

# Northeastern States Materials Engineer's Association

## Re-visiting Traffic Speed Deflectometry in Connecticut

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# Acknowledgements

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Connecticut Transportation Institute  
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Connecticut Dept. of Transportation



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# Agenda

- Historical Experience
- The Device
- Data Review
- Project-Level Analysis
- Network-Level Analysis
- Looking Forward



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# Historical Experience: Rolling Weight Deflectometer

- September 2007
- 212 Lane Miles
- 26 Roadways
- Mean deflection values ranged from 5 to 13 mils
- ARA Analysis:
  - 15.4% Very Good
  - 61.5% Good
  - 23.1% Fair



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<https://www.fhwa.dot.gov/pavement/management/rwd/images/index02.jpg>

# The Device: Traffic Speed Deflectometer

- Surveyed over 1,300+ miles in 2018
  - 640 Miles Composite
  - 715 Miles Flexible
  - 16.6 Miles Concrete
- Recently completed 1,000+ mile survey this year

*IRI, Cracking, Rutting, Continuous Deflection, Geometry, Texture, GPS, Imaging*



<http://arrbgroup.net/services/pavement-structural-assessment/#lightbox/0/>



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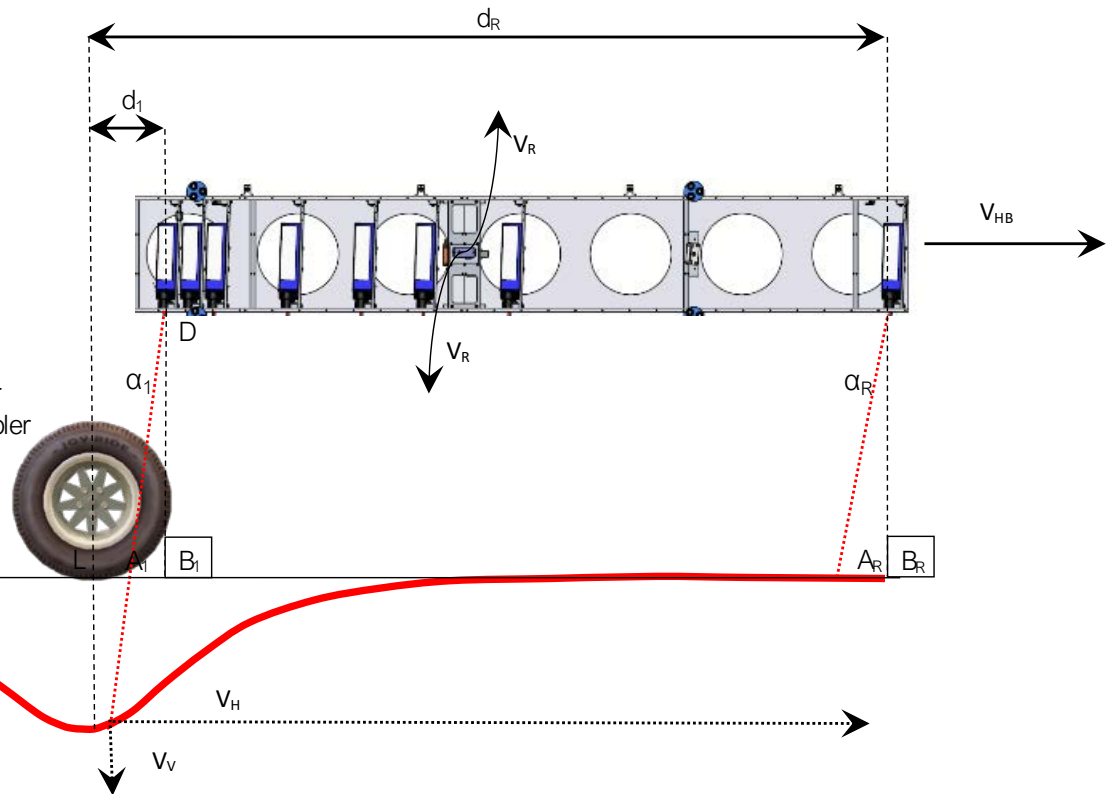
# Dynamic Deflection Measurement

## Geometric Constants

- L = centre of load (known fixed)
- D = the doppler (known fixed)
- $D_1$  = distance from load to Doppler (known fixed)
- $D_R$  = distance from load to Reference Doppler (known fixed)
- $\alpha_1$  = the angle of the measurement Doppler (calibrated fixed)
- $\alpha_R$  = the angle of reference Doppler (calibrated fixed)
- $A_1$  = doppler measurement location (calculated)
- $A_R$  = doppler measurement location (reference calculated)
- $B_1$  = vertical projection of the measurement (calculated)
- $B_R$  = vertical projection of the reference measurement (calculated)

## Dynamic Measurement Variables

- $V_{\text{raw}}$  = Vertical velocity of pavement surface – raw measure by Doppler
- $V_{\text{Hraw}}$  = Horizontal velocity of pavement surface – raw measure by Doppler
- $V_{\text{HB}}$  = Horizontal velocity of beam – measured by DMI
- $V_r$  = Velocity of beam rotation – measured by gyroscope



