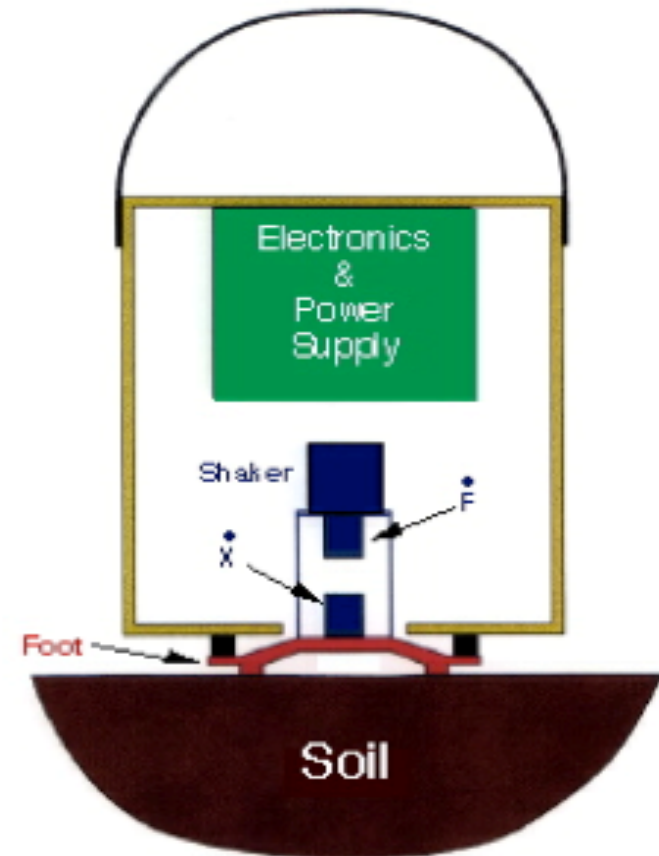
$$k = \frac{P}{\delta}$$



- A measure of the resistance offered by a elastic body to deformation
- Where
 - P is the force applied
 - δ is the displacement produced by the force

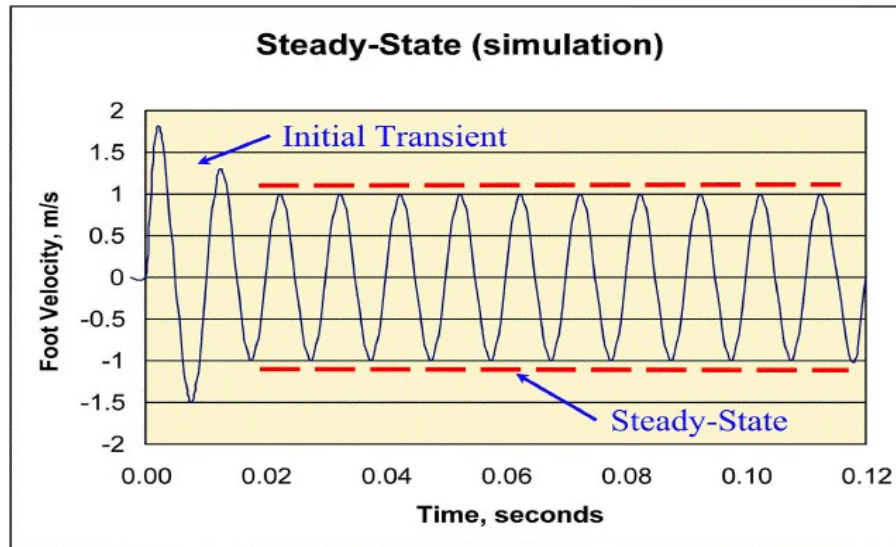
Humboldt GeoGauge: What It Is?

