UDOT Performance Testing, SCB-FI

Howard Anderson, P.E.
UDOT Engineer for Asphalt Materials

FHWA Asphalt Mix ETG
Fall River, MA
May 9, 2018

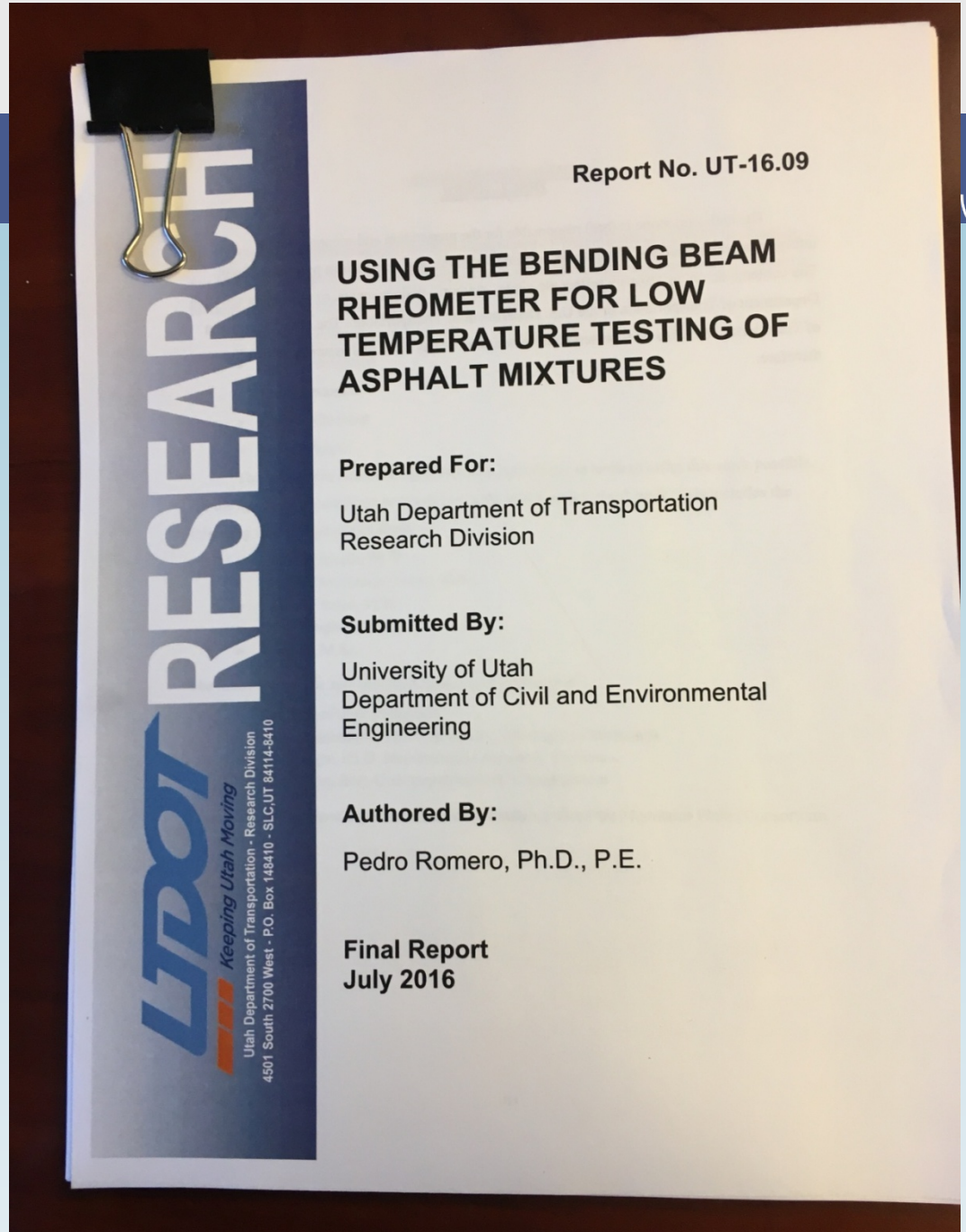
UDOT
Keeping Utah Moving


Photo by Mike Evans

ETG Mtg. SLC (April 2016): Dr. Romero, BBR Research

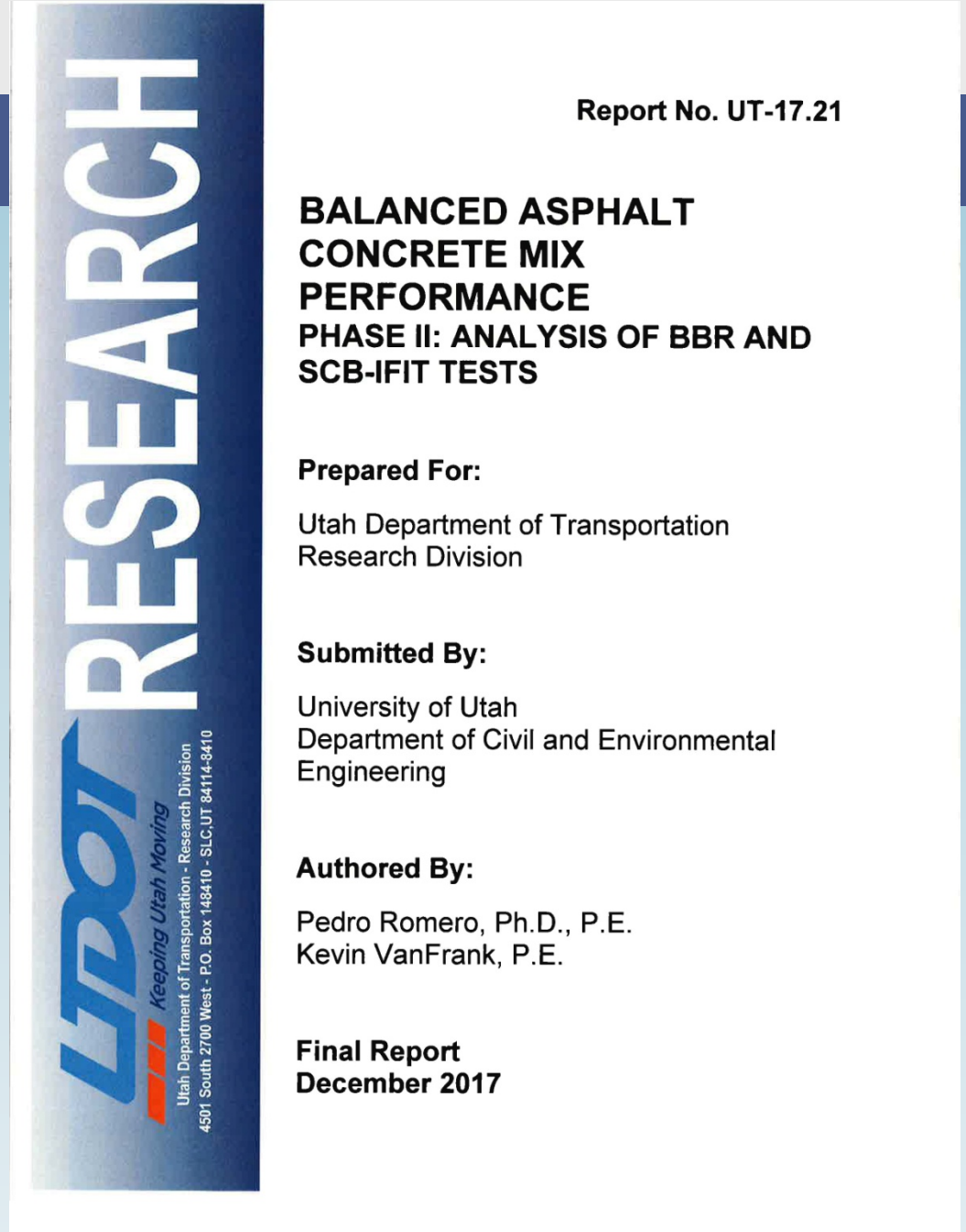
AASHTO TP-125

http://www.udot.utah.gov/main/uconowner.gf?n=29815215897055076



Completed and Ongoing Research

http://www.udot.utah.gov/main/uconowner.gf?n=38759512976096400



Research Goals: SCB-FI Testing

Followed AASHTO TP 124-16

udot.utah.gov

- **Evaluate SCB IFIT Test to see if it distinguish the following for cracking:**
  - **Binder Content**
  - **RAP Content**
  - **Mix Aging**

