Kentucky Concrete Pavement Forensic Analysis

KENTUCKY TRANSPORTATION CABINET

Southeastern States Pavement Management and Design Conference

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Kentucky Transportation Cabinet
Division of Highway Design

Kentucky Interstate System

- Original Construction (1960-1980)

  Concrete = 70%

  Asphalt = 30%

- Current (Rehabilitated 1985-Present)

  Concrete = 7%

  Asphalt = 93%

1960's Era Pavements

- Jointed Plain Concrete Pavement
  - 50-foot joint spacing
- Average Age to Rehabilitation = 25.5 years
- Major Distresses
  - Joint deterioration
  - Mid-panel cracking

1980's Era Pavements

- Jointed Plain Concrete Pavement
  - – 12,13,15,17 random joint spacing
- Average Age to Rehabilitation = 20 years
- Major Distresses
  - – Joint Faulting
  - – Tie-bar and Dowel-bar deterioration

Concrete Pavement Forensic Analysis

2 case studies

By:

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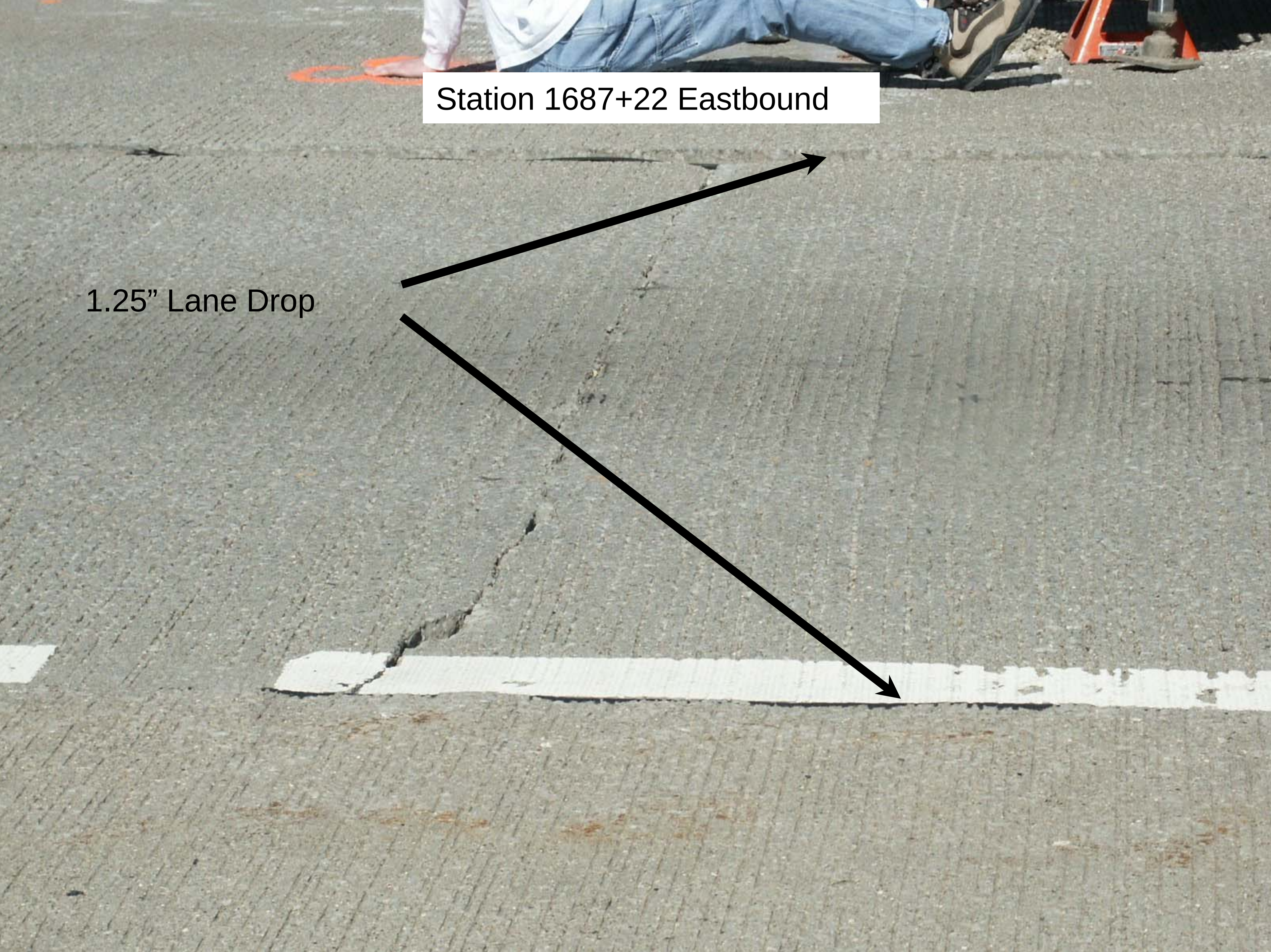
Overview

- Case study #1
  - Using GPR to determine why a concrete pavement (PCCP) has been settling on I-265 in Louisville, Kentucky and how it has changed the project design
- Case study #2
  - Different strategies for collecting concrete pavement distress information for rehabilitation design purposes—Project I-65 Central Kentucky
- Questions

Case Study: #1
Using GPR to identify why a PCCP pavement has been settling

- Project background
  - 3-mile long project on I-265 in Louisville, KY. Mileposts 15 to 18
  - 10 inch concrete pavement that was constructed in 1987
  - Right driving lane has differentially settled approximately 1 to 2 inches from the shoulder and the left driving lanes
  - Urgency for inspection: 2003, one motorcycle fatality had occurred due to the pavement settlement


Station 1687+22 Eastbound
1.25” Lane Drop

What did we use and how did we use it?

Ground Penetrating Radar

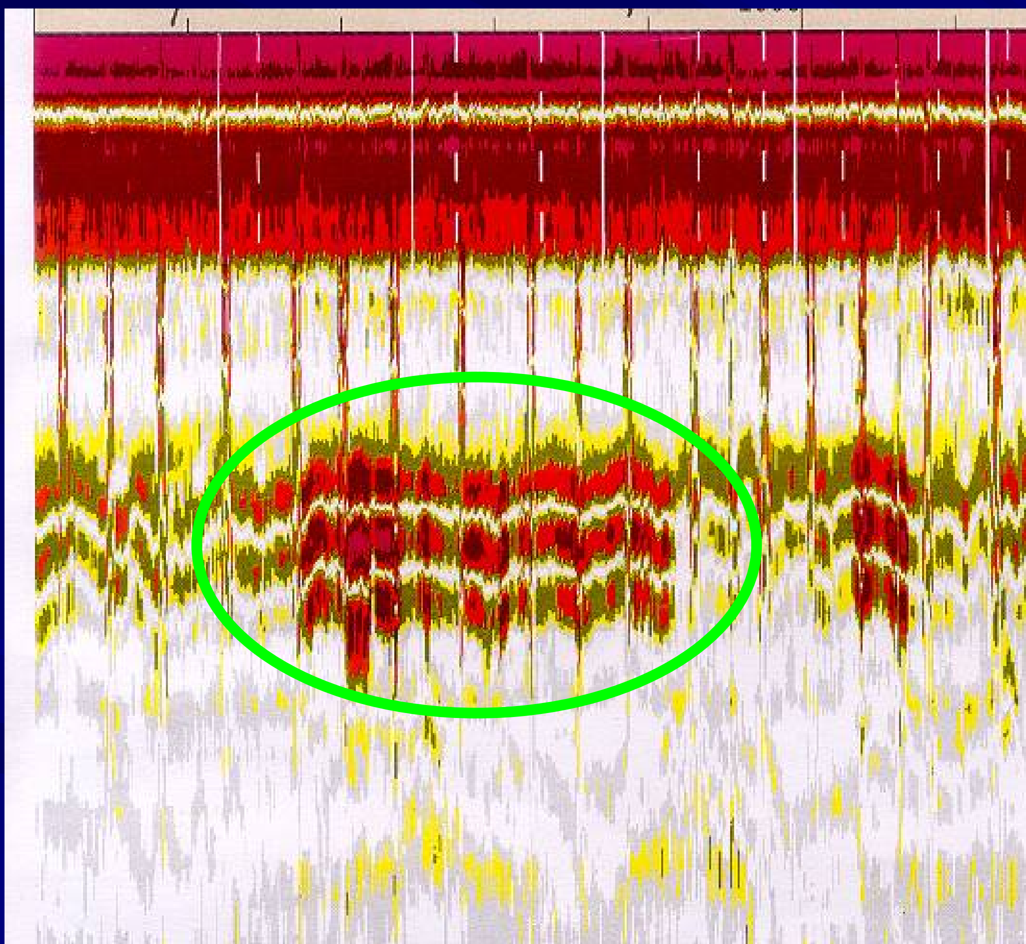
Equipment
900 MHz. antenna
Approx. depth 3 ft.

Data collection location
1 pass per lane
CWP

Data collection density
3 scans per foot

Data collection speed
20 m.p.h. (3 hrs.)

