LOUISIANA STATE UNIVERSITY

Cost-Effective Detection and Repair of Moisture Damage in Pavements

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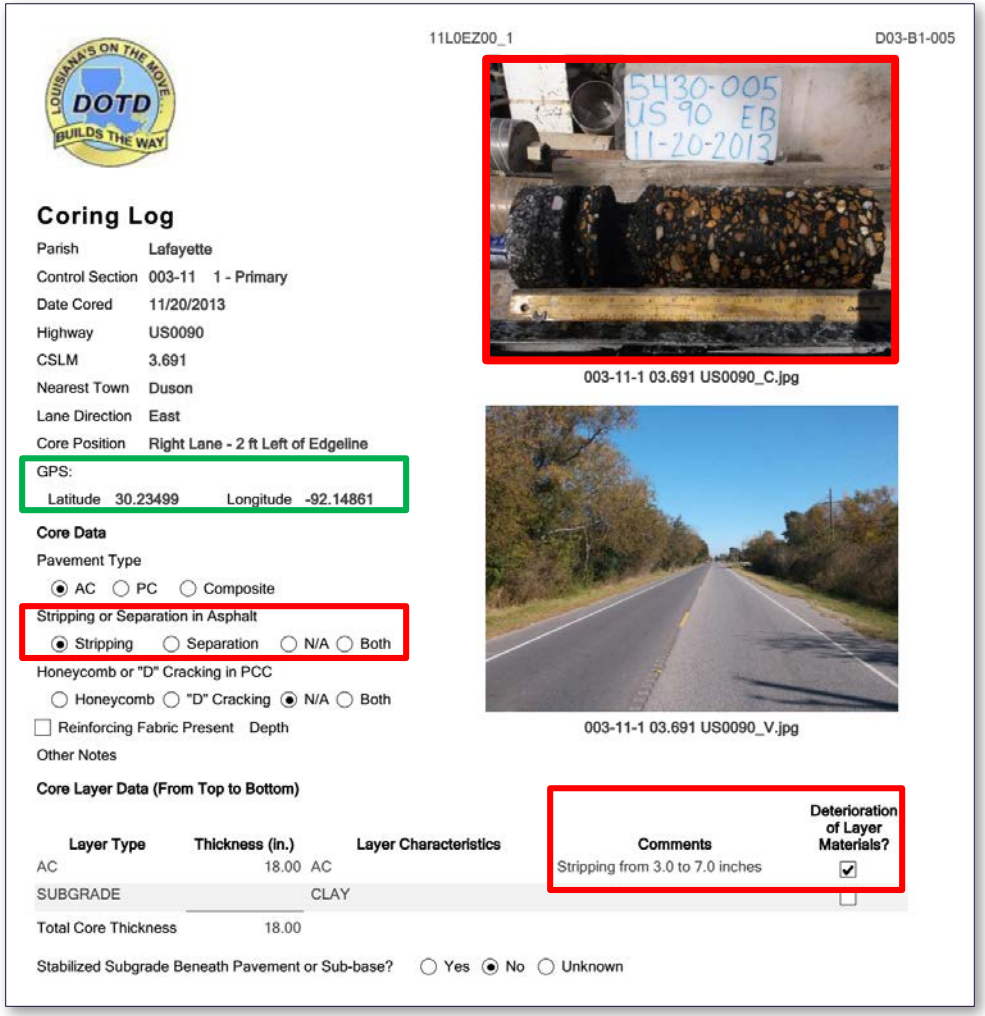
Introduction

- Moisture damage is a significant distress that affects overall pavement performance:
  - Stripping
  - Potholes
  - Delamination, …
- Appears at the surface after detrimental damage has already progressed in underlying layers
- Early detection and repair are critically needed:
  - Retard progressive failure
  - Reduce need for reconstruction/ major rehabilitation

Stripped Sections in LA

- Identified based on pavement coring
- Coring logs are available in the PMS.
- Sections were identified based on:
  - Core conditions
  - Presence of stripping
  - Comments on HMA deterioration
- Location of the sections:
  - GPS coordinates



11L0EZ00_1 D03-B1-005

Coring Log

Parish Lafayette
Control Section 003-11 1 - Primary
Date Cored 11/20/2013
Highway US0090
CSLM 3.691
Nearest Town Duson
Lane Direction East
Core Position Right Lane - 2 ft Left of Edgeline
GPS:
Latitude 30.23499 Longitude -92.14861

Core Data

Pavement Type
(•) AC ( ) PC ( ) Composite
Stripping or Separation in Asphalt
(•) Stripping ( ) Separation ( ) N/A ( ) Both
Honeycomb or "D" Cracking in PCC
( ) Honeycomb ( ) "D" Cracking (•) N/A ( ) Both
[ ] Reinforcing Fabric Present Depth
Other Notes

Core Layer Data (From Top to Bottom)