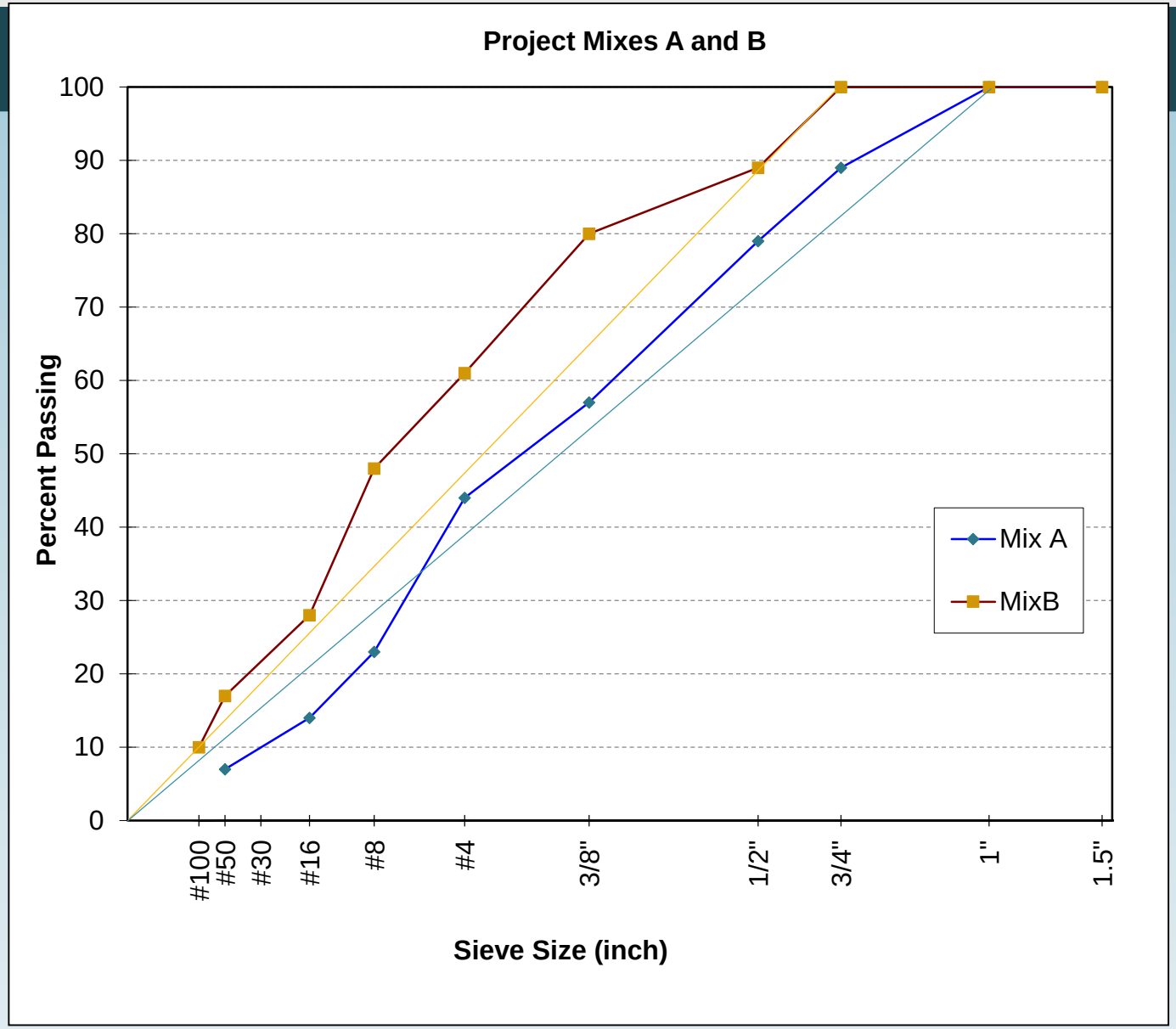
Mix A

- 4.6% Asphalt Binder Content
- ¾ Inch NMA size
- 100 Gyration for N Design
- PG 64-28UT Binder
- Aggregate - Low Absorption Limestone
- 1 percent hydrated lime

Mix B

- 5.25% Asphalt Binder Content
- 1/2 Inch NMA size
- 75 Gyration for N Design
- PG 64-28UT Binder
- Aggregate - Quartzite and Granite
- 1 percent hydrated lime

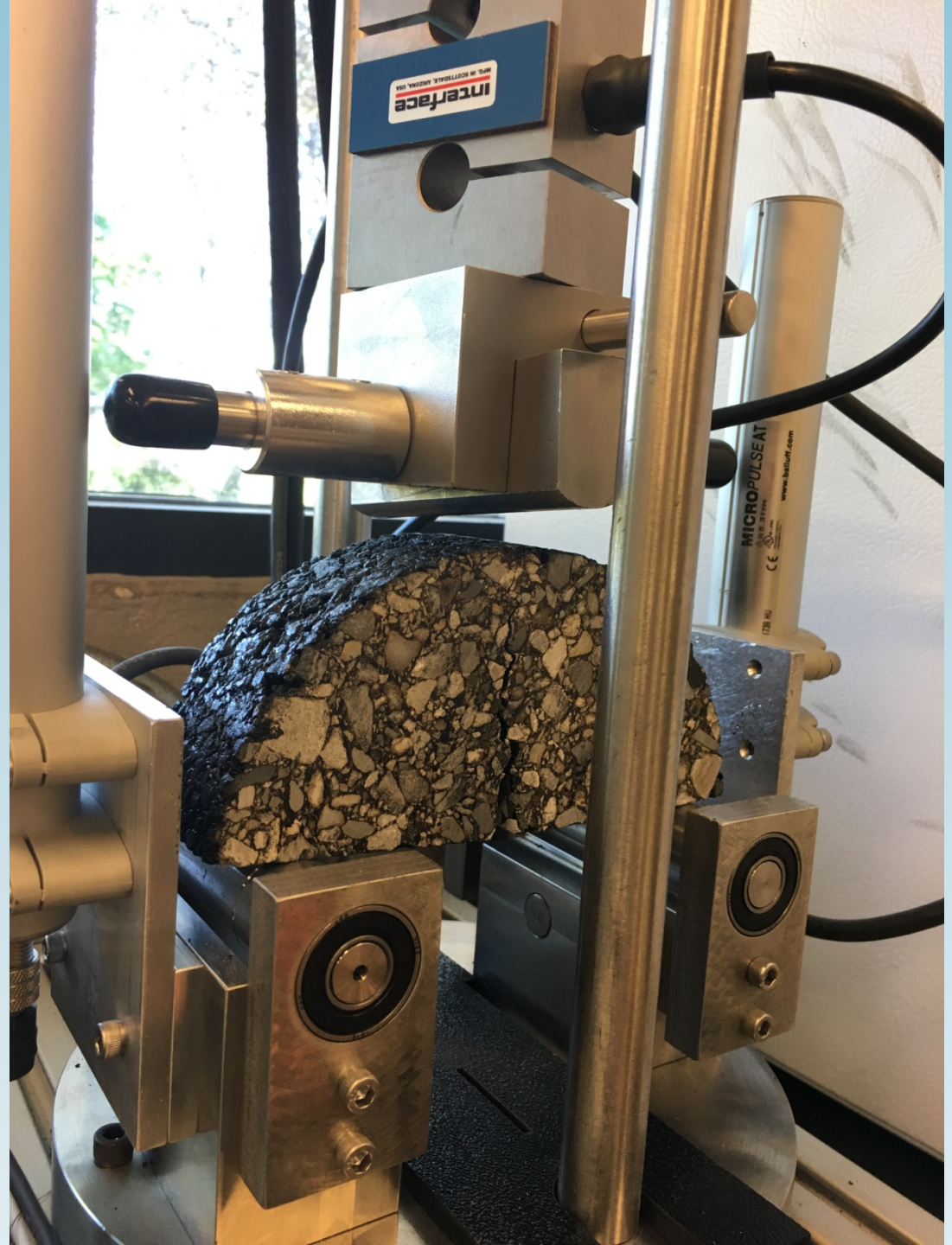
Gradations

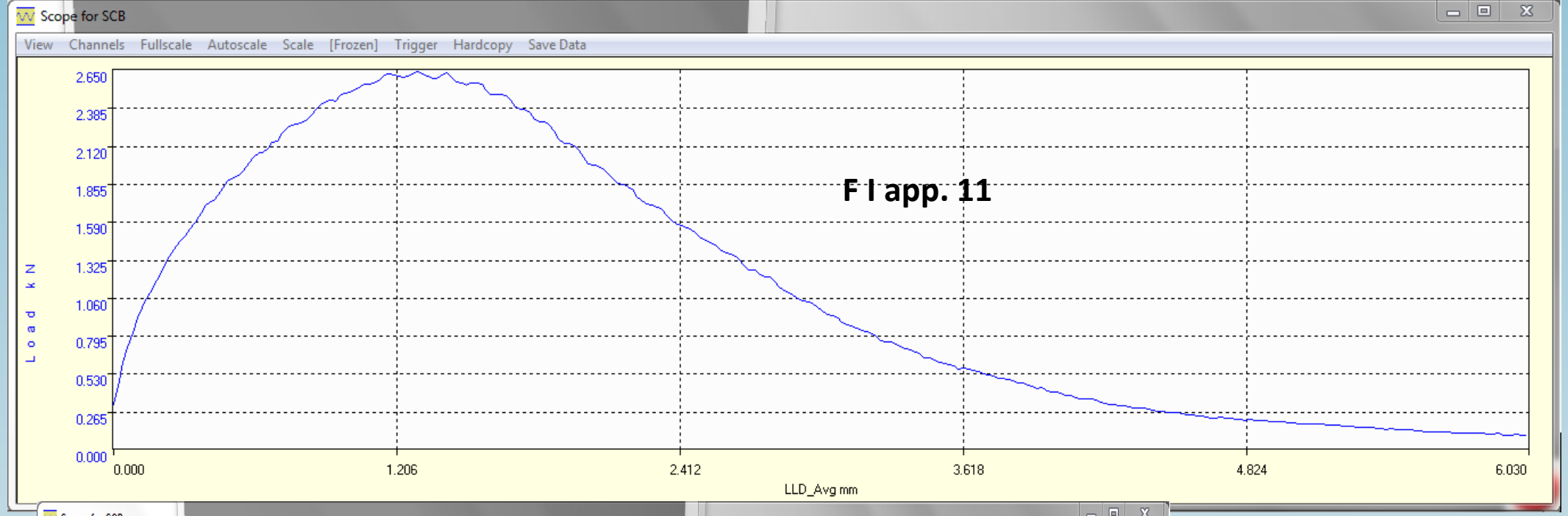

Project Mixes A and B
Percent Passing
100
90
80
70
60
50
40
30
20
10
0
#100
#50
#30
#16
#8
#4
3/8"
1/2"
3/4"
1"
1.5"
Sieve Size (inch)
Mix A
MixB