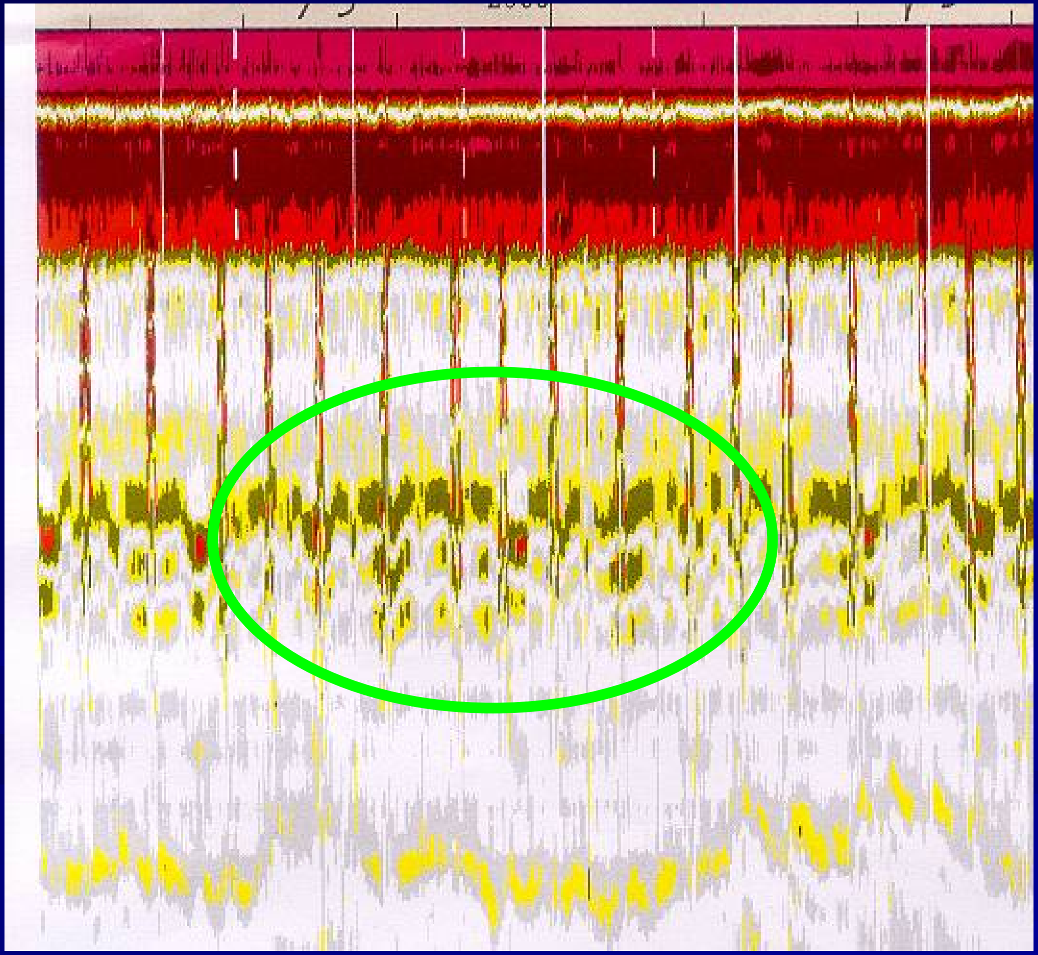
First: used GPR to locate different degrees of saturated sub-base beneath PCCP



Degree of saturation scale

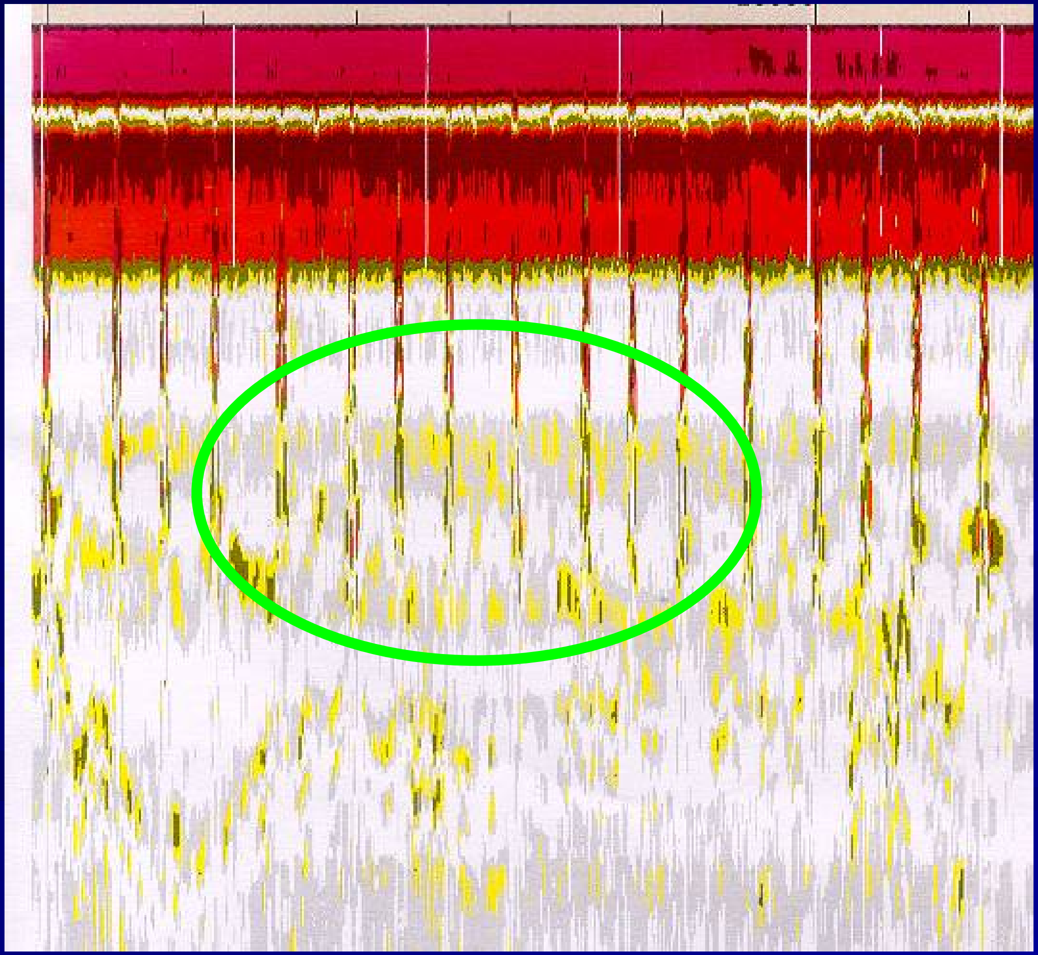
severe
moderate
minimum

Moderate water beneath PCCP



Degree of saturation scale

Minimum water beneath PCCP



Degree of saturation scale

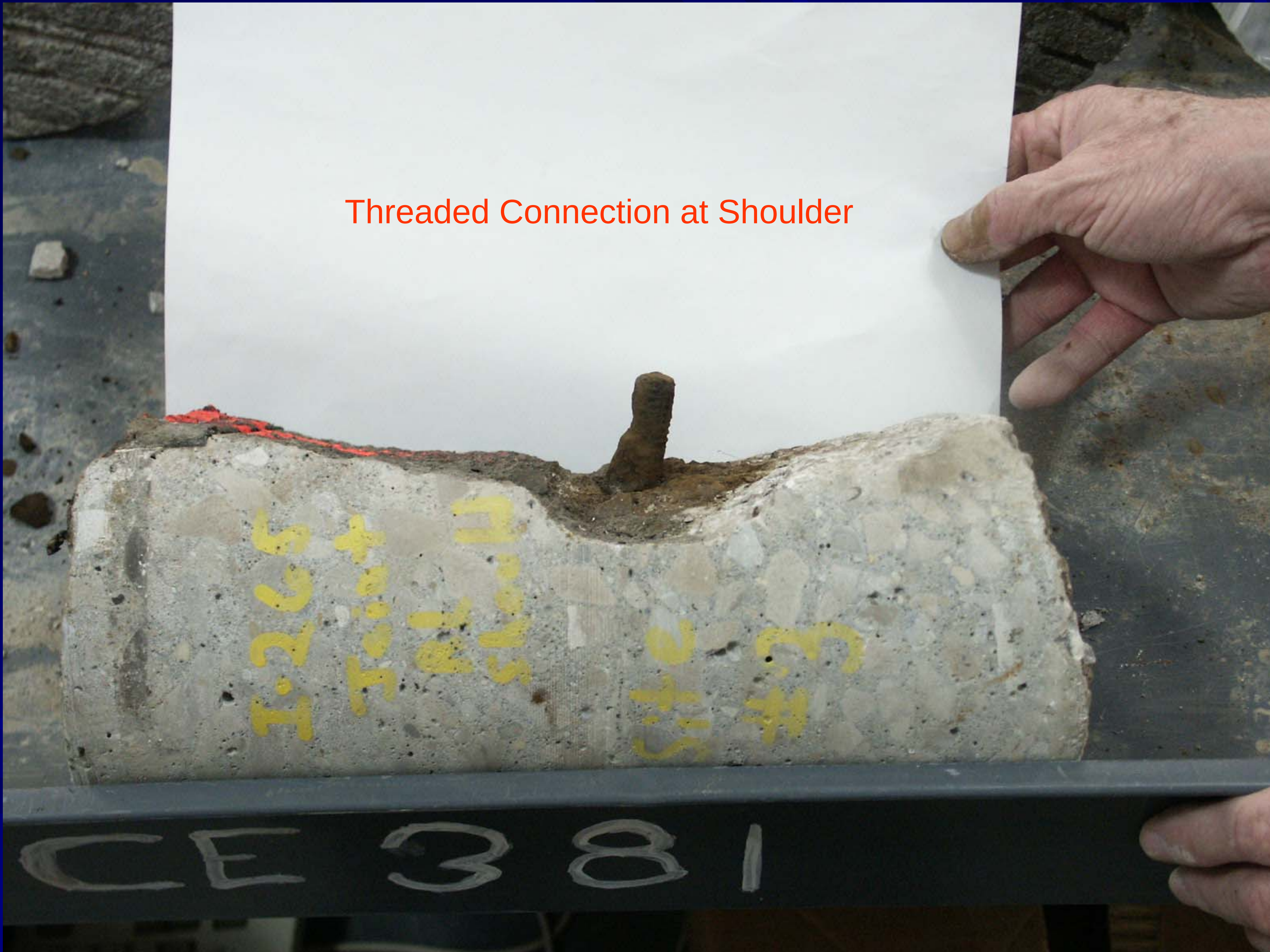
Second: used GPR to locate tie bars between lanes

