An Introduction to Deflection Testing

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November 15, 2011

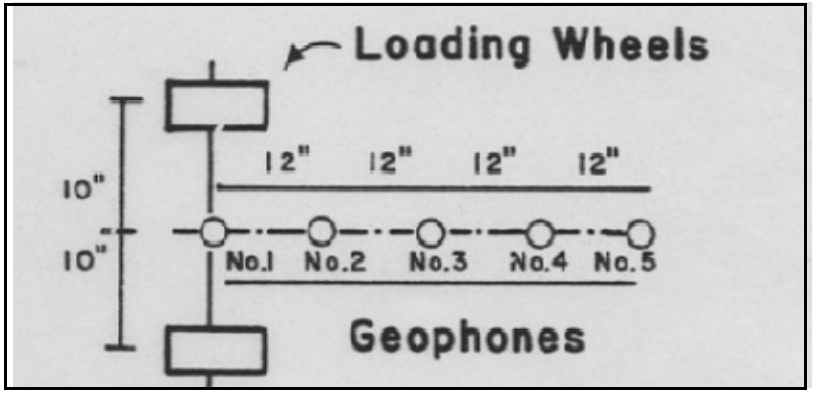
Outline

- History of deflection testing
- What is an FWD?
- How does it work?
- Different uses
- Data from testing
- Analysis
- Limitations
- Advantages

History

There are two broad categories:

- Static devices
- Dynamic devices
  - Vibratory
  - Impulse



What is an FWD?

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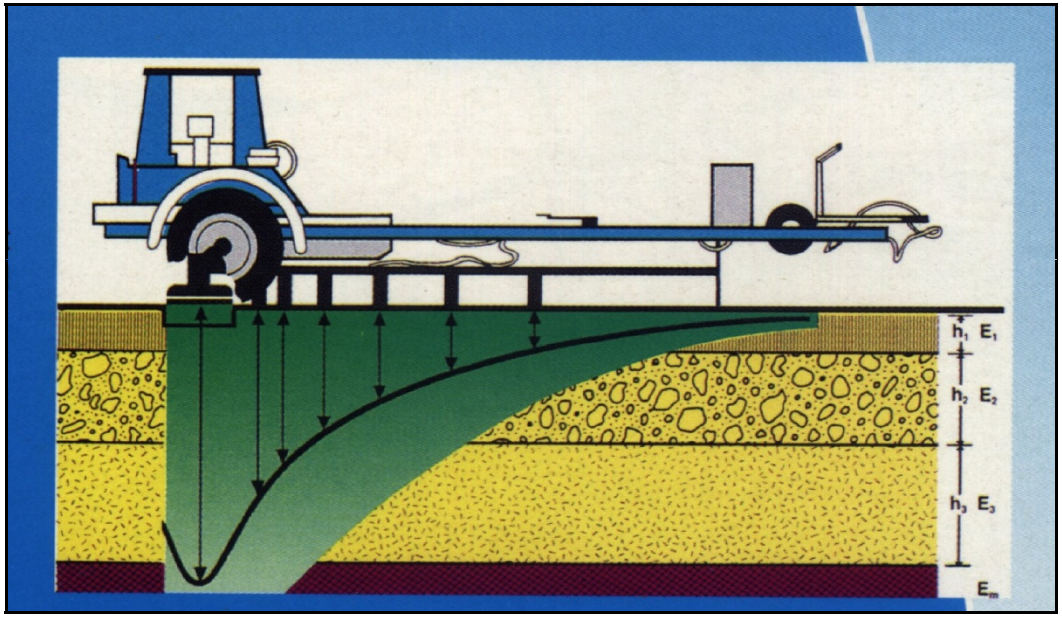
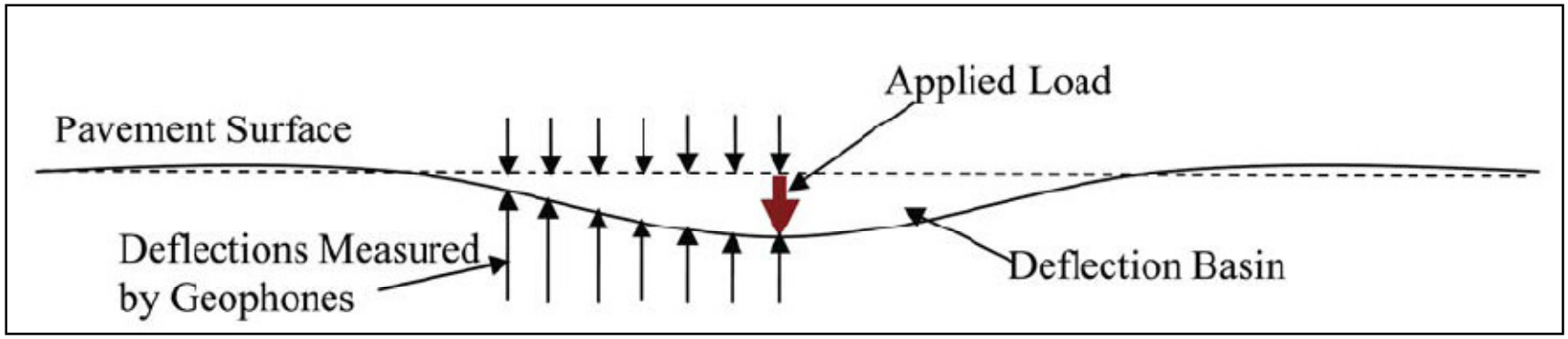
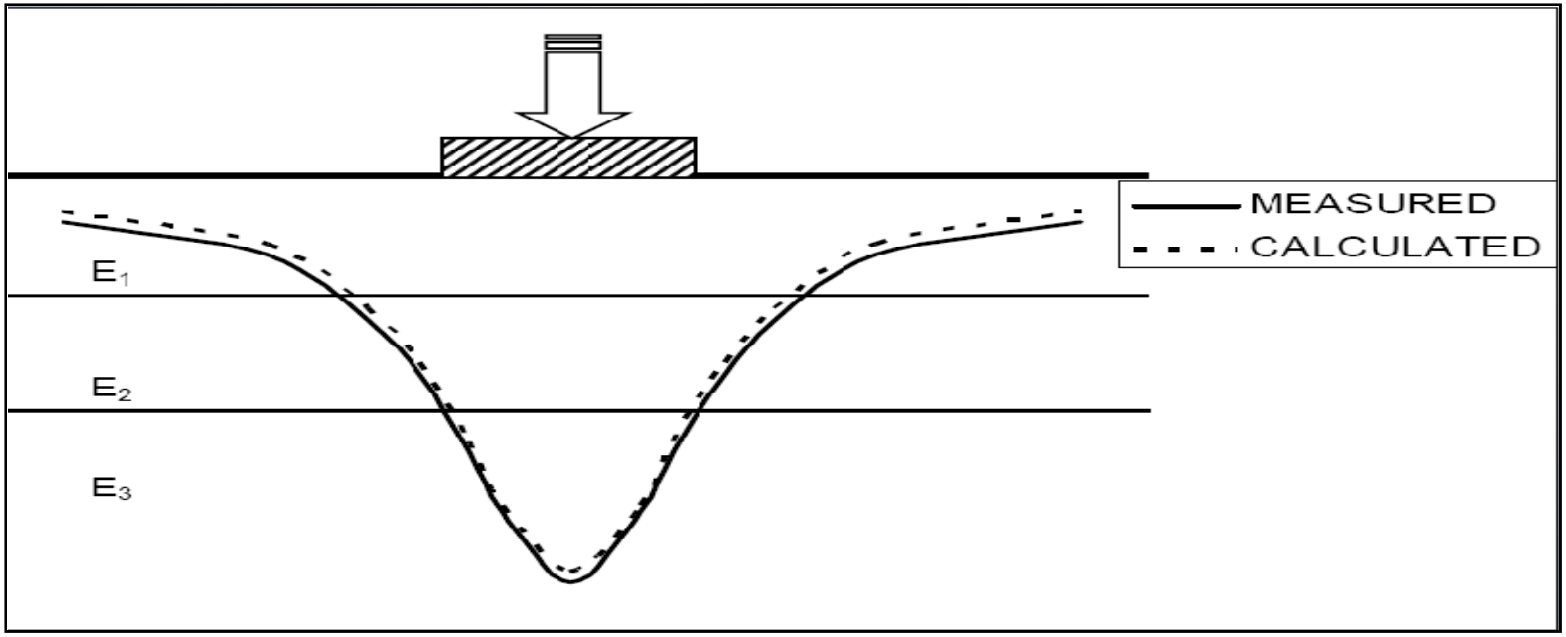


