FLORIDA INSTITUTE OF TECHNOLOGY - CIVIL ENGINEERING DEPARTMENT

FLORIDA DEPARTMENT OF TRANSPORTATION

BDV28 977-04

Development and Testing of the Miniaturized Pressuremeter Test for Use in Unbound Pavement Layers

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[2016-GRIP MEETING]

Problem Statement

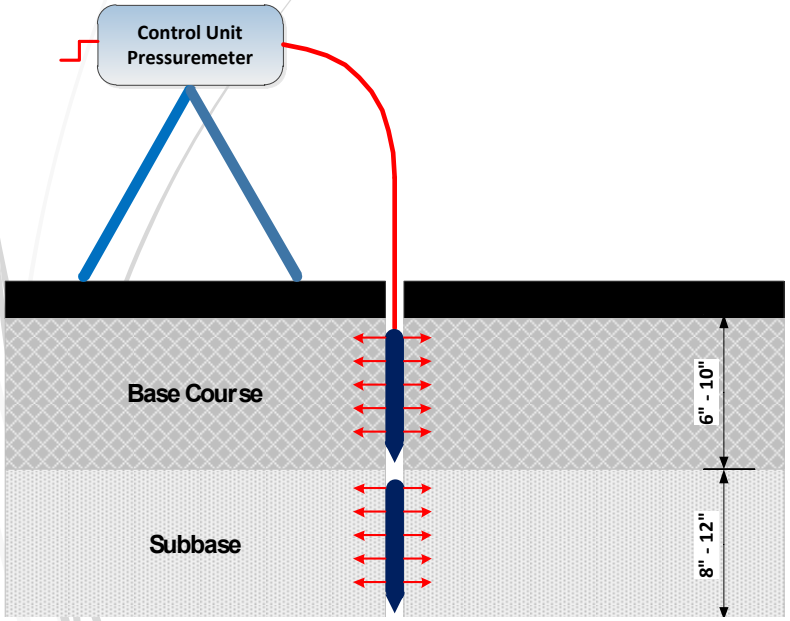
Testing Limitations of NDG

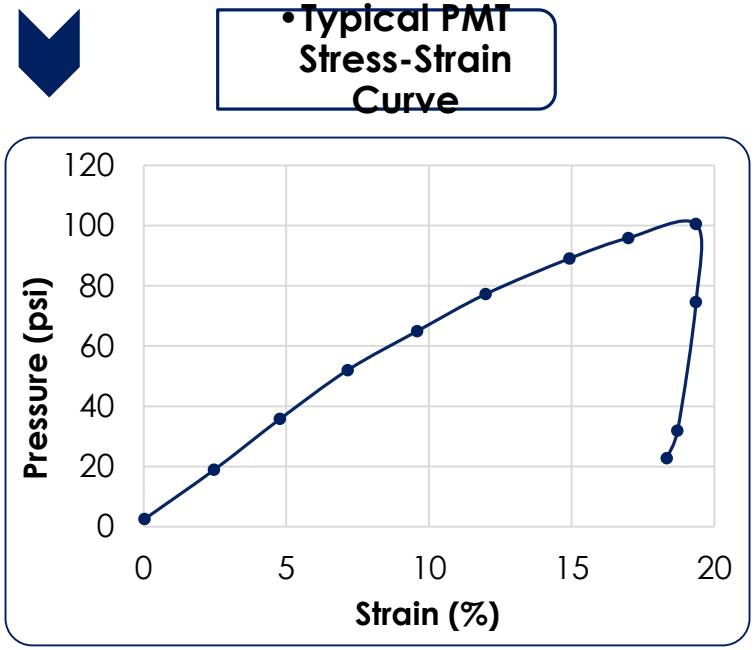
- Radioactive source.
- Usage requires significant administrative effort.
- Produces density and moisture content not strength and stiffness.

Nuclear Gauge

Research Objective

The objective is to develop a miniaturized PMT field test that can be completed in about five minutes to measure stress-strain pavement material responses.





