Accelerated Loading Evaluation of Base & Sub-base Layers

Zhong Wu, Ph.D., P.E.
Louisiana Transportation Research Center (LTRC)

April 2006

What is Accelerated Loading?

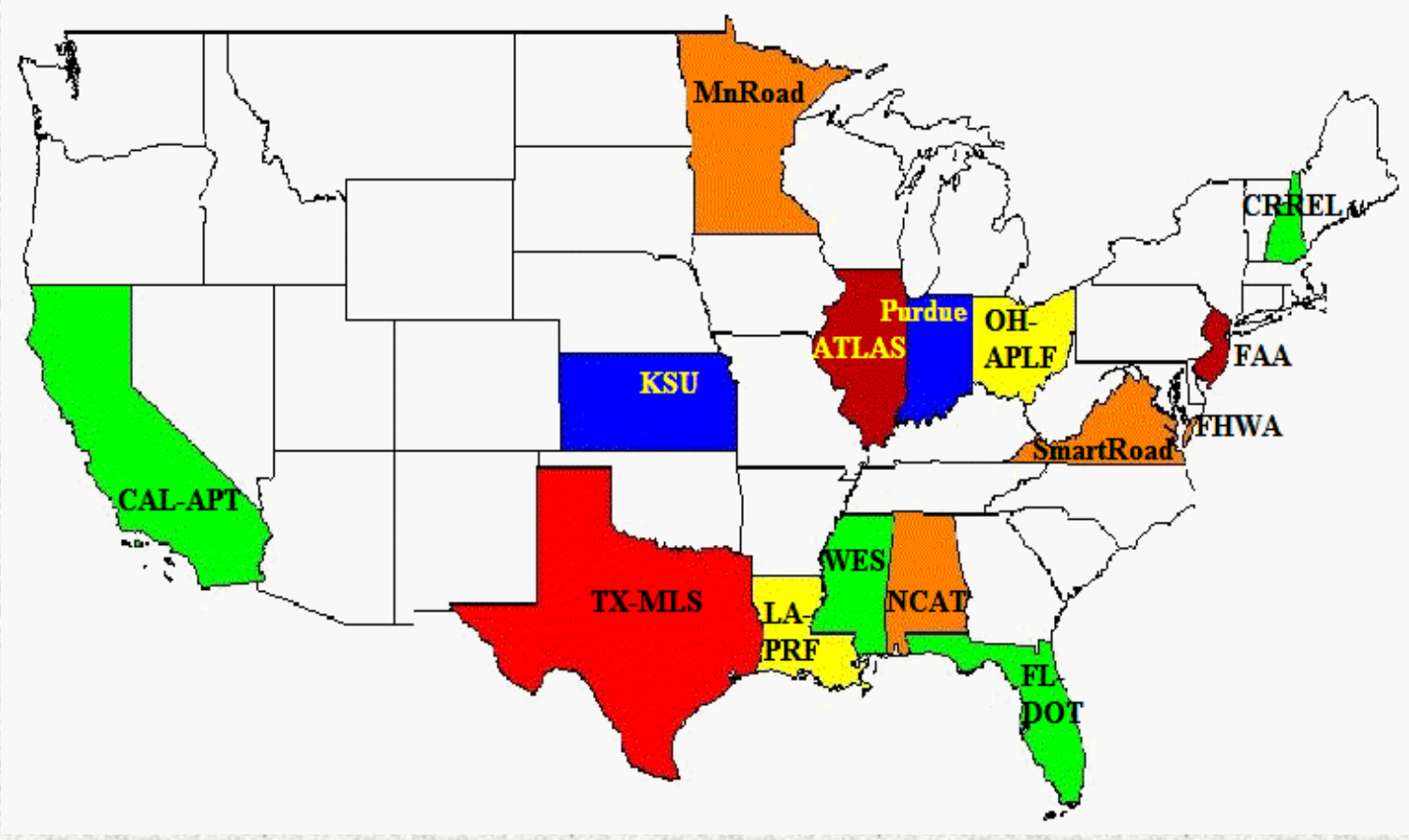
- Accelerated loading refers to
  - Accelerated Pavement Testing (APT).
- It represents
  - an outdoors, full-scale pavement test
  - A specialized wheel loading device applies repeated heavy loads on pavements.
  - Pavement structure fails in a fraction of the time required under normal traffic.

Why Use APT?

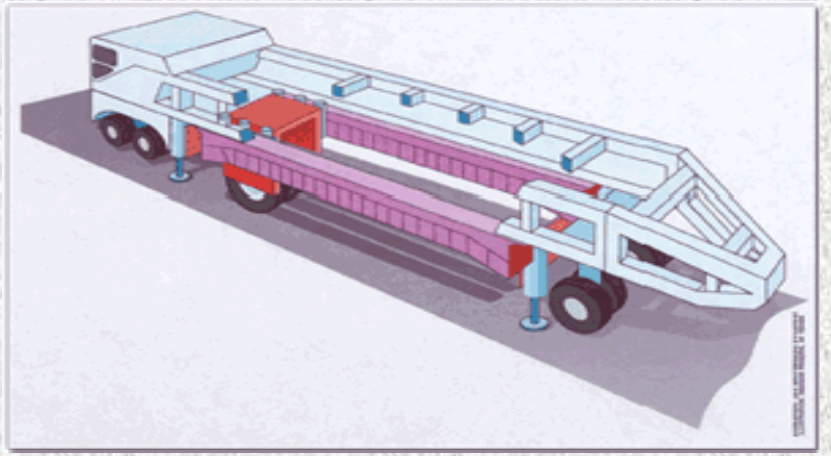
- The average gross weight of trucks
  - increased over time
- Pavement life shortened due to
  - Heavier axle loads
  - Increased tire pressures
- Laboratory material tests do not contain
  - Full-scale paving technologies
  - Repeated heavy loads
- APT is an advance research tool

APT Programs in U.S.

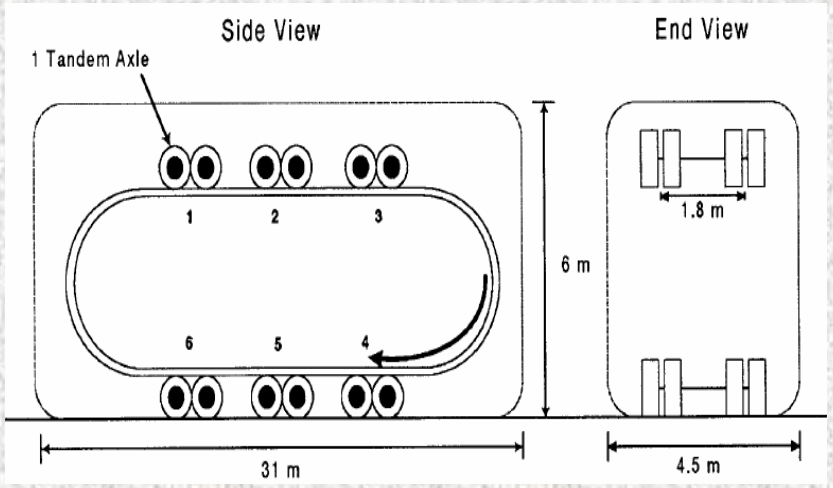
- Reported as early as 1909
  - a test track built in Detroit.
- Currently, about 15 APT test facilities national wide.