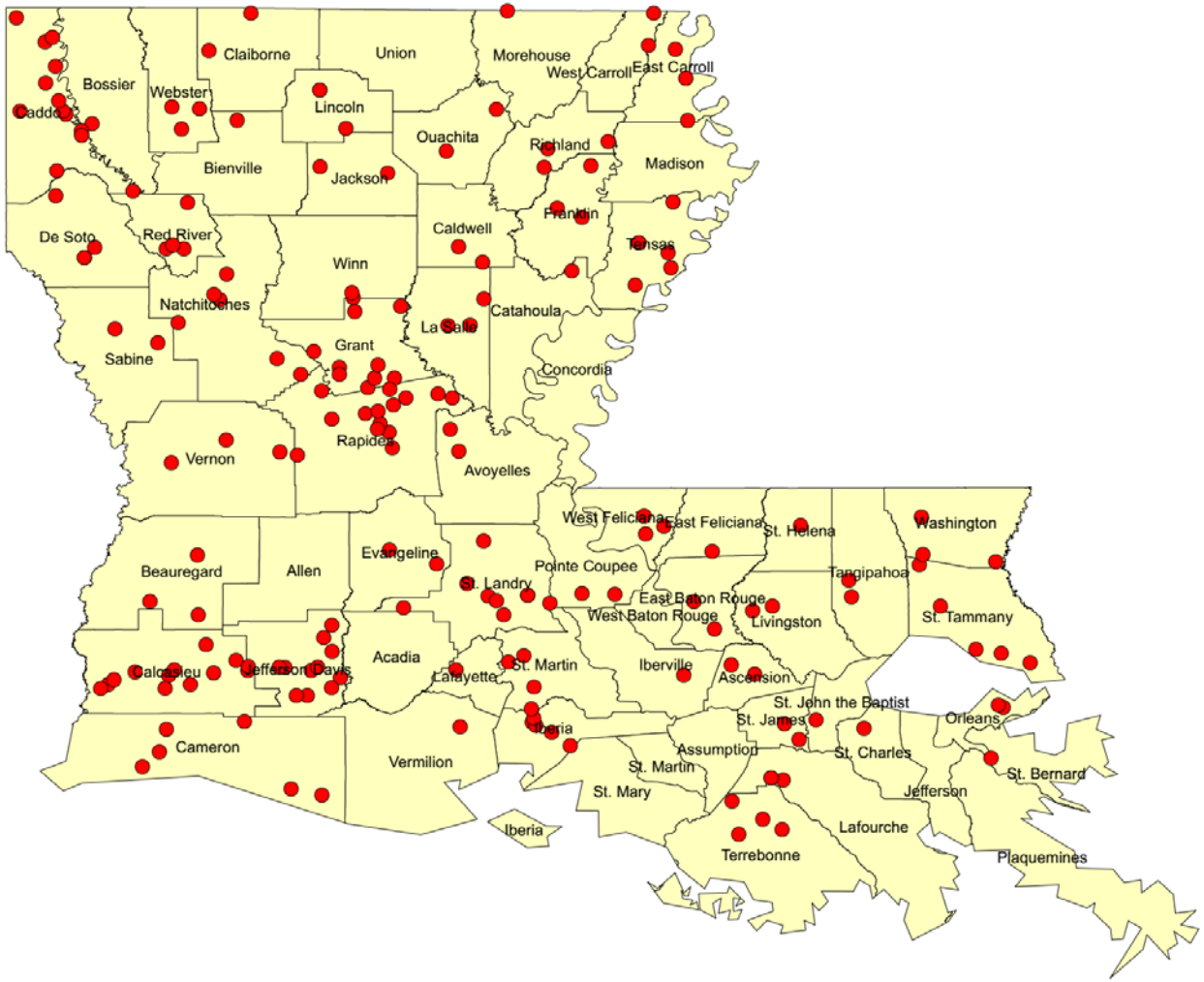
Layer Type	Thickness (in.)	Layer Characteristics	Comments	Deterioration of Layer Materials?
AC	18.00	AC	Stripping from 3.0 to 7.0 inches	☑
SUBGRADE		CLAY		☐
Total Core Thickness	18.00			

Stabilized Subgrade Beneath Pavement or Sub-base? ( ) Yes (•) No ( ) Unknown

003-11-1 03.691 US0090_C.jpg

003-11-1 03.691 US0090_V.jpg

Scale of Moisture Damage in LA



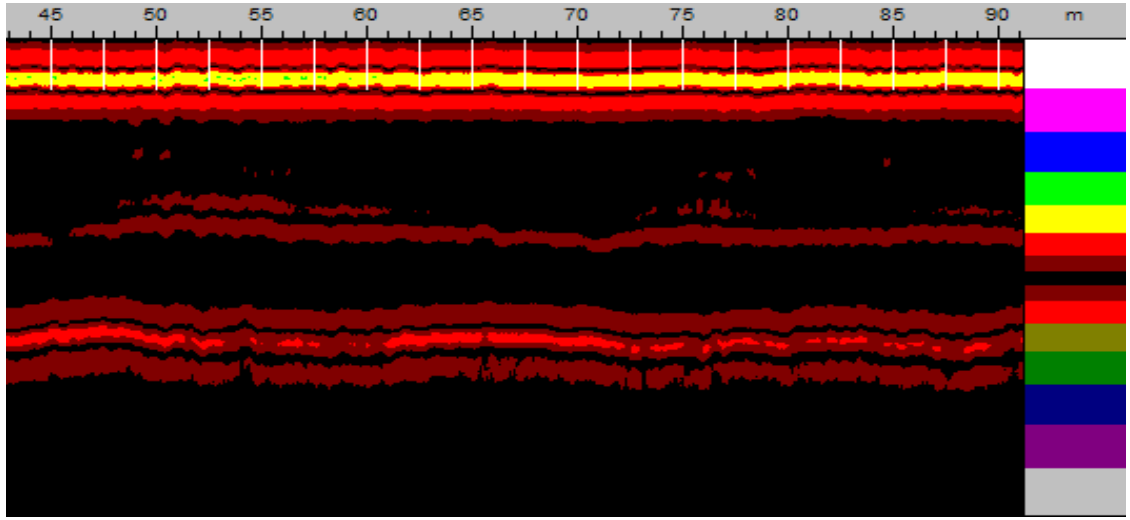
Moisture Damage Detection

- Core extraction
  - Destructive
  - Time consuming
  - Rarely conducted
- Nondestructive Evaluation (NDE)
  - Ground Penetrating Radar (GPR)
  - Portable Seismic Properties Analyzer (PSPA)
    - Ultrasonic Surface Waves
    - Impact Echo
  - Ultrasonic Tomography (MIRA)
  - Falling Weight Deflectometer (FWD)
  - Infra-Red Thermography (IRT)

Ground Penetrating Radar (GPR)