1.25” Lane Drop


Driving Lane Side
Shoulder Side

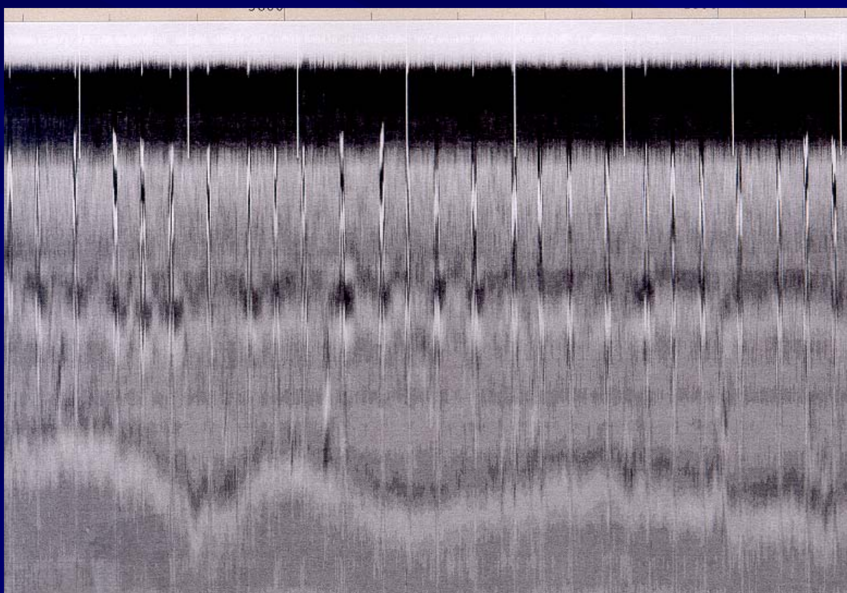
Driving Lane Side

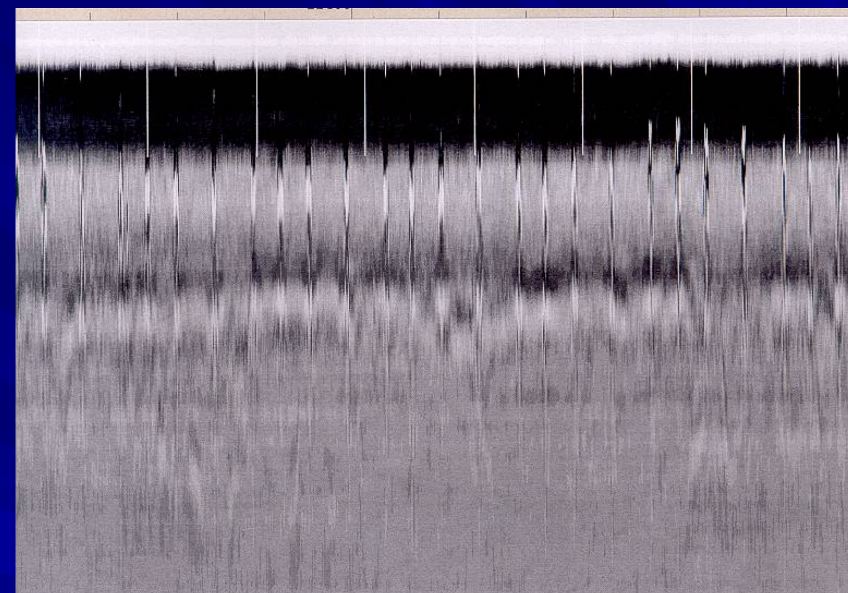
Shoulder Side


Threaded Connection at Shoulder
CE 381

Third: used GPR to locate dowel bars at the transverse joint

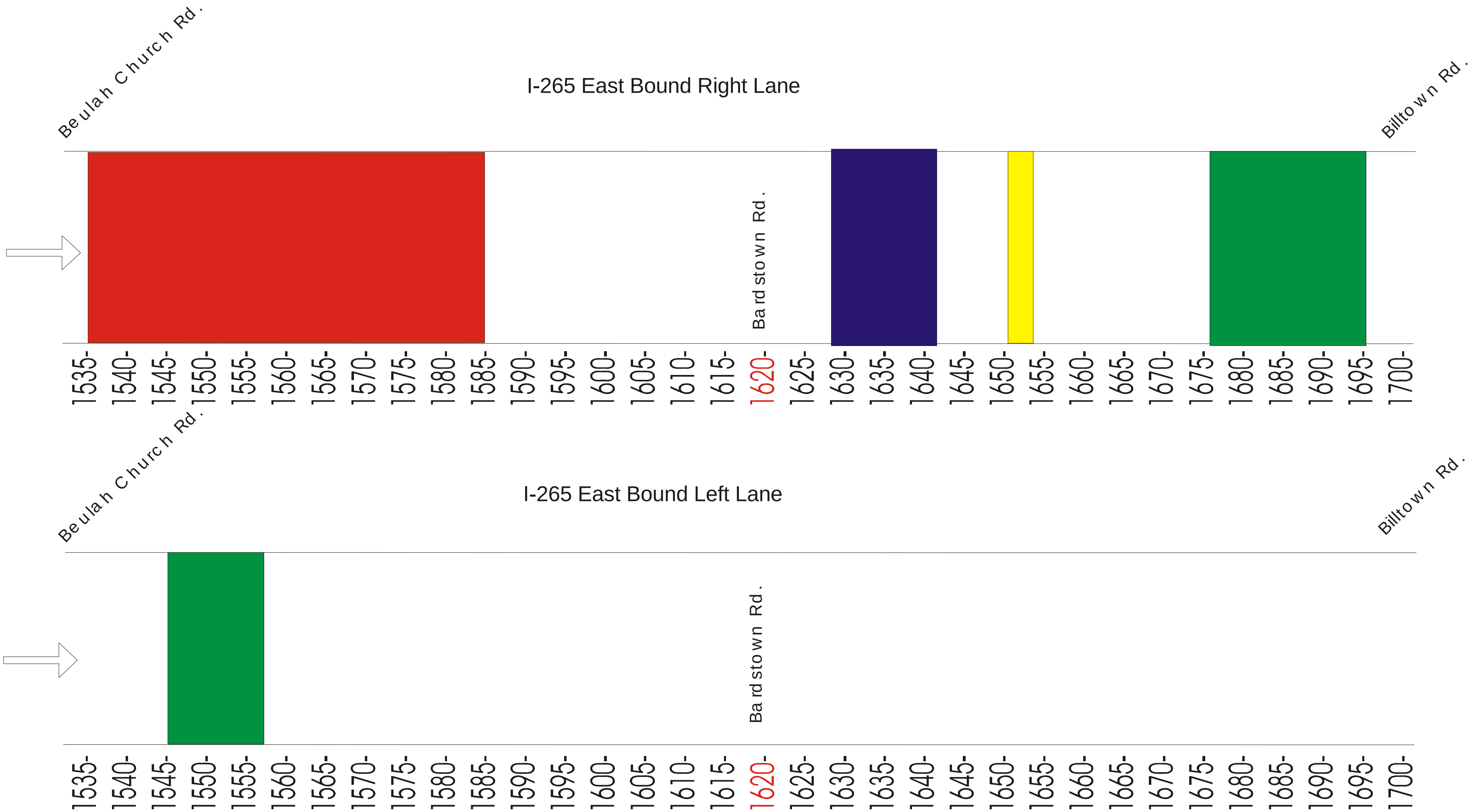
Fourth: GPR was used to find clay layer between D.G.A. and apparent rock roadbed





<u>Core Information</u>
Station 1582+43
Approx. 2” between lane faulting
PCCP: 9.75” - 10.25”
DGA: 5.75” – 6.25”
Clay soil: 8” – 10”

<u>Core Information</u>
Station 1699+73
No between lane faulting
PCCP: 10.00” - 10.25”
DGA: 4.75” – 5.25”
Apparent rock roadbed:



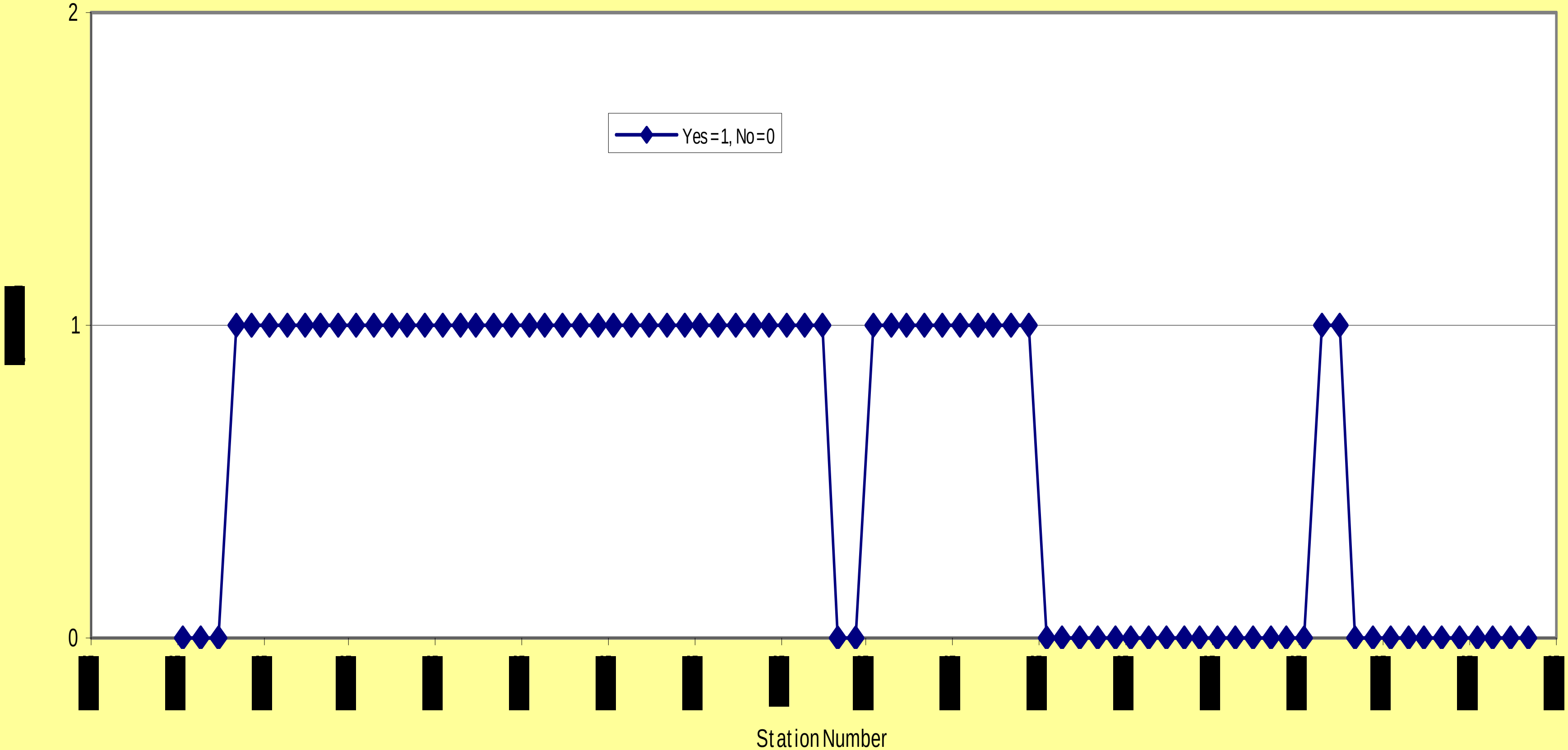
1” or more settlement, less than 50% load transfer, & moderate to severe water