Project Tasks

- Literature Search
- Miniaturize the Pressuremeter Probe
- Determine Field Testing Sites
- Conduct Field Comparison Testing
- Conduct Laboratory Comparison Testing
- Analyze and Finalize MiniPMT Testing Results
- Complete Final Report

Project Schedule

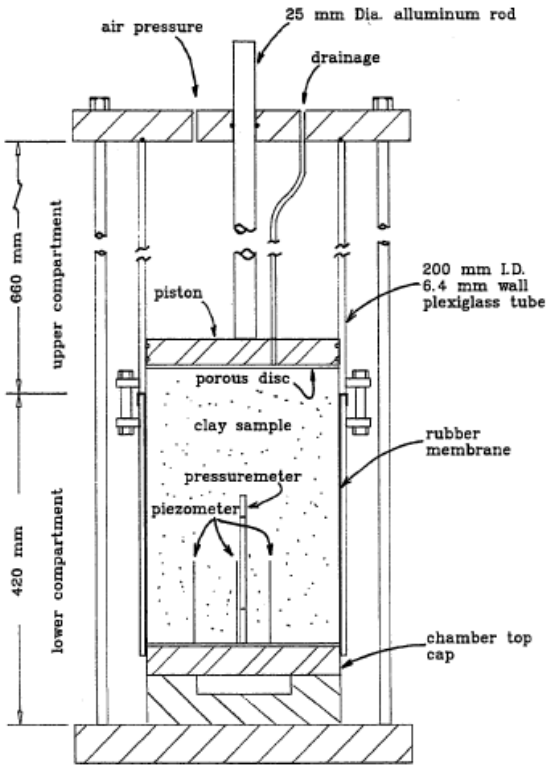
RESEARCH TASK	1-Nov 2015	1-Dec 2015	1-Jan 2016	1-Feb 2016	1-Mar 2016	1-Apr 2016	##### 2016	1-Jun 2016	1-Jul 2016	1-Aug 2016	1-Sep 2016	1-Oct 2016	1-Nov 2016	1-Dec 2016	1-Jan 2017	1-Feb 2017	1-Mar 2017	1-Apr 2017	##### 2017	1-Jun 2017	1-Jul 2017	1-Aug 2017	1-Sep 2017	1-Oct 2017
Task 1 Literature Search	1	2	3	4																				
Task 2 Miniaturization of PMT Probe		1	2	3	4	5	6	7	8	9	10													
Task 3 Determine Field Testing Sites				1	2	3	4	5	6															
Task 4 Conduct Field Comparison Testing					1	2	3	4	5	6	7	8	9	10	11	12	13	14						
Task 5 Conduct Laboratory Comparison Testing		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15								
Task 6 Draft Final Report and Technology Transfer																		1	2	3	4			
Task 7 Final Report																						1	2	3

[Deliverables/Schedule]

- **TASK 1** FEB 2016
- **TASK 2** SEP 2016
- **TASK 3** JUL 2016
- **TASK 4** APR 2017
- **TASK 5** FEB 2017
- **TASK 6** JUL 2017
- **TASK 7** OCT 2017

Background / Lit Search

- Field Quality Control
  - Falling Weight Deflectometer
  - Lightweight Deflectometer
  - Klegg Impact Hammer
  - Nuclear Density Gauge
  - Dynamic Cone Penetrometer
- Miniature Pressuremeter
  - Purdue University
    - 4.73 inches x 0.473 inches