Major APT Loading Devices



(a) Heavy Vehicle Simulator (HVS)



(b) Texas MLS

Louisiana
Accelerated Loading Facility (ALF)

- Approximately 100-ft long and 55-ton
- One half of a single axle
- Load adjustable from
  - 9,750 lbs ~ 18,950 lbs
  - Simulate traffic wander
- Speed - 10.5 mile per hour
- Operated by
  - Pavement Research Facility (PRF) in Port Allen

Total Load = 9,750 lbs

Tire Pressure = 105 psi

LTRC Project No. 03-2GT

- *Accelerated Loading Evaluation of A Subbase Layer on Pavement Performance*

- State Project No. 736-99-1124

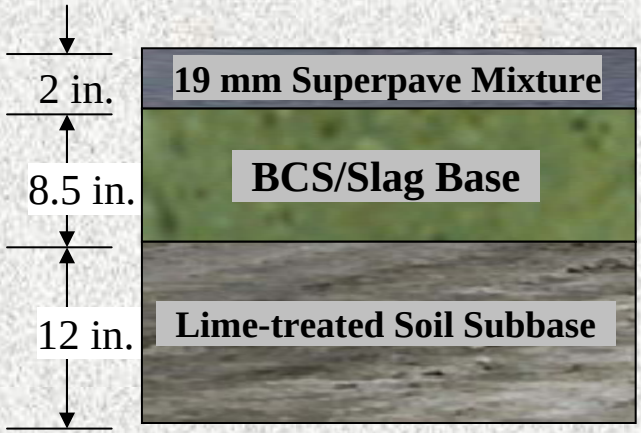
Objectives

- For Base Layers:
  - to assess field performance of Blended Calcium Sulfate (BCS) materials stabilized with fly ash and furnace slag.
  - to evaluate field performance of foamed asphalt treated materials.

Objectives

- For Subbase Layer
  - to prove that a cement treated subbase layer will
    - provide a working table for pavement construction;
    - also provide a layer that contributes to the pavement's overall structural bearing capacity.

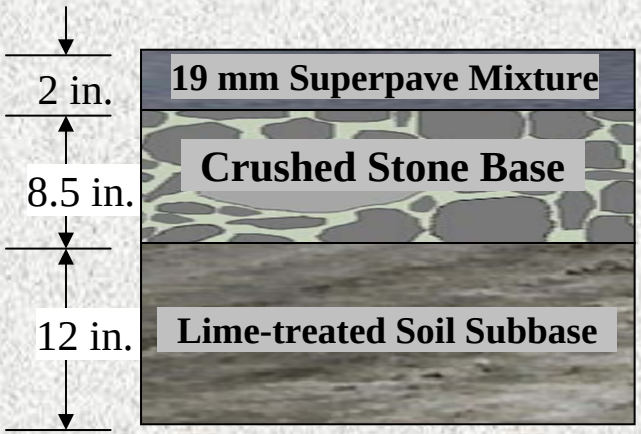
Pavement Structures



Section 4-1A

Section 4-2A

Section 4-3A



Section 4-1B

Section 4-2B

Section 4-3B

Pavement Structures

Factors in Experimental Design

- Pavement Structure and Materials
- Loading and Sequence
- Failure Criteria
  - e.g. for asphalt pavements, rutting and fatigue cracking
- Performance Data Collection
  - Surface Distress Survey
  - Field Non Destructive Test (NDT)
  - Instrumentation

Loading and Failure Criteria

- Loading consideration
  - Two phase testing
    - Phase-I- “A” sections: 4-1A, 4-2A and 4-3A
    - Phase-II- “B” sections: 4-1B, 4-2B and 4-3B
  - 9,750-lb load for first 175,000 passes
  - Use 7.5” wander function
  - Move the device at every 25,000 passes
- Failure Criteria
  - Rut depth >= 0.75 in
  - Fatigue cracks in 50% loading area >= 5 ft /ft^2

Pavement Materials

- Hot Mix Asphalt (HMA) mixture
- Stabilized BCS materials
- Foamed asphalt stabilized materials
- Lime or cement treated soil materials
- Subgrade soils

HMA Mixture

- 19-mm Superpave Level –II mixture
- Polymer-modified PG 76-22
  - Supplied by Marathon
  - Optimum binder content: 4.4%
- Aggregate blend
  - 45.4% #67 coarse granite aggregate,
  - 17.1% #11 crushed siliceous limestone,
  - 10.3% coarse sand,
  - 12.9% crushed gravel, and
  - 14.3% reclaimed asphalt pavement (RAP).

Stabilized BCS Base Materials

- BCS material is
  - Short for “Blended Calcium Sulfate”
  - by-product from hydrogen fluoride production.
  - Major engineering concern
    - water susceptibility.
- BCS stabilized with the grade 120 granulated ground blast furnace slag (GGBFS) – Section 4-1A
    - 10 percent by volume
- BCS stabilized with flyash (15% by volume) – Section 4-1B
- Field performance: *UNKNOWN*

Foamed Asphalt Base

- Foamed asphalt (FA) process
  - When cold water injected into the hot asphalt, it turns to steam:
    - contains thousands of tiny asphalt bubbles
    - causes the asphalt expands many times in volume
    - decreases the binder viscosity.
- Section 4-3A is a FA stabilized base
  - Components
    - 2.8% PG 58-22 asphalt binder
      - 3% water
    - 48.6% RAP, and
    - 48.6% recycled soil cement

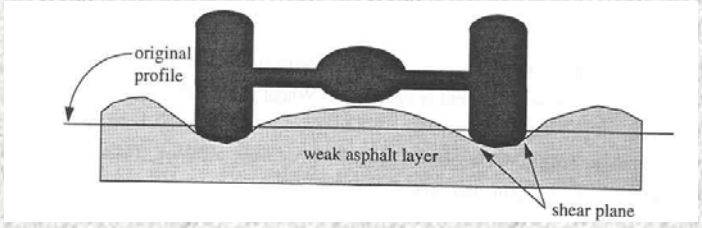
Subbase and Subgrade

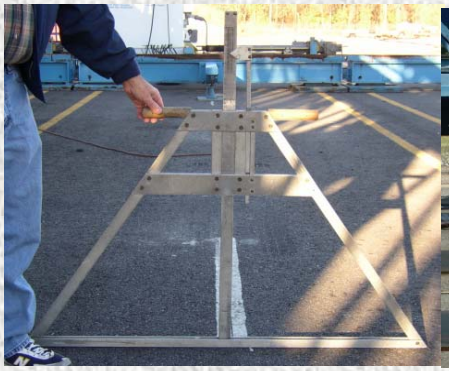
- Subbase Materials:
  - in-place lime treated soils (10 % by volume)
    - Sections 4-1A, 4-1B & 4-2A
  - in-place cement treated soils (8 % by volume)
    - Sections 4-2B, 4-3A & 4-3B
- Soil Properties

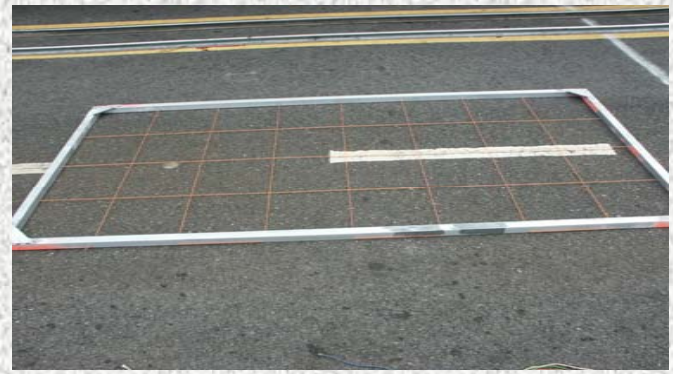
Passing # 200 (%)	Clay (%)	Silt (%)	LL(%)	PI	W_{opt} (%)	γ_d (kN/m^3)	Classification	
							USCS	AASHTO
91	23.5	60.3	31	10	18.5	17.1	CL-ML	A-6

