The Long Road to BMD

A Multi-Year Study of Performance Tests Compared to Field Data in CT

CTDOT

UCONN | COLLEGE OF ENGINEERING

CONNECTICUT ADVANCED PAVEMENT LABORATORY

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NEAUPG – Harrisburg, PA

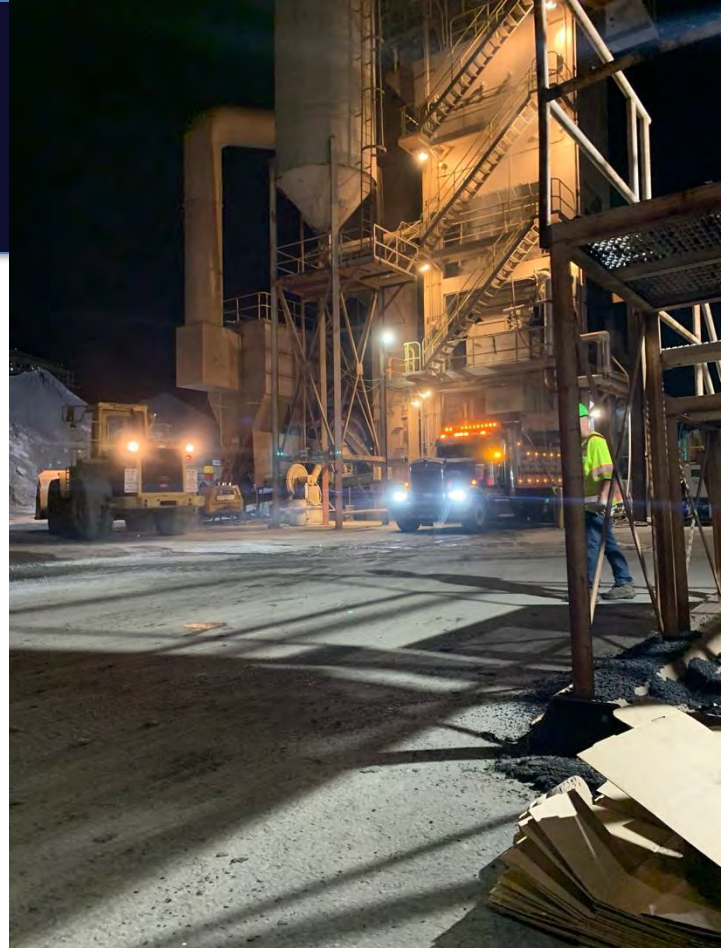
UCONN

Problem Statement

1. What is the benchmark for CTDOT-Approved Superpave Mixes for various performance tests

2. Do performance tests relate to the field performance of any of our materials

3. T.B.D.



Acknowledgments

Thank you to the research team and Agency Sponsor [CTDOT]

CAP Lab Co Authors: Scott Zinke, Jim Mahoney & John Dadalt

CT DOT: Eliana Carlson, Dave Howley and the MESU BMD Team

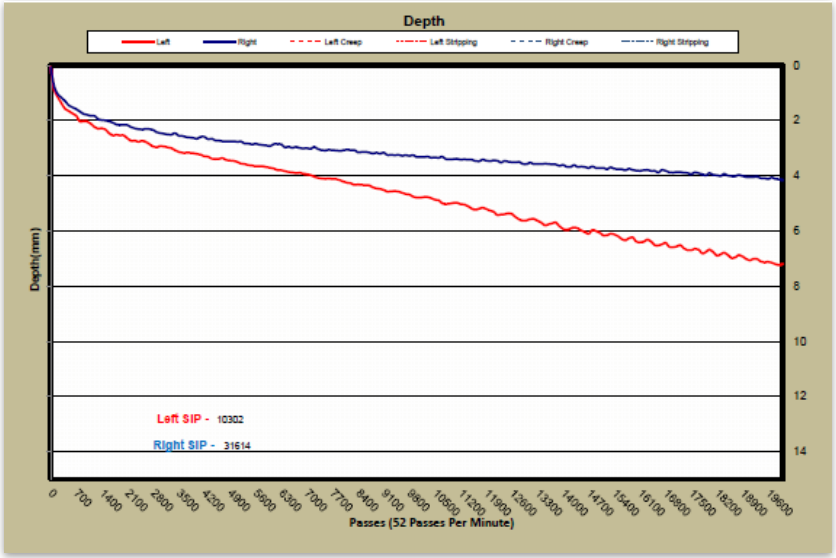
Summary of the Work

- More than 90 plant samples collected over 8 years
- 14+ Plants sampled (most are sampled annually)
- Approximately 500 lb of material taken per sample
- Suite of 5 (+/-) performance tests run on each sample[1]
- More than 2,000 Gyratories Produced for this study
- All samples were 12.5 NMAS, L2/L3 and 64S/64E - 22

[1]*Tests have been added/removed with trends in HMA performance testing over the years (i.e. cantaboro, flow number, IDEAL CT/RT)*

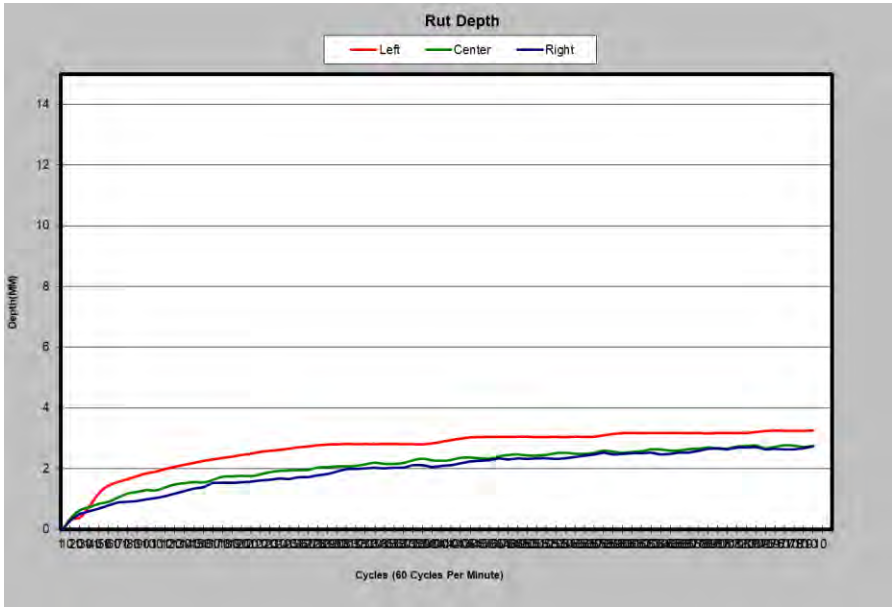
P M L C

Test Overview: Hamburg Wheel/ AASHTO T324



- Steel Wheel track directly on HMA Samples Submerged in hot water (50℃ (20,000 cycles)
- Overall rut depth reported at end of test (average of 2 or 3 wheels) and Stripping Inflection Point (if applicable)

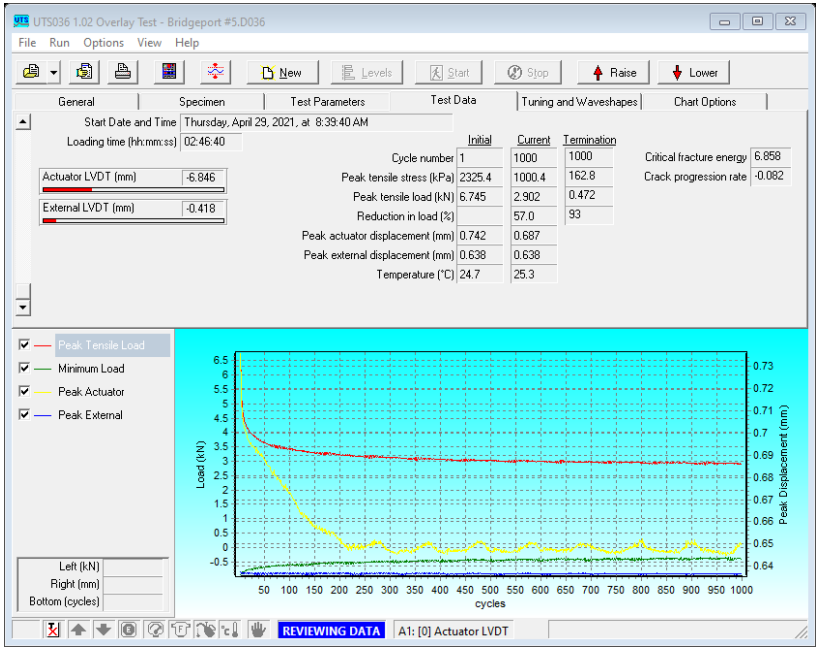
Test Overview: APA/ AASHTO T340



- Wheel tracking on pressurized tubing at high PG (8,000 cycles)
- Overall rut depth reported at end of test (average of 3 wheels)