1” settlement and severe water

1” settlement (possible slab jacking)

Less than 50% load transfer, some settlement and/or water

Presence of Clay layer (yes/no)

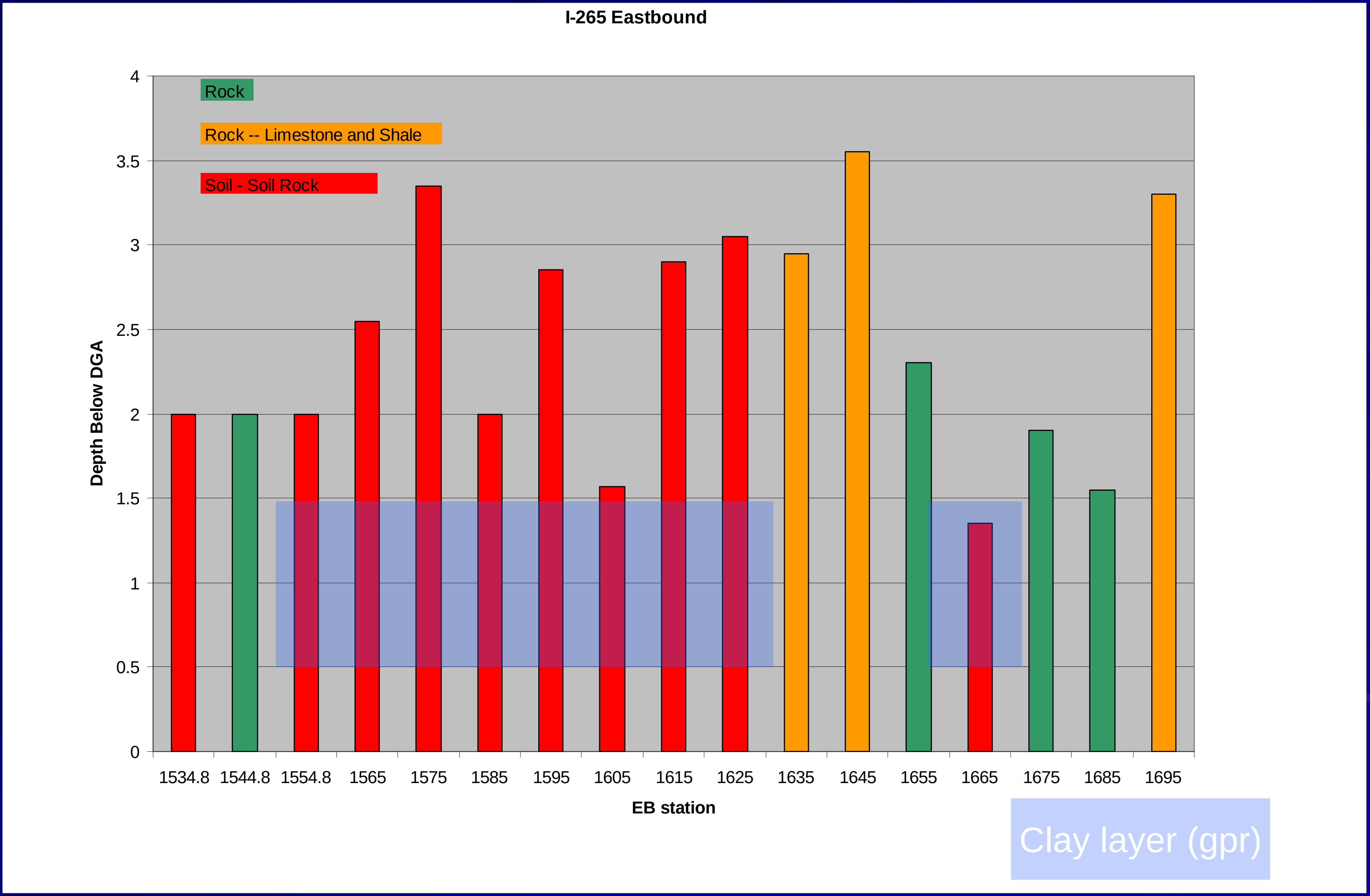


KYDOT compared information provided by GPR to initial design proposals

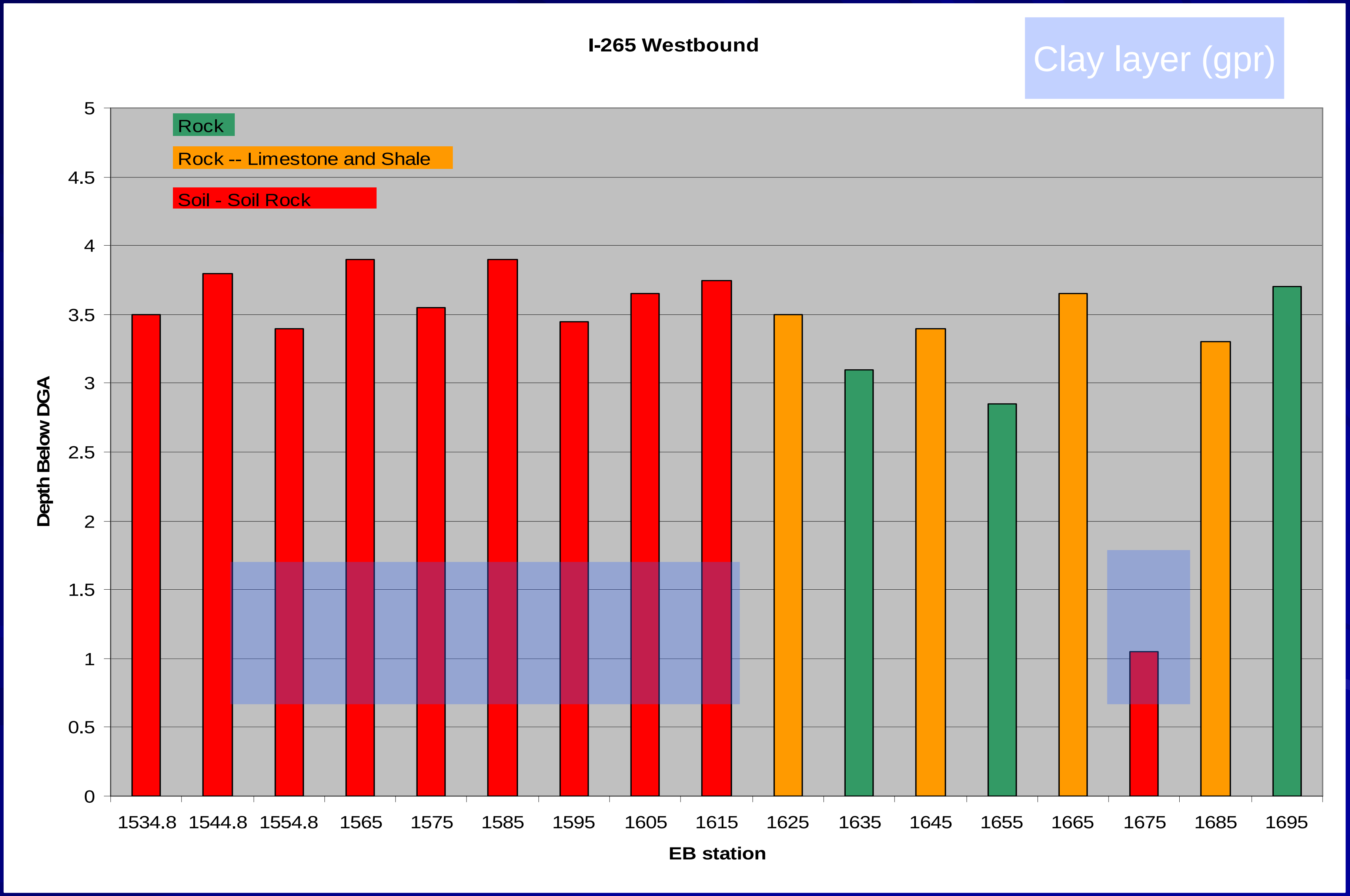
Originally design firm proposed 7 different pavement rehabilitation designs

- $6,710,373 remove right driving lane slab/replace, rework D.G.A. shoulders
- $6,055,364 remove right driving lane slab/replace, rework D.G.A. shoulders
- $8,260,344 remove right driving lane slab/replace, weekend work, rework D.G.A. shoulders
- $13,196,072 remove all slabs/replace, install edge-drains, rework D.G.A. shoulders
- $10,959,017 1” bond breaker—9” PCC overlay, rework D.G.A. shoulders
- $8,258,970 break and seat existing pavement—10” asphalt overlay, rework D.G.A. shoulders
- $17,476,275 remove all slabs/replace, install edge-drains, concrete shoulders

Additional GeoTech. work eastbound (boring log)