How does it work?

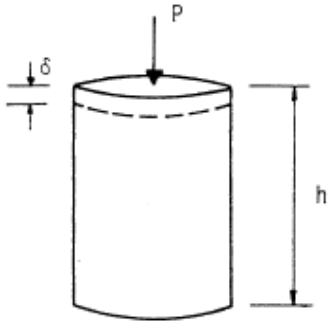




Uses

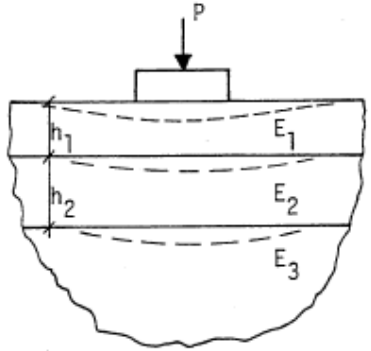
- Structural Testing/Remaining Life
- Joint Load Transfer
- Void Detection
- Load Restrictions
- Super Heavy Load (Evaluation/Permits)
- Project Acceptance

Uses - Layer Moduli



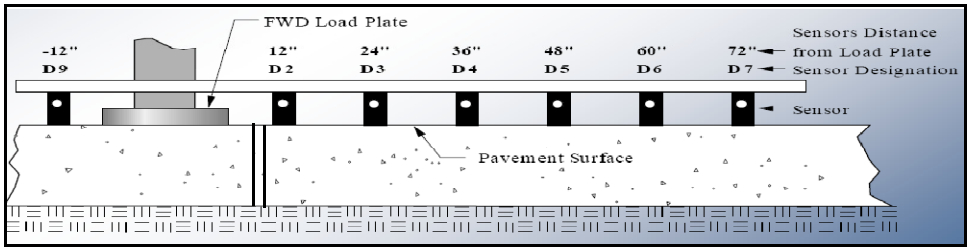
1. Apply axial load
2. Measure axial deformation
3. Compute Modulus "E"