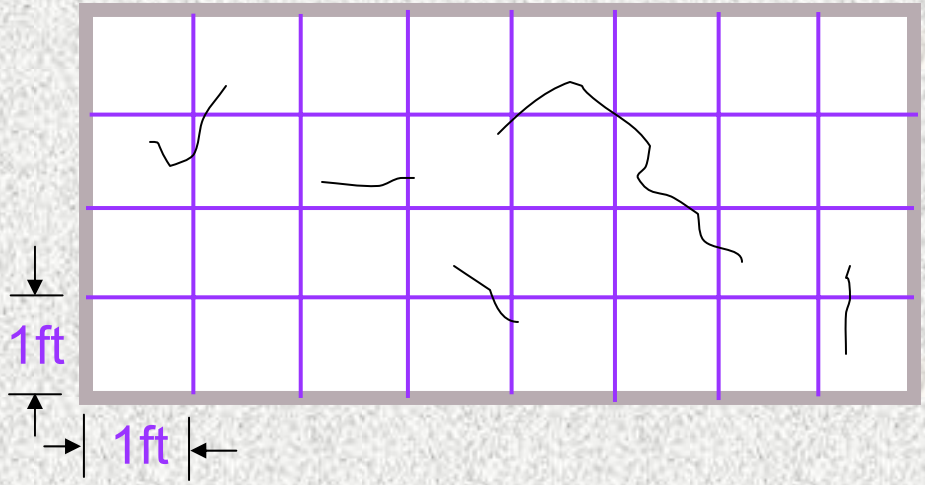
Surface Distress Survey

- Rut Measure Device
  - "A" Frame
- Crack Mapping
- Profiler
  - Moving profiler