Miniaturization of PMT Probe

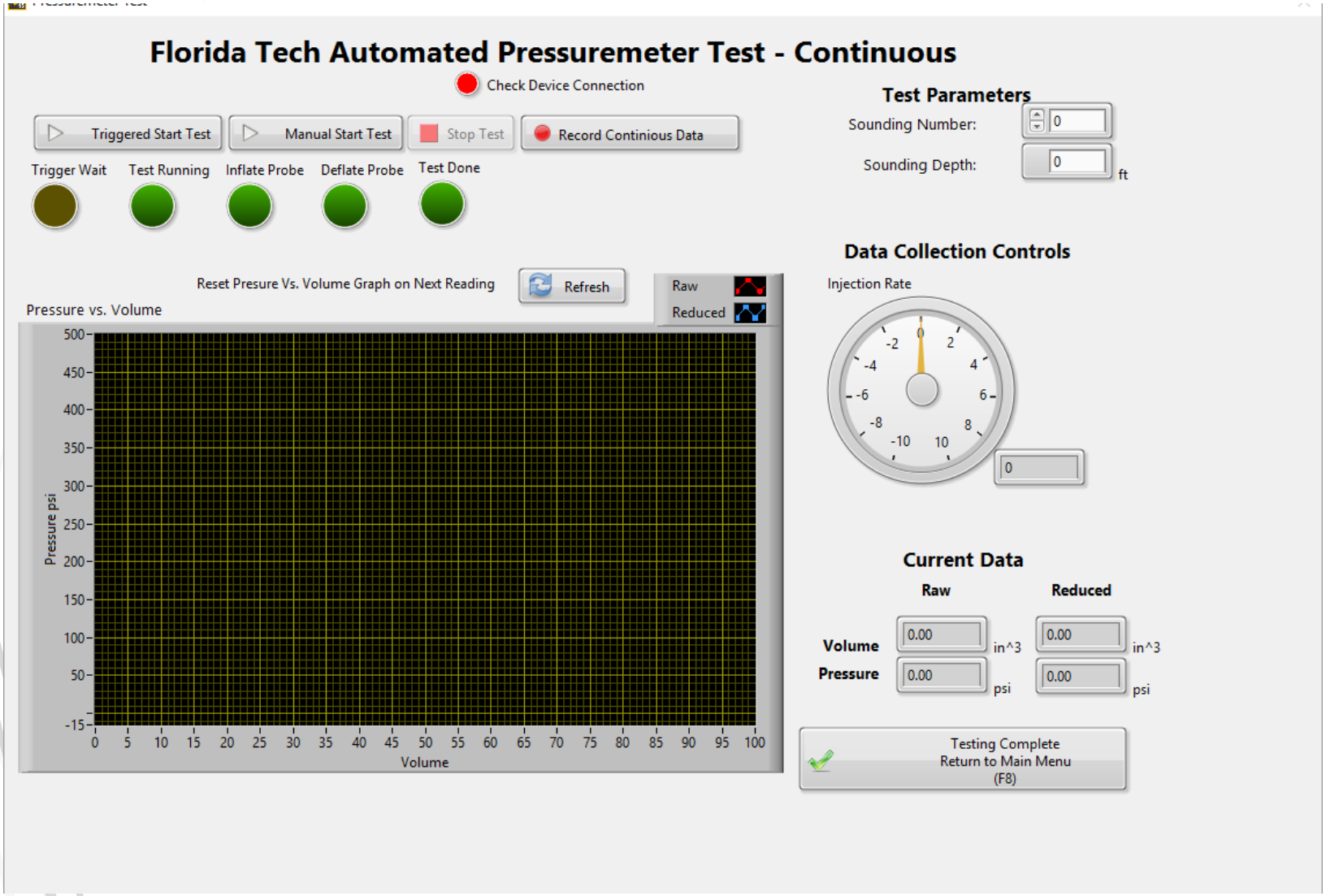
- Should fit into the same size hole as the NDG.
- Should test the entire pavement layer.
  - Research limited to 6 & 12 inch probes.
- Prove the new probe provides consistent results.
- Determine if correlations exist between other field tests and mini-PMT.