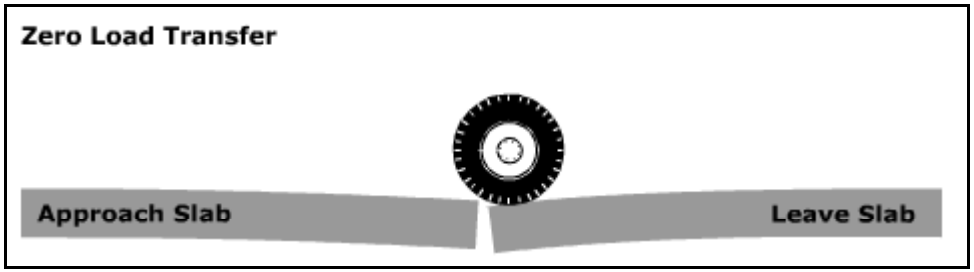
$$E = \sigma / \delta$$

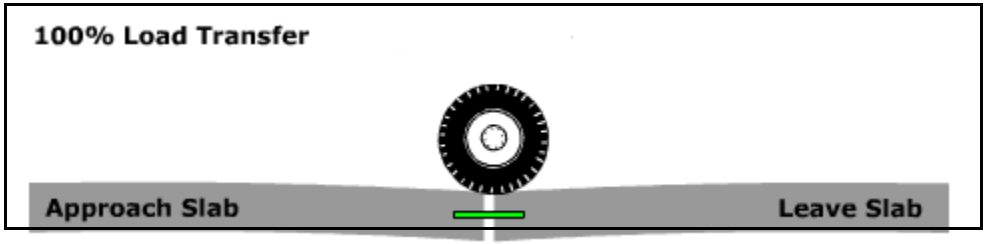


1. Apply FWD load
2. Measure Surface deflection
3. Compute Modulus

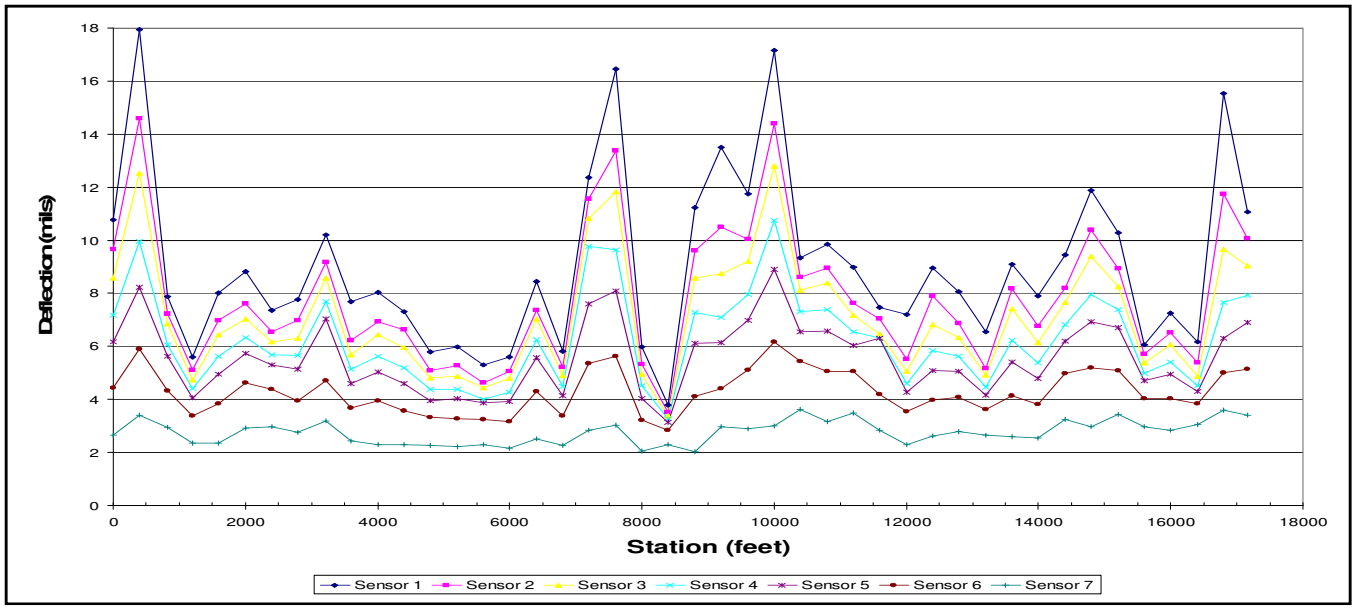
Uses - Load Transfer Efficiency

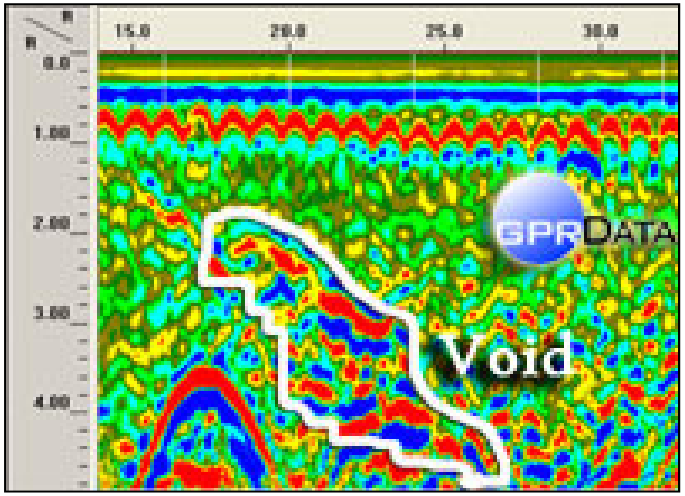




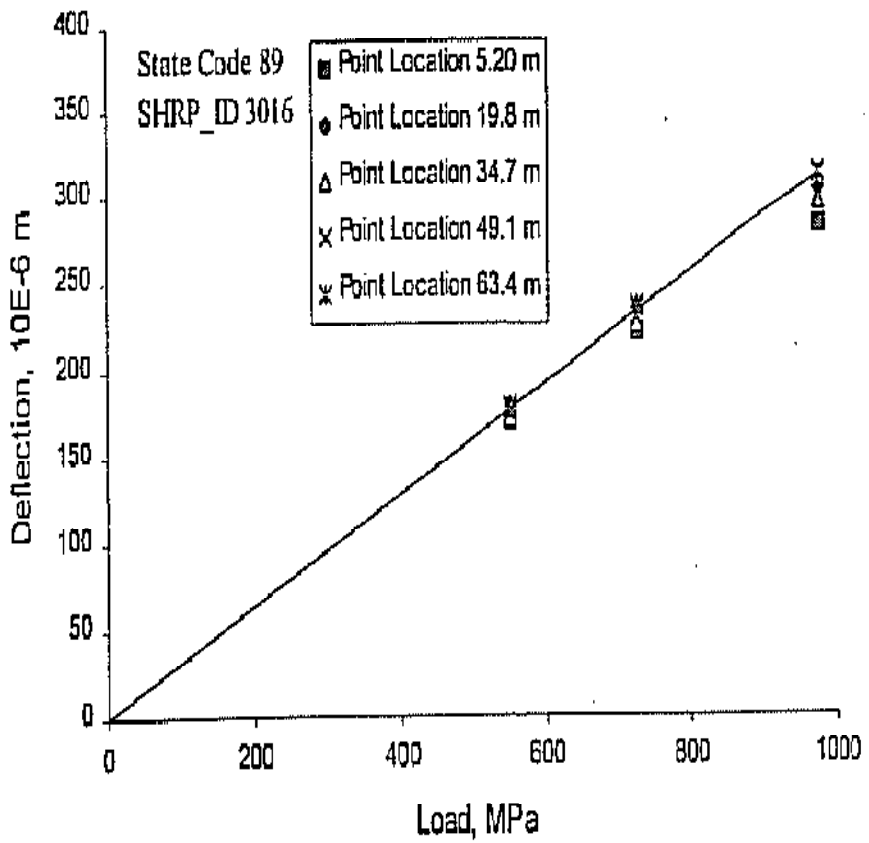


Uses - Void Detection

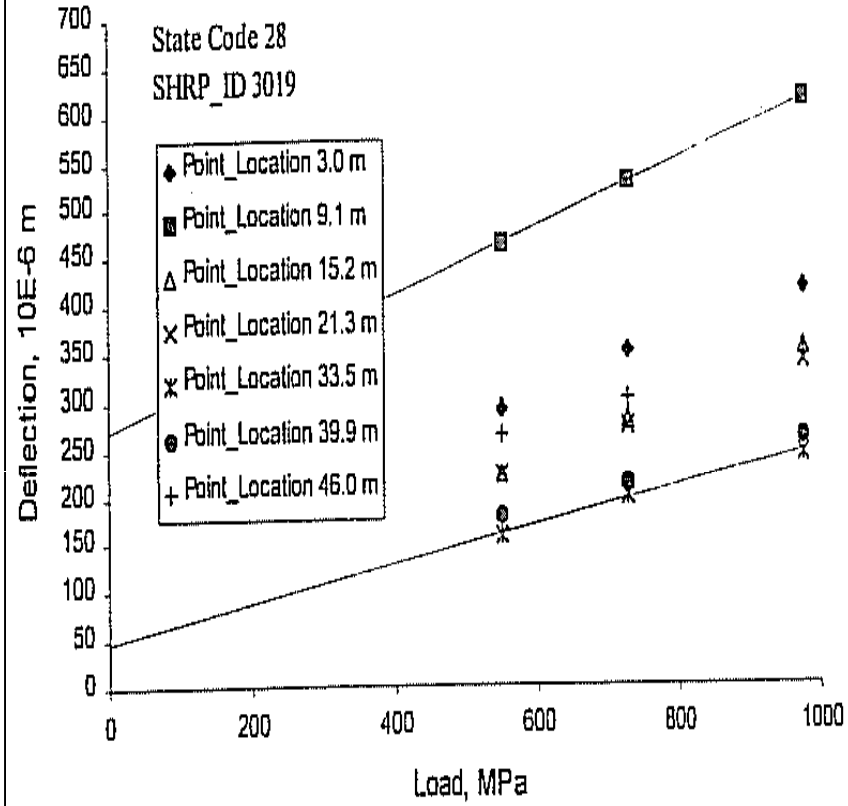




Uses - Void Detection



a. Section without void under the slab.



b. Section with void under the slab.