- Measures Stiffness in 75 sec. per ASTM D6758
- Non-Destructive
- Depth of measurement: ~ 9"
- Size: 11" OD x 10" tall
- Weight: 22 lb.
- No Licensing or Safety Requirements
- Causes No Construction Delays



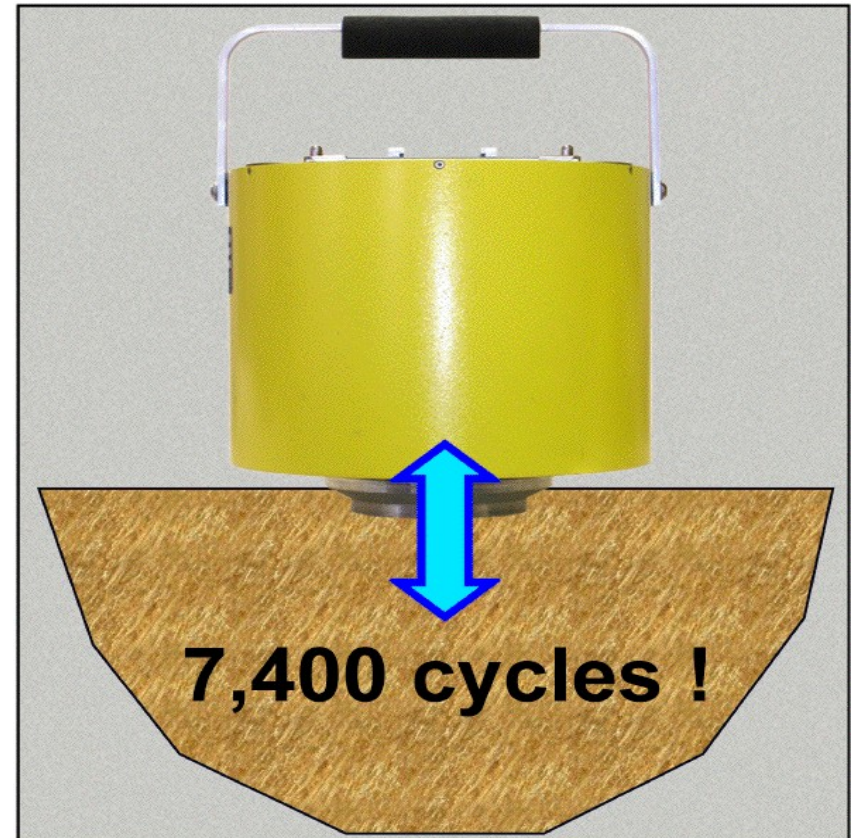
How it Works

Vibrates Ground & Measures the Deflection



*Steady-State, Low Strain,
Low Frequency Loading*

*Most Like Resilient Modulus Of
Any In-Place Measurement*



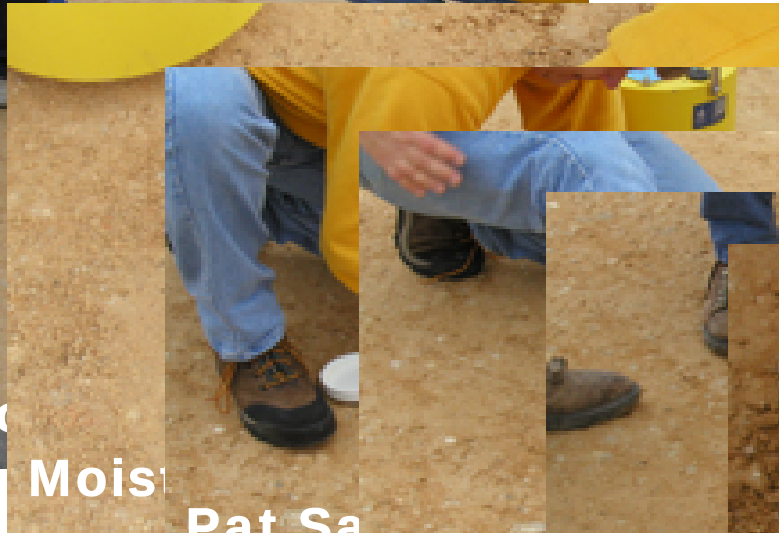
How To Make A Measurement



Remove



Smooth



Moisture



Pat Sand



Place



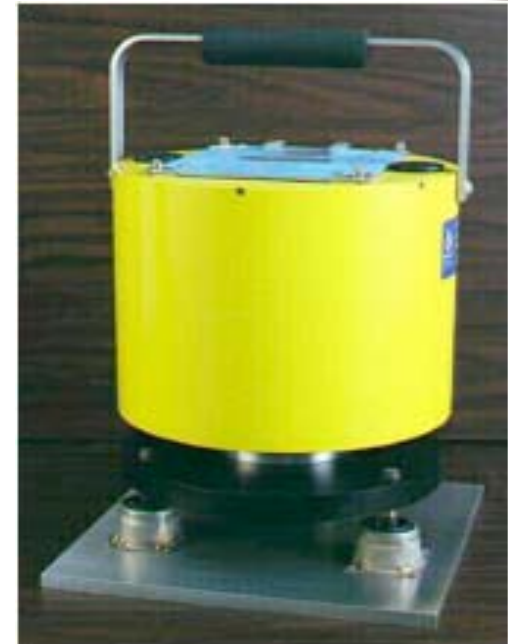
Press



Result In 75 Seconds

Precision & Bias

- Precision (repeatability)
 - Typical Coefficients Of Variation
 - Lime Rock Base: 3.7% to 5.6% (Sand Assisted)
 - Stabilized A-2-4 Subgrade: 3.1% to 8.8% (No Sand)
 - Asphalt Pavement: 2.6% to 4.2% (Sand Assisted)
 - Current Basis
 - 1000s Measurements Made by State DOTs
