

"Long Term Validation of an Accelerated Polishing Test Procedure for HMA Pavement"

SJN: 134413

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**Email Questions To:
Research@dot.state.oh.us**

Outline

- Background
- Objectives of Study
- Accelerated Polishing Machine
- Laboratory Test Procedure and Results
- Field Testing Procedure and Results
- Predictive Models for SN(64)R
- Predictive Model for F60
- Application Example
- Conclusions

- Skid resistance is a statistically significant factor in explaining the wet accident rate. Thesis (Jeffrey, S. Kuttesch., 2004)
- It has been reported that wet pavements are involved in approximately 25 percent of all crashes and 14 percent of all fatal crashes. (Julian, F., and Moler, S., 2008)

Skid Number Requirements

Agency	SN	Speed (mph)/Type of Tire
FDOT Safety Improvement Program Manual	■ >= 35 ■ >= 30	■ > 45/(Ribbed) ■ < 45/(Ribbed)
OKDOT	■ >= 35	■ REGARDLESS/(Ribbed)
NYDOT	■ >= 32	■ 40/(Ribbed)
ODOT*	■ >= 32 ■ >= 23	■ 40/(Ribbed) ■ 40/(Smooth)
INDOT	■ >= 20	■ 40/(Smooth)
NCHRP-37	■ >= 37	■ REGARDLESS/(Ribbed)

* Relationship between SN and Wet -Accident location, State Job Number 134323, November 2008

Objectives of the Study

- Develop an Accelerated Polishing Machine and Testing Procedure for Screening Purpose
- Develop Laboratory Based Procedure to Predict Friction Behavior of In-Service Asphalt Pavement Surfaces

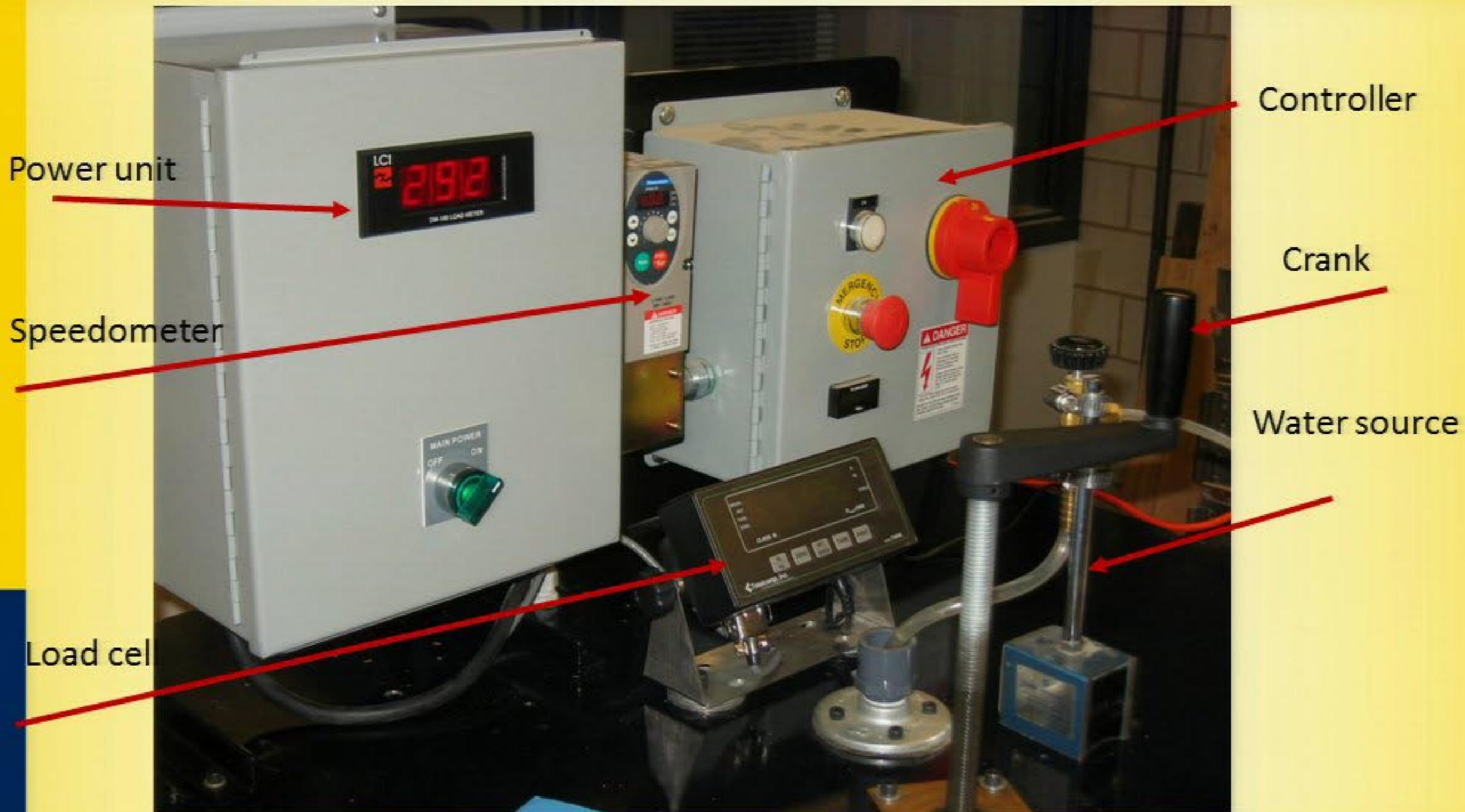
ODOT Requirements for Accelerated Polishing Machine

1. Small-size HMA specimens (i.e., 6" gyratory compacted specimens)
2. Short test duration
3. Simple test procedure
4. Efficient test method (less labor efforts)
5. Simulate tire polishing action

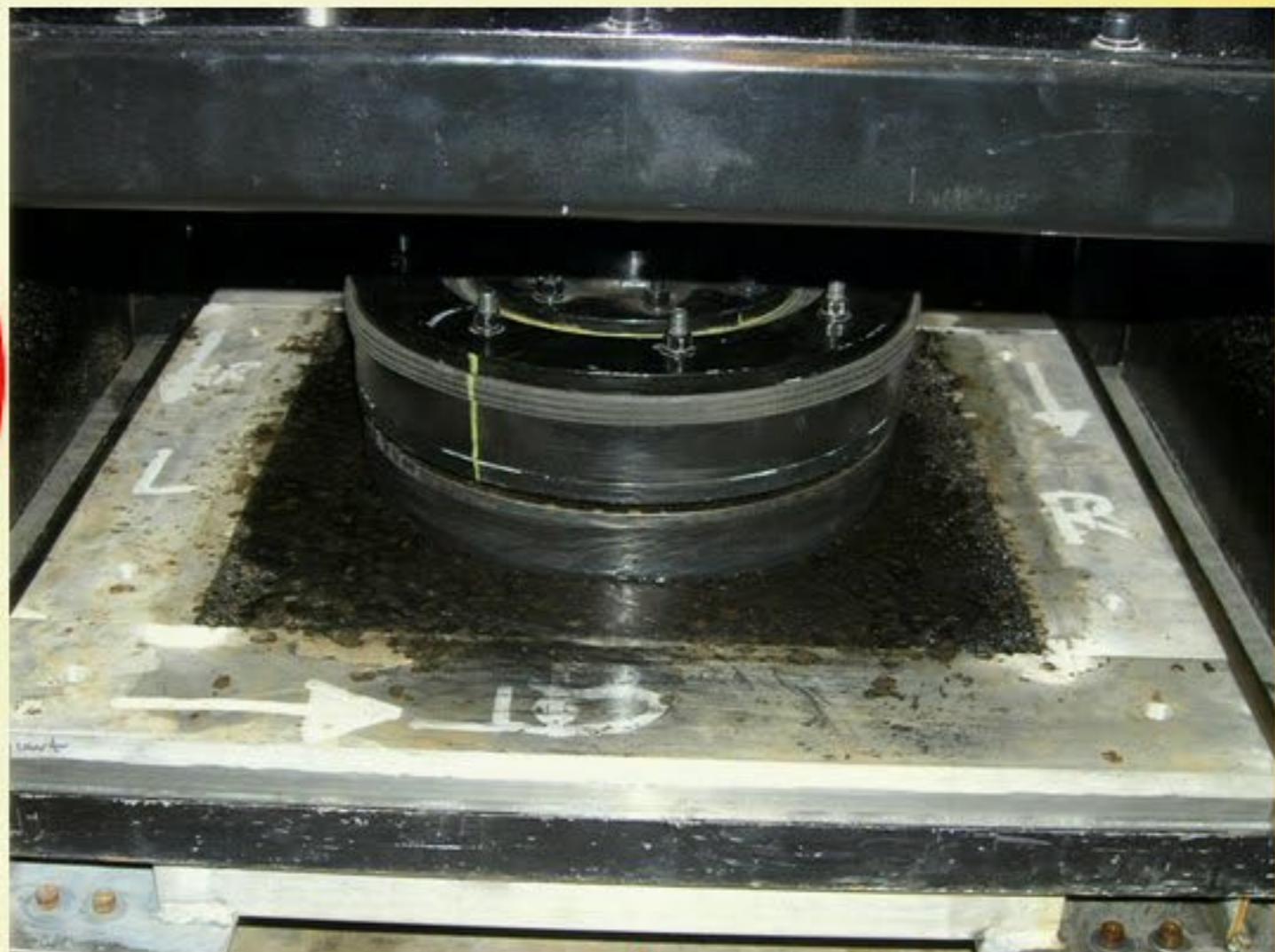
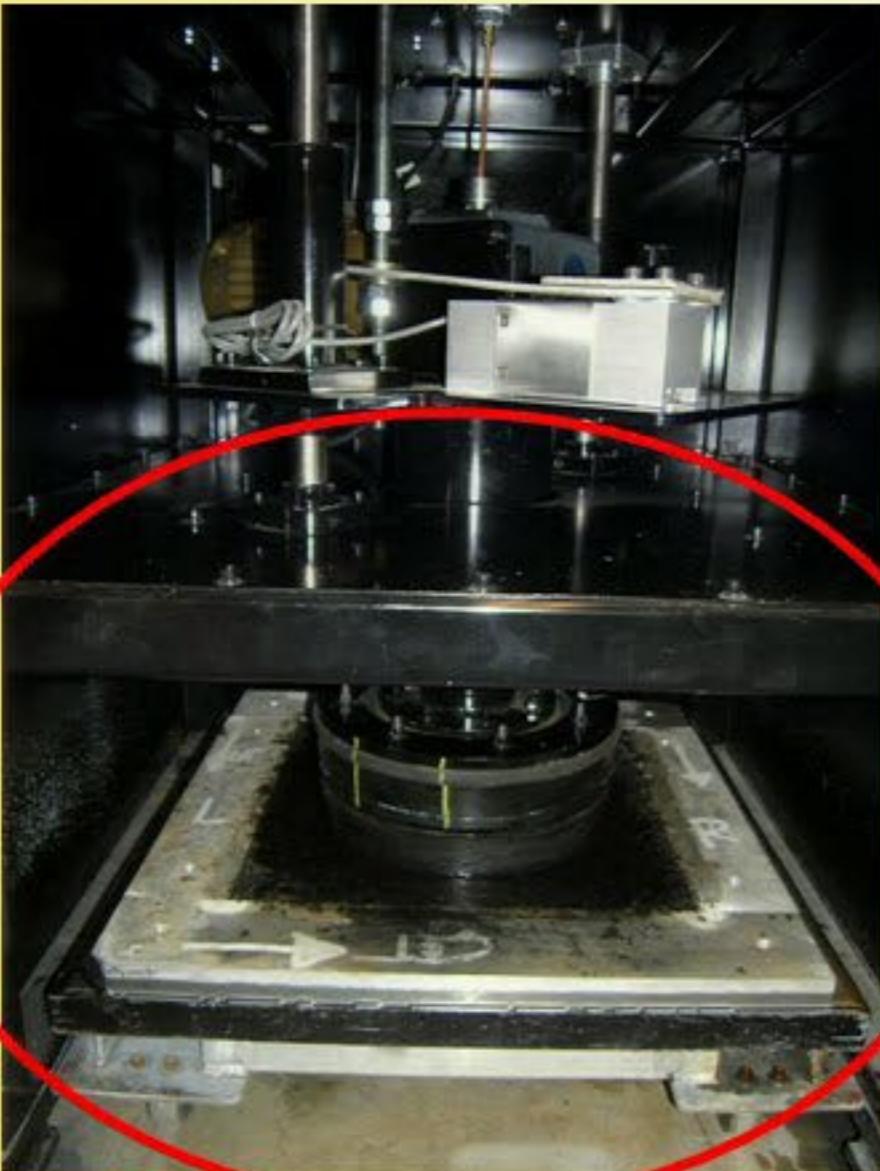
Research Grade Accelerated Polishing Machine



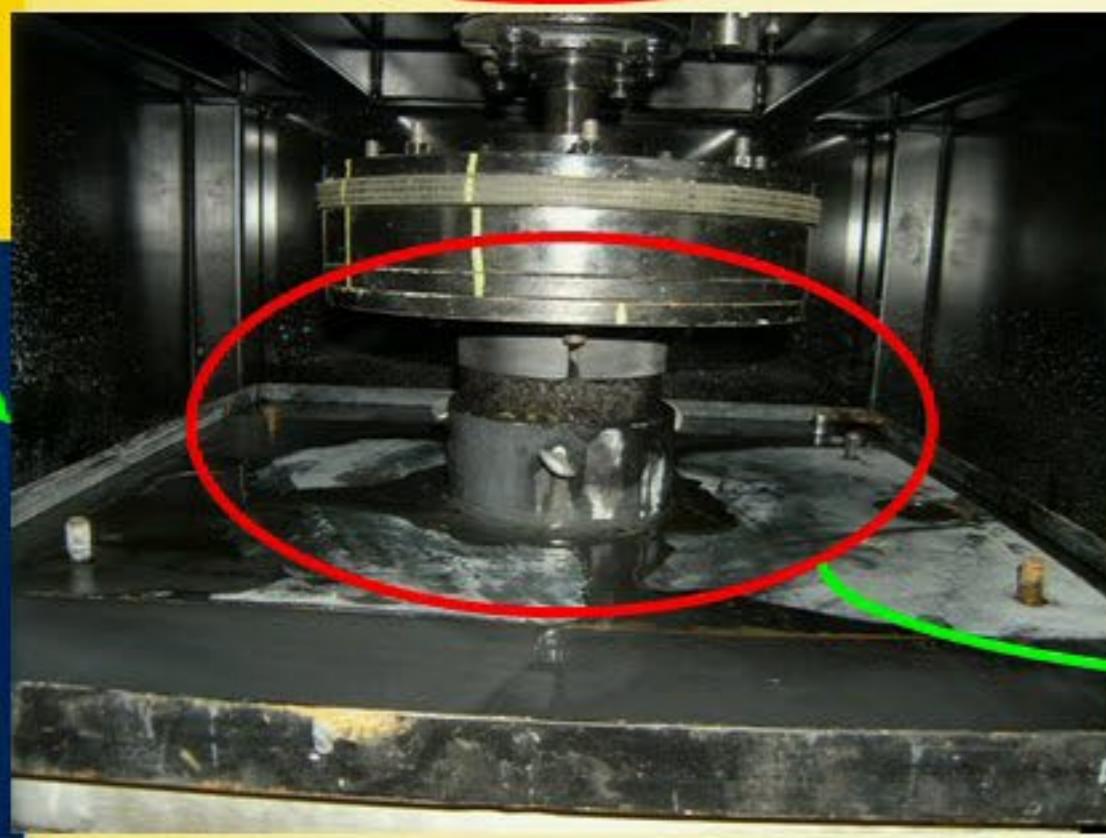
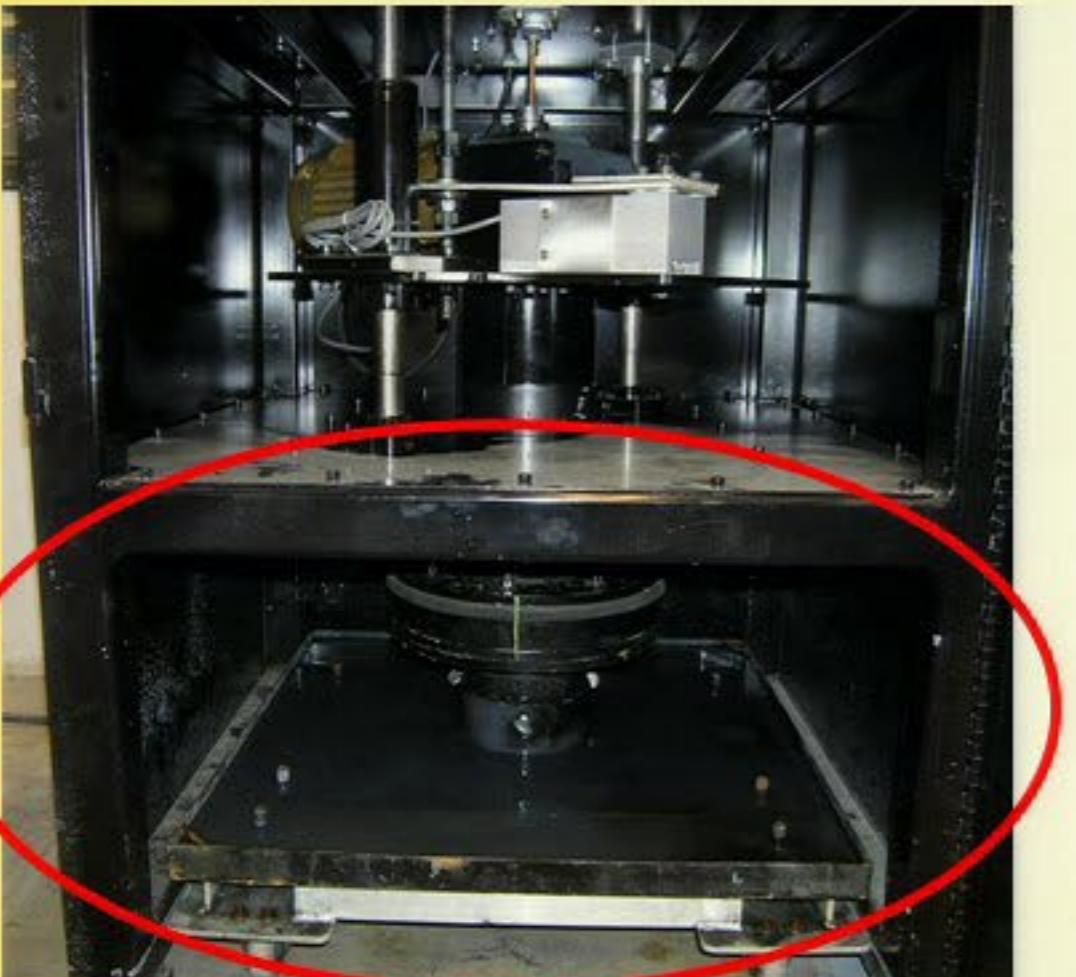
UA Accelerated Polishing Machine



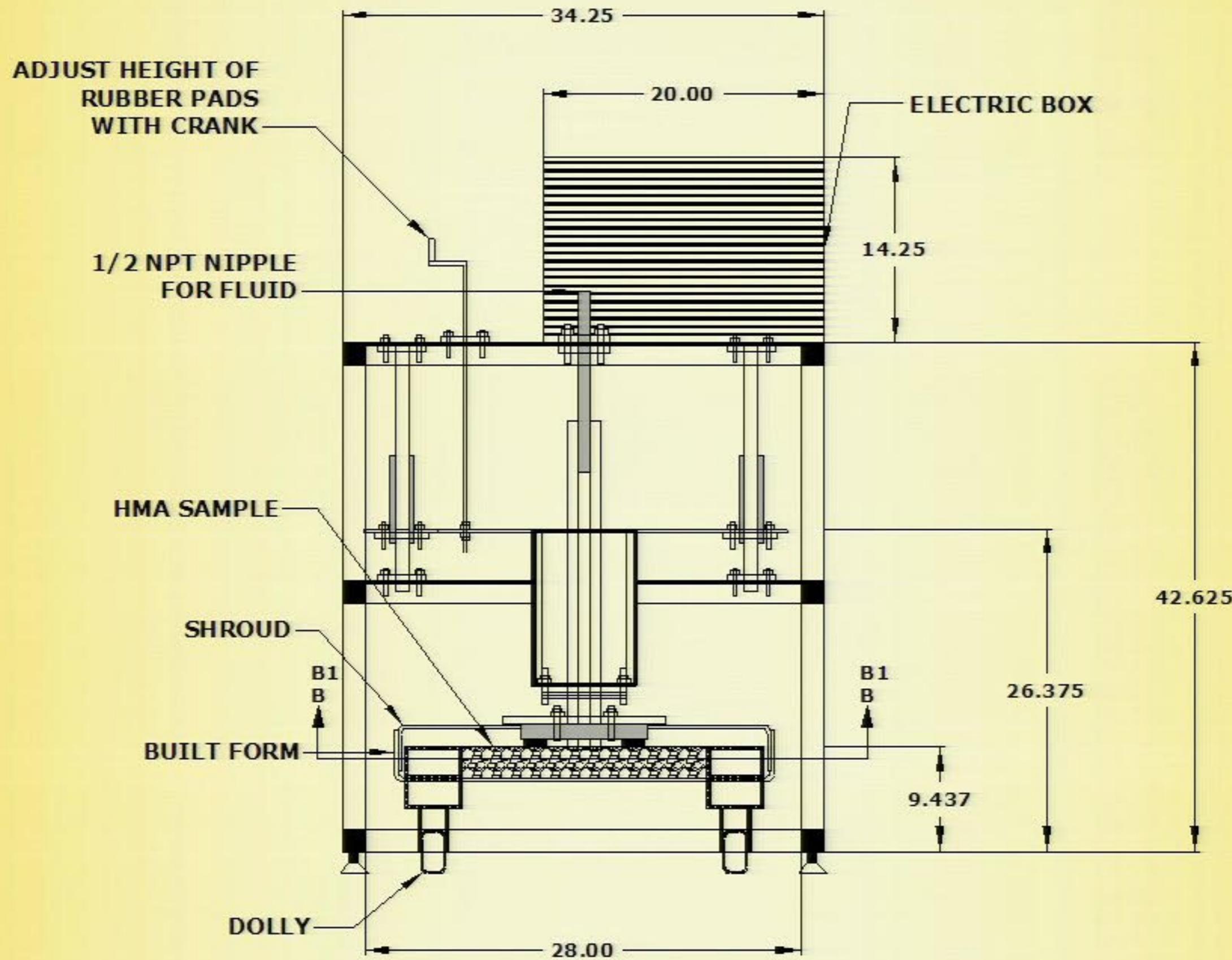
Details on Slab Specimen Mounting



Details on 6" Specimen Mounting



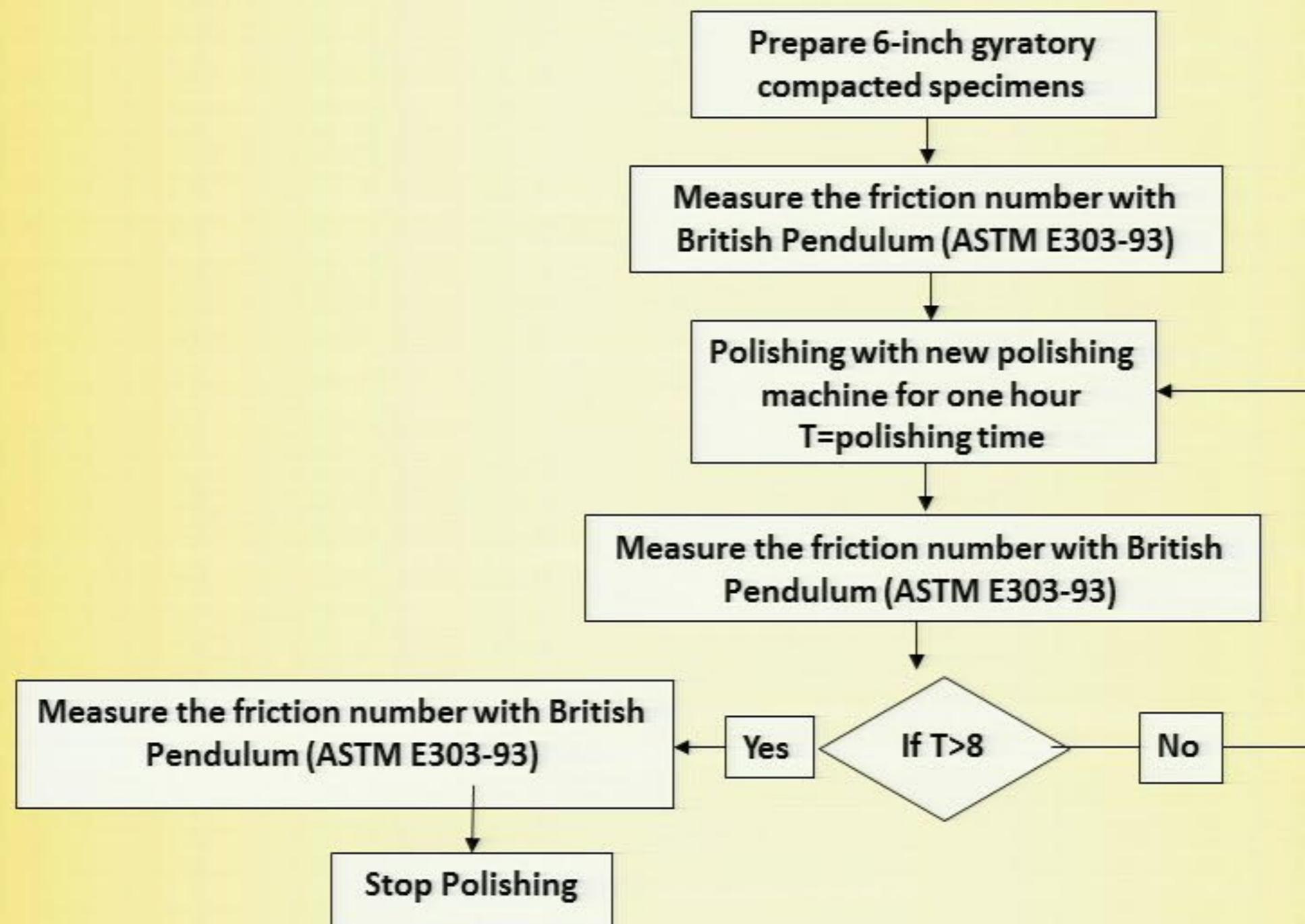
UA Accelerated Polishing Machine



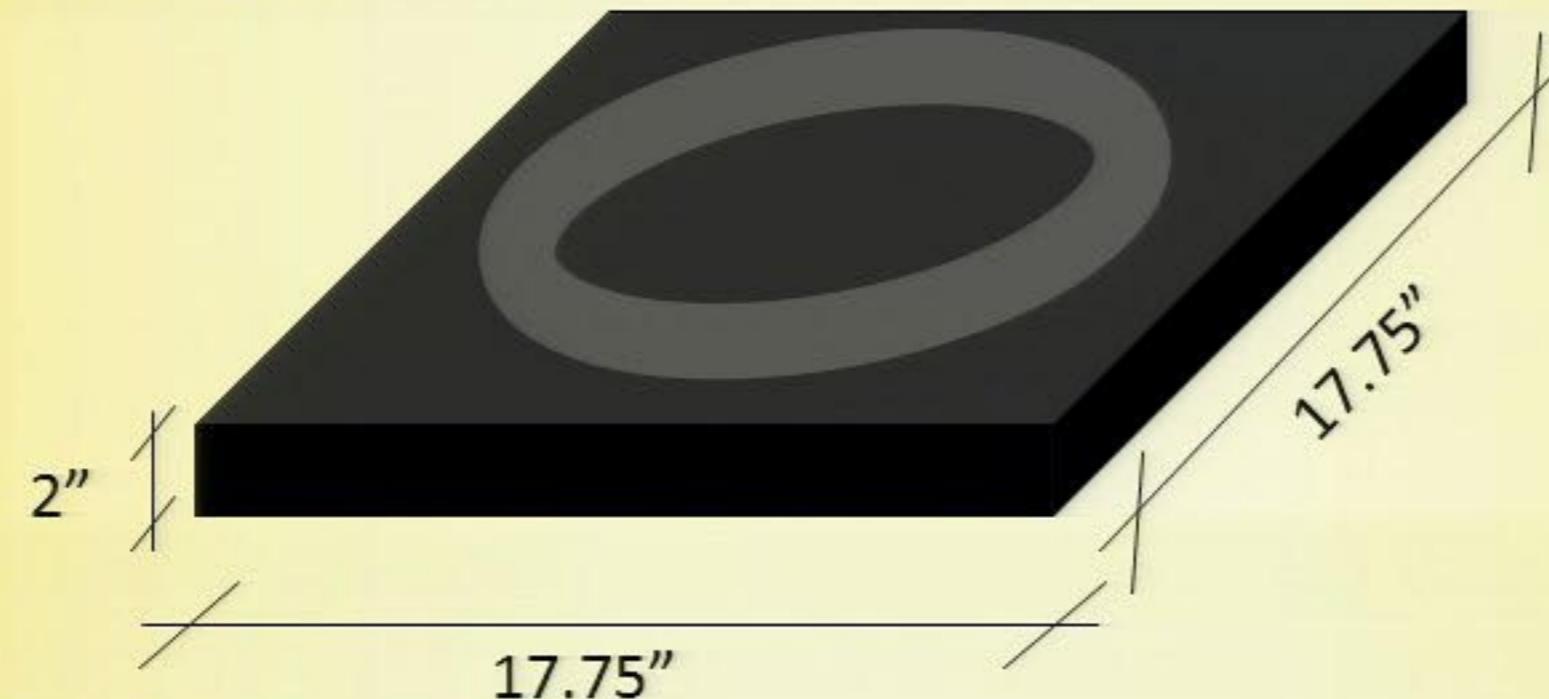
Operational Parameters

	Slab Specimens	6" Specimens
Rotational Speed	30 ± 6 rpm	30 rpm
Vertical Force	185 ± 45 Lb	290 Lb
Water Feeding Rate	200 ± 10 ml/min	100 ± 10 ml/min
Total Time of Polishing	16 hrs	8 hrs

Laboratory work procedure



Friction and Texture Measurements (Slab Specimen)