Miniature Probe Designs

New Mini-PMT Test Procedure

- Develop and Validate a Continuous PMT Test
  - Constant Strain Rate Test
  - 20 – 50 cc injected volume
  - Automatic Estimation of E_0 , P_0 and P_L^*
  - Software Guides Operator Through Test Sequence

Continuous Test Software



Determine Field Testing Sites

- Field Testing Sites approximately 60 minutes from Melbourne, FL
- Site should have 6 or 12 inch Base and / or Subbase Layers
- Ability to conduct:
  - Standard Pencel and Mini PMT
  - Lightweight / Falling Weight Deflectometers
  - Dynamic Cone Testing
  - Density Testing
- Current Site
  - Campus test sites – Preliminary equipment evaluation
  - Heritage Parkway, Palm Bay

Field Comparison Testing

Miniaturized Pressuremeter Test

- P_o = Lift-off Pressure
- E_i = Initial Modulus
- P_L = Limit Pressure

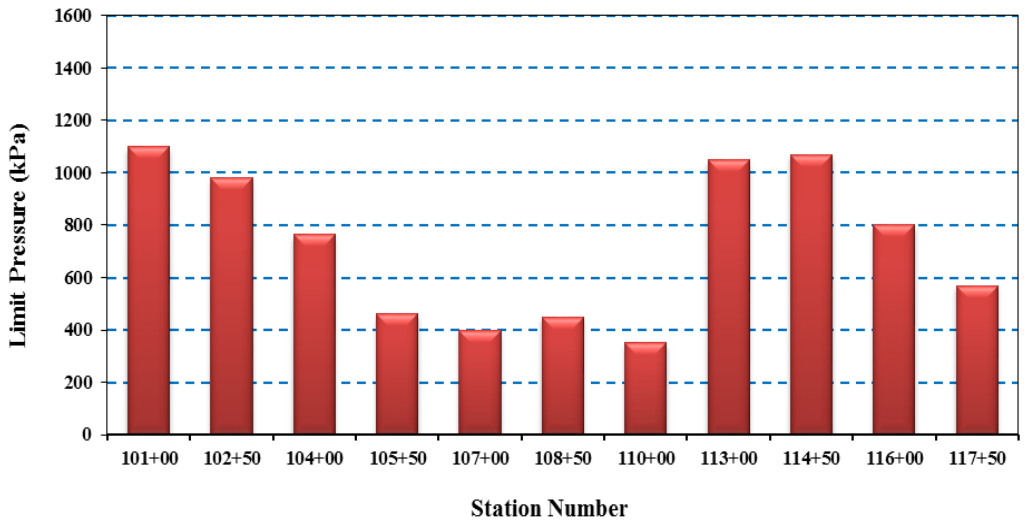
Light Weight Deflectometer	S_d = Surface Deflection	D_c = Degree of Comp	E_d = Dynamic Modulus
Nuclear Density Gauge	γ_w = Wet Unit Weight	W = Moisture Content	γ_d = Dry Unit Weight
Dynamic Cone Penetrometer	DCPI = Pen. Index	CBR = Bearing Ratio	M_r = *Resilient Modulus*