Uses – Load Restrictions/Super Heavy Loads

Data

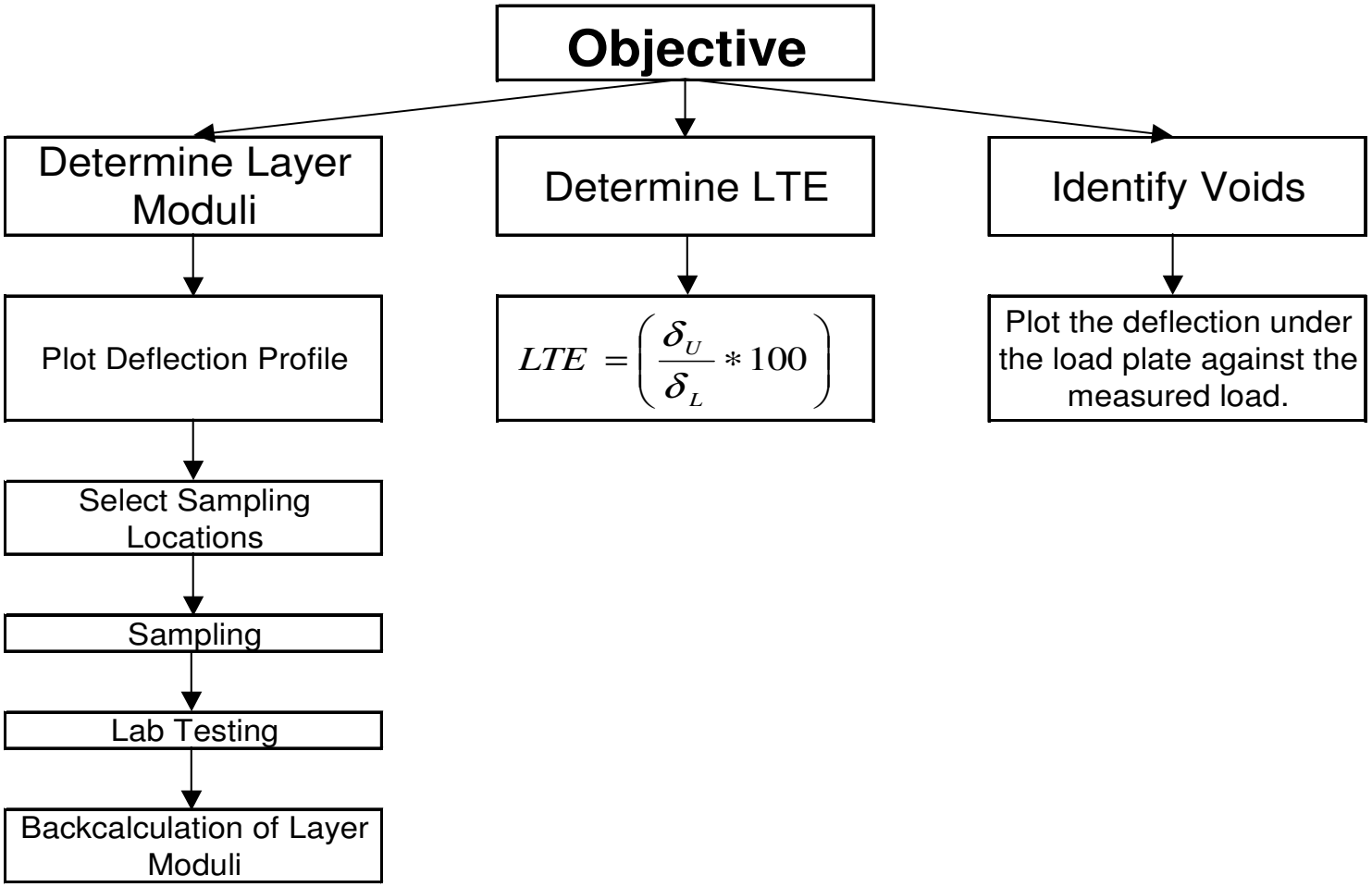
- Load and deflection readings
- Surface and Air Temperatures
- Additional measurements of HMAC layer temperature

Microsoft Access - [Drops : Table]

File Edit View Insert Format Records Tools Window Help

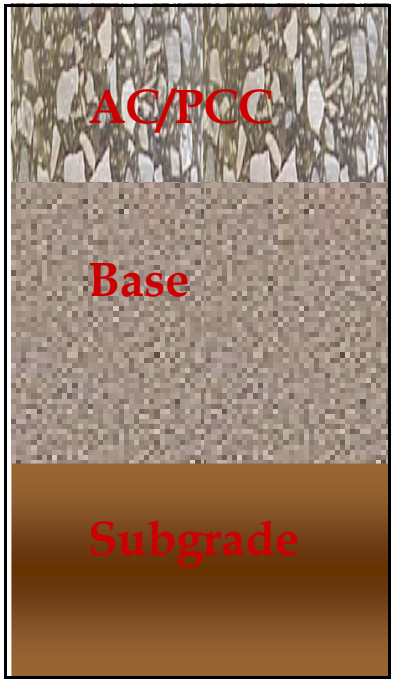
StationID	DropID	History	Stress	Force	D1	D2	D3	D4	D5	D6	D7
1	1	☐	89.3	9787	4.65	4.59	4.28	3.89	3.69	3.65	1.93
1	2	☐	89.3	9787	4.61	4.52	4.24	3.82	3.65	3.57	1.93
1	3	☐	117.4	12858	6.19	6.03	5.75	5.20	4.98	4.73	2.71
1	4	☐	141.2	15463	7.35	7.09	6.80	6.22	5.98	5.53	3.22
2	5	☐	89.3	9783	4.74	4.69	4.37	4.07	3.85	3.37	2.07
2	6	☐	89.2	9768	4.75	4.73	4.45	4.02	3.89	3.34	2.11
2	7	☐	116.9	12805	6.43	6.37	6.09	5.44	5.32	4.52	2.87