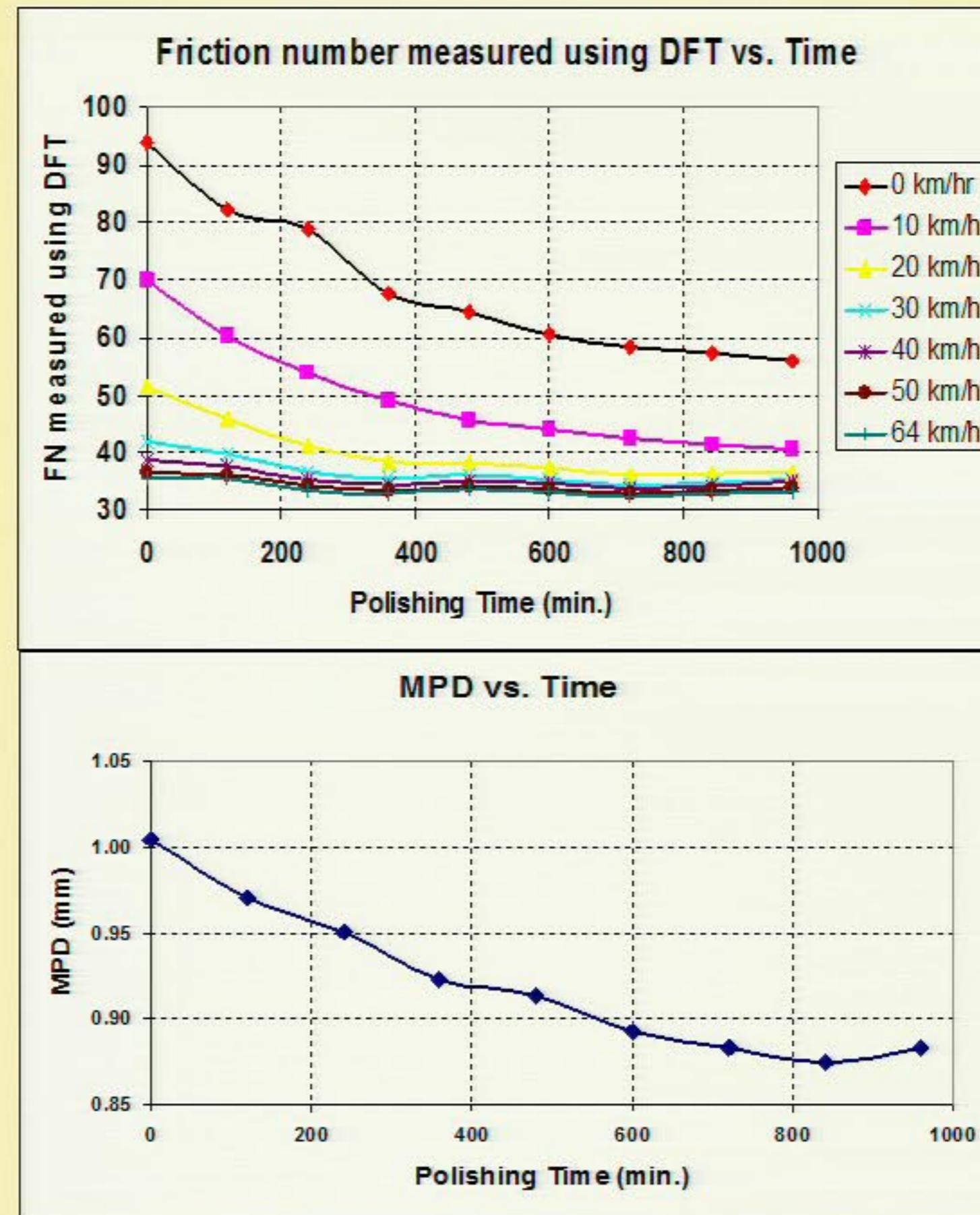


Dynamic Friction Tester

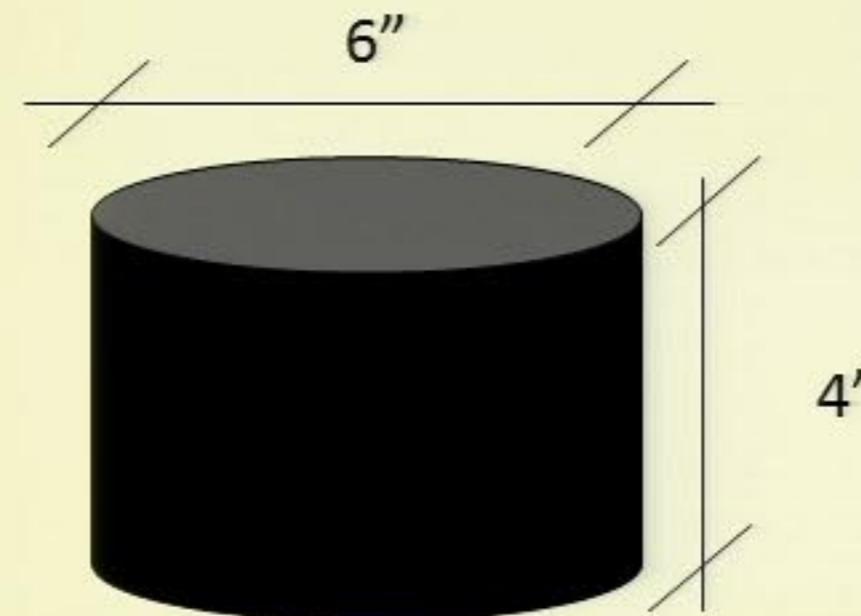


Circular Texture Meter

Typical Results for Slab Specimen



Friction and Texture Measurements (6" Specimen)



British Pendulum Tester



Sand Patch Method

Lab Test Results--BPN

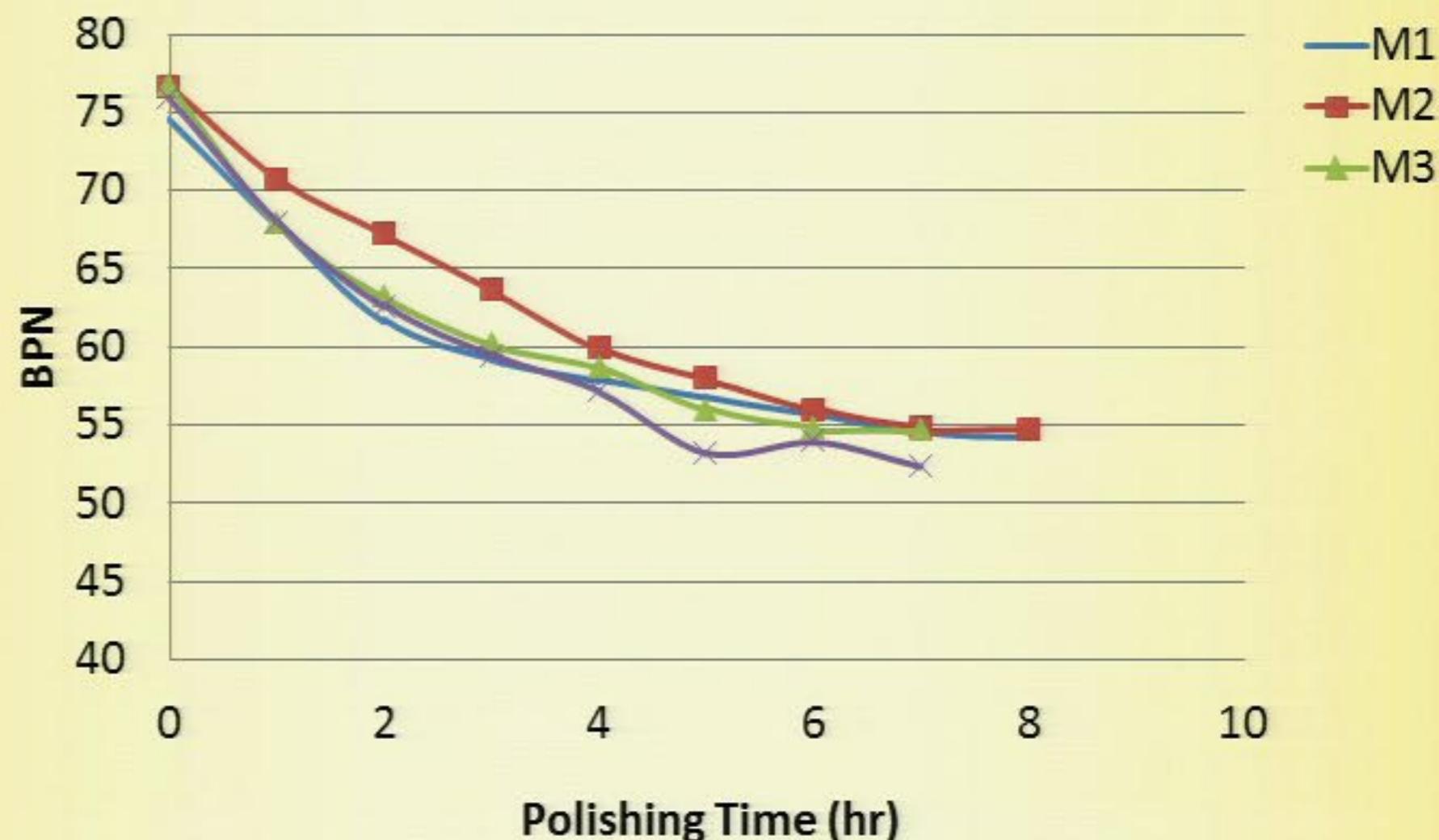
JMF	Initial BPN	Final BPN	ΔBPN	Average ΔBPN	% Decrease	Average % Decrease
L1	73.08	58.67	14.41	14.83	20	20
L2	76.50	59.17	17.33		23	
L3	72.50	59.75	12.75		18	
M1	74.50	54.25	20.25	21.88	27	29
M2	76.67	54.75	21.95		29	
M3	76.75	54.92	21.83		28	
M4	76.08	52.58	23.50		31	
H1	70.50	45.83	24.67	24.67	35	35

Lab Test Results--MTD

JMF No.	Initial MTD	Final MTD	ΔMTD	Average ΔMTD	% Decrease	Average % Decrease
L1	0.88	0.80	0.08	0.23	9	18
L2	1.51	1.03	0.48		32	
L3	0.99	0.86	0.13		13	
M1	1.53	1.14	0.39	0.30	26	25
M2	1.03	0.81	0.22		21	
M3	1.11	0.82	0.29		26	
M4	1.06	0.78	0.28		26	
H1	1.39	0.95	0.44	0.44	32	32

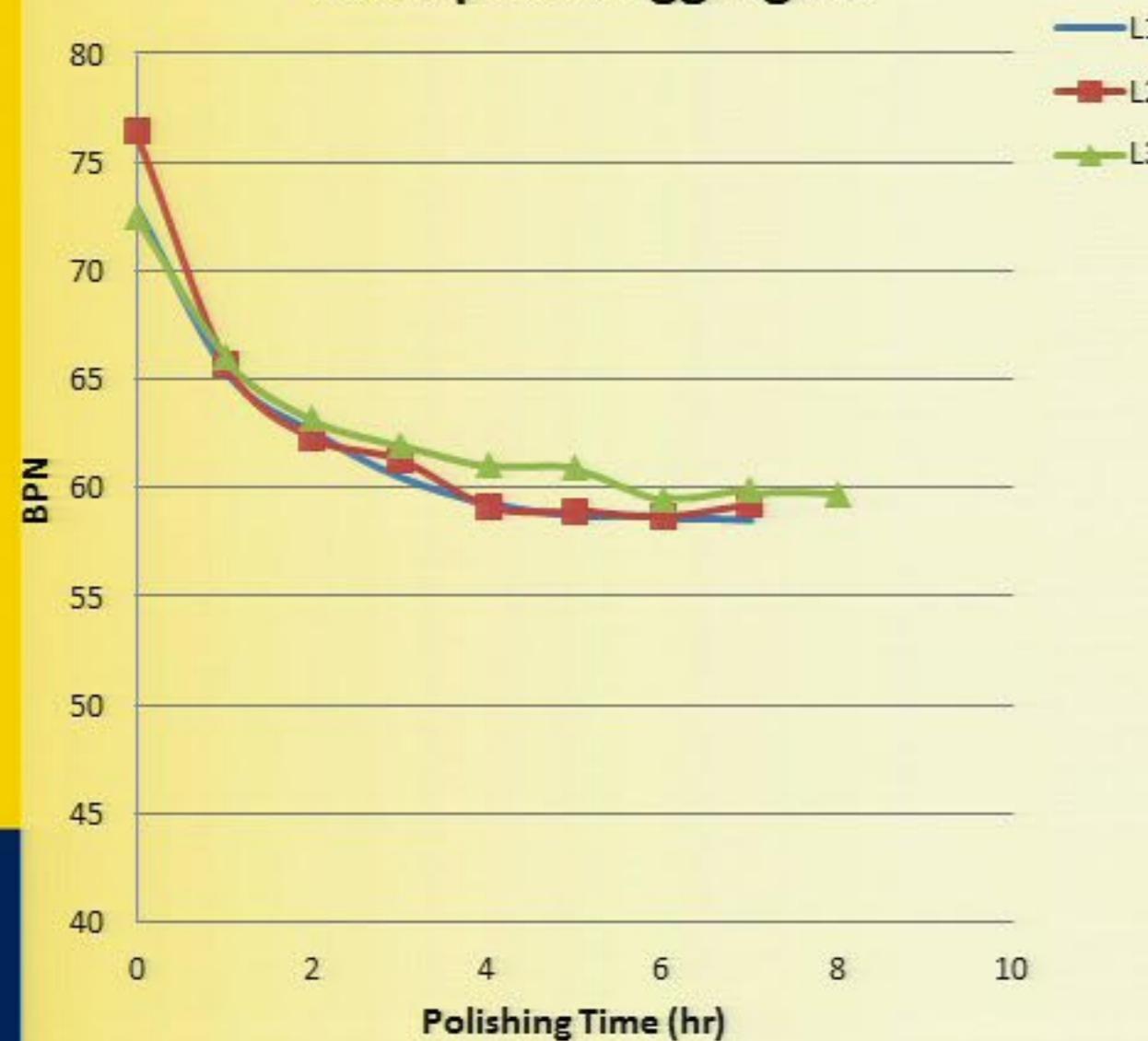
Laboratory Results

laboratory results for medium polishing
susceptible aggregate

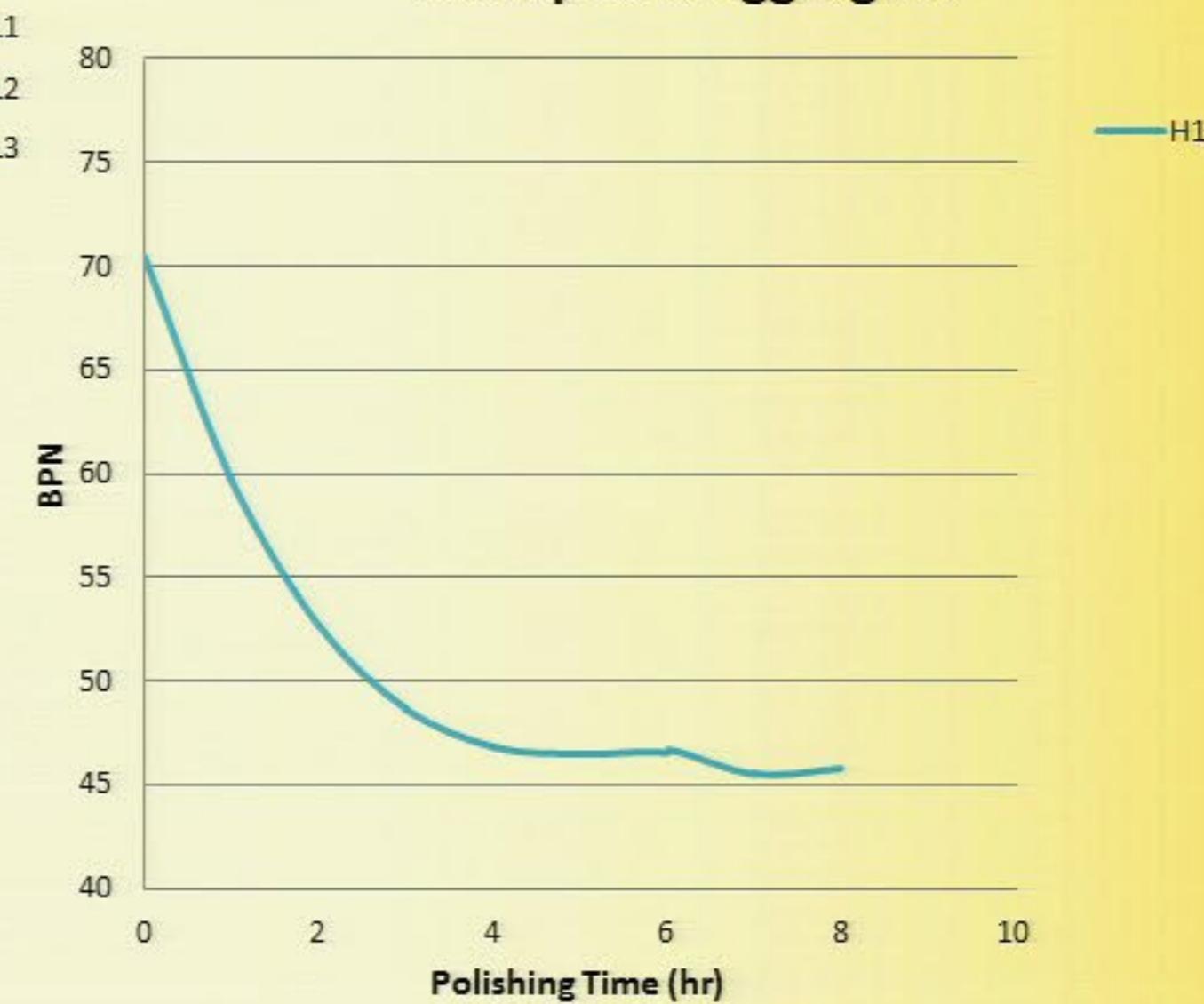


Laboratory Results

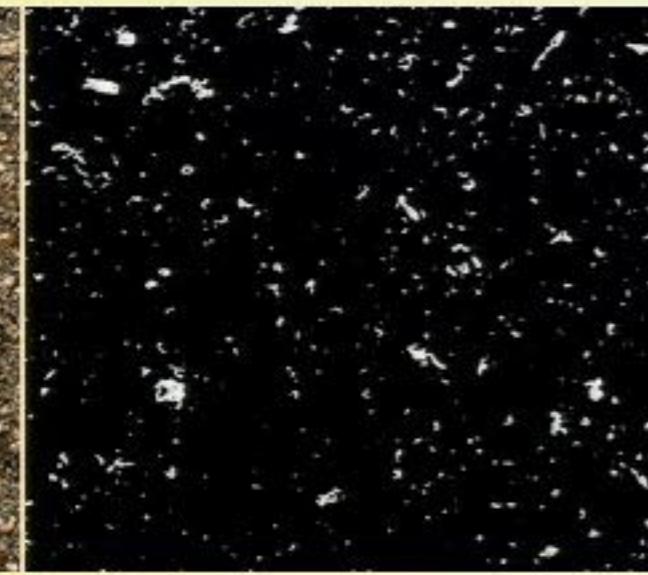
Laboratory results for low polishing susceptible aggregate



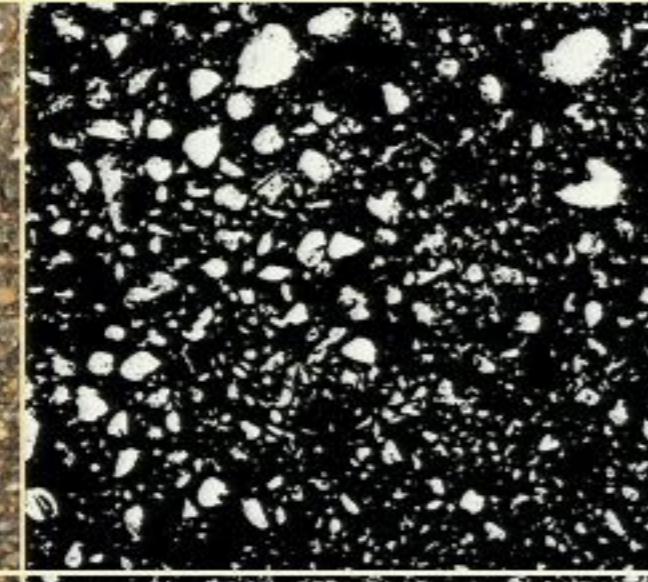
Laboratory results for high polishing susceptible aggregate



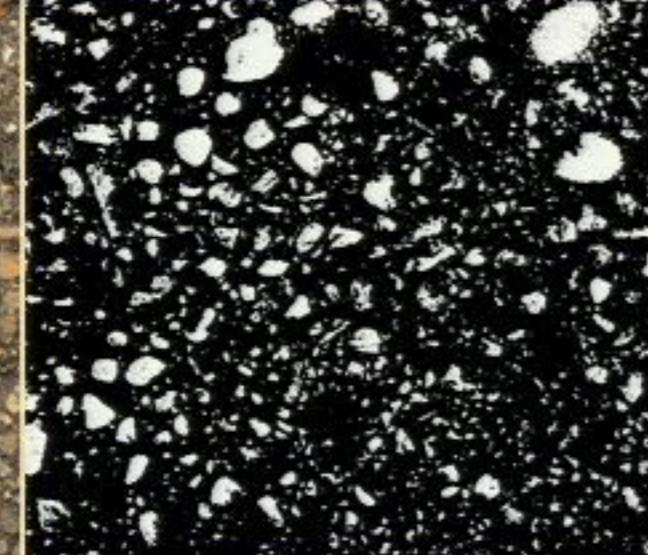
Aggregate Exposure (6" Specimen)



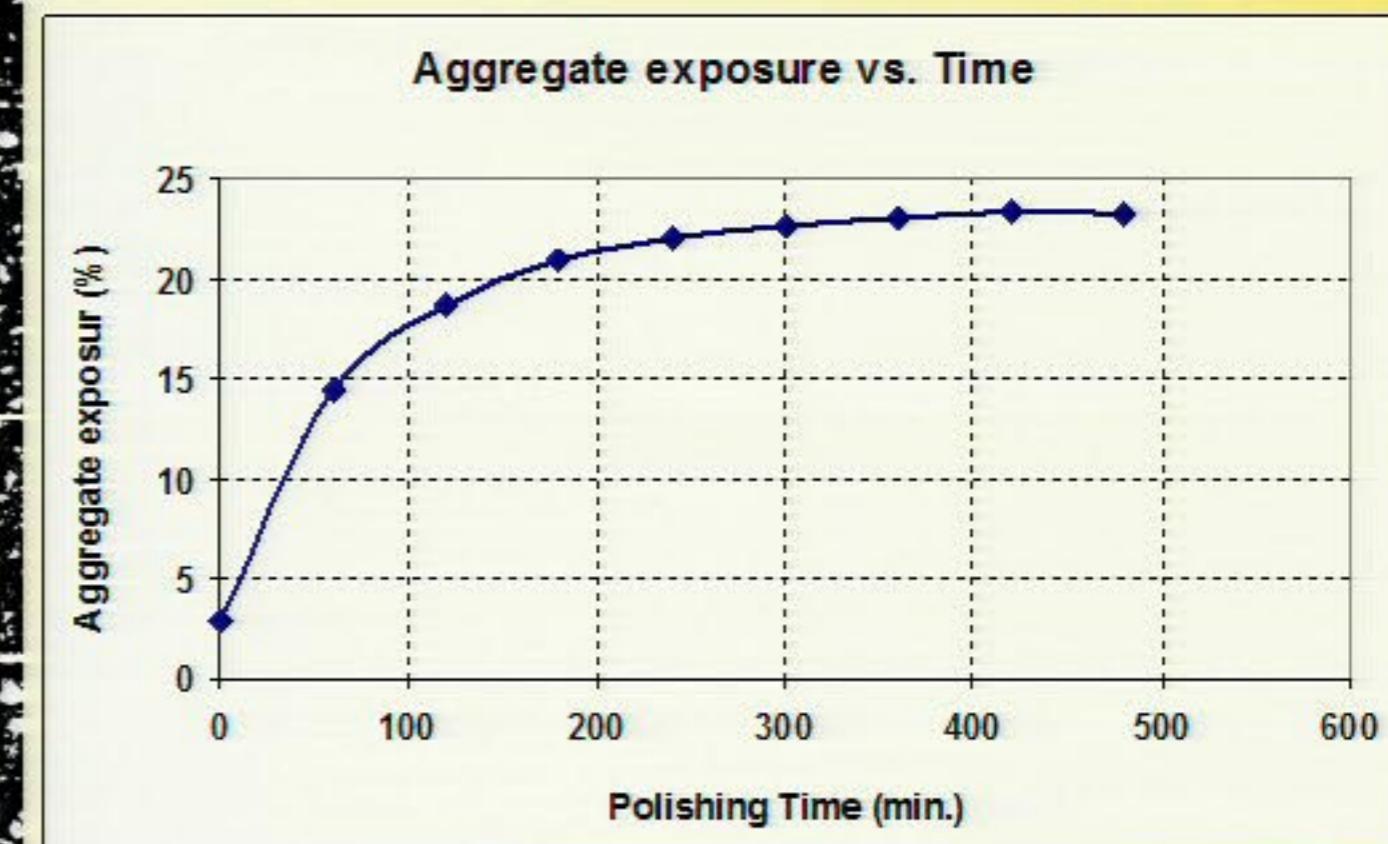
0 min.



240 min.



480 min.



Existing/New Pavement Sections

Districts

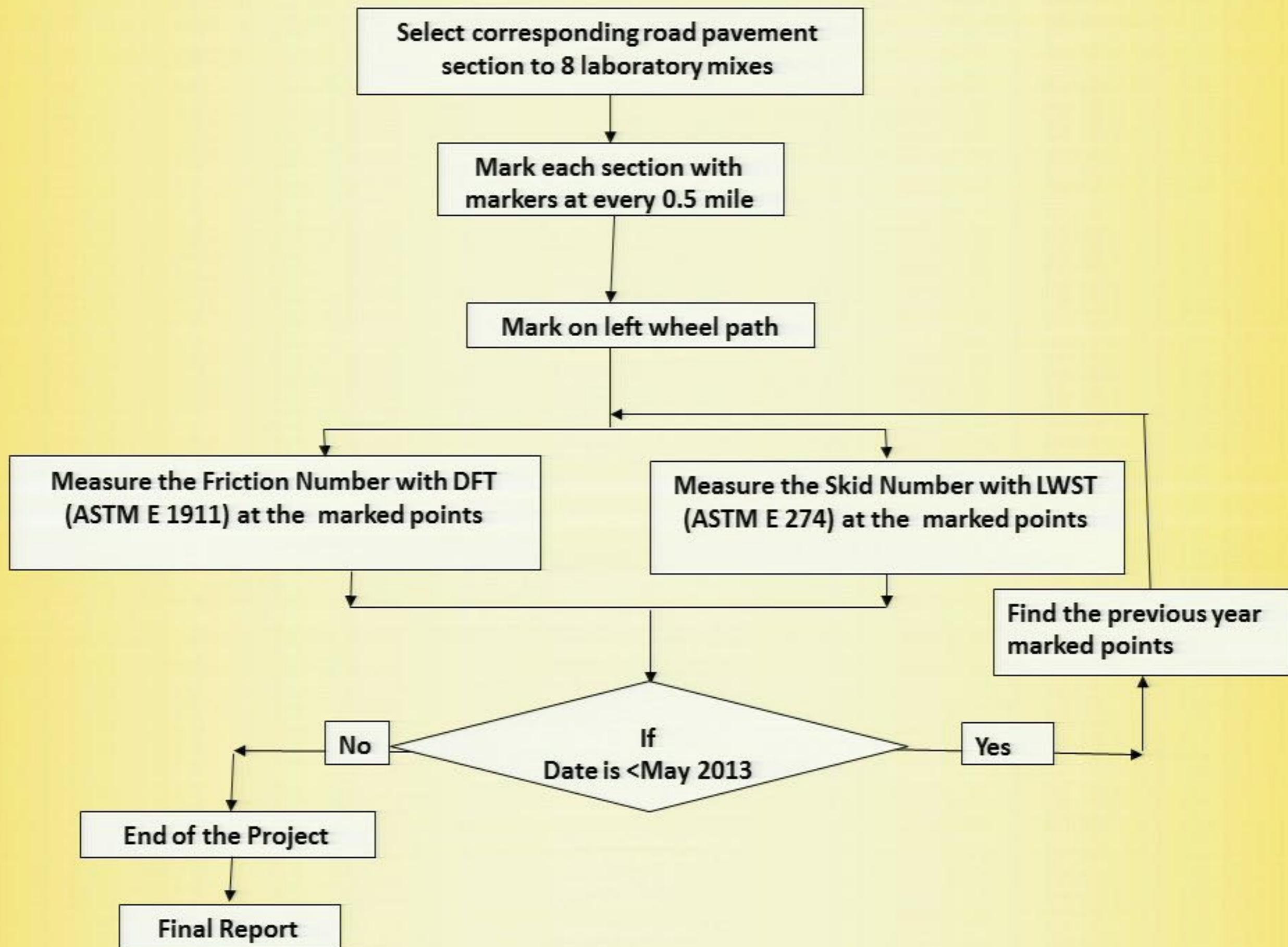


- Existing Pavement Sections.
- New Pavement Sections.