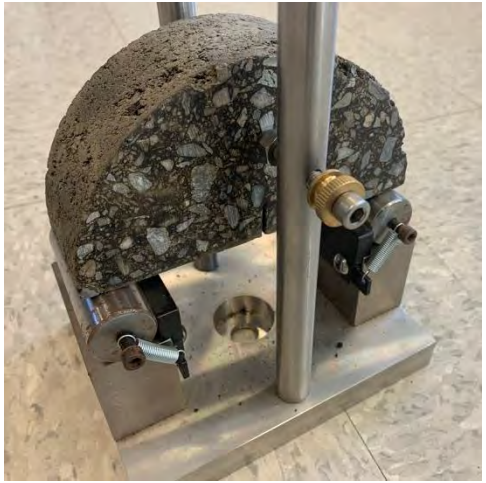
Test Overview: APA vs Hamburg Wheel

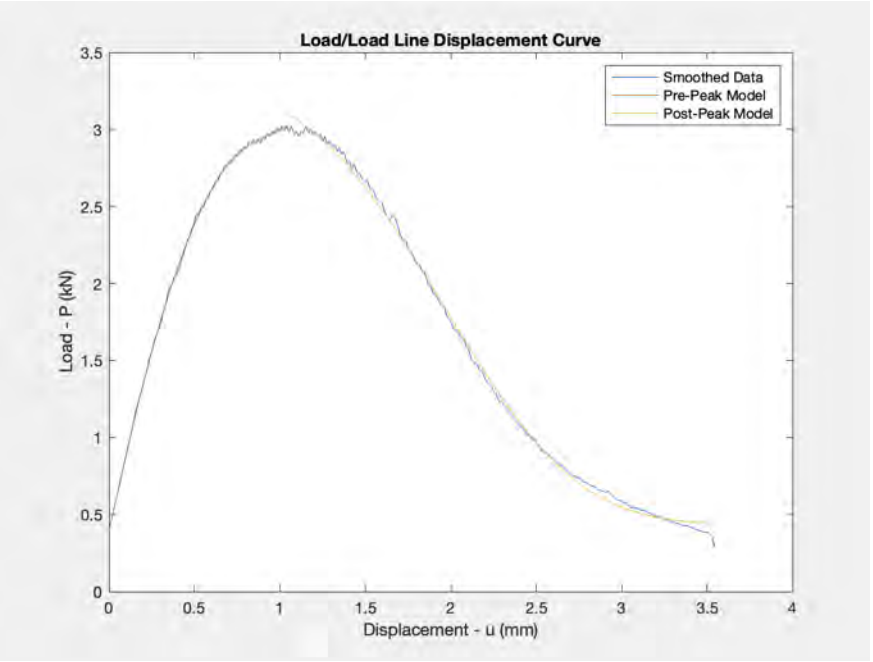
Test Overview: Texas Overlay Test



- Strain-controlled cyclic elastic recovery test
- Report cycles to failure, crack progression rate, and critical facture energy

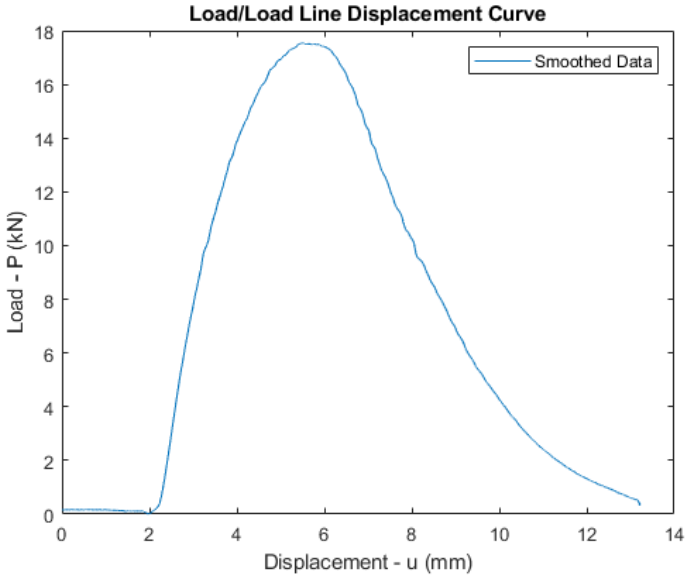
Test Overview: Illinois Flexibility Index Test (i-FIT) (AASHTO T393)





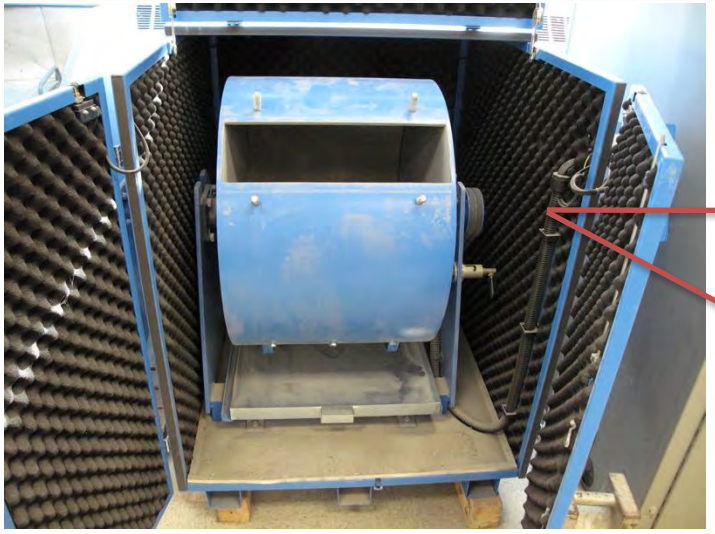
- 3-point Flexural Failure Test on a Semi-Circular Beam at room temperature
- Constant Displacement
- Fracture Energy/Flexibility Index Reported

Test Overview: IDEAL-Cracking Test (ASTM D8225)



- Indirect Tensile Test at room temperature
- Constant Displacement
- Fracture Energy and CT Index Reported

Test Overview: Cantabro Test (Tex-245)



- Degradation Test Utilizing L.A. Abrasion Machine
- Ran on first 2 years of data
- Broke L.A. Machine Drum

Test Overview: Flow Number Test (AASHTO TP79)

- Initially identified as a rutting test [FHWA]
- Multiple years of testing CT Mixes suggested little to no correlation with other rutting data in our state [CAP Lab]

Test Overview: IDEAL RT / HT-IDT

- More recently developed rapid tests that are correlating well with longer-duration wheel tracking tests.

Field Performance

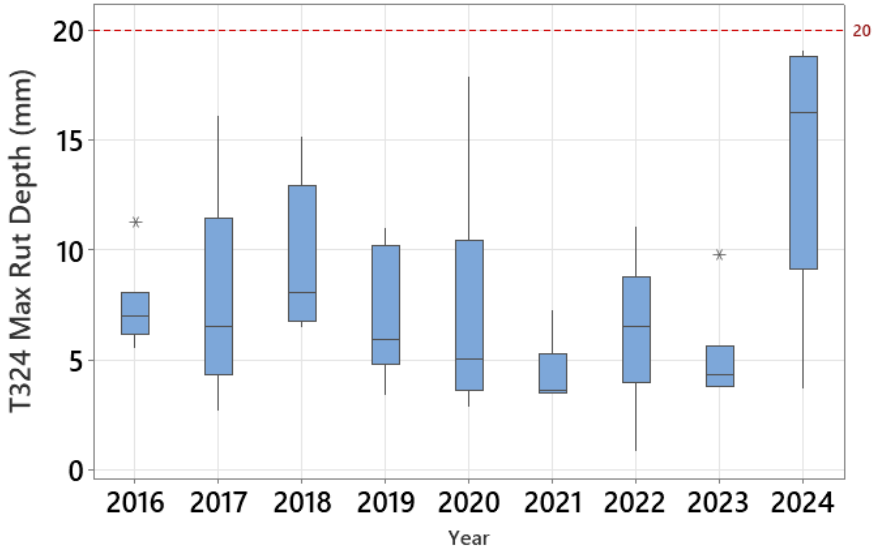
- Extract Condition data from CTDOT Automated Road Survey Vehicle
- Performance metrics for a given project length for a given surface age are averaged
- Identify trends between lab measurements and field observations

  (Technically Step 5/Benchmarking from BMD Implementation)