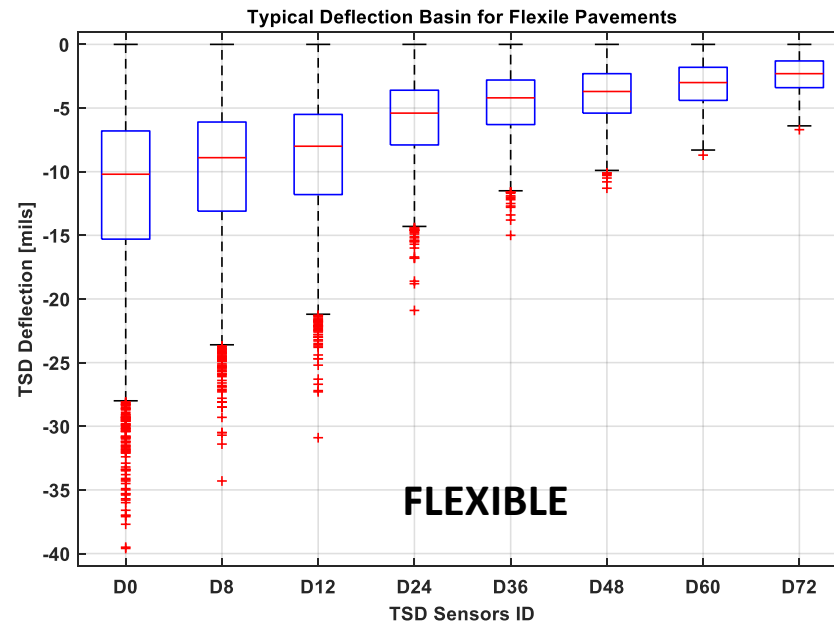
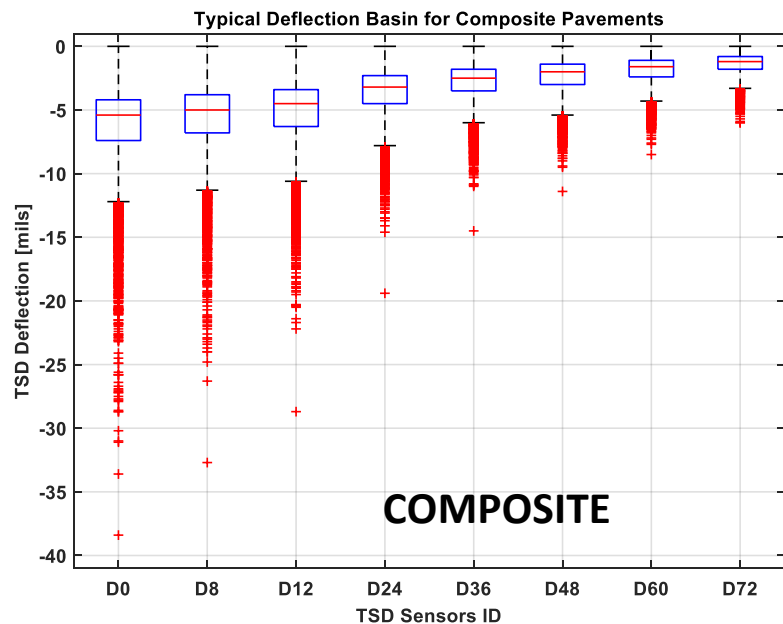
\*not to scale

## Result for each laser sensor location

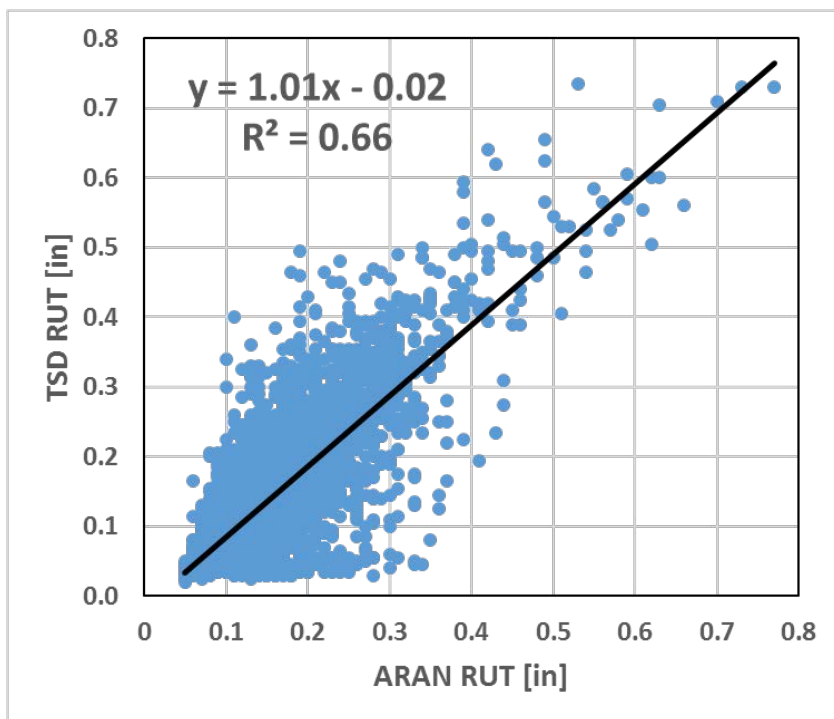
- Vertical velocity of pavement surface =  $V_V$
- Horizontal velocity of pavement surface =  $V_H$
- Deflection Slope =  $V_V/V_H$

# Data Review: Traffic Speed Deflectometer

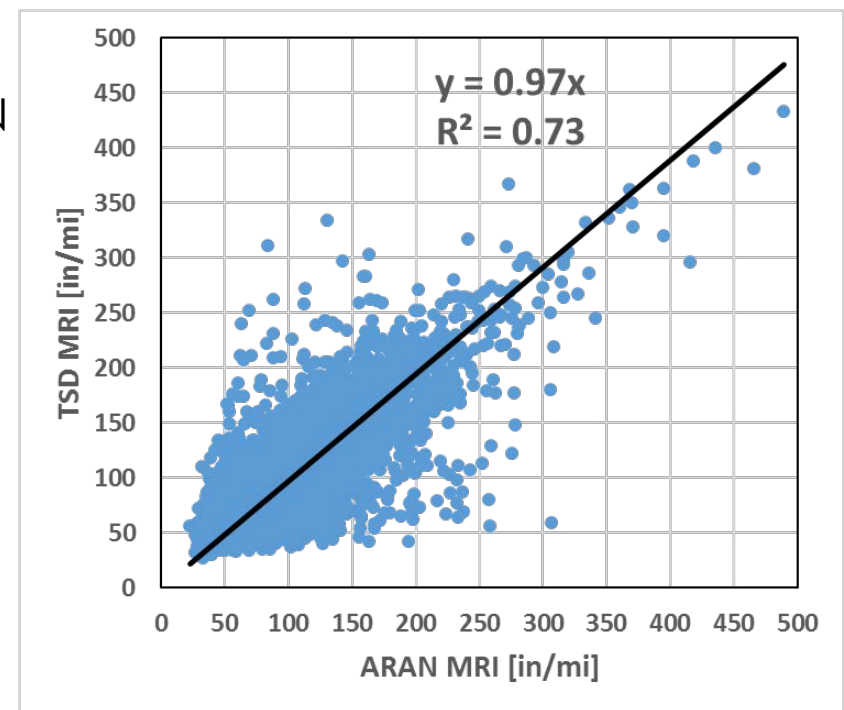
## Sample Distribution of Deflection Basins



