Intelligent Compaction:
Are We There Yet?

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TxDOT

Outline

- Why need Intelligent Compaction (IC)?
- What is it?
- How does it work?
- What does it do?
- National research
- TxDOT experience
- Summary

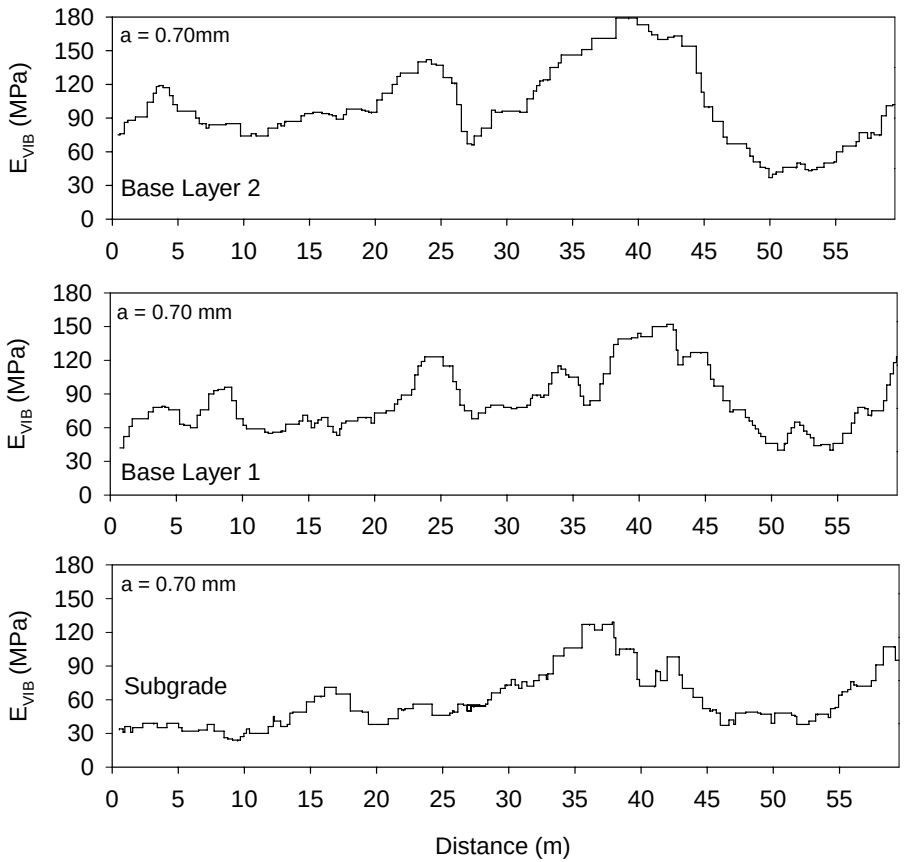
Significance of Quality Compaction

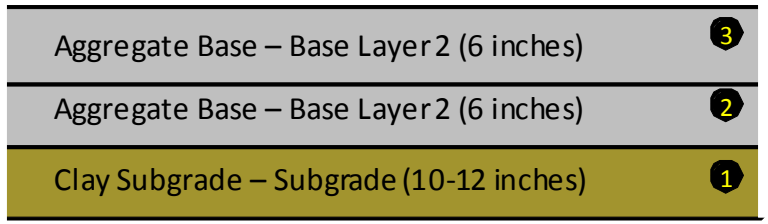
We've known it for a long time…

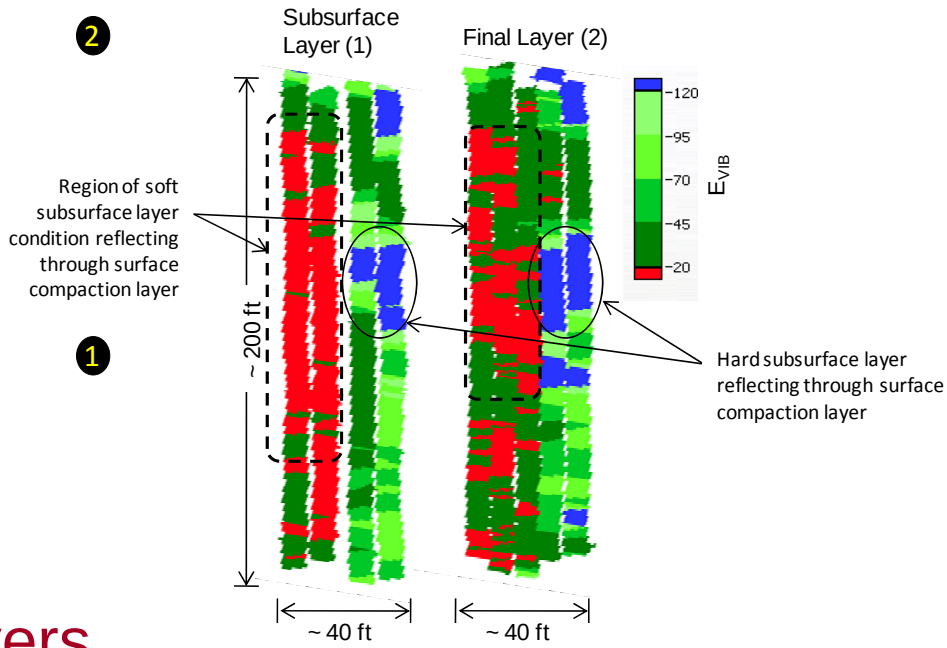
"The importance of compaction in highway construction has long been recognized. Recent laboratory and field investigation have repeatedly emphasized the value of thorough consolidation in both the base and surfacing courses."