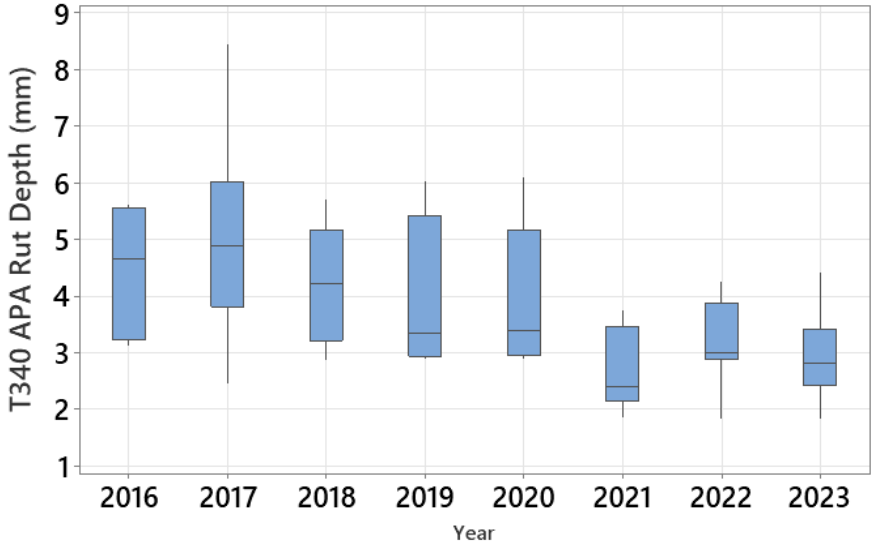
	A	B	C	D	E	F	G	H	I	J
1	Year	RoadName	From	To	Age	FunClass	MRI	WP	NWP	RUTmax
2	2017	001L	8.97	12.88	0	3	254.9	54.3	33.4	0.245
3	2017	001L	35.48	37.03	0	3	99.7	7.3	4.1	0.095
4	2019	005L	9.19	11.09	0	4	87.4	0.8	1.1	0.097
5	2018	005L	12.14	15.07	0	4	191.7	47.8	62	0.296
6	2016	008L	2.43	4.79	0	2	125	2	12	0.294
7	2018	008L	2.43	4.79	0	2	62.2	0.2	0.9	0.065
8	2017	008L	27.44	29.66	0	2	59.4	0.9	3.5	0.065
9	2017	008R	27.44	29.66	0	2	60	0.5	3	0.06
10	2019	008R	41.02	46.82	0	2	56.6	1.1	1.9	0.167
11	2017	016L	0	7.3	0	4	129.1	37.2	15.7	0.189
12	2017	030L	17.81	20.94	0	5	95.1	0.1	0.2	0.061
13	2018	031L	6.9	11.1	0	5	108.2	0.5	0.9	0.06
14	2016	032L	25.46	28.55	0	3	133.2	19.4	24.2	0.234
15	2017	032L	39.8	43.16	0	4	91.1	0.4	0.3	0.066
16	2017	037L	15.64	16.68	0	4	127.7	1.2	1.3	0.122
17	2016	044L	38.77	42.29	0	3	93	0.4	0.9	0.116
18	2016	084R	26.48	30.04	0	1	48.2	0	0	0.095
19	2017	091L	29.35	33.07	0	1	76.6	64.5	43.8	0.168
20	2016	095L	78.9	83.9	0	1	82.5	3.1	11.8	0.107
21	2017	095L	78.9	83.9	0	1	72.5	1.1	11.2	0.099
22	2016	095R	78.9	83.9	0	1	69.7	0.9	3.9	0.11
23	2017	095R	78.9	83.9	0	1	56.1	0.1	2.6	0.089
24	2017	095R	101.04	104.19	0	1	88	61.3	30.1	0.155
25	2016	097L	0	2.94	0	4	152.7	39.3	31.1	0.171
26	2017	136L	8.35	10.49	0	4	181.1	32.9	15	0.214
27	2019	140L	19.18	22.5	0	5	141.7	0.5	0.6	0.124
28	2019	142L	1.14	1.76	0	4	113.2	0.2	1	0.065
29	2017	148L	6.88	10.27	0	5	73.1	0.3	0.3	0.077
30	2018	167L	4.96	10.41	0	4	93.5	0	0	
31	2017	179L	8.77	12.06	0	5	90.6	0.4	0.5	0.102
32	2017	272L	6.02	10	0	5	271	51.5	20.5	0.392
33	2017	313L	0.57	3.42	0	4	91.6	2	1.2	0.08

Results & Analysis
Wheel Tracking

HWT (T324)
All Data

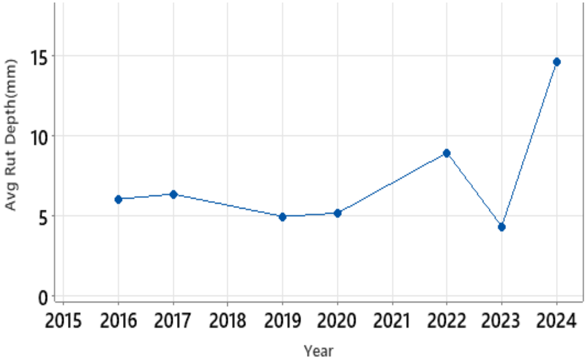


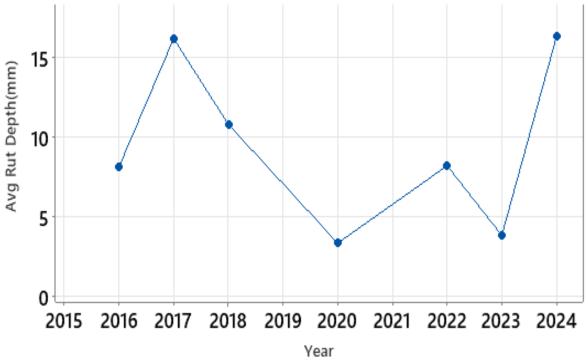
APA (T340)
All Data

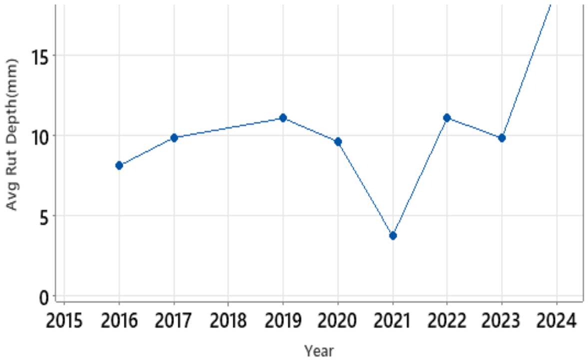


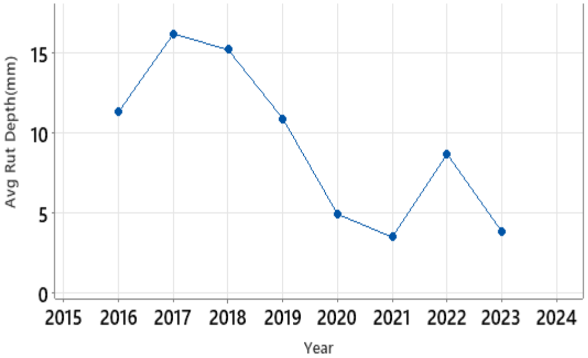
Results & Analysis
Hamburg Wheel Tracking (T324)

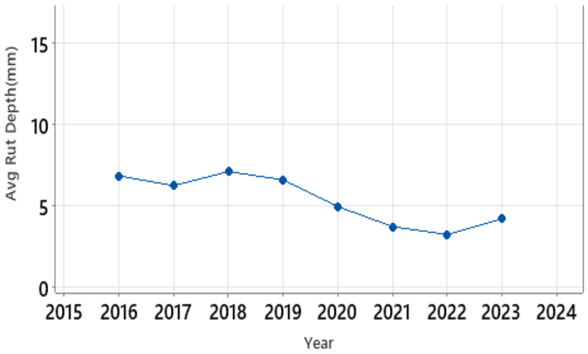
Each graph is data from a single plant over time.

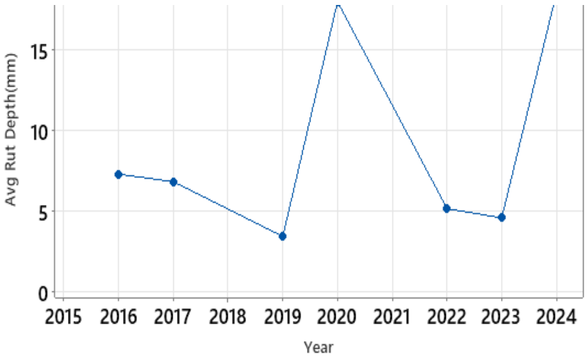






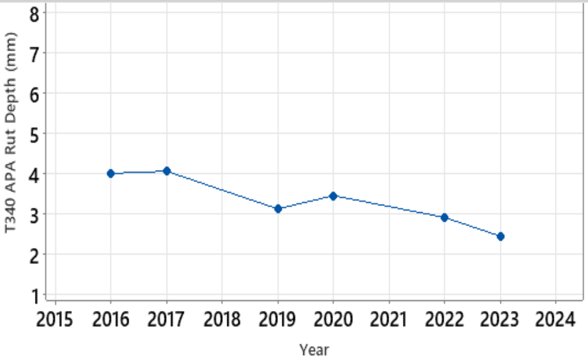


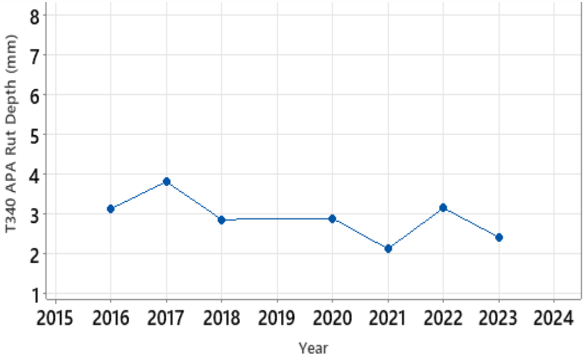


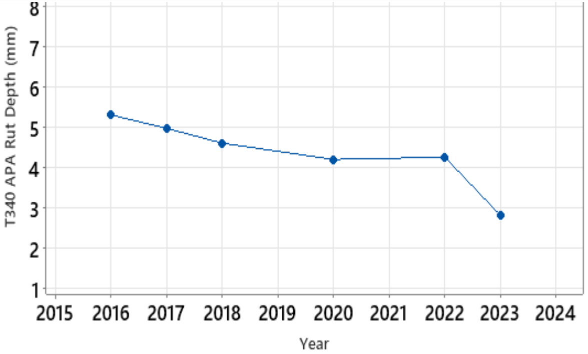


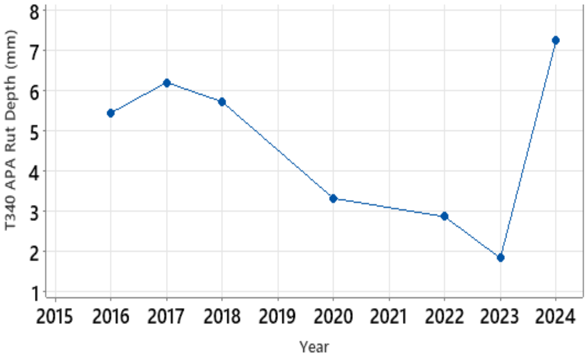
Results & Analysis
Advanced Pavement Analyzer (T340)