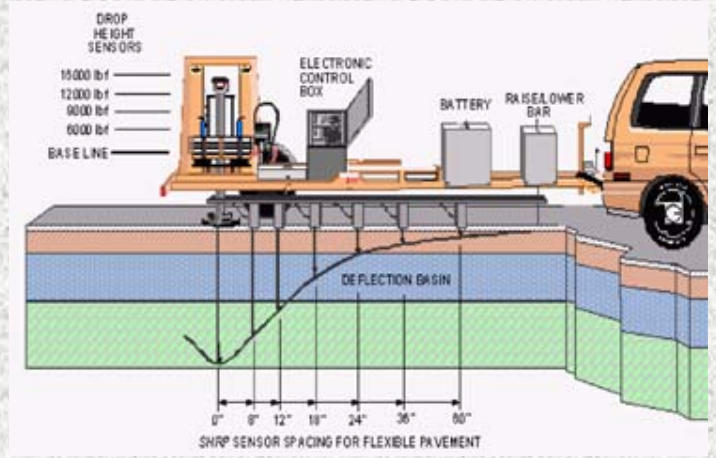




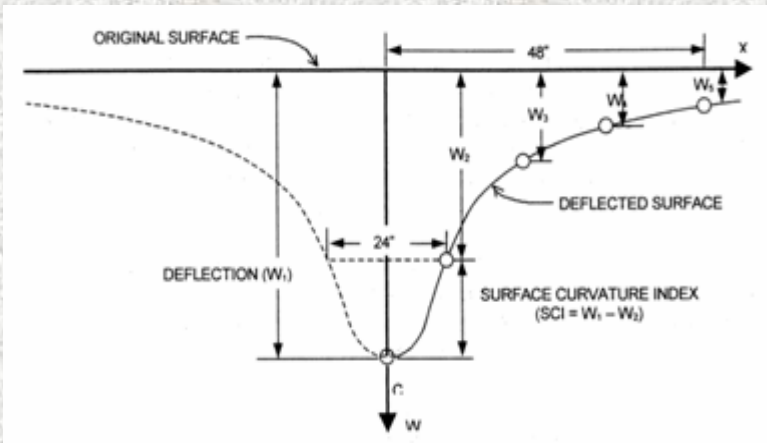
Field NDT Tests

- **Falling Weight Deflectometer (FWD) Test**

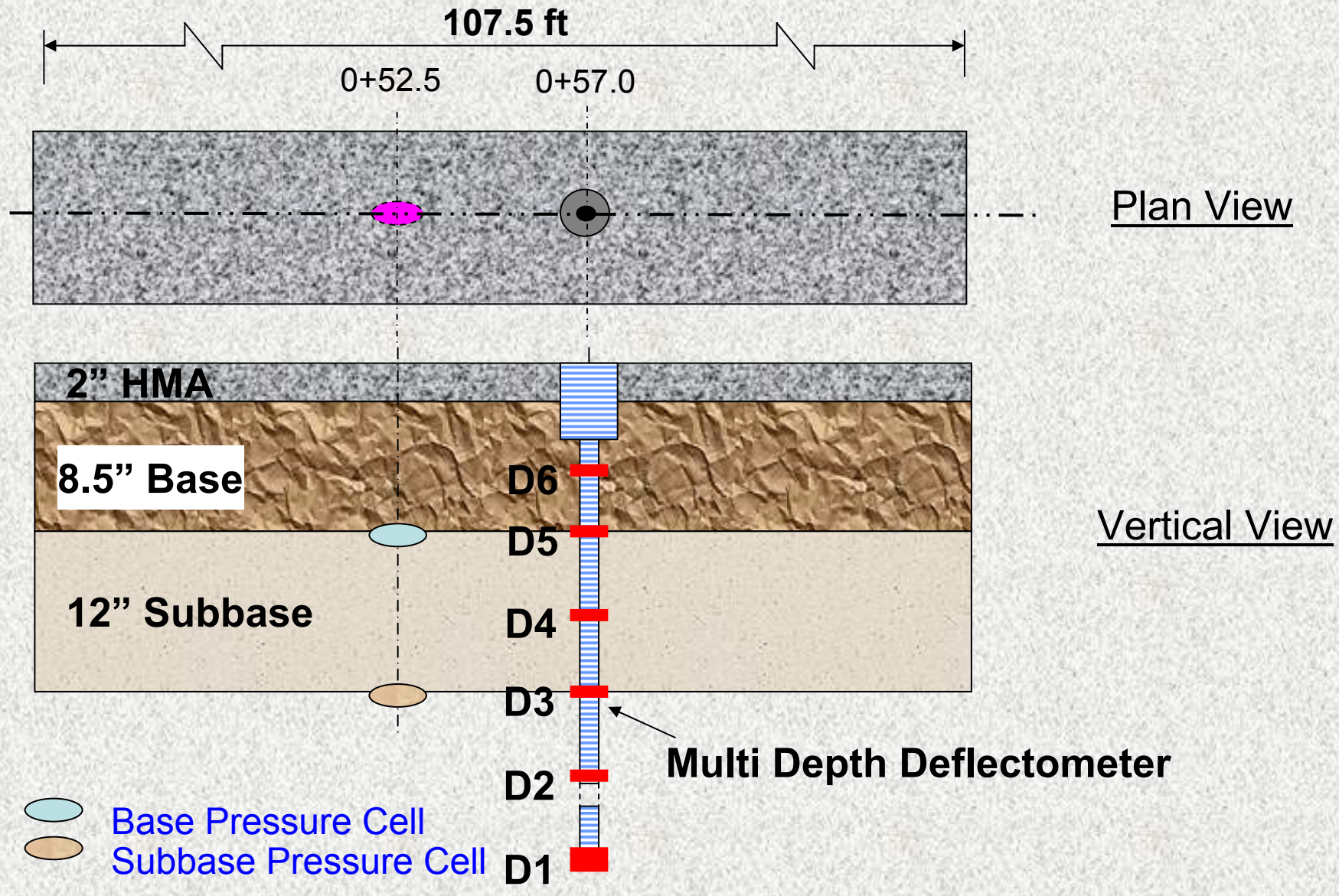

Dynatest 8002 model



- **DYNAFLECT Test**



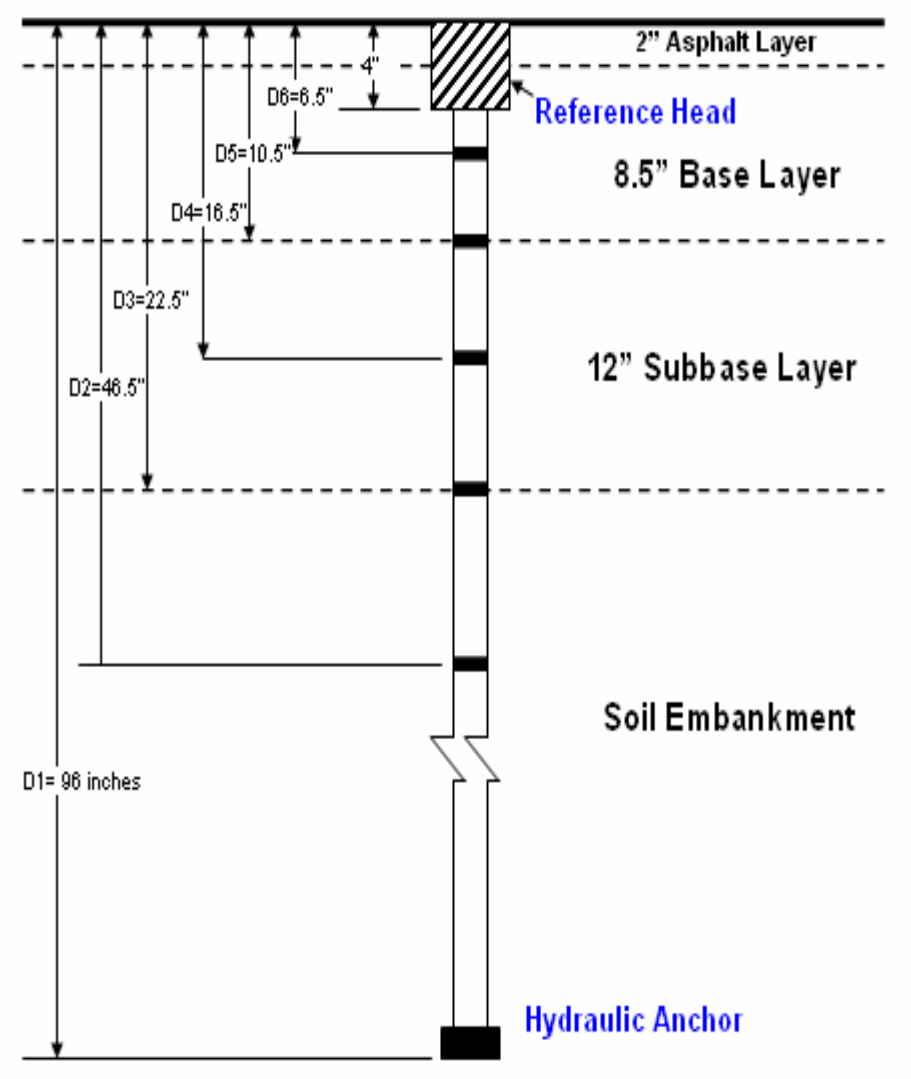
Field Instrumentation Layout



Earth Pressure Cell

- Geokon model 3500
  - Hydraulic type
  - 9 in. diameter
  - 5 lbs
  - designed to measure total pressure in earth fills up to 100psi

Multi-Depth Deflectometer (MDD)



- Snap MDD
  - Construction Technology Laboratories, Inc. Illinois
- Measure
  - compressively elastic & plastic deformations
  - up to seven depths
- Installation
  - bore hole
  - 5-in in diameter
  - 10-ft deep

Current Test Sections

- Current testing on
  - Section 4-1A
  - Section 4-2A
  - Section 4-3A

4-1A

2” HMA
8.5” BCS/Slag Base
12” Lime treated soil (10%)

4-2A

2” HMA
8.5” BCS/Flyash Base
12” Lime treated soil (10%)

4-3A

2” HMA
8.5” Foamed Asphalt Base (50%SC+50%RAP)
12” Cement treated soil (8%)

Discussion of Test Results

- Covered:
  - 125,000 ALF load repetitions
  - three test sections: 4-1A, 4-2A, and 4-3A.
- Includes:
  - Instrumentation Results
  - NDT Test Results
  - Surface distress survey