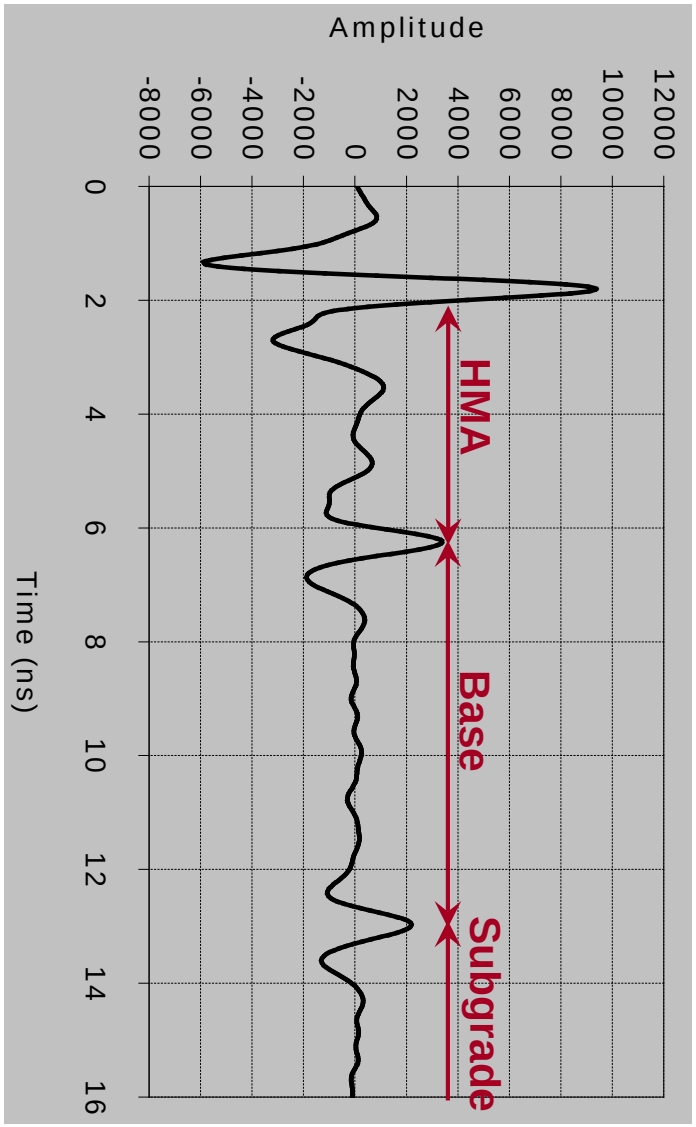
- Non-destructive and continuous tool
  - transmits short pulses of electromagnetic waves into ground
  - reflections from the material boundaries and subsurface anomalies are identified from the reflected signal.
- Noninvasive, continuous, and high-speed evaluation
- Capabilities:
  - Pavement layer thickness estimation
  - detection of subsurface moisture
  - density variations and voids
  - underground utility locations…

GPR Results



Profile – (B Scan)

Trace (A-Scan)

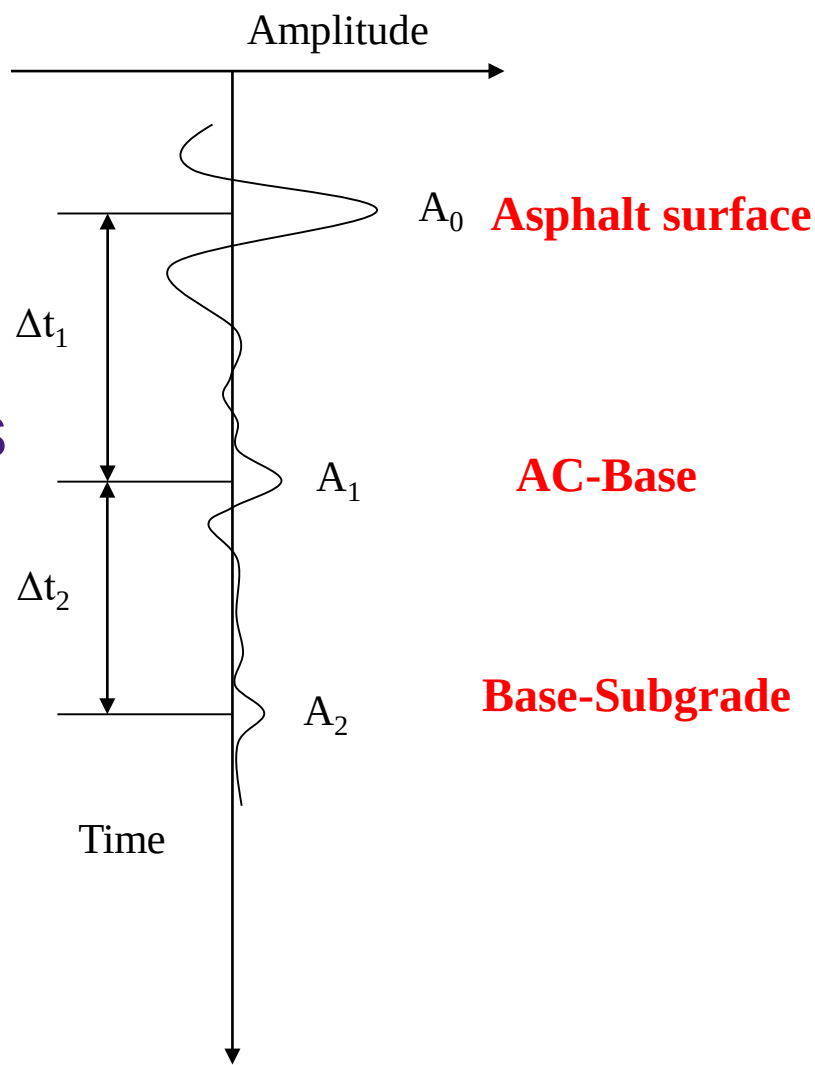


Objectives

- To evaluate the capabilities of GPR in detecting the presence, extent, and severity of moisture damage in in-place pavement sections using:
  1. Surface dielectric constants
  2. Visual Inspection of GPR traces
  3. Uniformity Index (UI)
  4. Finite Element Analysis