 - 1000s Measurements Made by Humboldt & Midwest
 - Multiple Gauges & Multiple Operators
- Bias (traceability to a reference, factory calibration)
 - Reference: Moving Mass
 - Known Mass: 10 Kg (22 Lb)
 - 25 Known Frequencies: 100 to 196 Hz
 - Stiffness = $-jW^2M$
 - Coefficient of Variation: < 1%
 - Basis: 1,000s of Humboldt. Midwest & FHWA Measurements



Verification

Field Check of Proper Operation



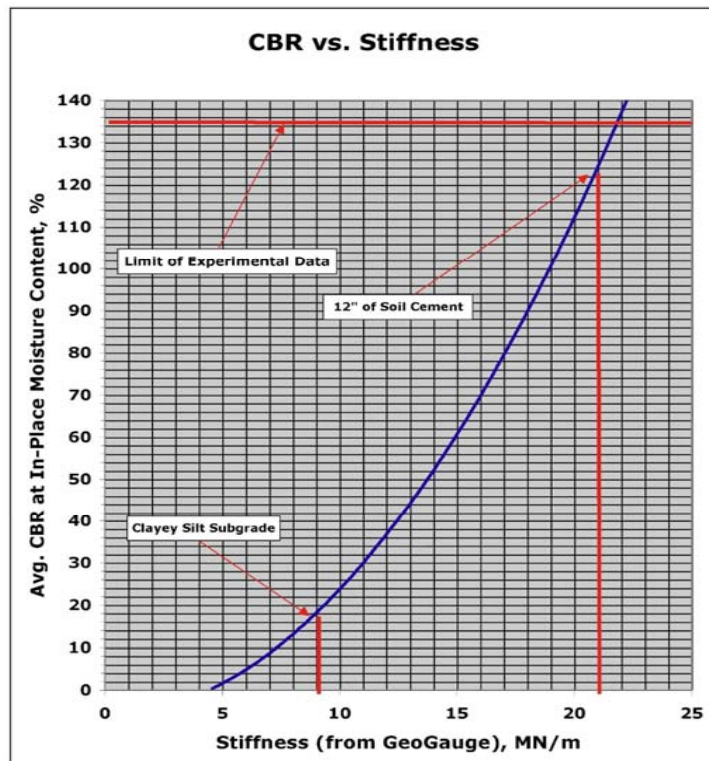
- Verifier Mass Assembly on flat, rigid surface
- Wipe clean ring foot
- Lubricating oil on the shoulder of the Verifier Mass.
- Set the on Verifier Mass.
- Rotate GeoGauge.
- Press the MEAS button
- Record the stiffness.
- Remove the GeoGauge & reset
- Average of 3 to 5 measurements
- An average stiffness ~ -8.6 to -9.8 MN/m



Correlation to CBR (Unsoaked)

$$CBR = 0.0039(8.672 K_G)^2 - 5.75$$

- CBR is in percent (%)
- K_G is the GeoGauge stiffness in MN/m
- Correlation coefficient (R^2) is 0.84.