Analysis

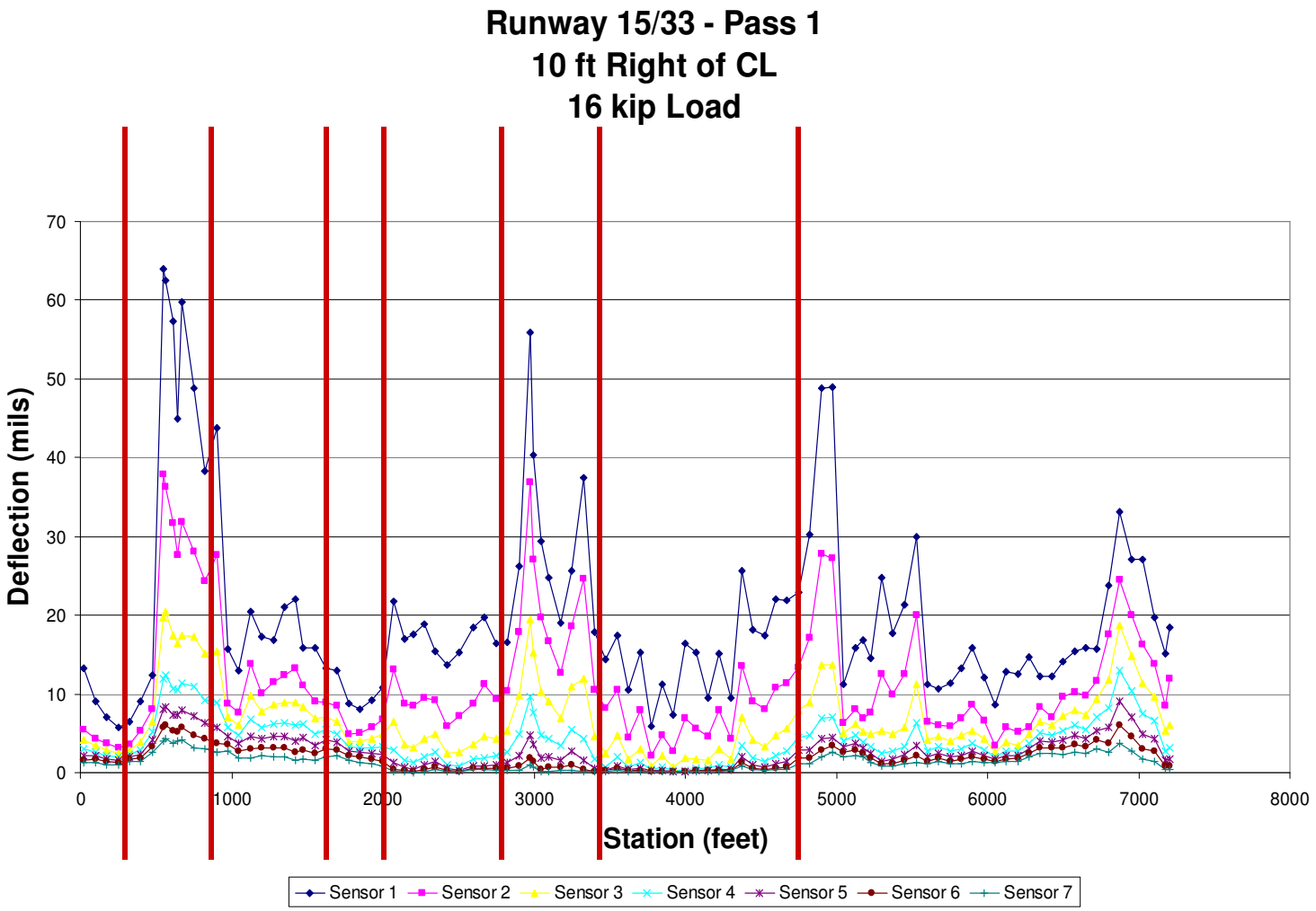

Objective
Determine Layer Moduli
Determine LTE
Identify Voids
Plot Deflection Profile
$LTE = \left(\frac{\delta_U}{\delta_L} * 100 \right)$
Plot the deflection under the load plate against the measured load.
Select Sampling Locations
Sampling
Lab Testing
Backcalculation of Layer Moduli

Analysis – Additional Information Required

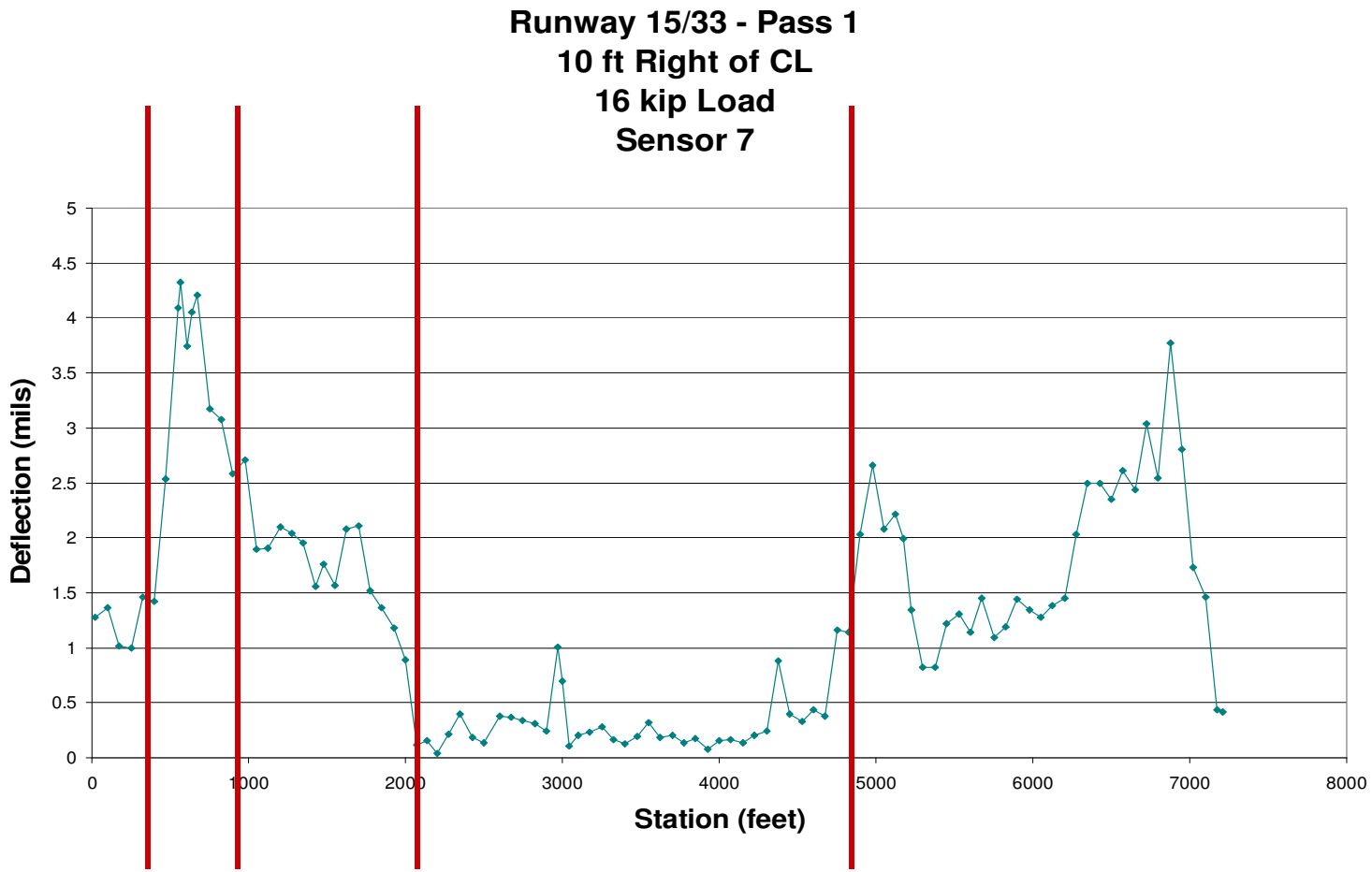
- Layer Thickness
- Material Types
- Moisture Contents
- Shallow bedrock layer