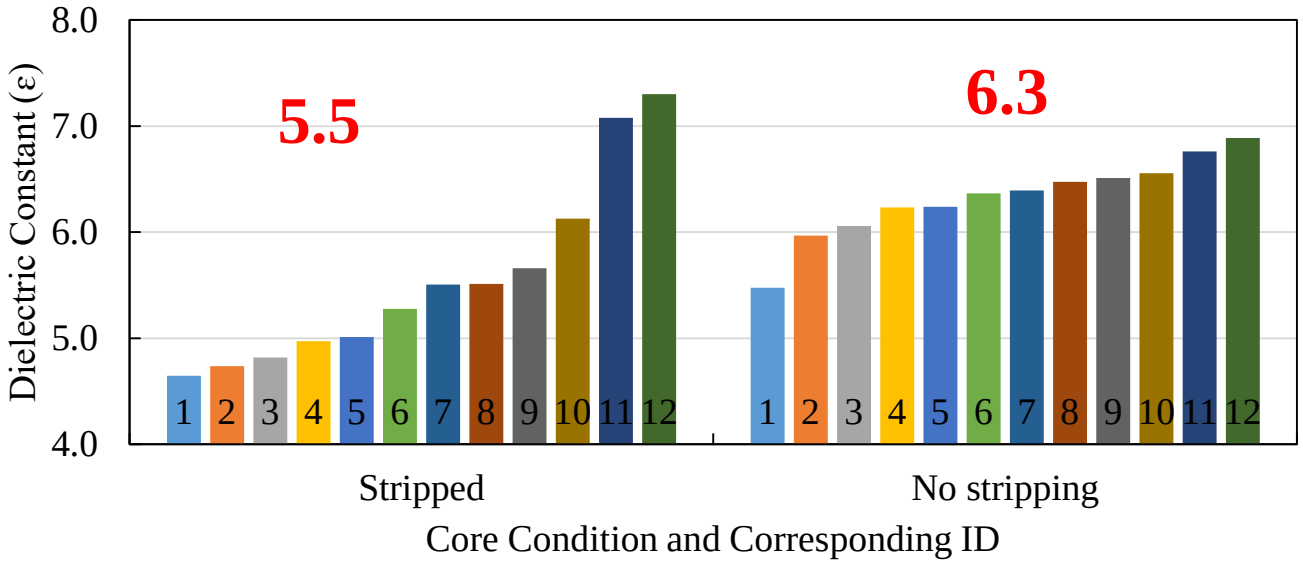
1-Surface Dielectric Constants

- Dielectric constant is a measure of the dielectric permittivity of a material
  - Higher ε values mean less radar penetration (more attenuation)
- Dielectric mismatch results in transmission and reflection of energy at the interfaces



1-Surface Dielectric Constants

- Surface dielectric constants were calculated for 12 stripped and 12 non-stripped cores in Louisiana **during dry season**

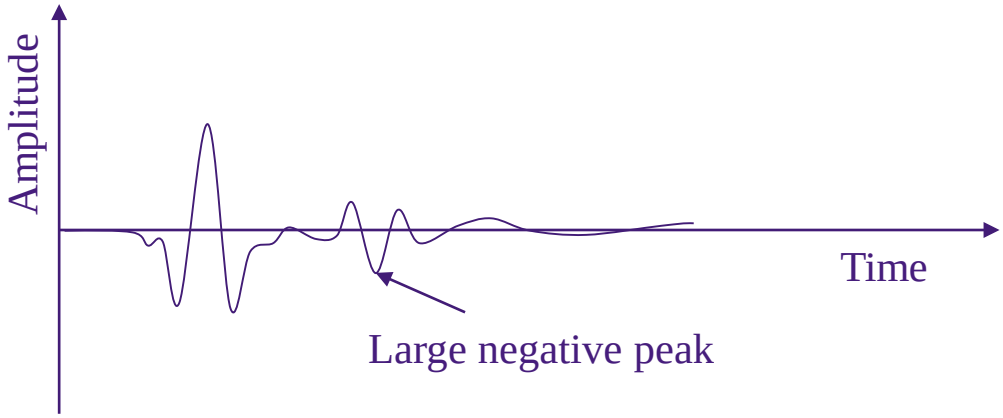


- Stripped sections exhibited lower dielectric values due to stripping induced voids

2-Visual Inspection of Traces

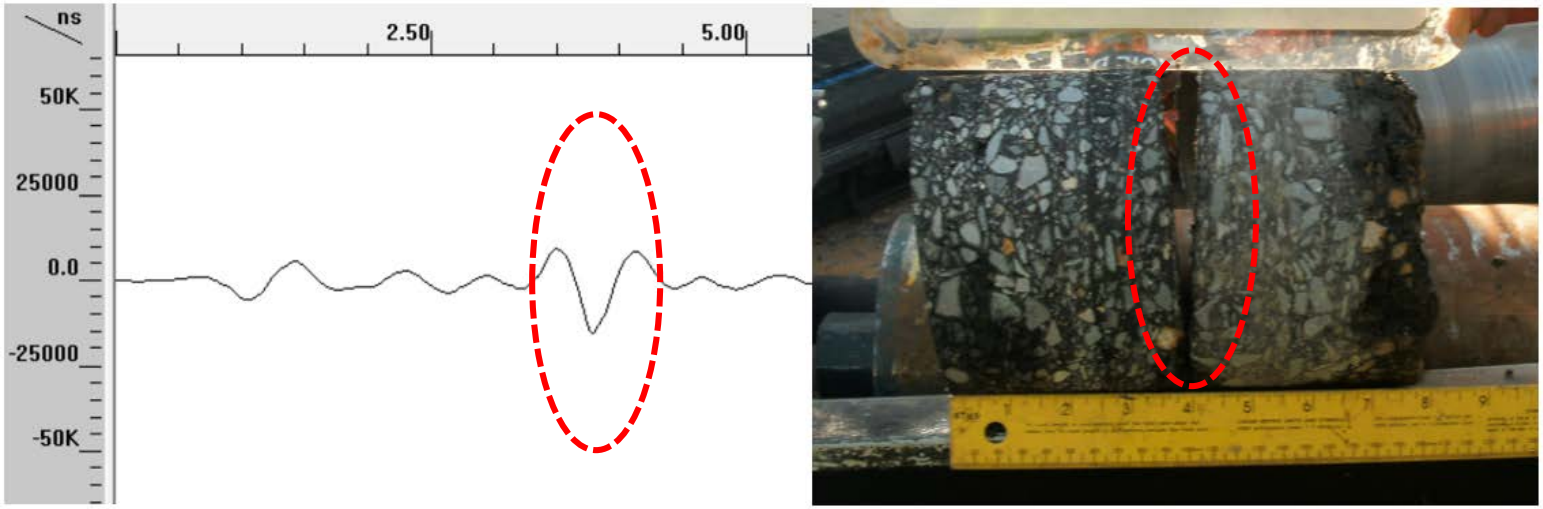
- Positive reflections occur when the signal moves to a layer of higher dielectric property
- A negative peak is associated with the transition from a high to lower dielectric material.

