A Multi-Purpose Pavement Testing Device for Airfield Pavements: The Rolling Dynamic Deflectometer

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Federal Aviation Administration
Airport Pavement Working Group Meeting
April 17, 2013

Presentation Outline

RDD Background

RDD Applications

SDD Applications

New Developments on the RDD

Conclusions


DC 10
Travel direction
RDD

Continuous Pavement Testing Devices

- **Road Deflection Tester (Sweden)**
- **Rolling Wheel Deflectometer (USA)**
- **Traffic Speed Deflectometer (Denmark)**
- **Rolling Dynamic Deflecotometer (USA)**

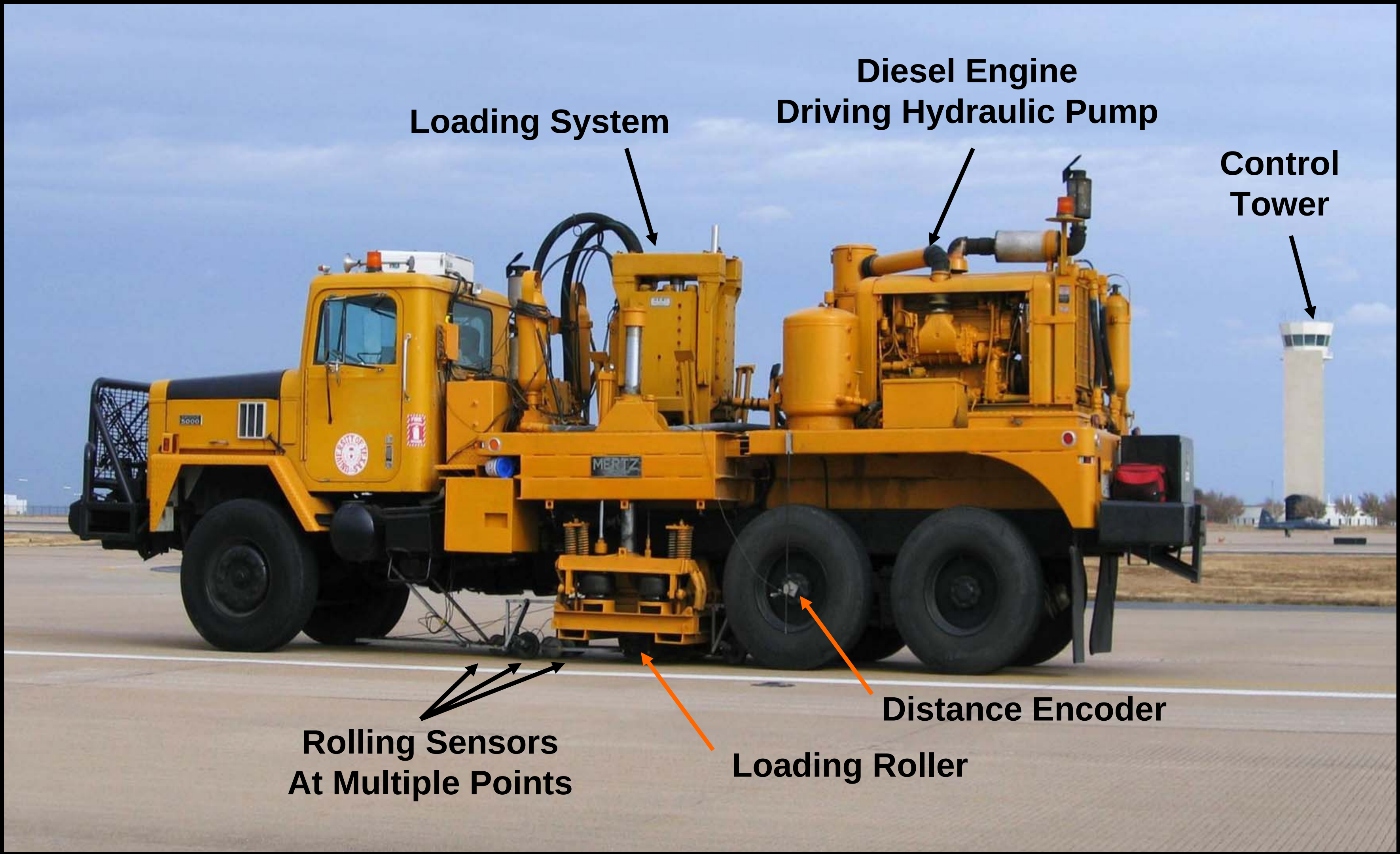
Comparison of continuous NDT testing devices (after Arora et al. 2006)

Testing Methods	Sensor Type	Testing Speed	Sensor Accuracy	Applied Loading	Averaging Distance Resolution	Manufacturer
Rolling Wheel Deflectometer (RWD)	Laser displacement sensor	55 mph	±2.75 mils	18 kips (fixed)	100 ft	Applied Research Associates
Airfield Rolling Weight Deflectometer (ARWD)	Laser displacement sensor	20 mph	0.8 mil	9 kips	90 ft	Dynatest Consulting and Quest Integrated
Rolling Deflection Tester (RDT)	Laser displacement sensor	36 mph	± 10 mils	8 to 14 kips	66 ft	Swedish National Road Administration and VTI
High Speed Deflectograph (HSD)	Laser doppler sensor	45 mph	± 4 mils/s	11 kips	33 ft	Greenwood Engineering
Rolling Dynamic Deflectometer (RDD)	Geophone (velocity transducer)	1 mph	0.05 mils	10 kips static + 5 kips dynamic	1.5 to 3 ft	University of Texas at Austin

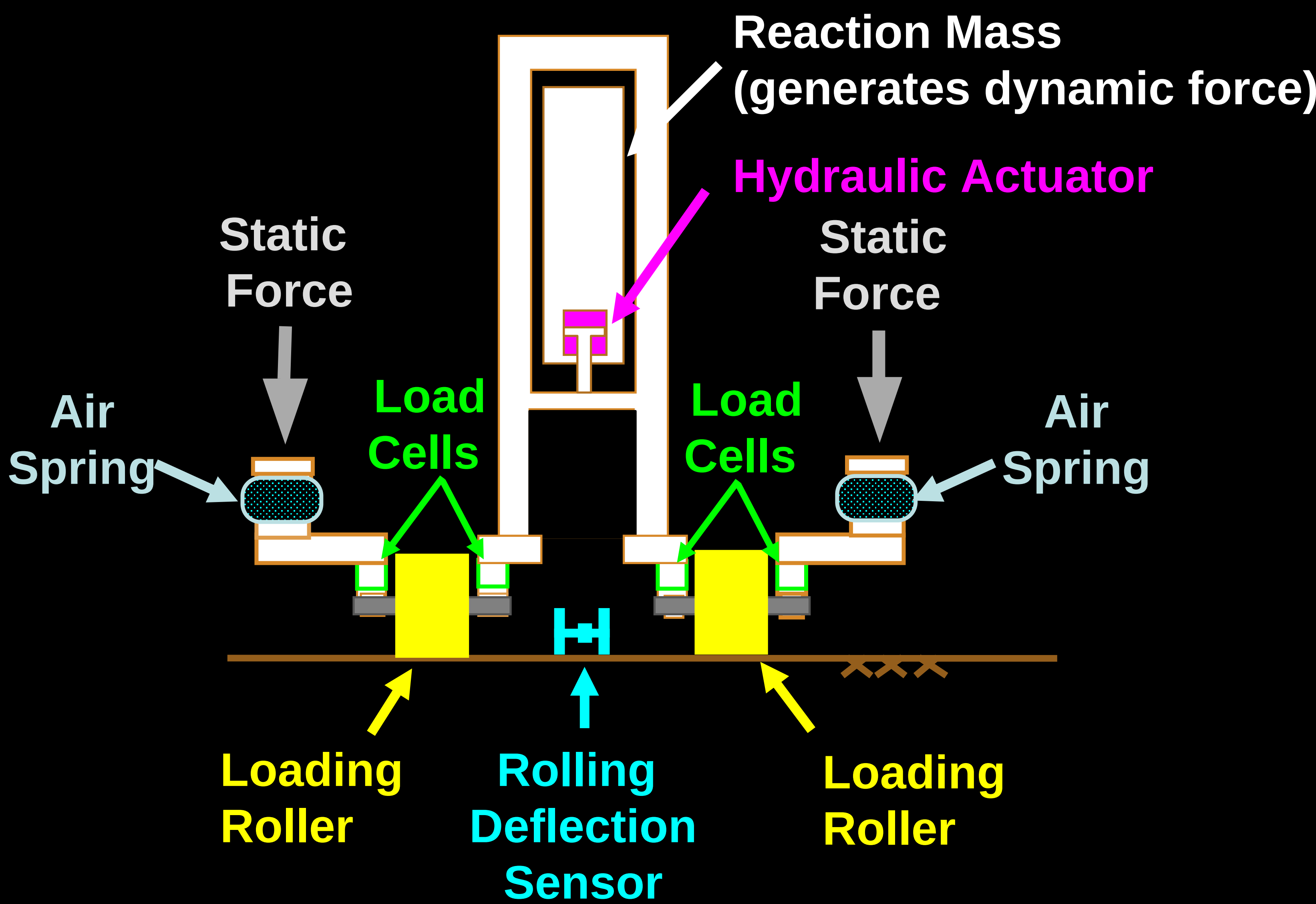
Overview of RDD

- Mobile platform
  - moves continuously along pavement
  - used to apply dynamic loads to pavement
  - rolling sensors measure resulting dynamic deflections
- Dynamic loading system
  - electro-hydraulic shaker
  - two loading rollers
  - four load cells
  - high fidelity, single-frequency sinusoidal loading
- Deflection measurement system
  - multiple rolling sensors that contact pavement
  - 2-Hz geophones on 3-wheel carts
  - measurements at multiple locations

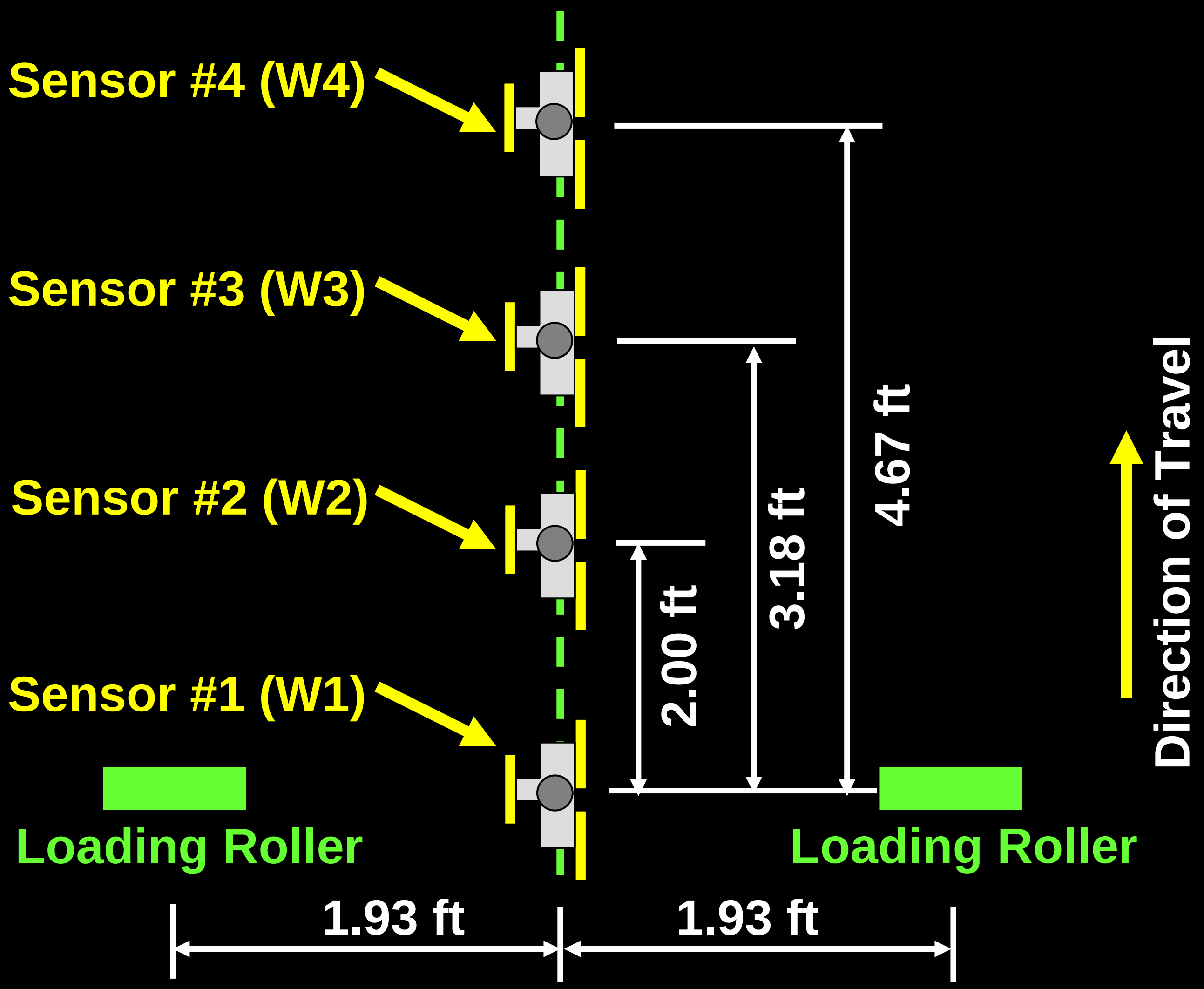
Rolling Dynamic Deflectometer (RDD)