Reference -- "Public Roads, **May 1939**, authors J.T. Pauls and J.F. Goode"

Significance of Quality Compaction

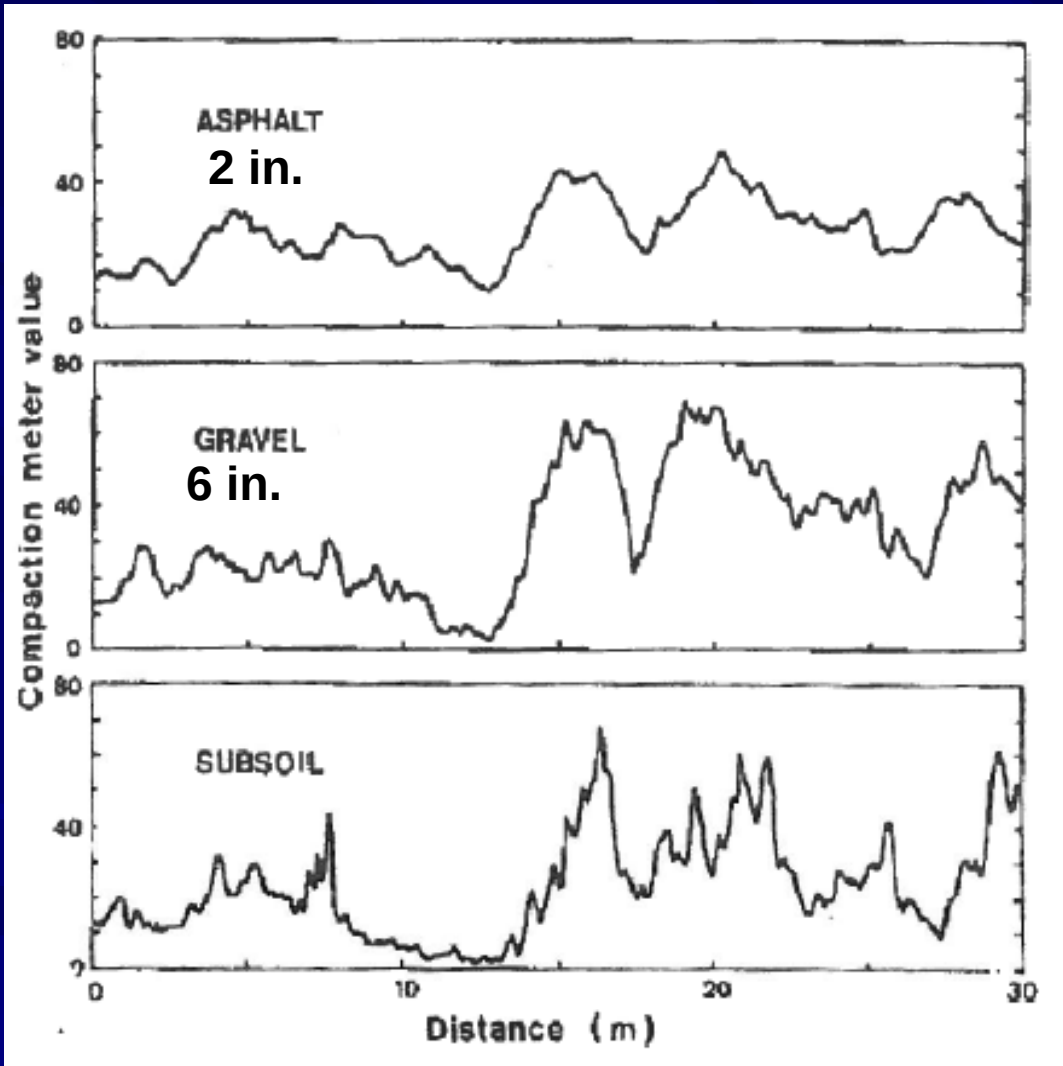






Reflection of underlying non-uniformity to overlying layers

Significance of Quality Compaction



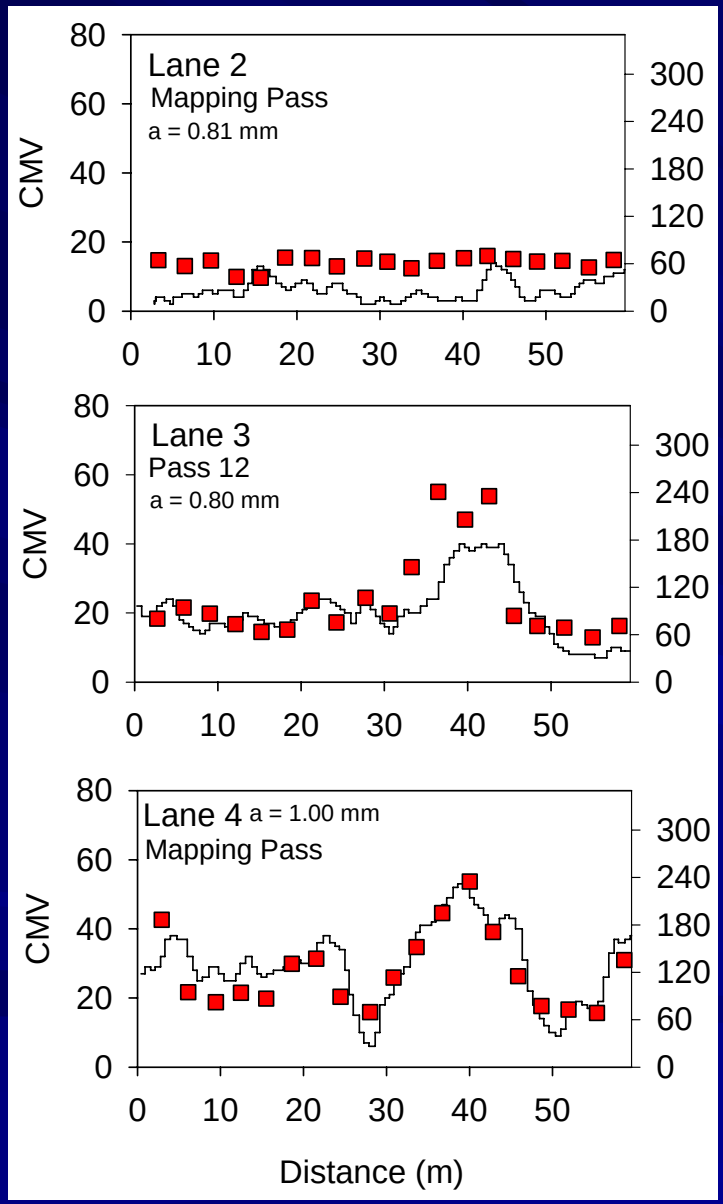
(from Thurner and Sandstrom, 1980)