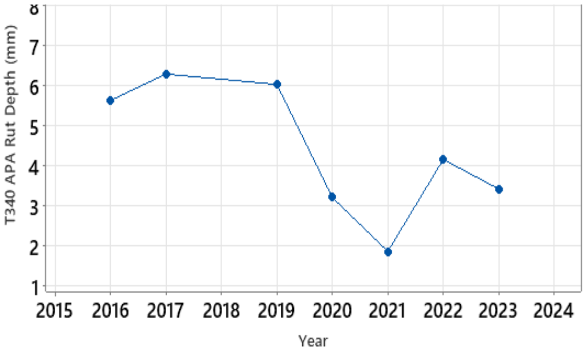
Each graph is data from a single plant over time.

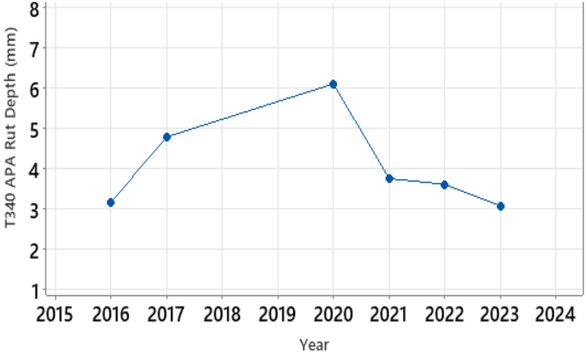








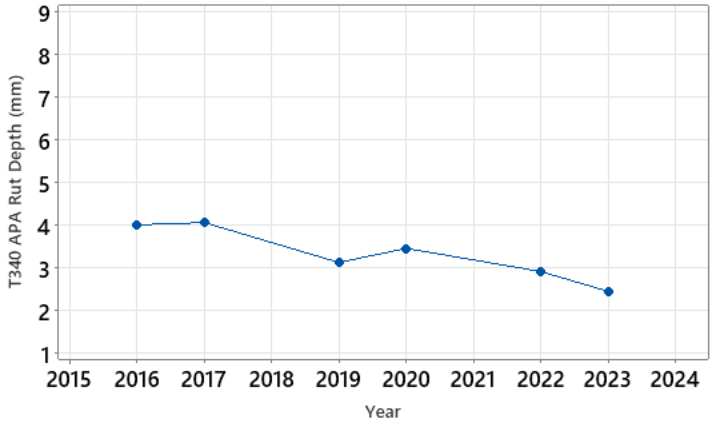




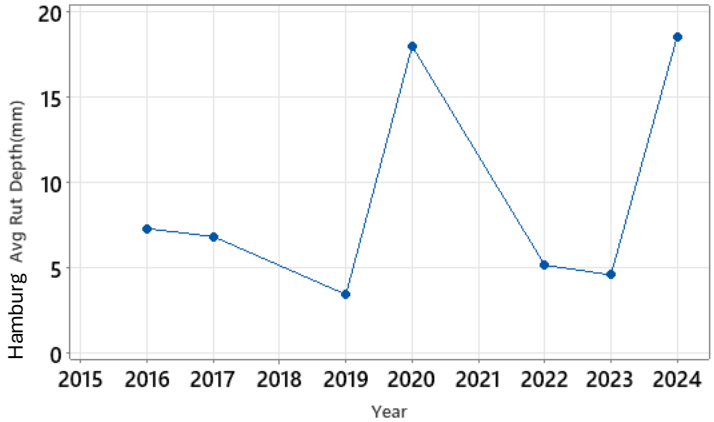
Results & Analysis
T340 vs. T324

Same Plant, sampled over time

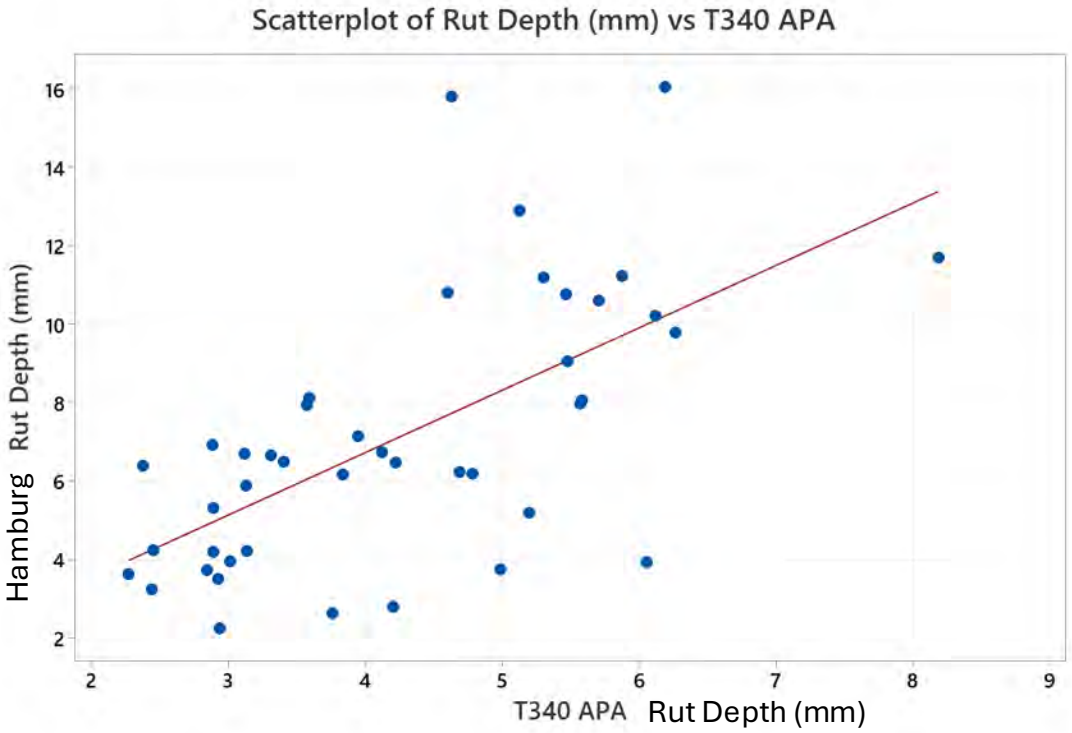
APA (T340)



HWT (T324)



Results & Analysis
Wheel Tracking



The regression equation is
Rut Depth (mm) = 0.363 + 1.591 T340 APA

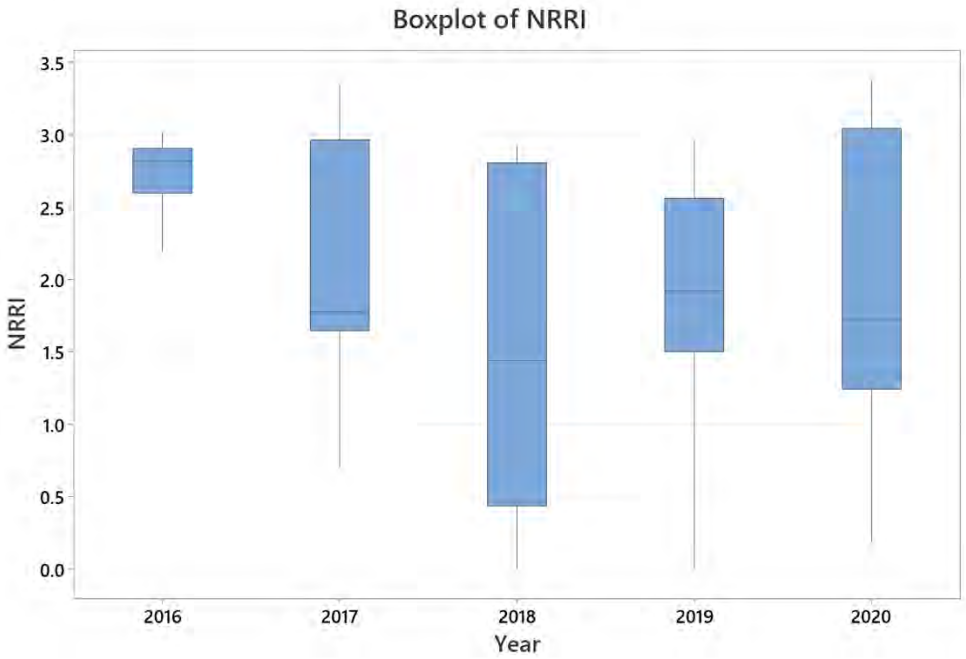
Model Summary

S	R-sq	R-sq(adj)
2.66285	40.66%	39.21%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	199.171	199.171	28.09	0.000
Error	41	290.721	7.091		
Total	42	489.891			