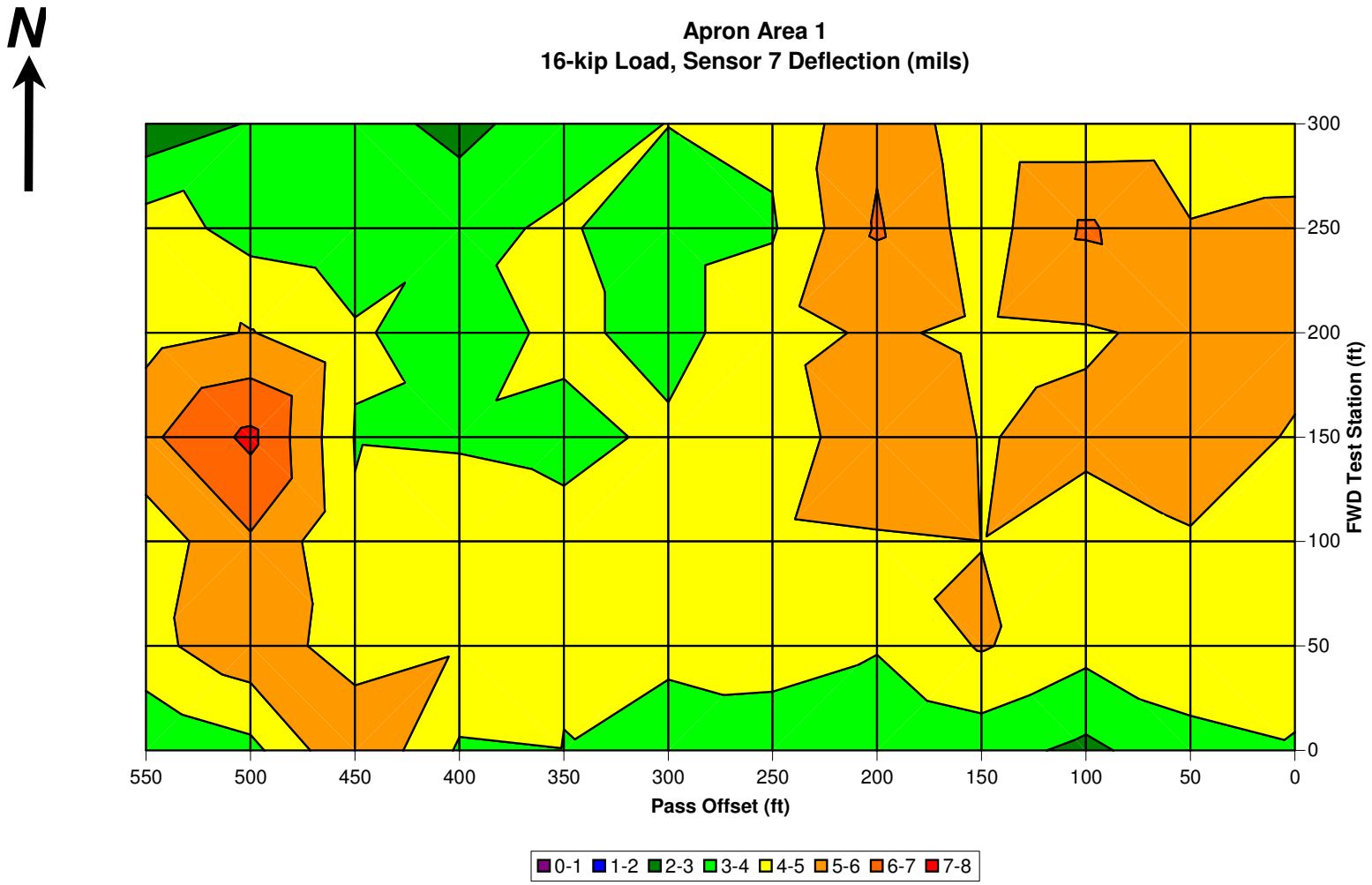
Analysis – Profile Plots



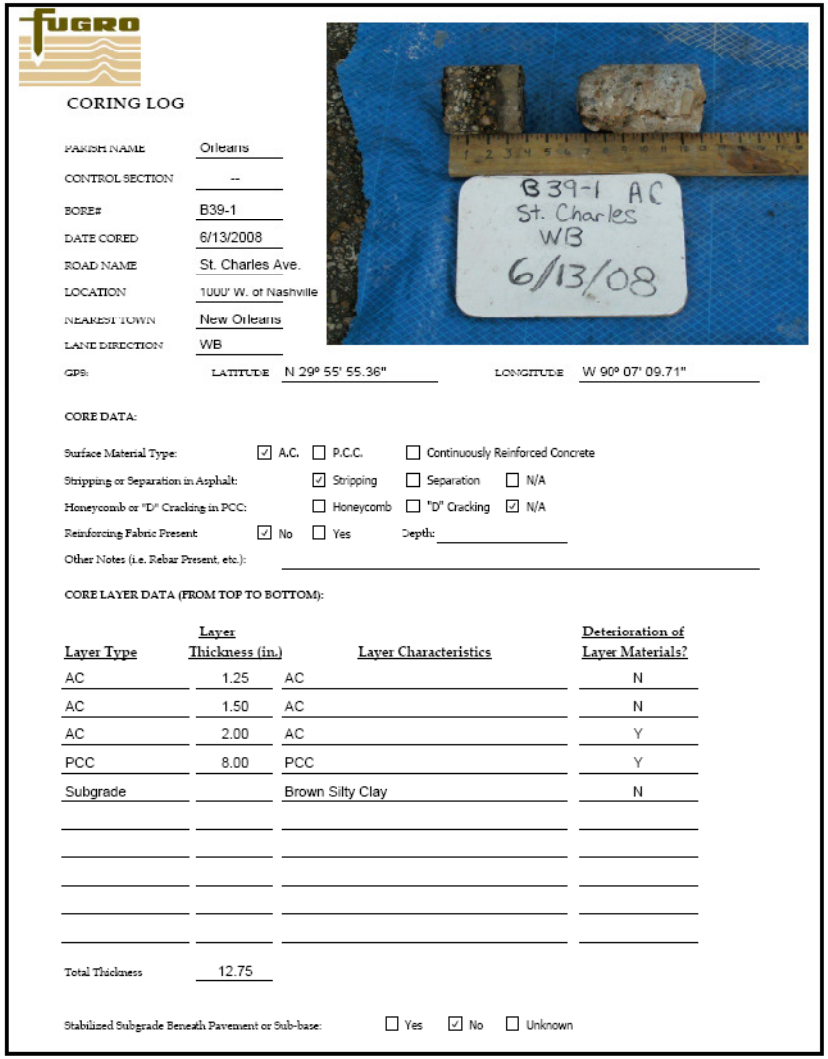
Analysis – Profile Plots



Analysis – 2-D Profile Plots



Analysis - Material information



CORING LOG

PARISH NAME	Orleans
CONTROL SECTION	--
BORE#	B39-1
DATE CORED	6/13/2008
ROAD NAME	St. Charles Ave.
LOCATION	1000' W. of Nashville
NEAREST TOWN	New Orleans
LANE DIRECTION	WB
GPS: LATITUDE	N 29° 55' 55.36"
LONGITUDE	W 90° 07' 09.71"

CORE DATA:

Surface Material Type: ☑ A.C. ☐ P.C.C. ☐ Continuously Reinforced Concrete

Stripping or Separation in Asphalt: ☑ Stripping ☐ Separation ☐ N/A

Honeycomb or "D" Cracking in PCC: ☐ Honeycomb ☐ "D" Cracking ☑ N/A

Reinforcing Fabric Present: ☑ No ☐ Yes Depth: ____

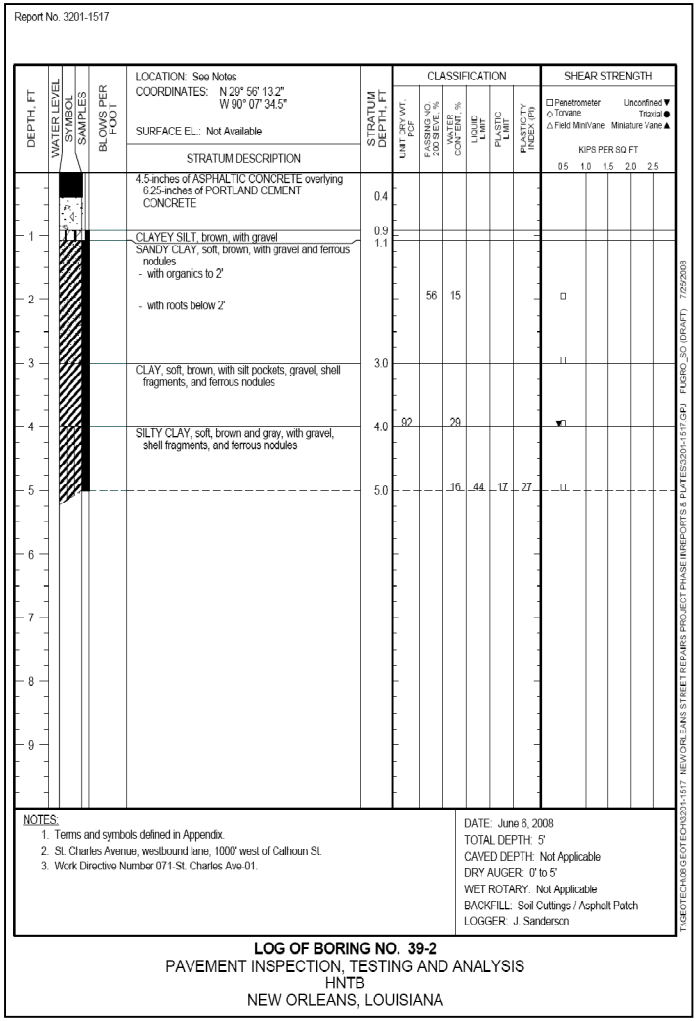
Other Notes (i.e. Rebar Present, etc.): ____

CORE LAYER DATA (FROM TOP TO BOTTOM):

Layer Type	Layer Thickness (in.)	Layer Characteristics	Deterioration of Layer Materials?
AC	1.25	AC	N
AC	1.50	AC	N
AC	2.00	AC	Y