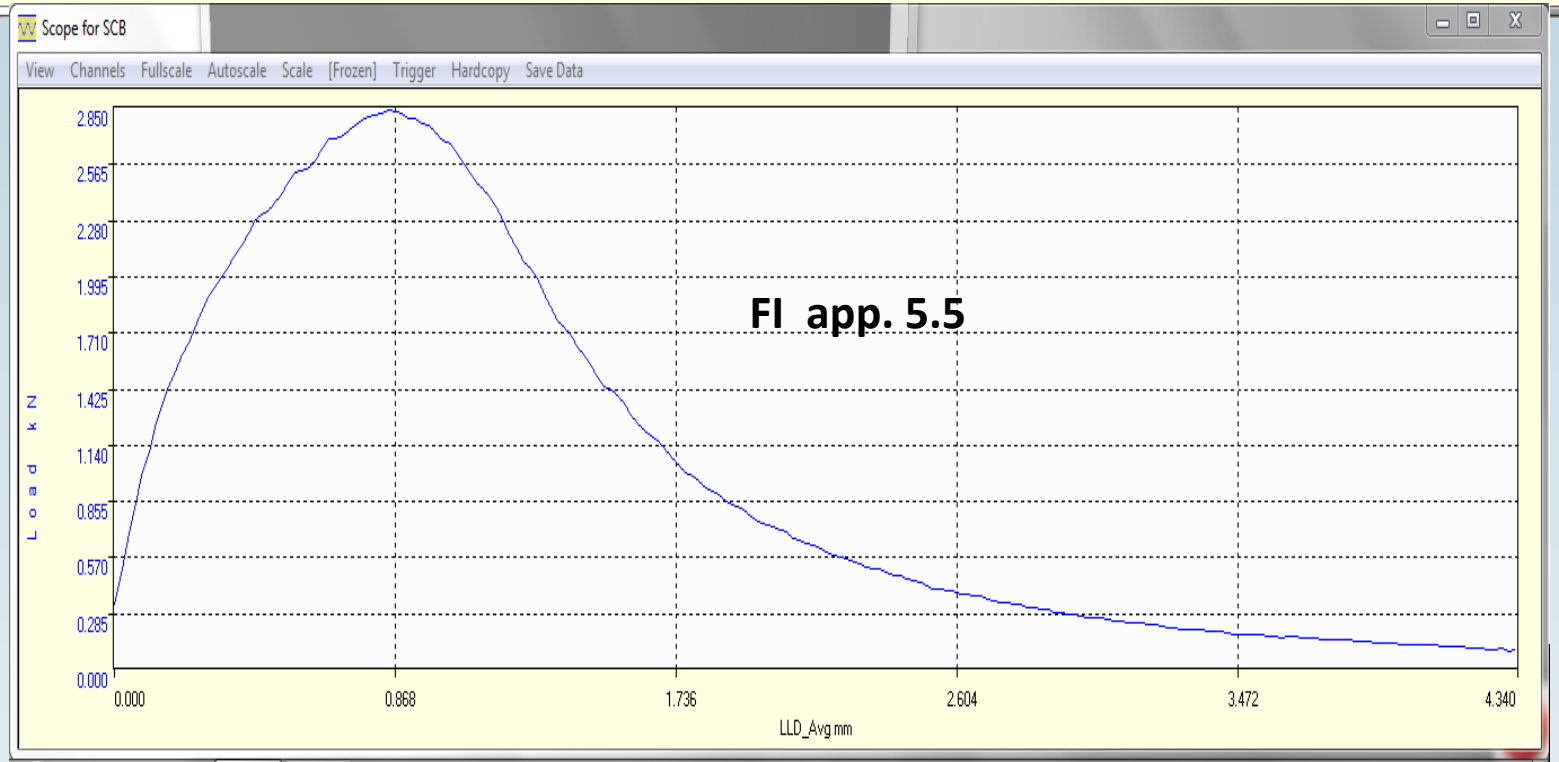
SCB IFIT Sample Preparation and Testing Procedures

- Testing following: AASHTO TP124-16.
- 160 mm tall sample at 7% Voids compacted
- Cut the next day, 4 test sample prepared and tested
- Used saws and templates from TestQuip
- SCB Samples 60 mm thick (not 50 mm)
- Standard Test Rate (50 mm/min) and Temperature (25C)
- Averaged 3 lowest FI's per puck


DYNAMIC MODULUS
AND
FLOW NUMBER
TEST PROCEDURES
TEST QUIP


interface
MICROPULSEAT


Scope for SCB
View Channels Fullscale Autoscale Scale [Frozen] Trigger Hardcopy Save Data
2.650
2.385
2.120
1.855
1.590
1.325
1.060
0.795
0.530
0.265
0.000
Load kN
0.000
1.206
2.412
3.618
4.824
6.030
LLD_Avg mm
FI app. 11


Scope for SCB
View Channels Fullscale Autoscale Scale [Frozen] Trigger Hardcopy Save Data
2.850
2.565
2.280
1.995
1.710
1.425
1.140
0.855
0.570
0.285
0.000
Load kN
0.000
0.868
1.736
2.604
3.472
4.340
LLD_Avg mm
FI app. 5.5

Center Value from Mix Design

Investigated 0.5% above and below the mix target

udot.utah.gov

	Binder Content for Study		
Mix A	**4.1%**	**4.6%**	**5.1%**
Mix B	**4.75%**	**5.25%**	**5.75%**

Flexibility Index
Mix A Binder Sweep

Mix A CME 4.1 Binder

Sample				Reject	Average
1	3.7	3.91	5.05	5.88	4.22
2	7.27	4.31	5.06	11.13	5.55
3	3.73	4.59	5.39	8.17	4.57

Mix A UDOT 4.1 Binder

Sample				Reject	Average
1	6.95	5.14	6.06	9.05	6.05
2	3.98	5.34	3.76	5.48	4.36
3	4.77	5.73	3.62	6.35	4.71

Mix A CME 4.6 Binder

Sample				Reject	Average
1	10.47	9.82	8.73	12.86	9.67
2	9.12	7.37	6.98	10.82	7.82
3	7.17	8.56	11.2	13.94	8.98

Mix A UDOT 4.6 Binder

Sample				Reject	Average
1	6.07	6.21	4.44	7.08	5.57
2	9.96	3.38	8.97	10.14	7.44
3	7.07	6.48	5.04	8.44	6.20

Mix A CME 5.1 Binder

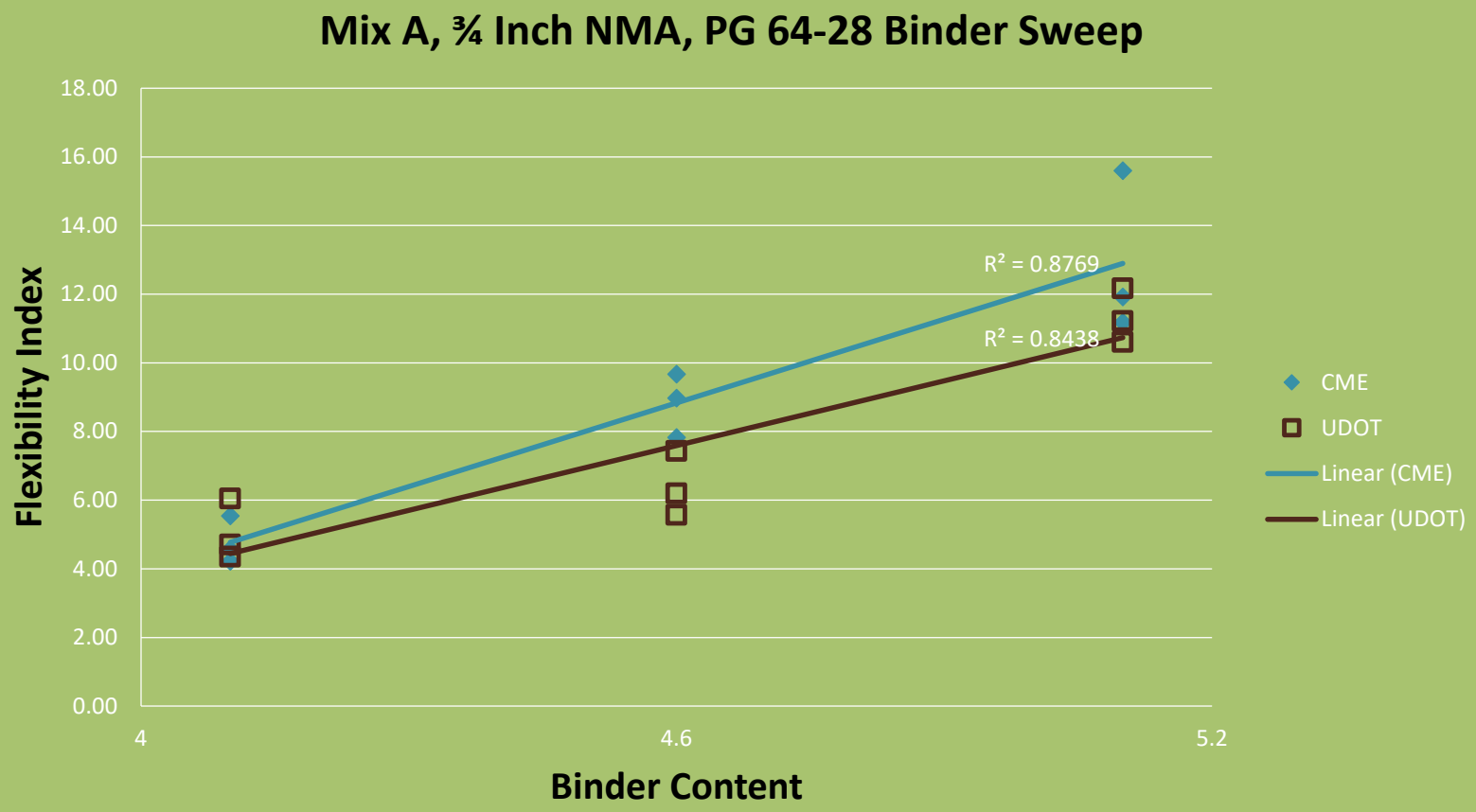
Sample				Reject	Average
1	10.93	13.33	9.29	15.36	11.18
2	16.52	18.52	11.76	20.12	15.60
3	10.77	13.25	11.74	21.66	11.92