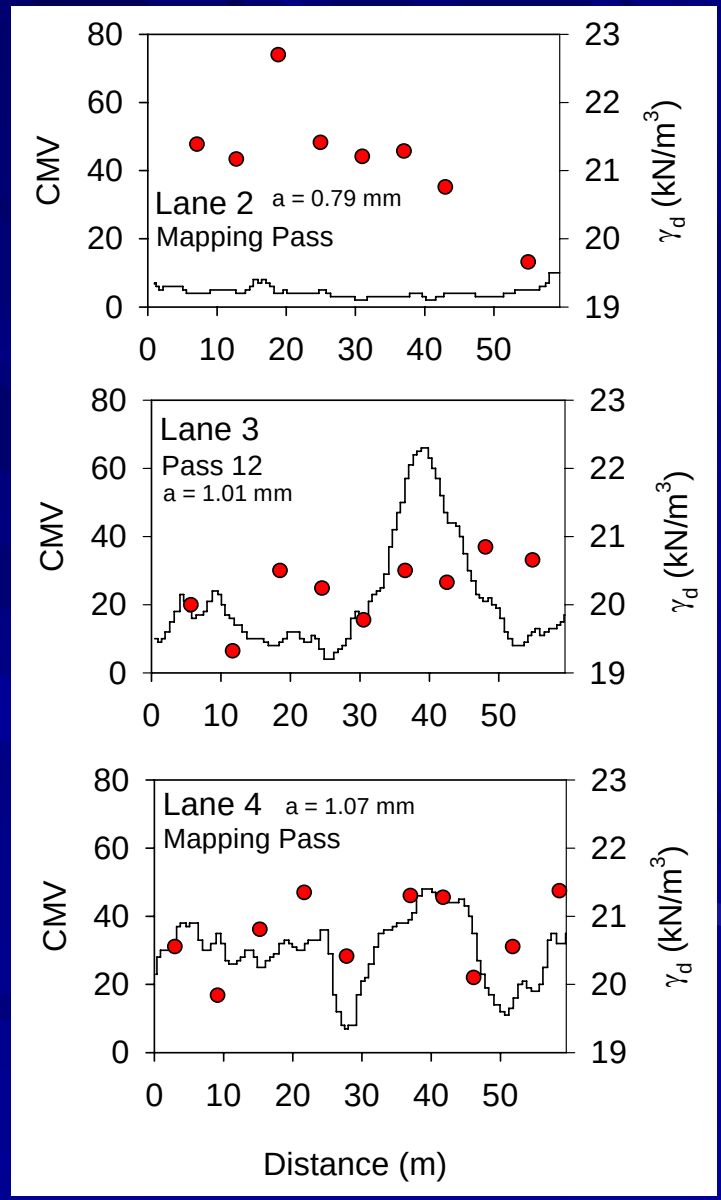
- **Reflection of underlying non-uniformity to surface layers**
- The quality of asphalt can not make up for a poor subgrade or base.

Why Need Intelligent Compaction?

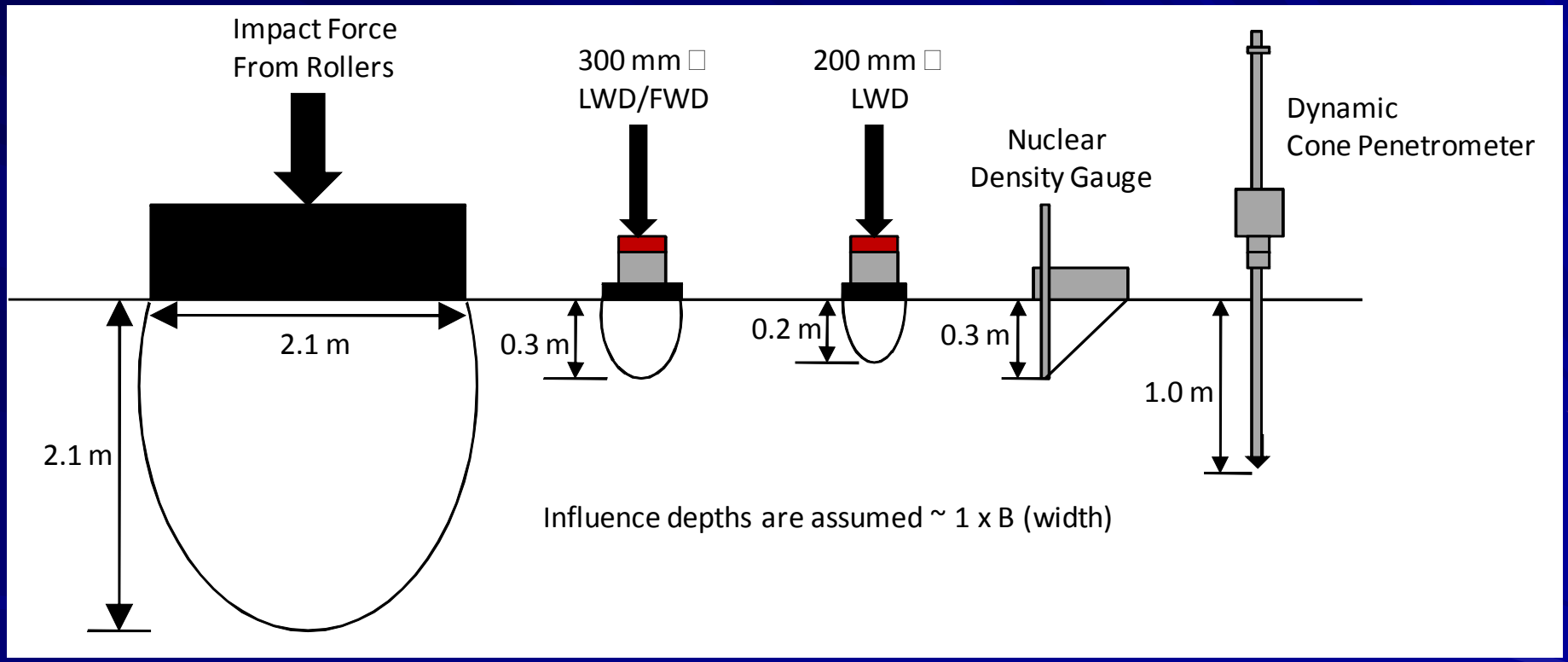
- How do we control or evaluate the quality of compaction?
  - Ordinary Compaction - Proof Rolling
  - Density Control – Nuclear Gauge Density
- Is density the best way to characterize the quality of compaction?
  - Do we use density in our pavement design?
  - Density measurements are spot check and layer specific, and may not be representative of entire section and full depth
  - How well does density correlate with stiffness/modulus of the materials?
  - How sensitive does density response to compaction?