Field Study Pavement Sections

pavement sections			
Location	Aggregate	Stockpile	Number of Points
Harrison R-022 (Dist.11)	L1 (Gravel)	Stocker Sand & Gavel @ Gnadenhutten	12
Harrison R-250 (Dist.11)	L3 (Gravel)	Martine Marietta @ Apple Grove	10
Huron R-162 (Dist.3)	M1 (Limestone)	Sandusky Crushed @ Parkertown	18
Huron R-25 (Dist.3)	M2 (Limestone)	Sandusky Crushed @ Parkertown	6
Lucas R-64 (Dist.2)	M3 (Dolomite)	Stone co @ Maumee	14
Wood R-025 (Dist.2)	M4 (Dolomite)	Stone co @ Maumee	36
Washington R-007 (Dist. 10)	H1 (Limestone)	Chesterville @ Stockport	8

Field Testing Procedure



Marked location for the subsequent FN_{DFT} measurement



Measuring Texture by CTM



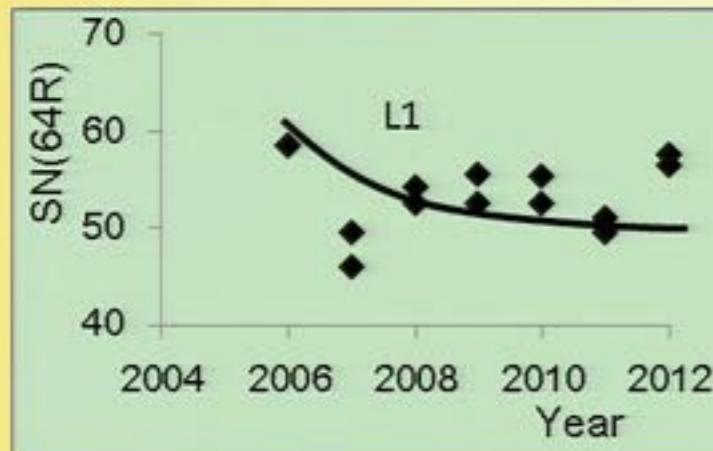
Placing the DFT for friction measurement



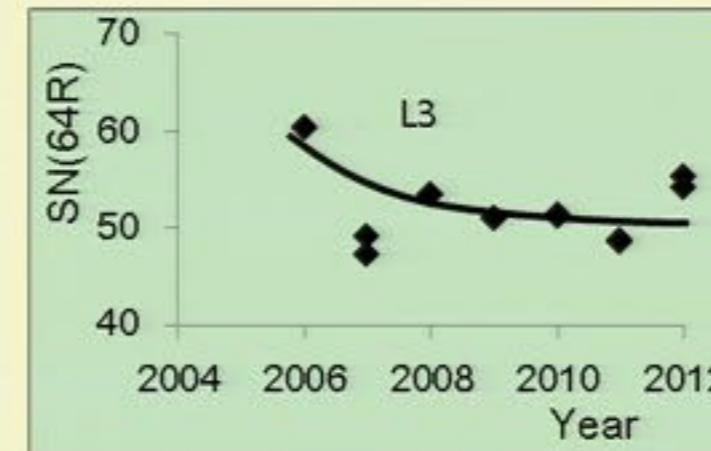
Friction Measurement with BPT



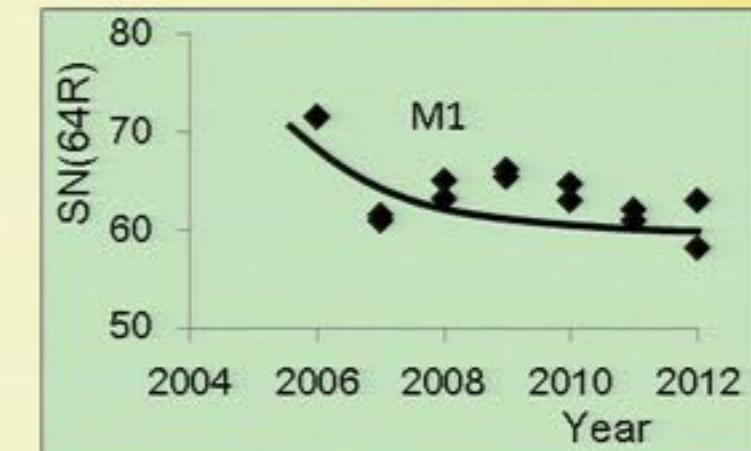
SN(64)R vs. In-service years



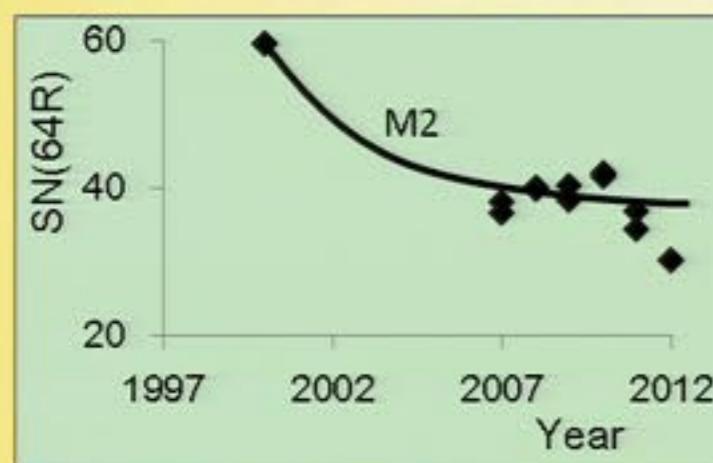
SN(64)R—L1



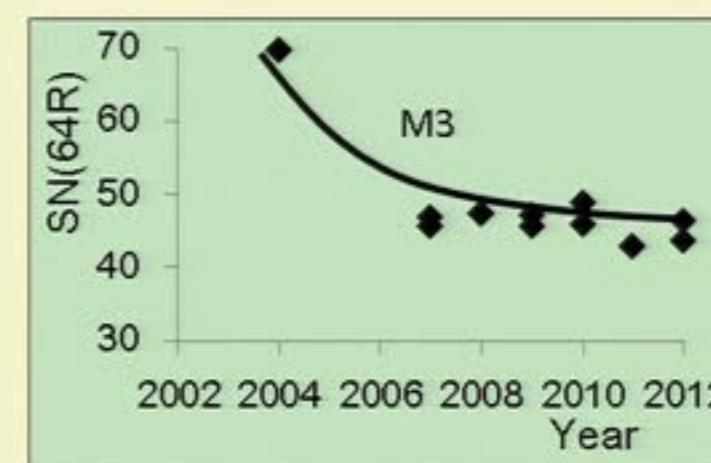
SN(64)R—L3



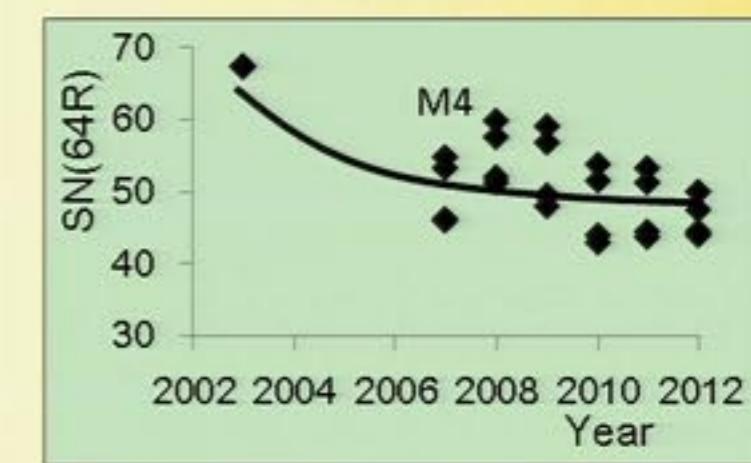
SN(64)R—M1



SN(64)R—M2



SN(64)R—M3



SN(64)R—M4

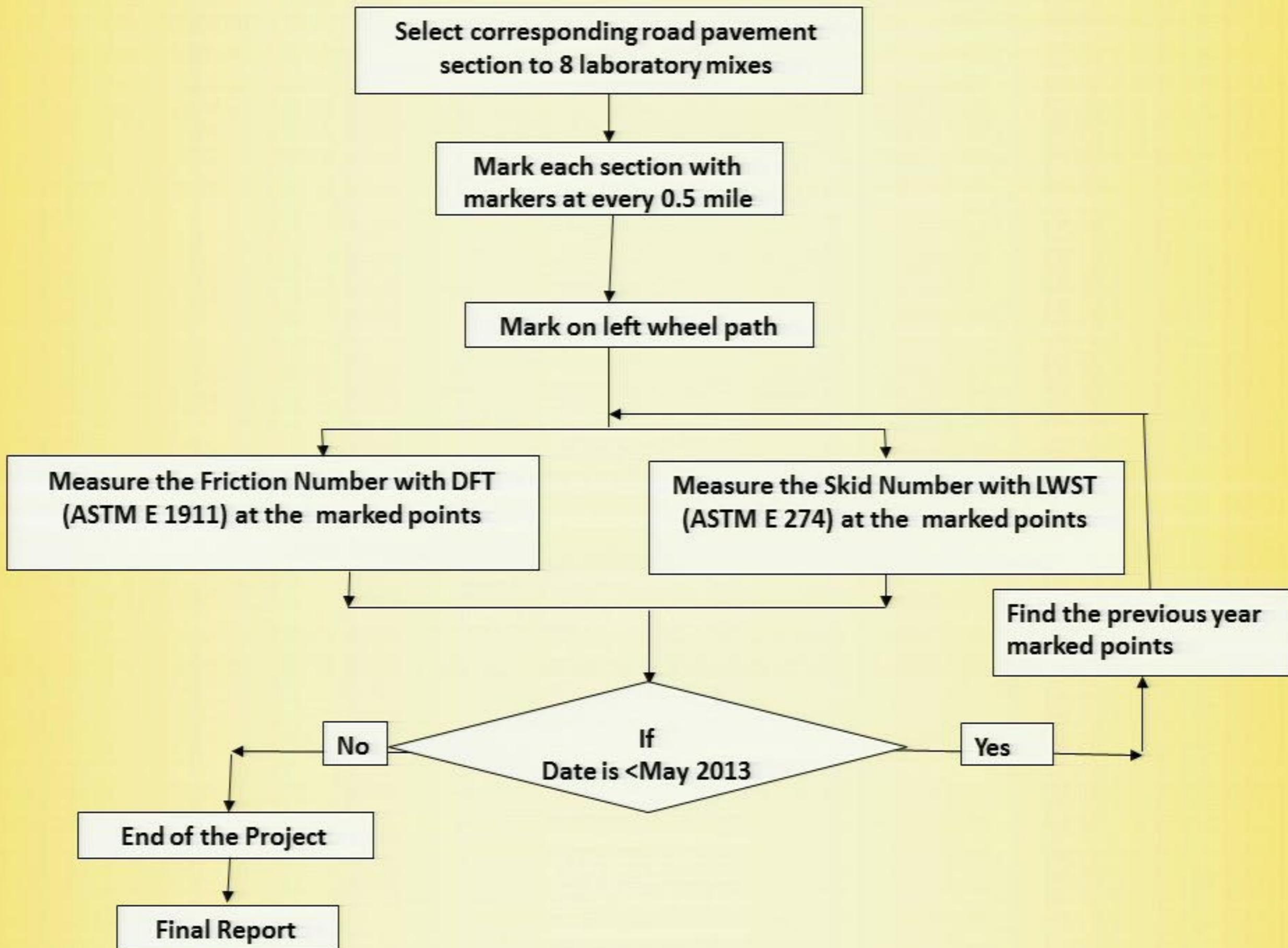
Friction Measurement with BPT



Placing the DFT for friction measurement



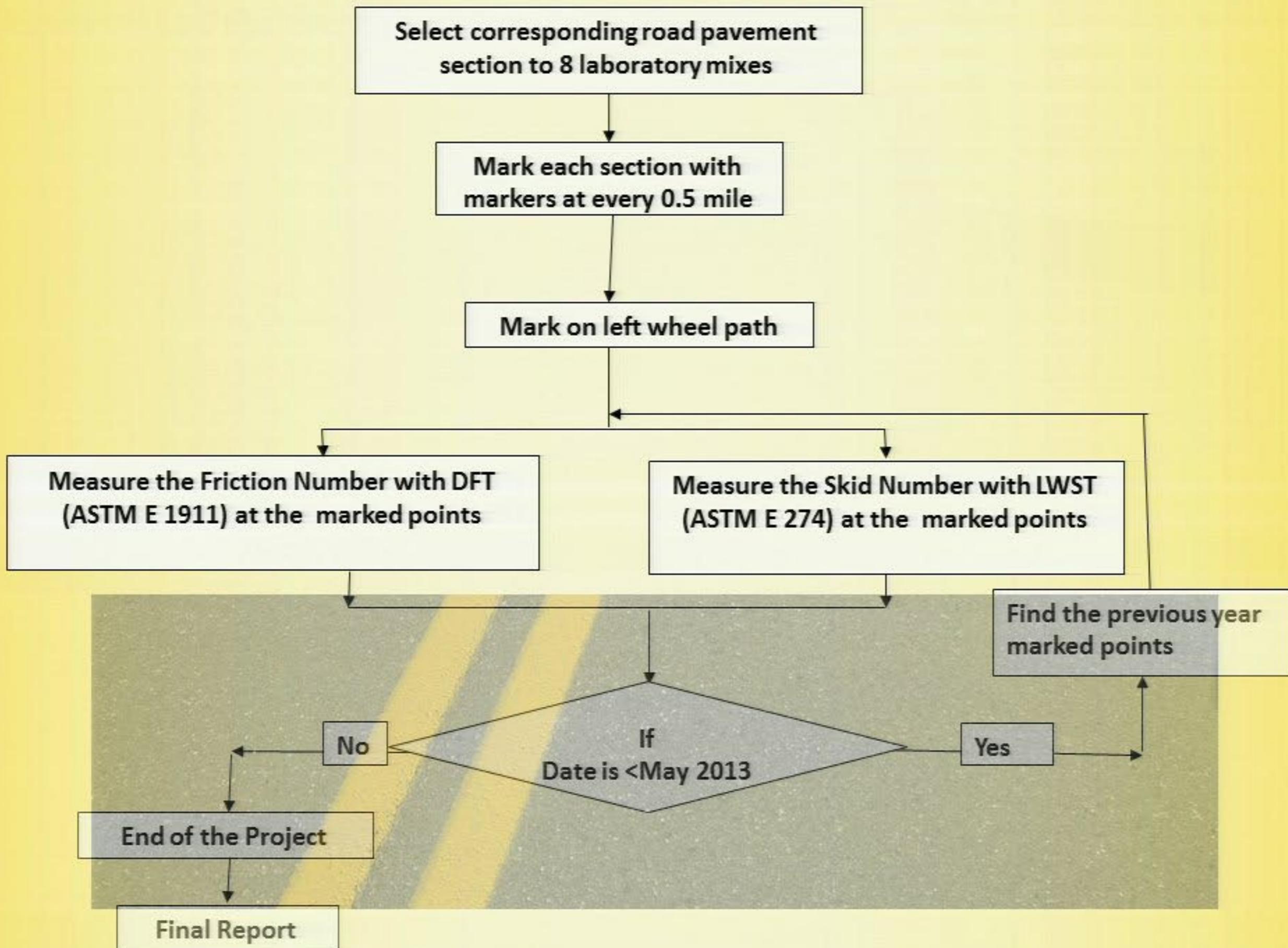
Field Testing Procedure



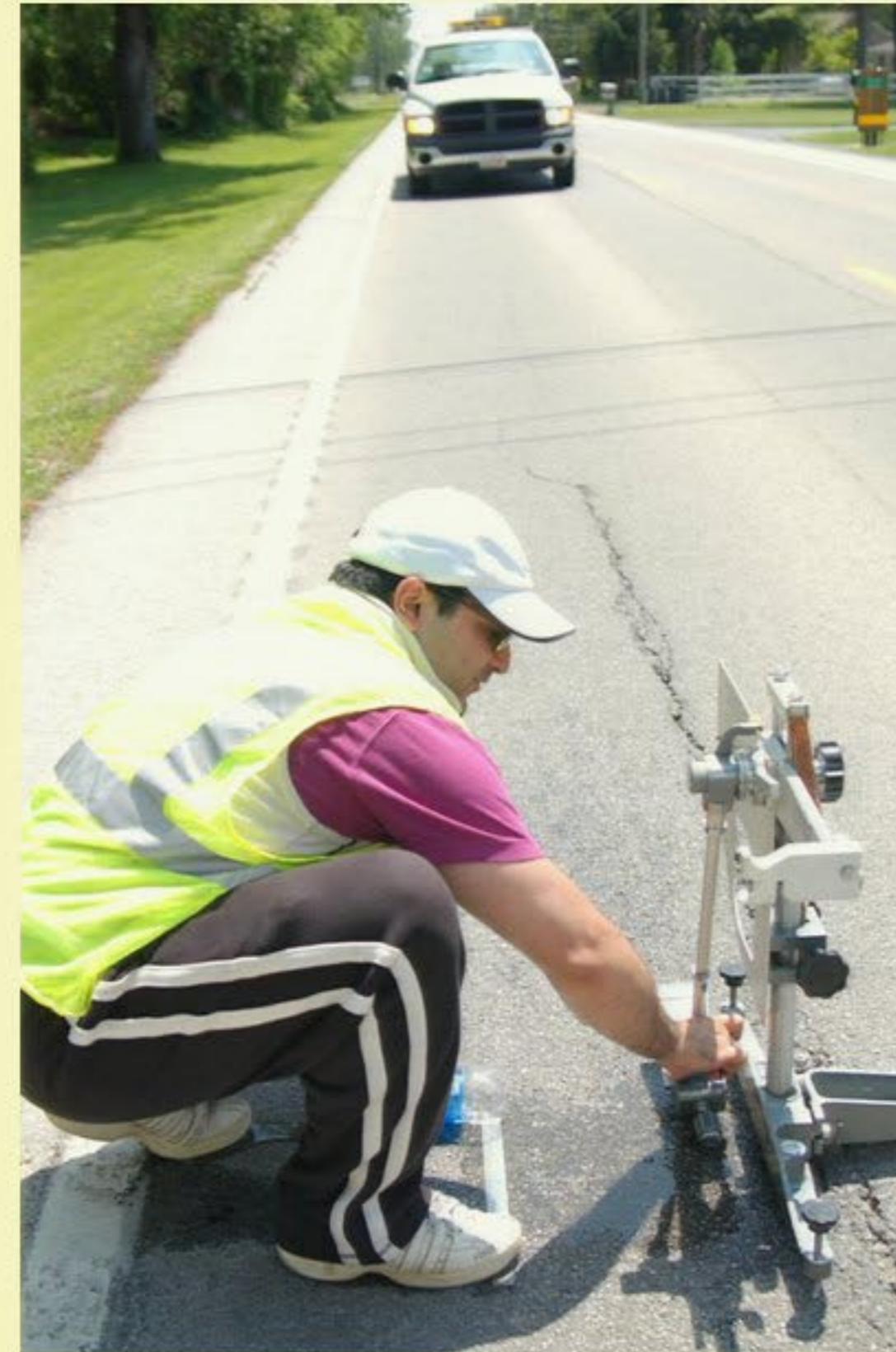
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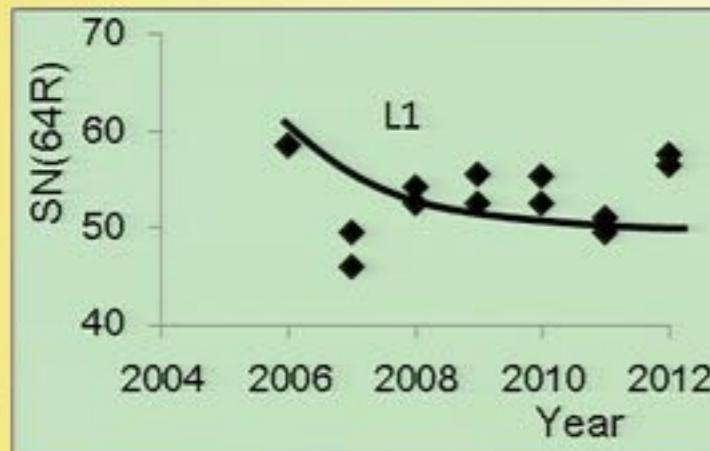
Field Testing Procedure