An additional negative peak in between the surface and base reflections may indicate stripping



2-Visual Inspection of Traces

- Careful visual inspection of the traces was used in identifying the stripped locations.



3-Uniformity Index (UI)

- Relative increase in the reflection activities from the pavement layers indicates moisture induced damages.
- GPR uniformity index (UI) correlates stripping with increased reflection activities
  - Compares the reflection amplitudes from a station with neighboring locations.

$$UI\ (x) = \frac{\overline{A}(x)}{\overline{A}\left(x \pm \frac{L}{2}\right)}$$

where

$\overline{A}$ = average reflection amplitude at current location

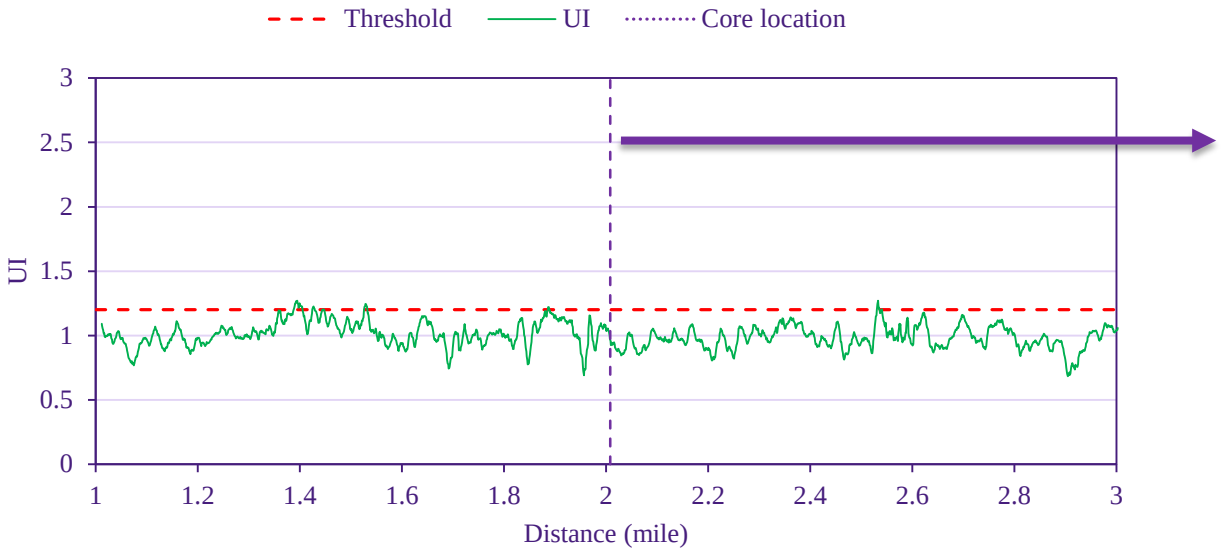
x = current station, and

L = normalization length.

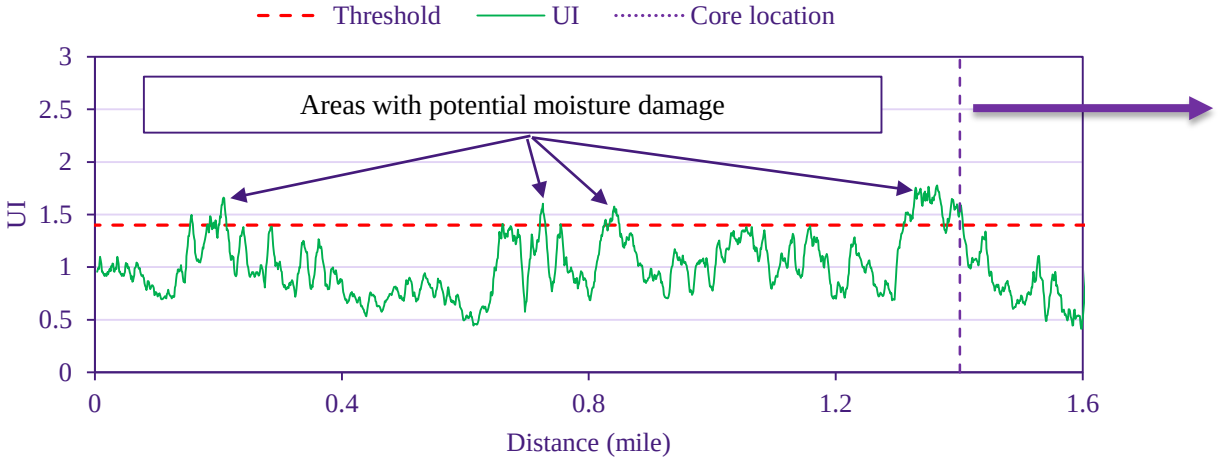
Core Depth	UI threshold
3 to 7 in.	1.2
7 to 17 in.	1.4