Mix A UDOT 5.1 Binder

Sample				Reject	Average
1	8.27	7.65	15.9	17.73	10.61
2	8.83	12.85	11.98	13.32	11.22
					12.17

Flexibility Index, Mix A Binder Sweep

Binder	Stat.	CME	UDOT
4.10	AVE	4.78	5.04
	Stdev	0.69	0.89
	CV	14 %	18%
4.6	AVE	8.82	6.40
	Stdev	0.94	0.95
	CV	14 %	15%
5.1	AVE	12.90	11.33
	Stdev	2.37	0.79
	CV	14%	7.0%


Mix A, ¾ Inch NMA, PG 64-28 Binder Sweep
Flexibility Index
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
4
4.6
5.2
Binder Content
R² = 0.8769
R² = 0.8438
CME
UDOT
Linear (CME)
Linear (UDOT)

Flexibility Index
Mix B Binder Sweep

Mix B CME 4.75

Sample				Reject	Average
1	17.63	18.8	12.89	23.06	16.44
2	14.01	11.12	15.3	19.11	13.48
3	17.45	14.7	10.69	18.43	14.28

Mix B UDOT 4.75

Sample				Reject	Average
1	12.63	9.95	10.77	12.82	11.12
2	15.53	13.05	13.67	15.53	14.08
3	11.16	8.67	12.57	13.83	10.8

Mix B CME 5.25

Sample				Reject	Average
1	33.36	29.96	21.27	52.95	28.20
2	30.63	24.13	18.01	31.14	24.26
3	22.06	21.75	14.66	23.64	19.49

Mix B UDOT G 5.25

Sample				Reject	Average
1	12.65	15.35	15.14	29.78	14.38
2	20.07	19.15	20.32	20.8	19.85
3	20.93	18.31	17.86	28.44	19.03

Mix B CME 5.75

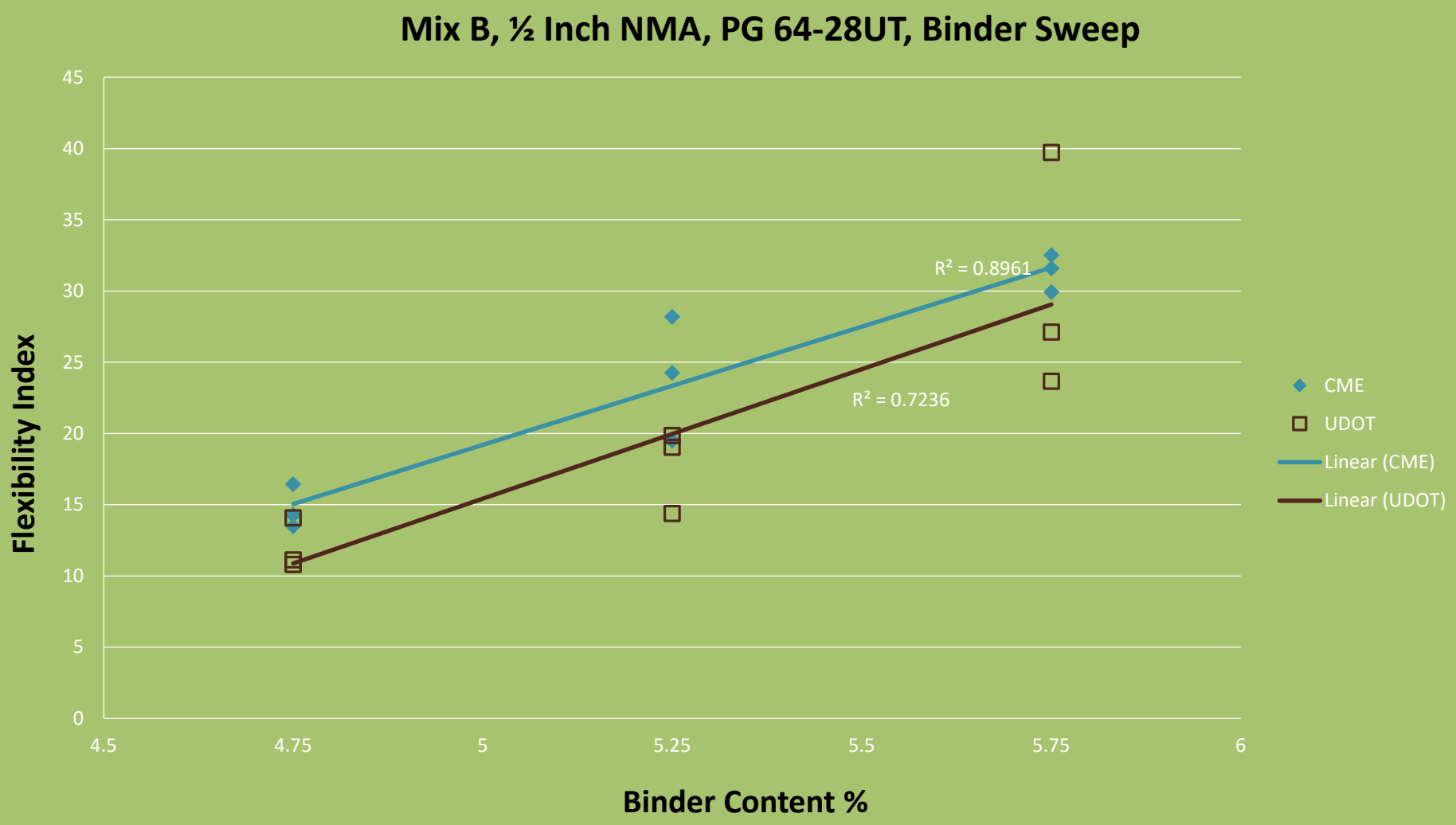
Sample				Reject	Average
1	36.54	18.91	34.31	49	29.92
2	37.28	36.17	21.32	58.46	31.59
3	32.91	31.95	32.72	38.64	32.53