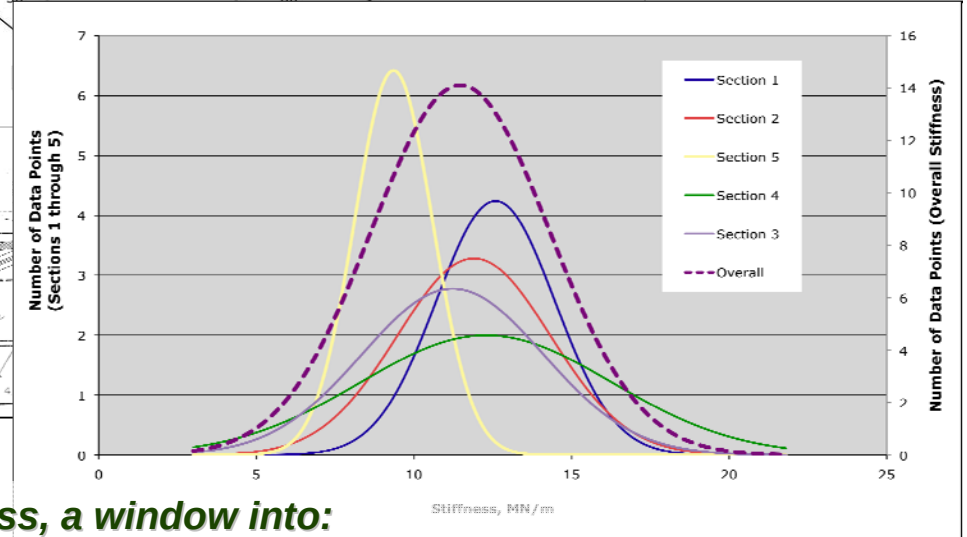
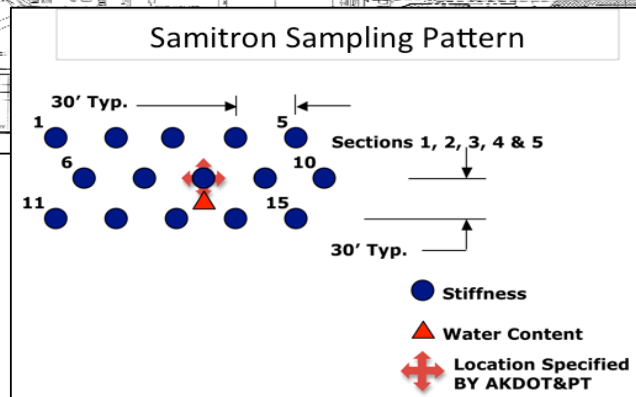
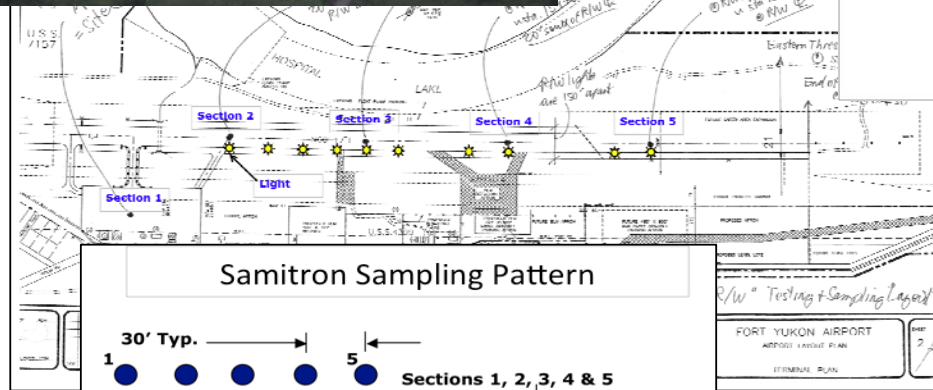
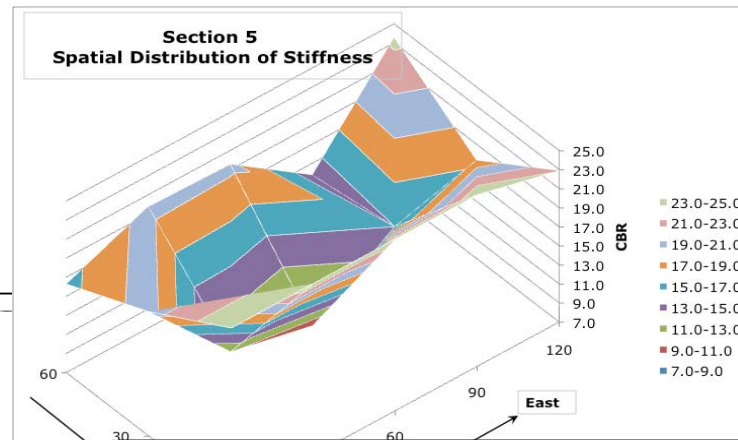