PCC	8.00	PCC	Y
Subgrade		Brown Silty Clay	N

Total Thickness 12.75

Stabilized Subgrade Beneath Pavement or Sub-base: ☐ Yes ☑ No ☐ Unknown



Report No. 3201-1517

LOCATION: See Notes
COORDINATES: N 29° 56' 13.2" W 90° 07' 34.5"
SURFACE EL.: Not Available

DEPTH, FT	STRATUM DESCRIPTION	STRATUM DEPTH, FT	UNIT DRY WT. PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
0	4.5-inches of ASPHALTIC CONCRETE overlying 6.25-inches of PORTLAND CEMENT CONCRETE	0.4						
1	CLAYEY SILT, brown, with gravel	0.9						
	SANDY CLAY, soft, brown, with gravel and ferrous nodules - with organics to 2'	1.1						
2	- with roots below 2'			56	15			
3	CLAY, soft, brown, with silt pockets, gravel, shell fragments, and ferrous nodules	3.0						
4	SILTY CLAY, soft, brown and gray, with gravel, shell fragments, and ferrous nodules	4.0	92		29			
5		5.0			16	44	17	27

SHEAR STRENGTH
□ Penetrometer ▽ Unconfined
◇ Torvane Triaxial ●
△ Field MiniVane Miniature Vane ▲
KIPS PER SQ FT
0.5 1.0 1.5 2.0 2.5