UI Profile

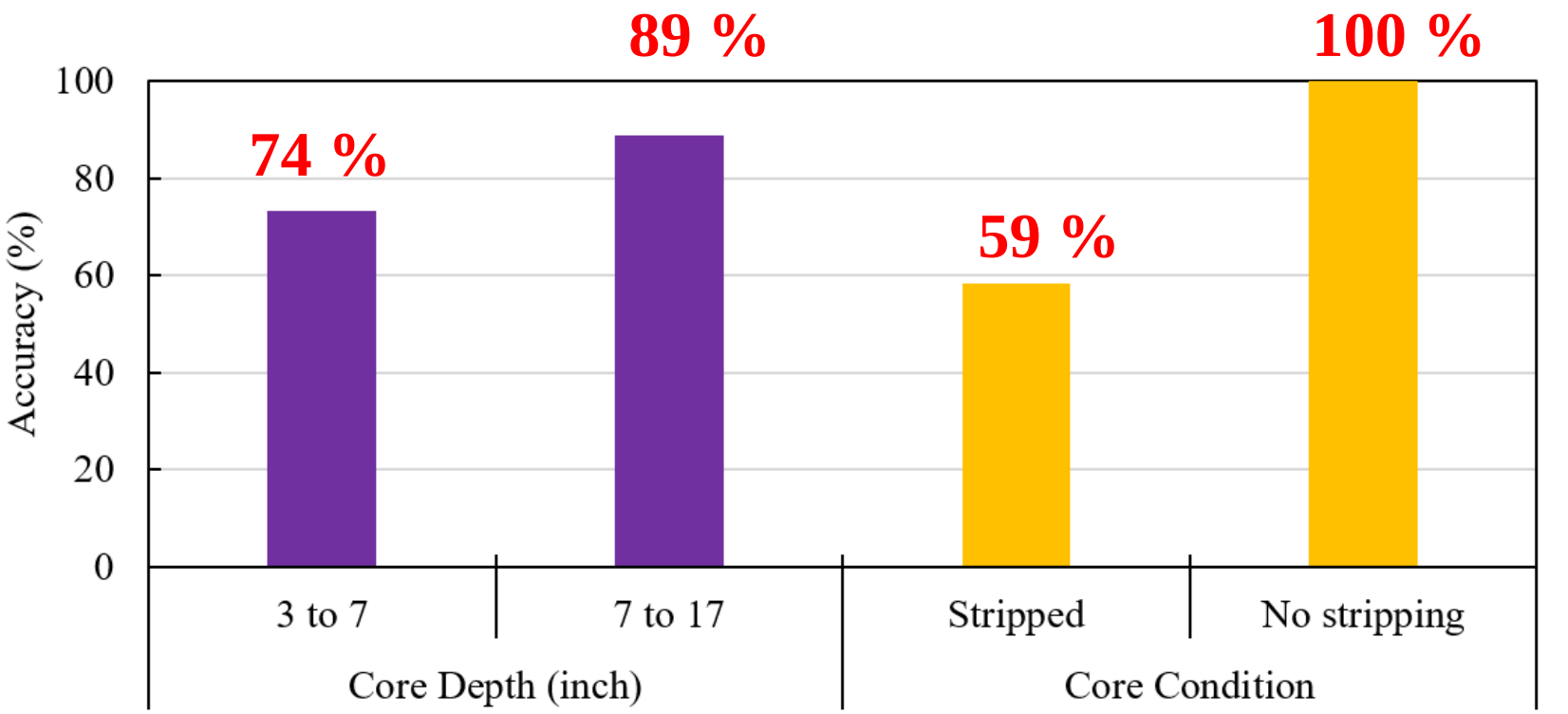
(088-03)



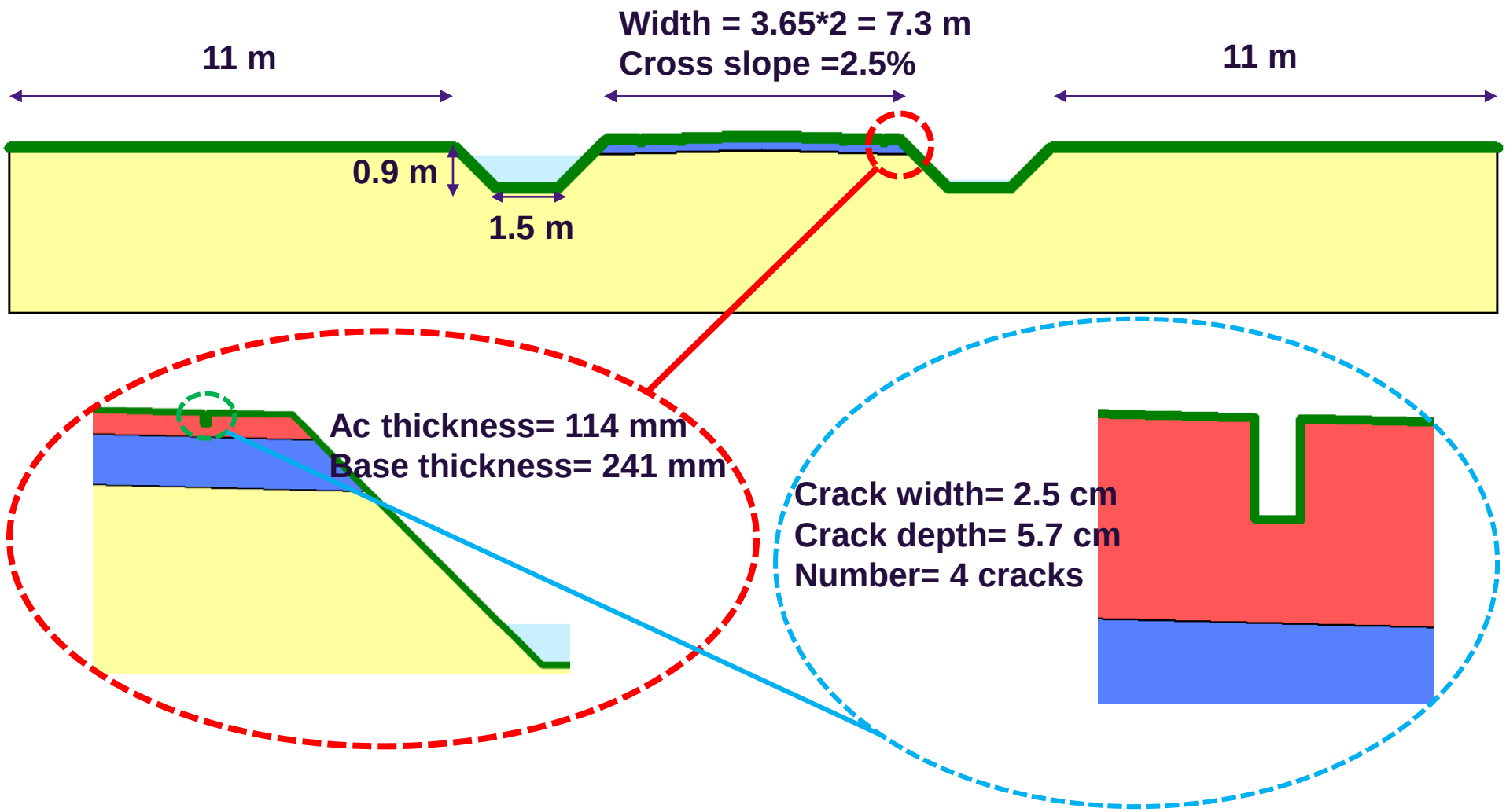
(105-03)