Instrumentation Results



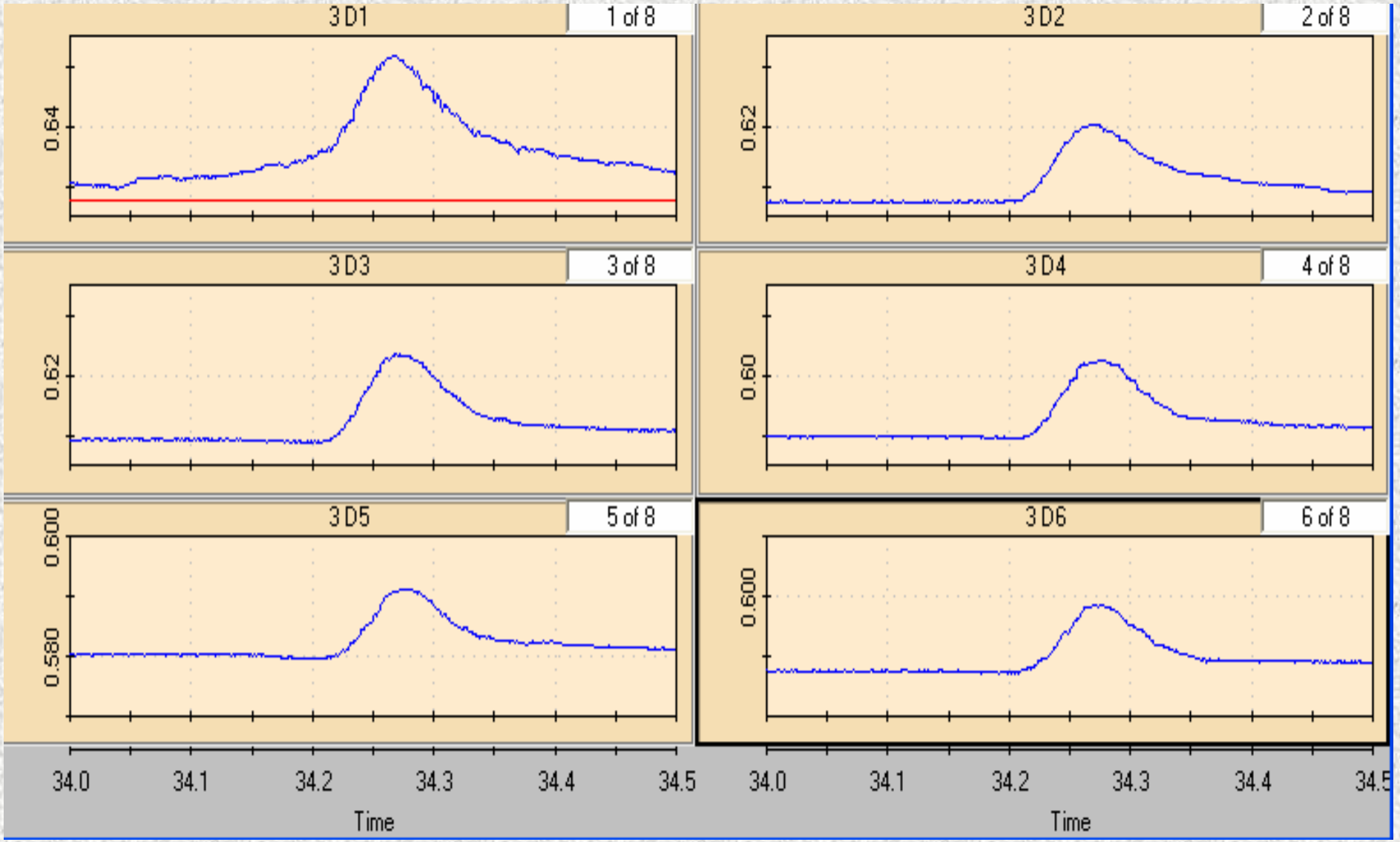




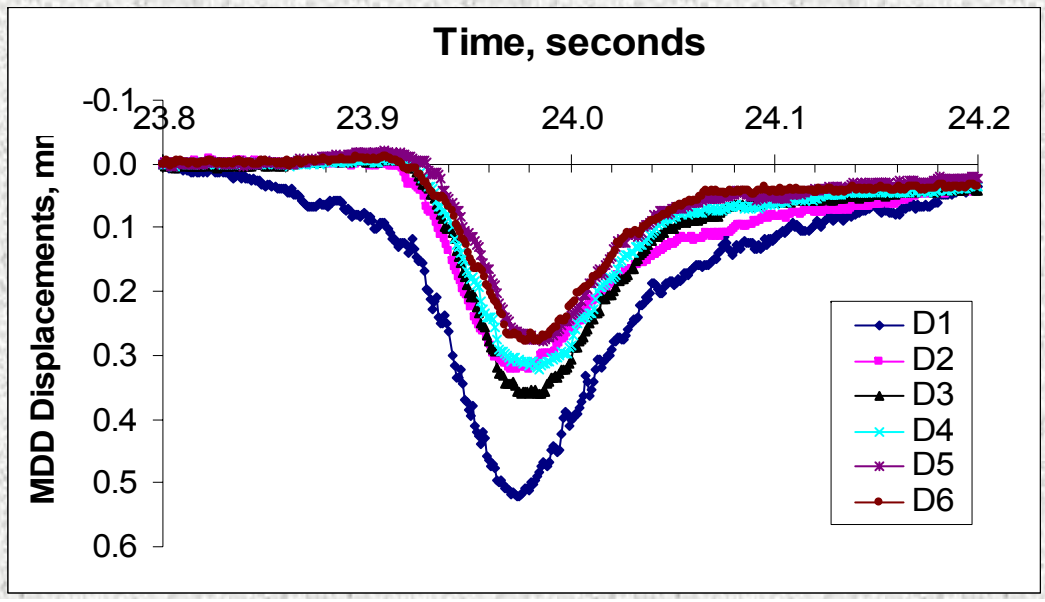


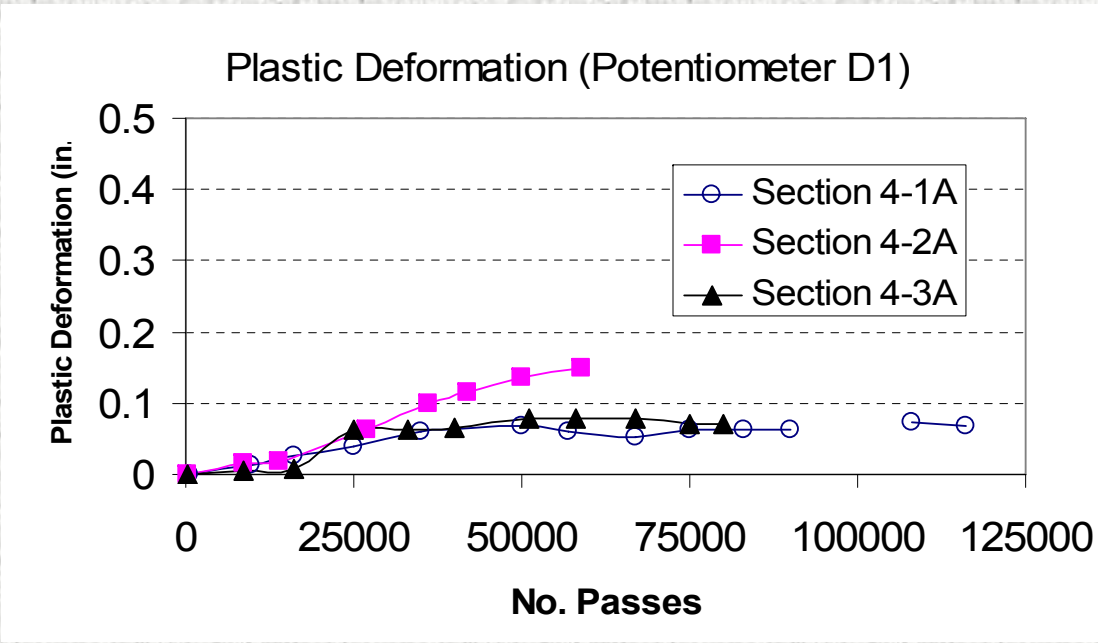


Typical MDD Potentiometer Readings

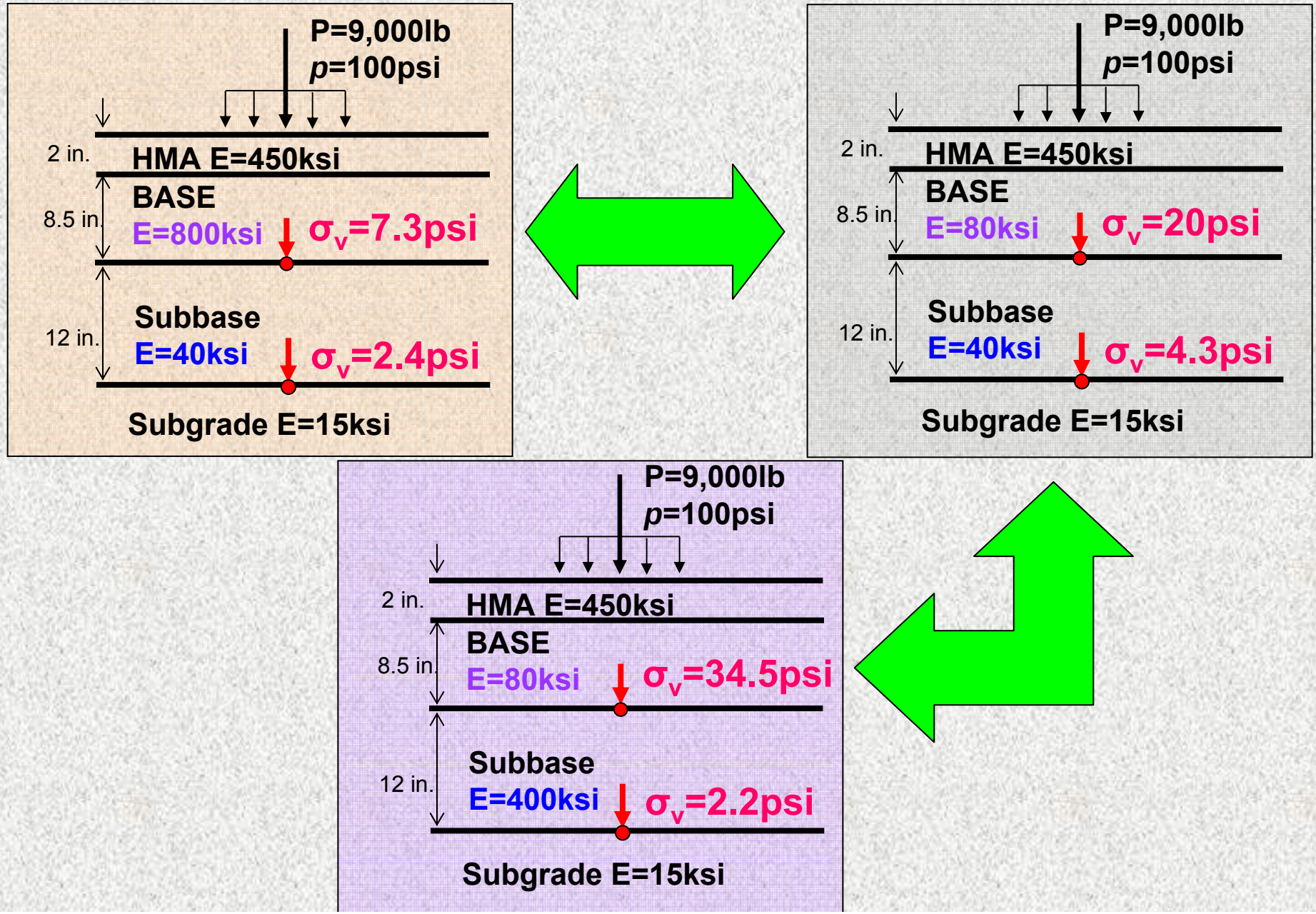


MDD Test Results





Earth Pressure Cell Results