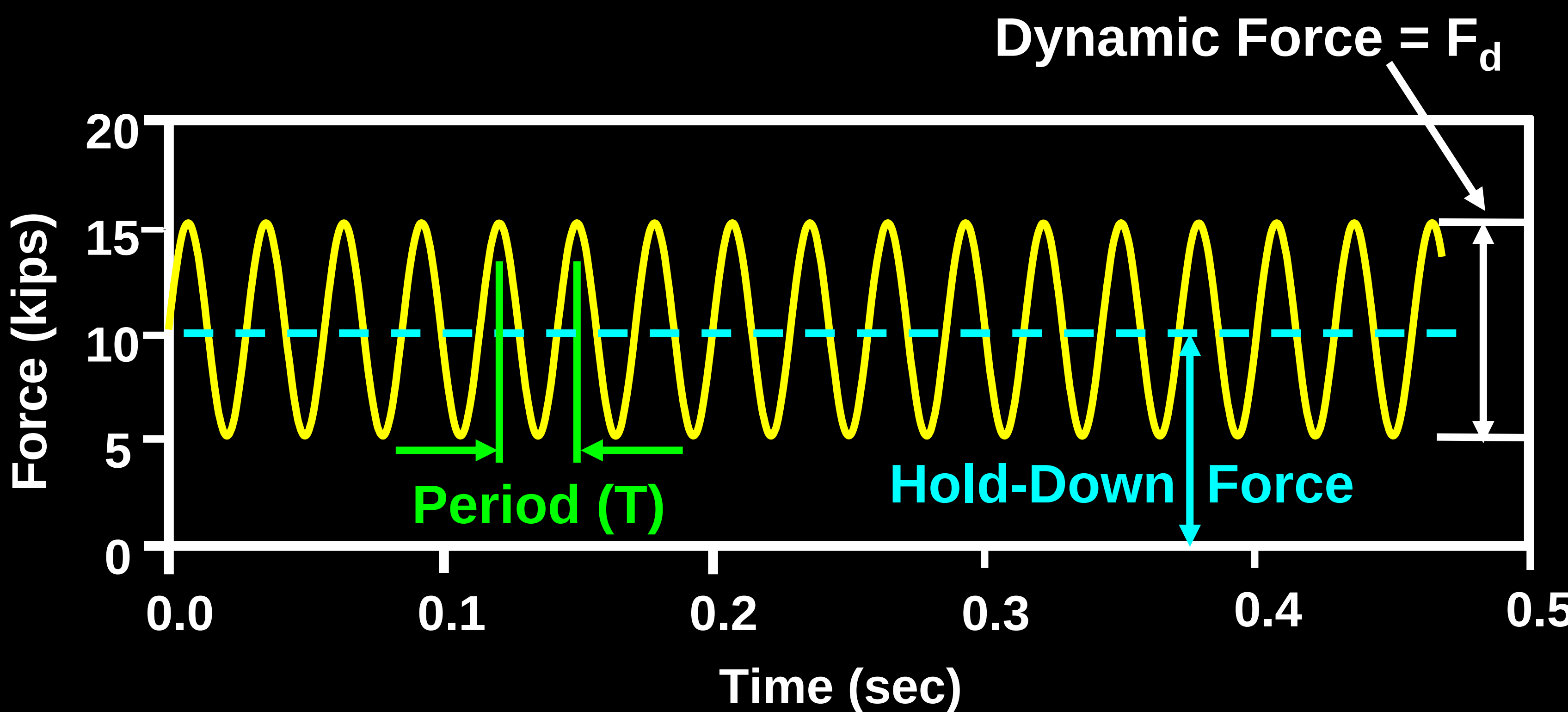
Cross Section of RDD



Arrangement of Rolling Sensors



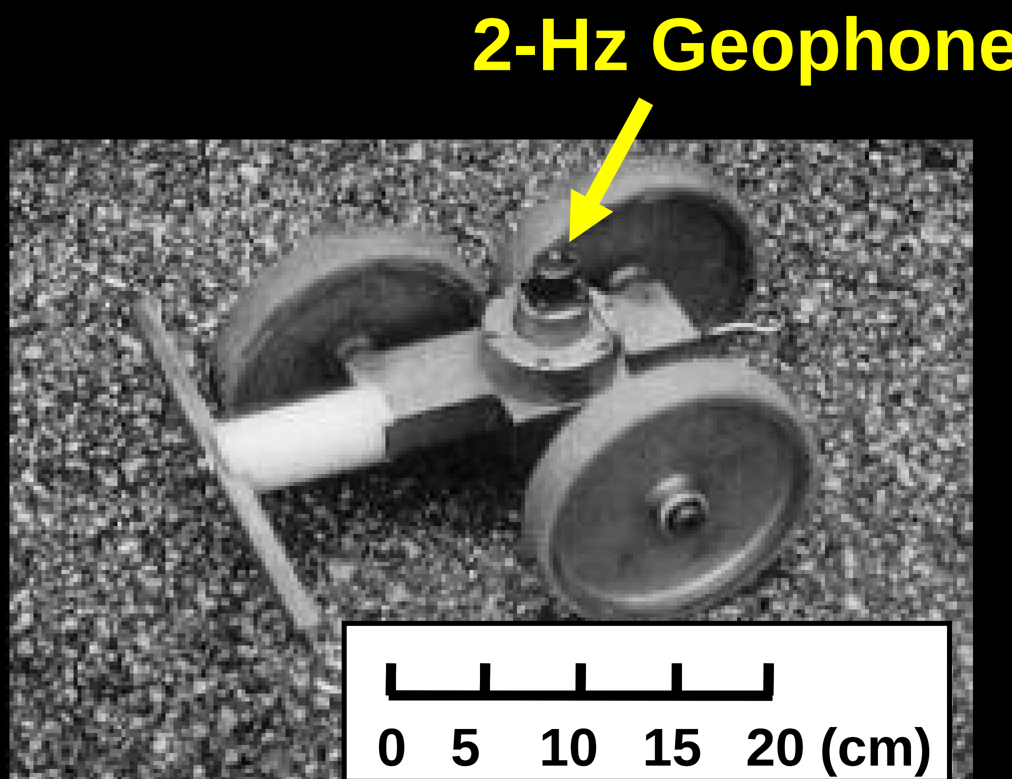
RDD Forcing Function



Notes:

1. Typical Load frequency = 1/T = 30 Hz
2. Measuring dynamic pavement deflections due F_d
3. 1 kip = 4.45 kN

Original Rolling Sensor Used to Measure Dynamic Deflections



Original RDD Specifications

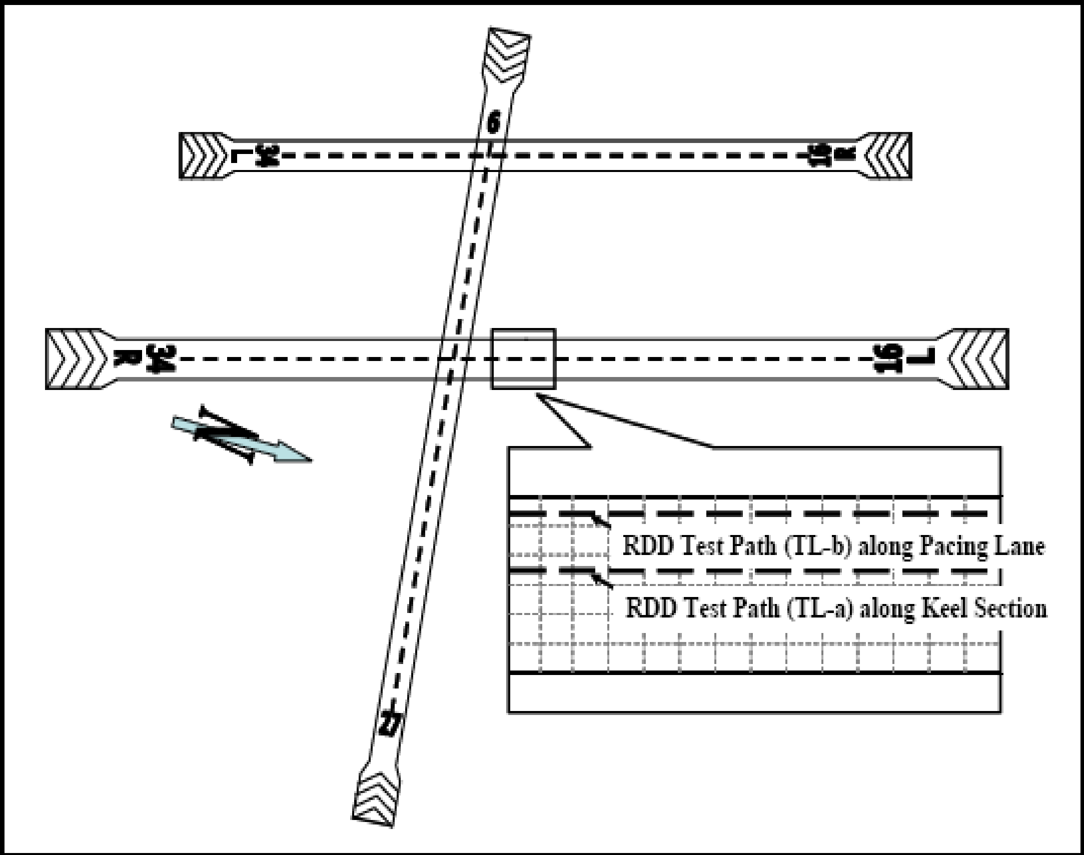
Gross Weight [1]	50 kips (222 kN)
Static Hold-Down Force	10 ± 4 kips (36 ± 18 kN)
Typical Dynamic Force (p-p)	8 ± 4 kips (26 ± 13 kN)
Operating Frequency	30 Hz
Typical Testing Speed	1 to 2 mph (1.6 to 3.2 km/hr)
No. of Rolling Sensors	3 to 4

Note:

1. Used to apply static hold-down force

RDD Applications

Fort Worth Mecham International Airport



Runway 16L/34R:

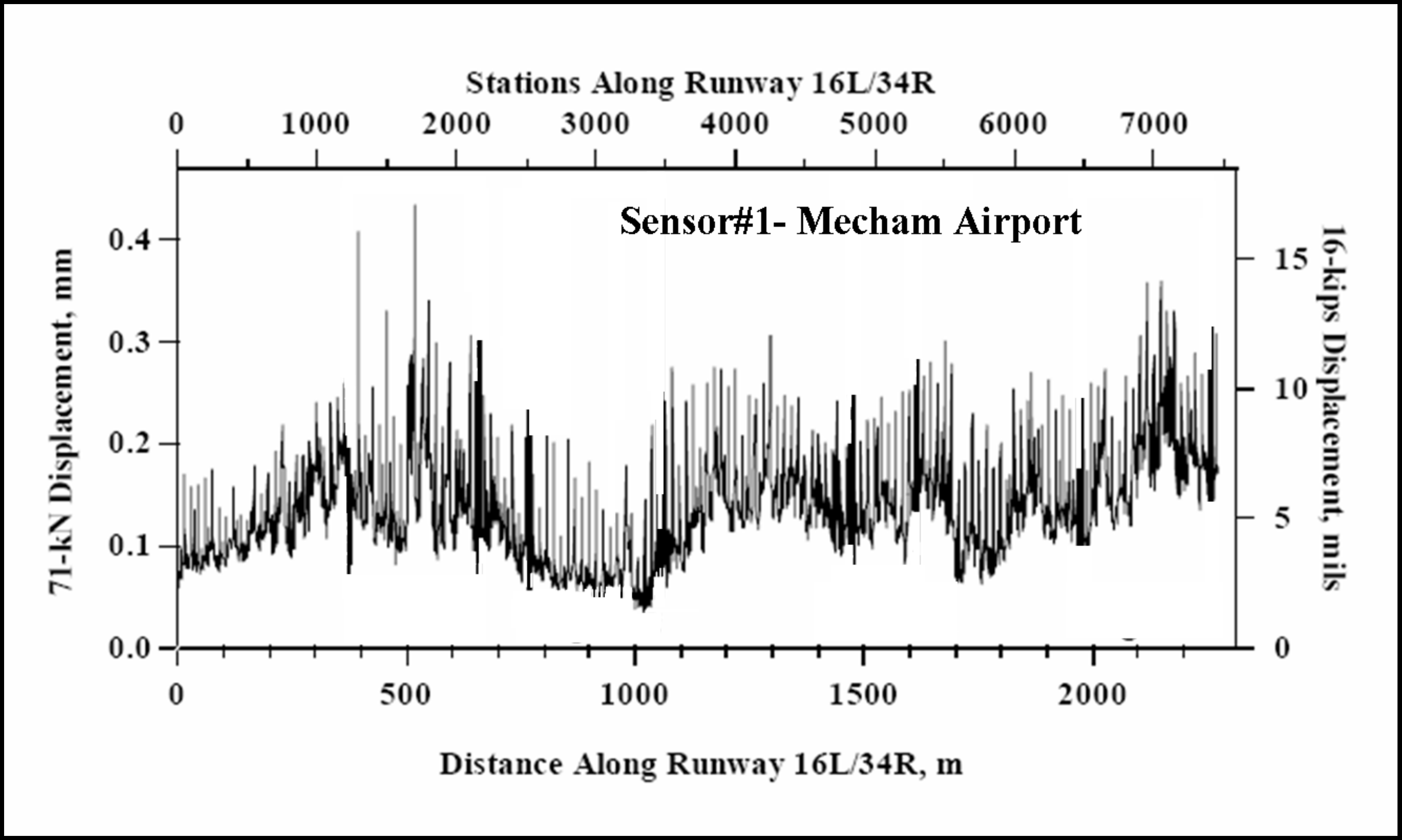
- 1.4 mile (2.3 km) long
- 150 ft (46 m) wide
- Slab size: 25x25 ft (7.6x7.6 m)

Rehabilitation Plan:

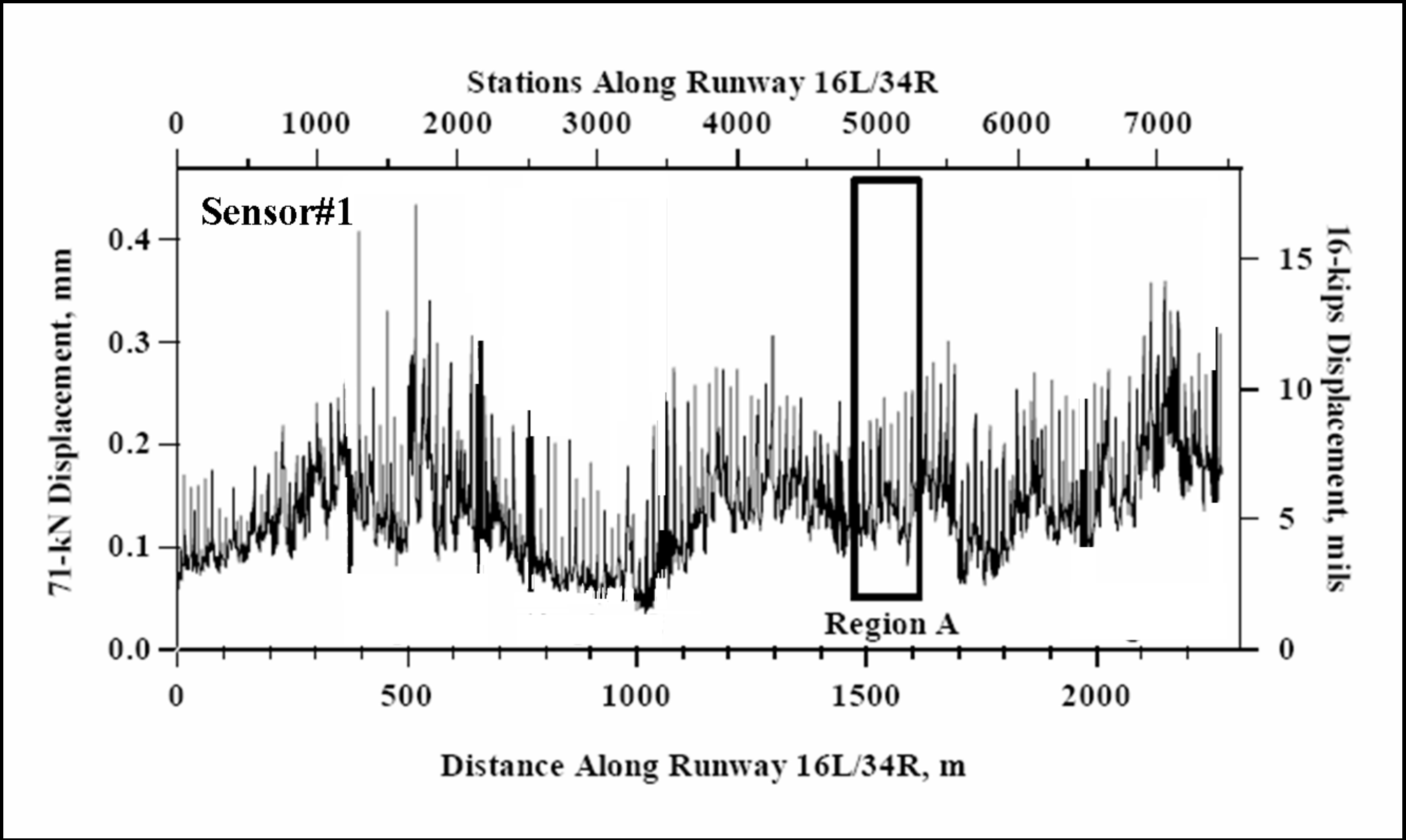
- Original reha. plan was a 9-in. (23-cm) unbondeD JCP overlay

- RDD profiling was used to delineate areas not to be repaired.

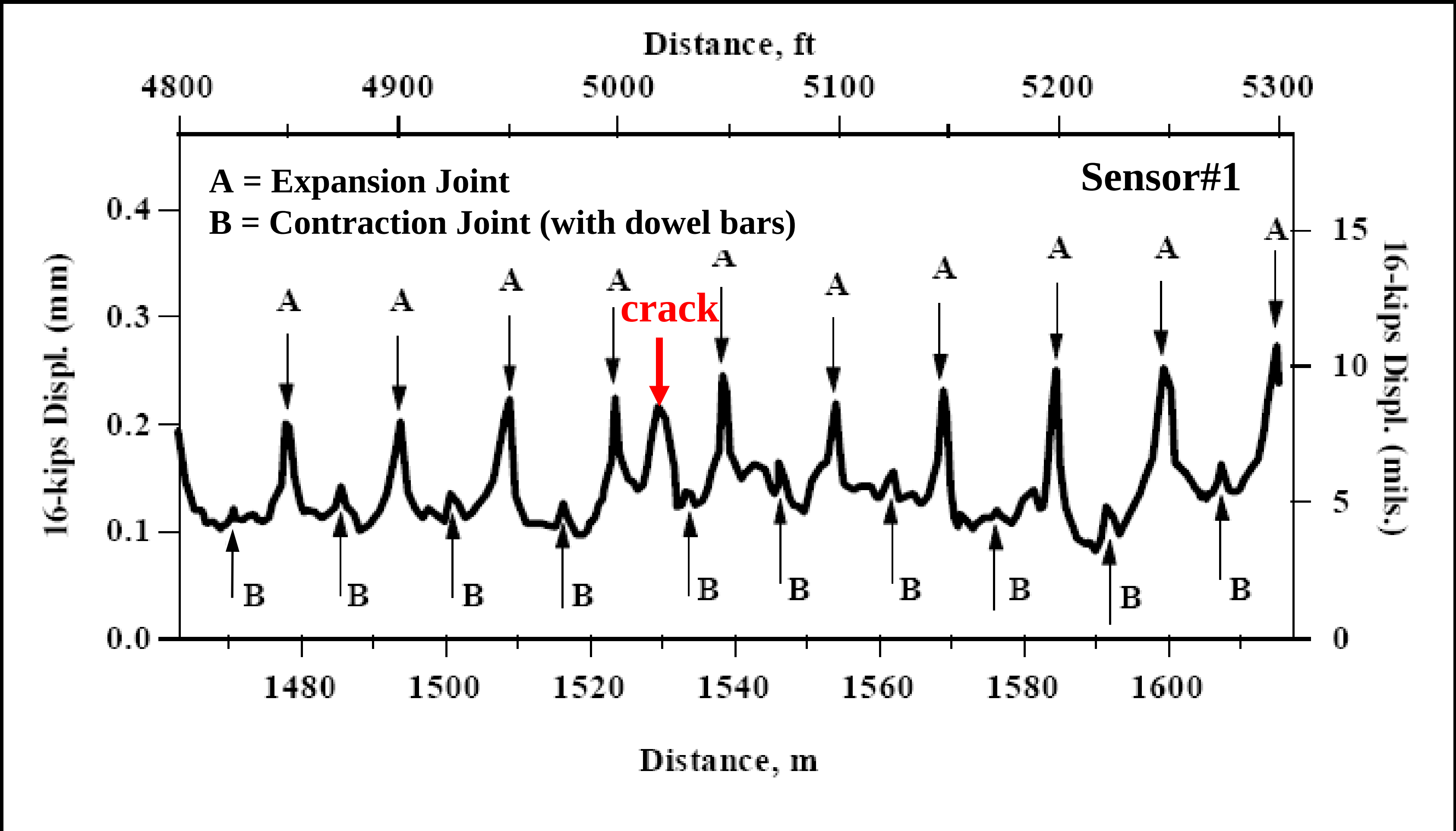
Typical Continuous Deflection Profile along a JCP



Typical Continuous Deflection Profile along a JCP

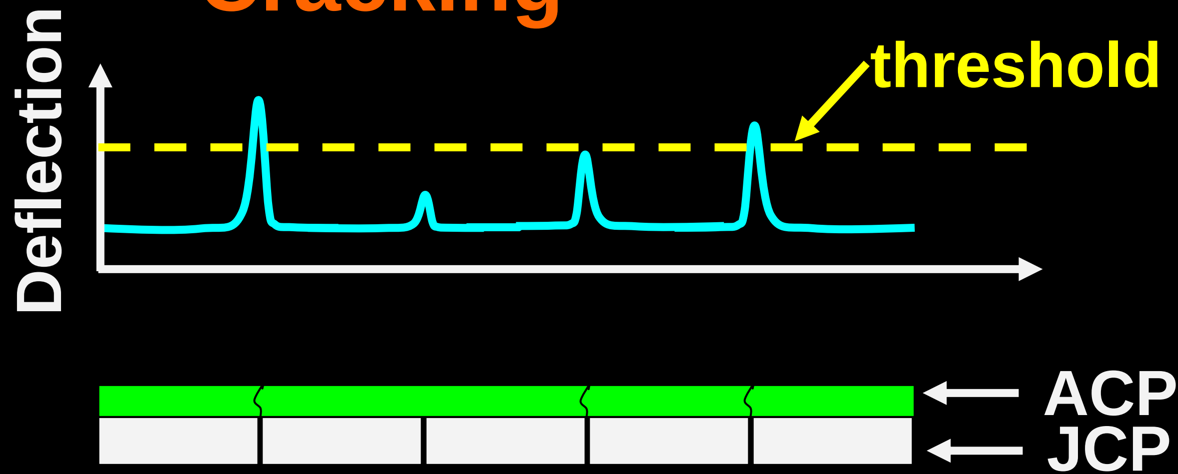


Expanded Profile of Region A



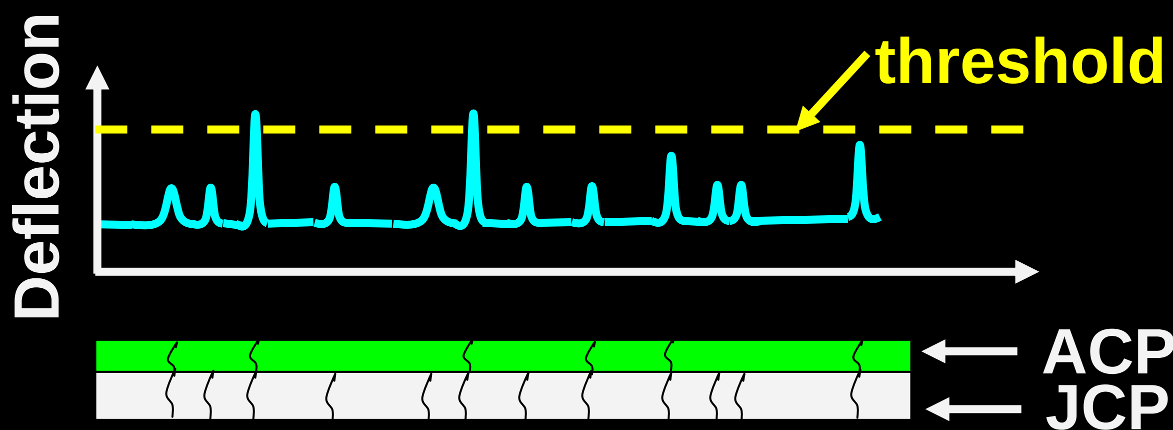
Threshold Deflections for Reflection Cracking

Jointed Concrete Pavement (JCP)



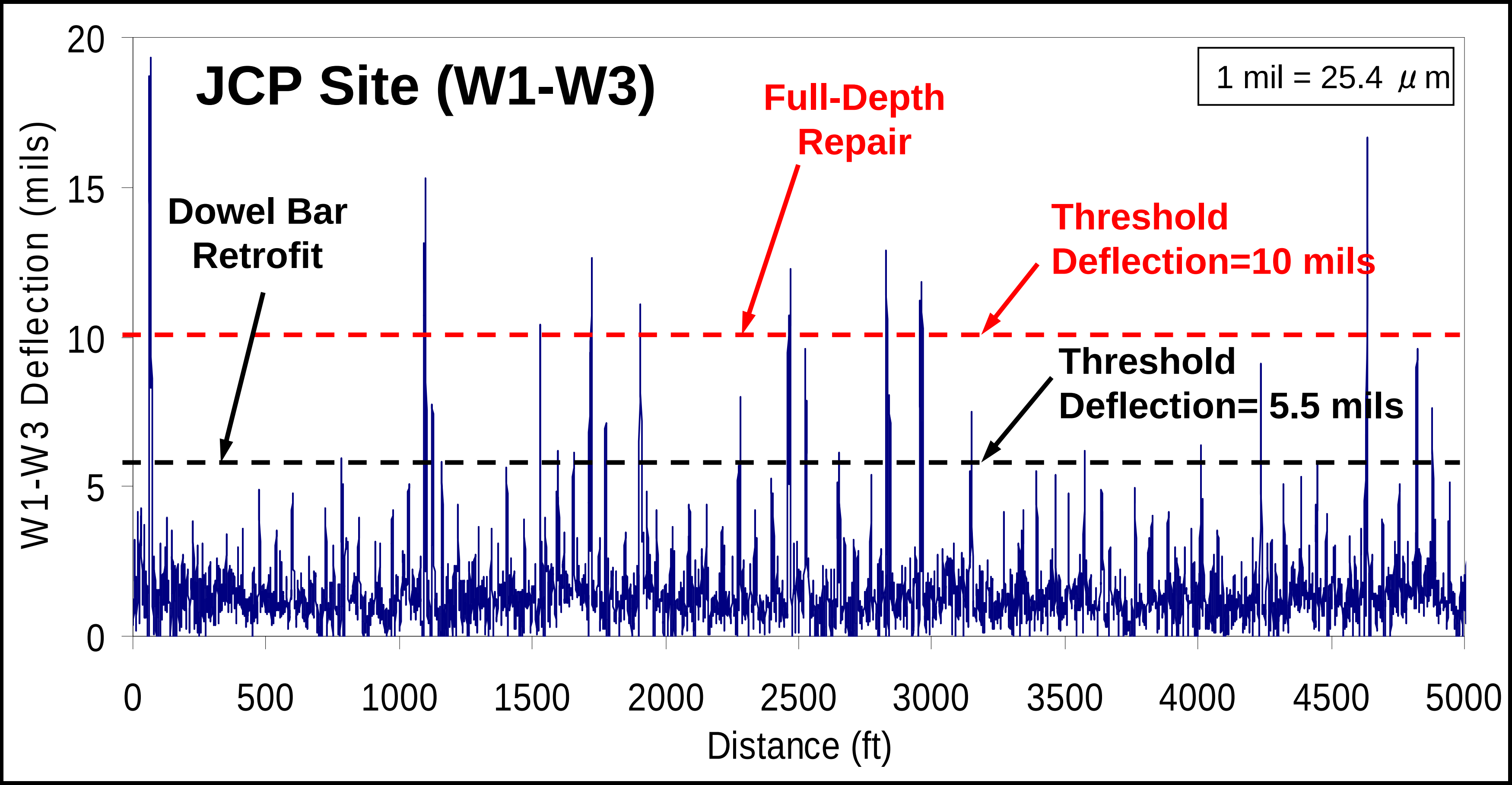
typical joint spacing around 6 m

Continuously Reinforced Concrete Pavement (CRCP)