- Hundreds of comparison tests
 - Sands
 - Silts
 - Clays
- Developed by Louisiana Transportation Research Center

(Murad Y. Abu-Farsakh, Ph.D., P.E., Khalid Alshibli, Ph.D., P.E, Munir Nazzal, and Ekrem Seyman, Assessment Of In-Situ Test Technology For Construction Control Of Base Courses And Embankments, May, 2004, Louisiana Transportation Research Center, Baton Rouge, LA 70808, FHWA/LA.04/385)

Gravel Runway Surface Assessment

Midwest Runway Survey, '08: Ft. Yukon, AK



Stiffness, a window into:

- Structural Degradation (safety)
- Needed Maintenance

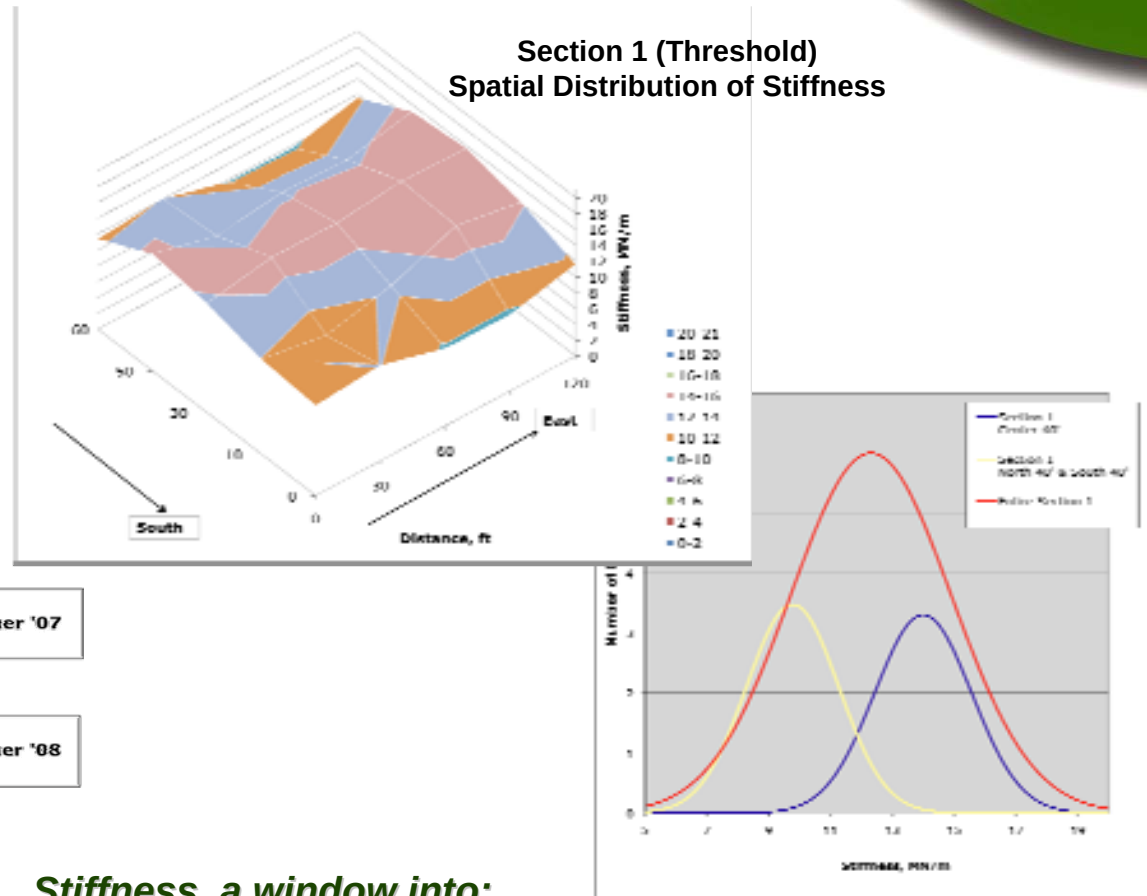
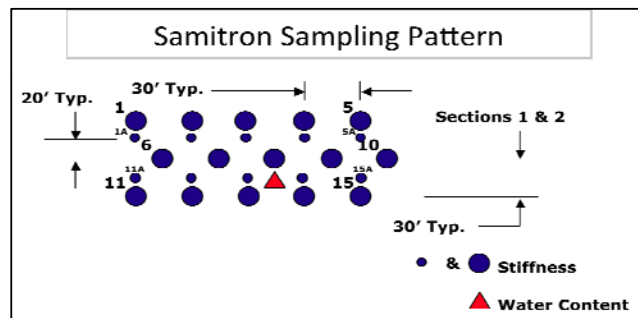
Gravel Runway Surface Assessment