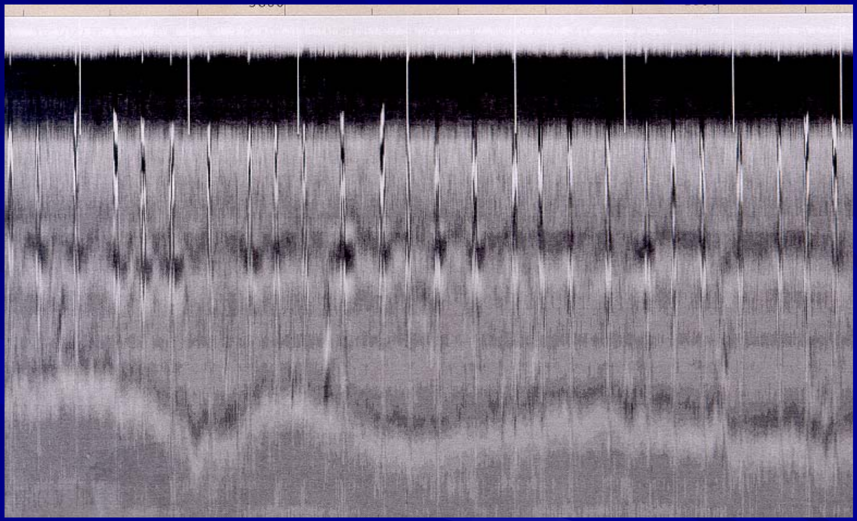
Additional GeoTech. work westbound (boring log)



A new pavement design was created

- Break and remove existing concrete pavement, excavate sub-grade (clay layer), replace with number 2 size stone, place new concrete pavement, and install edge-drains
- Project currently under construction approx. $14 million

I-265 pavement structure after excavation



Why the pavement has settled

- Provided that traffic predominately travels in the right driving lane, over time the saturated clay beneath the DGA layer has compressed thus allowing for differential settlement of the right driving lane

Case Study: #2

Different strategies for collecting concrete pavement distress information for rehabilitation design purposes

Project: I-65 Central Kentucky

Case Study: #2

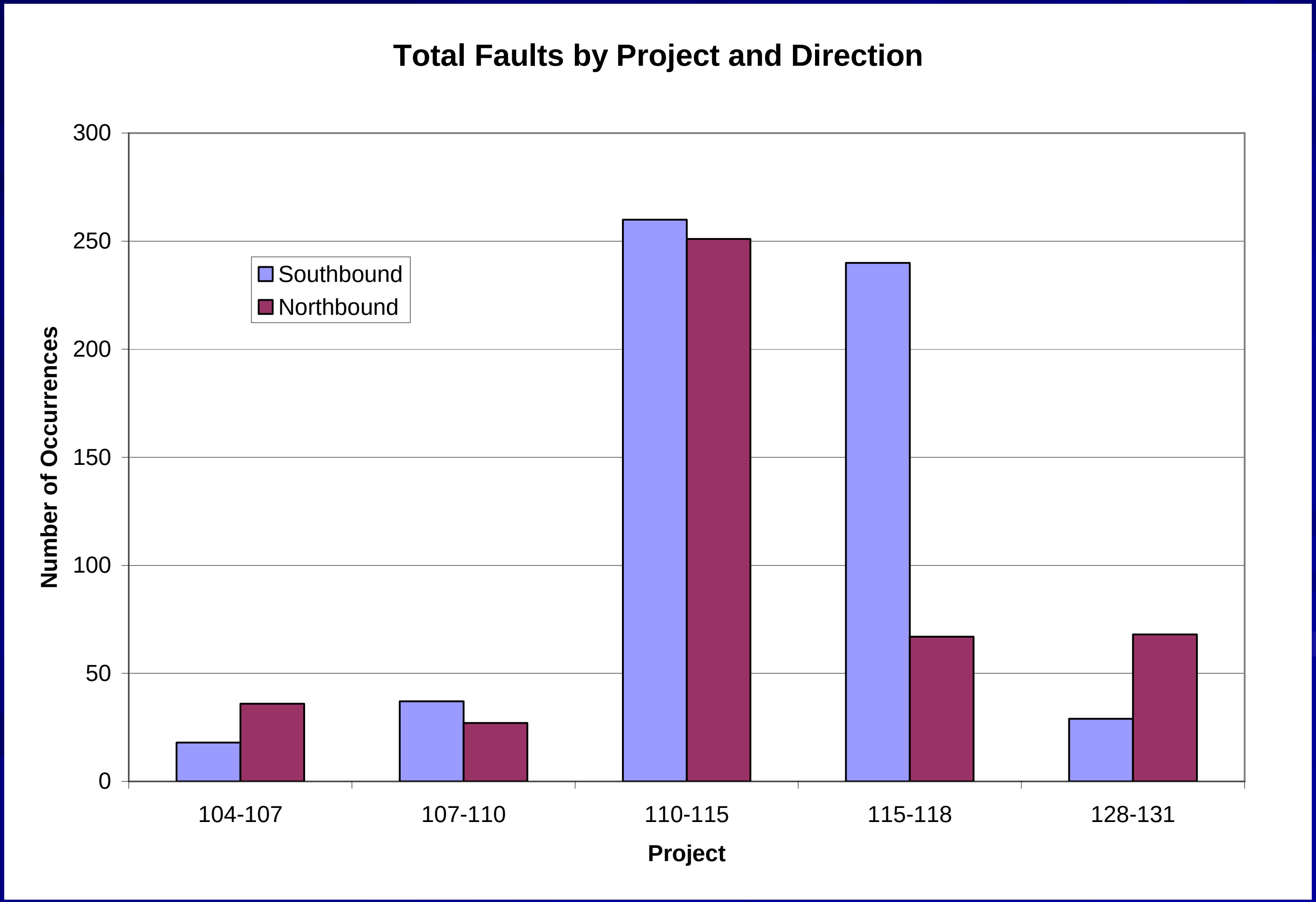
- Project background
  - 27-mile long project on I-65 in central, KY.
  - 10 inch concrete pavement constructed in 1987
  - Right driving lane has differentially settled approximately 1 to 2 inches from the shoulder and the left driving lanes in various areas
  - Approach slabs have settled on three different bridges

Pavement Evaluation

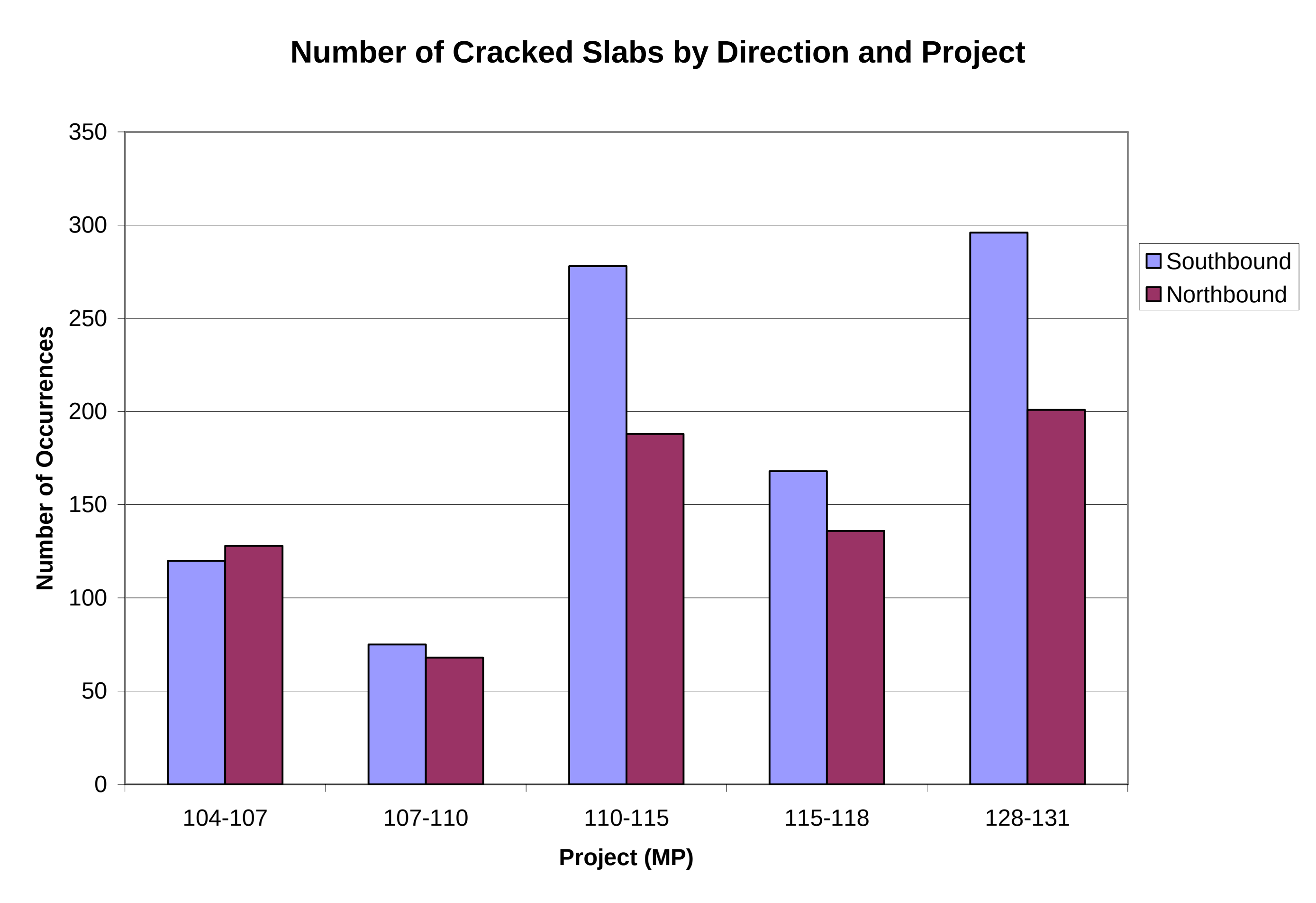
- Visual survey of cracking, settlement, and faulting
- FWD and CBR Analysis
- Assessment of tie assembly
- Degree of Moisture beneath the concrete slab
- Thickness of slab
- Subgrade thickness