# Data Review: Traffic Speed Deflectometer



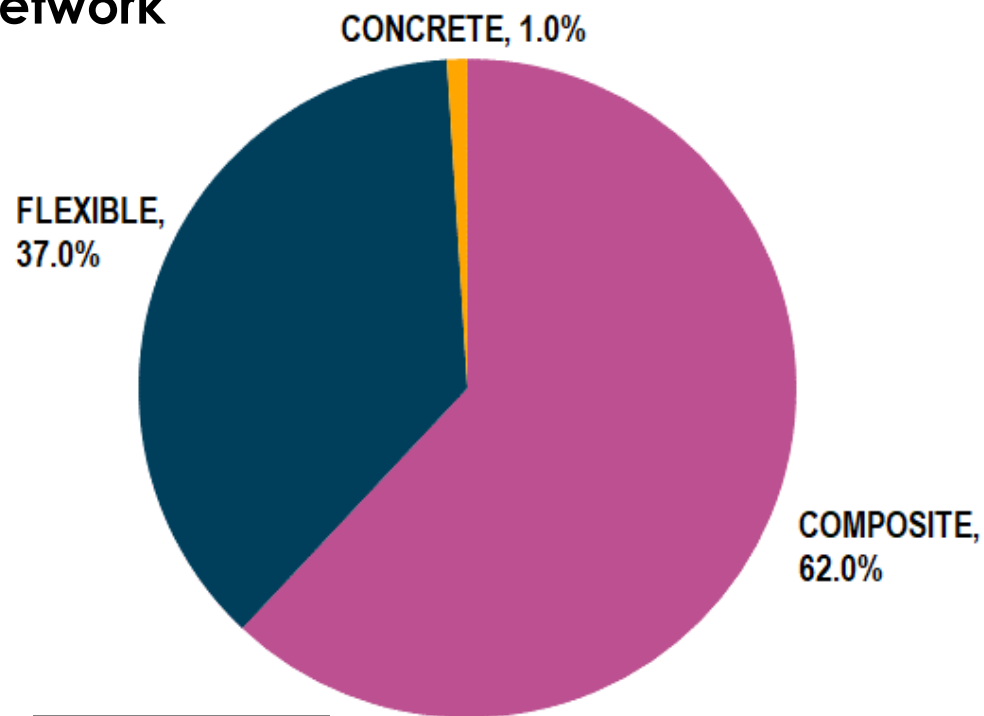
TSD vs. ARAN  
MRI →  
← RUT



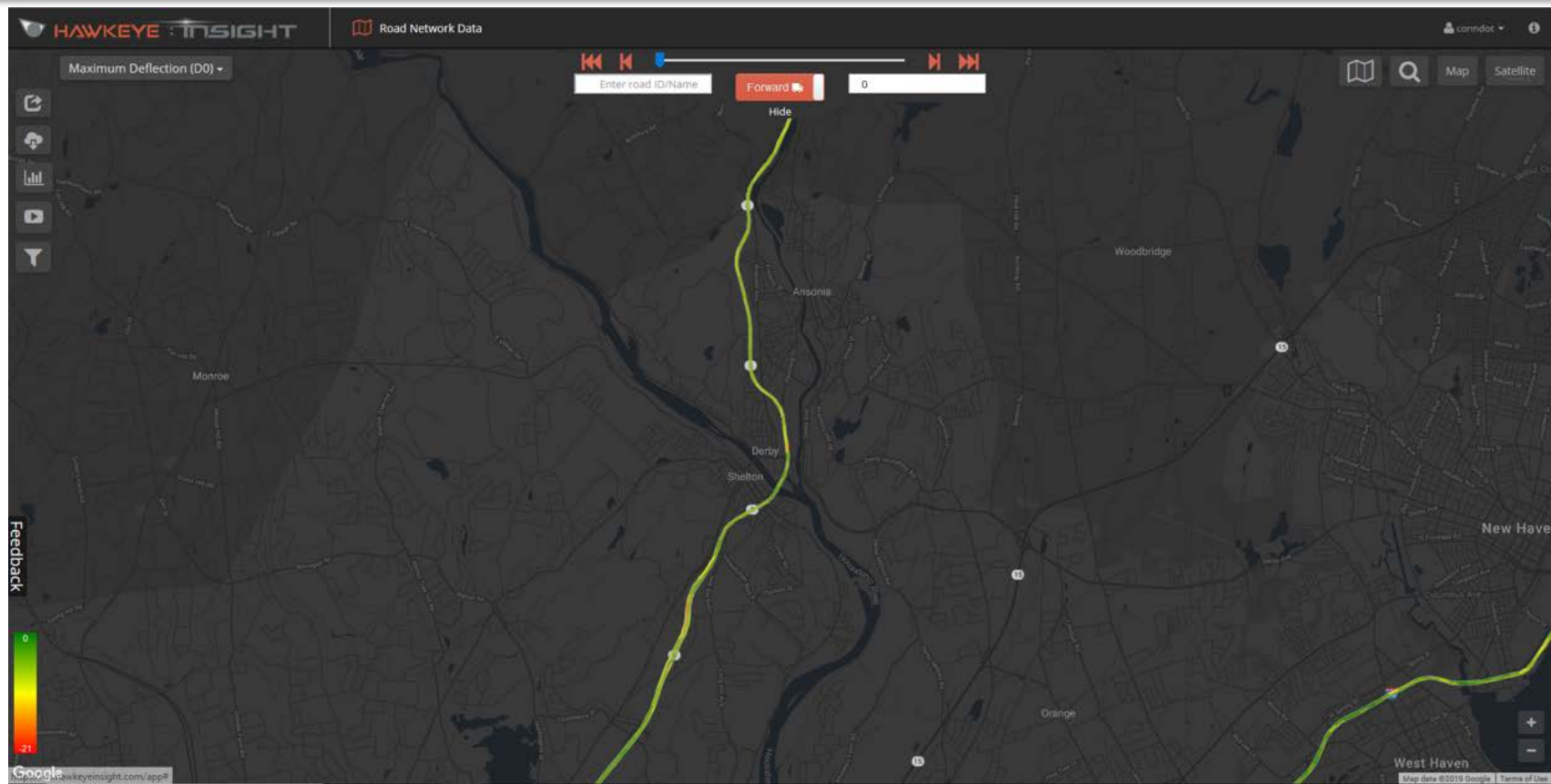


# Data Review: Traffic Speed Deflectometer

**% Network**



# Project-Level Analysis

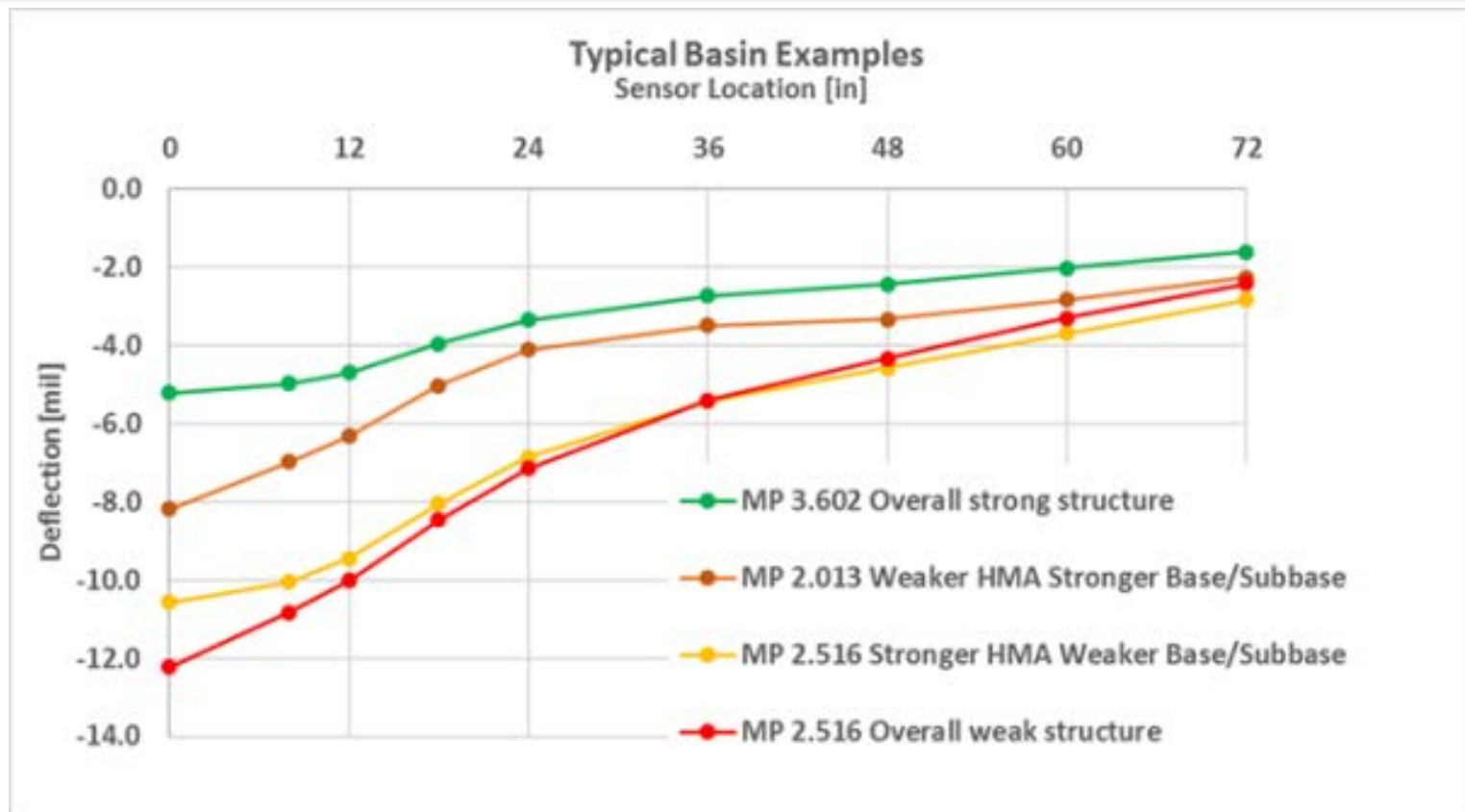


# Project-Level Analysis

SCI8 = D8-D0

SCI12 = D12-D0

SCI\_SUBGRADE = D60-D36



# Project-Level Analysis

SCI8 = D8-D0  
 SCI12 = D12-D0  
 SCI\_SUBGRADE = D60-D36

Table 3. Categorical Grouping for Cumulative Difference for Top AC Stiffness (SCI8), Subgrade Stiffness (SCI\_Subgrade), PSR, and MRI

Rank	Top AC Stiffness	SG Stiffness	MRI [in/mi]	PSR
Excellent				>8
Good	$\leq 1.05$	$\geq -1.1$	$\leq 95$	$6 \leq 8$
Fair	$1.05 \leq 1.6$	$-1.1 \geq -1.6$	$95 \leq 170$	$4 \leq 6$
Poor	$> 1.6$	$< -1.6$	$> 170$	$\leq 4$