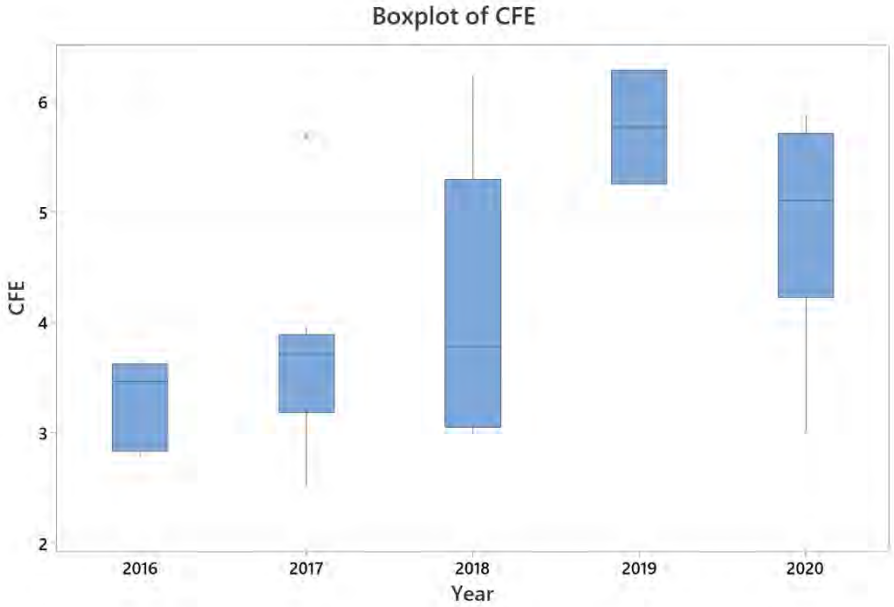
Results & Analysis
HWT (AASHTO T324)



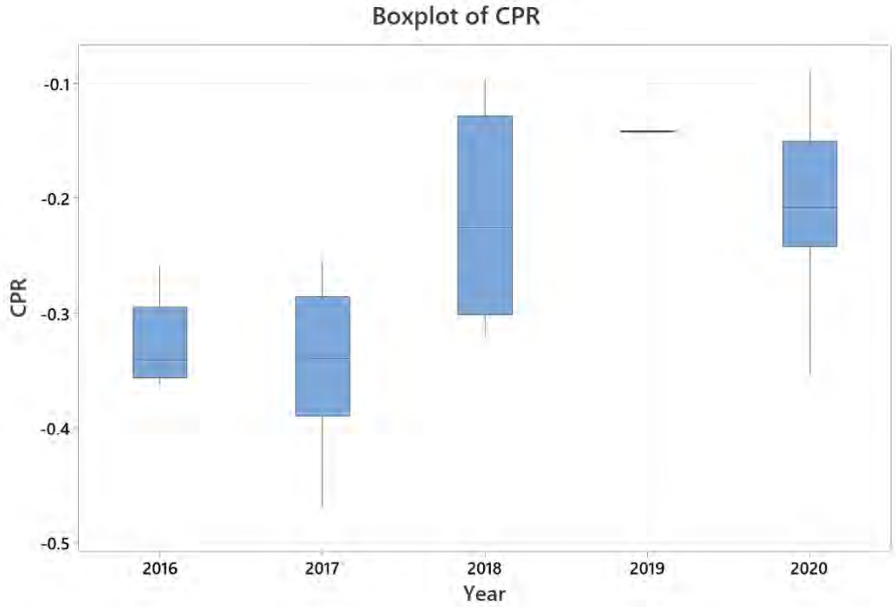
$$NRRI = \frac{[N \times (1 - RD)]}{Minimum\ RRI}$$