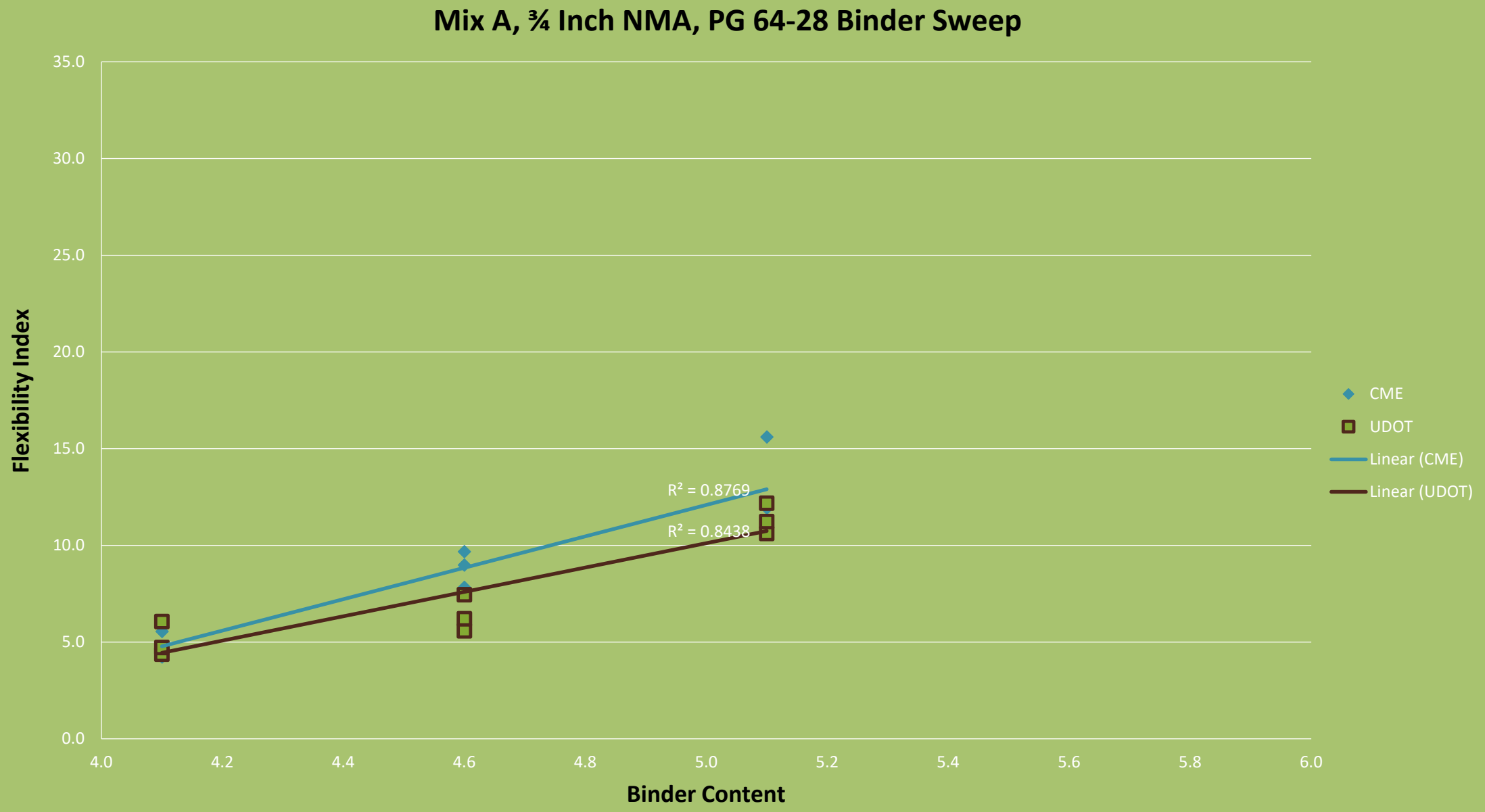
Mix B UDOT 5.75

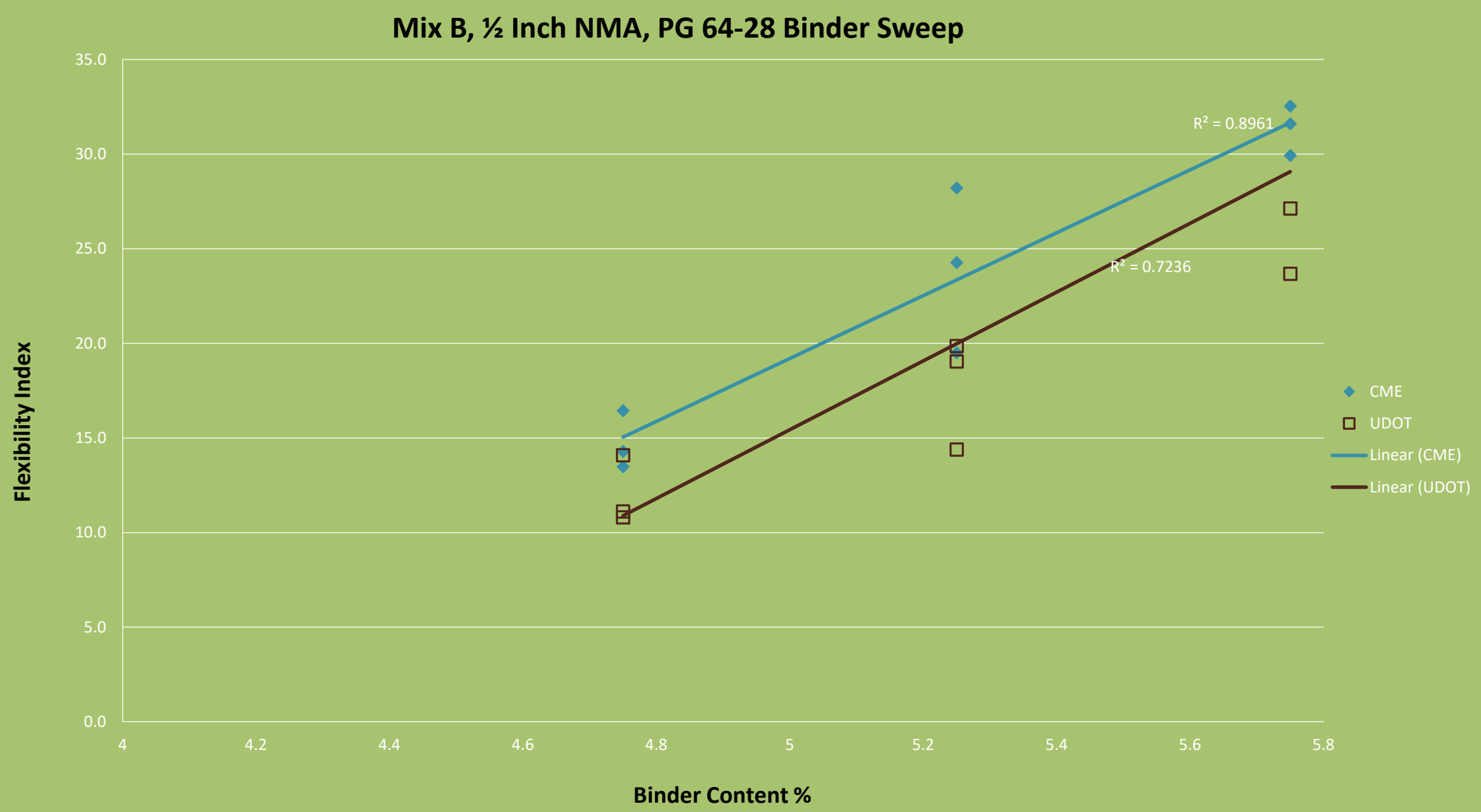
Sample				Reject	Average
1	24.1	25.83	21.08	47.68	23.67
2	37.5	48.8	32.9	63.14	39.73
3	25.34	25.18	30.82	55.27	27.11

Flexibility Index, Mix B Binder Sweep

Binder	Stat.	CME	UDOT
4.75	AVE	14.73	12.00
	Stdev	1.5	1.8
	CV	10%	15%
5.25	AVE	23.98	17.75
	Stdev	4.4	2.9
	CV	18%	17%
5.75	AVE	31.35	30.17
	Stdev	1.3	8.5
	CV	4%	28%


Mix B, ½ Inch NMA, PG 64-28UT, Binder Sweep
Flexibility Index
45
40
35
30
25
20
15
10
5
0
4.5
4.75
5
5.25
5.5
5.75
6
Binder Content %
R² = 0.8961
R² = 0.7236
CME
UDOT
Linear (CME)
Linear (UDOT)


Mix A, ¾ Inch NMA, PG 64-28 Binder Sweep
Flexibility Index
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
4.0
4.2
4.4
4.6
4.8
5.0
5.2
5.4
5.6
5.8
6.0
Binder Content
R² = 0.8769
R² = 0.8438
CME
UDOT
Linear (CME)
Linear (UDOT)


Mix B, ½ Inch NMA, PG 64-28 Binder Sweep
Flexibility Index
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
4
4.2
4.4
4.6
4.8
5
5.2
5.4
5.6
5.8
Binder Content %
R² = 0.8961
R² = 0.7236
CME
UDOT
Linear (CME)
Linear (UDOT)

RAP Content Investigated with Target Binder Content

RAP Binder Subtracted Out of Virgin Binder

	RAP Content				Compacted Aging AASHTO R-30	
Mix A 4.6%	0%	15%	25%	35%	Short (2 hr) 135C	Long (120 hr) 85C
Mix B 5.25%						

Flexibility Index
Mix A RAP Sweep

Short Term Age, Loose Mix 2 Hours at 135C

Mix A CME 0% RAP

Sample				Reject	Average
1	10.47	9.82	8.73	12.86	9.67
2	9.12	7.37	6.98	10.82	7.82
3	7.17	8.56	11.2	13.94	8.98

Mix A CME 15% RAP

Sample				Reject	Average
1	4.52	3.49	3.18	6.1	3.73
2	3.54	3.06	6.04	6.21	4.21
3	5.27	4.96	8.08	32.42	6.10

Mix A CME 25% RAP

Sample				Reject	Average
1	1.69	1.44	1.36	2.06	1.50
2	2.61	1.85	3.41	5.33	2.62
3	2.02	1.88	1.46	3.4	1.79

Mix A CME 35% RAP

Sample				Reject	Average
1	1.57	1.27	2.46	2.46	1.767
2	1.91	1.28	1.21	3.28	1.47
3	1.27	0.87	1.59	1.71	1.24

Long Term Age, Compacted 120 Hours at 85C

Mix A CME 0% RAP

Sample				Reject	Average
1	7.26	8.76	7.07	10.04	7.70
2	7.79	7.93	6.01	8.39	7.24
3	6.94	11.7	5.92	12.53	8.19

Mix A CME 15% RAP

Sample				Reject	Average
1	3.77	2.13	3.57	4.23	3.16
2	2.64	2.78	2.72	4.49	2.71
3	2.8	2.09	2.39	3.42	2.43

Mix A CME 25% RAP

Sample				Reject	Average
1	3.67	2.75	2.25	3.77	2.89
2	1.47	0.72	1.26	2.47	1.15
3	1.47	1.5	1.26	3.33	1.41

Mix A CME 35% RAP

Sample				Reject	Average
1	0.8	0.59	0.62	0.99	0.67
2	0.79	1.12	1.12	1.51	1.01
3	1.11	1.01	0.85	1.44	0.99