Comparison of CMV and FWD/Dry Density





Correlation w/ In-Situ Testing



Courtesy of Dr. David White

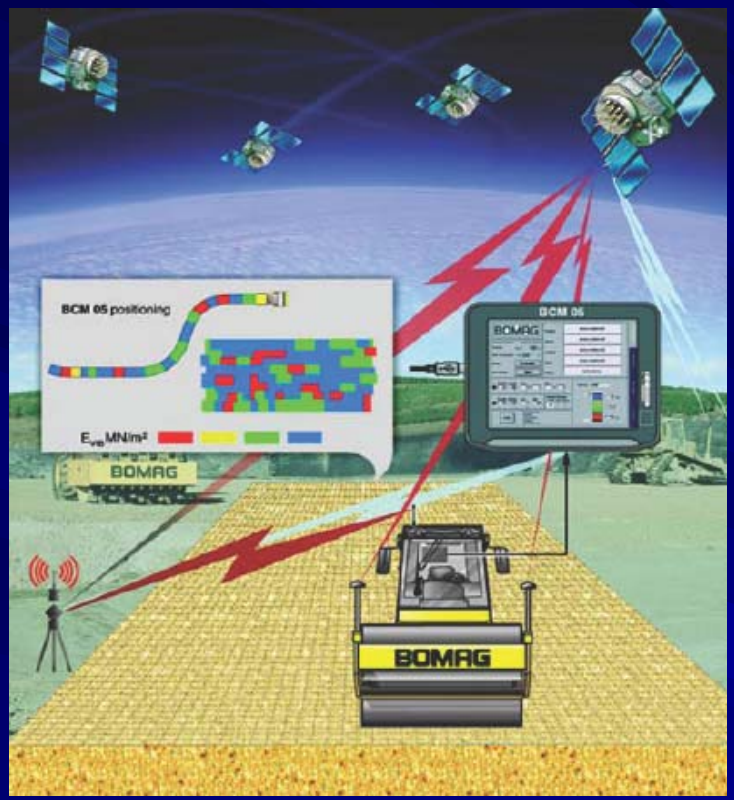
Why Need Intelligent Compaction?

- How do we know the desired/target density has been achieved?
  - Experience
  - Nuclear density gauge/sand cone
  - Density properties are not measured until after the compaction is complete
- How Can We Do Better?
  - Intelligent compaction technology appears to offer *"a better or smarter way"*

What is Intelligent Compaction (IC)?

- Vibratory rollers with a feedback control measurement system
  - Measure material stiffness instead of density
  - Control system automatically changes parameters (amplitude and frequency) based on measured material stiffness feedback
- GPS-based documentation systems
  - Continuous recording material's stiffness
  - Continuous recording corresponding roller location
  - Color-coded mapping of stiffness

How Does It Work?



Display Panel

GPS Receiver

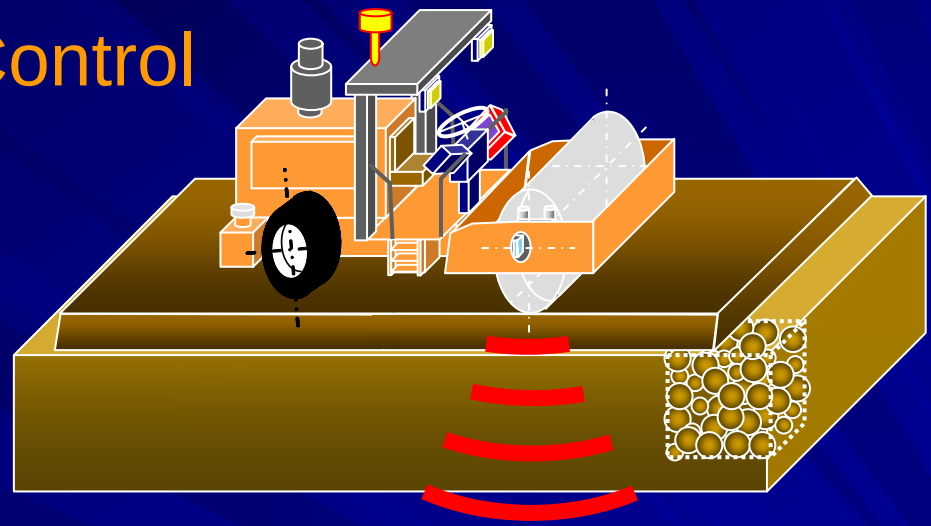
Accelerometer

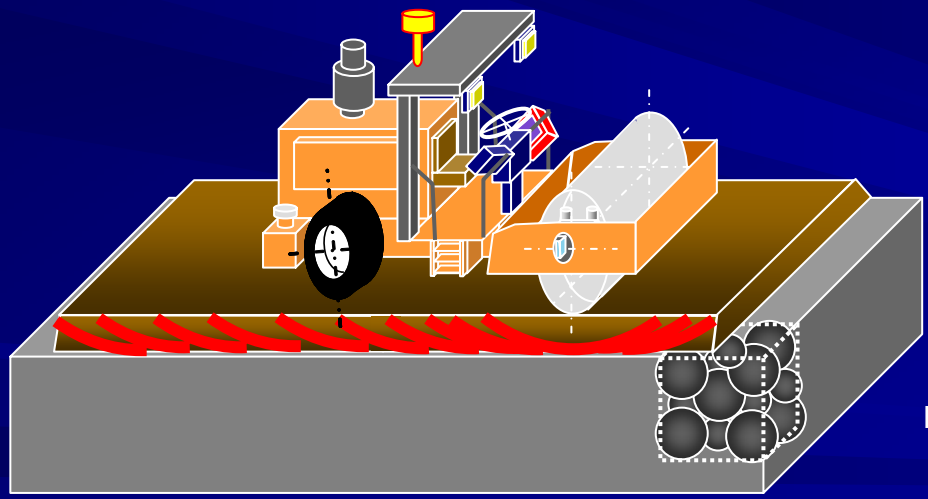
How Does It Work?