UI Accuracy


89 %
100 %
74 %
59 %
100
80
60
40
20
0
Accuracy (%)
3 to 7
7 to 17
Stripped
No stripping
Core Depth (inch)
Core Condition

4-FE Analysis: Cracked AC Pavement Section



Sensitivity Analysis

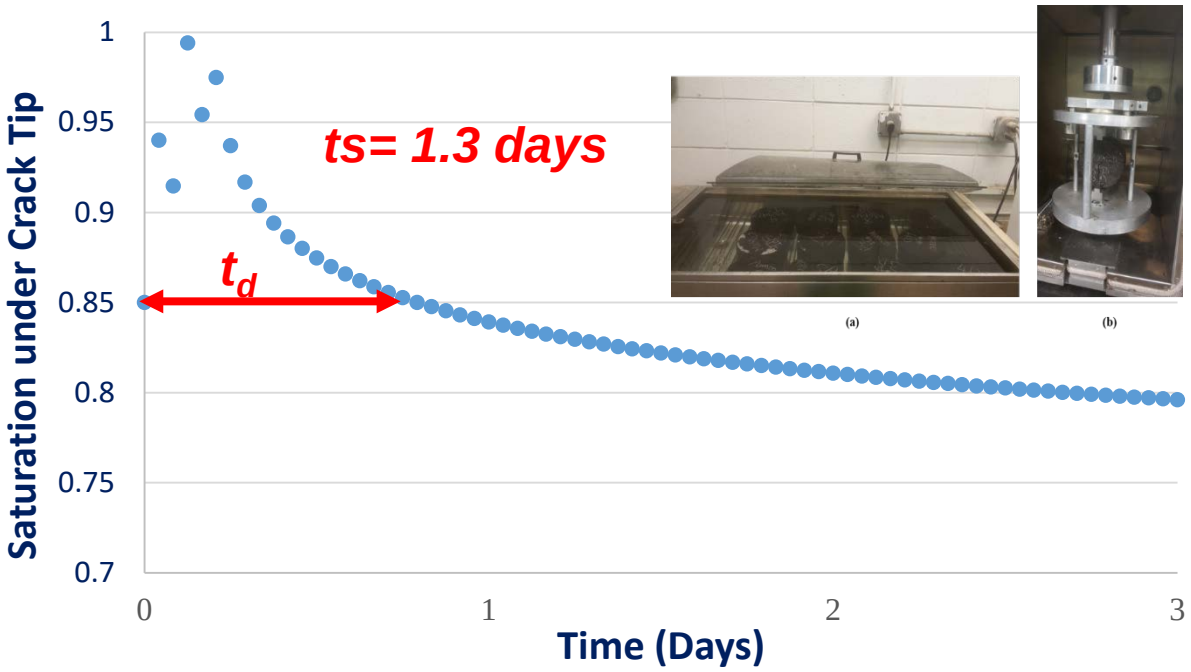
Hourly Transient Analysis (72 hours)

4 Hours Rainfall | ***68 Hours dry period***

➢ Variables

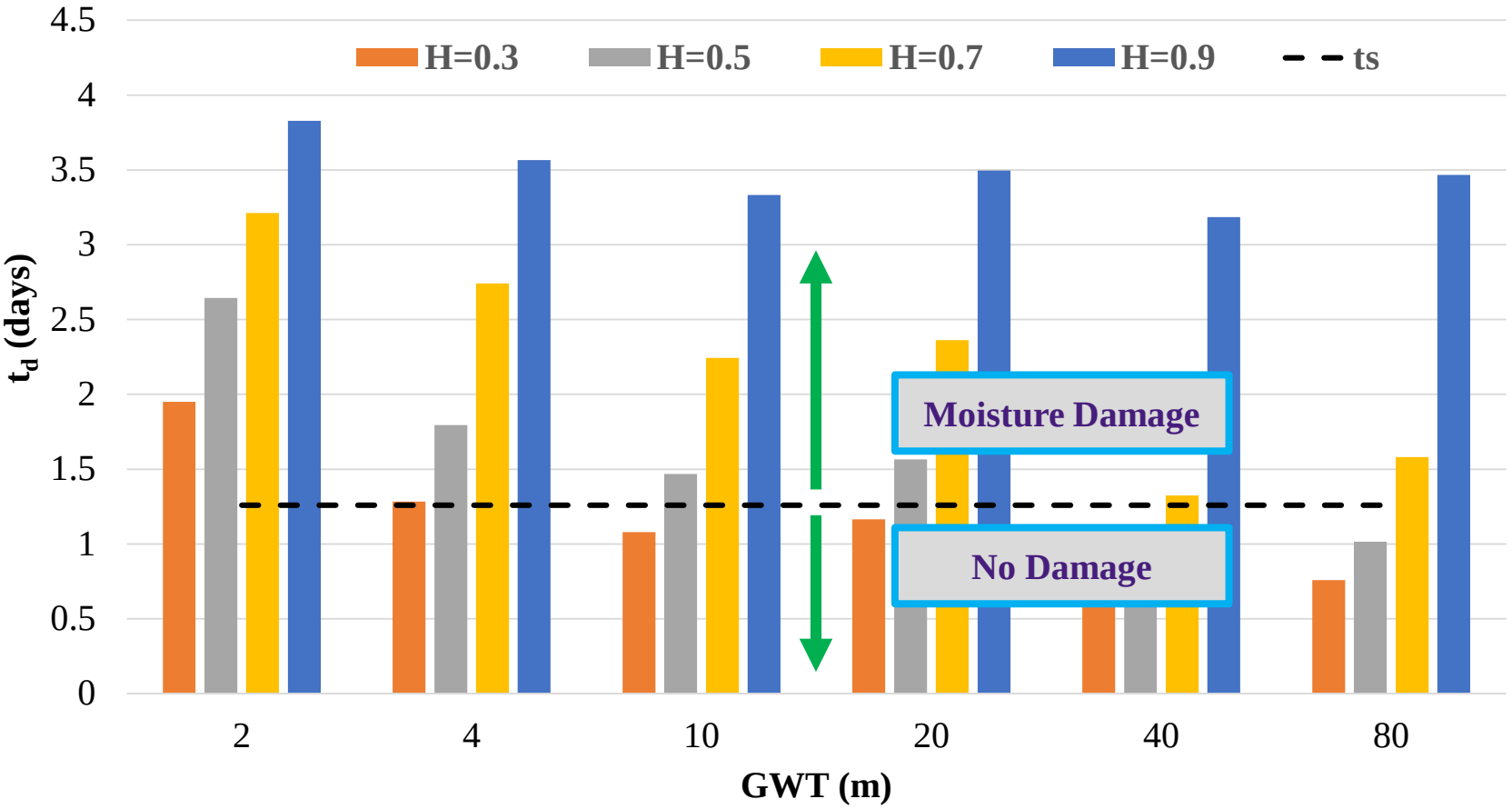
- GWT
- Relative humidity
- Air temperature
- Rain intensity
- Hydraulic conductivity