Short Term Age, Loose Mix 2 Hours at 135C

Mix A UDOT S 0% RAP

Sample				Reject	Average
1	6.07	6.21	4.44	7.08	5.57
2	9.96	3.38	8.97	10.14	7.44
3	7.07	6.48	5.04	8.44	6.20

Mix A UDOT 15% RAP

Sample				Reject	Average
1	2.27	3.86	2.88	3.97	3.00
2	2.92	2.9	3.05	4.9	2.96
3	3.5	3.04	4.52	4.58	3.69

Mix A UDOT 25% RAP

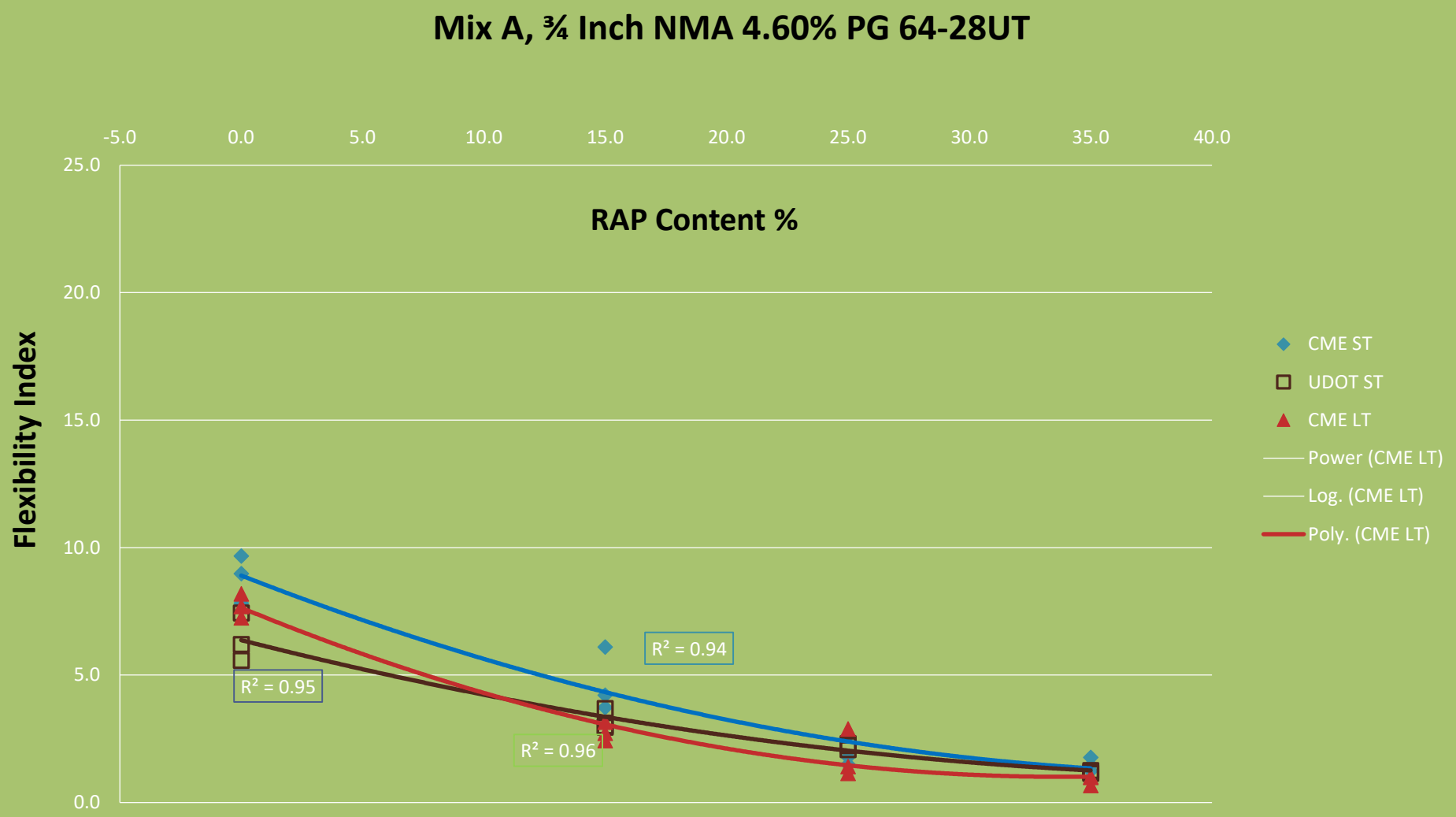
Sample				Reject	Average
1	2.01	1.88	2.35	3.45	2.08
2	2.49	2.13	2.09	2.76	2.24
3	2.63	2.27	2.03	3.27	2.31

Mix A UDOT 35% RAP

Sample				Reject	Average
1	0.94	1.41	1.41	1.71	1.25
2	1.38	0.88	1.31	1.99	1.19
3	1.14	1.42	0.87	1.9	1.14

Flexibility Index, Mix A Rap Sweep

% RAP		CME ST	CME LT	UDOT ST
0	AVE	8.82	7.71	6.40
	Stdev	0.9	0.5	0.9
	CV	11%	6%	15%
15	AVE	4.68	2.77	3.22
	Stdev	1.3	0.4	0.4
	CV	27%	13%	13%
25	AVE	1.97	1.82	2.21
	Stdev	0.6	0.9	0.1
	CV	30%	52%	5%
35	AVE	1.49	0.89	1.20
	Stdev	0.3	0.2	0.1
	CV	18%	21%	5%


Mix A, ¾ Inch NMA 4.60% PG 64-28UT
RAP Content %
Flexibility Index
-5.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
25.0
20.0
15.0
10.0
5.0
0.0
R² = 0.95
R² = 0.96
R² = 0.94
CME ST
UDOT ST
CME LT
Power (CME LT)
Log. (CME LT)
Poly. (CME LT)

Flexibility Index
Mix B RAP Sweep

Short Term Age
Loose Mix

2 Hours at 135C

Mix B CME 0% RAP

Sample				Reject	Average
1	30.63	24.13	18.01	31.14	24.26
2	22.06	21.75	14.66	23.64	19.49
3	28.51	19.64	29.63	35.2	25.93

Mix B CME 15% RAP

Sample				Reject	Average
1	10.02	16.9	11.82	23.06	12.91
2	15.18	13.24	14.02	19.11	14.15
3	10.73	11.74	11.06	18.43	11.18

Mix B CME 25% RAP

Sample				Reject	Average
1	14.8	9.02	11.03	12.96	11.62
2	8.18	9.94	9.13	11.77	9.08
3	4.42	4.42	12.58	14.3	7.14

Mix B CME 35% RAP

Sample				Reject	Average
1	5.97	5.59	5.51	7.32	5.69
2	5.59	6.55	6.95	7.67	6.36
3	3.5	4.9	4.47	4.93	4.29

Long Term Age
Compacted

120 Hours at 85C

Mix B CME 0% RAP

Sample				Reject	Average
1	14.47	12.5	19.16	20.68	15.38
2	23.04	11.62	25.47	32.54	20.04
3	13.9	12.98	15.65	20.61	14.18

Mix B CME 15% RAP

Sample				Reject	Average
1	7.85	10.32	7.93	11.25	8.70
2	7.31	10.61	6.15	12.6	8.02
3	5.68	7.34	7.72	8.74	6.91

Mix B CME 25% RAP

Sample				Reject	Average
1	6.45	5.18	5.92	8.22	5.85
2	4.68	7.95	5.67	6.24	6.10
3	3.98	7.59	7.04	11.03	6.20

Mix B CME 35% RAP

Sample				Reject	Average
1	3.71	4.28	5.91	58.11	4.63
2	3.44	2.24	4.18	4.39	3.29
3	2.27	3.88	5.37	5.42	3.84

Short Term Age
Loose Mix

2 Hours at 135C

Mix B UDOT 0% RAP

Sample				Reject	Average
1	12.65	15.35	15.14	29.78	14.38
2	20.07	19.15	20.32	20.8	19.85
3	20.93	18.31	17.86	28.44	19.03

Mix B UDOT 15% RAP

Sample				Reject	Average
1	10.12	9.75	10.18	11.5	10.02
2	16.21	12.12	7.69	18.24	12.01
3	11.3	9.47	12.54	15.47	11.10