Visual survey of faulting, cracking, and settlement

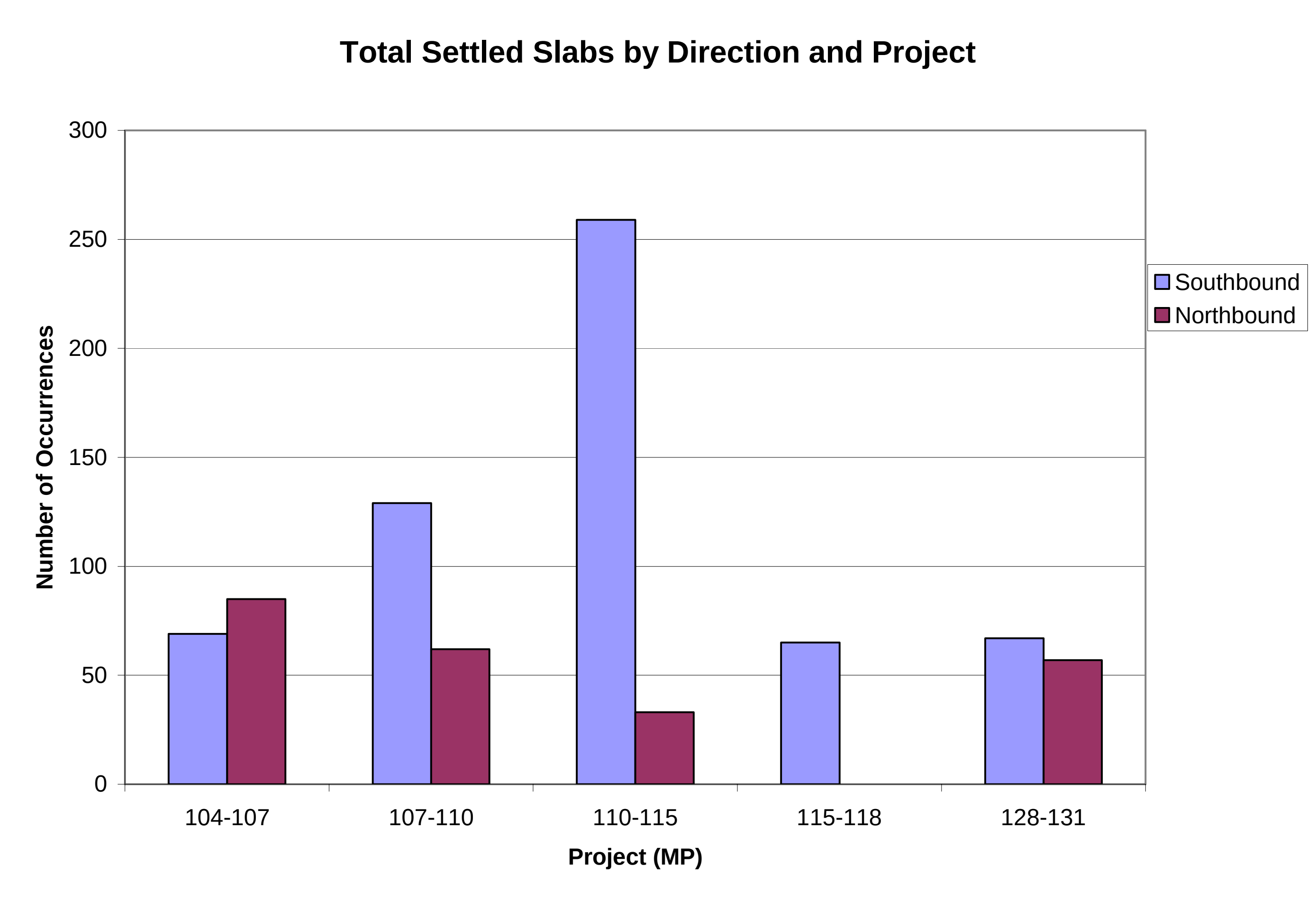
Number of Faulted Slabs per Project



Number of Cracked Slabs per Project



Number of Settled Slabs per Project

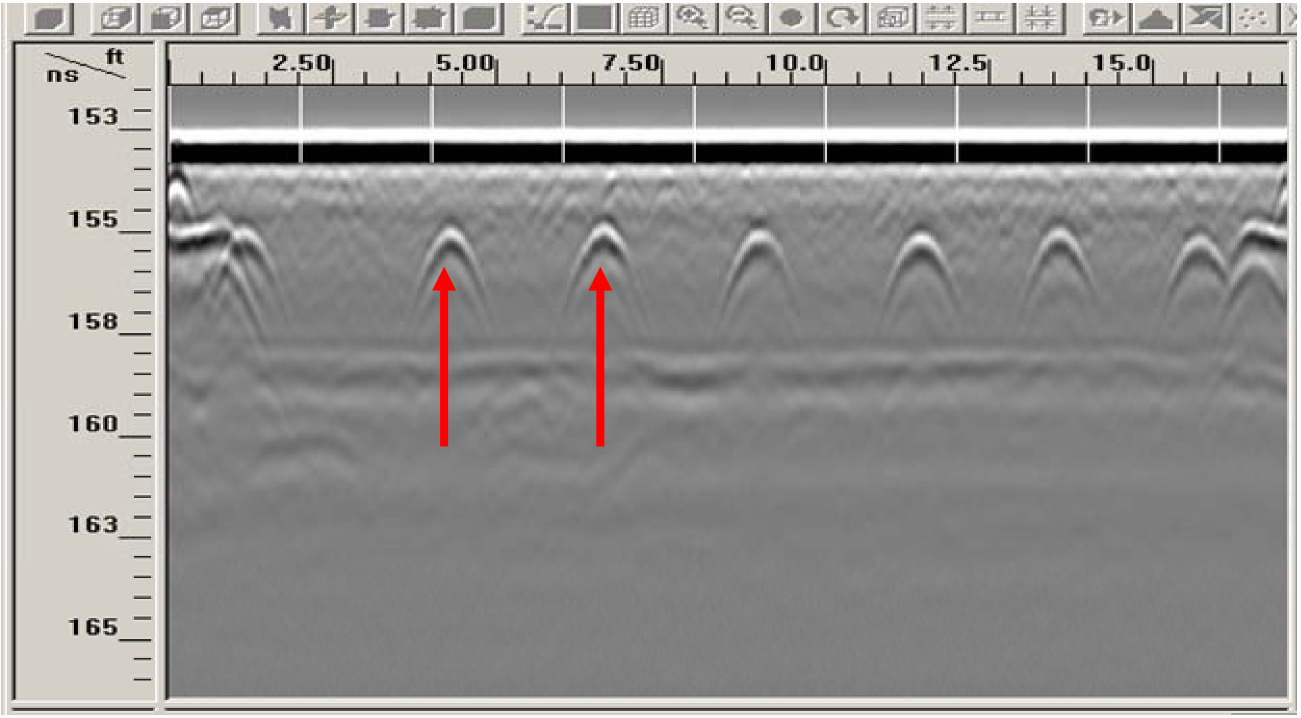


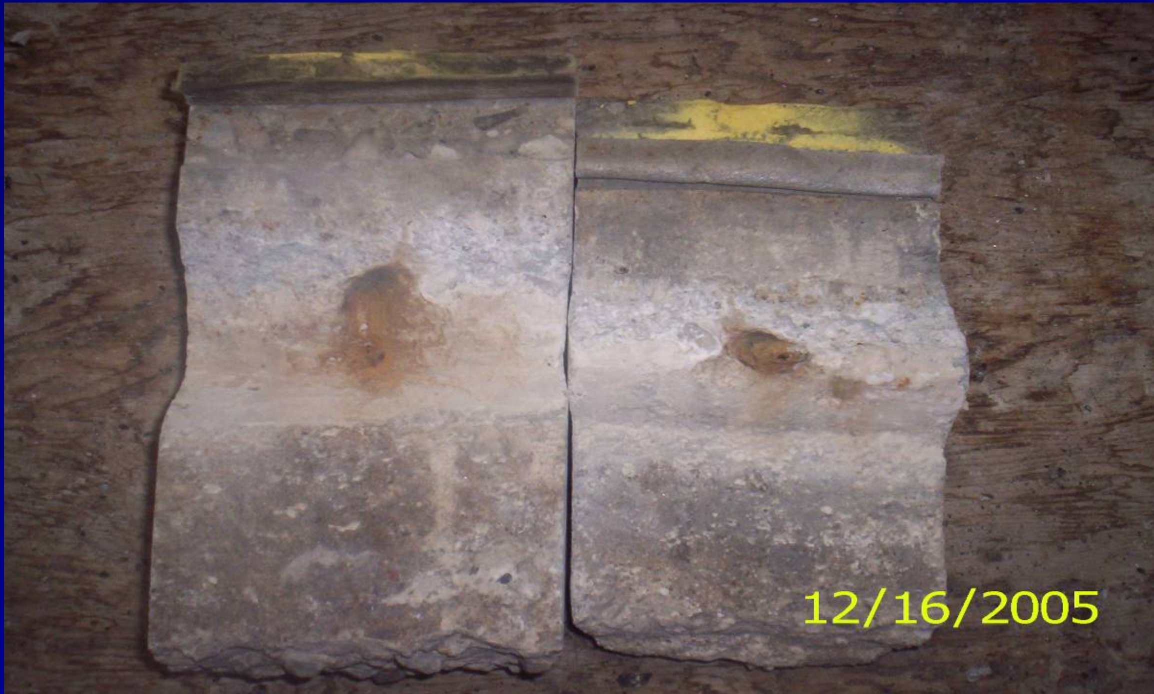
FWD and CBR Analysis

Station #	Load Transfer		Subgrade CBR	
	Inside Lane	Middle Lane	Inside Lane	Middle Lane
567+05	0.86	0.91	5.2	2.2
583+30	0.93	0.91	2.8	2.0
670+30	0.83	0.70	1.6	4.2

Assessment of tie assembly

Tie bar spacing between shoulder and right driving lane (30”): Northbound station 765+00