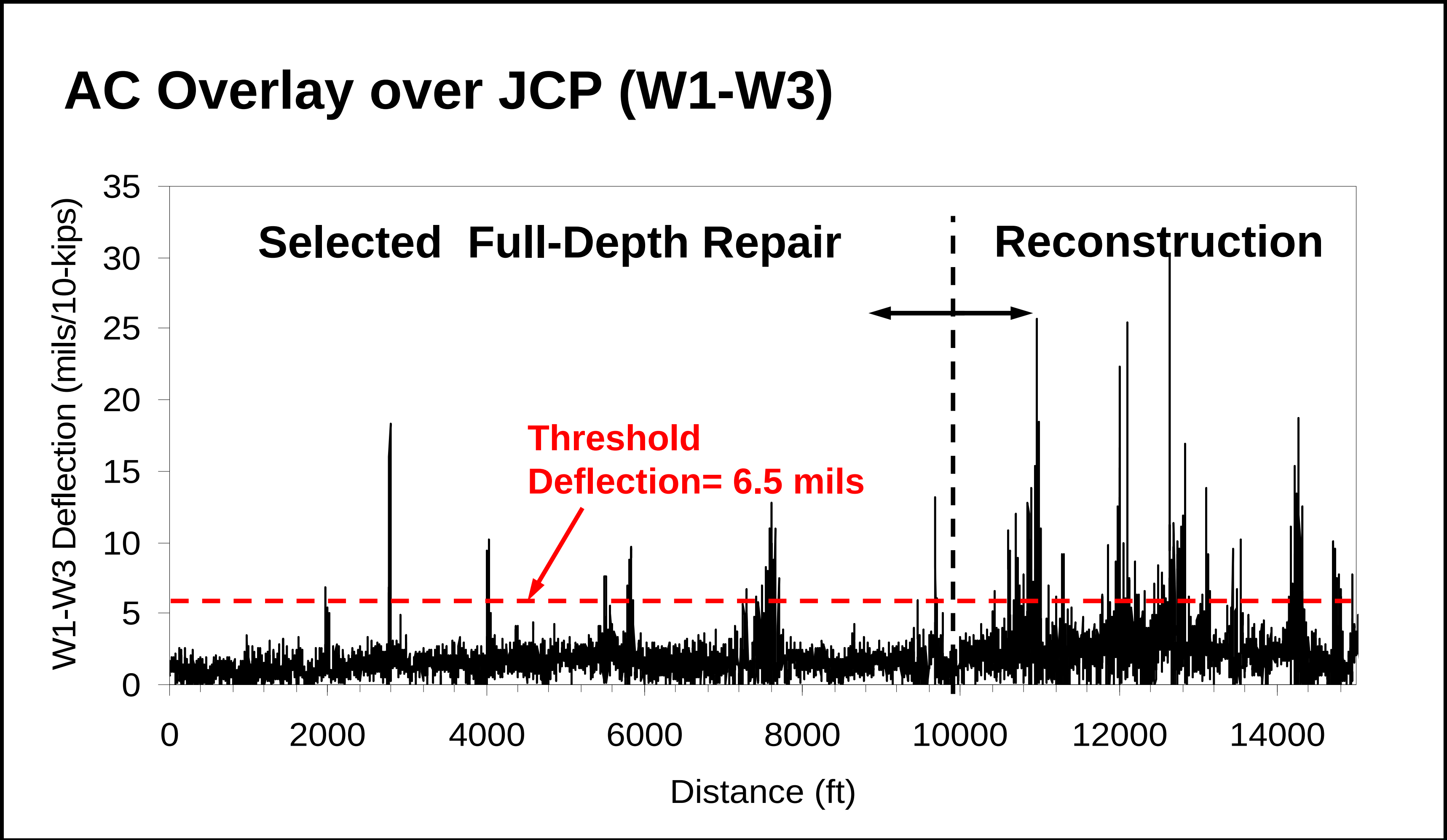


joint spacing is no longer regular, instead it is a distribution

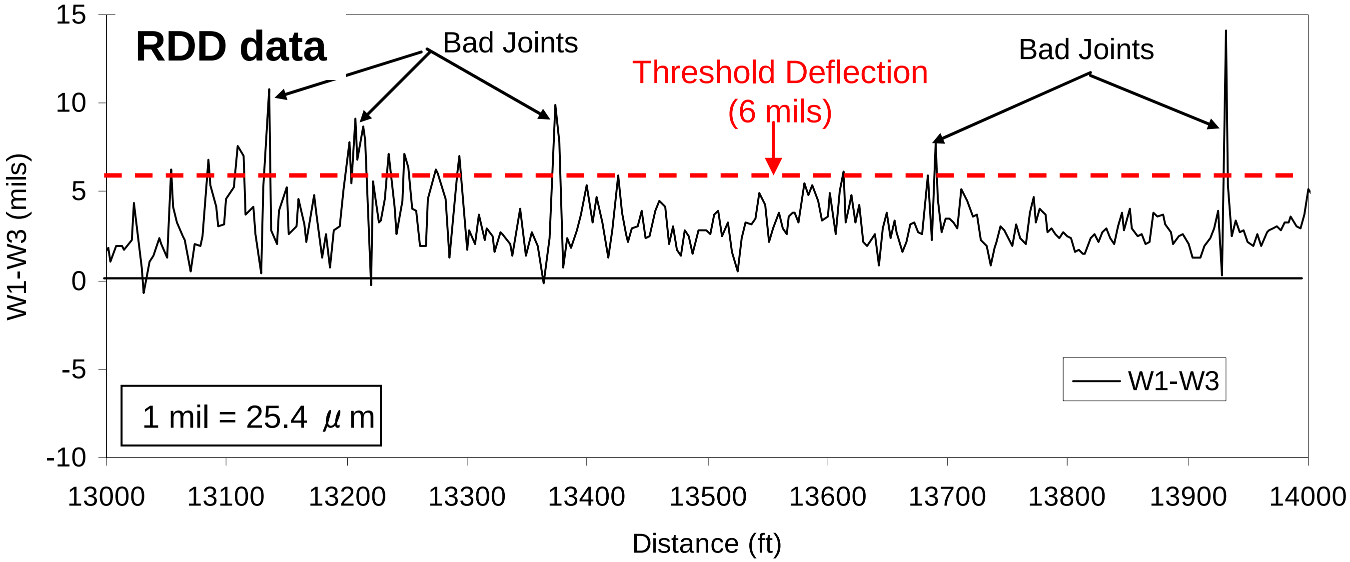
SH87, Bridge City, Texas: Dowel-Bar Retrofit Project

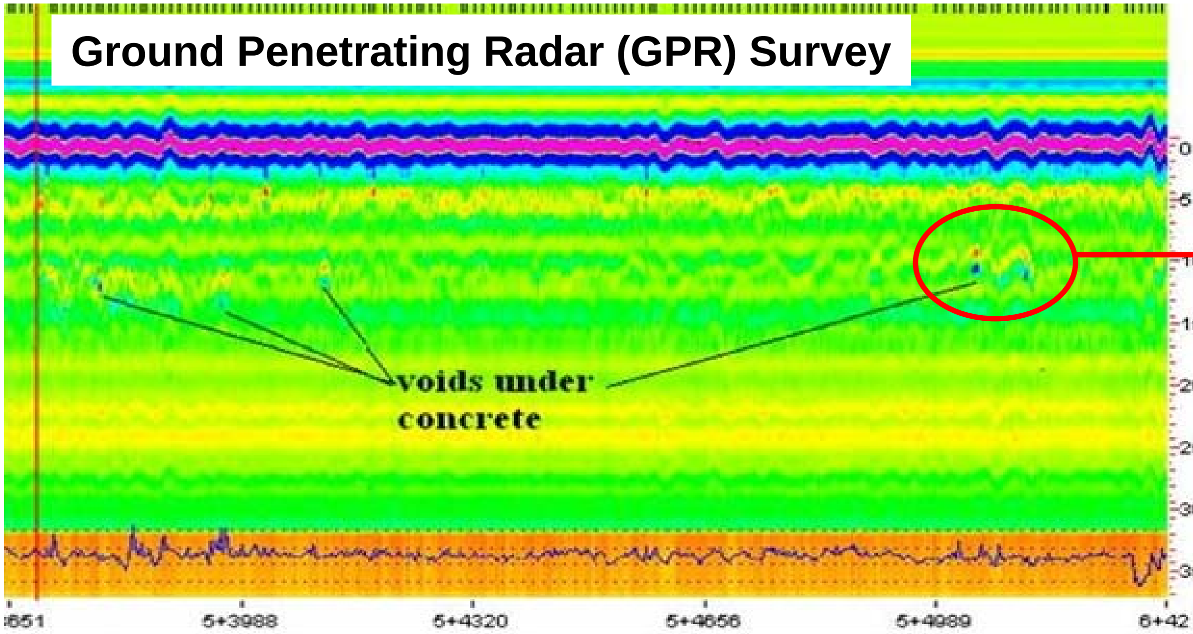


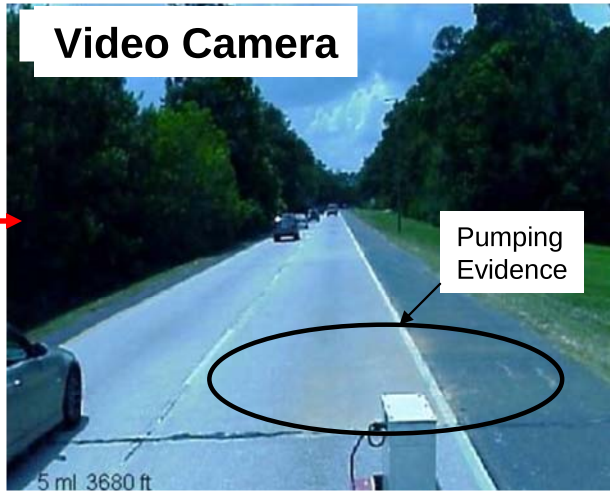
BU287, Tarrant County, Texas: Full-Depth Repair and Reconstruction