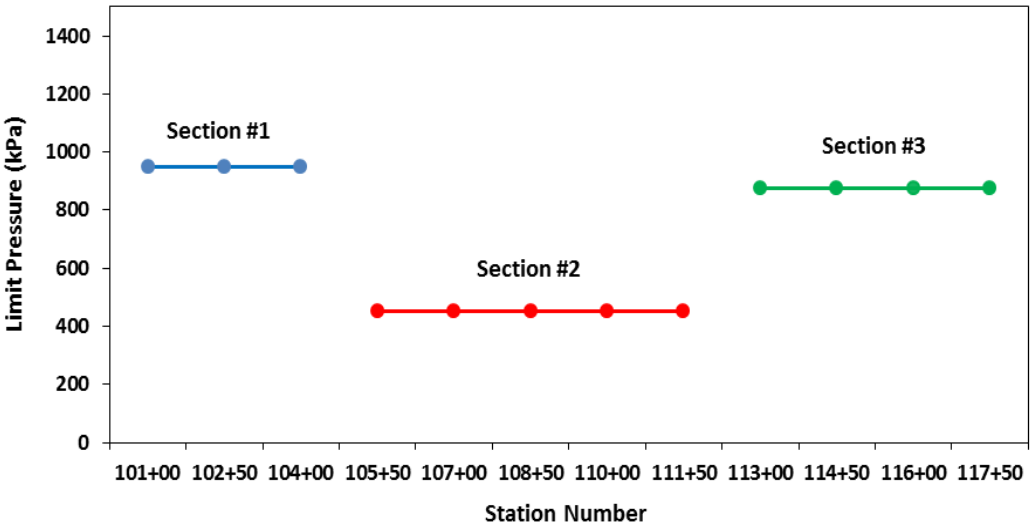
Field Testing Measurements

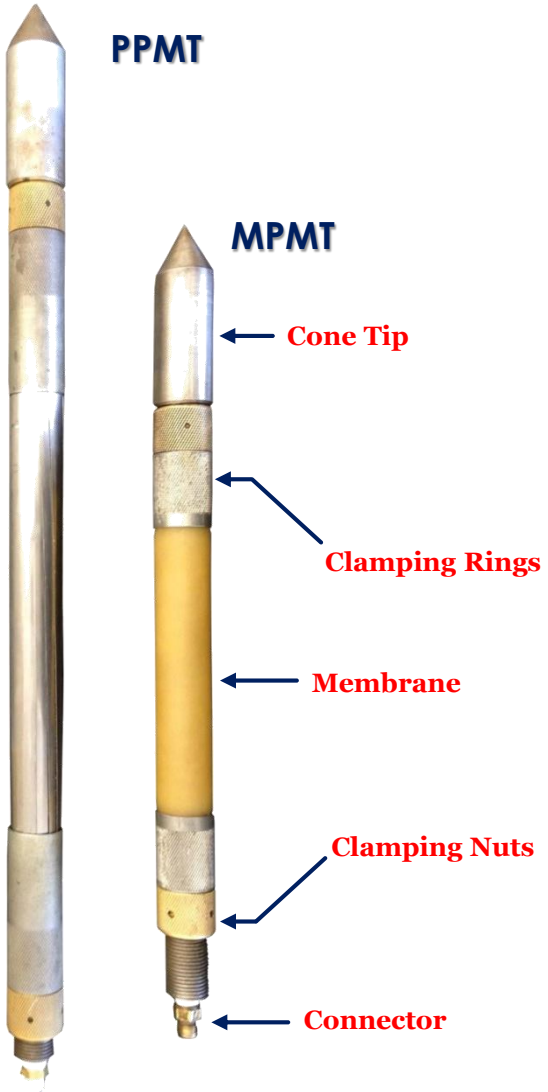
Pavement Layer	Modulus Parameters			Strength Parameters			Compaction Parameters		
Soil Property	**Mr**	**Ed**	**Ei**	**CBR**	**PL**	**Po**	**DC**	**γ_d**	**w**
Subgrade Soils	↑	↑	↑	↑	↑	↑	↑	↑	↑
Base Course	DCP	LWD	MPMT	DCP	MPMT	MPMT	LWD	NDG	NDG
	↓	↓	↓	↓	↓	↓	↓	↓	↓

$$\textbf{Mean} = \frac{\sum x_i}{\mathbf{N}} \quad \Rightarrow \quad \textbf{Std.} = \sqrt{\frac{\sum (x_i - \bar{x})^2}{\mathbf{N}}} \quad \Rightarrow \quad \textbf{COV} = \frac{\textbf{Std.}}{\textbf{Mean}}$$

Determining Consistency of Field Testing Measurements







Laboratory Testing Measurements

Basic Engineering Properties

Grain Size Distribution

- **American Society for Testing and Materials (ASTM D6913-2009)**
- **American Association of State Highway and Transportation Officials (AASHTO T 331)**

Atterberg Limits

- **American Society for Testing and Materials (ASTM D4318-2010)**
- **American Association of State Highway and Transportation Officials (AASHTO T 89)**