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# Project-Level Analysis

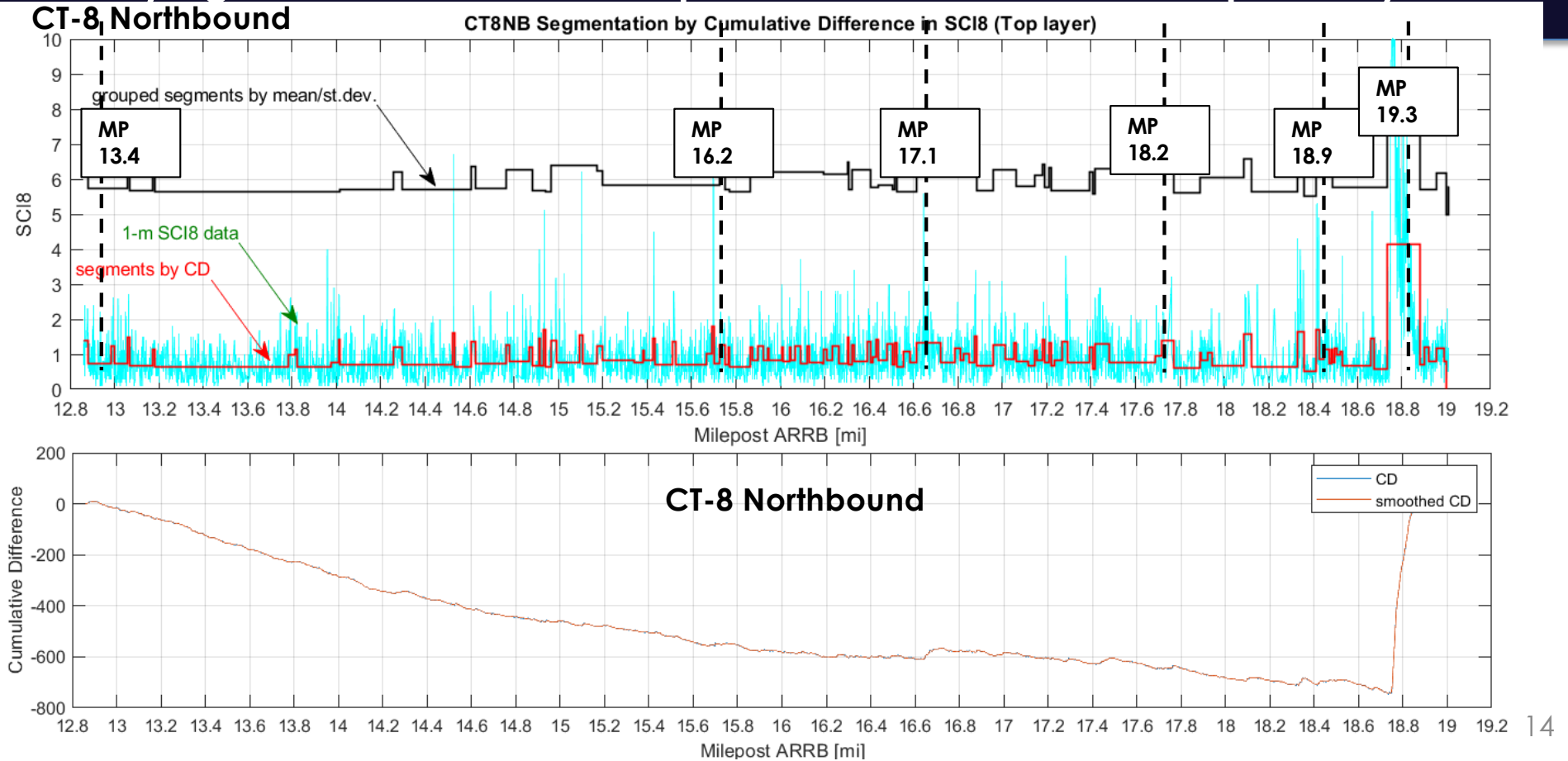
## CT-8 NB

Uniform PMIS Section (DH Limits)	Length [mi]	ADT	Construction Year	Last Treatment Year	MRI [in/mi]	Mean PSR	Mean Crack Length ft/10 lane-m	Pavement Type
13.4 – 16.2	2.8	59711	1959	2013	78	7.8	2.3	Composite
16.2-17.1	0.9	57650	1962	2013	102	7.6	2.6	Composite
17.1-18.2	1.1	53730	1962	2013	83	7.7	1.7	Composite
18.2-18.9	0.7	43030	1993	2008	153	6.1	70	Composite
18.9-19.3	0.4	47325	1949/1962	2009	89	6.4	76	Composite
19.3-19.55	0.25	49900	1982	2009	91	6.3	68	Flexible

# Project-Level Analysis

Method 1: Cumulative Difference

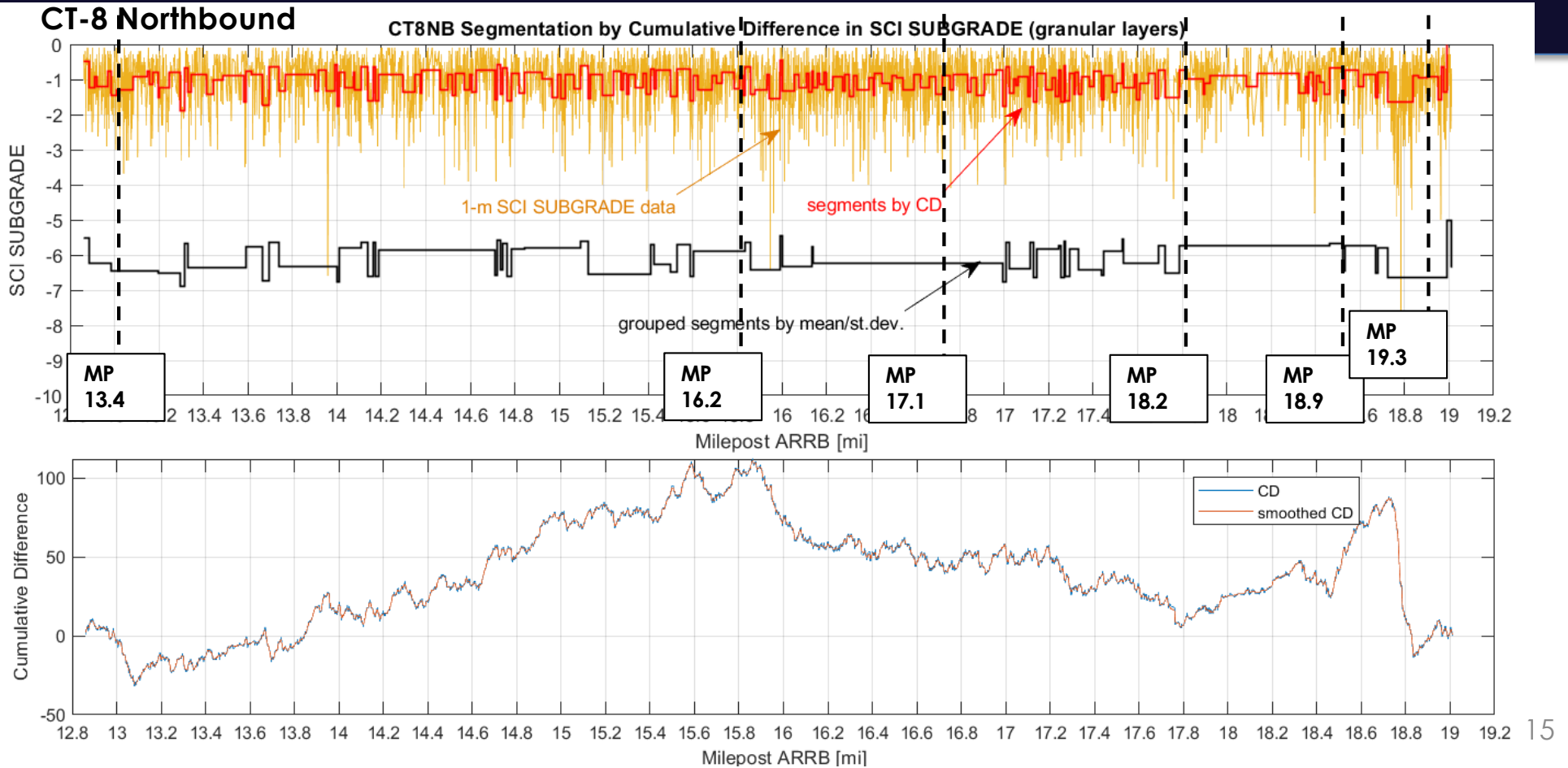
## Identifying uniform sections and problematic locations in top AC layer