Mix B UDOT 25% RAP

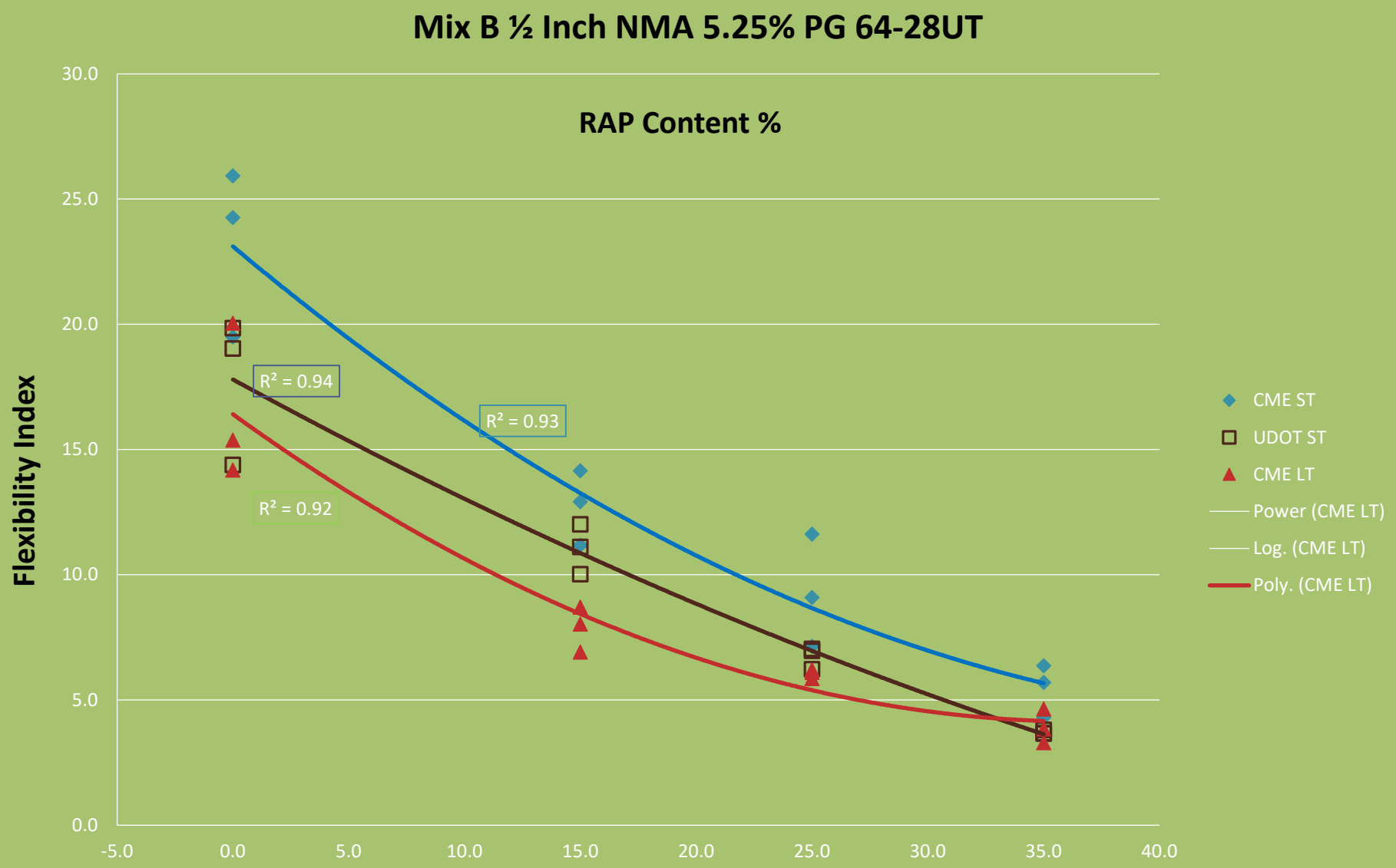
Sample				Reject	Average
1	6.04	5.7	6.92	9.55	6.22
2	8.15	6.5	6.23	10.16	6.96
3	8.17	5.19	7.76	11.83	7.04

Mix B UDOT 35% RAP

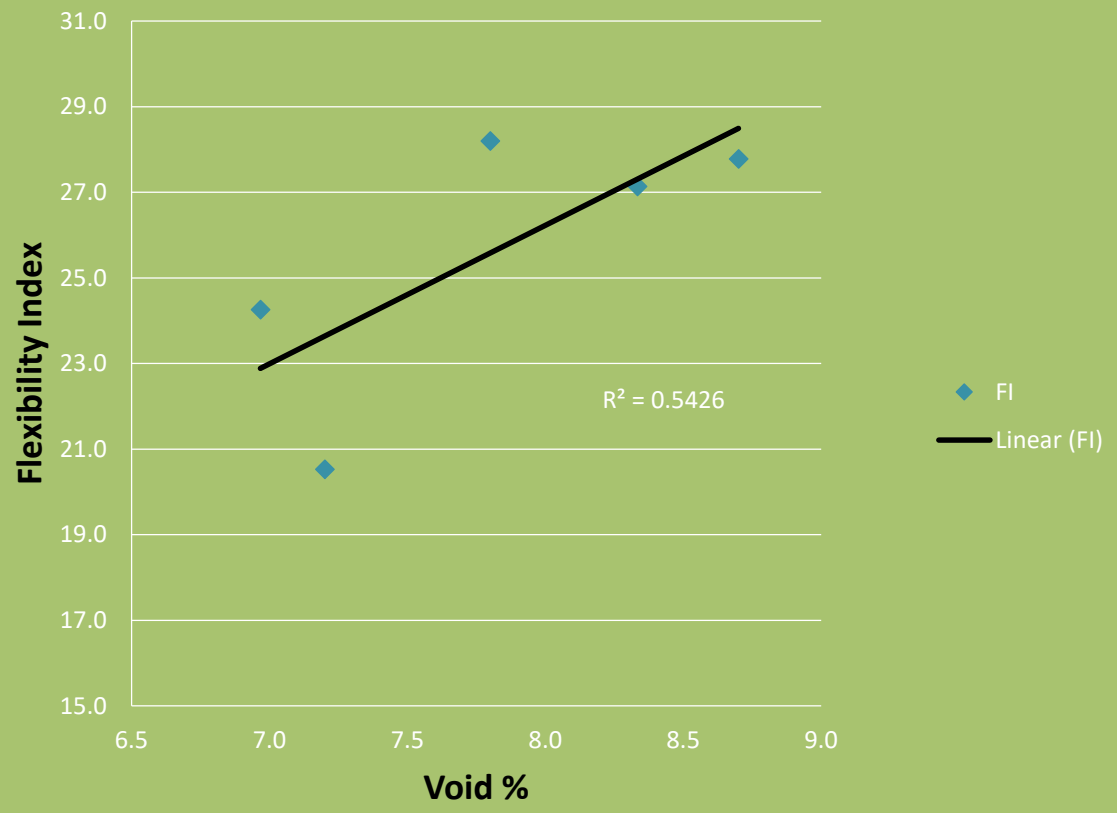
Sample				Reject	Average
1	3.84	4.14	3.43	4.38	3.80
2	2.8	4.07	4.14	5.46	3.67
3	4.36	3.51	3.09	5.21	3.65

Flexibility Index, Mix B Rap Sweep

% RAP		CME ST	CME LT	UDOT ST
0	AVE	23.22	16.53	17.75
	Stdev	3.3	3.1	2.9
	CV	14%	19%	17%
15	AVE	12.75	7.88	11.04
	Stdev	1.5	0.9	1.0
	CV	12%	11%	9%
25	AVE	9.28	6.05	6.74
	Stdev	2.2	0.2	0.5
	CV	24%	3%	7%
35	AVE	5.45	3.92	3.71
	Stdev	1.1	0.7	0.1
	CV	19%	17%	2%


Mix B ½ Inch NMA 5.25% PG 64-28UT
RAP Content %
Flexibility Index
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
R² = 0.94
R² = 0.93
R² = 0.92
CME ST
UDOT ST
CME LT
Power (CME LT)
Log. (CME LT)
Poly. (CME LT)