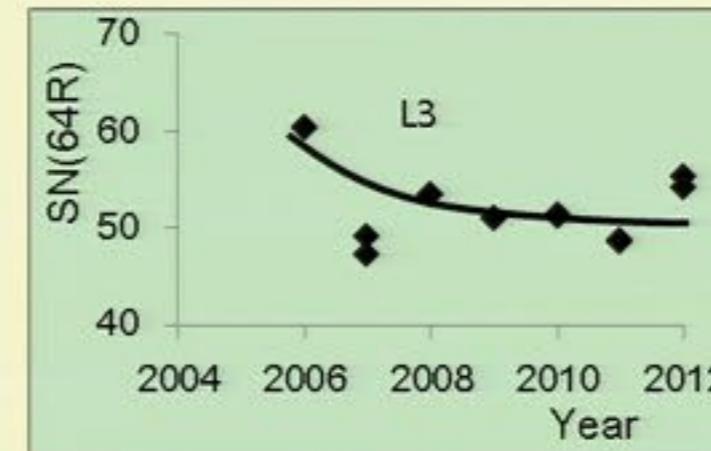
Friction Measurement with BPT



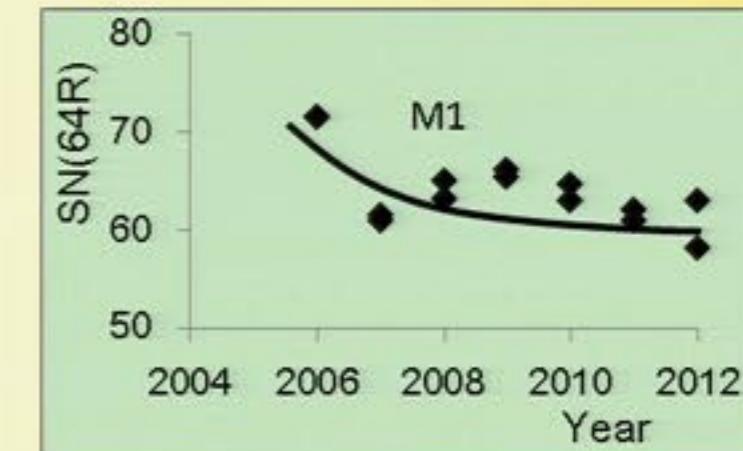
SN(64)R vs. In-service years



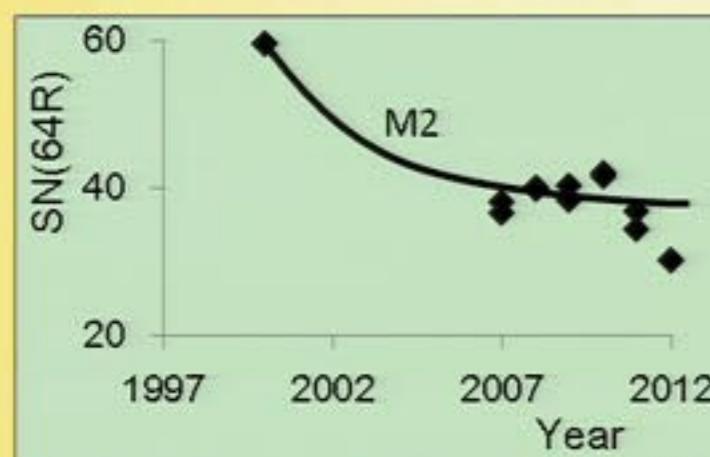
SN(64)R—L1



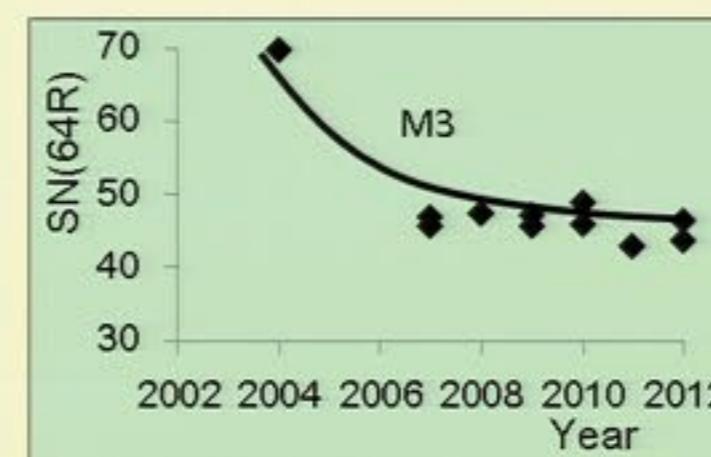
SN(64)R—L3



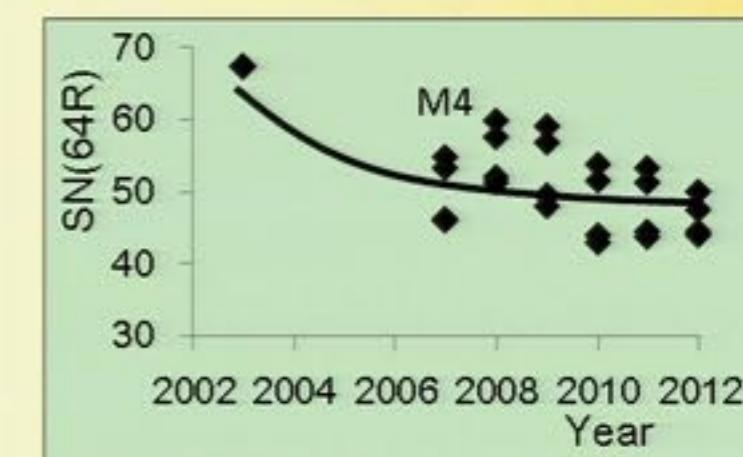
SN(64)R—M1



SN(64)R—M2

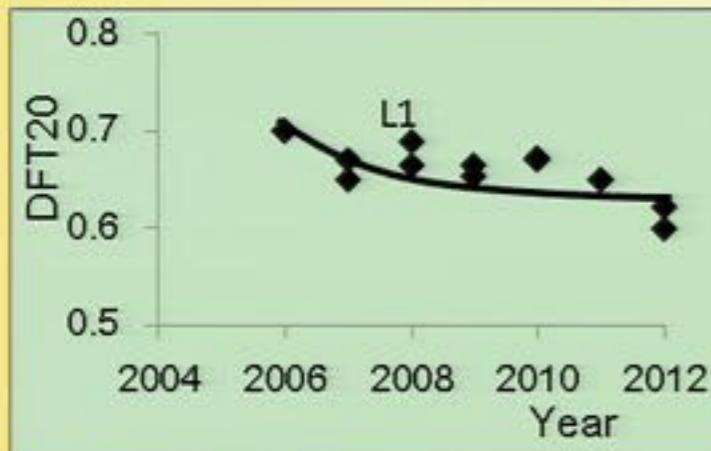


SN(64)R—M3

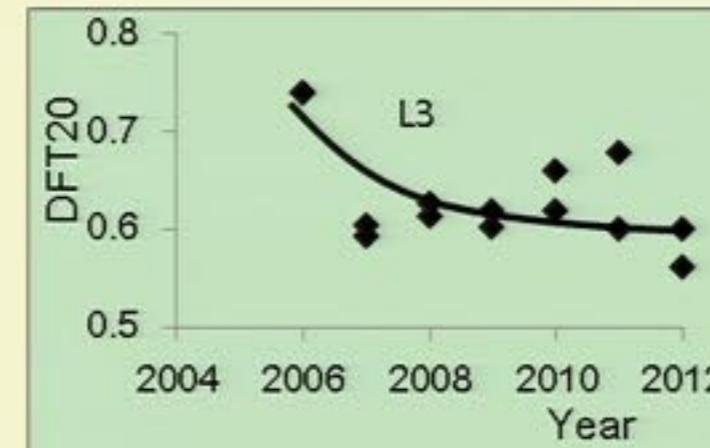


SN(64)R—M4

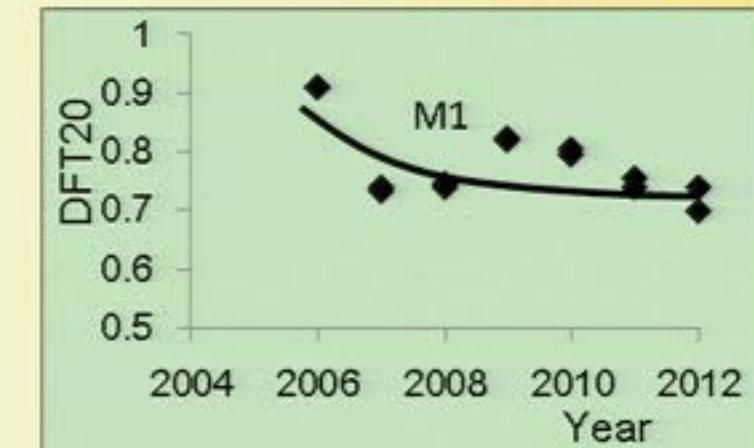
DFT20 vs. In-service years



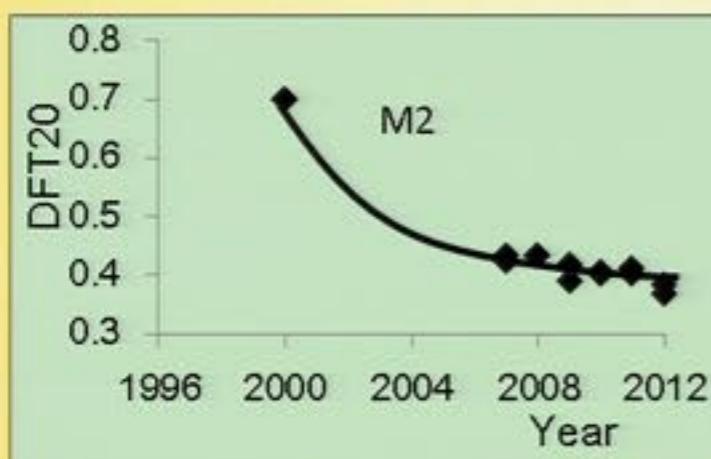
DFT20—L1



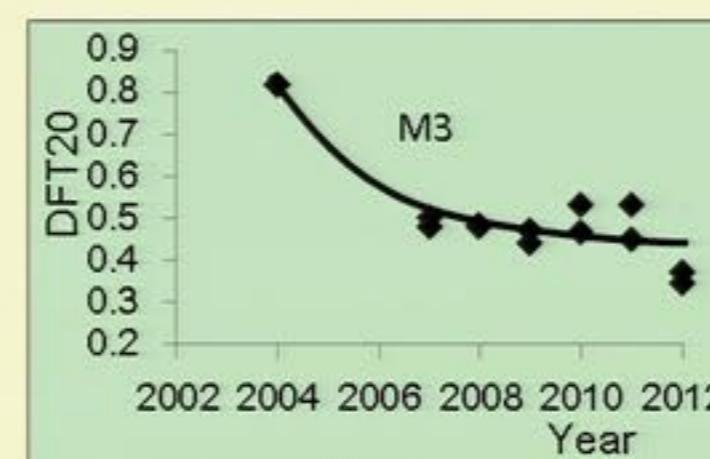
DFT20—L3



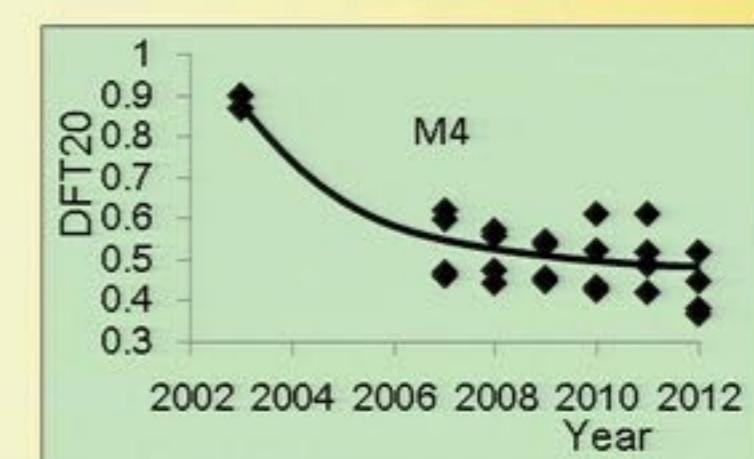
DFT20—M1



DFT20—M2

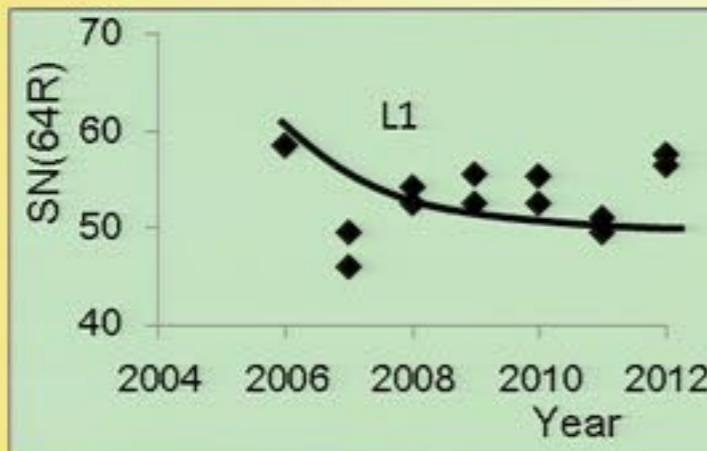


DFT20—M3

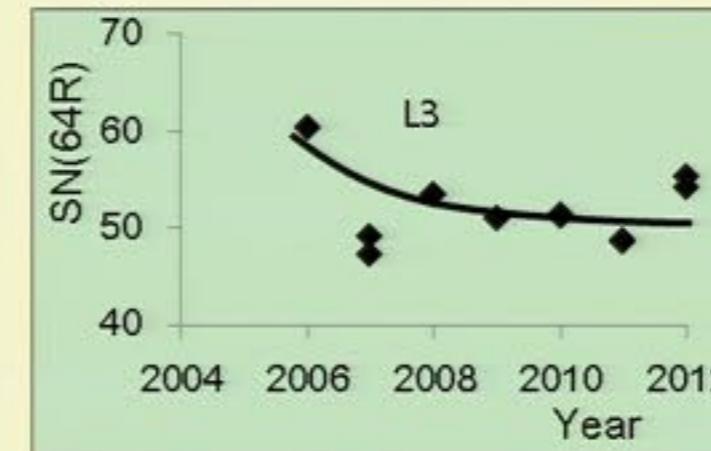


DFT20—M4

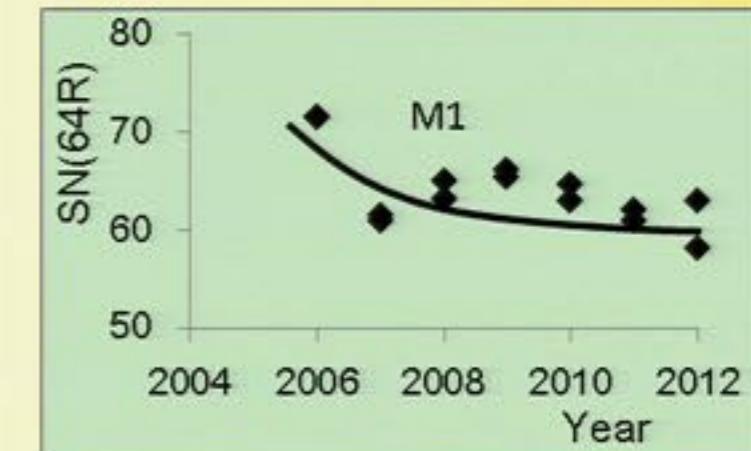
SN(64)R vs. In-service years



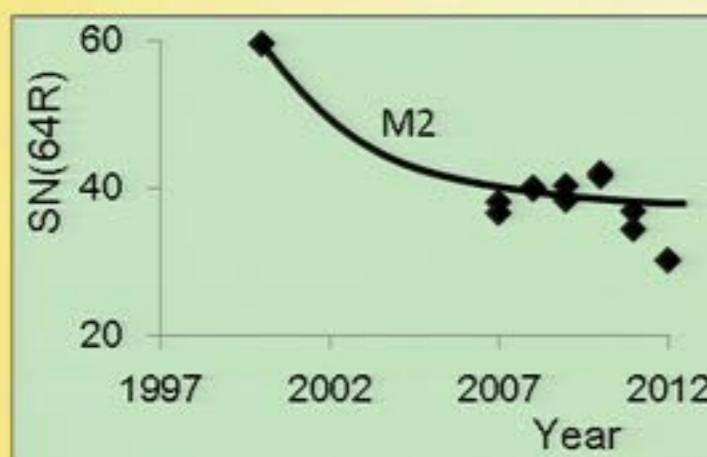
SN(64)R—L1



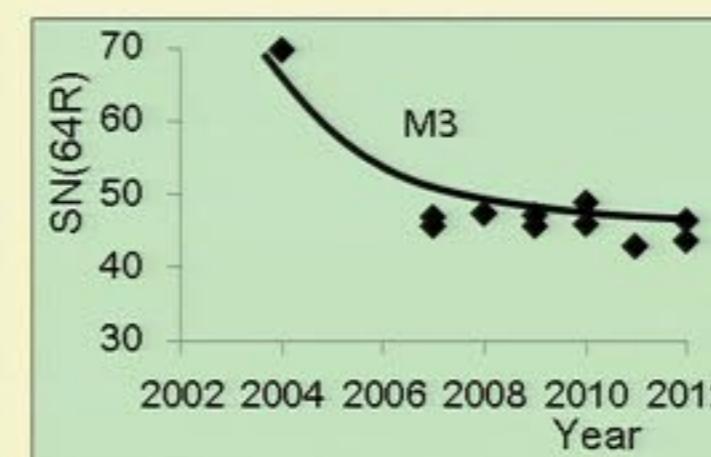
SN(64)R—L3



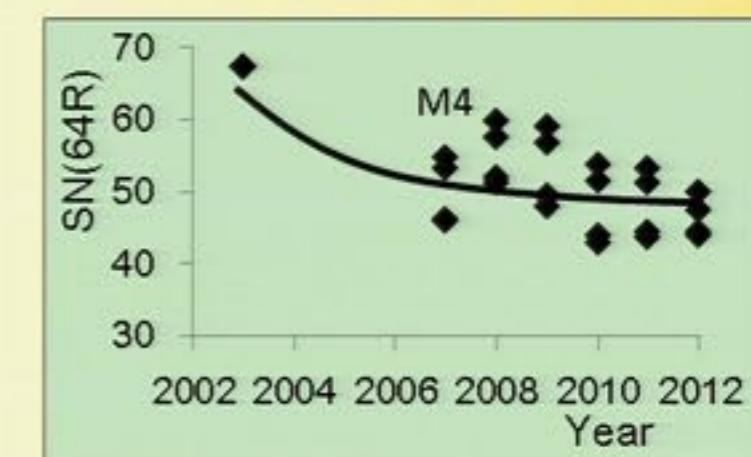
SN(64)R—M1



SN(64)R—M2

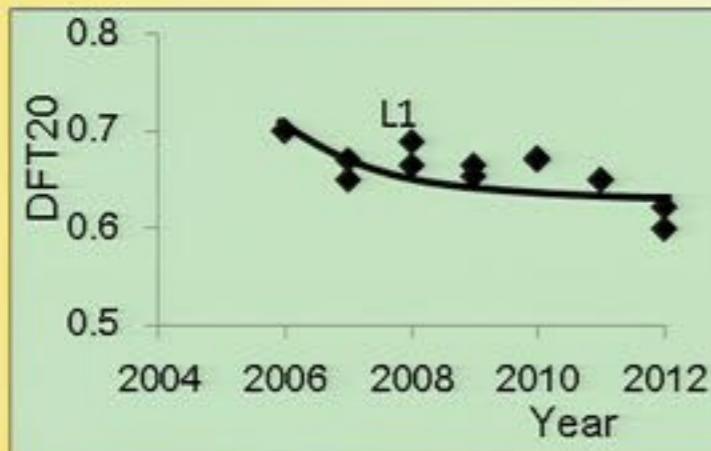


SN(64)R—M3

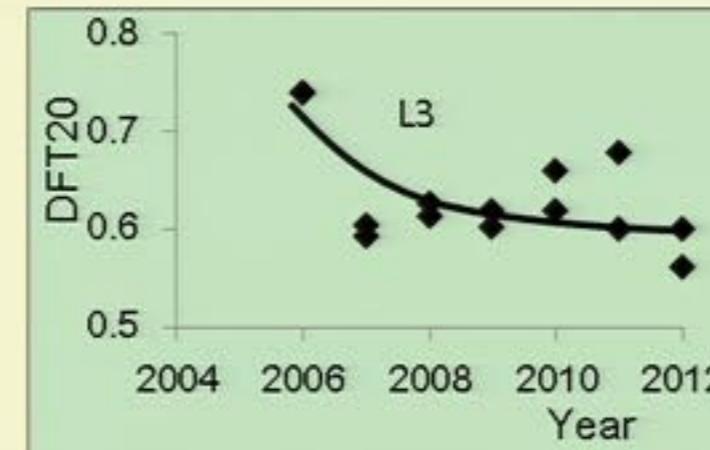


SN(64)R—M4

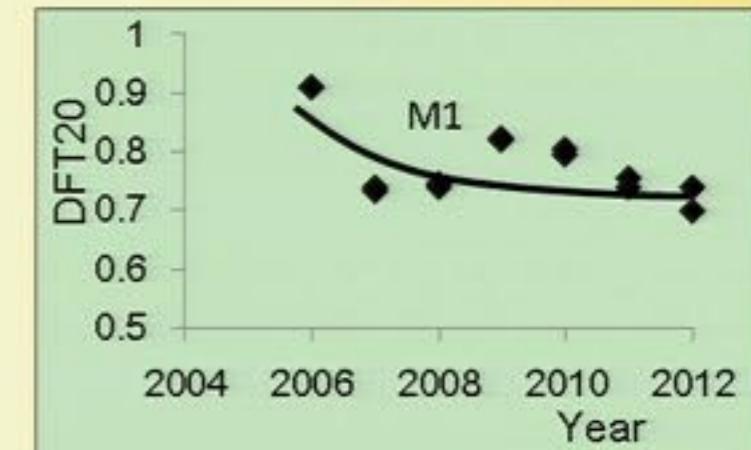
DFT20 vs. In-service years



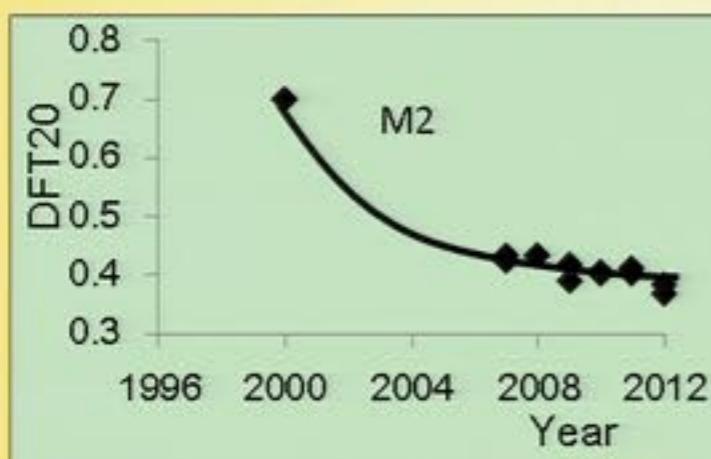
DFT20—L1



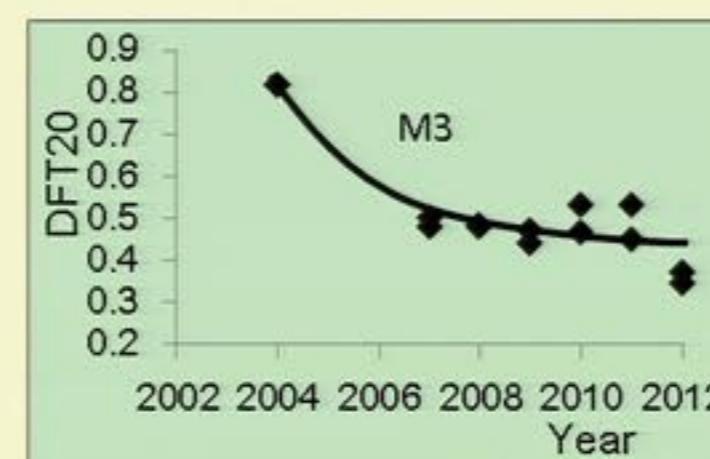
DFT20—L3



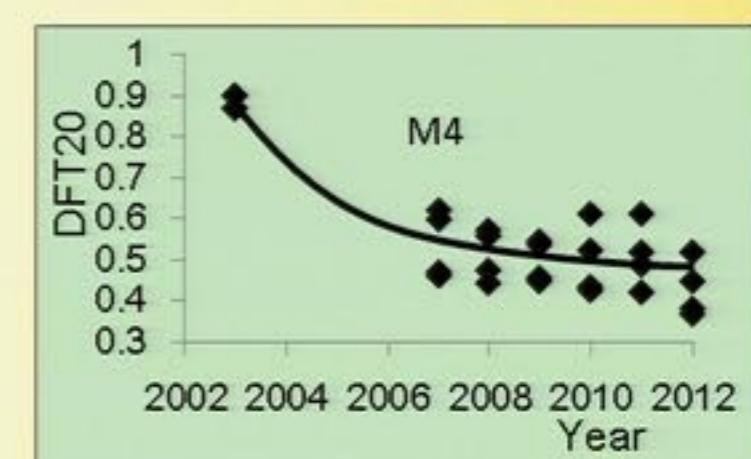
DFT20—M1



DFT20—M2

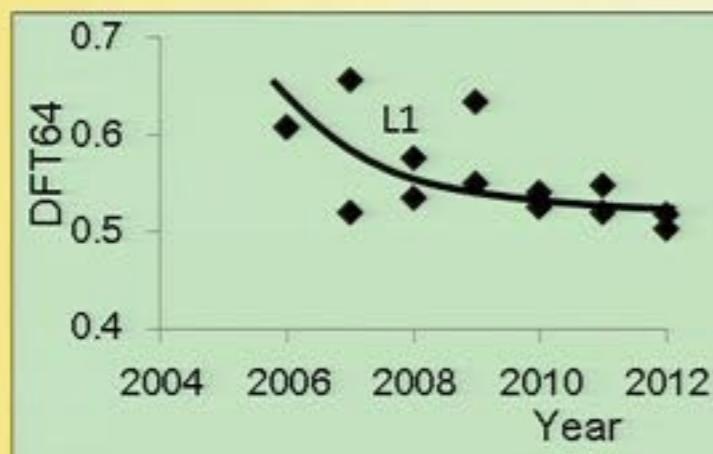


DFT20—M3

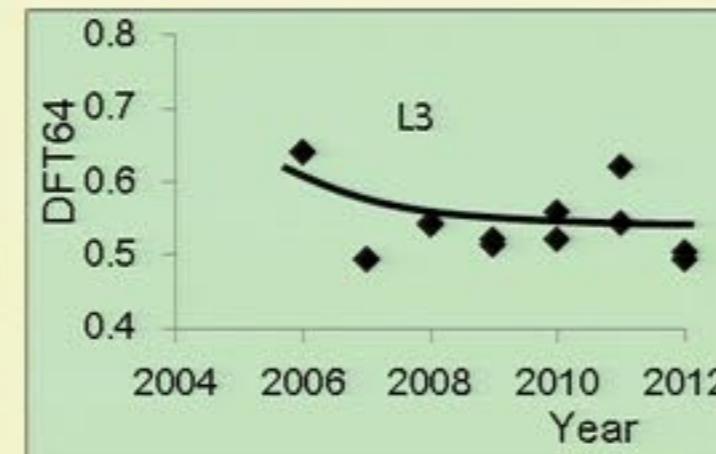


DFT20—M4

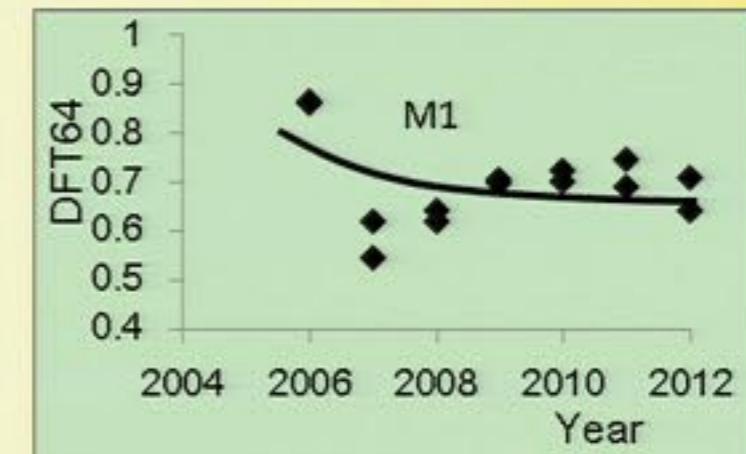
DFT64 vs. In-service years



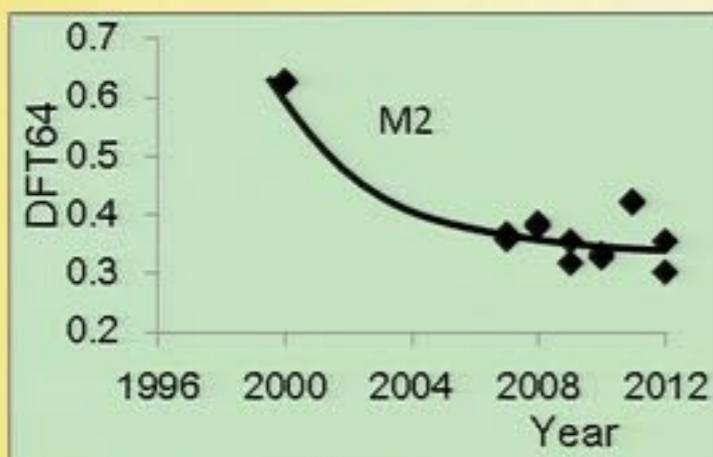
DFT64—L1



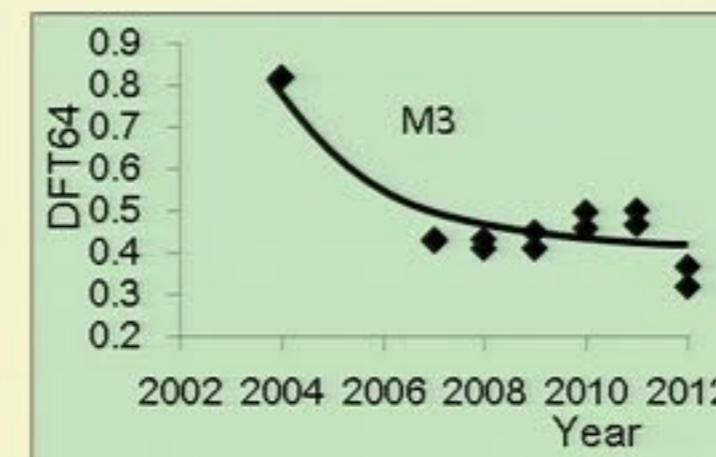
DFT64—L3



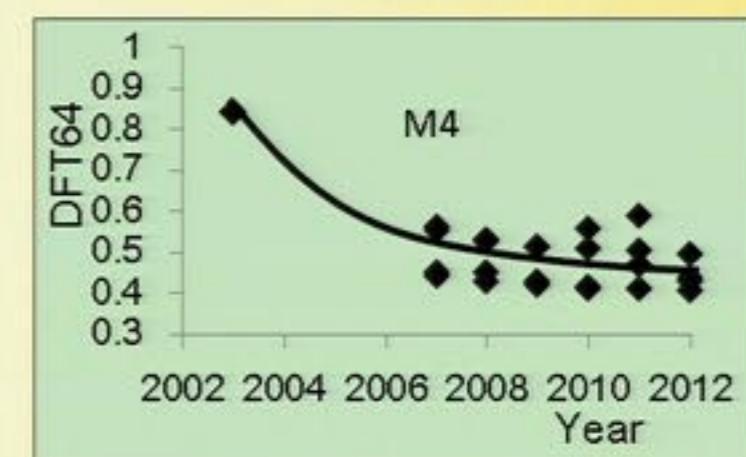
DFT64—M1



DFT64—M2

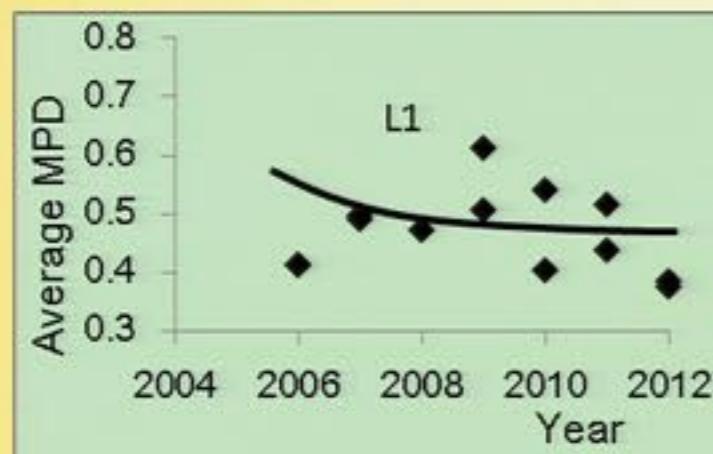


DFT64—M3

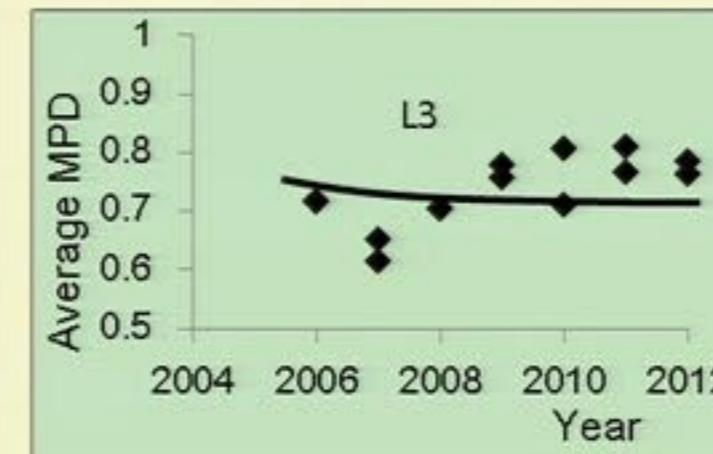


DFT64—M4

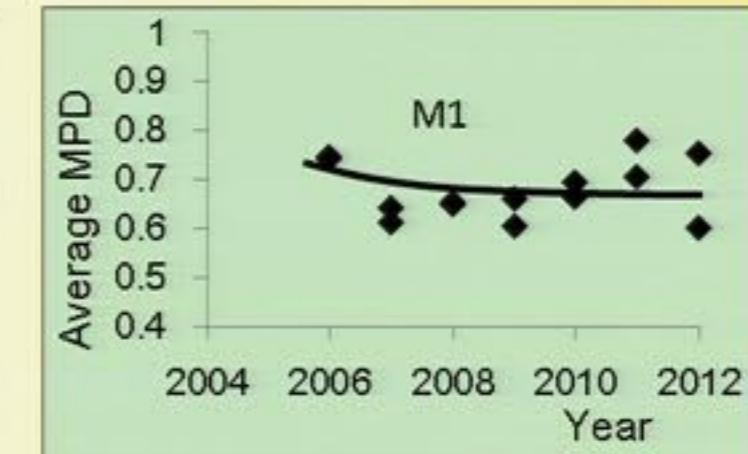
Average MPD vs. In-service years



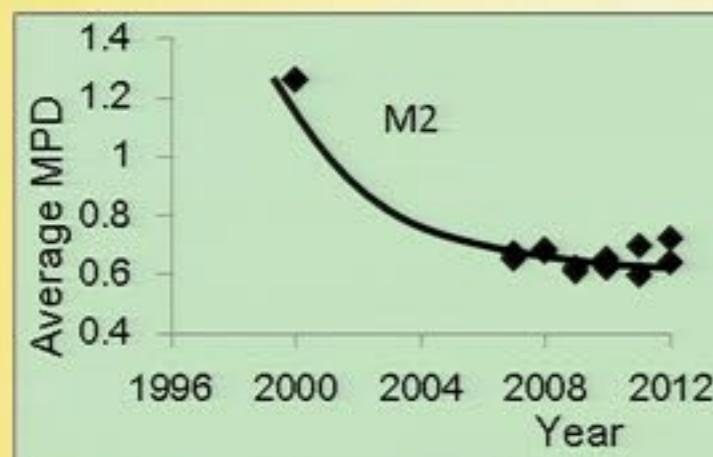
Average MPD—L1



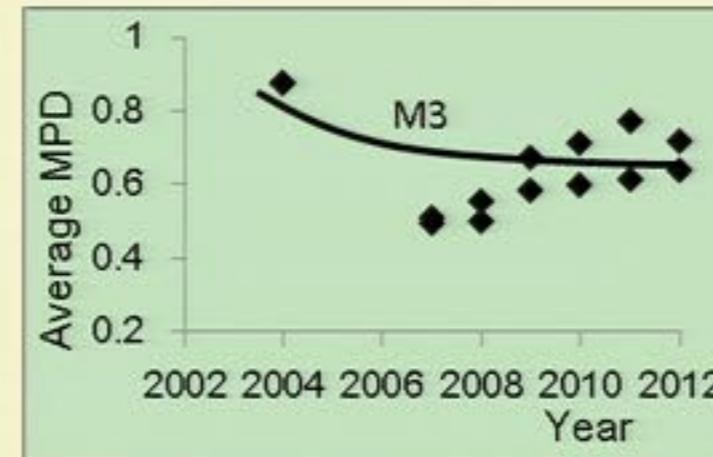
Average MPD—L3



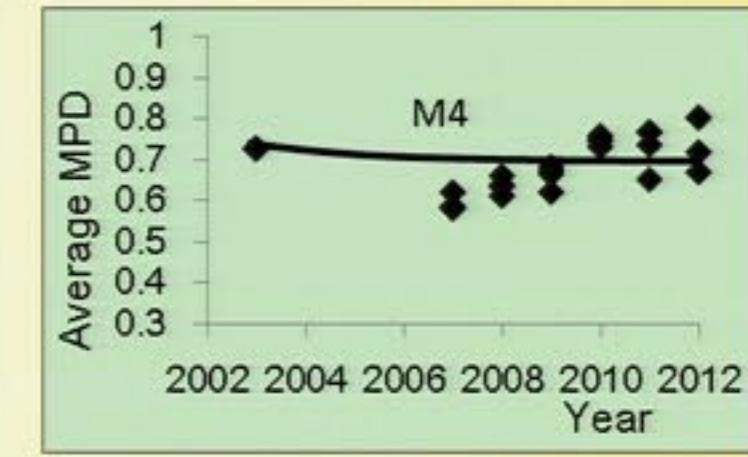
Average MPD—M1



Average MPD—M2

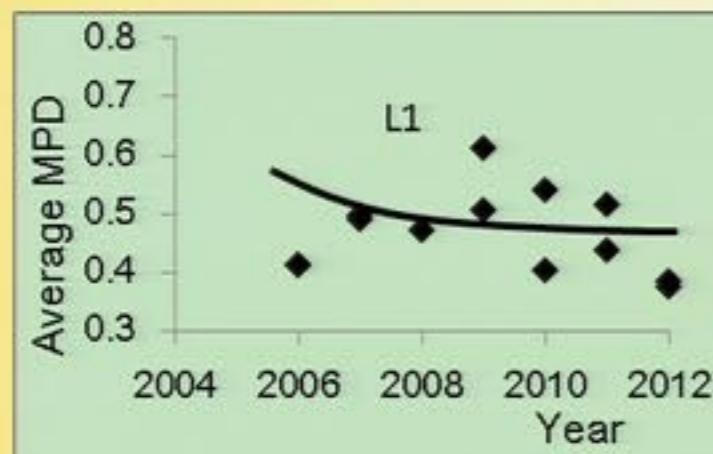


Average MPD—M3

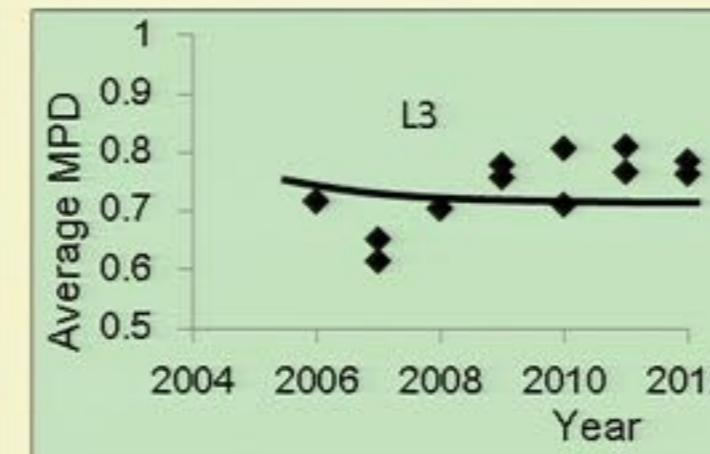


Average MPD—M4

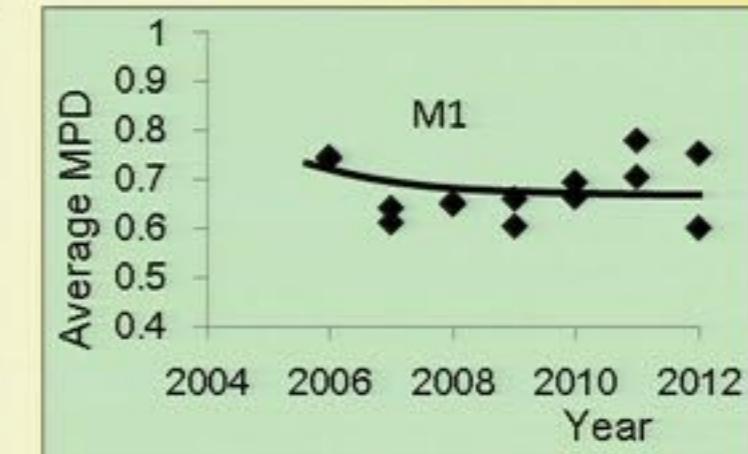
Average MPD vs. In-service years



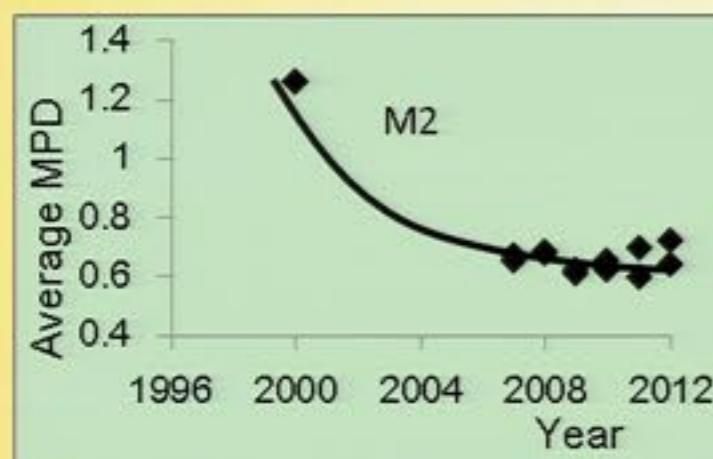
Average MPD—L1



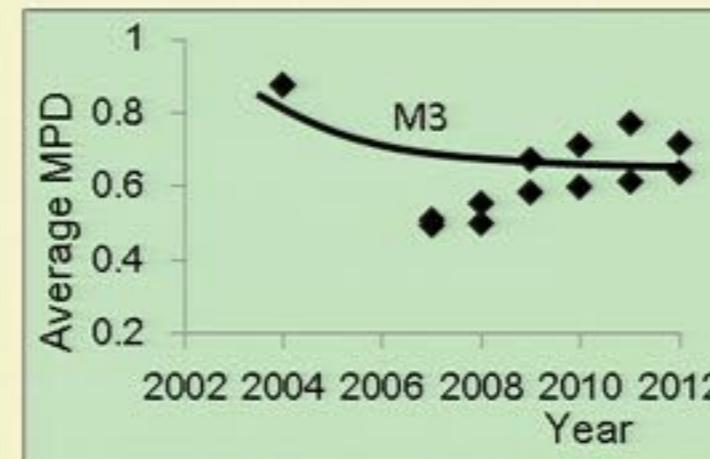
Average MPD—L3