Woodlands Pkwy, Woodlands, Texas: Pavement Forensic Investigation



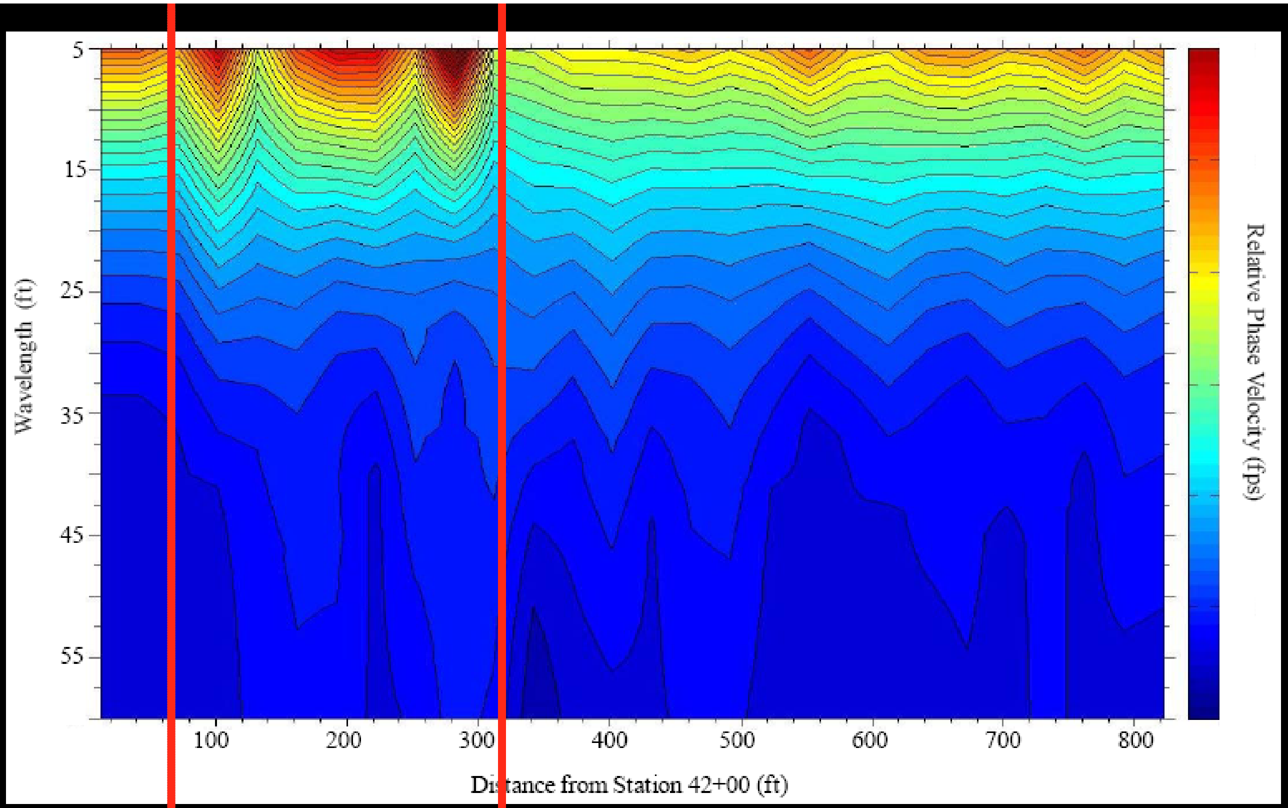




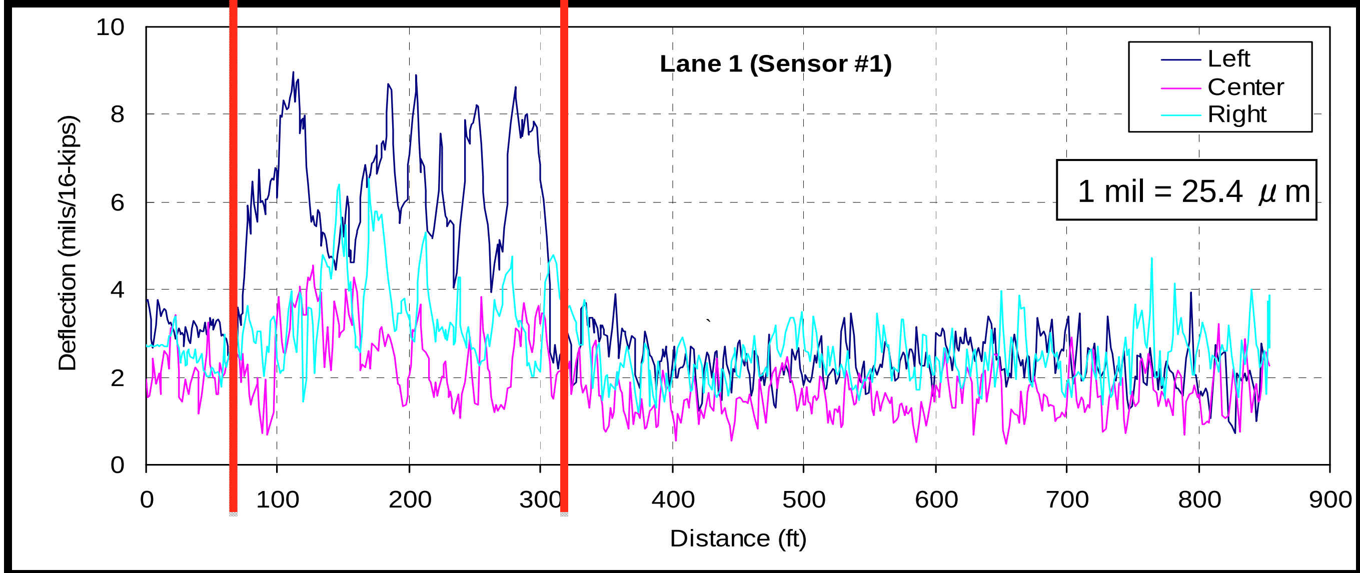
Taxiway R, Little Rock National Airport: Slab-Support Condition Assessment

Multi-Channel Analysis of Surface Wave (MASW)

Rolling Dynamic Deflectometer (RDD)

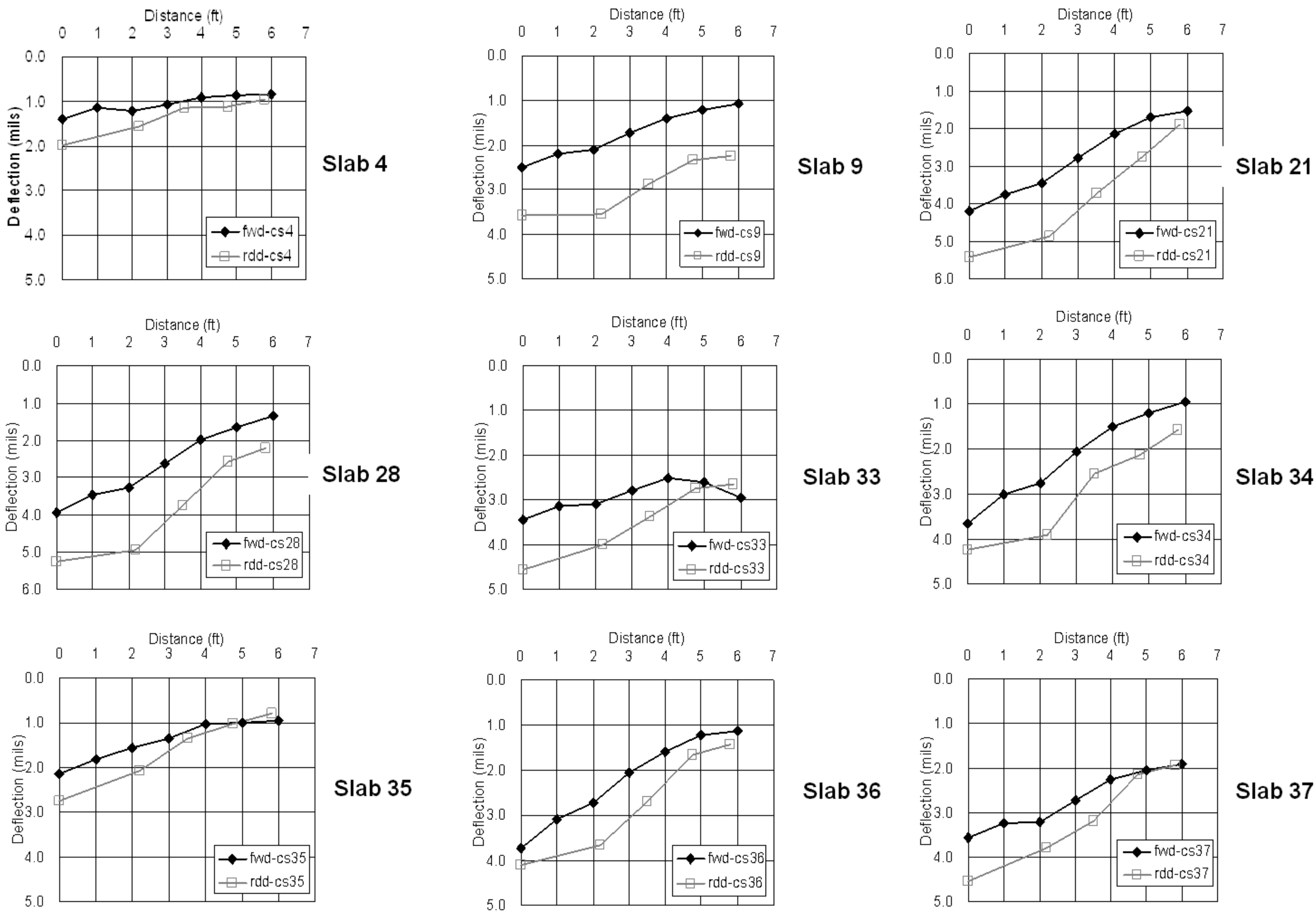


MASW Data



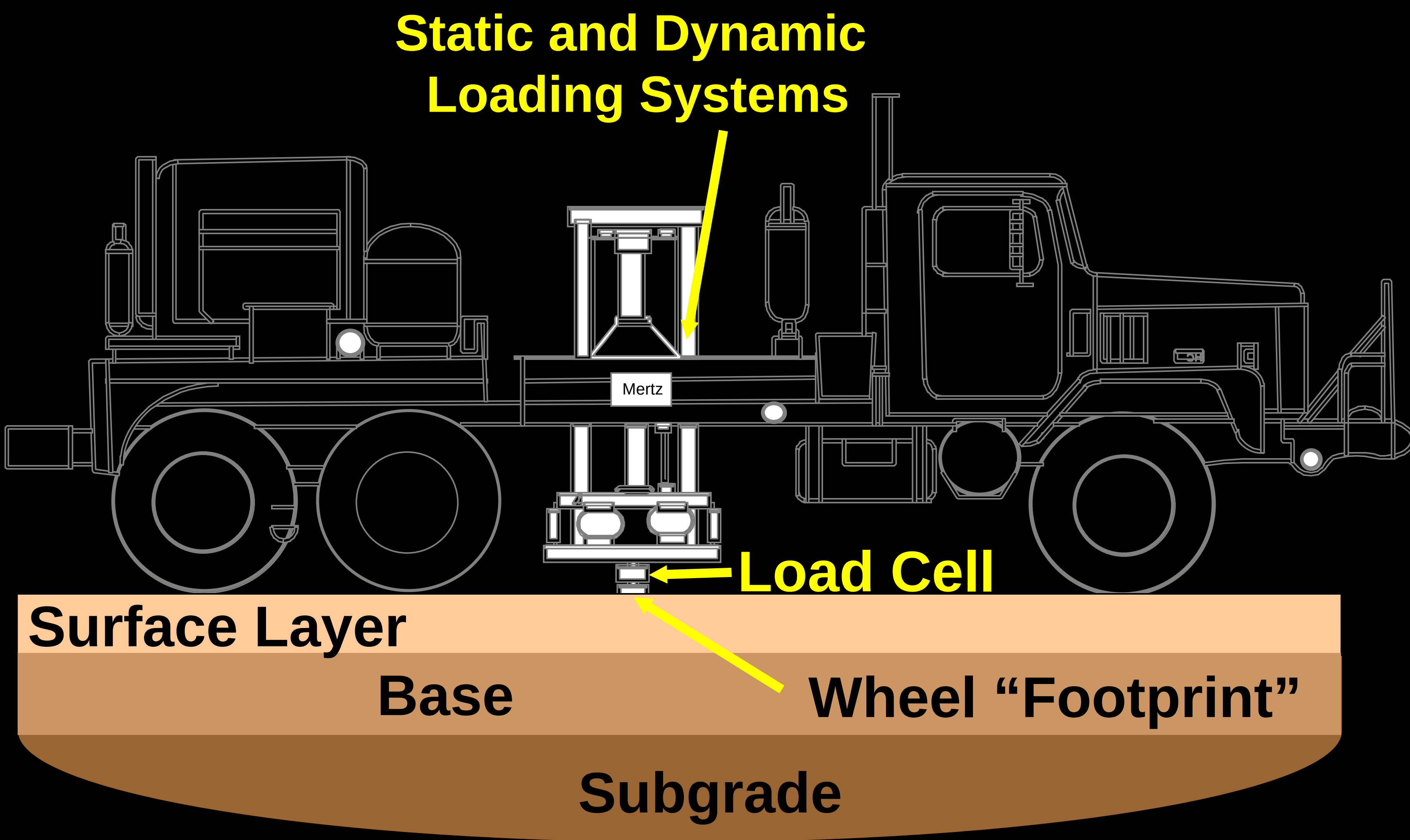
RDD Data

ACRP Graduate Research Grant: Continuous RDD Deflection Bowls

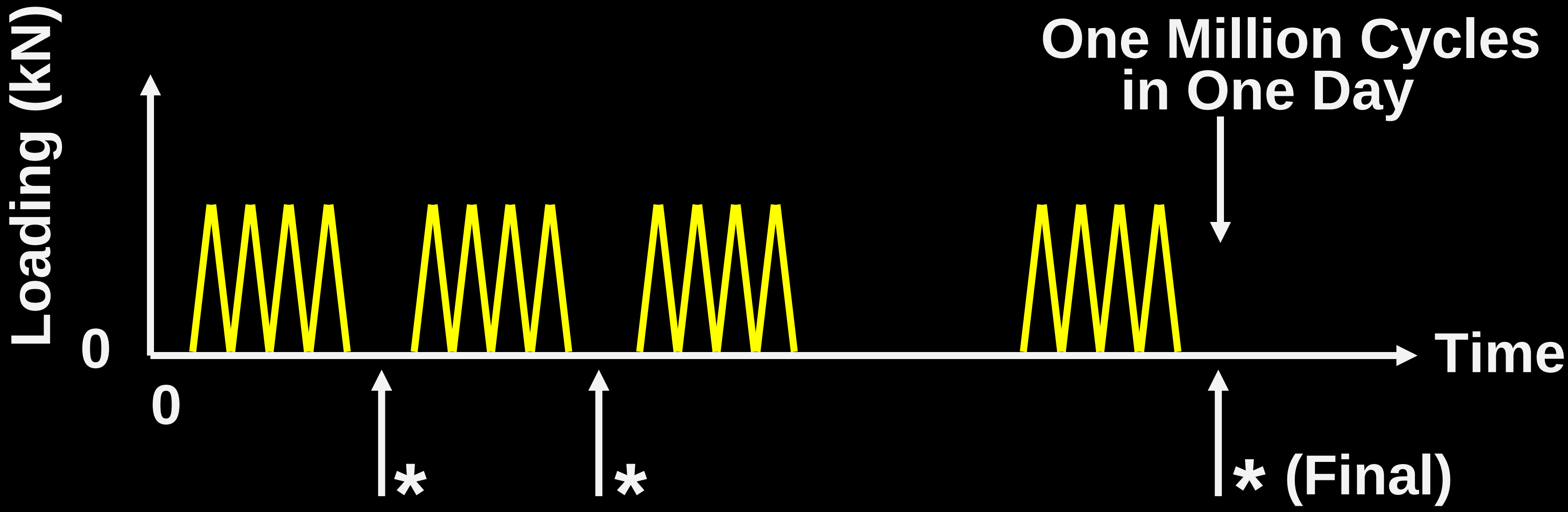


SDD Applications

Operating the DD as a Stationary Dynamic Deflectometer (SDD)