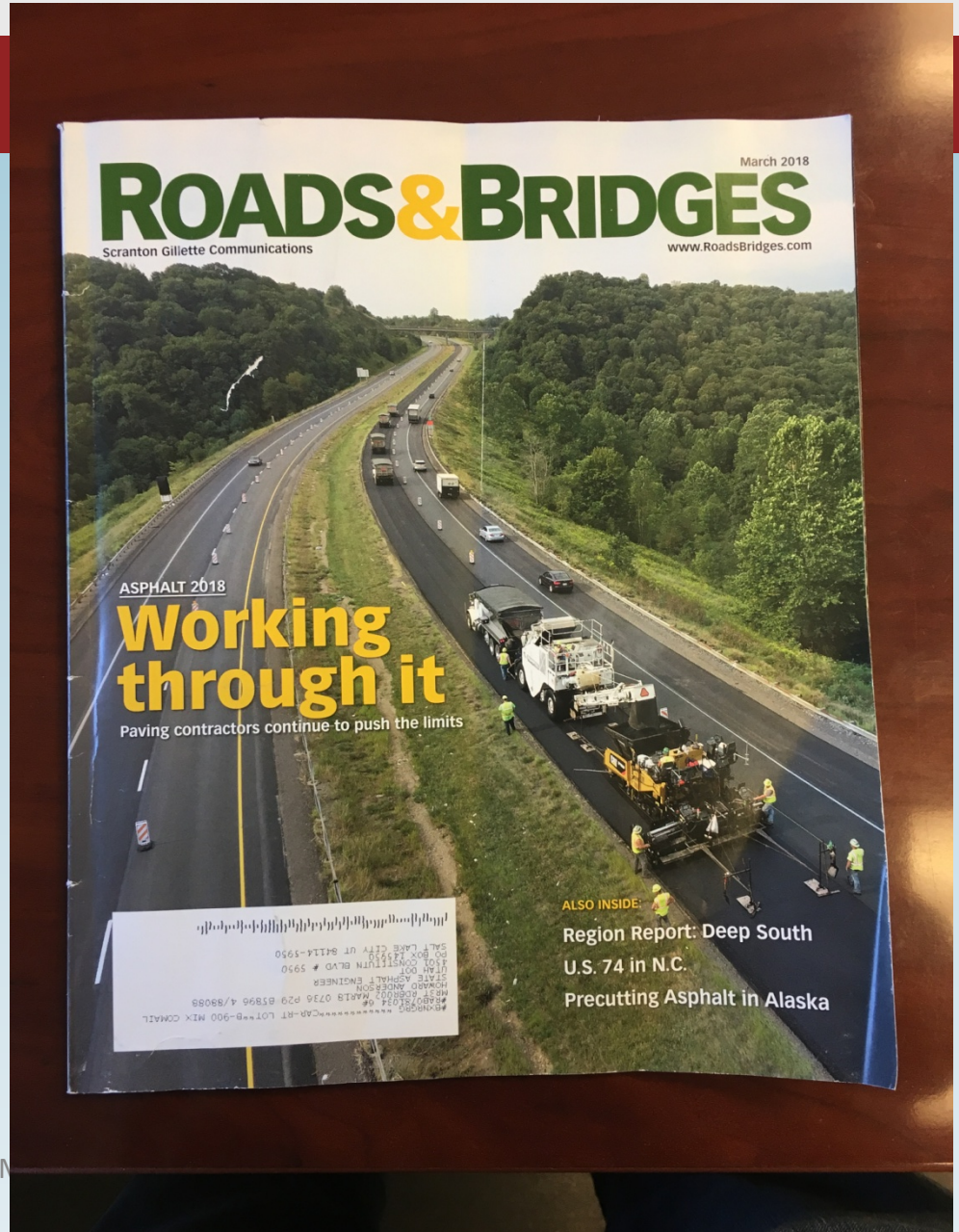
Flexibility Index vs Voids, Mix B

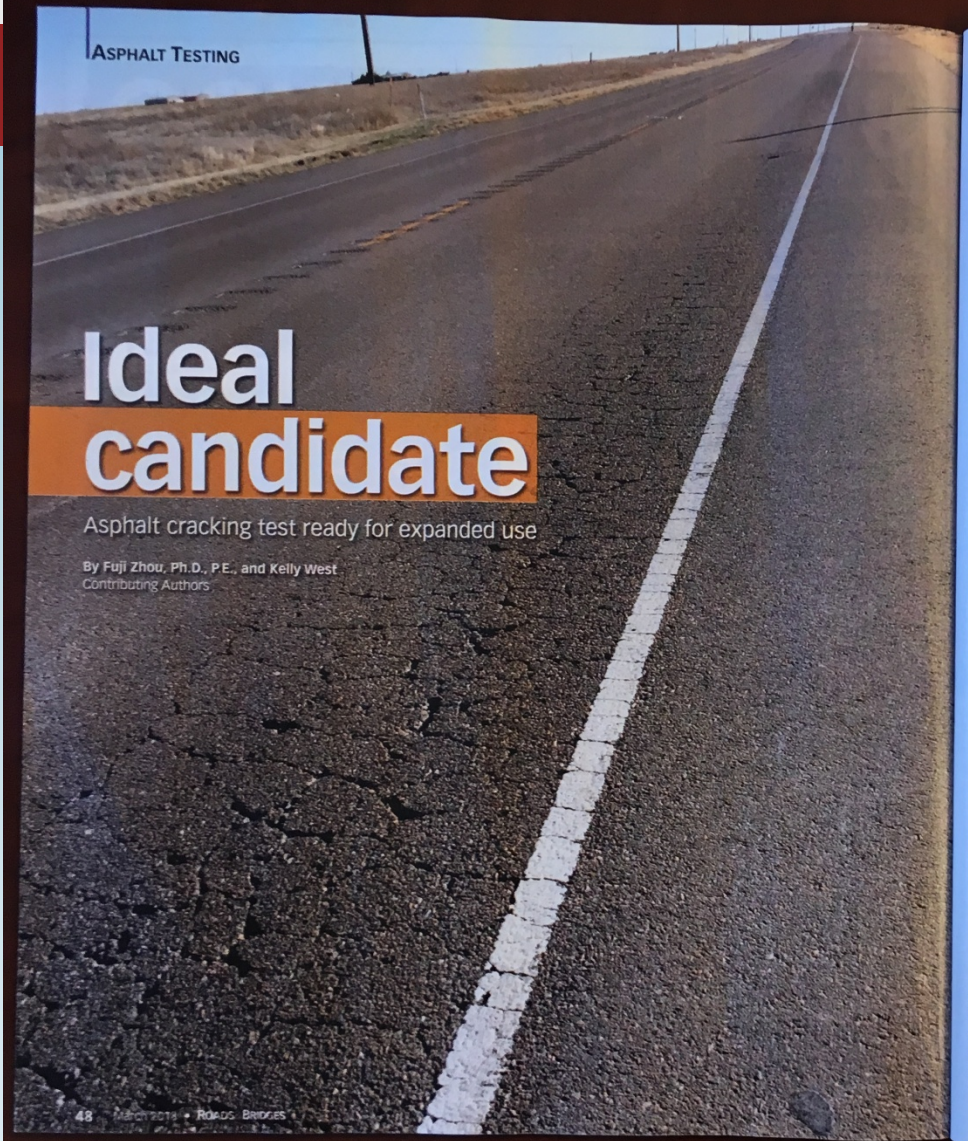


Next UDOT Funded Research

Evaluate the IDEAL Test

- Ideal Test has some advantages
- Compare with SCB results





Ideal candidate

Asphalt cracking test ready for expanded use

By Fujie Zhou, Ph.D., P.E., and Kelly West
Contributing Authors

Nationwide, all state departments of transportation (DOTs) have long dealt with the problem of asphalt cracking, which is the primary type of distress that creates the need for pavement rehabilitation.

With a focus in recent years on making asphalt mixes more affordable, the use of recycled materials and binder modifications has grown, thus increasing complaints that these mixes are even more susceptible to cracking. Many cracking tests have been developed in the past, but no single test is simple, practical, repeatable, and adequately performance-related. For a long time now, there has been a real need for a practical cracking test to be used routinely in the process of asphalt mix design, quality control (QC) and quality assurance (QA) testing.

Recently, the Texas A&M Transportation Institute (TTI) developed and validated an Indirect Tension Asphalt Cracking Test (IDEAL-CT) under NCHRP IDEA Project 195. Thorough lab and field testing presents strong evidence that the test meets standards set in NCHRP 9-57, which has identified seven desirable features for an ideal cracking test:

- Simplicity: No instrumentation, cutting, gluing, drilling, or notching to specimen;
- Practicality: Minimum training needed for routine operation;
- Efficiency: Test completion within one minute;
- Test equipment: Cost less than $10,000;
- Repeatability: Coefficient of variation (COV) less than 25%;
- Sensitivity: Sensitive to asphalt mix composition (aggregates, binder, etc.); and
- Correlation to field performance: Good correlation with field cracking.

The IDEAL-CT is now ready for the next phase of expanded lab and field testing. It is available to contractors, DOTs, and even researchers in academia to routinely use in mix designs and QC/QA. This article highlights a basic description of the test and how it was developed and validated.

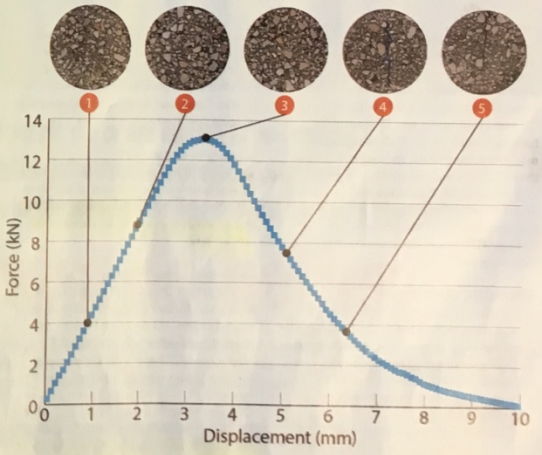
What the test covers

The IDEAL-CT is similar to the traditional indirect tensile strength test, and it is run at room temperature with cylindrical specimens at a loading rate of 50 mm/minute. Any size of cylindrical specimens with various diameters (100 or 150 mm) and thicknesses (38, 50, 62, 75 mm, etc.) can be tested. For mix design and laboratory QC/QA in this study, researchers used the same size specimen as the Hamburg wheel tracking test: 150 mm diameter and 62 mm height with 7±0.5% air voids, since agencies are familiar with molding such specimens. Either lab-molded cylindrical specimens or field cores can be directly tested with no need for instrumentation, gluing, cutting, notching, coring or any other preparation. Below is a typical IDEAL-CT: cylindrical specimen, test fixture, test temperature, loading rate, and the measured load vs. displacement curve.

How is the test performed?

1. Mold three to five of these cylindrical specimens in a Superpave gyratory compactor with target air voids of 7±0.5%. Prior to compaction, loose mix is short-term aged in an oven for four hours at 135°C;
2. Condition the specimens for a certain time (i.e., two hours) at testing temperature (such as 25°C);
3. To run the test, enter necessary specimen information and place and align the specimen in the loading frame. Then load the specimen at a constant deformation rate of 50 mm/minute until fracture failure occurs; and
4. The software provided with the IDEAL-CT system continuously records the load and vertical deformation and automatically calculates the Cracking Test Index or CT-index. The larger the CT-index, the better the cracking resistance.

Because the test does not require additional cutting, notching, drilling, gluing, and further instrumentation, the IDEAL-CT automatically meets the top two desirable features: simplicity and practicality. With the loading rate at 50 mm/minute, and the test time within one minute, the need for



A typical IDEAL-CT showing the specimen samples and measured load vs. displacement curve.

Questions?