Midwest Runway Survey, '08: Tanana, AK



Brown Runway 40' Wide South Edge
EK-35A at 1 gal per 40 ft² applied in Summer '07
to full width of the runway

Blackish Runway 40' Wide Center
EK-35A at 1 gal per 80 ft² applied in Summer '08
to center of the runway



Stiffness, a window into:

- **Strength Increase & Uniformity (safety)**
- **Dust Prevention (bound fines)**
- **Preventive Maintenance**

Gravel Runway Surface Assessment & QC

AKDOT Runway Condition Assessment, '09

AKDOT&PF EK-35 Performance on Runways							
09 Summary: AKDOT&PF Runway Condition Assessment Program							
CBR (Surface Strength)							
Runway	Surface	Years Since Last Application	~ % Dust Reduction (July-09)	July-09	Annual Decrease	Projected Initial	Minimum Required
Chicken	Silty Sand	4	80%	17	38%	52	6
Boundary	Clayey Sand	2	80%	16	18%	27	6
Circle Hot Springs	Silty Sand	2	> 90%	34	?	?	6

Average CBR						
Location	2000	2006	% Deterioration, '08 to '09	Surface Material	Product	Approx. Age, Years
Big Lake	58.8				?	?
Boundary	15.4	19.1	19.5		EK-35A	2
Central	55.4				none	1
Chicken	16.0	27.1	41.0		EK-35A	4
Chilina	42.8				Permacyme	4
Circle	34.4				None	?
Eagle	14.8				EK-35A	4
Kaltag	178.5				EK-35B	0
McCarthy	80.1				Permacyme	3
Tanana	39.3	43.6	9.9		EK-35A	2 & 3
Tustin	46.2				Dura Soil	0
Willow	47.2				?	?
Circle Hot Springs	34.0				EK-35A	2
Ft. Yukon		32.8			EK-35A	3