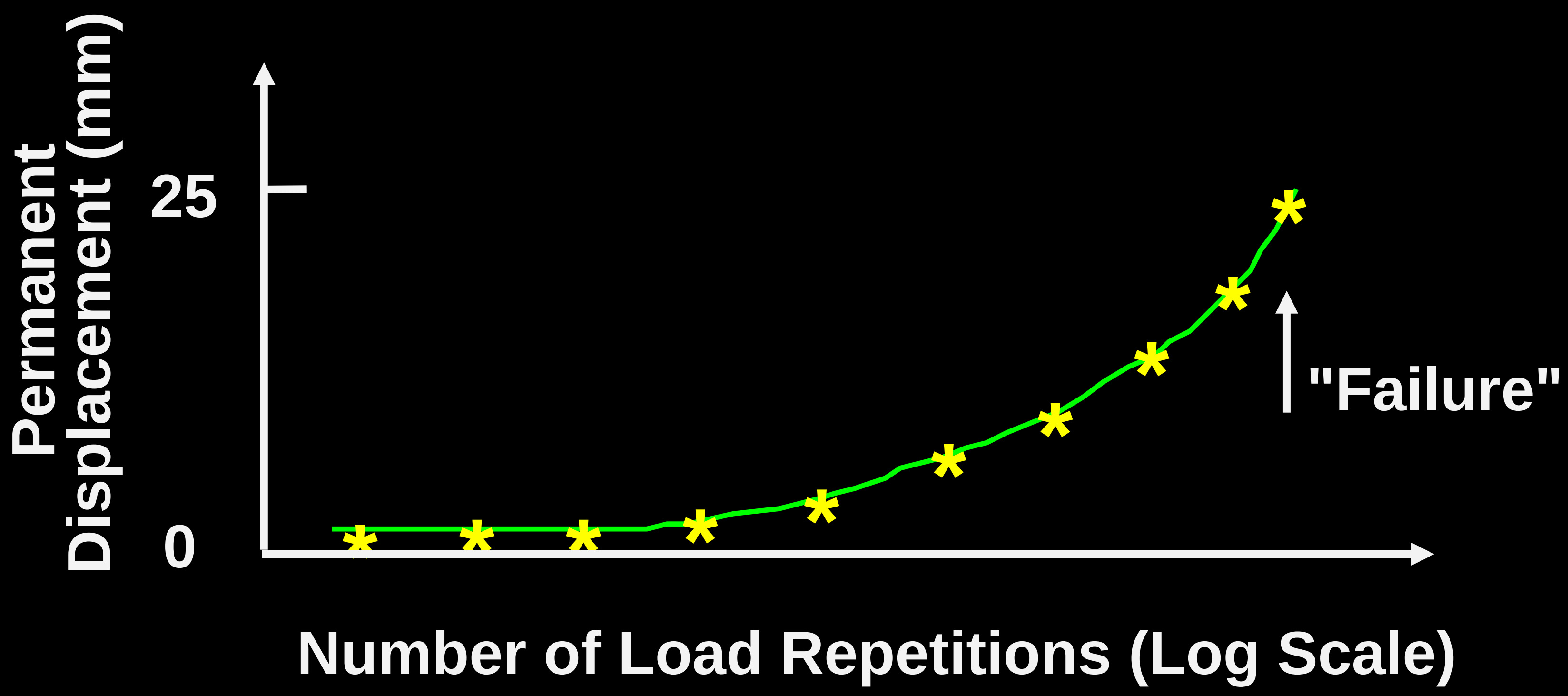


Sequence of Load Repetitions and Characterization Measurements

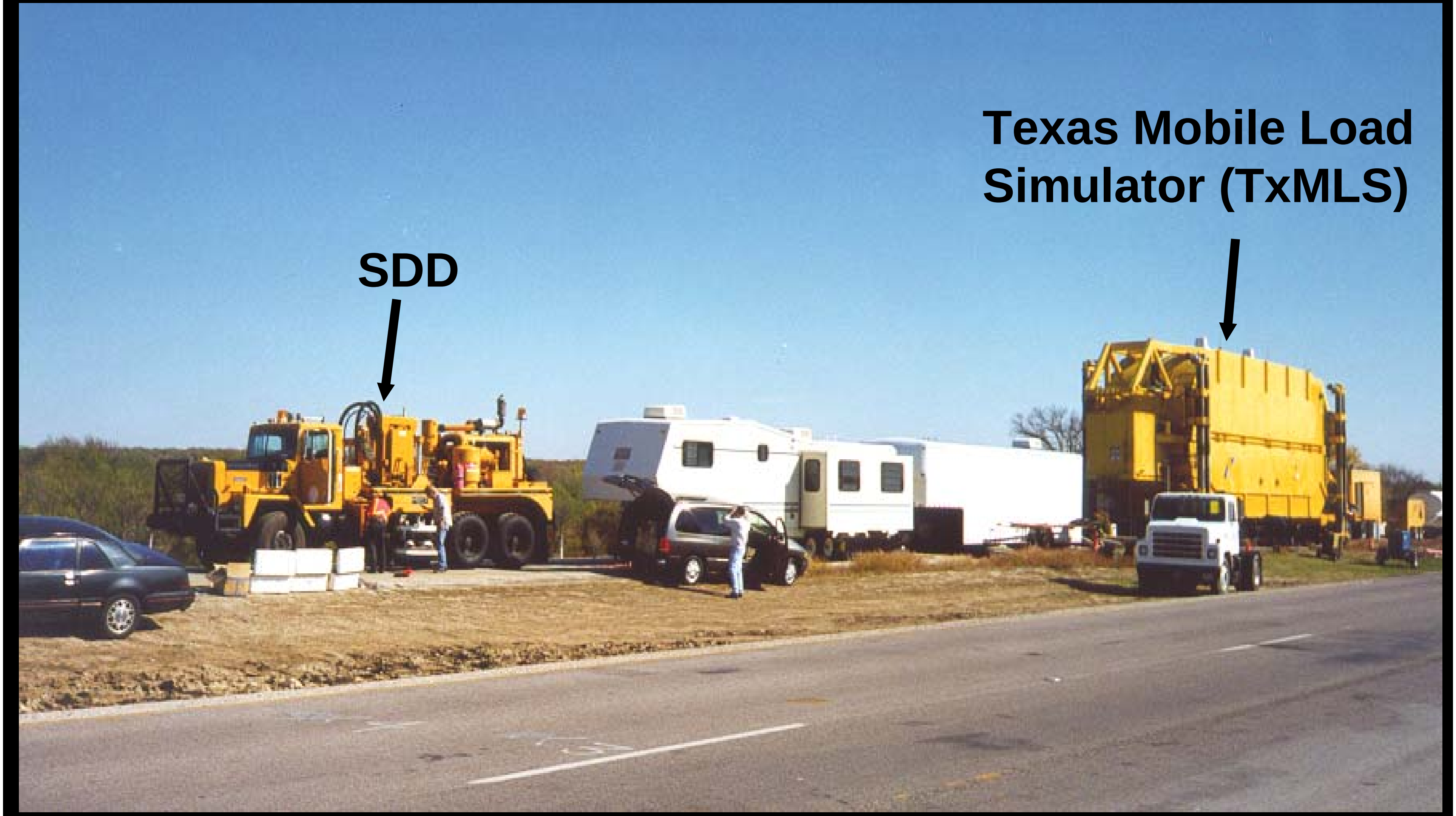


Note: * Characterization Measurements

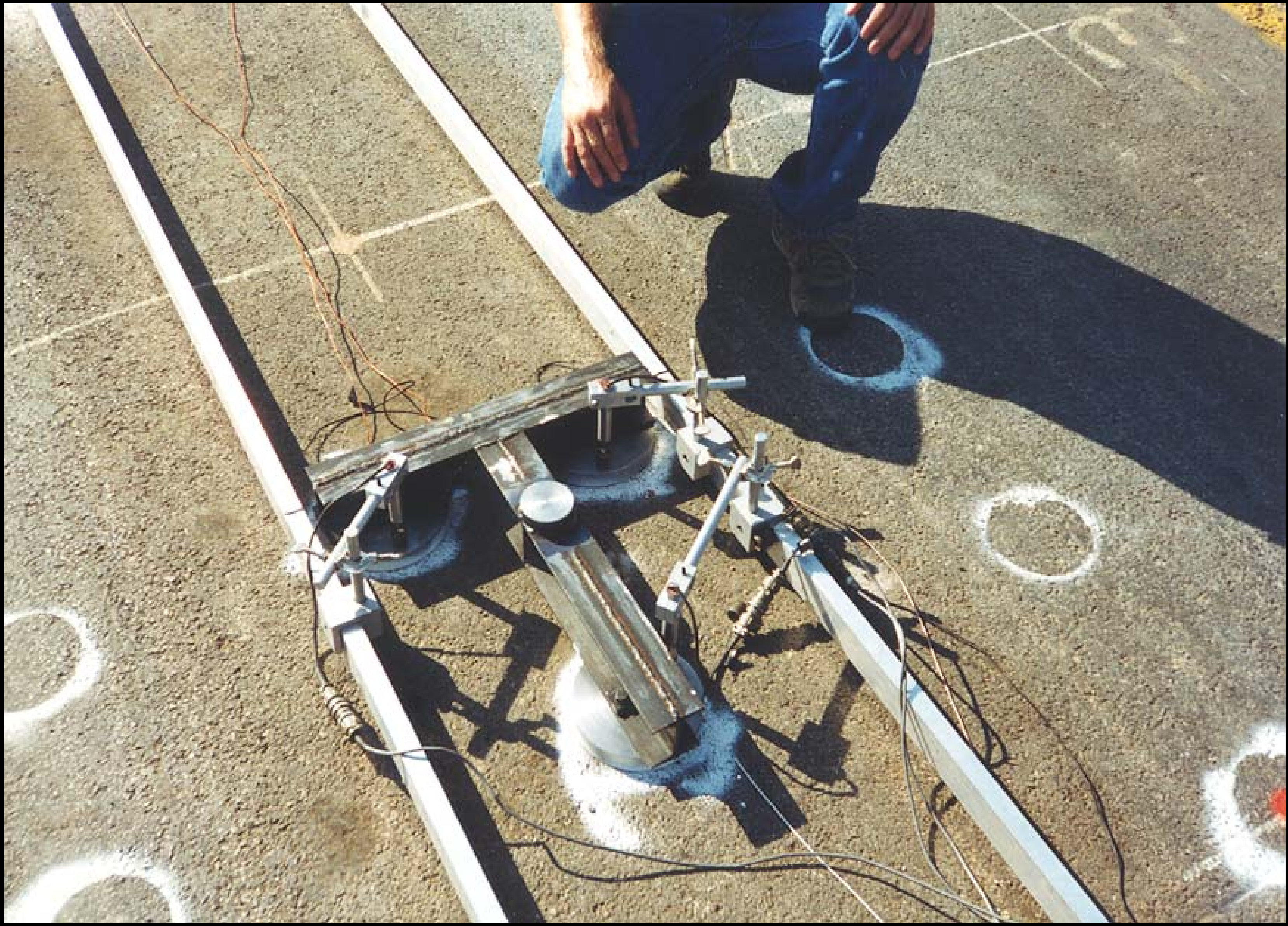
Representation of Pavement Performance During SAP Testing



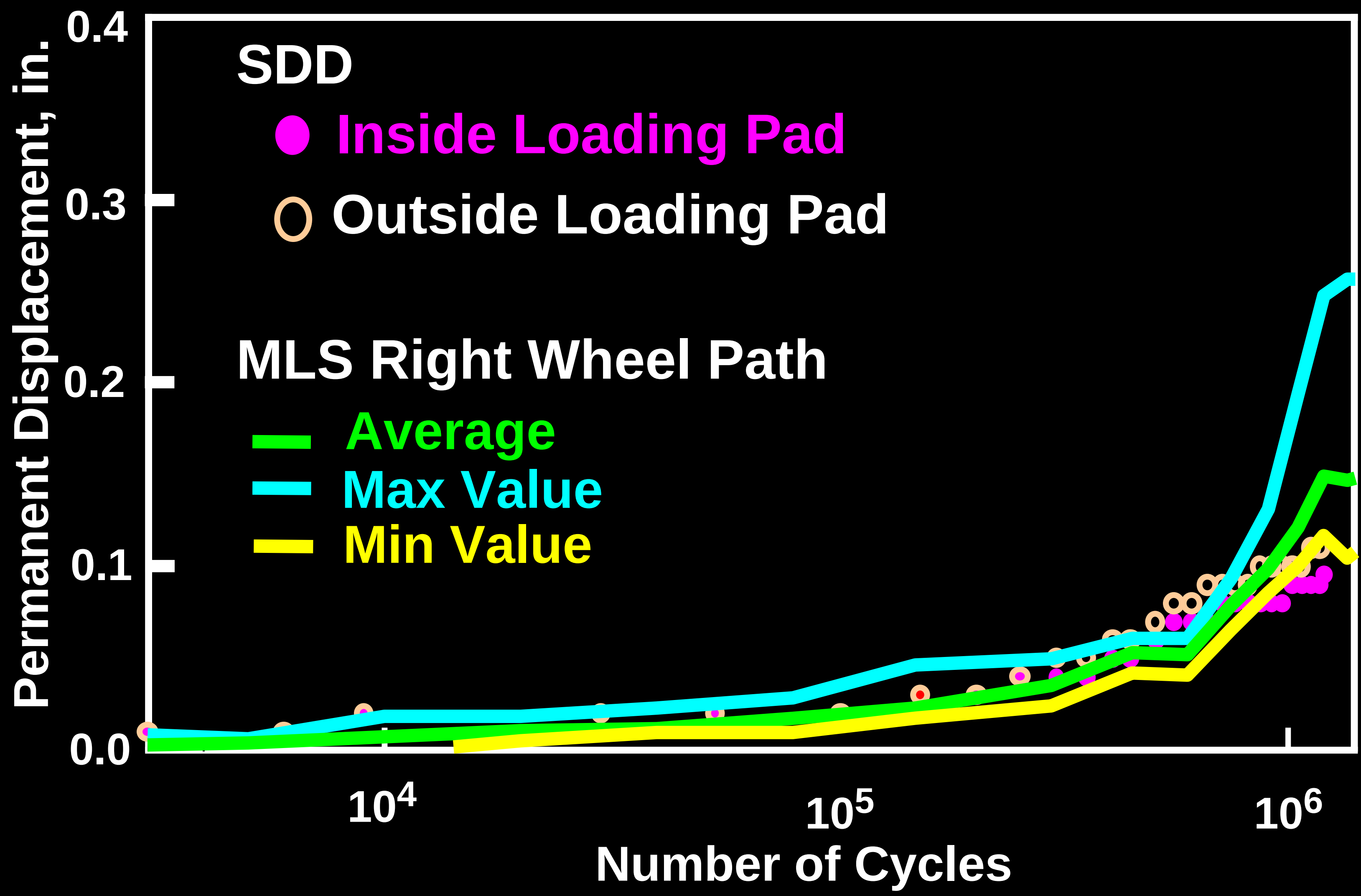
US 281, Jacksboro, Texas: SDD SAP Testing of an Flexible Pavement