# Project-Level Analysis

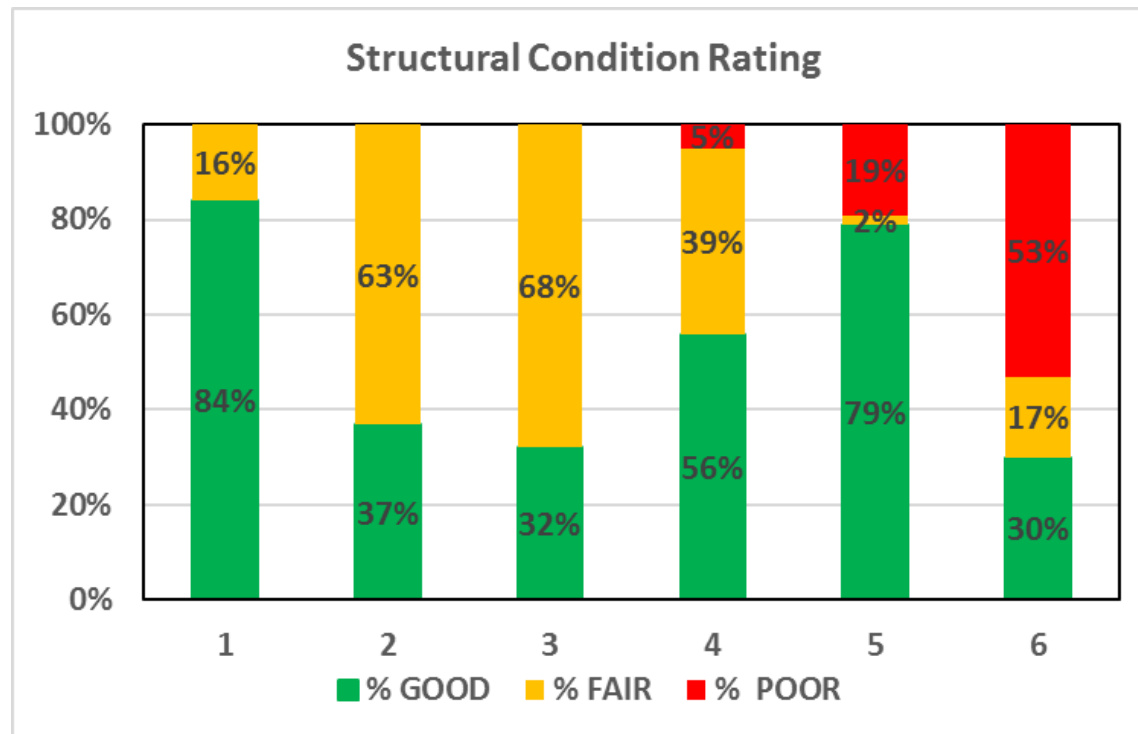
Identifying uniform sections and problematic locations in subbase layers