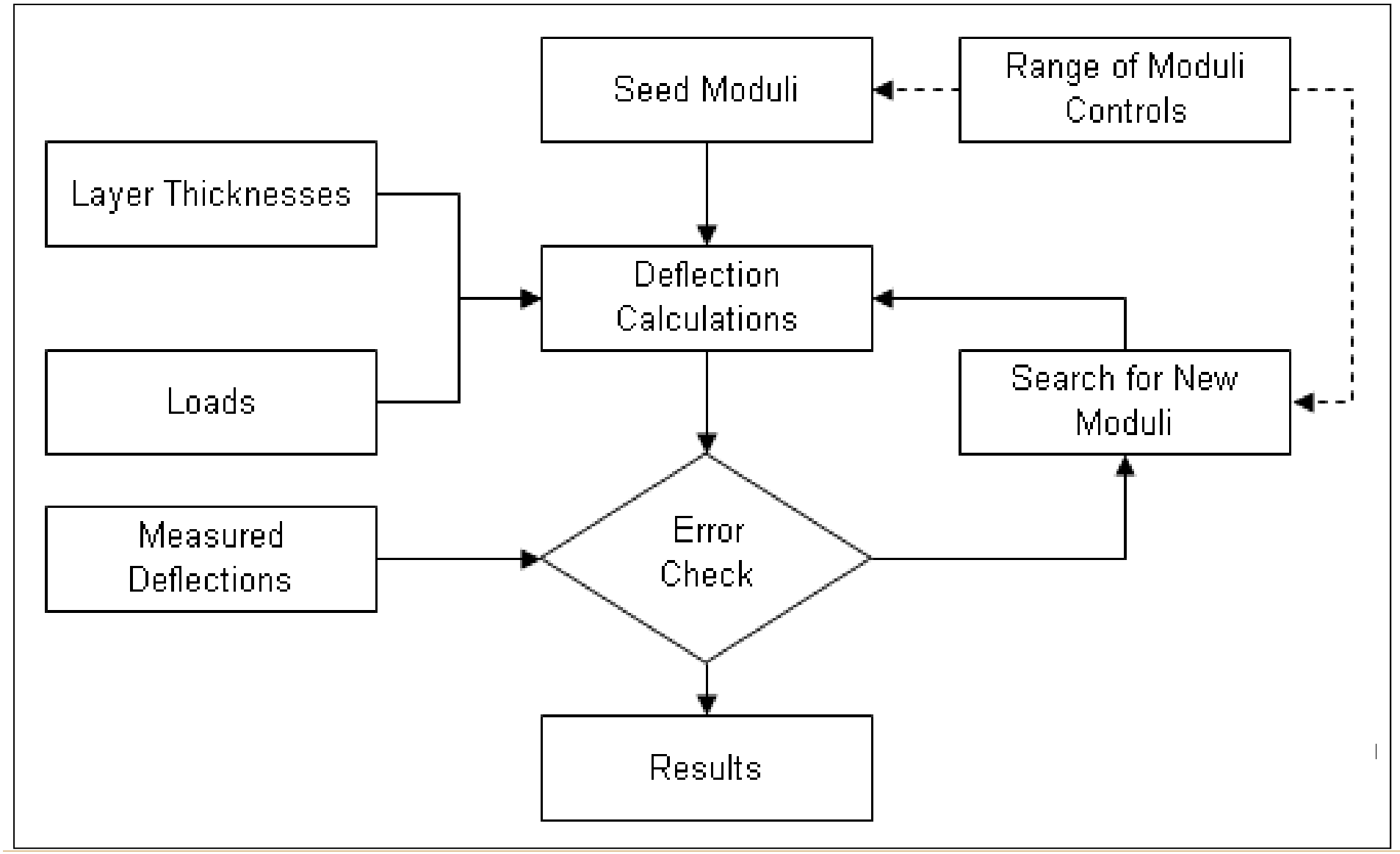
NOTES:
1. Terms and symbols defined in Appendix.
2. St. Charles Avenue, westbound lane, 1000' west of Calhoun St.
3. Work Directive Number 071-St. Charles Ave-01.

DATE: June 8, 2008
TOTAL DEPTH: 5'
CAVED DEPTH: Not Applicable
DRY AUGER: 0' to 5'
WET ROTARY: Not Applicable
BACKFILL: Soil Cuttings / Asphalt Patch
LOGGER: J. Sanderson

T:\GEOTECH\FIELD\TECH\3201-1517 NEW ORLEANS STREET REPAIRS PROJECT PHASE II\REPORTS & PLATES\3201-1517.GPJ FUGRO_3D (DRAFT) 7/29/2009

LOG OF BORING NO. 39-2
PAVEMENT INSPECTION, TESTING AND ANALYSIS
HNTB
NEW ORLEANS, LOUISIANA

Analysis – Backcalculation



Cost Comparison

Destructive Testing

Item	Quantity	Units	Average Unit Price	Cost
Cores/Bores	32*	cores	$300/core	$9,600.00
Traffic Control	3	days	$1000/day	$3,000.00
Atterberg	32	tests	$ 55.00/test	$1,760.00
Gradations	32	tests	$ 55.00/test	$1,760.00
Moisture Contents	32	tests	$ 15.00/test	$480.00
			Total	**$16,600.00**

* 1hole every 500 ft

Cost Comparison

NDT and Destructive Testing - 3 lane miles, 158 data points

Item	Quantity	Units	Average Unit Price	Cost
FWD Testing	8	hours	$250/hour	$2,000
Traffic Control	2	days	$1000/day	$2,000
Cores/Bores	8	samples	300	$2,400
Atterberg	8	tests	$ 55/test	$440
Gradations	8	tests	$ 55/test	$440
Moisture Contents	8	tests	$ 15/test	$120
Analysis of FWD Data	8	hours	$100/hour	$800
			Total	**$8,200**

Cost Savings

Subgrade Modulus, psi	SN Requirements		
	50,000 ESALs	5,000,000 ESALs	50,000,000 ESALs
3,000	2.77	5.80	8.08
5,000	2.28	4.92	6.97
7,000	1.99	4.39	6.31

Subgrade Modulus, psi	Difference in HMAC Thickness, in		
	50,000 ESALs	5,000,000 ESALs	50,000,000 ESALs
5,000	1.11	2.00	2.52
7,000	1.77	3.20	4.02

* Assuming a design modulus of 3,000 psi

Subgrade Modulus, psi	Cost Savings/mi, $		
	50,000 ESALs	5,000,000 ESALs	50,000,000 ESALs
5,000	15,244	27,378	34,533
7,000	24,267	43,867	55,067

* Assuming a design modulus of 3,000 psi

Limitations

- Shallow bedrock
- Interpreting results
  - Temperature
  - Moisture
- Model dependencies of analysis tools
  - Load Application
  - Material Characterization
- Temperature at time of LTE testing

Advantages of FWD Testing

- Nondestructive test
- Simulates Response of Moving Wheel
- In Situ response of pavement layers
- Better coverage
- Expediency in data collection
- Reduced evaluation costs
- Reduced construction costs

Summary

- History of deflection testing
- What is an FWD?
- How does it work?
- Different uses
- Data from testing
- Analysis
- Limitations
- Advantages

Questions