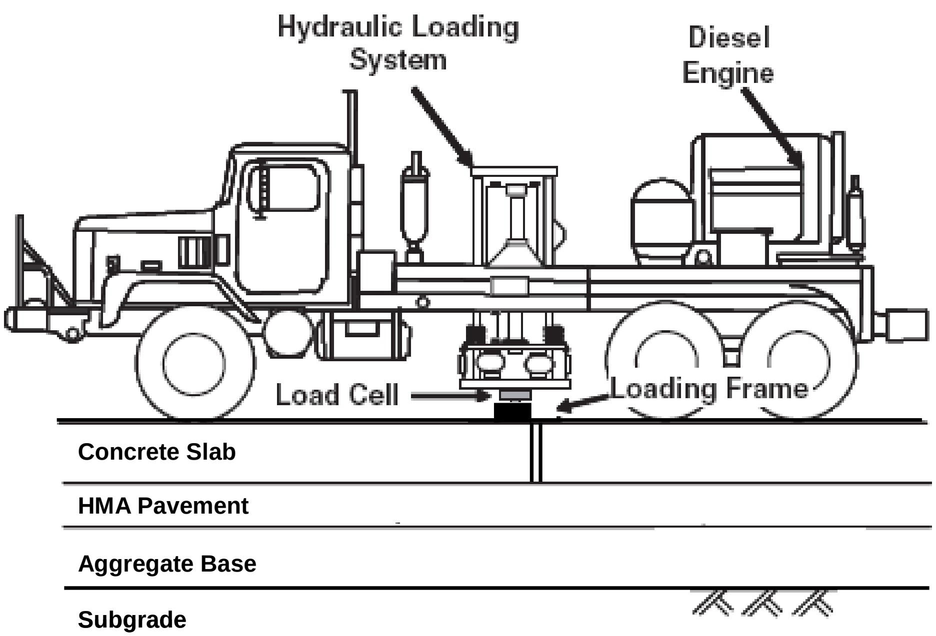
Load Assembly with 3 Pads



Rutting from SDD and MLS Accelerated Testing
Southbound Lane, US 281

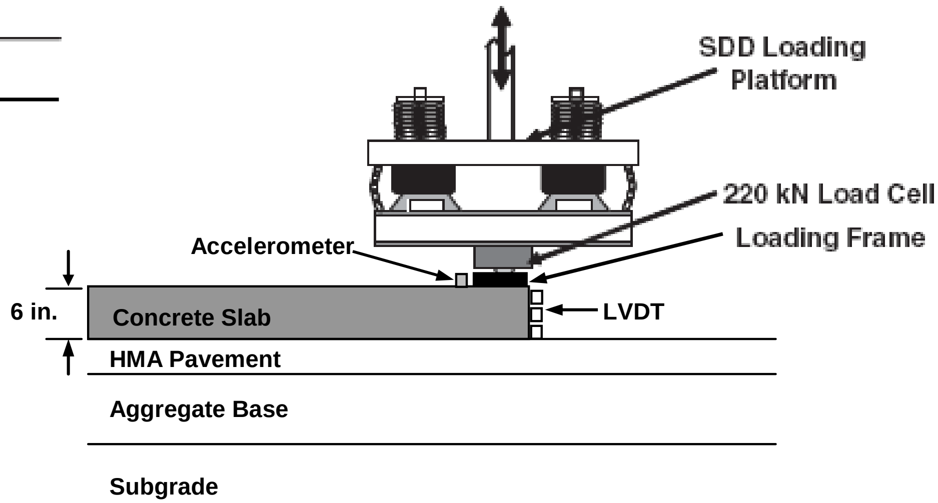


SDD Testing on a Concrete Overlay over Flexible Pavement

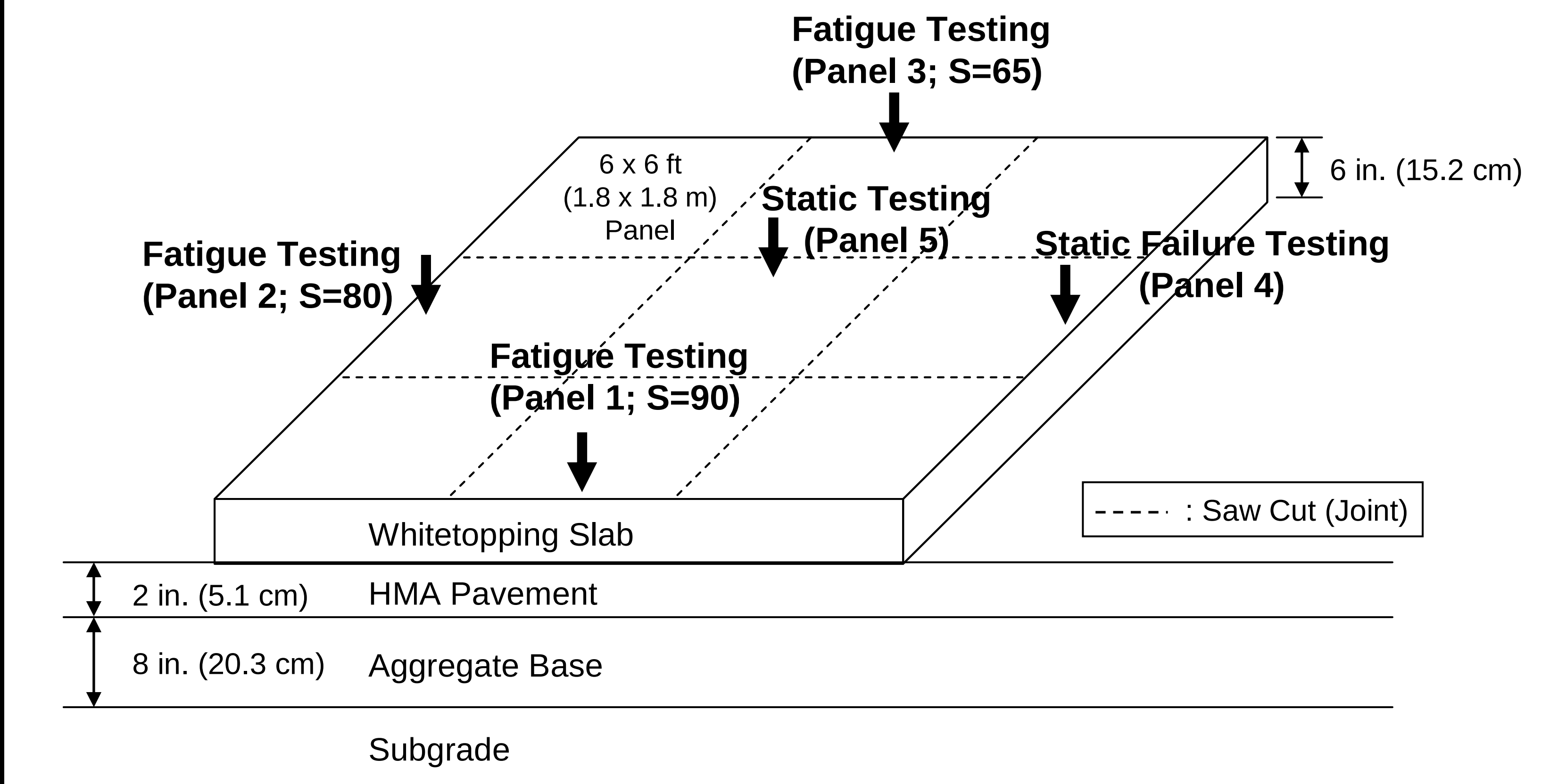


Schematic Diagram of the SDD

Loading and Sensing Configuration



SDD SAP Testing Plan



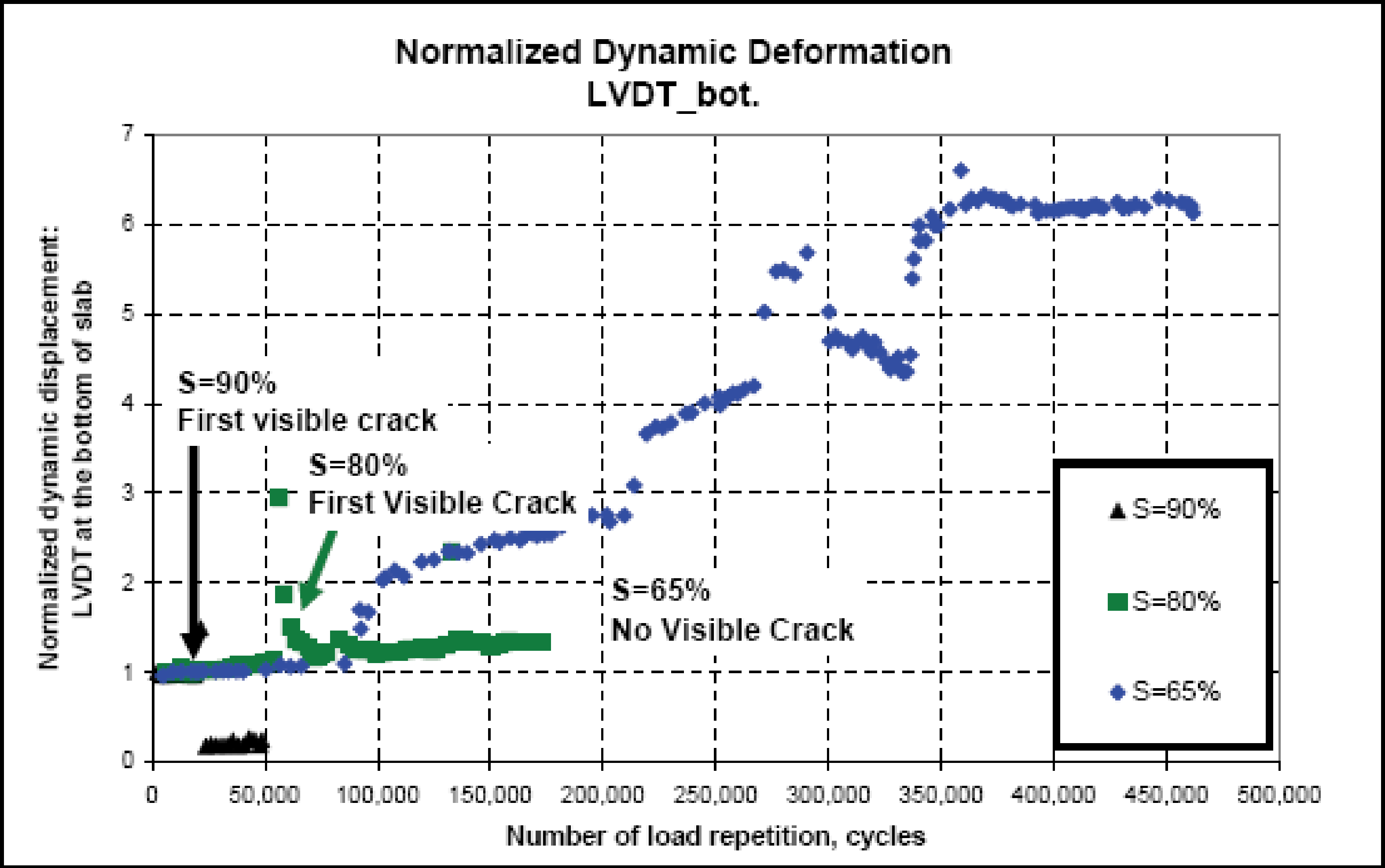
SDD SAP Testing on a Concrete Overlay over Flexible Pavement

- Static-load failure
- Failure load = 38 kips

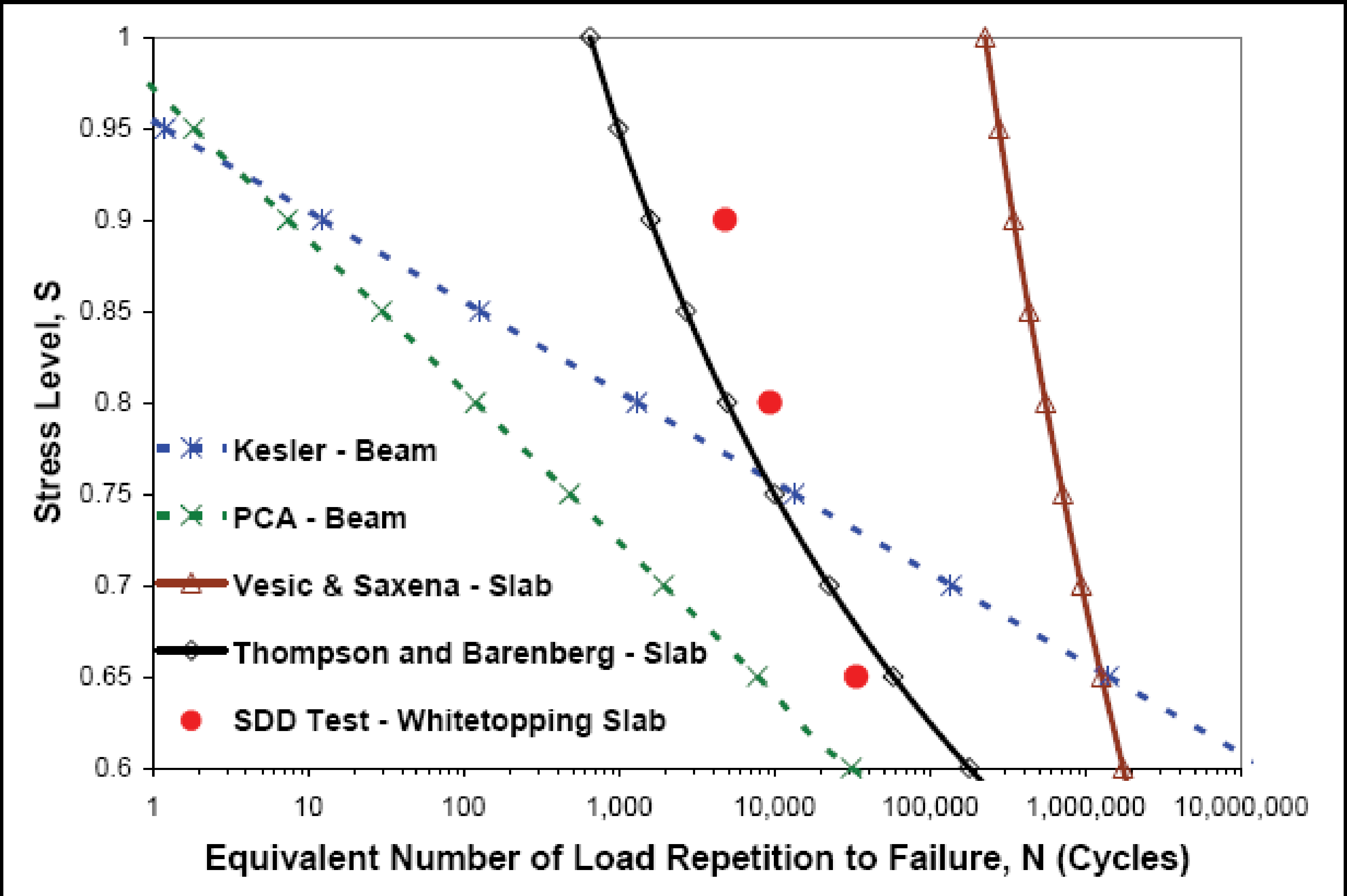
- SDD SAP testing
- Stress level = 90 %
- First visible crack at N_f = 19,000