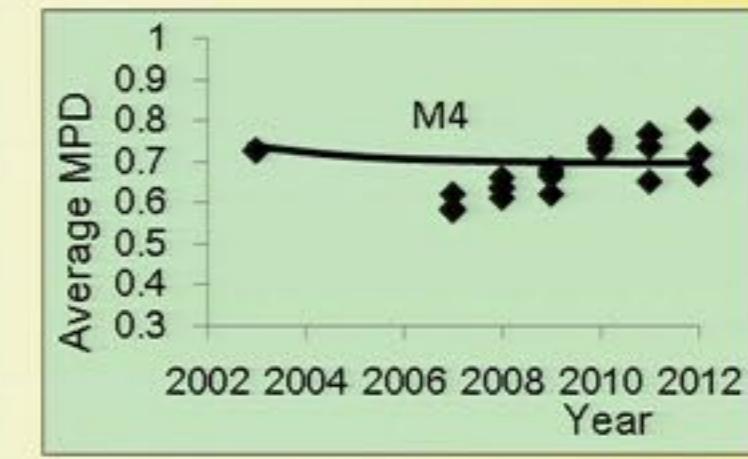
Average MPD—M1



Average MPD—M2

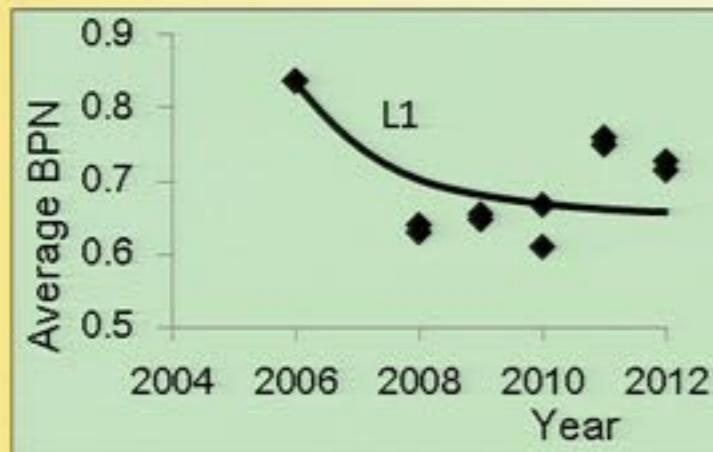


Average MPD—M3

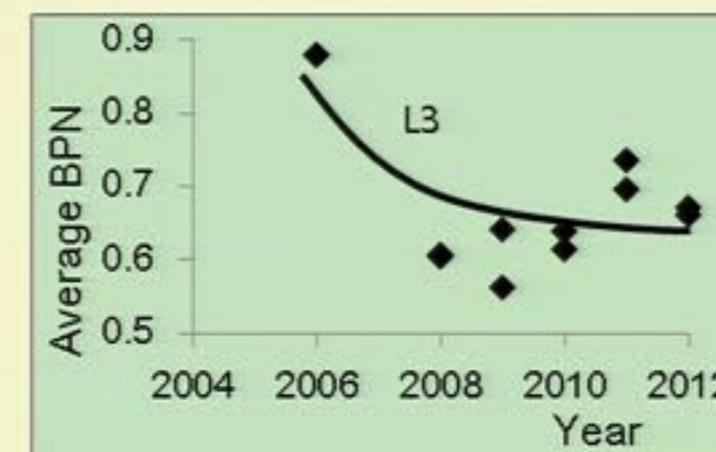


Average MPD—M4

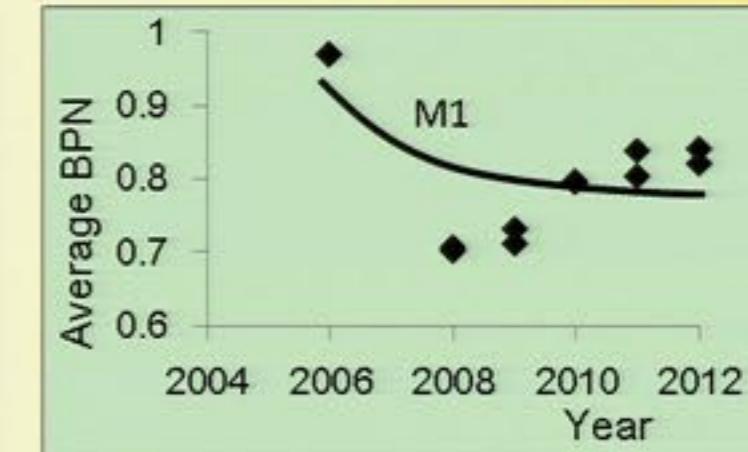
Average BPN vs. In-service years



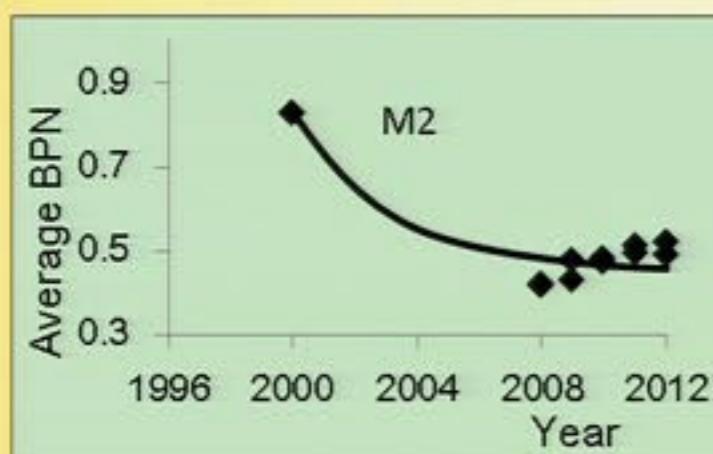
Average BPN—L1



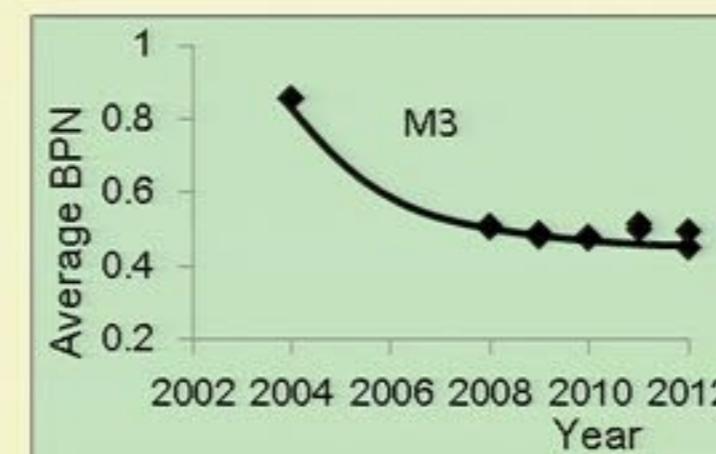
Average BPN—L3



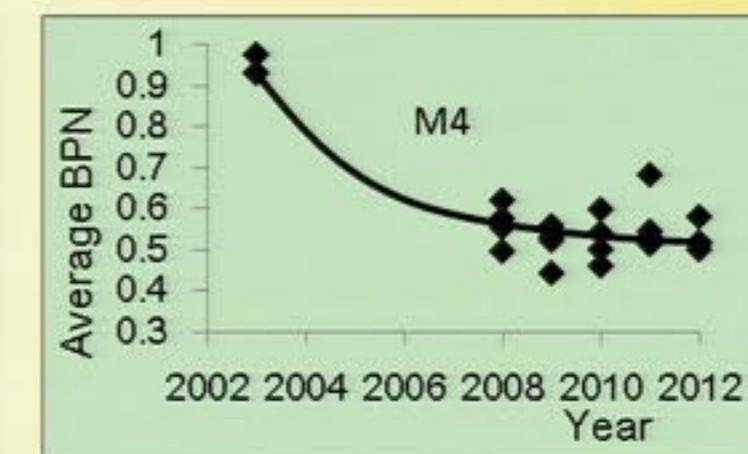
Average BPN—M1



Average BPN—M2

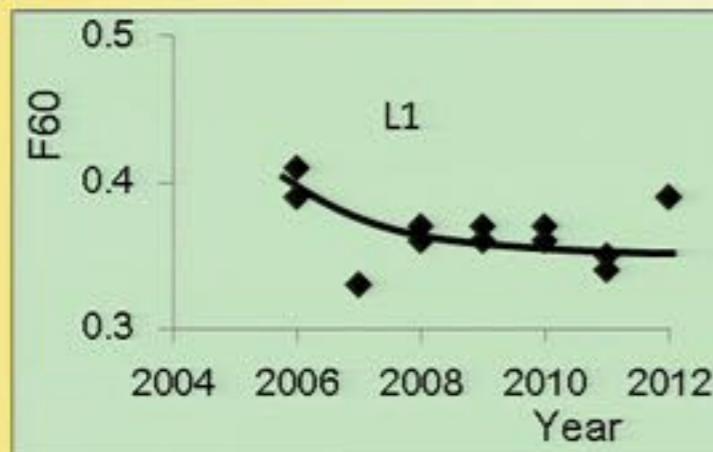


Average BPN—M3

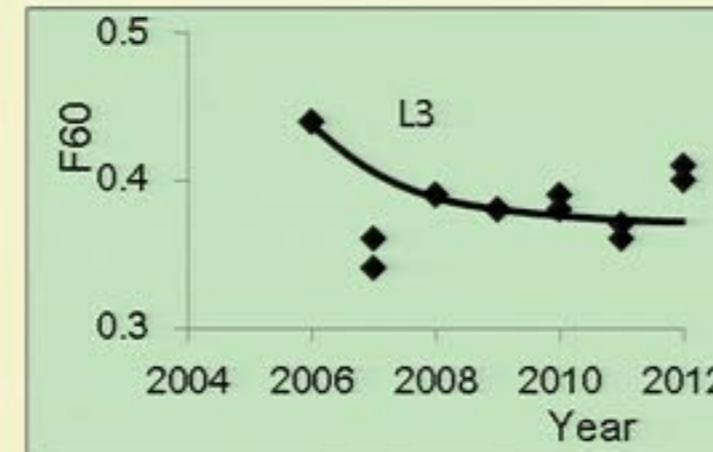


Average BPN—M4

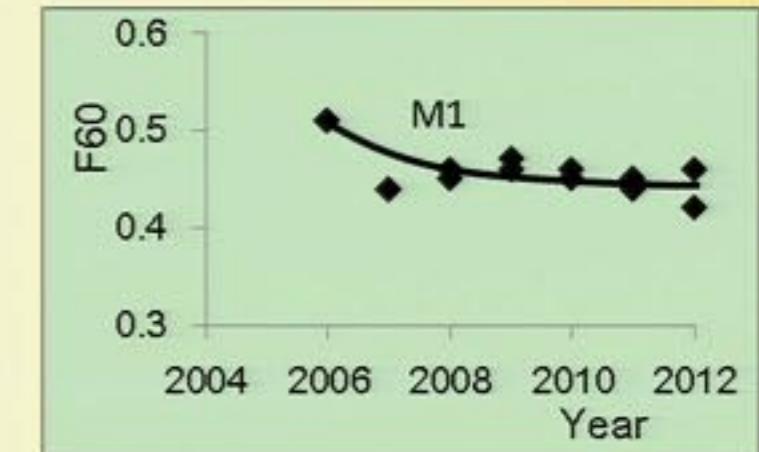
F60 vs. In-service years



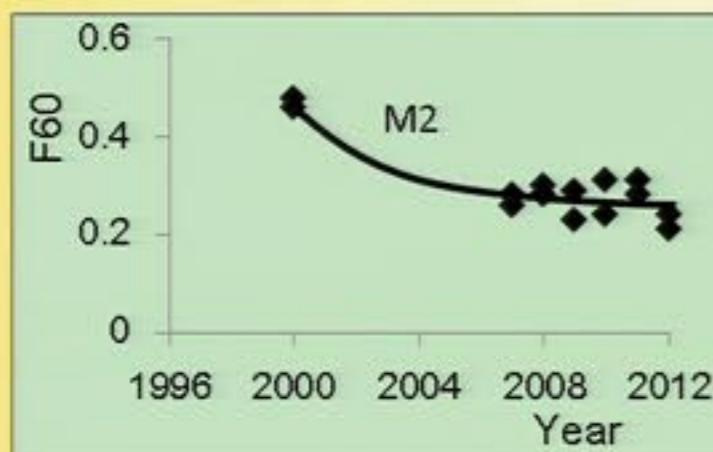
F60—L1



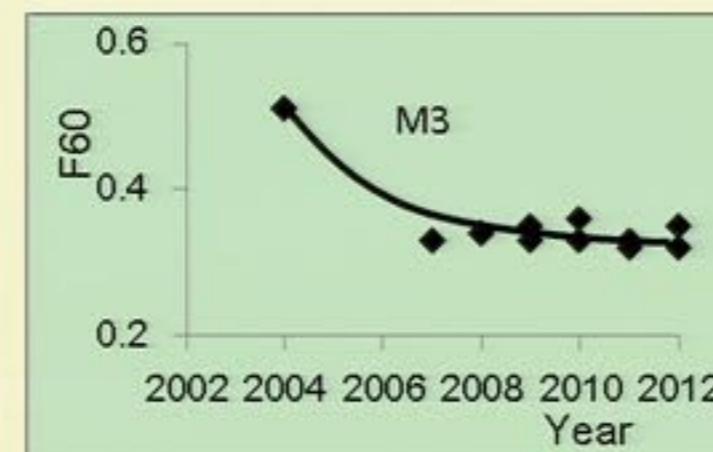
F60—L3



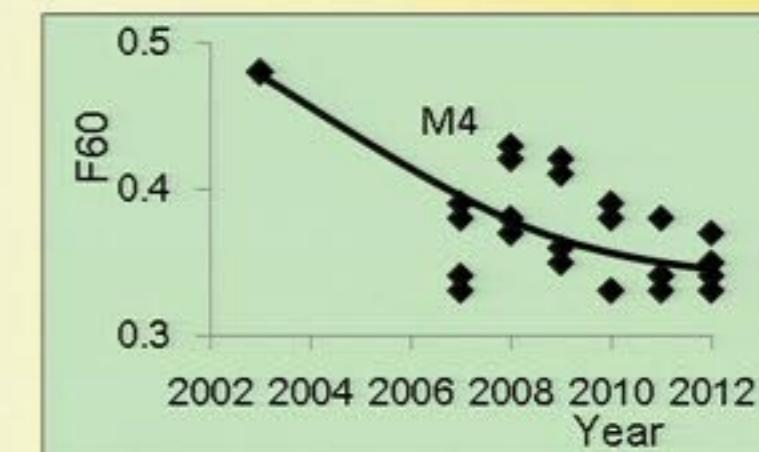
F60—M1



F60—M2



F60—M3



F60—M4

Commercial Grade Polisher



- 1: The Polisher;**
- 2: Control Panel;**
- 3: Access Door.**

Polishing Chamber



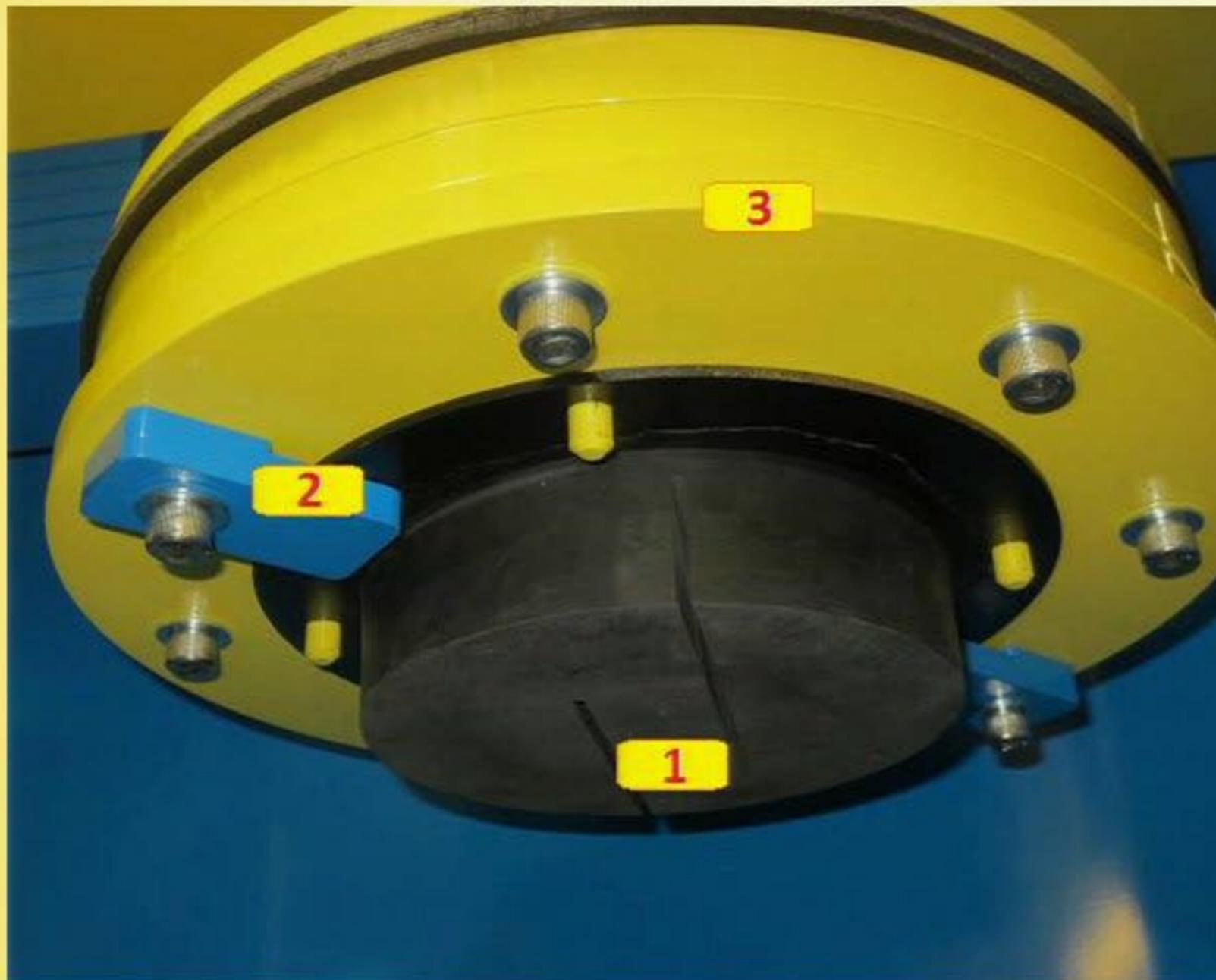
- 1: The Polishing Chamber;**
- 2: Sample Tray;**
- 3: Particle Trap;**
- 4: T-Bolt Band Clamp;**
- 5: Sample;**
- 6: Water Supply and Shut Off Valve;**
- 7: Shaft Assembly;**
- 8: Water Drain;**
- 9: Quick Disconnect Coupling.**

Polishing Chamber



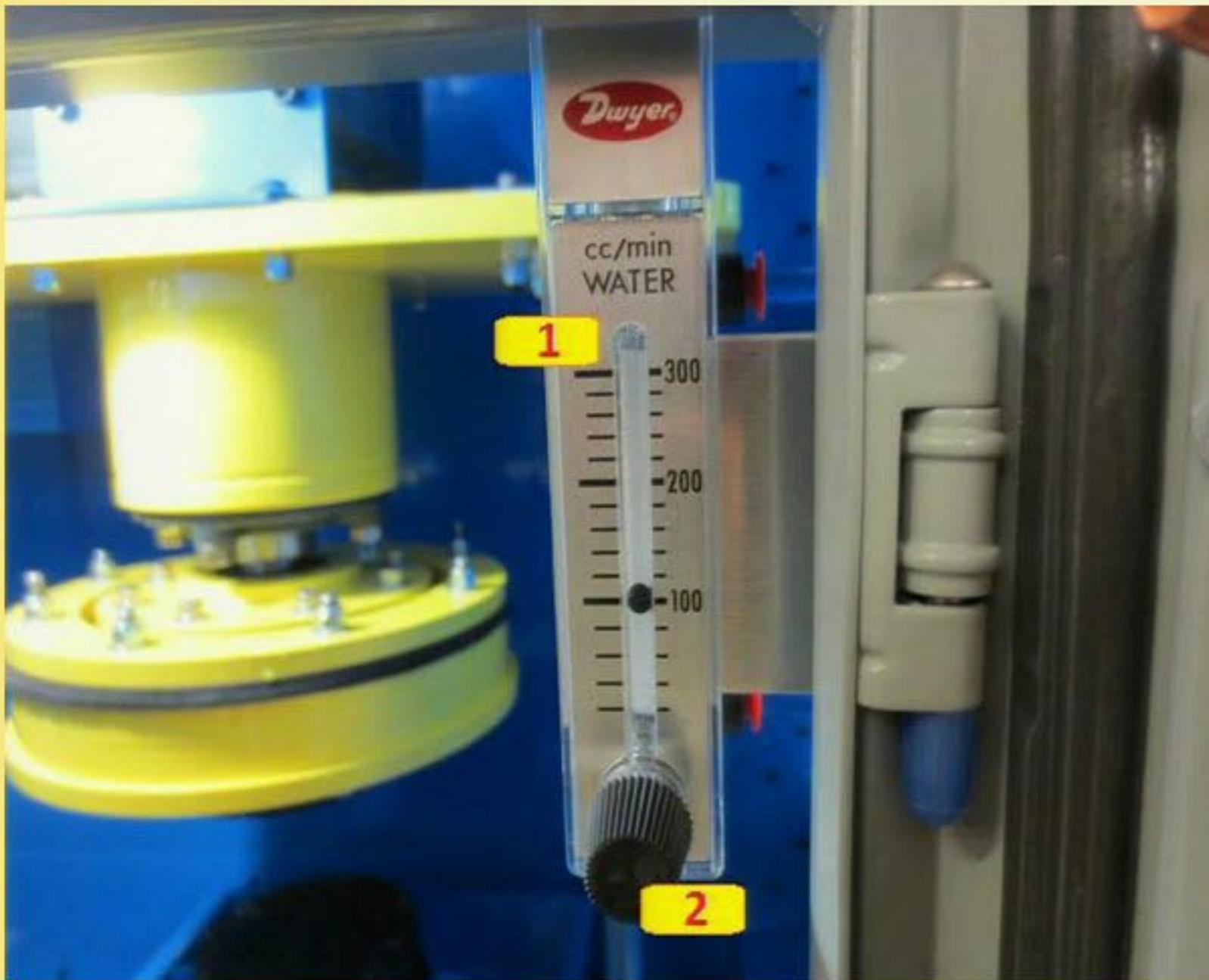
- 1: The Polishing Chamber;
- 2: Sample Tray;
- 3: Particle Trap;
- 4: T-Bolt Band Clamp;
- 5: Sample;
- 6: Water Supply and Shut Off Valve;
- 7: Shaft Assembly;
- 8: Water Drain;
- 9: Quick Disconnect Coupling.

Polish Disc



- 1: Polish Disc;**
- 2: Swivel Locks;**
- 3: Mounting Plate.**

Water Flow Meter



- 1: Water Flow Meter;**
- 2: Adjustment knob**

Control Panel



- 1: Timer;
- 2: Power On Light;
- 3: Work Light;
- 4: Hand/Off/Auto Switch;
- 5: Manual Actuator: Load/Unload;
- 6: Manual Rotation Switch;
- 7: Auto Mode Switch;
- 8: Control Panel Lock.

Samples



6''X4'' Sample

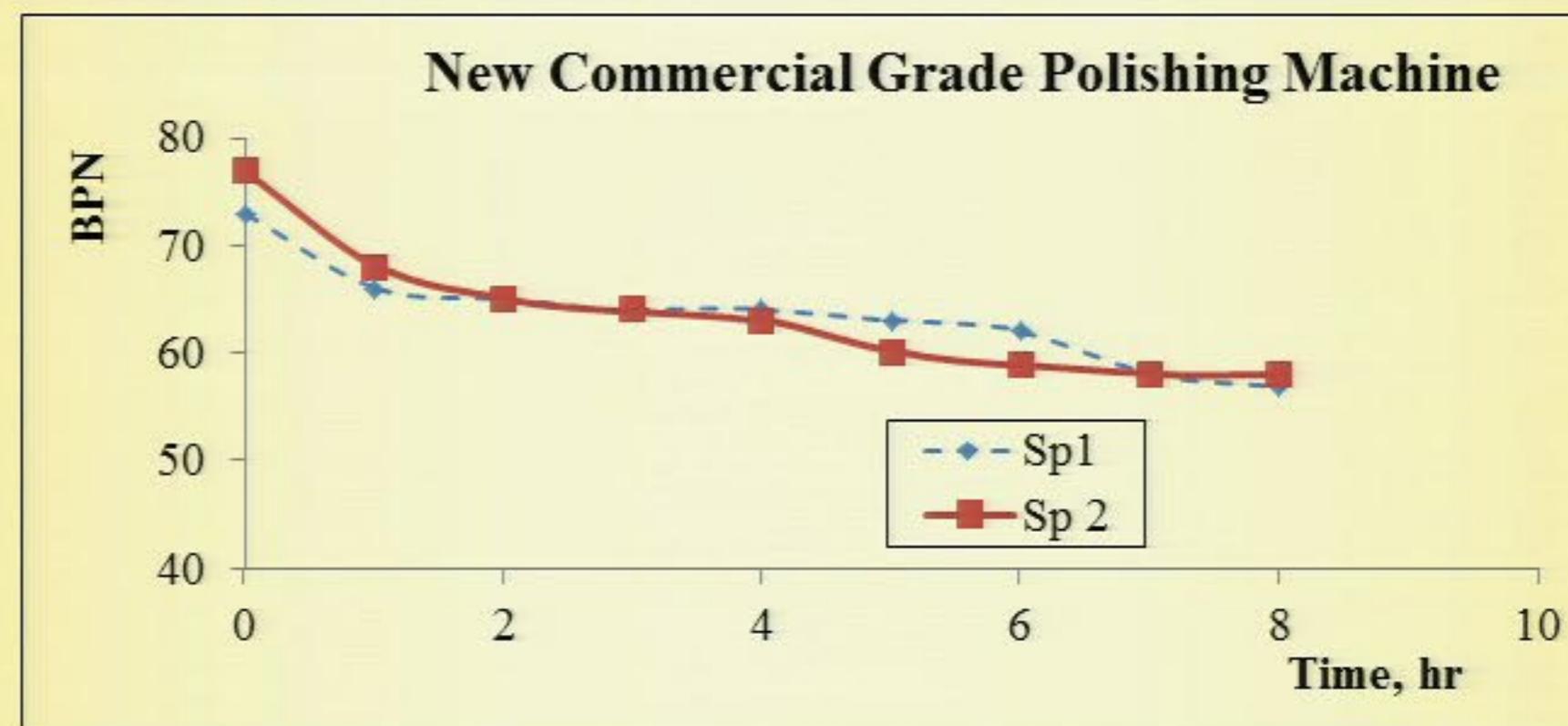
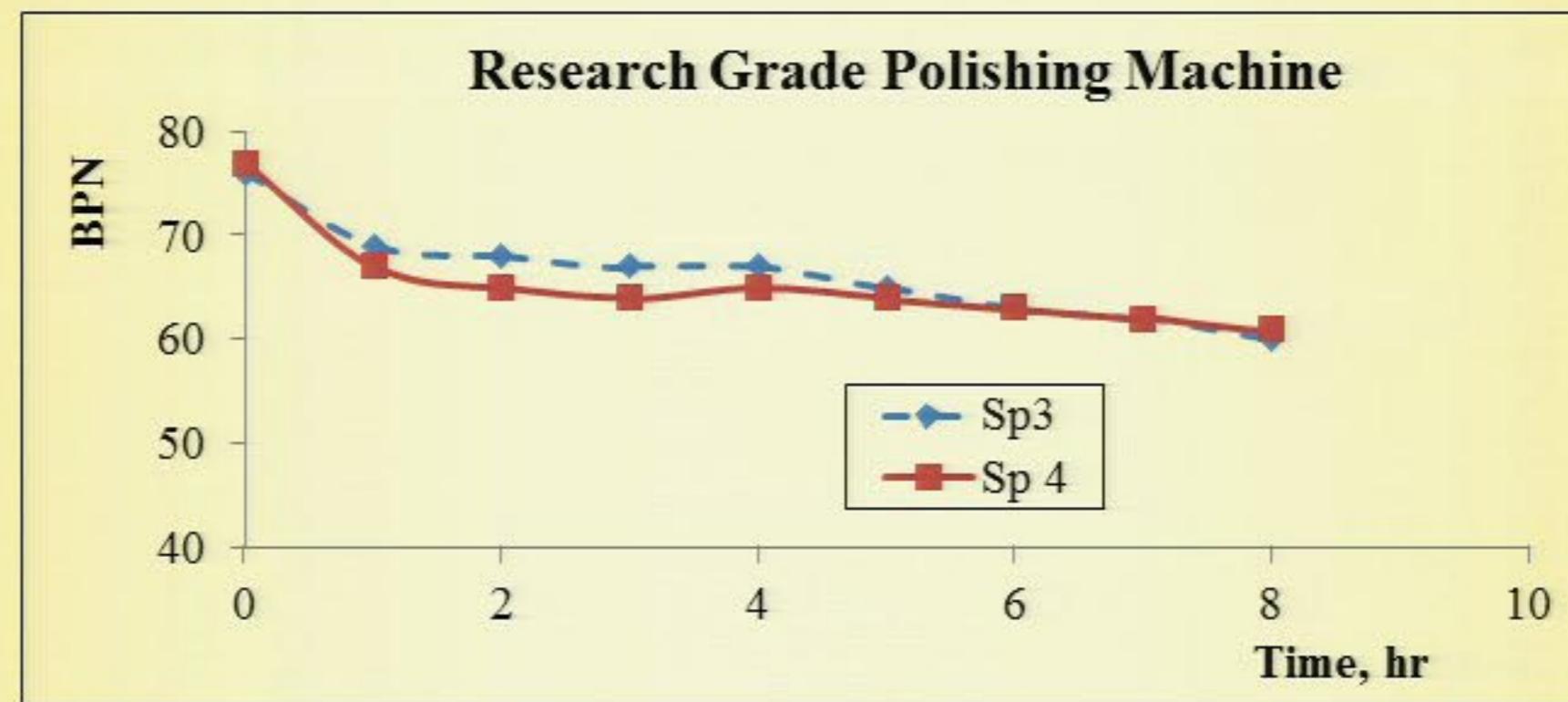


6''X6'' Sample

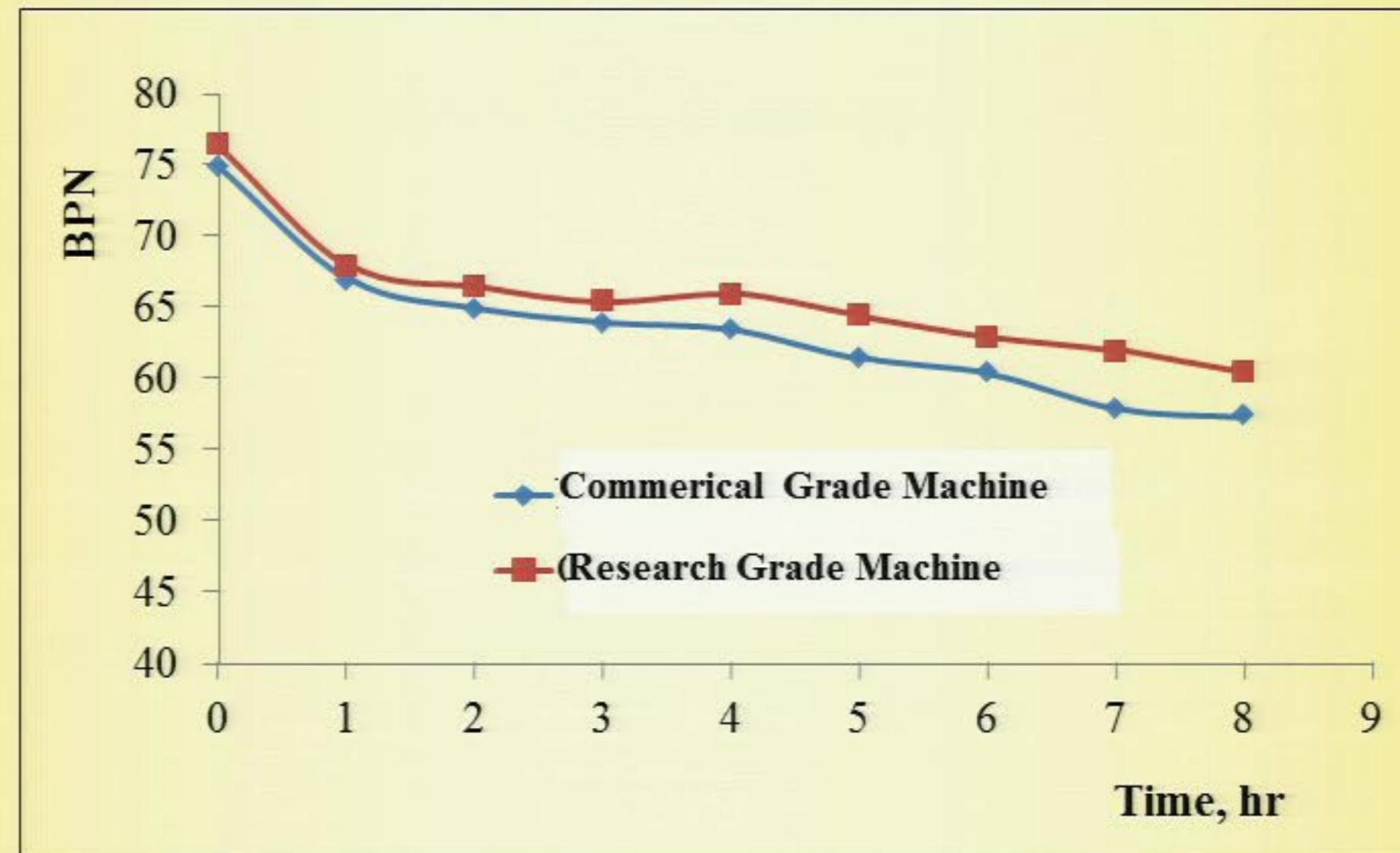
Inspecting Position of the Sample



Comparison Between Research Grade and Commercial Grade

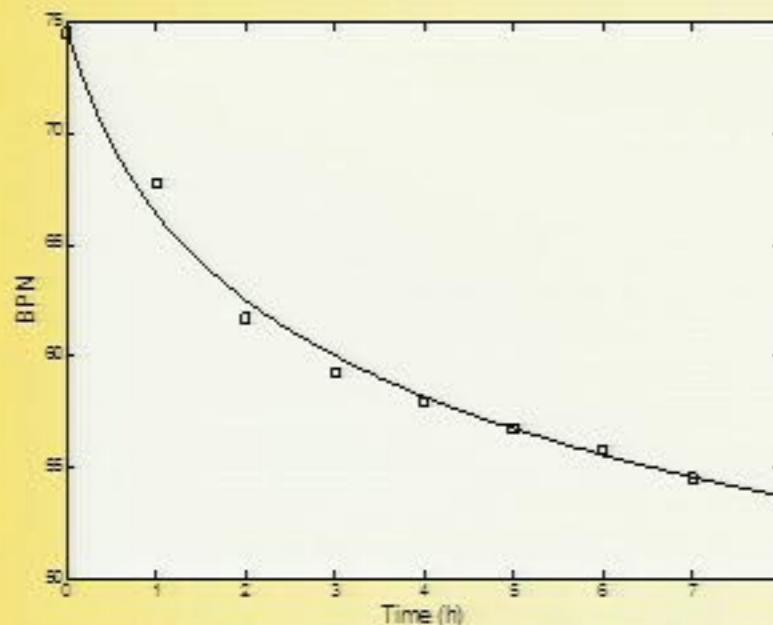


Commercial Grade vs. Research Grade

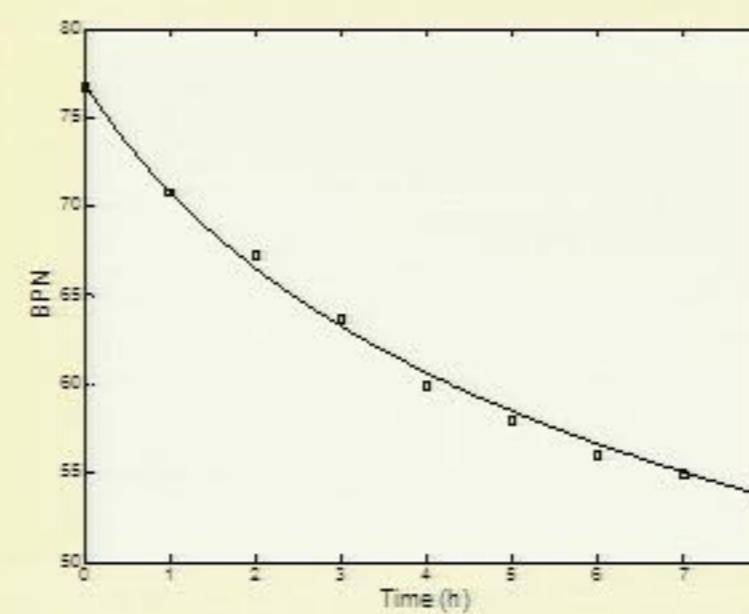


Prediction Models for Skid Resistance and International Friction Index

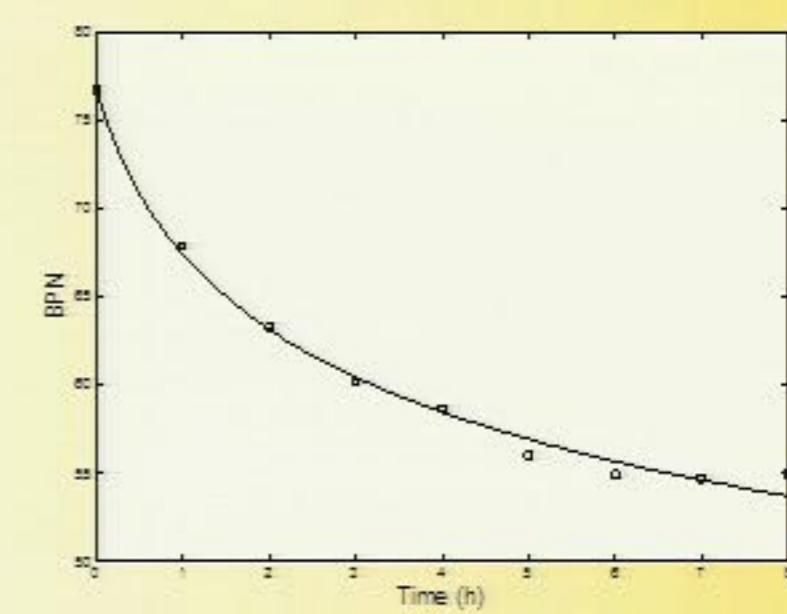
Lab test results for BPN values at different polishing durations