Method 1: Cumulative Difference



# Project-Level Analysis

## Summary of Structural Condition as Estimated from the Deflections





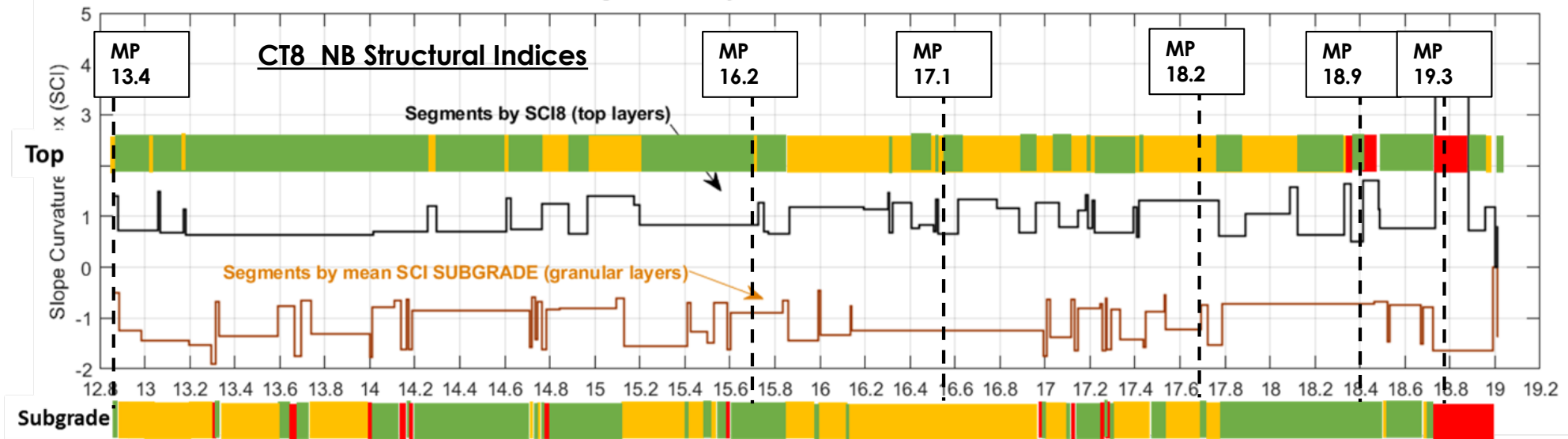
# Project-Level Analysis

## Superposition of segments by structural and functional ratings

### CT8 NB Functional Indices



CT8NB Segmentation by Cumulative Difference in Structural Indices




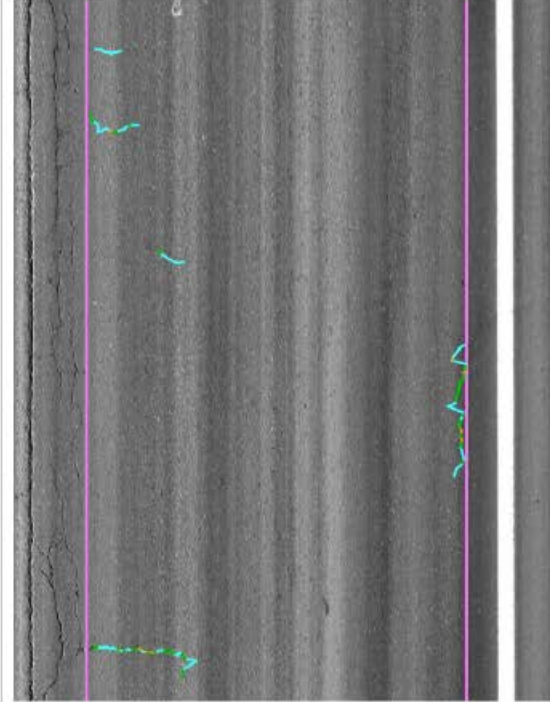
# Project-Level Analysis

## Summary of Structural Condition as Estimated from the Deflections

Direction	Condition Rank /Layer			SCI8 / Top AC Layer			SCI SUBGRADE/ Granular Layers			# of Critical Locations on Top Layer	# of Critical Locations on Subgrade
	Section #	PMIS Limits, MP	Length [mi]	% Length in GOOD	% Length in FAIR	% Length in POOR	% Length in GOOD	% Length in FAIR	% Length in POOR		
NB	1	13.4-16.2	2.8	84%	16%	0%	46%	49%	5%	3	14
NB	2	16.2-17.1	0.9	37%	63%	0%	29%	71%	0%	2	15
NB	3	17.1-18.2	1.1	32%	68%	0%	24%	72%	4%	1	6
NB	4	18.2-18.9	0.7	56%	39%	5%	92%	8%	0%	0	4
NB	5	18.9-19.3	0.4	79%	2%	19%	91%	9%	0%	36	8
NB	6	19.3-19.55	0.25	30%	17%	53%	7%	0%	93%	35	6
<b>Summary of Northbound</b>				<b>62%</b>	<b>34%</b>	<b>4%</b>	<b>45%</b>	<b>47%</b>	<b>7%</b>	<b>77</b>	<b>52</b>

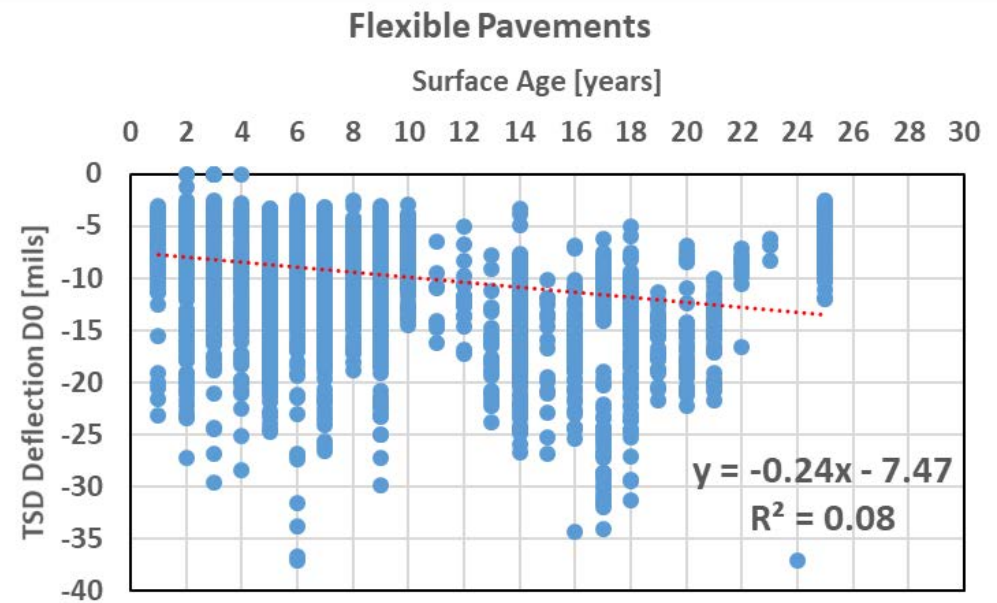
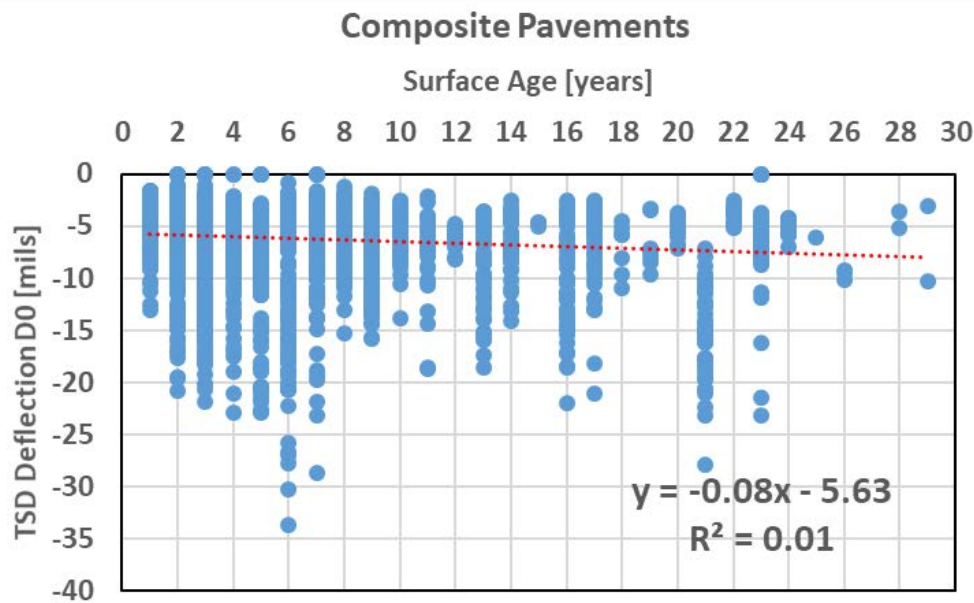
# Project-Level Analysis