https://scholarworks.utep.edu/cgi/viewcontent.cgi?article=2401&context=open_etd

Results & Analysis
Texas Overlay Test

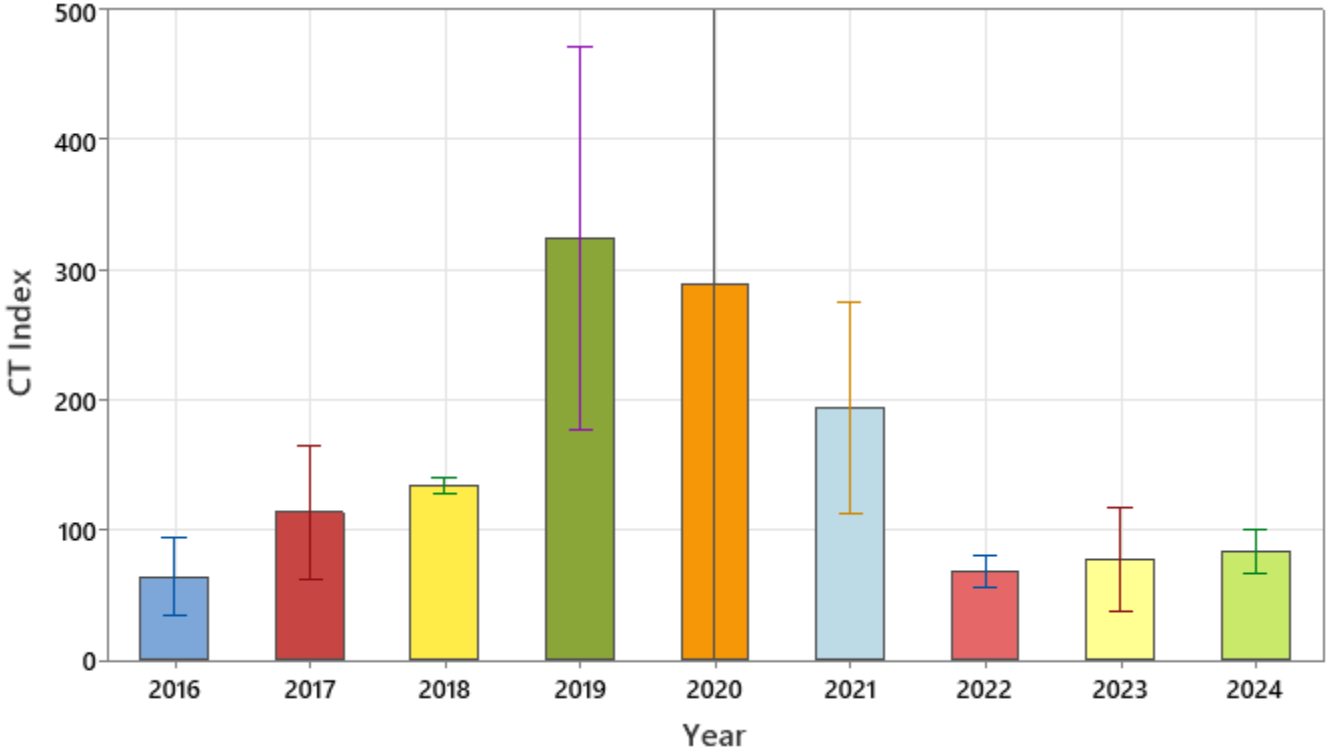


Critical Fracture Energy

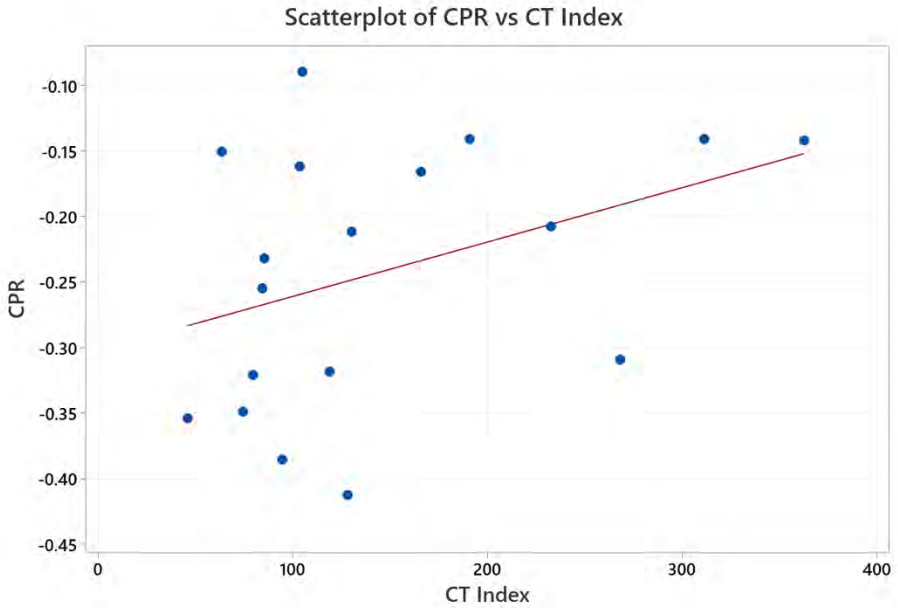


Crack Propagation Rate

Results & Analysis
IDEAL-CT



Results & Analysis
IDEAL-CT vs. TxOvly



ALL_TESTS

Regression Analysis: CPR versus CT Index

The regression equation is
CPR = - 0.3024 + 0.000415 CT Index

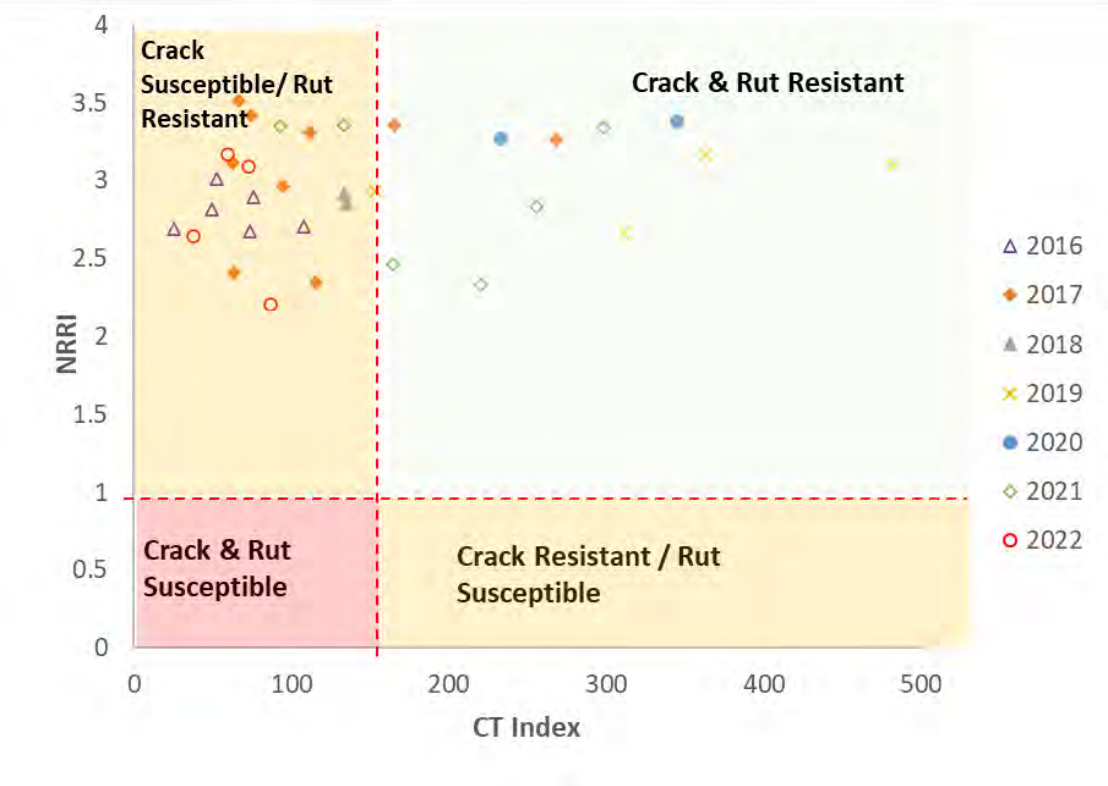
Model Summary

S	R-sq	R-sq(adj)
0.0944301	14.47%	9.12%

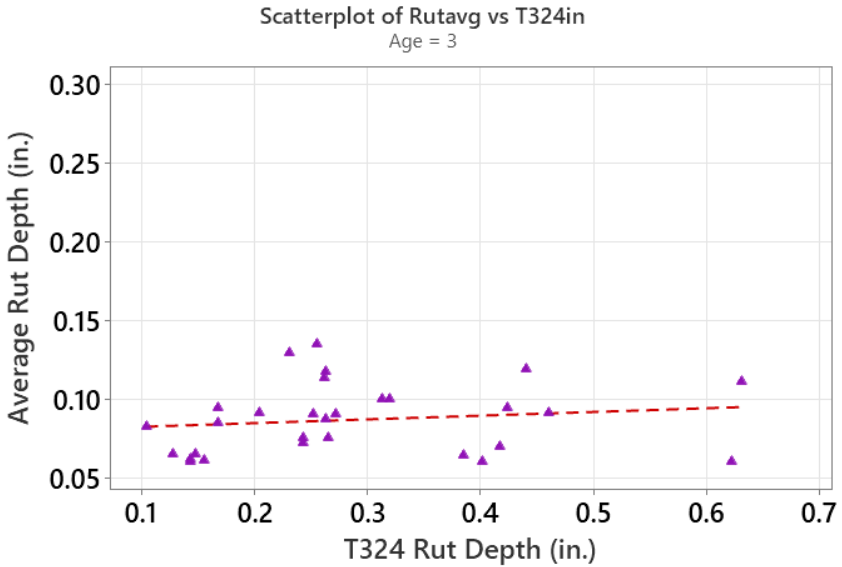
Analysis of Variance

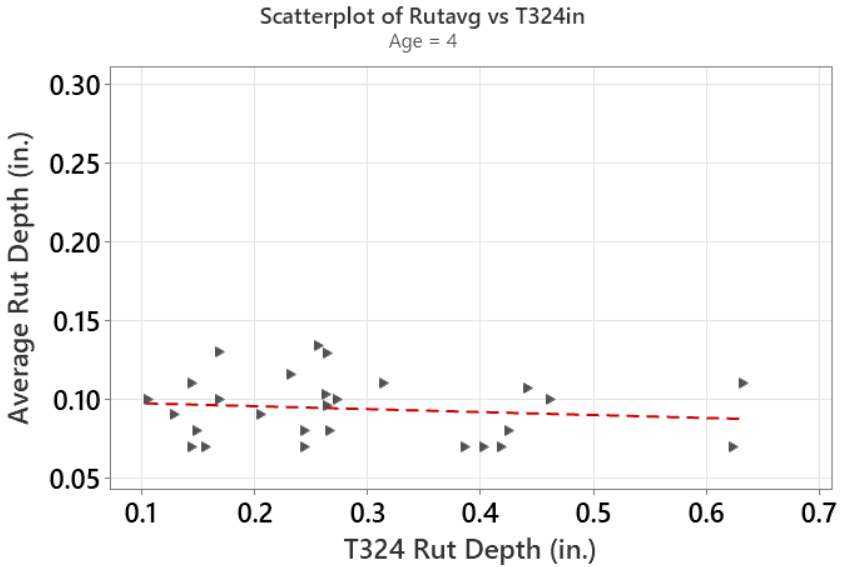
Source	DF	SS	MS	F	P
Regression	1	0.024129	0.0241290	2.71	0.119
Error	16	0.142673	0.0089170		
Total	17	0.166802			