Amplitude & Frenquency Control

Soft Soil, poor compacted; acting as a Spring

High Amplitude, Low Frequency, Penetrate Deeper



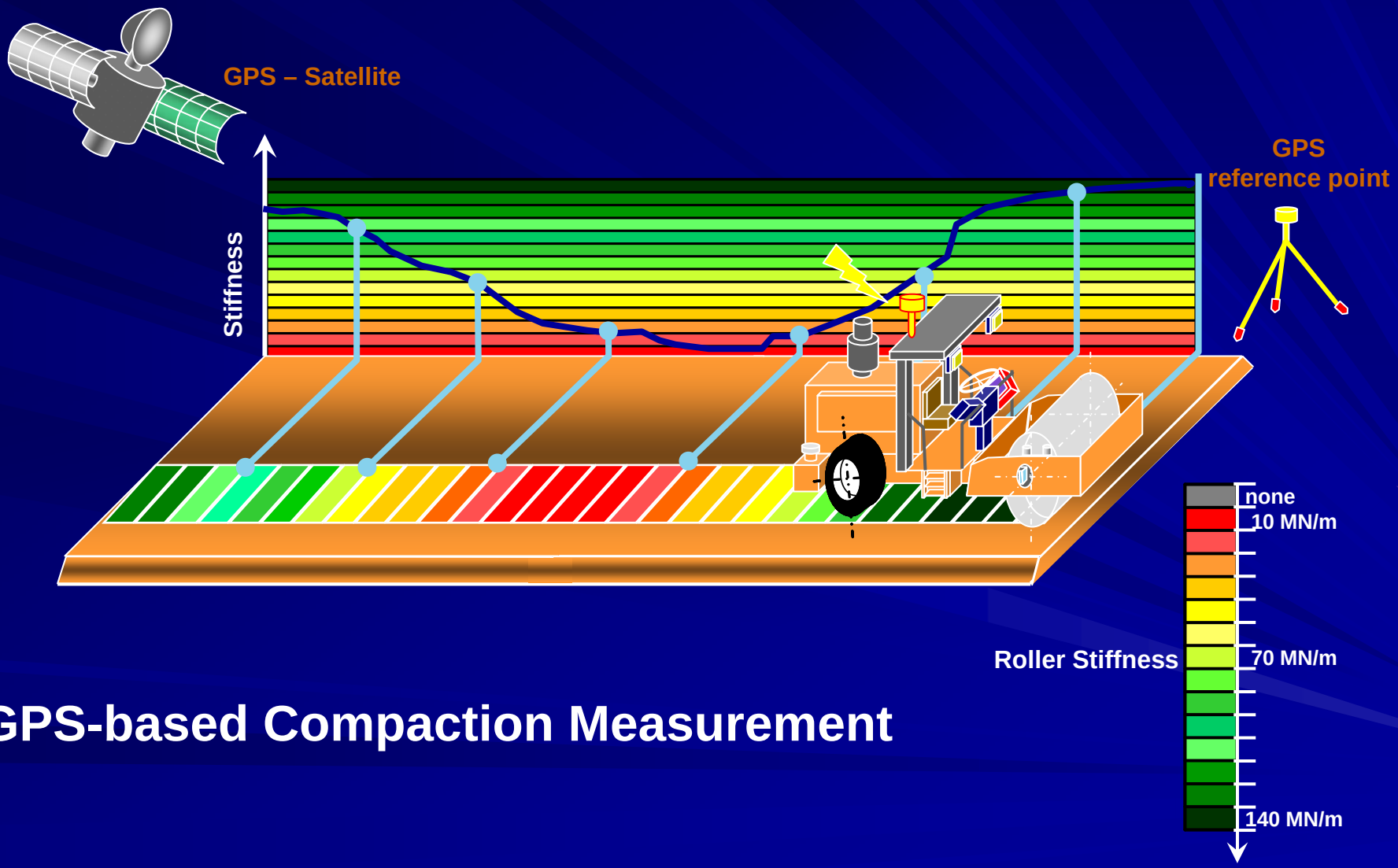


Hard Soil, well compacted; acting as an anvil

Low Amplitude, High Frequency, Compact Surface

Courtesy of Ammann America

How Does It Work?