Optimum Density and Moisture Content

- **American Society for Testing and Materials (ASTM D1557-2012)**
- **American Association of State Highway and Transportation Officials (AASHTO T 180)**

Limerock Bearing Ratio

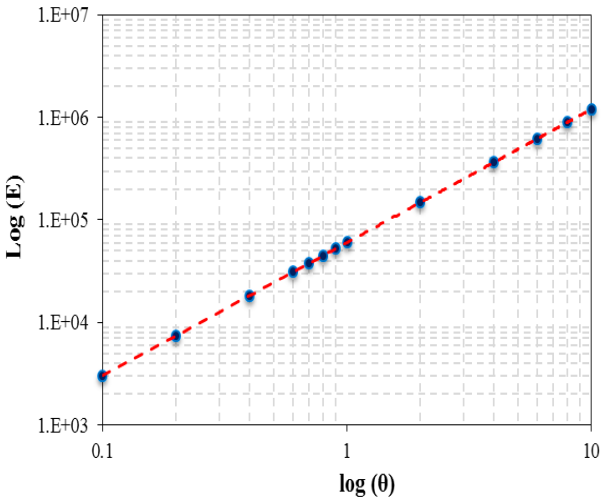
- **Florida Department of Transportation (FDOT FM 5-515)**

Laboratory Testing Measurements

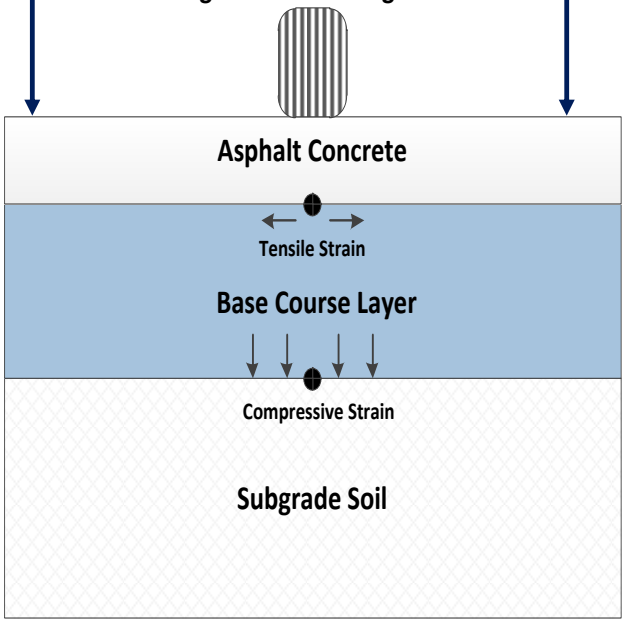
Resilient Modulus Test

k-Θ Model

$$\left[E = k\left(\frac{\theta}{P_a}\right)^{n_s}\right]$$



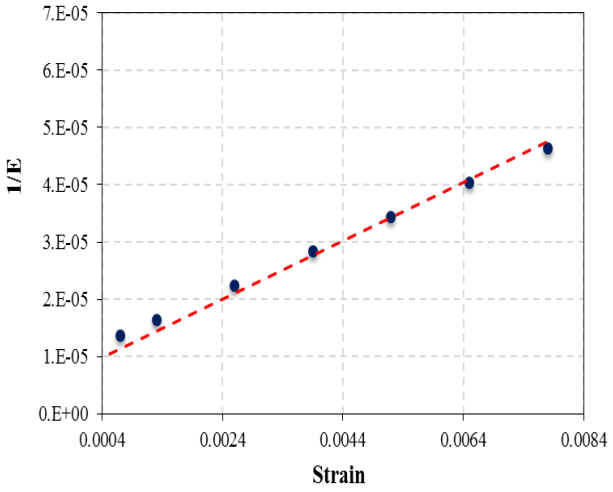
ILLIPAVE 2005
Non-linear Finite Element Software for Pavement Analysis and Design



Miniaturized PMT Test

Strain Model

$$\left[\frac{1}{E} = a + b\varepsilon\right]$$



QUESTIONS?