Results & Analysis
Lab Performance

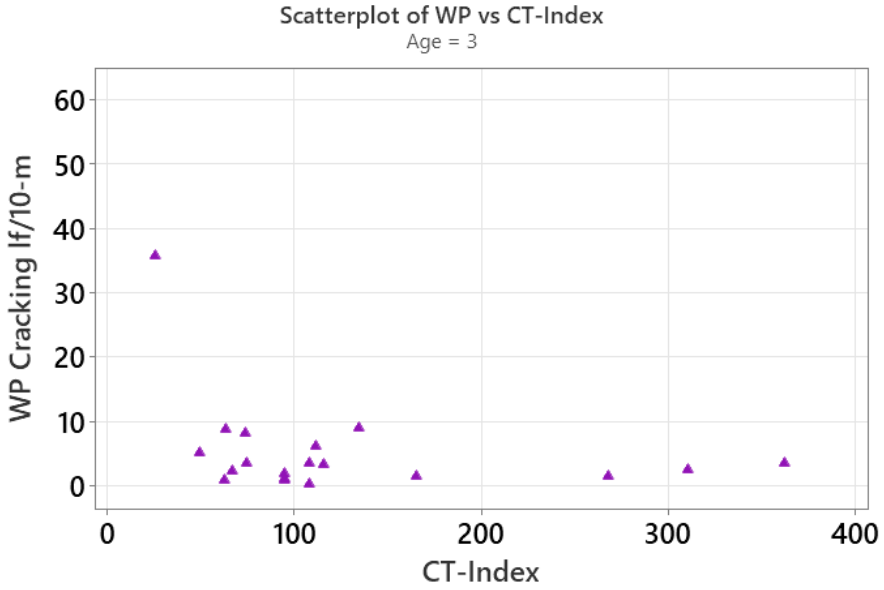


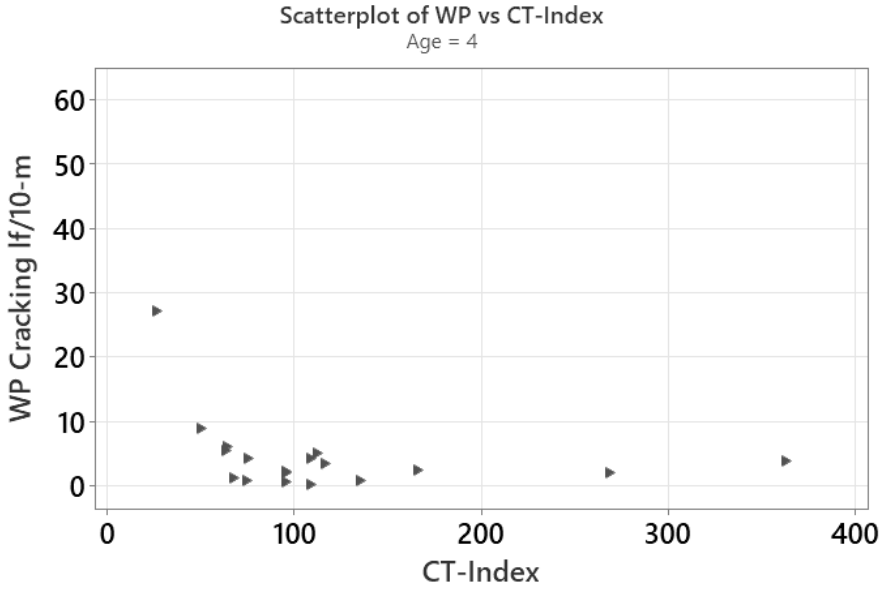
Results & Analysis
Condition Data



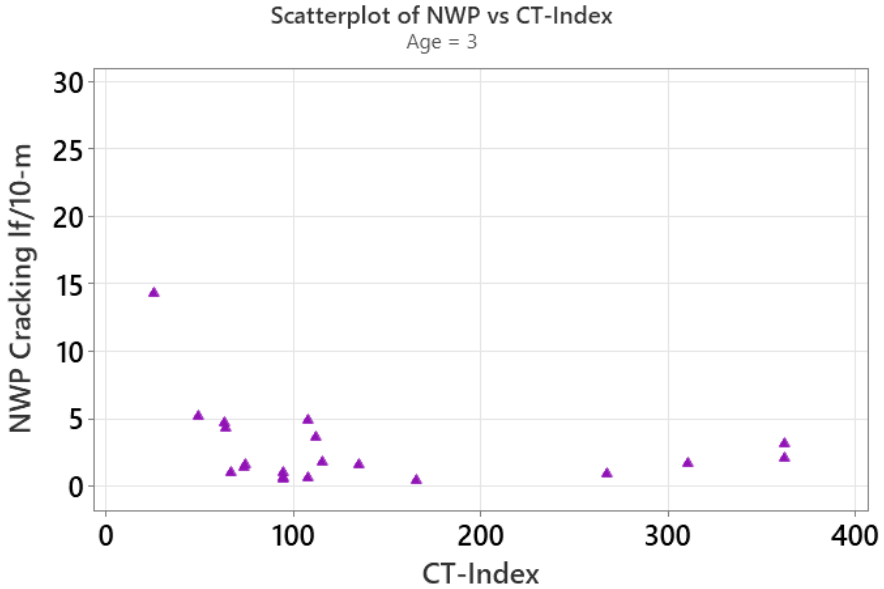


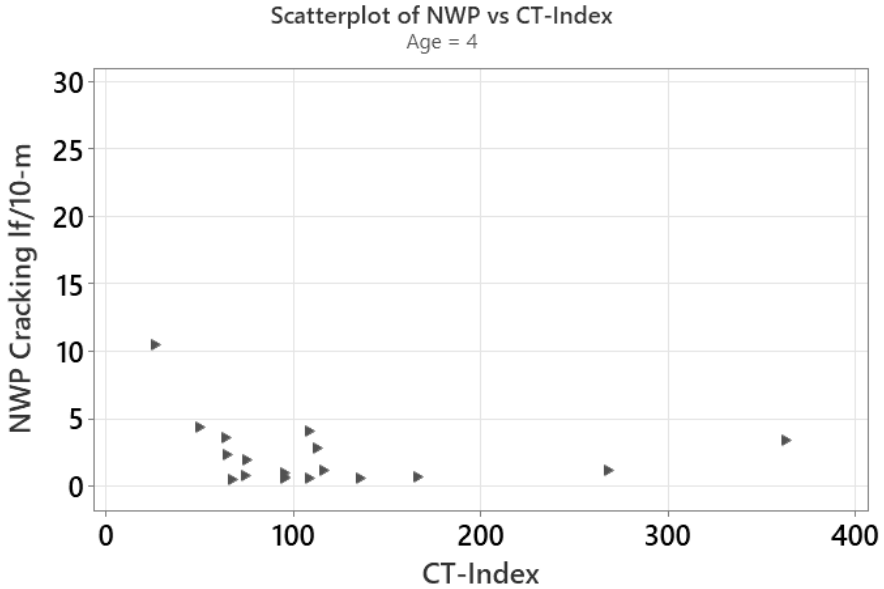
Results & Analysis
Condition Data



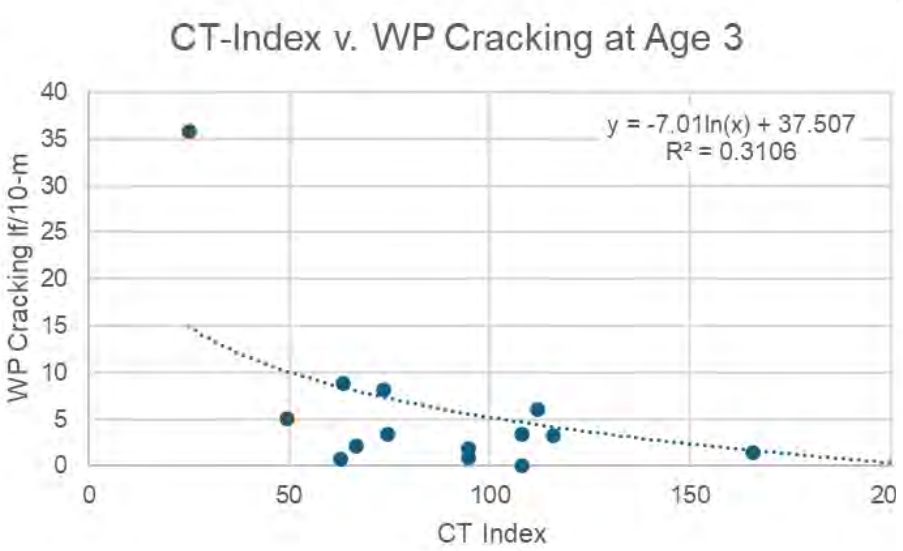


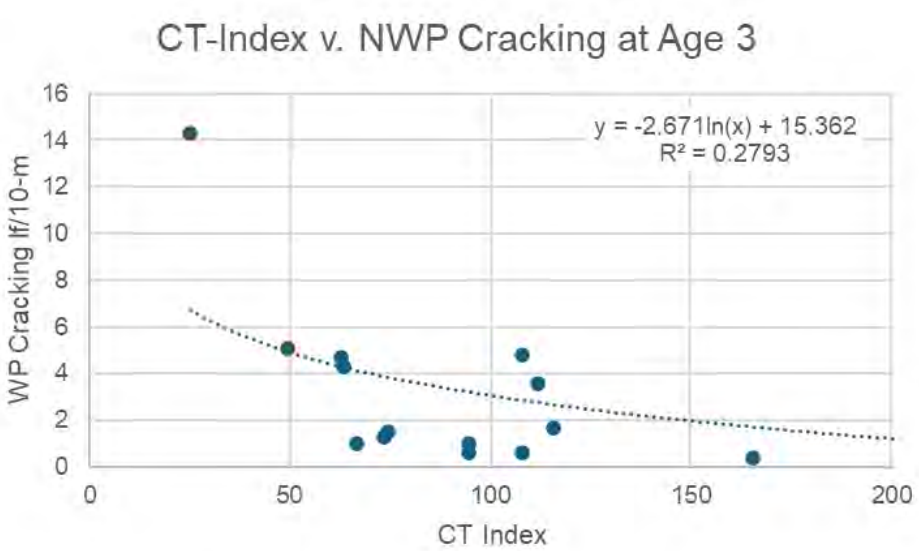
Results & Analysis
Condition Data





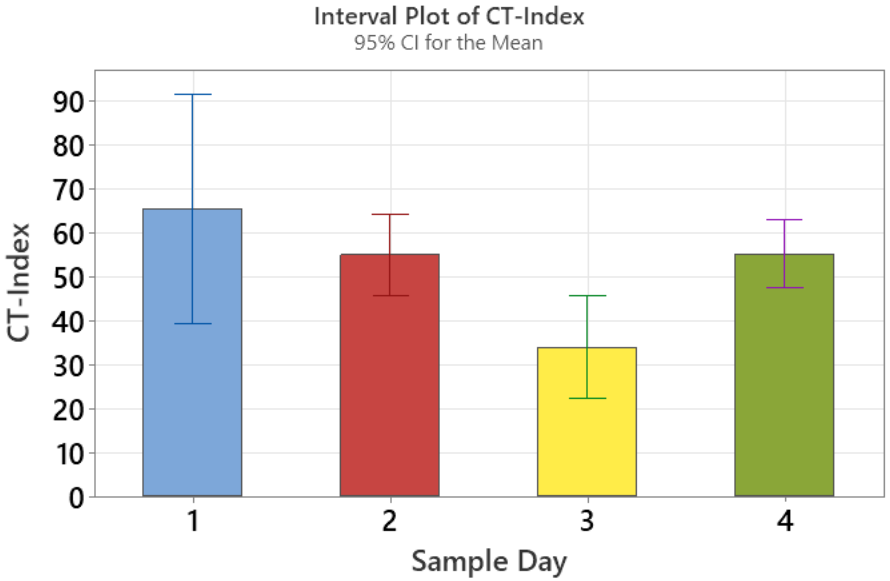
Results & Analysis
Condition Data

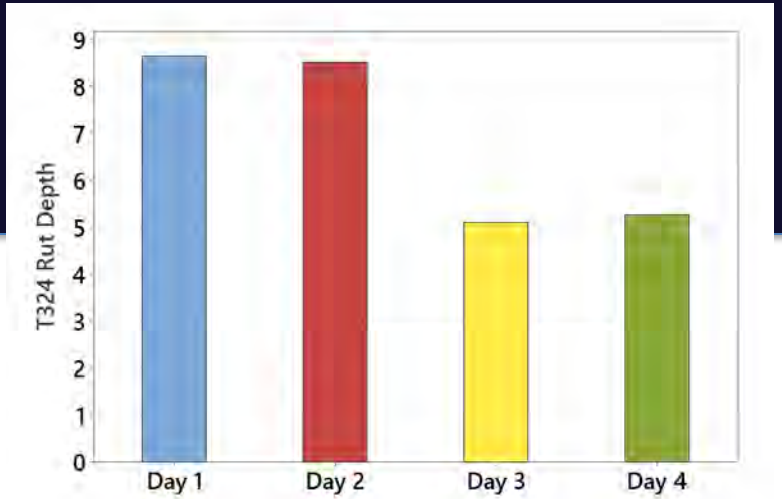


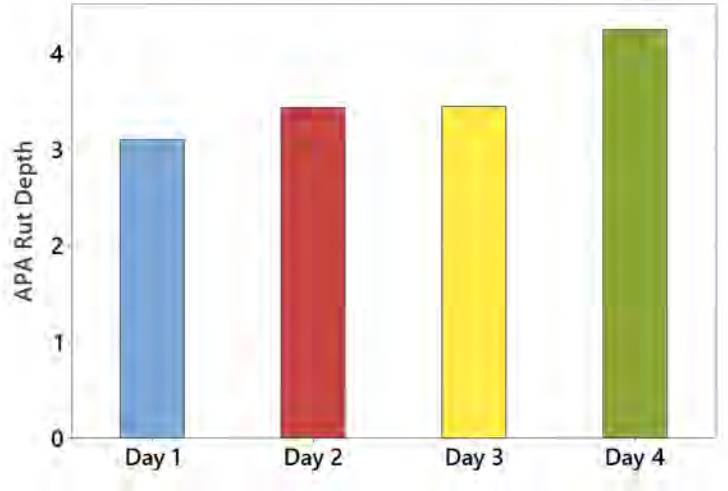


"TBD"
Multi-Day Testing

In 2022, we sampled the same project on 4 separate days



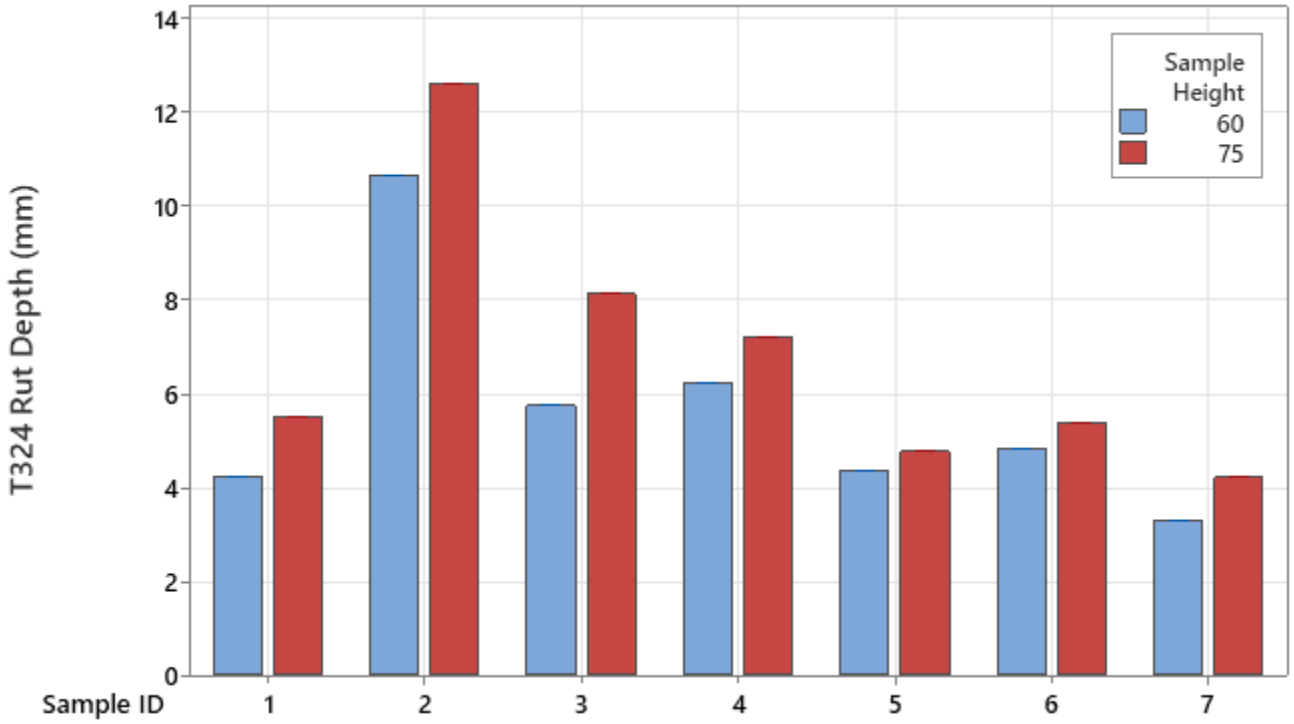