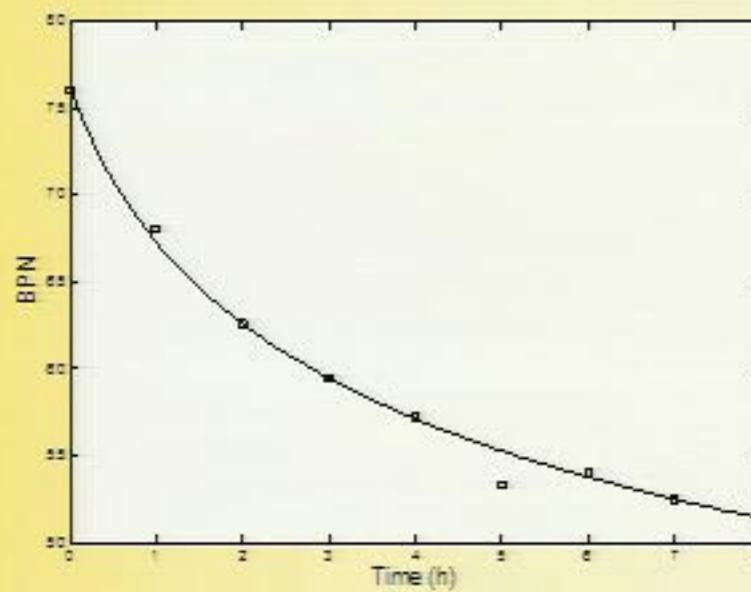
(a) BPN test of M1



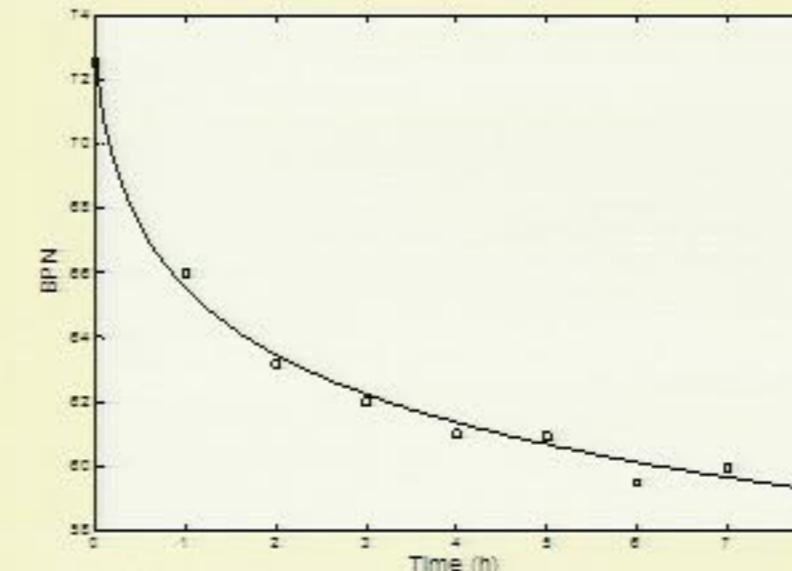
(b) BPN test of M2



(c) BPN test of M3



(d) BPN test of M4

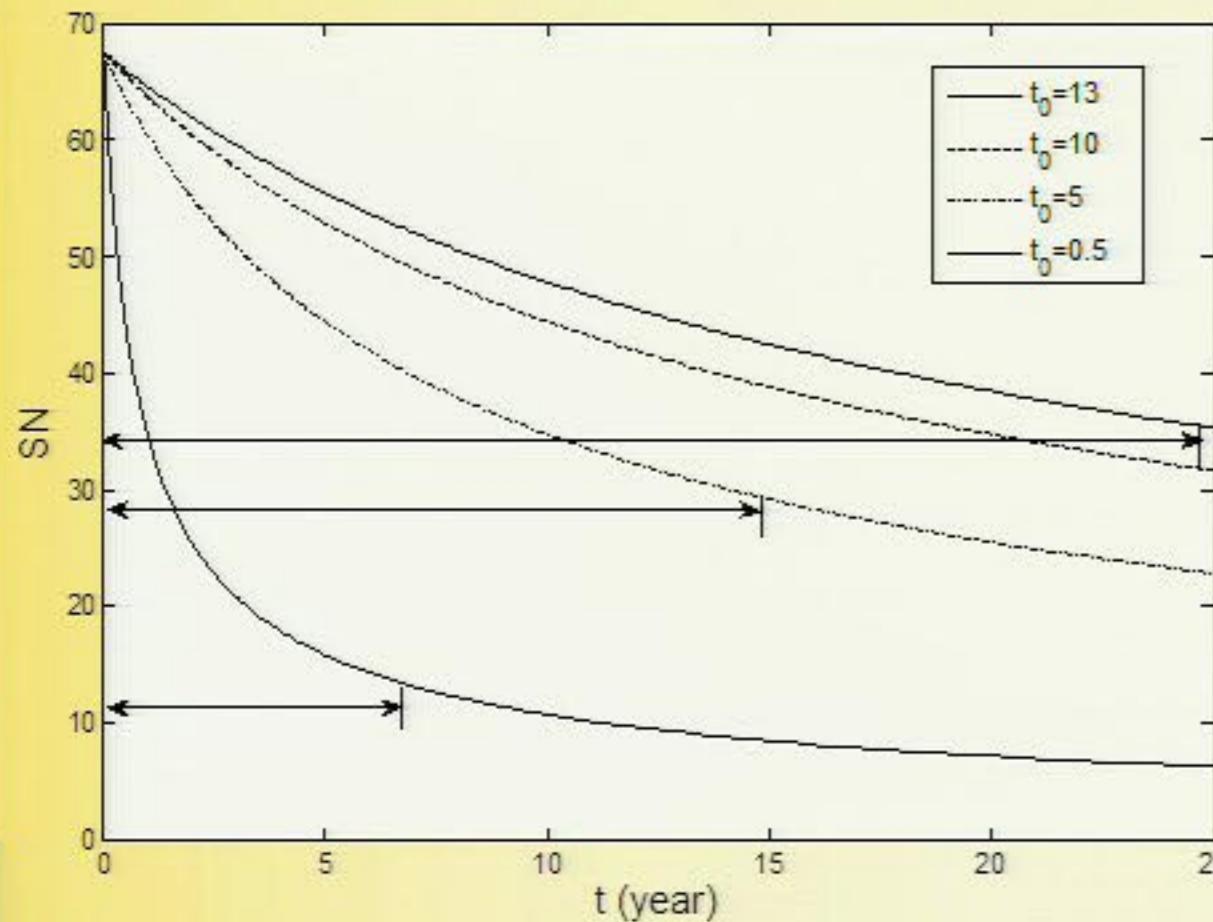
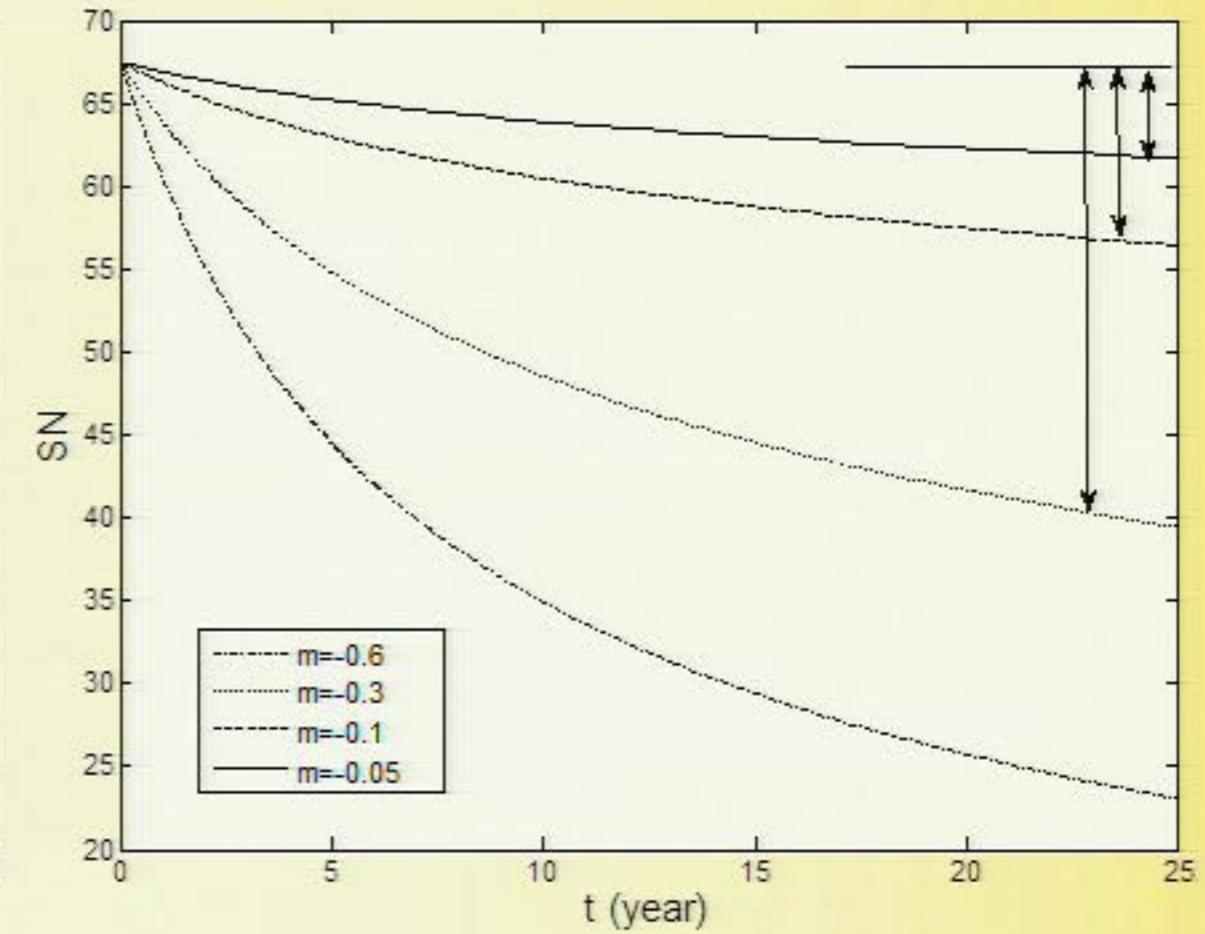


(e) BPN test of L3

Model function:

$$BPN = BPN_0 \left(1 + \frac{t}{t_0}\right)^m$$

$$BPN = BPN_0 \left(1 + \frac{t}{t_0}\right)^m$$

Time index: t_0 Scale index: m

Based on a literature review of relevant research work (particularly the work performed for TxDOT) and judging the available field data in this research.

$$\text{Time index: } t_0 = \alpha_1 ADT + \alpha_2 PV + \alpha_4 \kappa + \alpha_5 \lambda$$

$$\text{Scale index: } m = \beta_1 ADT + \beta_2 PV + \beta_4 \kappa + \beta_5 \lambda$$

Predictors				Responses	
ADT	PV (%)	κ	λ	t_0	m

ADT: Average daily traffic.

PV: Polishing value.

λ : scale parameter of Gradation Curve.

κ : shape parameter of Gradation Curve.

$$PV = \frac{BPN_o - BPN_8}{BPN_o} * 100$$

BPN_o = British pendulum friction number before polishing

BPN_8 = British pendulum friction number after 8 hours of polishing

Based on a literature review of relevant research work (particularly the work performed for TxDOT) and judging the available field data in this research.

$$\text{Time index: } t_0 = \alpha_1 ADT + \alpha_2 PV + \alpha_4 \kappa + \alpha_5 \lambda$$

$$\text{Scale index: } m = \beta_1 ADT + \beta_2 PV + \beta_4 \kappa + \beta_5 \lambda$$

Predictors				Responses	
ADT	PV (%)	κ	λ	t_0	m

ADT: Average daily traffic.

PV: Polishing value.

λ : scale parameter of Gradation Curve.

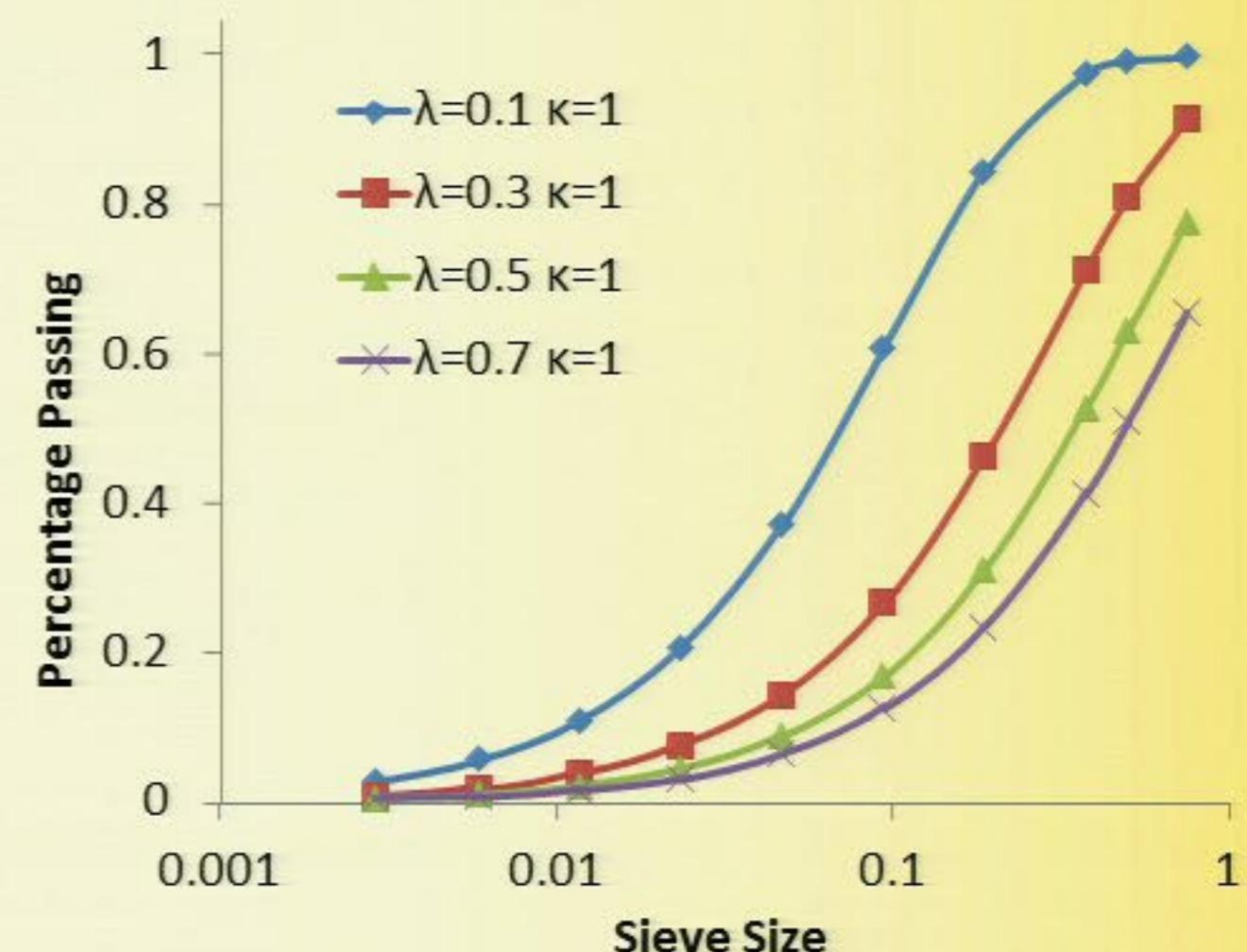
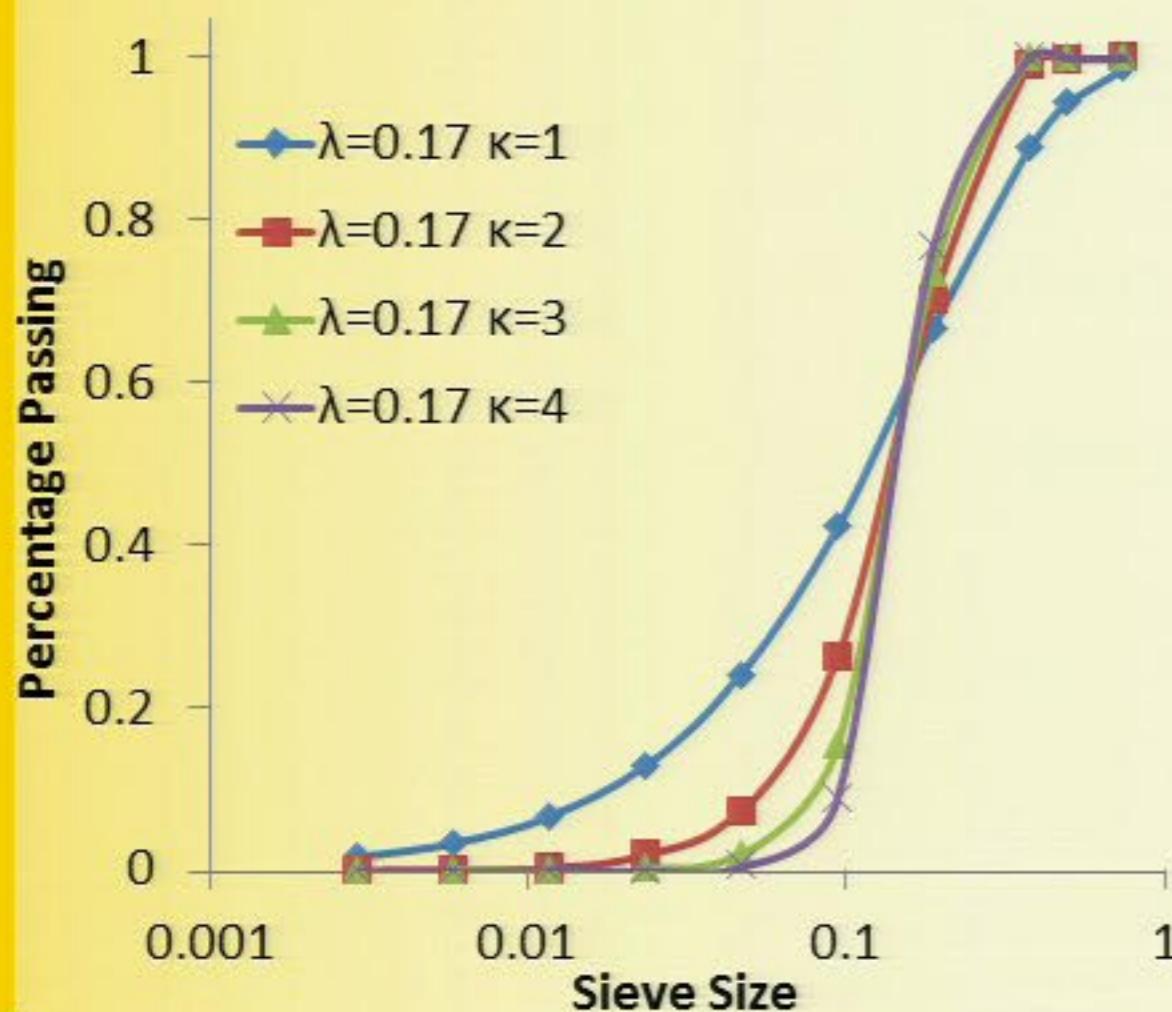
κ : shape parameter of Gradation Curve.

$$PV = \frac{BPN_o - BPN_8}{BPN_o} * 100$$

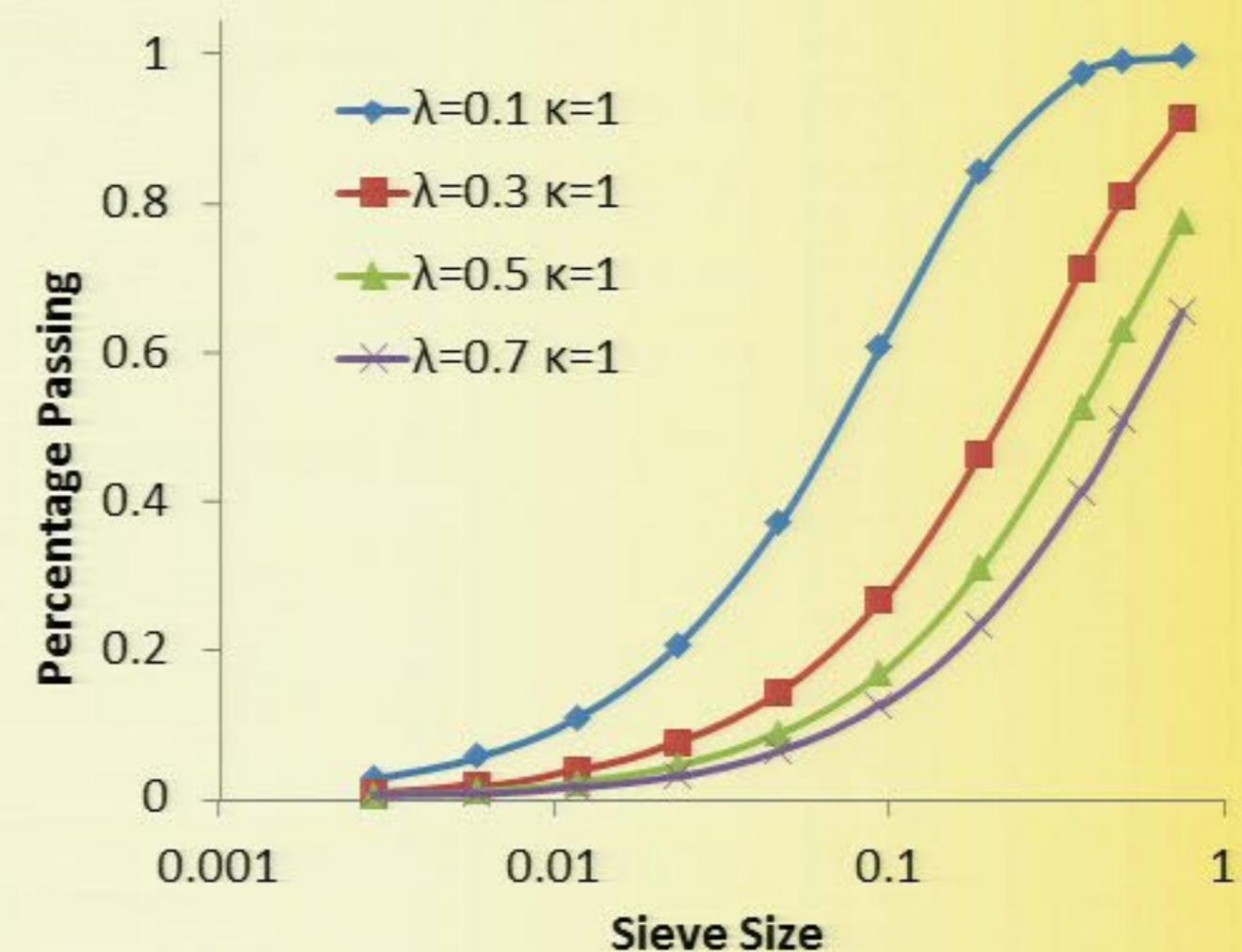
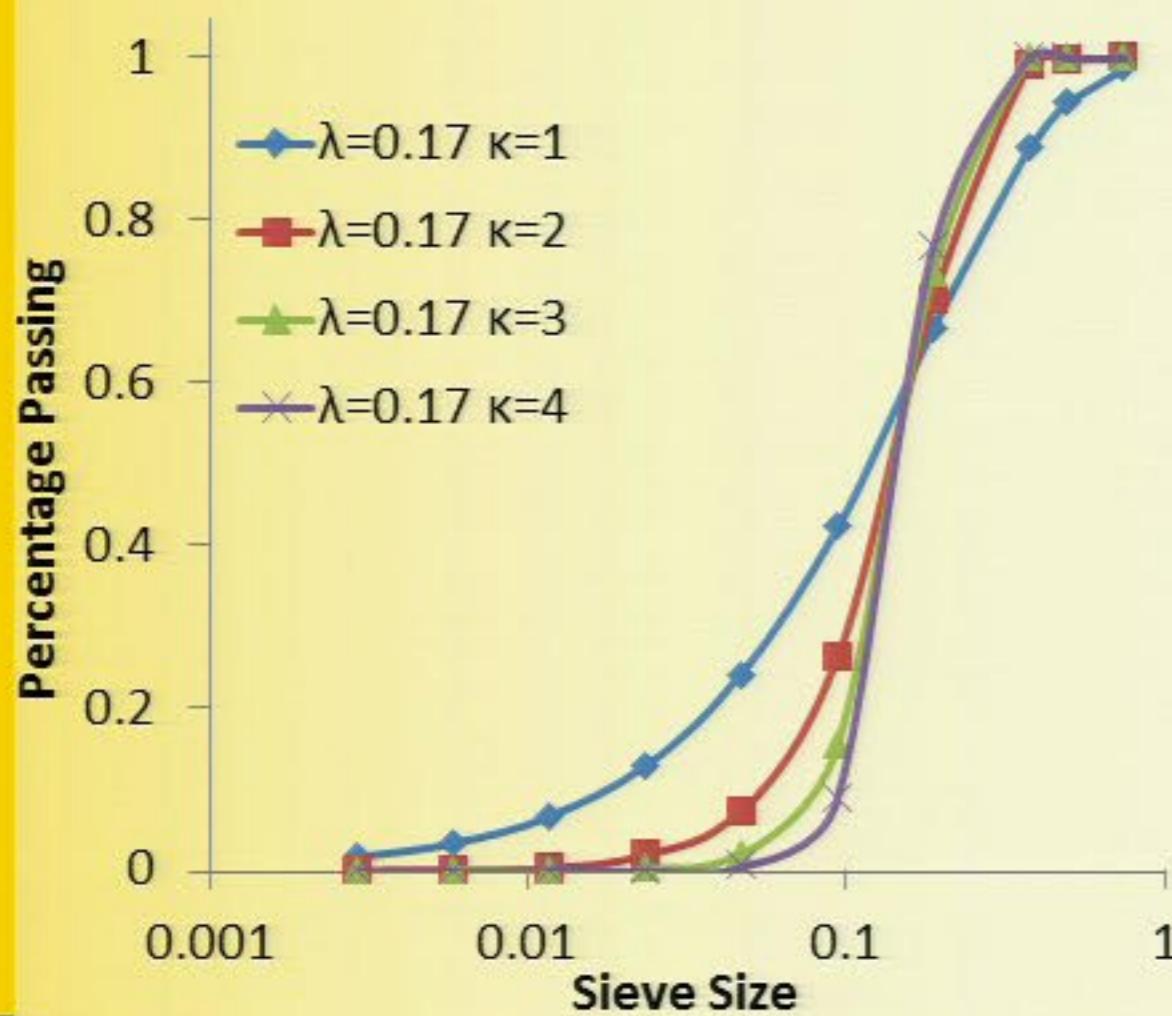
BPN_o = British pendulum friction number before polishing