➢ Output



Results

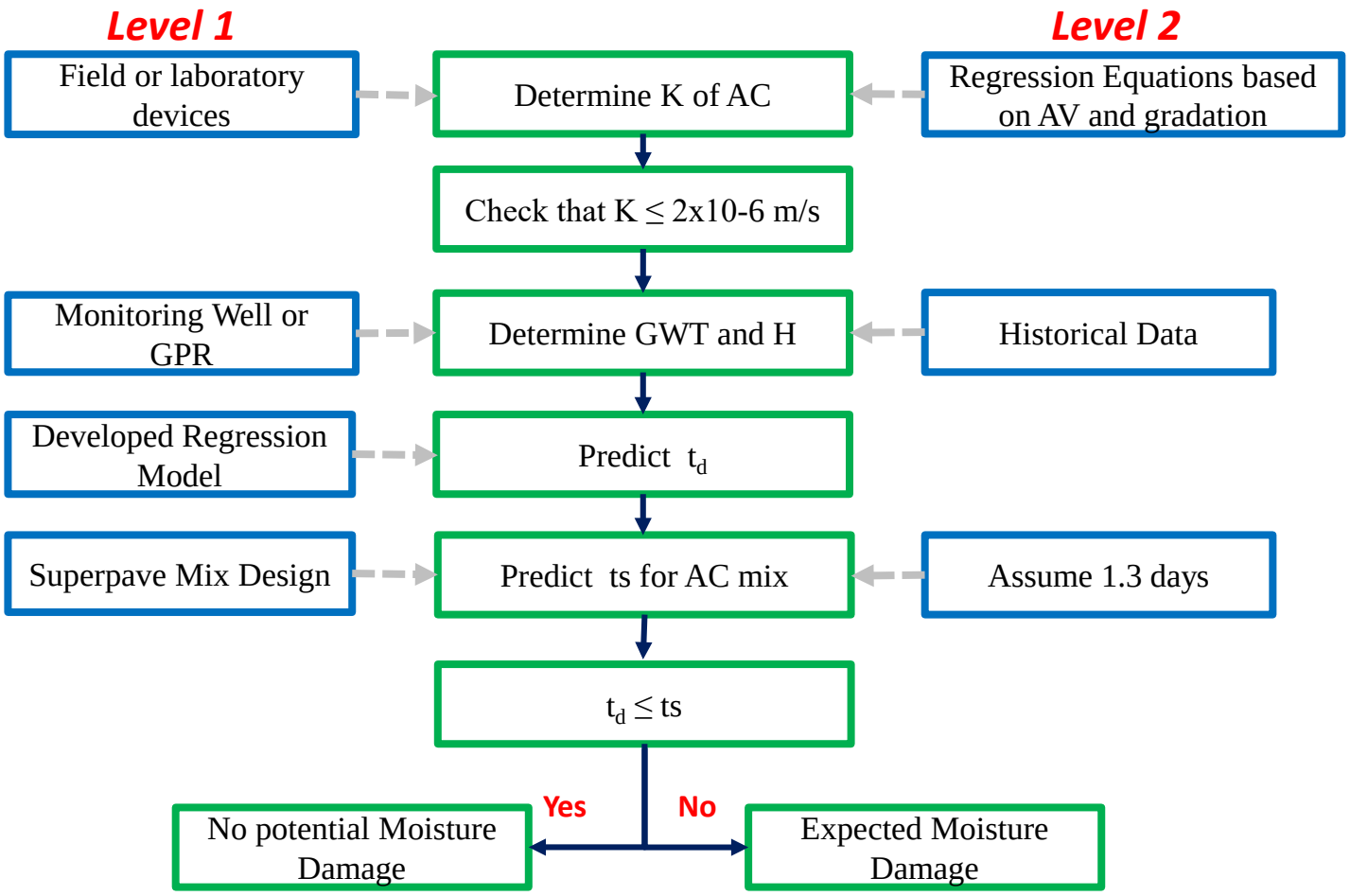
$$K \leq 2x10^{-6}\ m/s$$



$$t_d = 1.7621 - 0.0491\,GWT + 0.00044\,GWT^2 + 3.2473\,RH^3$$

R^2= 84 %

Detection of Moisture Damage using Regression Model



Summary and Conclusions

- Stripping was found to be associated with lower dielectric values of the HMA layers.
- Intermediate large negative peaks between the regular positive peaks in GPR traces indicated moisture damage.
- UI profile:
  - Varied around unity for homogenous sections.
  - Fluctuated greatly for non-homogeneous sections.

Summary and Conclusions

- Regions with relatively low air relative humidity and deep GWT are not expected to experience stripping due to accelerated drainage by evaporation.
- All previous techniques accompanied by core drilling will result in a highly accurate evaluation of moisture damage in AC pavements.

QUESTIONS?

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