## Example of High SCISUBGRADE with no related surface distress

Road ID/Notes	Chainage	Forward Camera (-1)	Pavement Camera
<p>CT-8 NB/ Forward</p> <p>Joints not fully reflected to surface, TSD data may be indicative of poor LTE.</p> <p>SCISUBGRADE: -4.3</p>	<p>18.9624</p>	<p>2018 - Road ID: CT-8 CT Route 8 Forward 18.962mi L0 [Front Center]</p> <p>Lat/Lon: 41.40724, -73.96946 Collected: 29 Sep. 2018 11:56:32 am</p> 	<p>2018 - Road ID: CT-8 CT Route 8 Forward 18.962mi L0 [ACD]</p> <p>Lat/Lon: 41.40724, -73.96946 Collected: 29 Sep. 2018 11:56:32 am</p> 

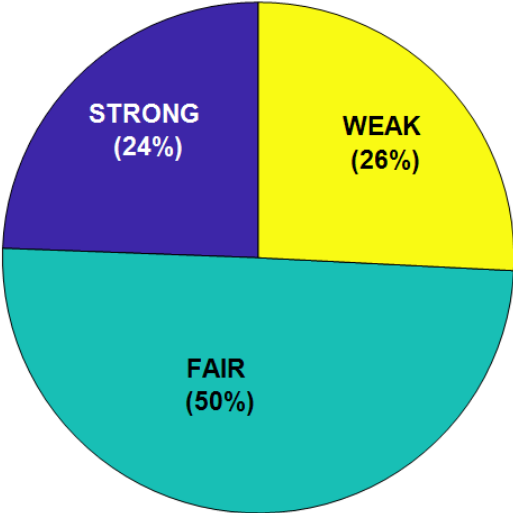
# Network-Level Analysis

## Deflection (D0) vs. Age



# Network-Level Analysis

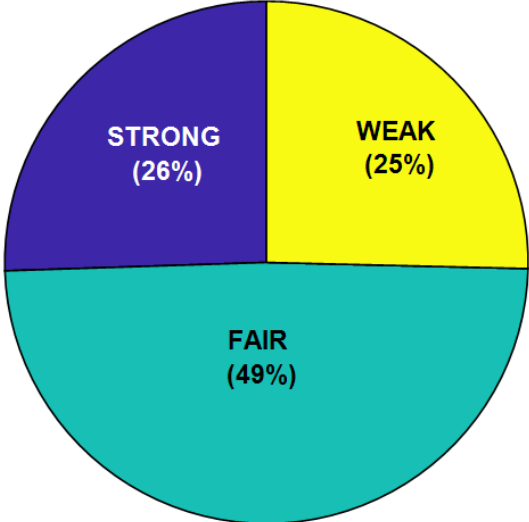
Composite



Rating	Criteria
STRONG	$D0 < 4.2$ (25 <sup>th</sup> percentile)
FAIR	$4.2 \leq D0 \leq 7.0$ (75 <sup>th</sup> percentile)
WEAK	$D0 > 7.0$

Rating by Percentile of D0

Flexible

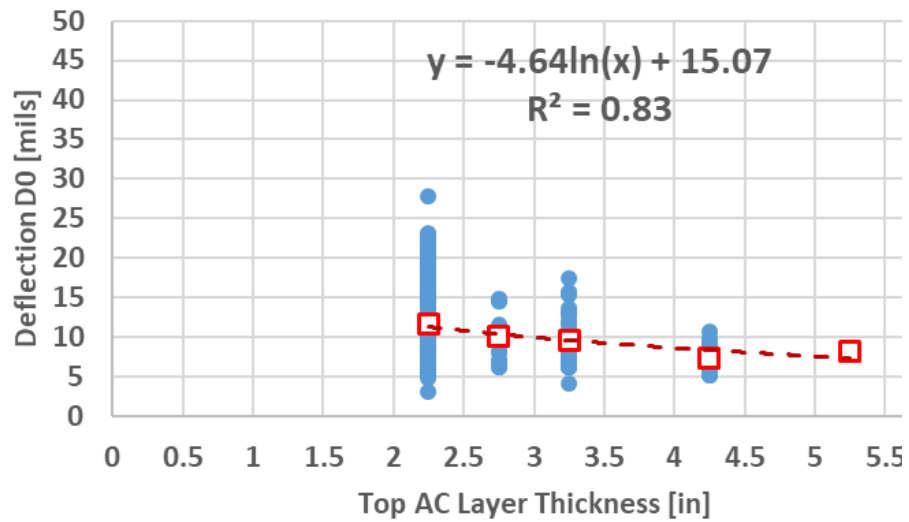


Rating	Criteria
STRONG	$D0 < 6.0$ (25 <sup>th</sup> percentile)
FAIR	$6.0 \leq D0 \leq 11.8$ (75 <sup>th</sup> percentile)
WEAK	$D0 > 11.8$

# Looking Forward

## Estimating Pavement Thickness

Composite Pavements



Flexible Pavement