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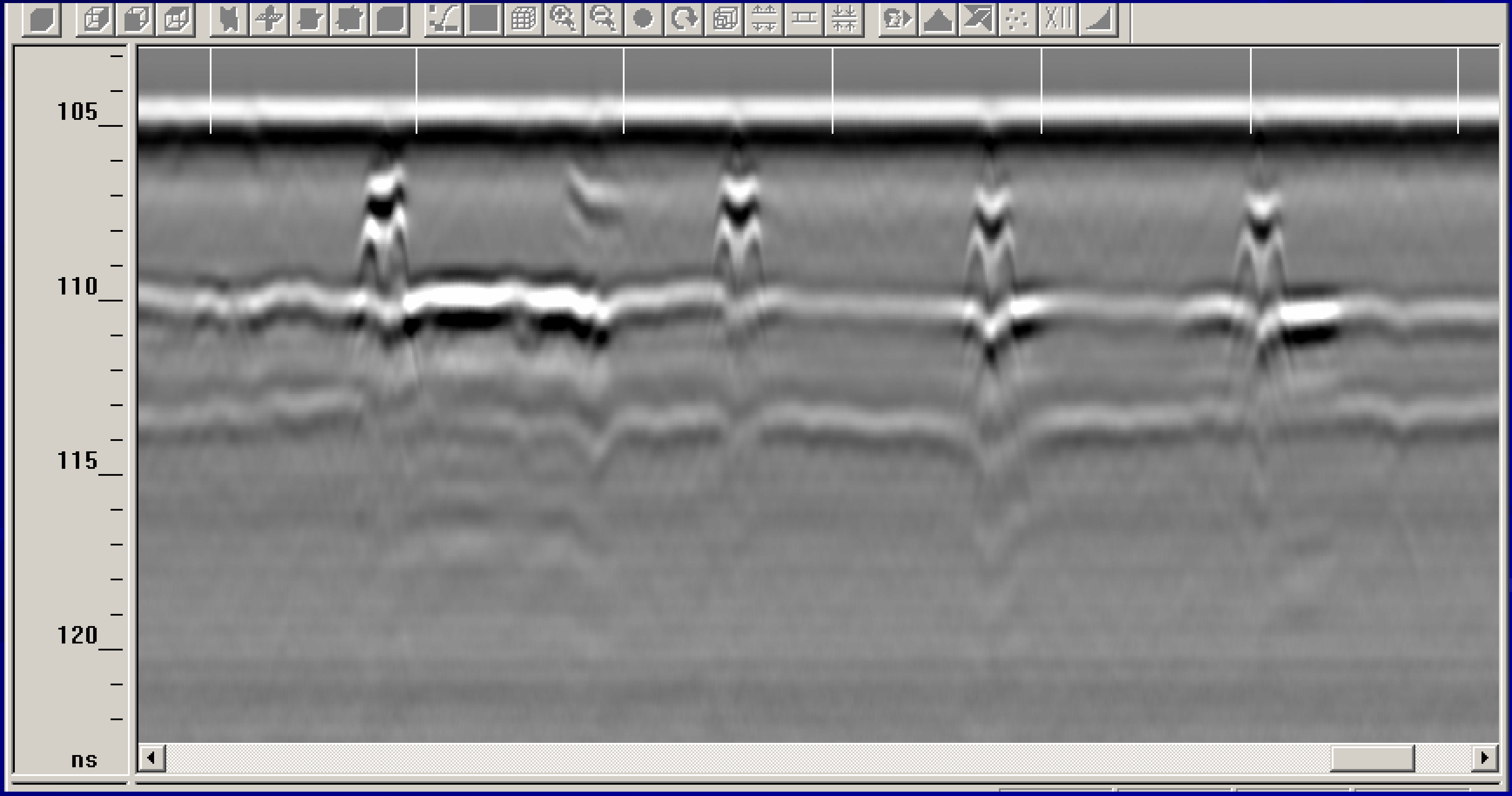
Longitudinal Tie Assembly
Keyed Joint

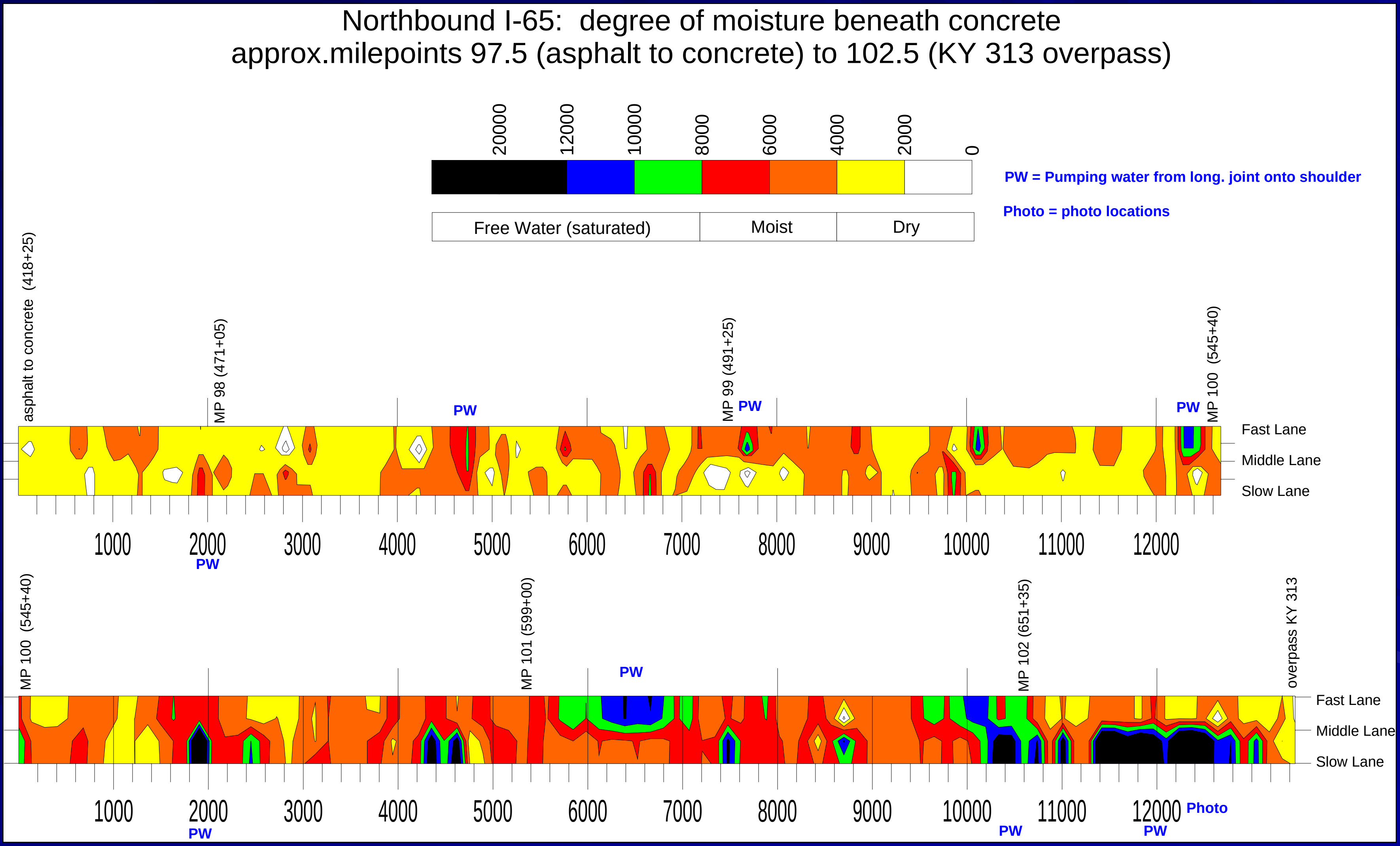
Degree of Moisture beneath the concrete slab

Water bleeding out of shoulder joint in patched area

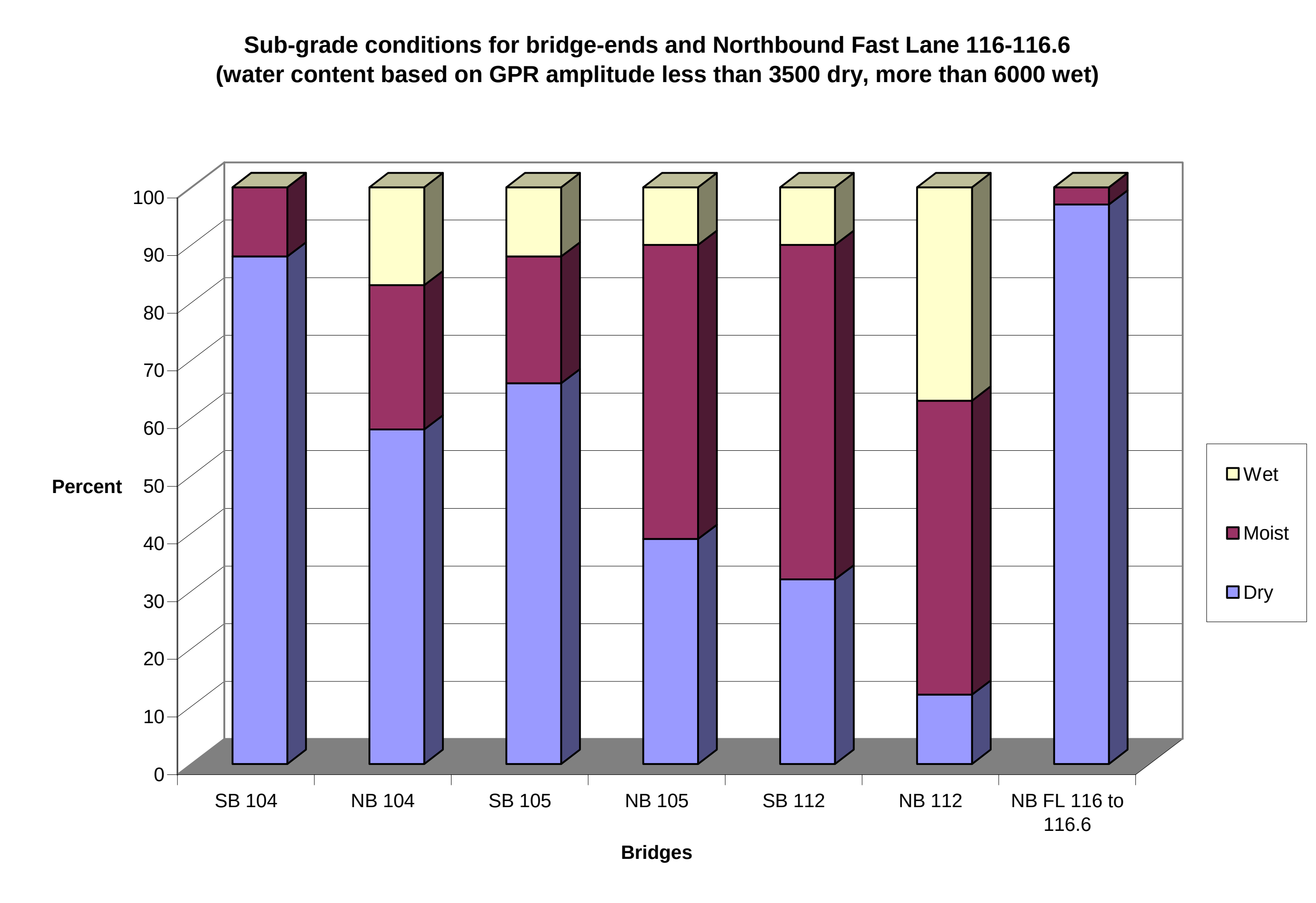
GPR data showing wet and dry sub-grade conditions beneath the concrete layer