GPS-based Compaction Measurement

Courtesy of Ammann America

National Research Efforts

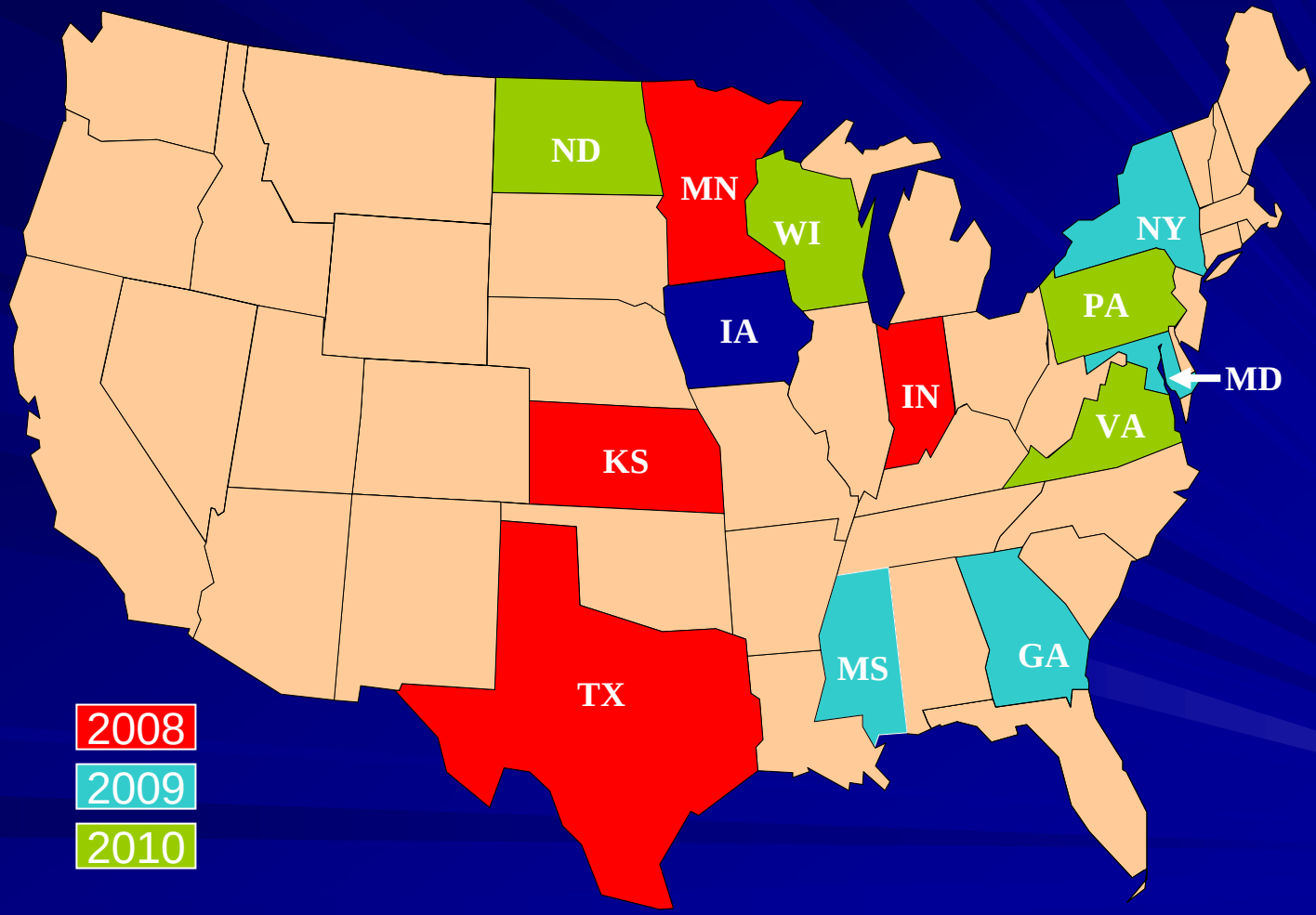
- NCHRP 21-09

  "Examining the Benefits and Adoptability of Intelligent Soil Compaction"
  - Report is under review

- Transportation Pooled Fund TPF-5(128)

  "Accelerated Implementation of Intelligent Compaction Technology for Embankment Subgrade Soils, Aggregate Base and Asphalt Pavement Material"
  - 12 states participated in this three-year pooled fund study
  - At least one demo project will be constructed in each participated state, either in soil/aggregate base or HMA

Transportation Pooled Fund, TPF-5(128)
12 States IC Demo Projects



http://www.intelligentcompaction.com/

Summary of Demo Projects

DOT	Dates	Materials	IC Rollers
Mn/DOT	June 2 to 23, 2008	HMA	Sakai tandem drum roller
TXDOT	July 20 to 27, 2008	Soil, lime stabilized soil and base	Case/Ammann single-drum: pad foot and smooth drum Dynapac single smooth drum
KSDOT	Aug. 17 to 24, 2008	Soil	Sakai and Caterpillar single pad foot drum
NYSDOT	May 18 to 22, 2009	Granular soil and subbase	Bomag single smooth drum Caterpillar single smooth drum Sakai double drum
MSDOT	July 13 to 17, 2009	Stabilized base and HMA	Caterpillar single drum padfoot Case/Ammann single smooth drum Sakai double drum
MDSHA	July 20 to 25, 2009	HMA	Bomag tandem drum Sakai double drum
GDOT	Sept. 14 to 18, 2009	HMA	Sakai double drum
INDOT	Sept. 21 to 25, 2009	HMA	Sakai double drum Bomag double drum

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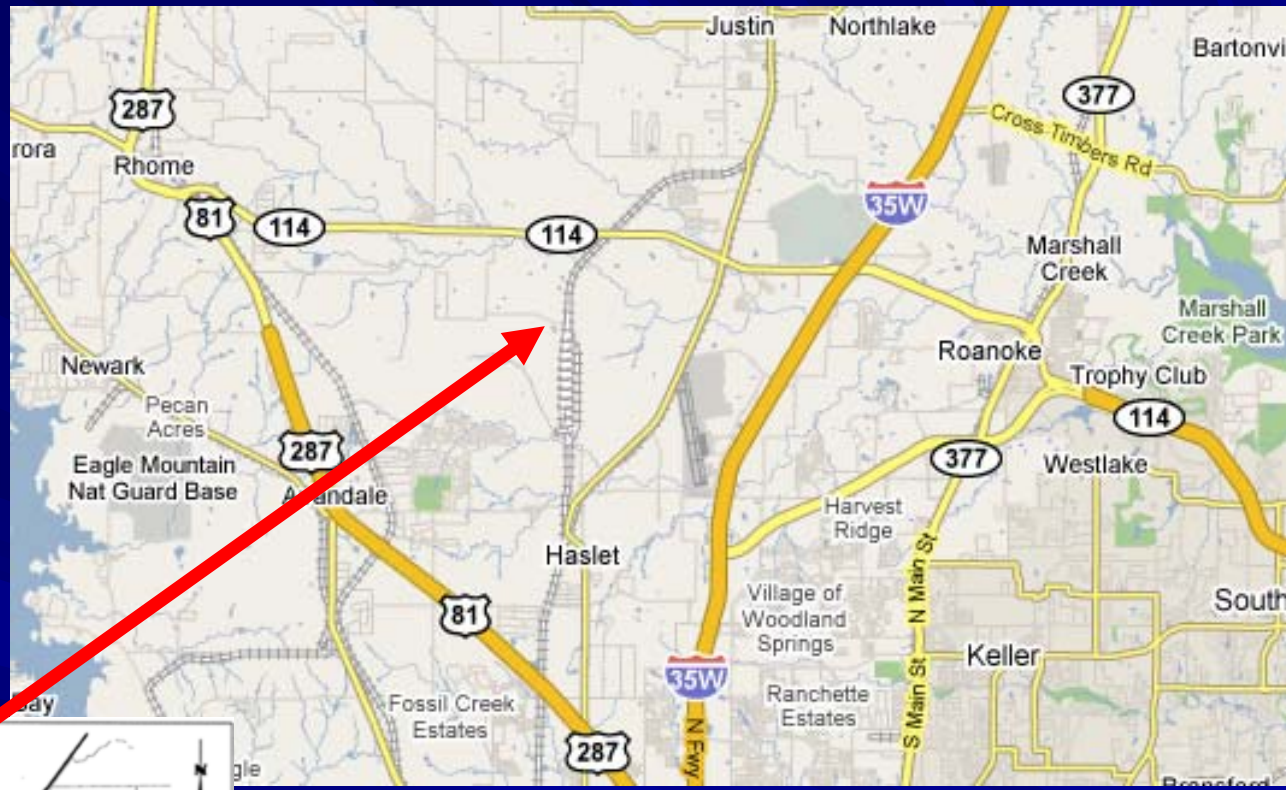
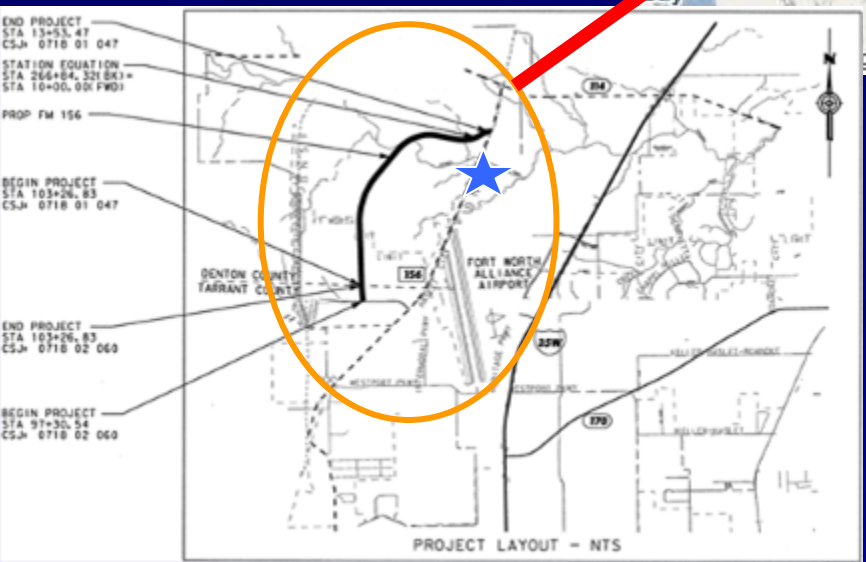
TxDOT Experience