BPN_8 = British pendulum friction number after 8 hours of polishing

λ : scale parameter of Gradation Curve.
 κ : shape parameter of Gradation Curve



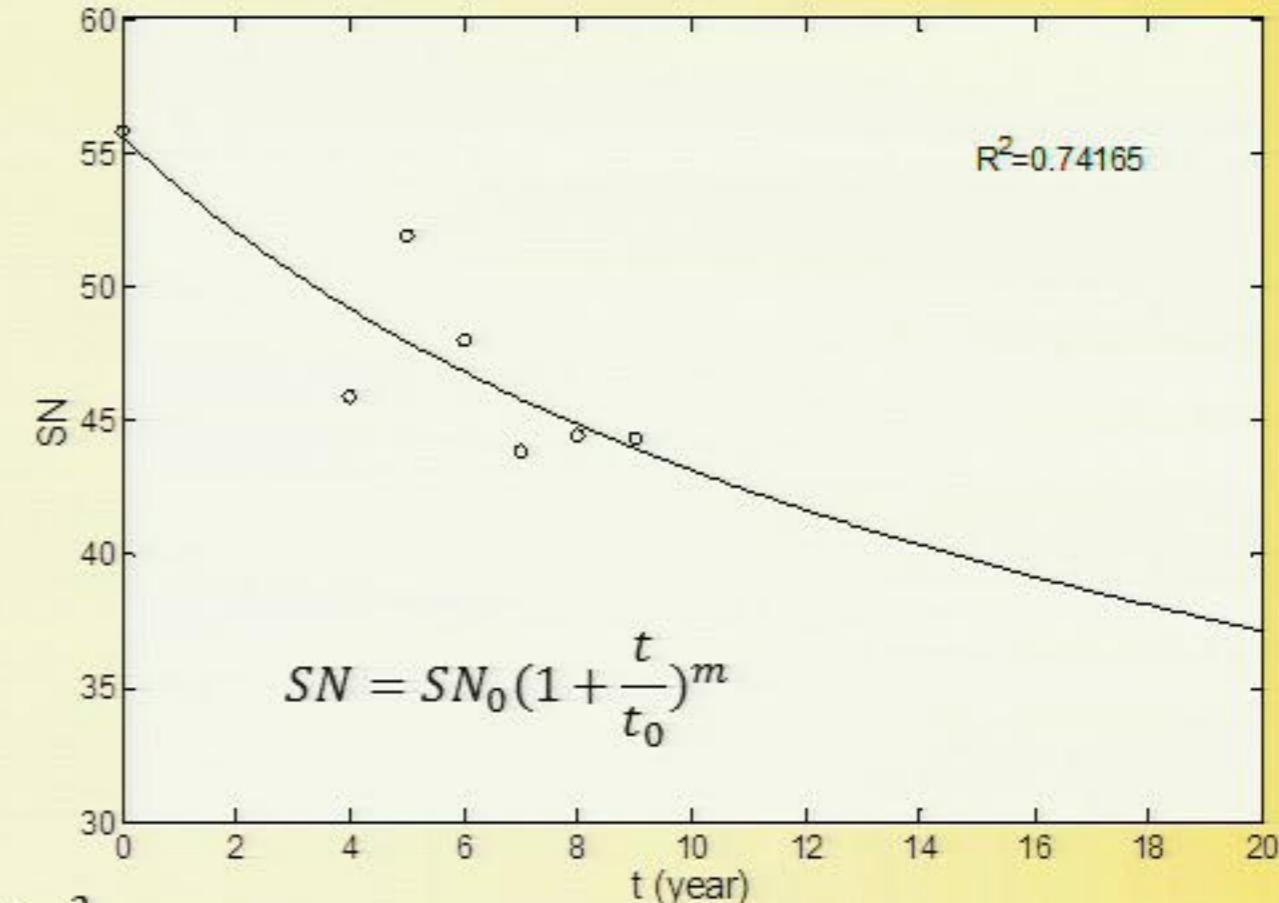
λ : scale parameter of Gradation Curve.
 κ : shape parameter of Gradation Curve



Determining the Model Coefficients

Set P as the factor Matrix

$$P = \begin{bmatrix} \text{ADT} & \text{PV} & \kappa & \lambda \\ a_{11} & a_{12} & a_{14} & a_{15} \\ a_{21} & a_{22} & a_{24} & a_{25} \\ \dots & & & \\ a_{n1} & a_{n2} & a_{n4} & a_{n5} \end{bmatrix} \begin{array}{l} \text{Material 1} \\ \text{Material 2} \\ \dots \\ \text{Material n} \end{array}$$



Time index: $t_0 = \alpha_1 ADT + \alpha_2 PV + \alpha_4 \kappa + \alpha_5 \lambda$

Scale index: $m = \beta_1 ADT + \beta_2 PV + \beta_4 \kappa + \beta_5 \lambda$

$$\alpha = P^{-1} * t_0$$

$$\beta = P^{-1} * m$$

Once we have the factor matrix and the regression result of t_0 and m from nonlinear regression work based on field data

The friction degradation model for SN(64)R for the in-service asphalt pavement surface

$$SN = SN_0 \left(1 + \frac{t}{t_0}\right)^m$$

Time index: $t_0 = -6 * 10^{-4}ADT + 0.287PV - 185.63\kappa + 1167.8\lambda$

Scale index: $m = -9.22 * 10^{-5}ADT + 0.0372PV - 2.33\kappa + 10.93\lambda$

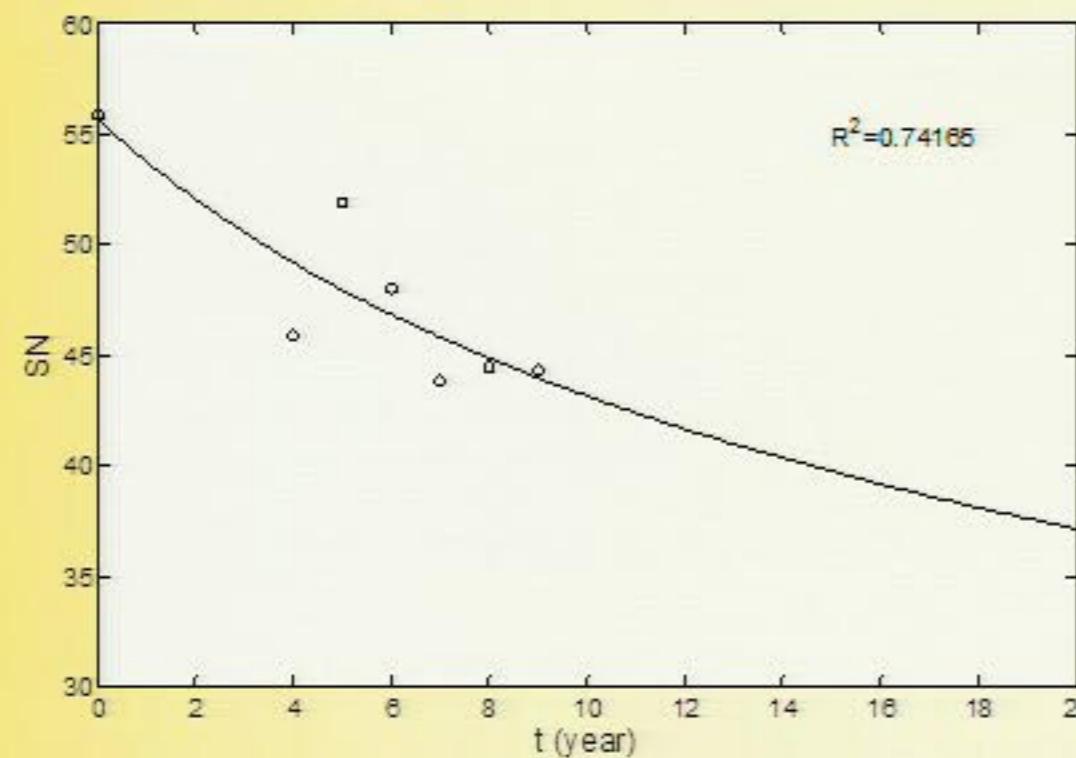
SN_0 : Initial value of skid number. For new project, without field measured SN_0 ,
The SN_0 could be determined by converting BPN_0 from the polishing test using
equation (Kissoff, N. V., 1988)

$$SN_0 = 0.862 * BPN_0 - 9.690$$

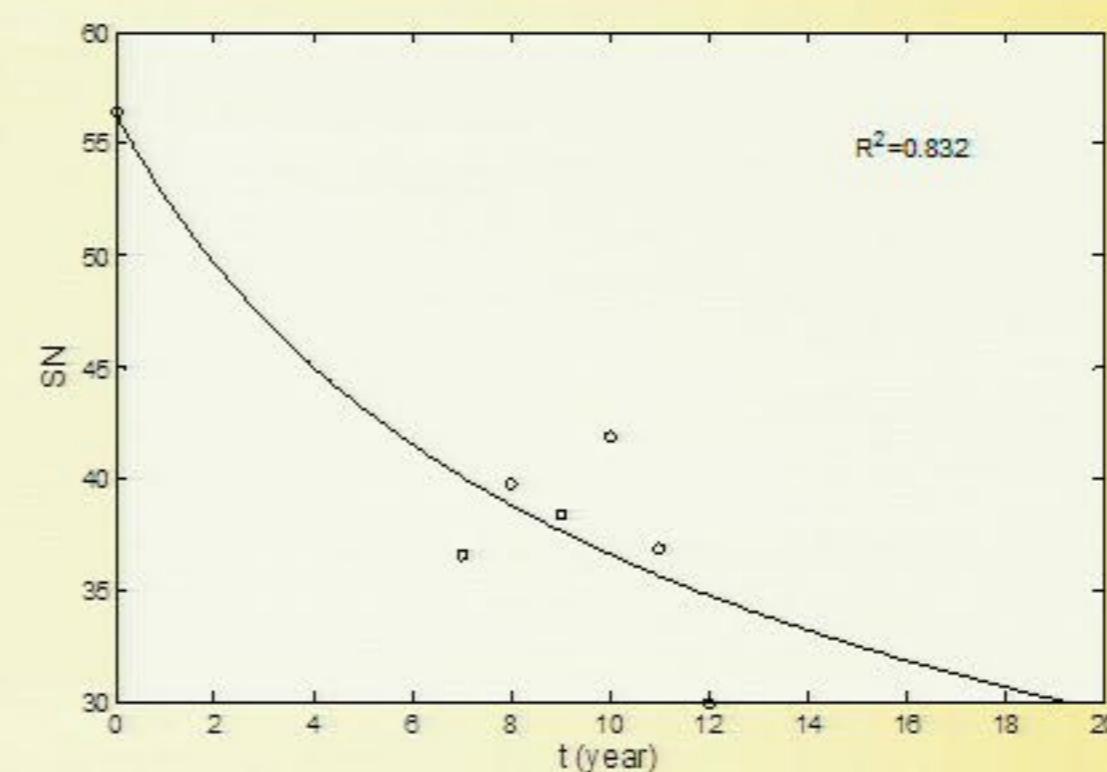
Prediction Results

The predictor and response values for four highway sections.

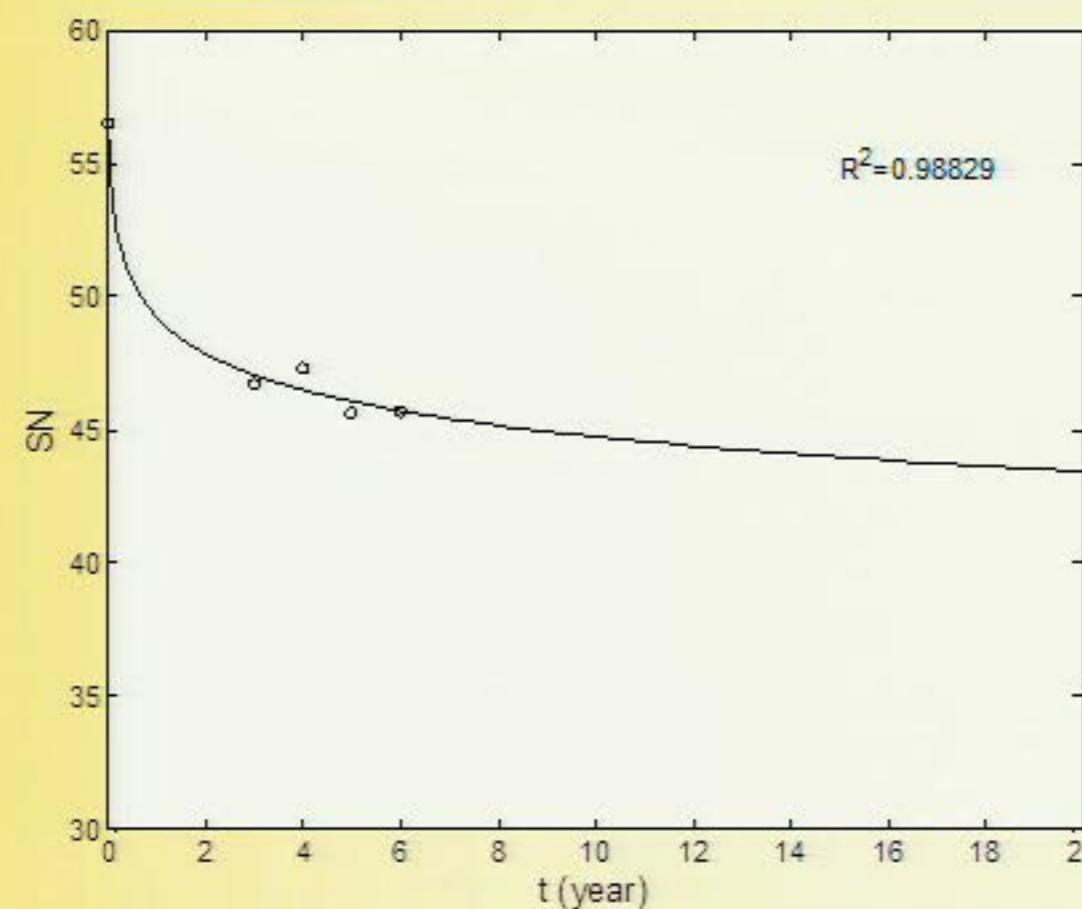
Highway	Material	ADT	PV (%)	κ	λ	t_0	m
Wood_drive	M4	11000	30.9	0.990772	0.164573	10.15	-0.37
Huron 250	M2	9290	28.6	1.150266	0.18598	5.97	-0.44
Lucas 64	M3	4390	28.4	1.092368	0.169079	0.041	-0.042
Harrison 250	L3	1430	17.6	1.086712	0.17634	8.35	-0.785



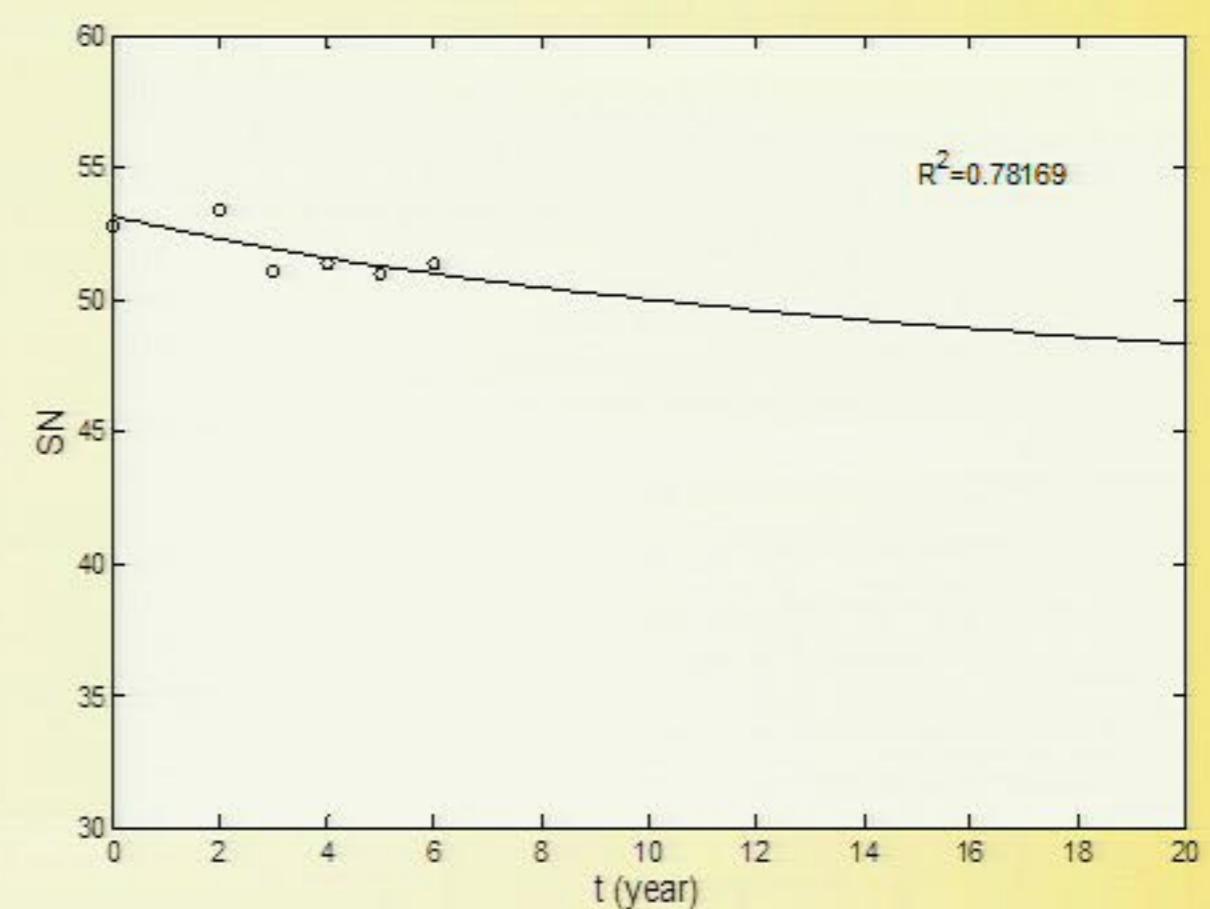
Wood_drive M4



Huron 250 M2



(d) Lucas 64 M3



(e) Harrison 250 L3

Developing the Predictive Model for F(60)

$$F60 = F60_0 \left(1 + \frac{t}{t_0}\right)^m$$

To reflect the texture characteristic, we add two more predictor called texture value (TV) and t_stable

$$TV = \frac{MTD_o - MTD_8}{MTD_o} * 100$$

MTD_o = Mean texture depth before polishing

MTD_8 = Mean texture depth after 8-hour polishing

t_stable (hour) is the time lasted until the BPN is stable during the lab test.

The procedure used to build up the prediction model of F60 is the same as the procedure described in the previous section for building the model for SN

Predictors						Responses	
ADT	PV (%)	t_stable (hour)	κ	TV (%)	λ	t_0	m

$$F60 = F60_0 \left(1 + \frac{t}{t_0}\right)^m$$

Time index: $t_0 = 3.26 * 10^{-4} ADT + 0.1154 PV - 1.111 t_{stable} + 0.0288 TV - 12\kappa + 84.71\lambda$

Scale index: $m = -3.38 * 10^{-5} ADT - 0.0123 PV + 0.0354 t_{stable} + 0.01938 TV - 1.373\kappa + 7.309\lambda$

The procedure used to build up the prediction model of F60 is the same as the procedure described in the previous section for building the model for SN

Predictors						Responses	
ADT	PV (%)	t_stable (hour)	κ	TV (%)	λ	t_0	m

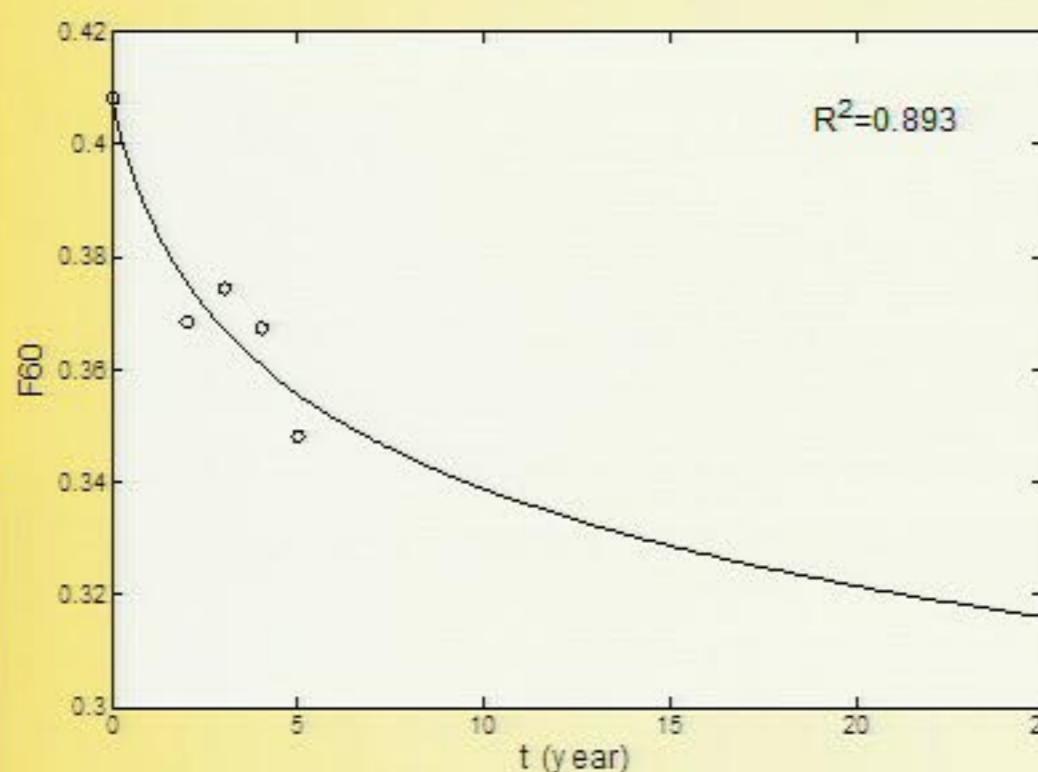
$$F60 = F60_0 \left(1 + \frac{t}{t_0}\right)^m$$

Time index: $t_0 = 3.26 * 10^{-4} ADT + 0.1154 PV - 1.111 t_{stable} + 0.0288 TV - 12\kappa + 84.71\lambda$

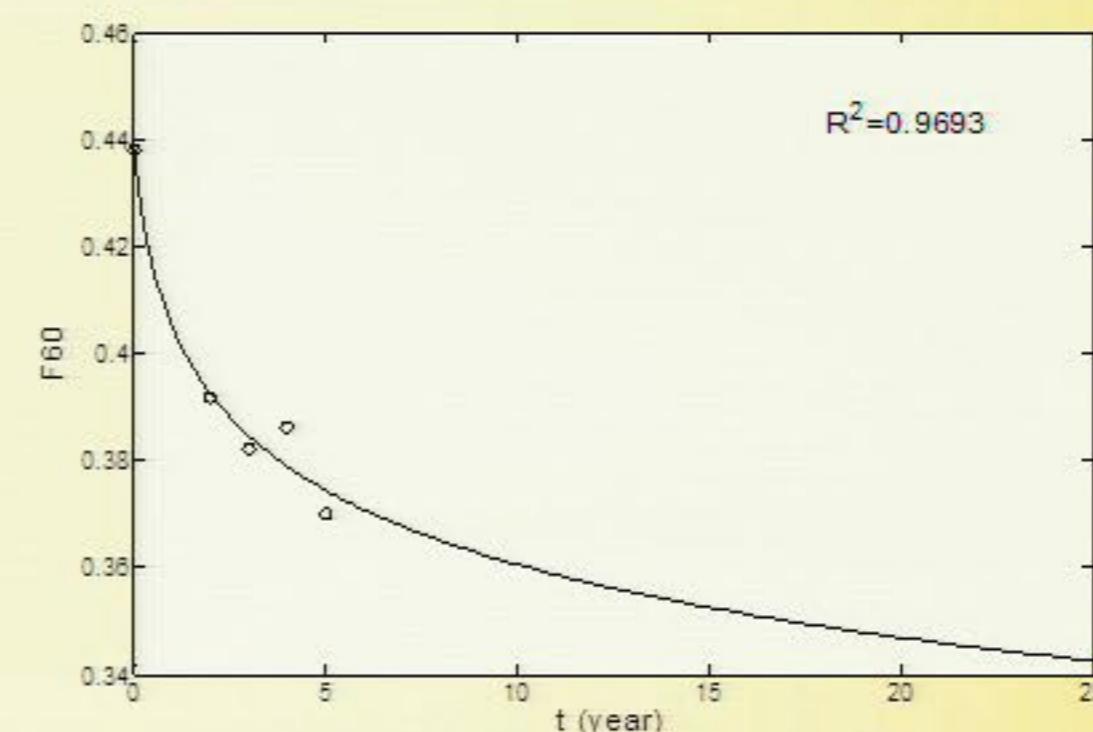
Scale index: $m = -3.38 * 10^{-5} ADT - 0.0123 PV + 0.0354 t_{stable} + 0.01938 TV - 1.373\kappa + 7.309\lambda$

The predictor and responses values for six highway sections

Highway	Material	ADT	PV (%)	t_stable	TV(%)	κ	λ	t_0	m
Wood pass	M4	11000	30.9	5	26.08286	0.990772	0.164573	4.397891	-0.22692
Huron 162	M1	6000	27.2	7	25.54028	1.150266	0.18598	0.00018	-0.0148
Huron250	M2	9290	28.6	7	21.01167	1.150266	0.18598	1.104774	-0.23093
Lucas 64	M3	4390	28.4	6	25.96934	1.092368	0.169079	0.000436	-0.04627
Harrison250	L3	1430	17.6	4	13.9	1.086712	0.17634	0.346147	-0.05723
Harrison 22	L1	1300	19.6	4	8.977273	1.008409	0.174143	1.146686	-0.0814



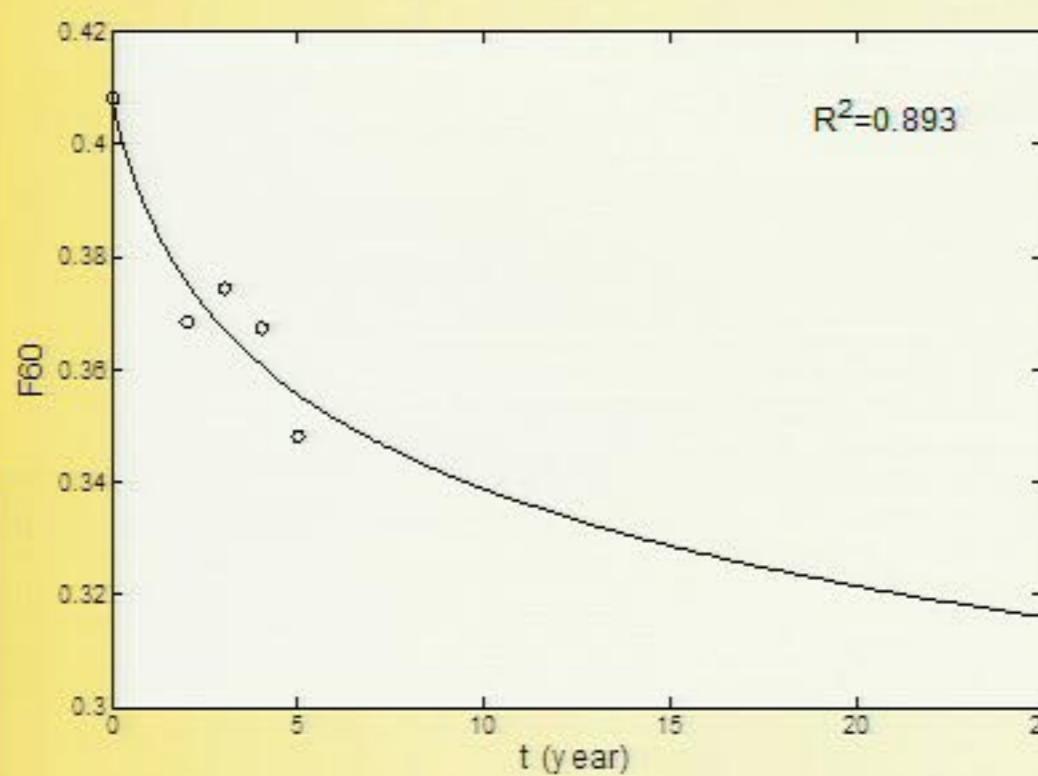
(a) Harrison 22L1



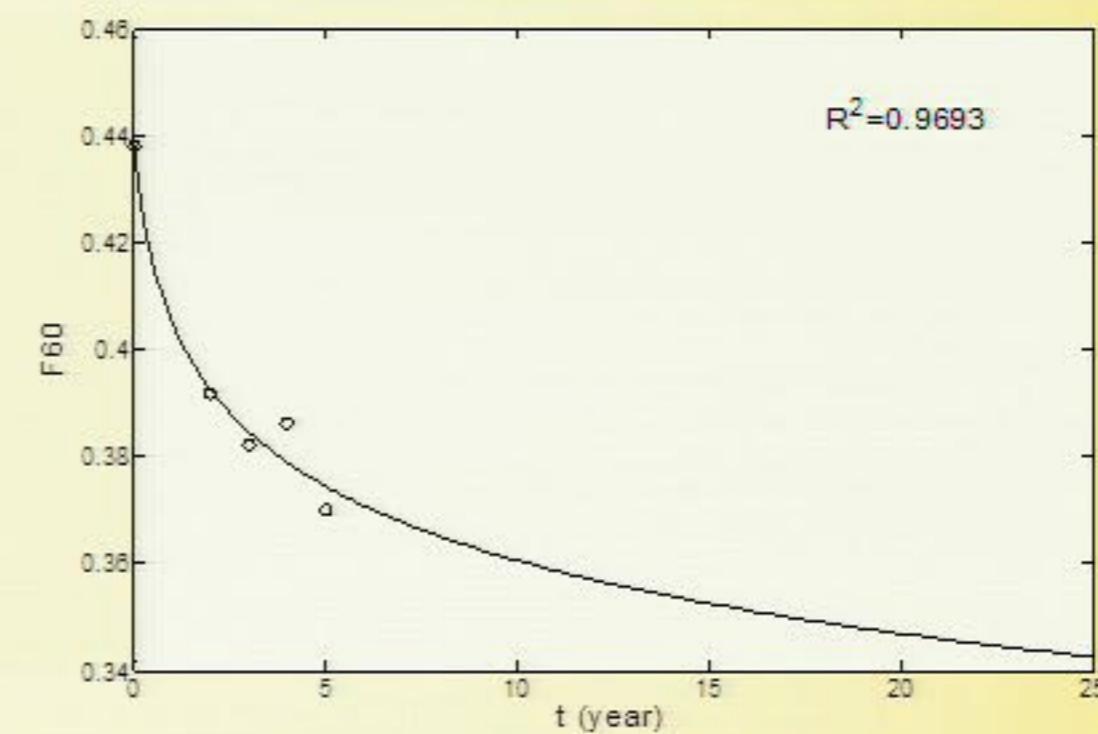
(b) Harrison 250L3

The predictor and responses values for six highway sections

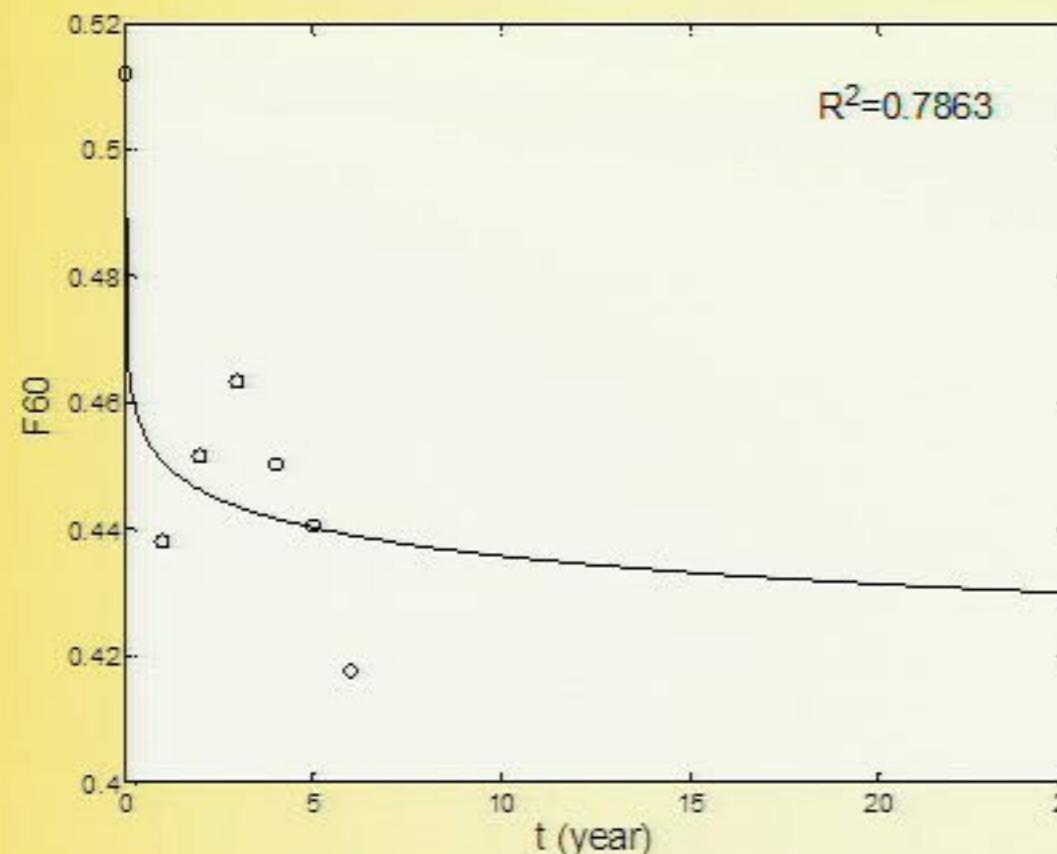
Highway	Material	ADT	PV (%)	t_stable	TV(%)	κ	λ	t_0	m
Wood pass	M4	11000	30.9	5	26.08286	0.990772	0.164573	4.397891	-0.22692
Huron 162	M1	6000	27.2	7	25.54028	1.150266	0.18598	0.00018	-0.0148
Huron250	M2	9290	28.6	7	21.01167	1.150266	0.18598	1.104774	-0.23093
Lucas 64	M3	4390	28.4	6	25.96934	1.092368	0.169079	0.000436	-0.04627
Harrison250	L3	1430	17.6	4	13.9	1.086712	0.17634	0.346147	-0.05723
Harrison 22	L1	1300	19.6	4	8.977273	1.008409	0.174143	1.146686	-0.0814