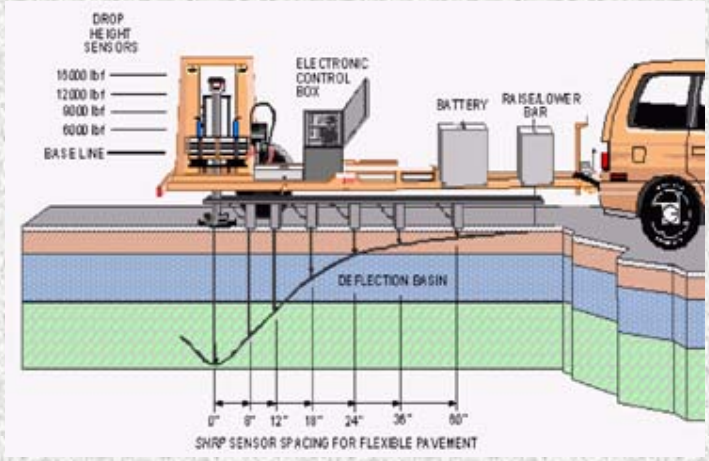


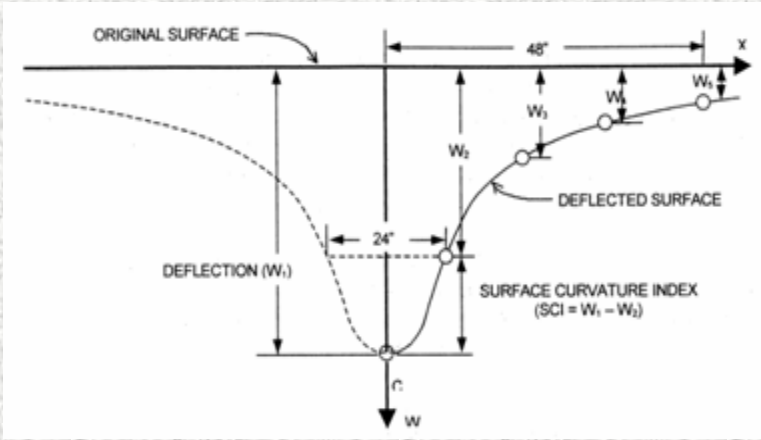
Measured Vertical Stresses

NDT Test Results

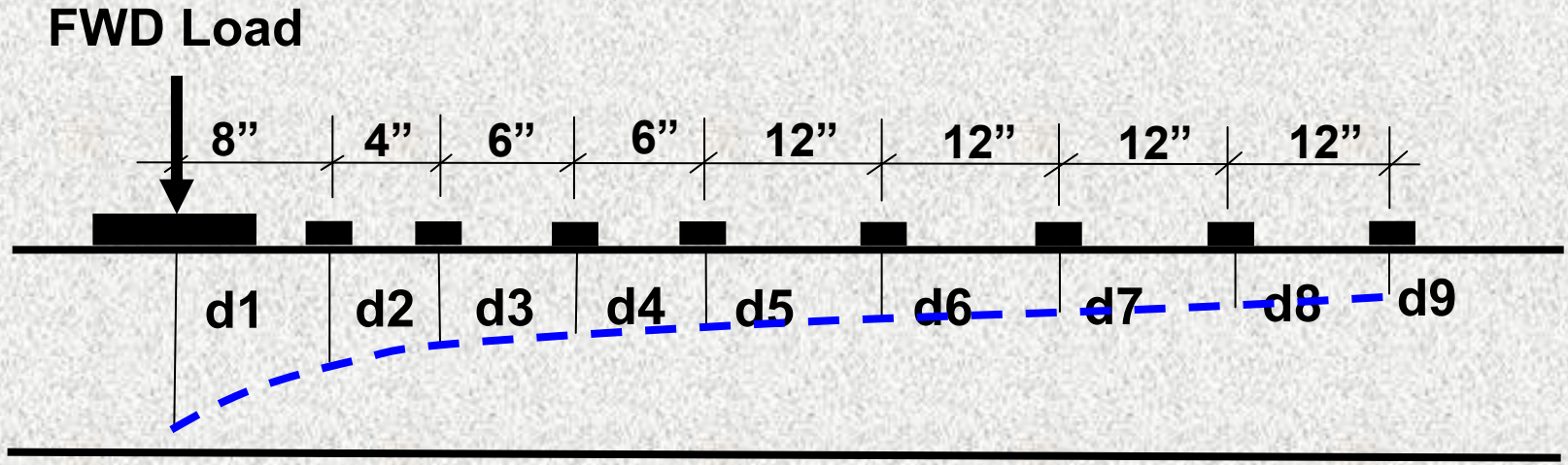
(a) FWD

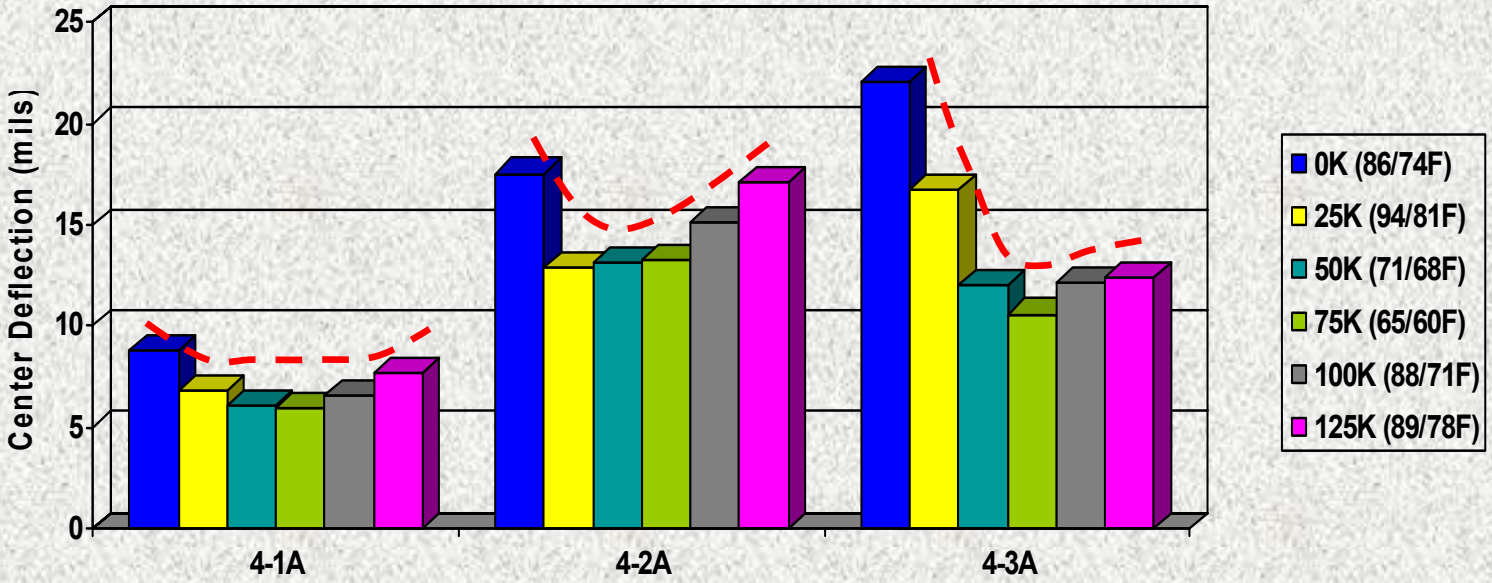
(b) Dynaflect





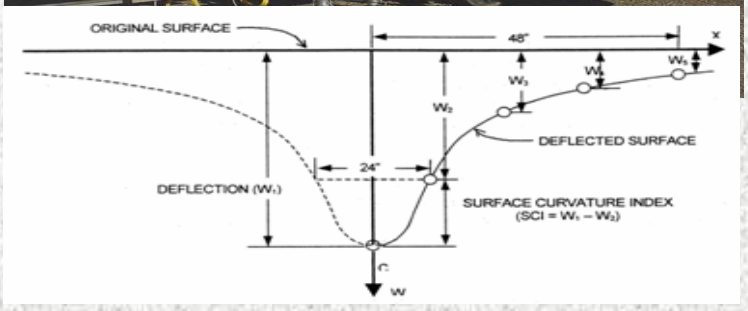
Average Measured Center FWD Deflection Results