Individual standard deviations are used to calculate the intervals.

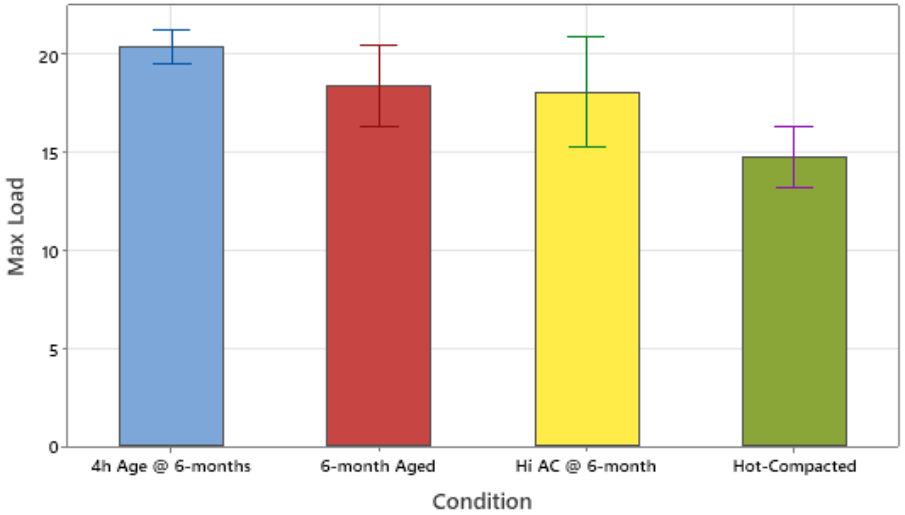
"TBD"
HWTT Sample Thickness

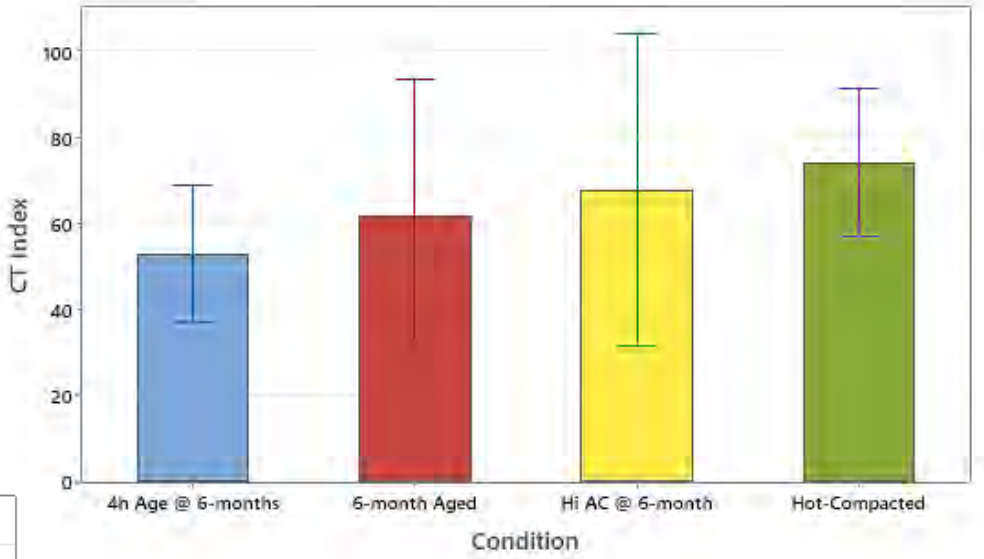
Each red-blue pair is from a single plant sample.



"TBD"
Specimen Lag Time

Plant sample returned hot to our lab
Some material compacted the same day
Also performed several oven-aging protocols





Repeated at 6 months

Attempted to increase AC manually for one sample set (yellow)

Future Work

This testing and analysis has informed a special provision CTDOT will be letting this winter for a summer ‘26 BMD Pilot Project

Questions? Thank you!

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