Demo Project on FM156





Fort Worth, Texas

TxDOT Experience

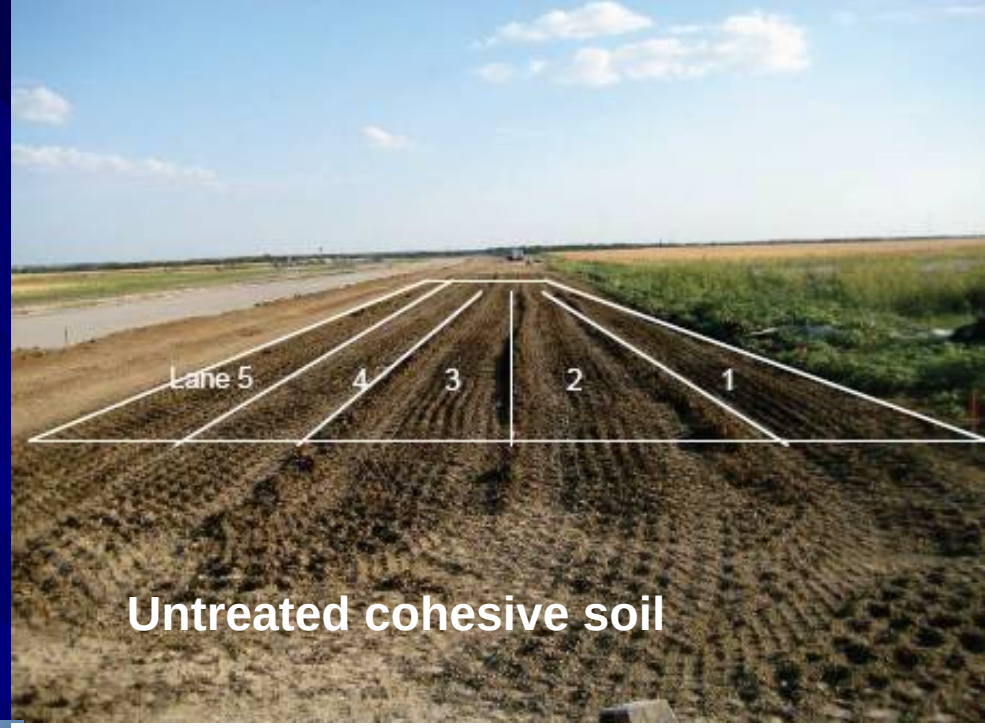
- Three IC rollers
  - Single padfoot and smooth drum steel wheel IC rollers from Case/Ammann
  - Single smooth drum steel wheel IC roller from Dynapac
- Three types of materials
  - Untreated cohesive soil
  - Lime treated soil
  - Flexible limestone base