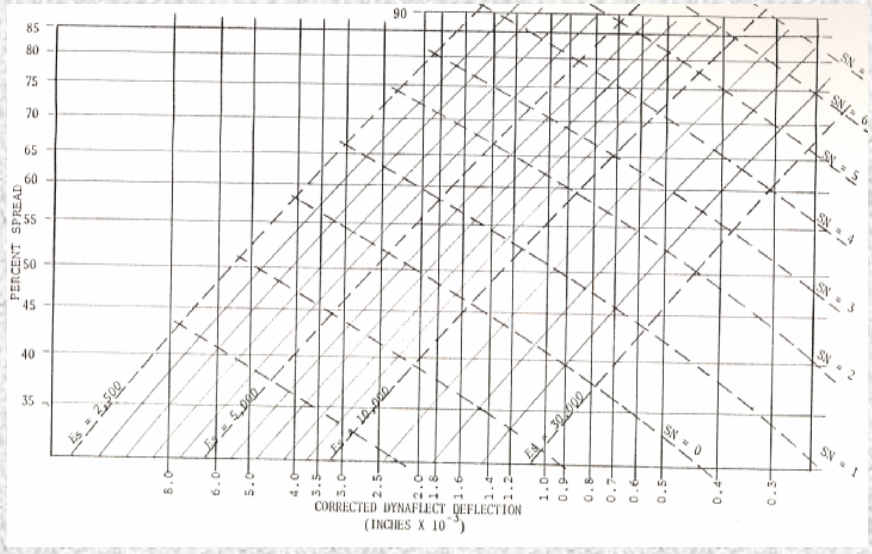


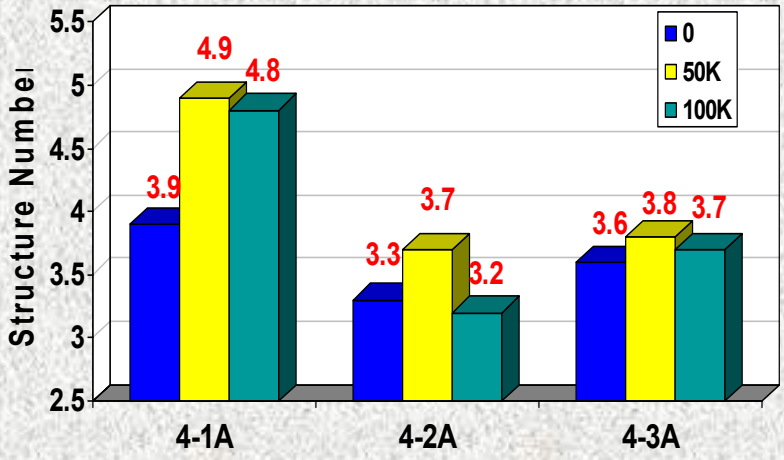


DYNAFLECT Results

- **Pavement structure number (SN) is defined as**
  - **$SN=a_1*H_1+a_2*H_2+a_3*H_3$**
- **SN determined from**
  - **center deflection**
  - **deflection basin parameter**