EK-35B to be applied
~ 41% deterioration in 1 year

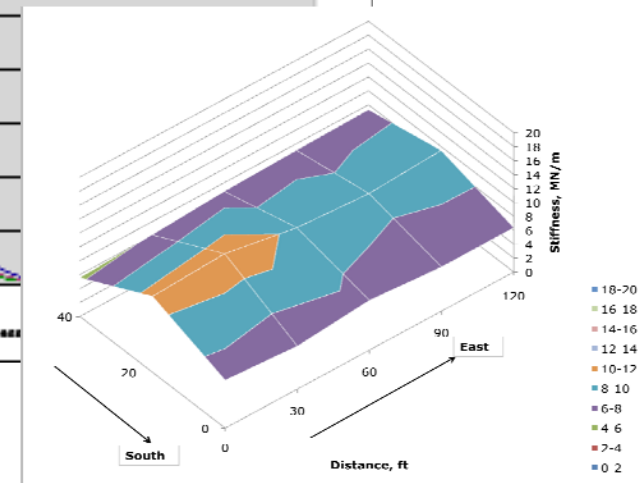
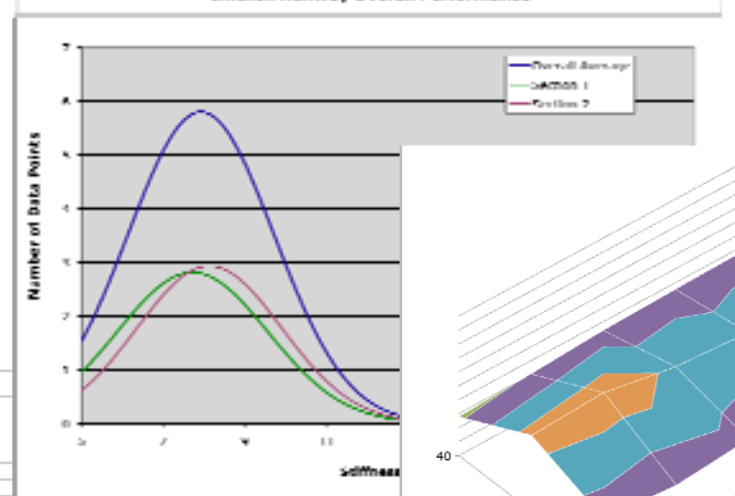
EK-35B to be applied

~ 10% deterioration in 1 year, CBR = 54.3
in center & 27.4 in outside lanes

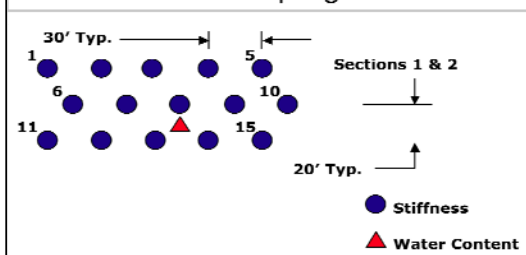
Goals:

- **Dust & Strength Assessment of 50+ Runways**
- **Basis for Evolving AKDOT QC & Performance Specs.**
- **Basis for Midwest Fines Preservation Program**
- Application Rate Model
- Value Propositions
- Performance Specs.

Chicken Runway Overall Performance



Samitron Sampling Pattern

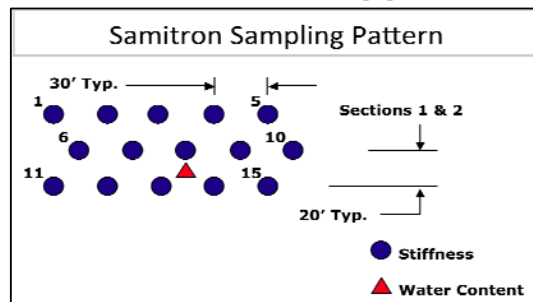


More Surface Assessment & QC

AKDOT & Midwest Runway & Roadway Condition Assessment, '10

- AKDOT: 28+ runways & 5+ roads
- Nunavut: 1 runways & 1 road
- Ontario, NWT, Quebec: 3 runways

**Threshold & center of runway
~ Each ½ mile of road
Before & After Application**



Ongoing Substantiation: Comprehensive Basis for Quantitative Performance

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*Alaska DOT
& University of Alaska,
2010*

- 7 products on roads in 10 villages
- 3 products on runways at 28 airports