Northbound: degree of moisture beneath concrete



Sub-grade moisture conditions for bridge-ends

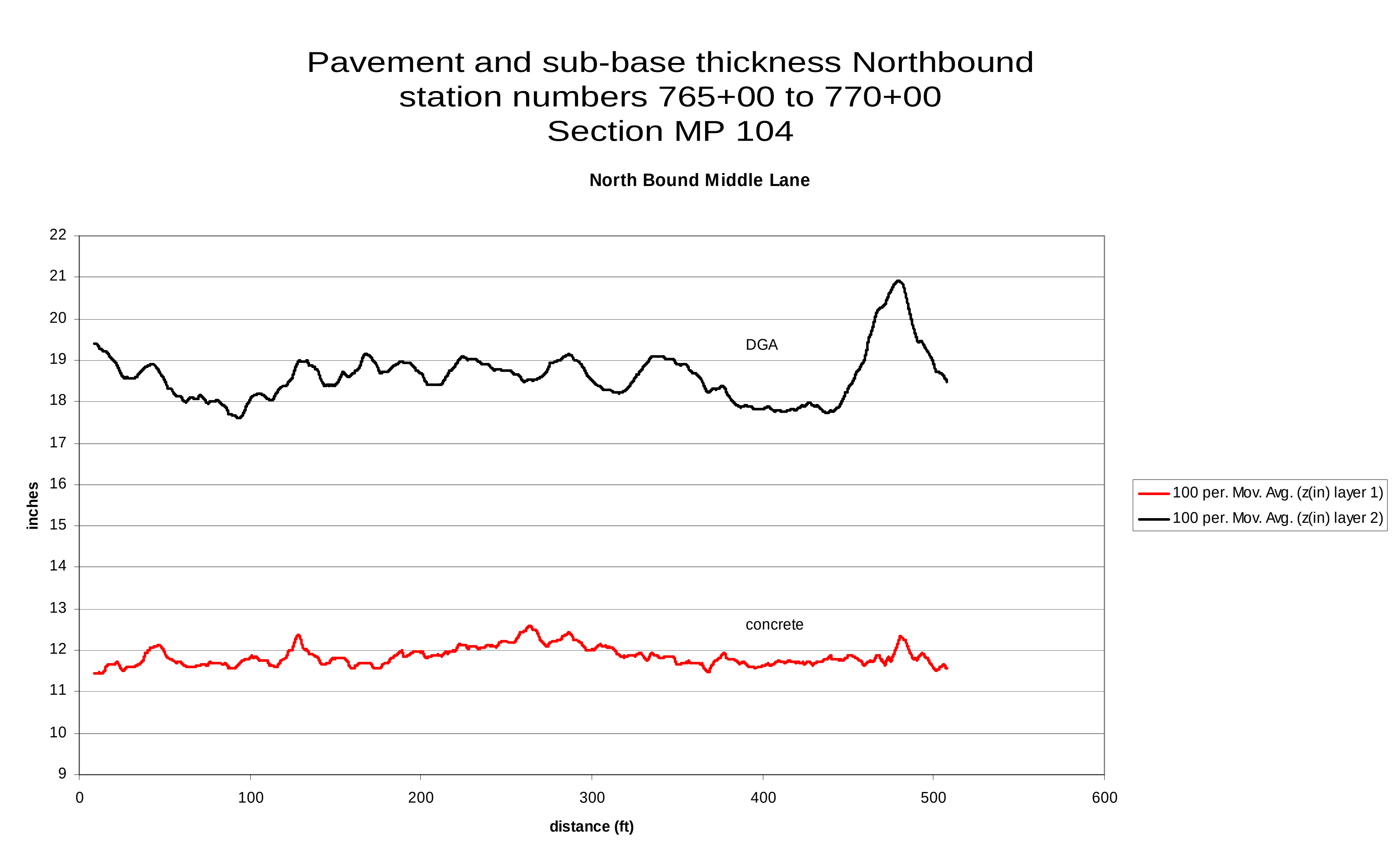


Pavement Conditions for bridge-ends

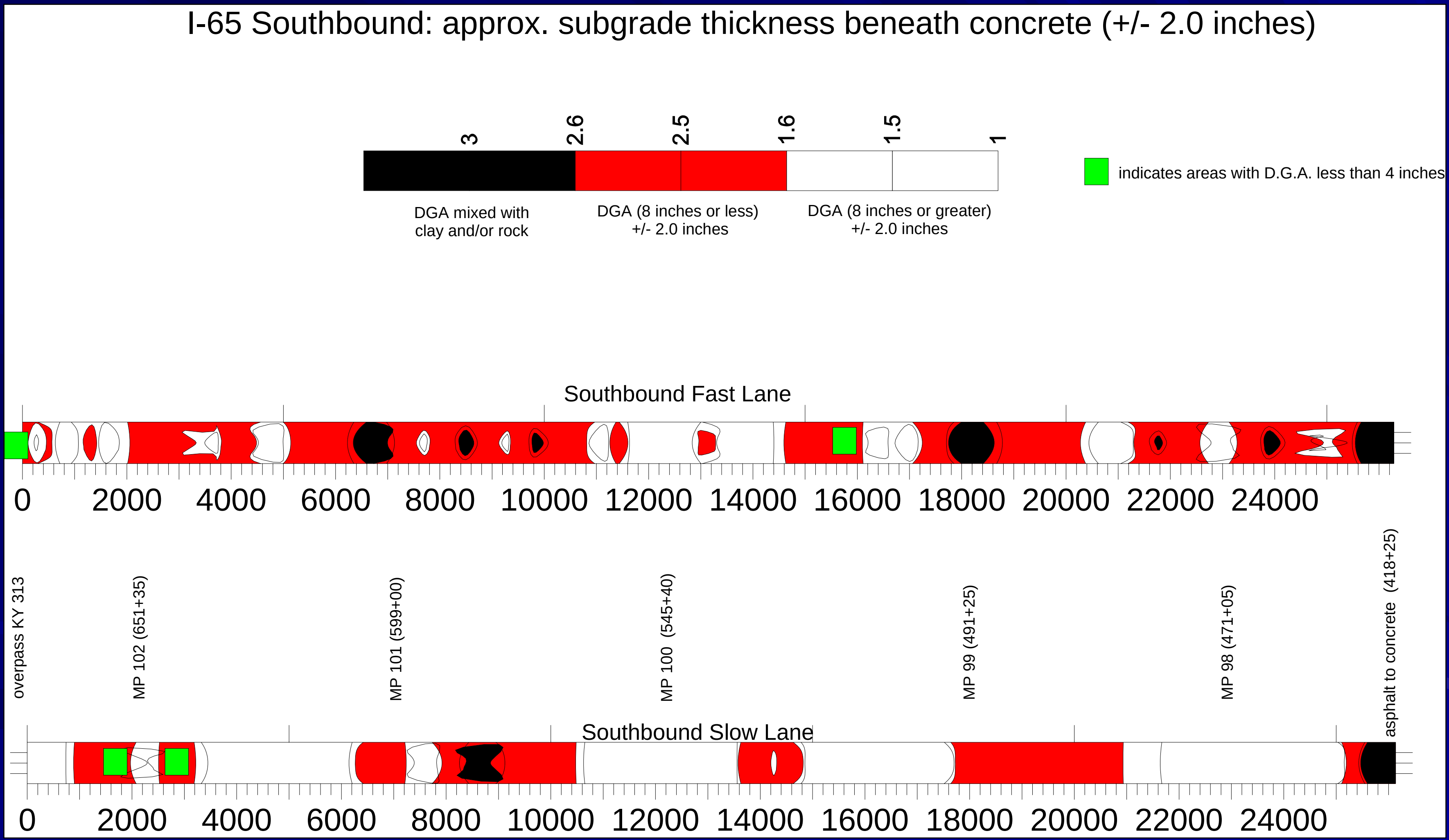
Asphalt overlay

Foam jacking

Thickness of slab & sub-grade using GPR



Sub-grade thickness and material type using GPR



Future Plans

To use some of the distress collection stragies discussed above to compare Kentucky’s concrete pavements built in the 60’s, that have an average age to rehabilitation of 26 years, to that of concrete pavements built in the 80’s that have an average age to rehabilitation of 20 years

Conclusion

- Case Study # 1:
  - GPR prompted a more thorough geotechnical investigation on I-265 that ultimately lead to a more appropriate pavement design to fix the underlying problem causing the concrete pavement to settle

- Case study # 2:
  - Different stragies of collecting and reporting concrete pavement distress information for rehabilation design purposes

Questions?

Thank You

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