- SDD SAP testing
- Stress level = 80 %
- First visible crack at N_f = 53,000

SDD SAP Testing Results



S-N Curves



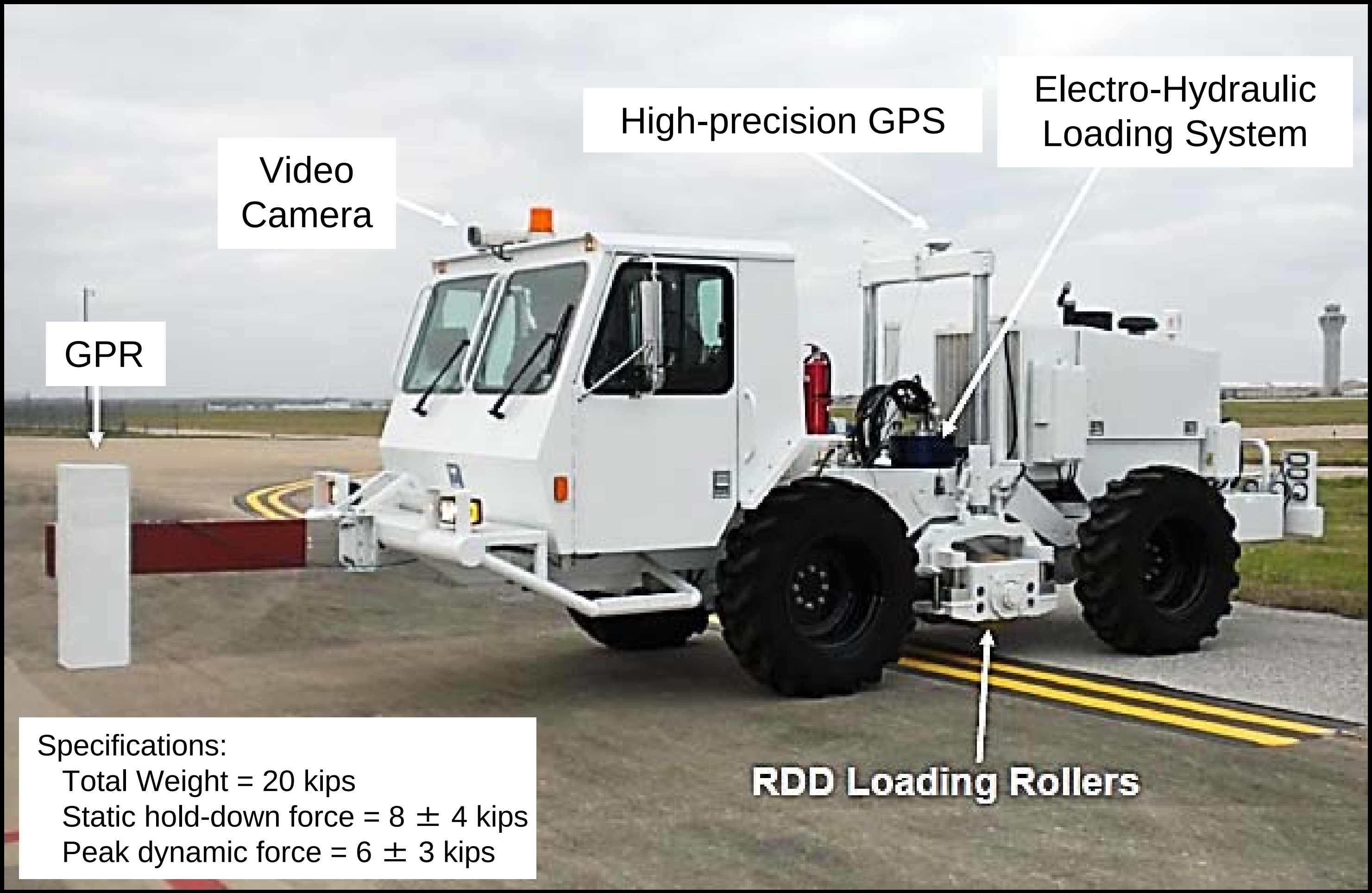
Stress Level, S
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
1
10
100
1,000
10,000
100,000
1,000,000
10,000,000
Equivalent Number of Load Repetition to Failure, N (Cycles)
Kesler - Beam
PCA - Beam
Vesic & Saxena - Slab
Thompson and Barenberg - Slab
SDD Test - Whitetopping Slab

New Developments on the RDD

Next-Generation Pavement Testing System: Currently Under Development

- Total Pavement Acceptance Device (TPAD)
  - Project-level studies
  - Continuous testing at 5 to 10 mph
  - Multi-function device
- Testing Functions
  - RDD measurements
  - Ground penetrating radar (GPR)
  - DMI and high-precision differential GPS
  - Surface temperature
  - Digital video imaging of pavement

Total Pavement Acceptance Device (TPAD)



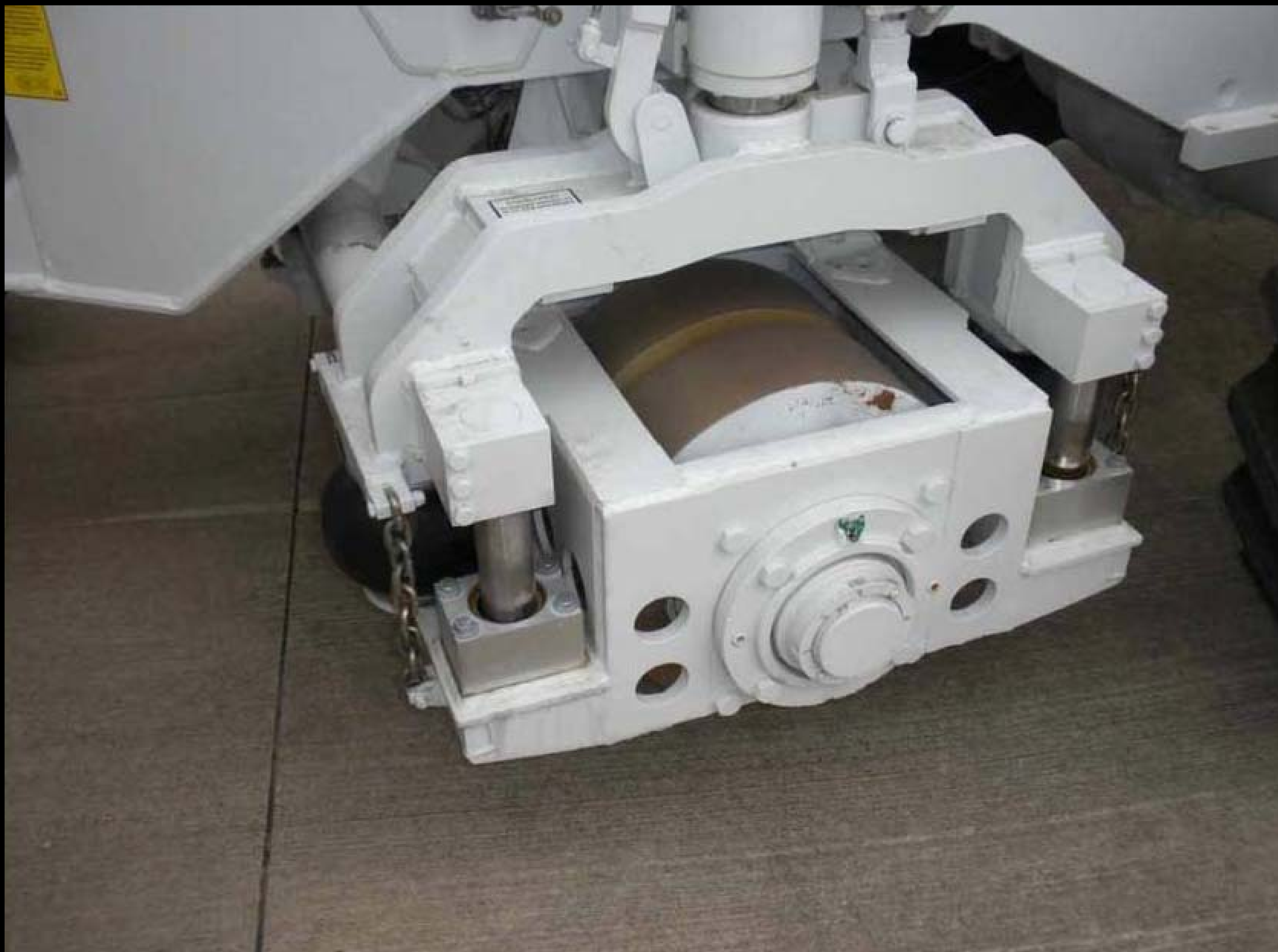
Concept Testing – July, 2009

Specifications:

Total Weight = 20 kips (89 kN)

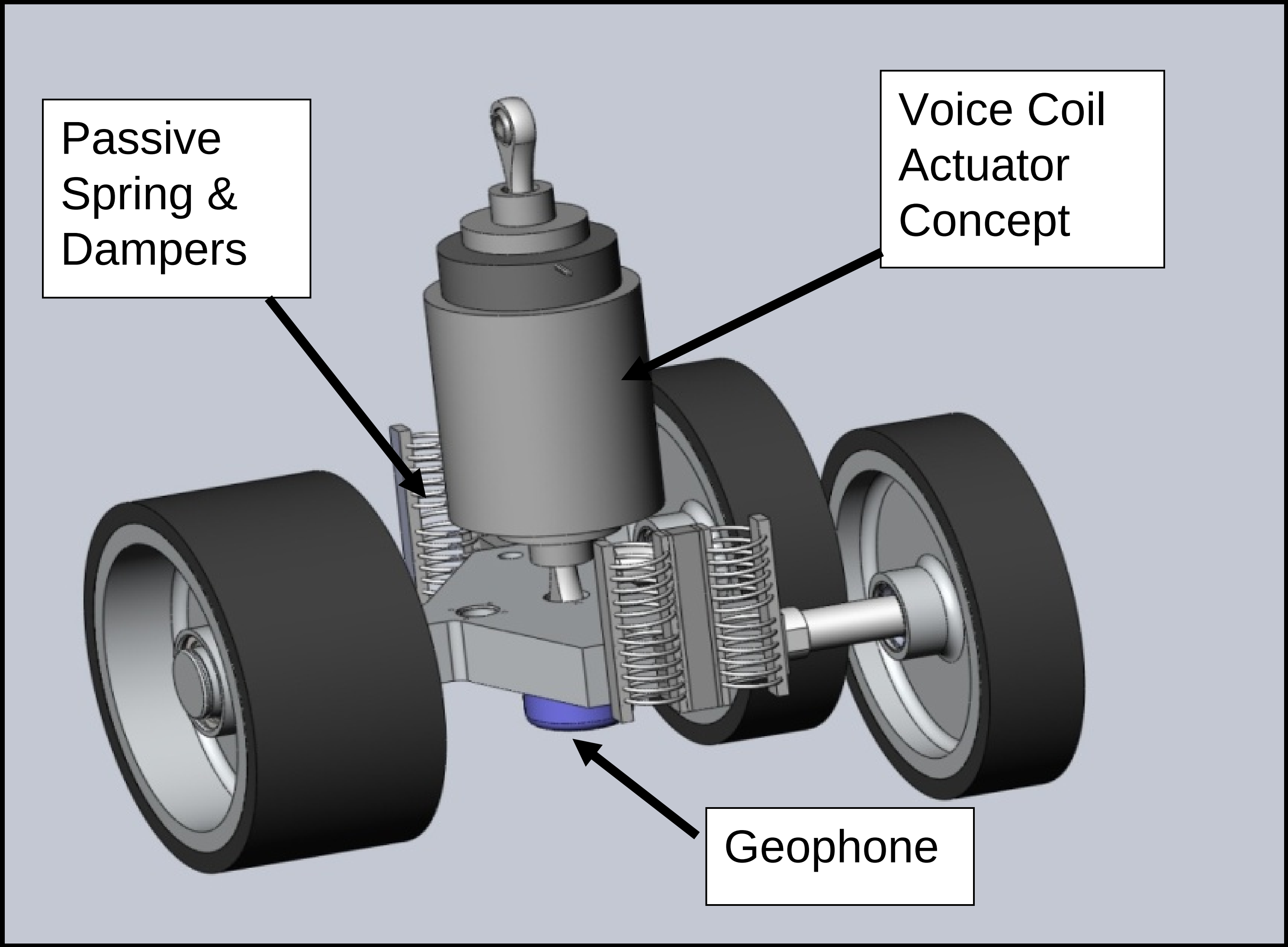
Static hold-down force = 8 ± 4 kips (36 ± 18 kN)

Peak dynamic force = 6 ± 3 kips (26 ± 13 kN)



Concept Testing – July, 2009

New Sensor Hold-Down System



Concluding Remarks

- The Rolling Dynamic Deflectometer is a multi-purpose pavement testing device. It can function as an RDD and an SDD.
- The RDD performs well; continuous deflection profiles are a powerful screening and evaluation tool.
- The SDD can apply a range of load forms; SAP testing has significant future applications.
- New development on the RDD (TPAD) is underway.

Acknowledgement

- Support from Prof. Kenneth H. Stokoe, II
- Funding support from the Texas Department of Transportation
- Many TxDOT personnel and UT crew

Thank you!

Question?