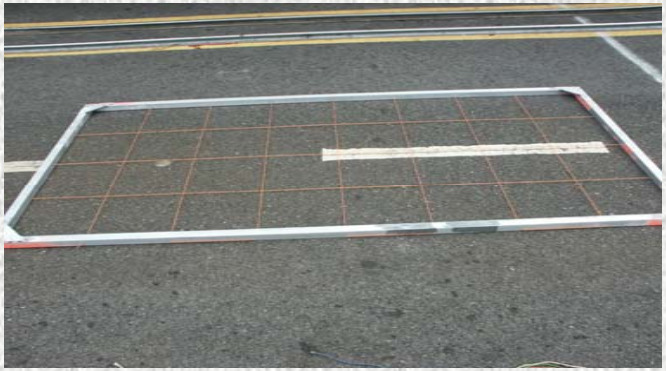


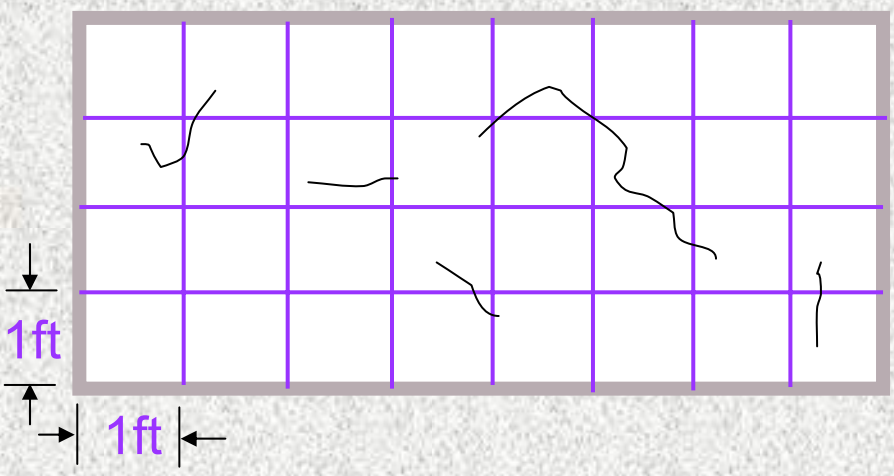


Ave. Structure Number

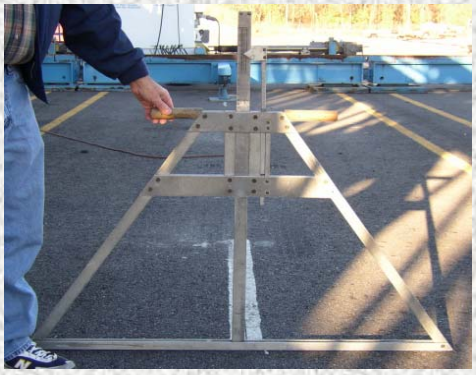
Surface Distress Survey

- Cracking





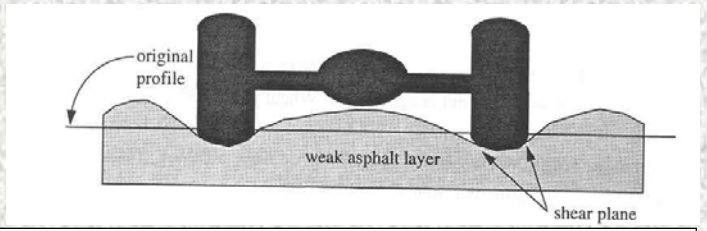
- Rutting

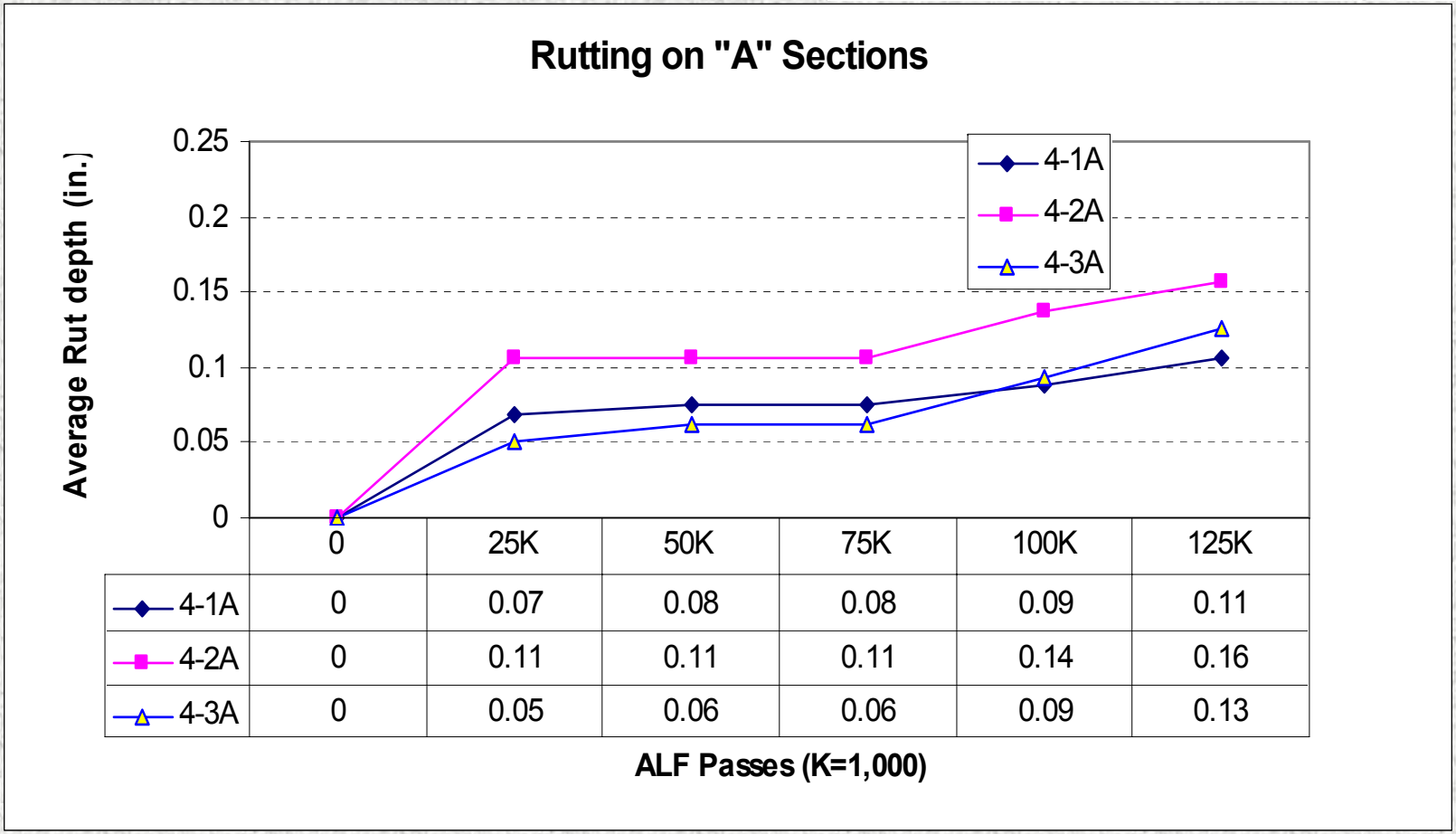


Cracking

- Only Section 4-2A developed some hairline-type cracks
  - *not severe*
- No visual cracks found on either Section 4-1A or 4-3A

Rutting





	0	25K	50K	75K	100K	125K
4-1A	0	0.07	0.08	0.08	0.09	0.11
4-2A	0	0.11	0.11	0.11	0.14	0.16
4-3A	0	0.05	0.06	0.06	0.09	0.13

Summary and Conclusions

1. 

perform better than

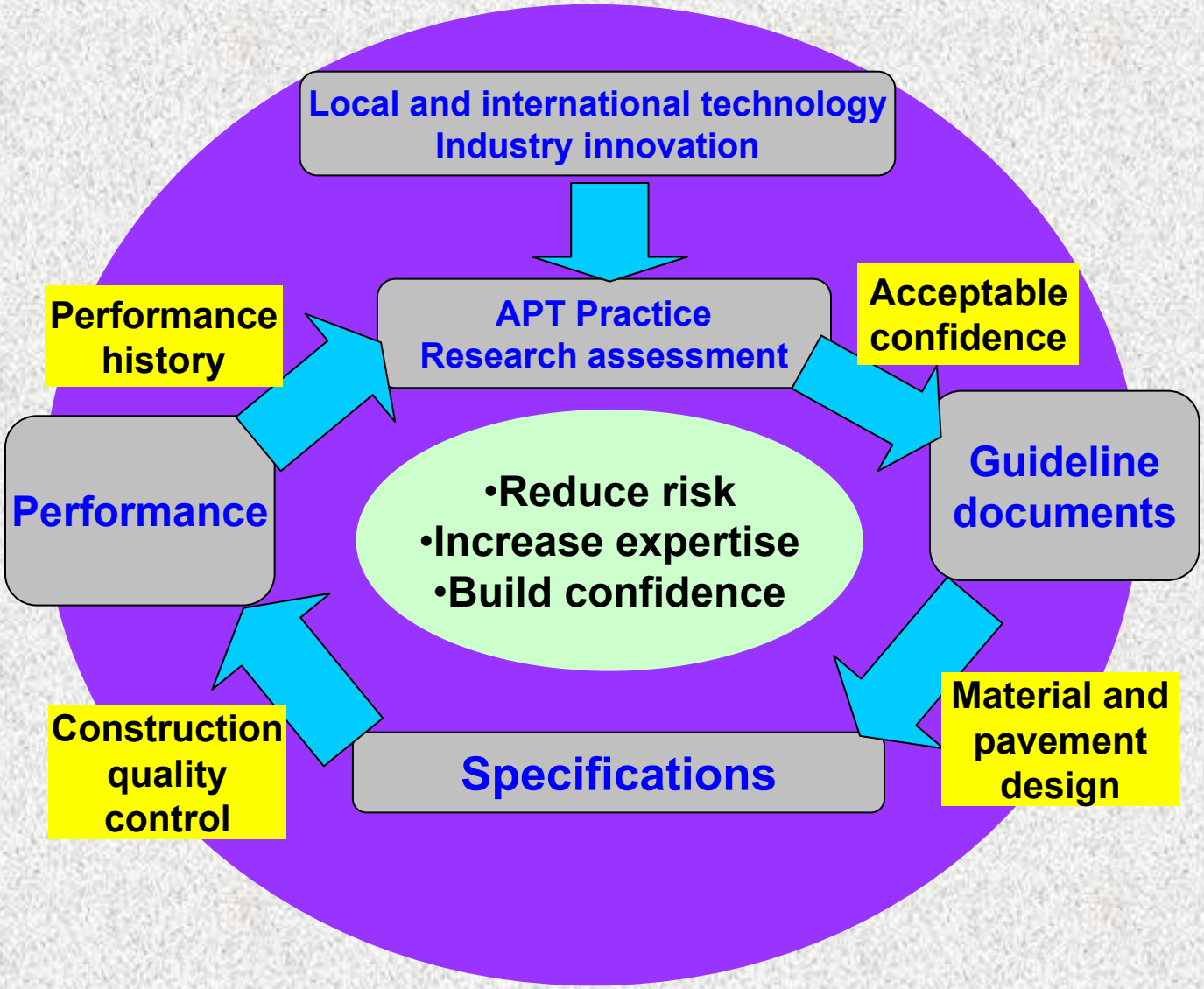

Evidenced by
- **Surface distresses**
- **FWD center deflections**
- **Dynaflect Structure Number**
- **Measured vertical stresses, and**
- **Measured MDD deformations.**

2. 

superior than


Evidenced by
- **Measured vertical stresses**

APT Research to Implementation



Questions?