Case/Ammann Single Drum IC Roller

Dynapac Single Drum IC Roller

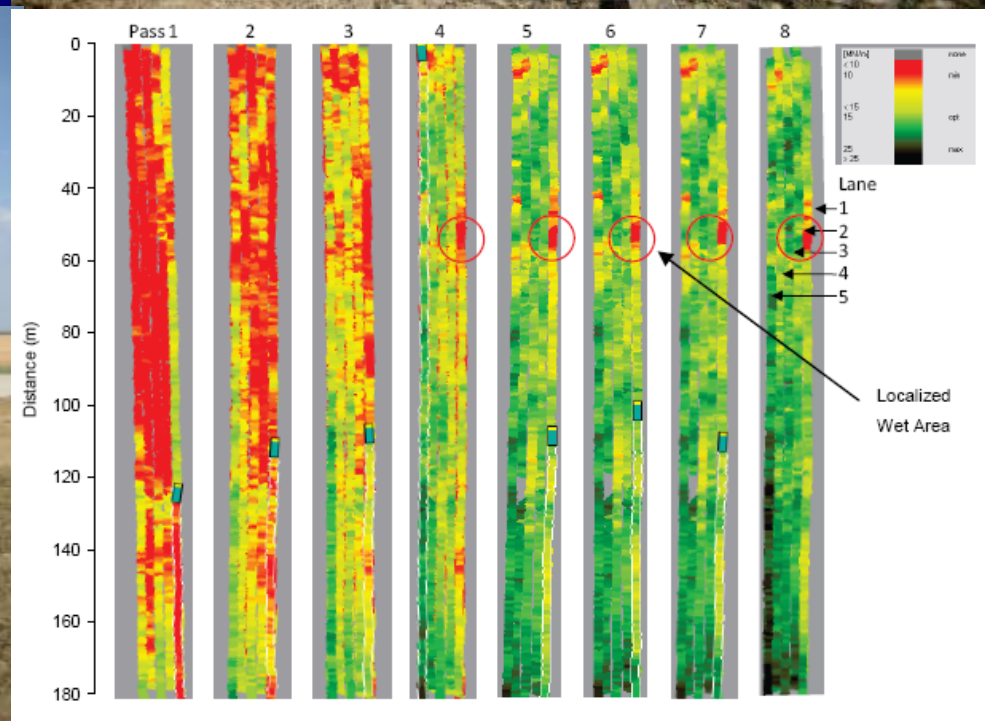
TxDOT Experience

Untreated Subgrade Soil

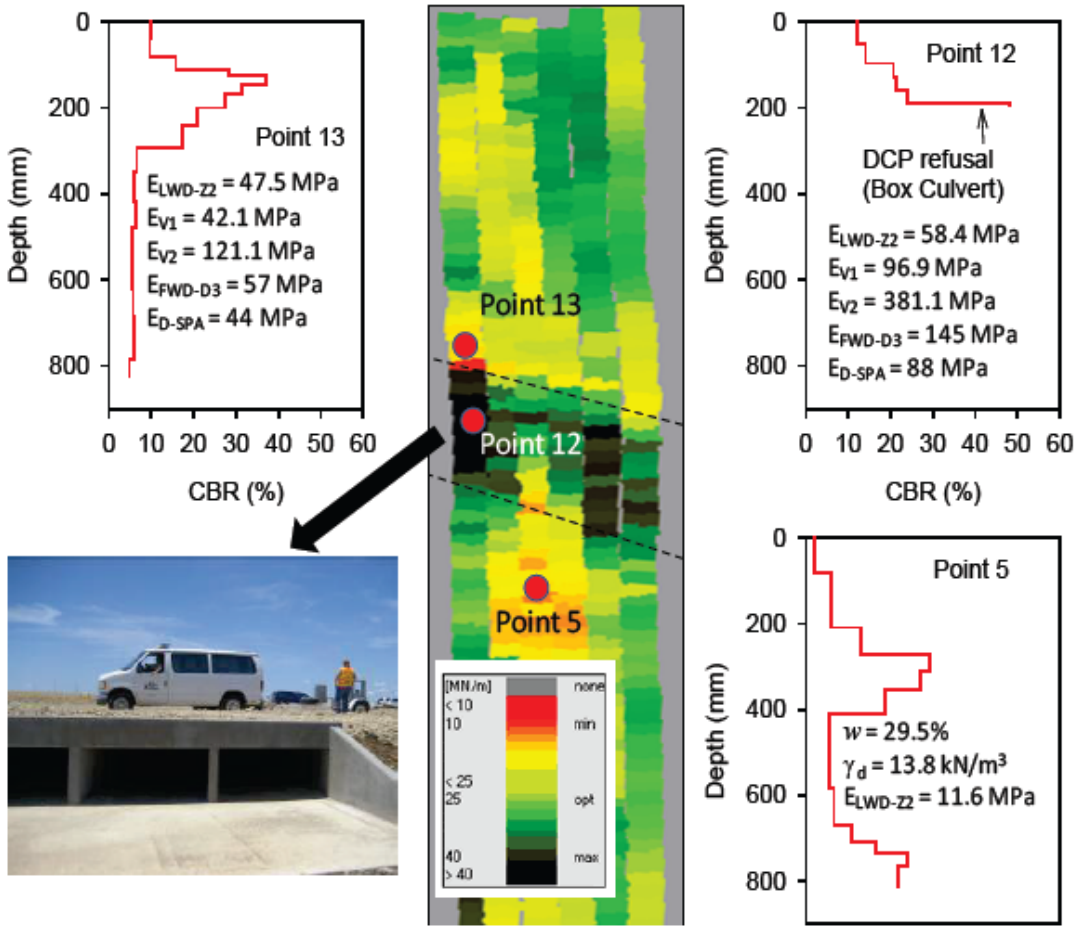


Untreated cohesive soil

Untreated cohesive soil



Flex Base (on both ends of the test bed) and Lime Stabilized Subgrade



Summary of TxDOT Experience

- Both padfoot and smooth drum rollers work well for the quality compaction of the untreated and lime treated subgrade clay material with good repeatability.
- Both roller CMVs and in-situ point measurements captured the wide variation in stiffness of the compacted lime stabilized and flex base materials.
- The CMV measurements are influenced by the vibration amplitude and show that increasing amplitude generally causes an increase in CMV value on the material tested.

Benefits of IC

- Intelligent compaction rollers measure and record the quality of compaction during the compaction process (on-the-fly)
  - Measure and record material stiffness values instead of density
  - Integration of design with construction and pavement performance (density vs. modulus/stiffness)
  - Real-time identify weak spots or non-compactable areas

Benefits of IC

- 100% coverage of compaction area for quality control
- Improve efficiency of the compaction process
  - Improve density uniformity of the pavement materials
  - Eliminate lost time and the expense of having to rework areas where under or over-compaction have occurred
  - Knowing when compaction is complete, taking the guess work out of compaction (less operator accountability)

Summary of Benefits

- Improve uniformity of density
  - better performance
- Improve efficiency of compaction
  - cost savings
- Increase information of compaction
  - better QC/QA

Research Needs

- Demonstrate that intelligent compaction leads to better compaction than conventional compaction by quantifying the differences between the two techniques.
- Study the depth of compaction that can be achieved by various rollers for various soils.
- Understand the interdependence between the modulus and water content.
- Develop a fast and simple field test to obtain the target modulus for IC roller calibration.
- Develop a fast and simple field test to measure the water content in real time.
- Develop standard specifications.

What is Next for TxDOT?

- Complete more pilot construction projects using IC technology to determine:
  - Which test is used for calibration of IC rollers
  - The benefits of using IC rollers over conventional rollers
- Develop a state-wide IC-based construction specification.
- Conduct training workshops for implementation of IC technology in districts.

Thank You

- Questions?