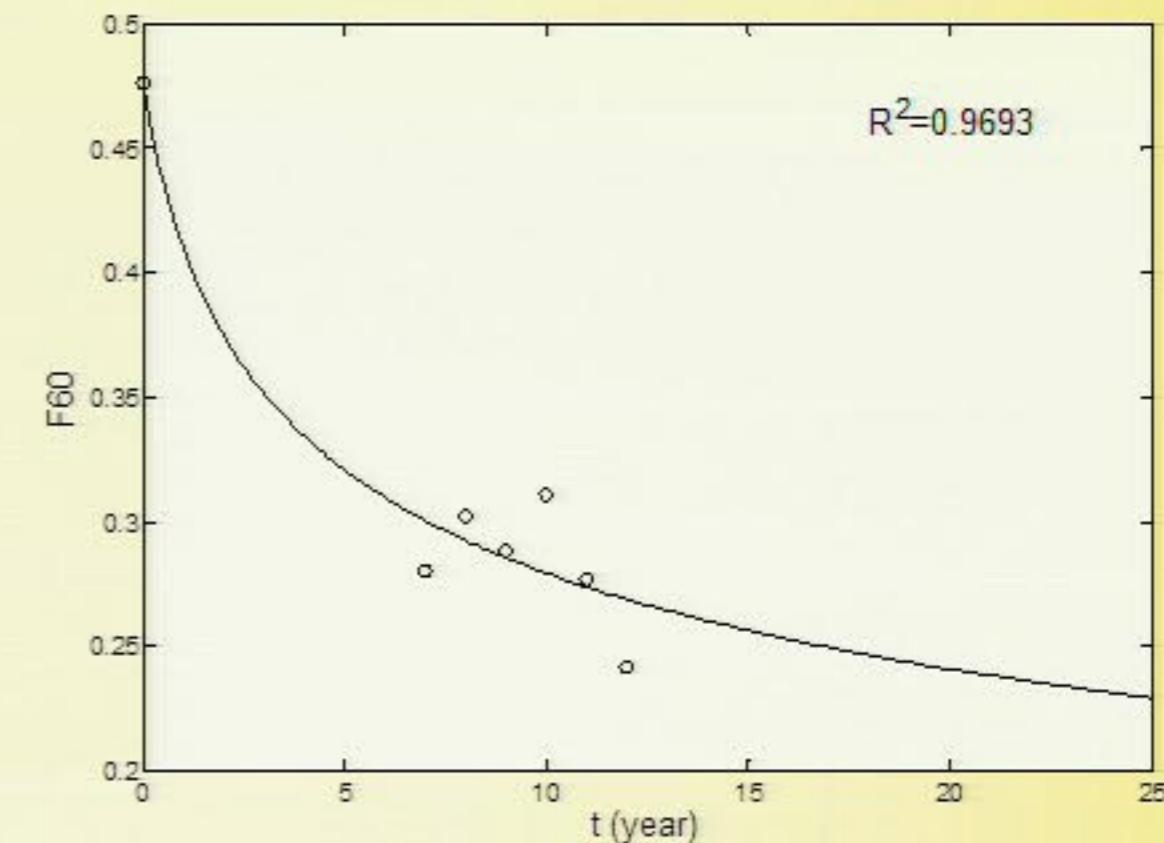
(a) Harrison 22L1



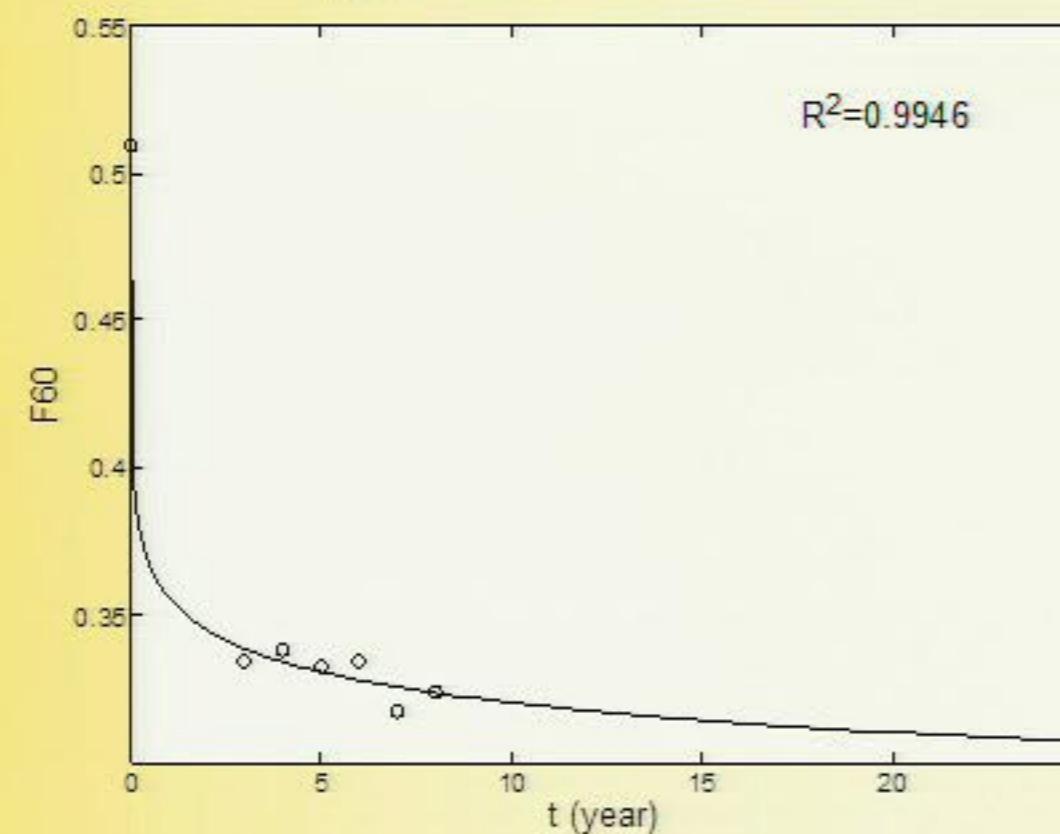
(b) Harrison 250L3



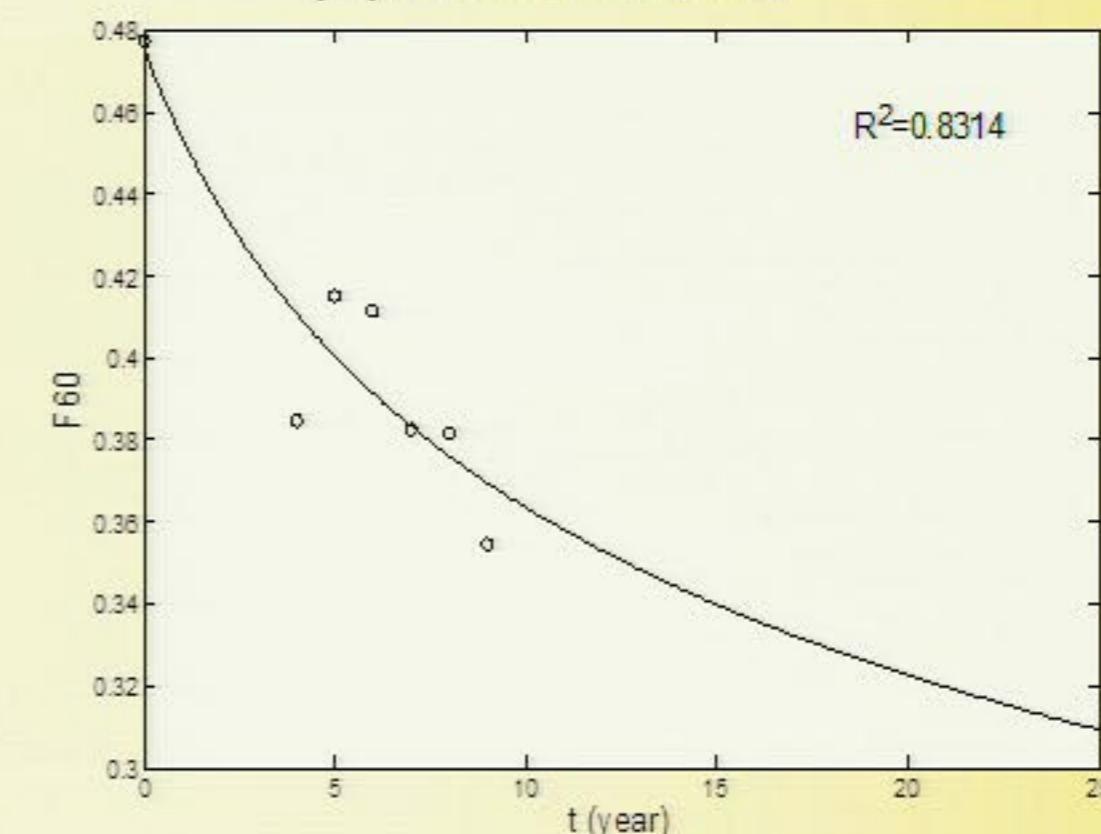
(c) Huron 162M1



(d) Huron 250M2



(e) Lucas 64M3



Wood pass M4

Application Example

1. Laboratory Test Procedure for Determining Final Friction Number

A minimum of two gyratory compacted samples prepared in accordance with the Job Mix Formula (JMF) are required to check for repeatability of test results.

Here we use M3 pavement specimen as an example.

3 samples were measured during the lab test and the measurements are shown below

Step 1: Measure initial BPN of the sample flat surface using British Pendulum Tester and record it as BPN_0 at time t_0

Step 2: Subject sample to a total of 8-hour polishing using the Polisher. Polishing action may be temporarily stopped for visual inspection to ensure that flat contact between sample surface and rubber disc surface is maintained.

Step 3: After 8-hour of polishing, measure final BPN of the sample flat surface and record it as BPN_f

Step 4: Repeat Step 1 to Step 3 for the second sample.

Sample #	Trials	Time (min.)									
		0	60	120	180	240	300	360	420	480	
1	1	76	68	63	60	60	58	56	56	57	
	2	76	68	64	61	60	56	56	56	56	
	3	75	69	63	60	59	57	56	55	56	
	4	75	69	64	61	59	56	57	55	56	
	Average	75.50	68.50	63.50	60.50	59.50	56.75	56.25	55.50	56.25	
2	1	76	68	62	59	58	56	54	55	55	
	2	77	68	64	61	57	57	54	54	54	
	3	77	67	62	61	59	57	54	55	54	
	4	76	67	63	60	59	55	54	54	54	
	Average	76.50	67.50	62.75	60.25	58.25	56.25	54.00	54.50	54.25	
3	1	78	68	63	59	59	55	55	53	54	
	2	78	68	64	60	57	54	55	54	54	
	3	78	68	63	60	59	56	54	55	54	
	4	79	67	64	60	58	56	54	54	55	
	Average	78.25	67.75	63.50	59.75	58.25	55.25	54.50	54.00	54.25	
Final BPN		76.75	67.92	63.25	60.17	58.67	56.08	54.92	54.67	54.92	

 BPN_0 $Average\ of\ 3\ samples$ BPN_f

Step 5: Compare both initial BPN_0 and final friction number BPN_f of the 3 samples to make sure that they are consistently within a reasonable range, plus or minus 2.

Step 6: convert BPN_f into equivalent SN_f using the following equation

$$SN_f = 0.862 * BPN_f - 9.690 = 0.862 * 54.92 - 9.690 = 37.65$$

Step 7: Compare $SN_f = 37.65$ with the established acceptance criterion $SN_{\text{acceptable}} = 32$

Step 5: Compare both initial BPN_0 and final friction number BPN_f of the 3 samples to make sure that they are consistently within a reasonable range, plus or minus 2.

Step 6: convert BPN_f into equivalent SN_f using the following equation

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2. Laboratory Test Procedure for Friction Degradation Curve

Here we still use M3 pavement specimen as an example.

3 samples were measured during the lab test and the measurements are shown before

Step 1: Measure initial BPN of the sample flat surface using British Pendulum Tester and record it as BPN_0 at time t_0

$$BPN_0 = 76.75$$

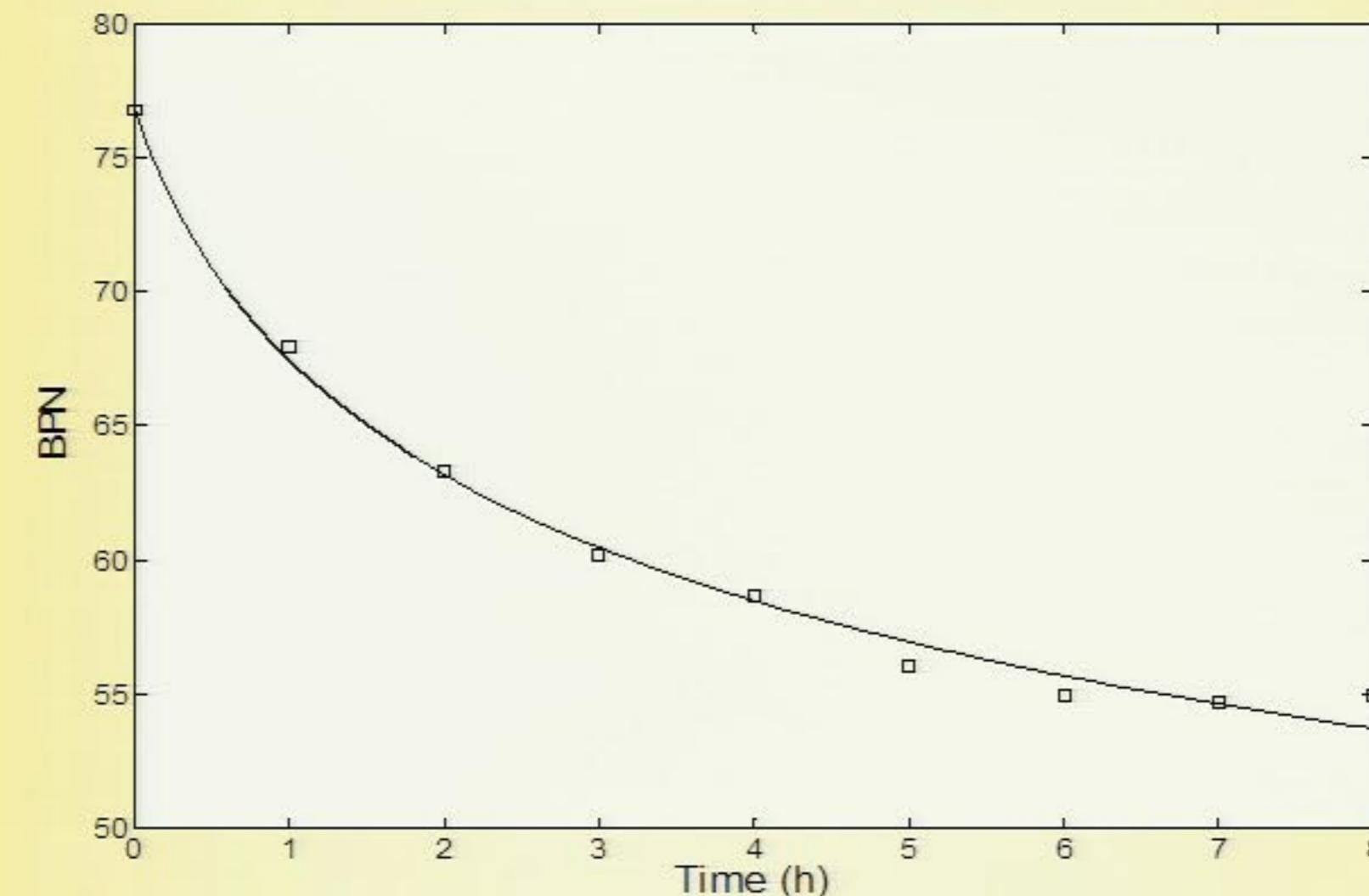
Step 2: Subject sample to one hour polishing in the Polisher

Step 3: Measure friction value using British Pendulum Tester and record it as BPN at t , where t indicates accumulated polishing duration

Repeat Step 2 and Step 3 for the next one-hour of polishing and measurement, until a total of 8- hours polishing duration is complete

$$BPN = [76.75 \ 67.92 \ 63.25 \ 60.17 \ 58.67 \ 56.08 \ 54.92 \ 54.67 \ 54.92]$$

Plot the Friction Degradation Curve using an average of test results of two samples.



3. Prediction of Actual Project Pavement Friction Over Expected Life

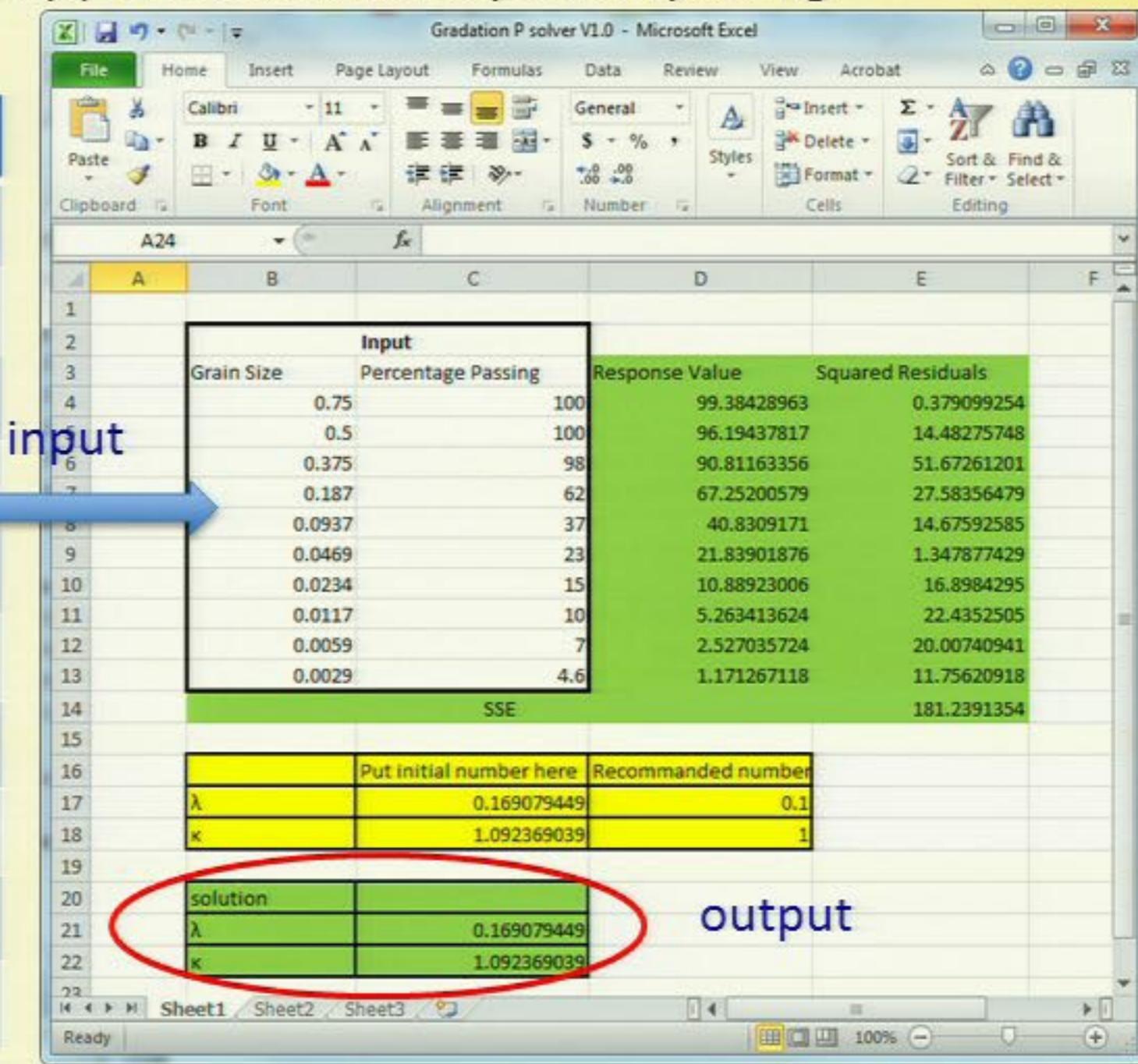
Here we still use M3 pavement specimen as an example.

1. Calculate fitting parameters to aggregate gradation curve: κ and λ

$$F(x) = 1 - \exp(-(x/\lambda)^\kappa)$$

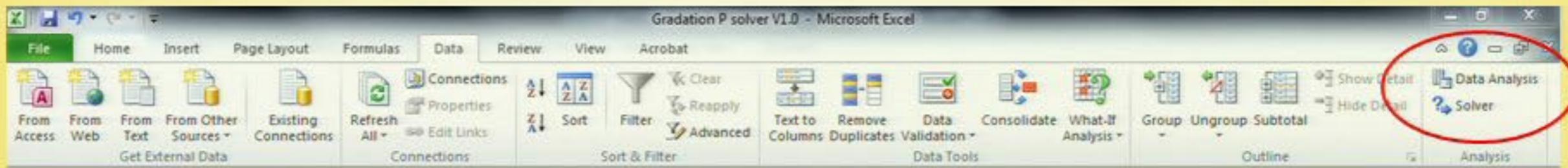
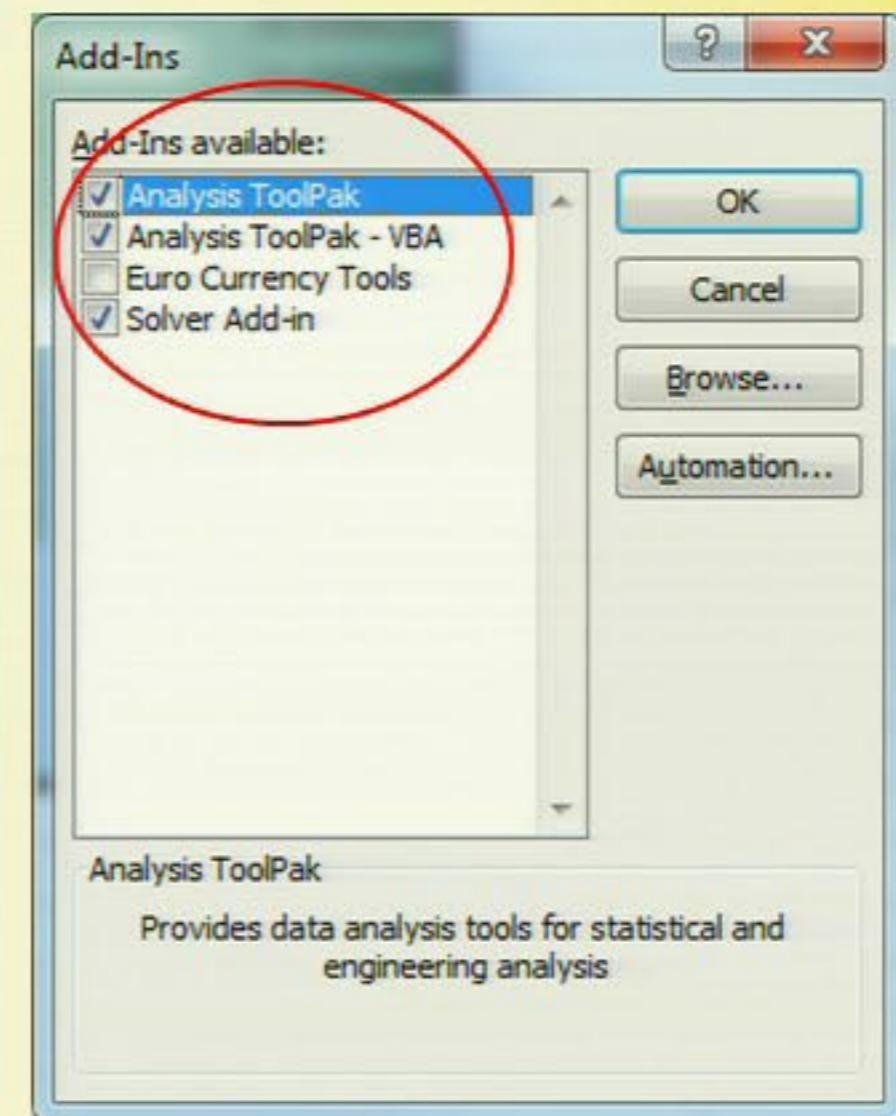
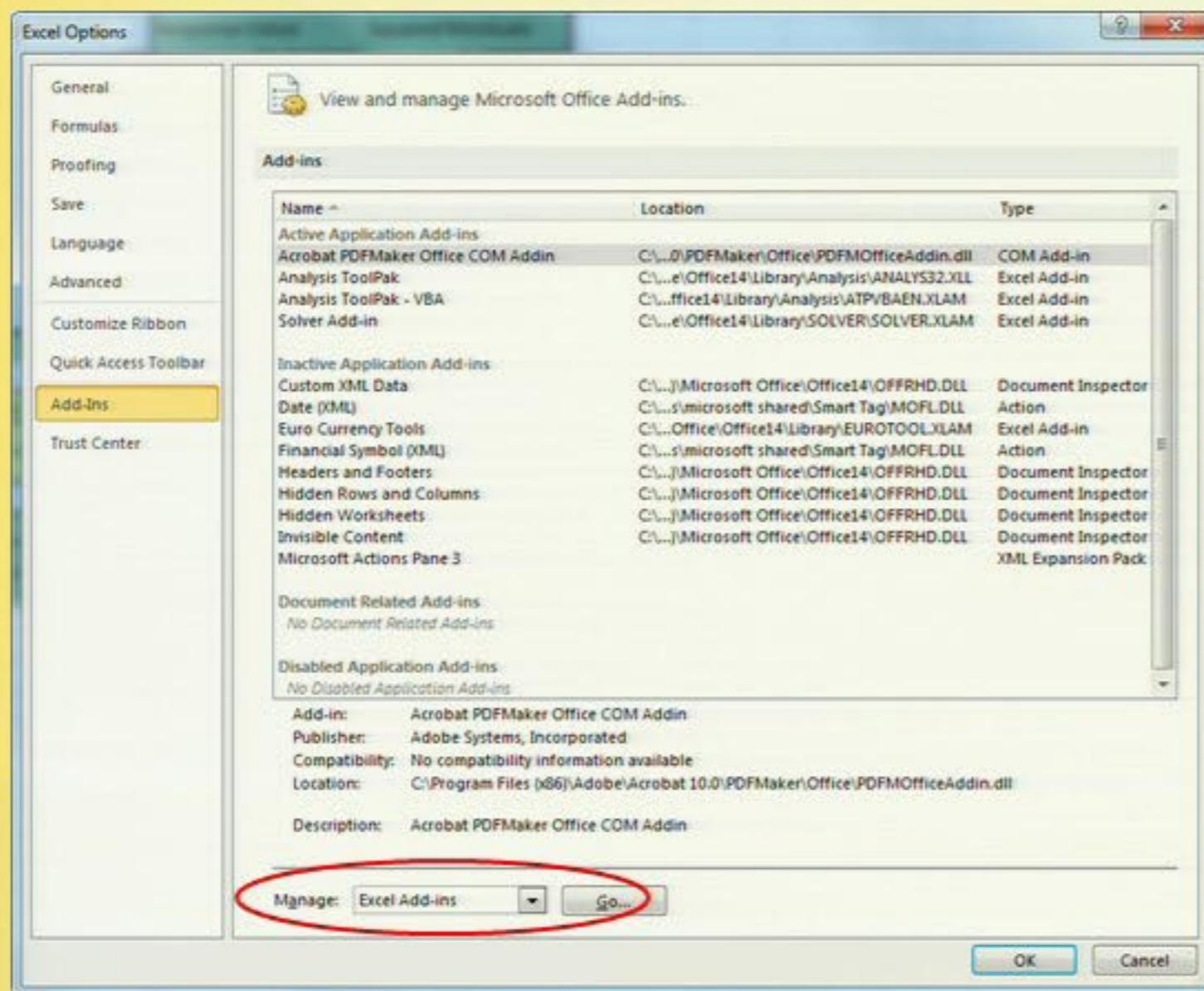
Where x is the sieve size and $F(x)$ is the cumulative percent passing.

Sieve Size (in)	Percentage Passing
0.75	100
0.5	100
0.375	98
0.187	62
0.0937	37
0.0469	23
0.0234	15
0.0117	10
0.0059	7
0.0029	4.6



Note: How to open the optimization solver in Excel

click File → Options → Add-ins → Manage (choose Excel Add-ins) → Go → choose analysis toolpak, analysis toolpak-VBA and solver Add-in → OK



2. Compute laboratory friction loss, PV, from Friction Degradation Curve as follows

$$PV = \frac{BPN_o - BPN_8}{BPN_o} * 100 = \frac{76.75 - 54.92}{76.75} * 100 = 28.44$$

where

BPN_o = British Pendulum Friction Number before Polishing

BPN_8 = British Pendulum Friction Number after 8hr Polishing

3. Obtain ADT (Average Daily Traffic) for the project pavement section

Here ADT=4390

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4. Use following equations to compute two index values: time index t_0 and scale index m

$$t_0 = -6.366 * 10^{-4} ADT + 0.2874 PV - 185.632 \kappa + 1167.8 \lambda = \\ -6.366 * 10^{-4} * 4390 + 0.287 * 28.4 - 185.63 * 1.092 + 1167.8 * \\ 0.1691 = 0.041$$

$$m = -9.2196 * 10^{-5} ADT + 0.0372 PV - 2.3262 \kappa + 10.9279 \lambda = \\ -9.2196 * 10^{-5} * 4390 + 0.0372 * 28.4 - 2.3262 * 1.092 + 10.9279 * \\ 0.1691 = -0.042$$

5. Select a required service life of the pavement surface in years, denoted as t_{req}

6. Use following Equation to convert initial BPN_0 reading in the Friction Degradation Curve into equivalent SN_0

$$SN_0 = 0.862 * BPN_0 - 9.690 = 0.862 * 76.75 - 9.690 = 56.5$$

7. Calculate the predicted SN at the selected $t=t_{req}$ using Equation

$$SN_t = SN_0 \left(1 + \frac{t}{t_0}\right)^m = 56.5 * \left(1 + \frac{t_{req}}{0.041}\right)^{-0.042}$$

t_{req} (year)	SN_t
5	46.16147
10	44.84466
15	44.08996
20	43.56169
25	43.15608

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Conclusions

- A new commercial grade accelerated polishing machine, The Polisher, was developed and delivered to ODOT.
- The comparison of test results between the research-grade machine and the Polisher confirms the operation of the Polisher
- The Polisher can be used to determine the polishing and friction behavior of HMA surfaces
- Supplemental notes was developed in which a step-by-step laboratory procedure was presented for obtaining the residual or terminal friction number of a given HMA mix
- Supplemental notes provide a step-by-step laboratory procedure to predict degradation of friction for in-service asphalt pavement surfaces

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- Supplemental notes provide a step-by-step laboratory procedure to predict degradation of friction for in-service asphalt pavement surfaces

Implementations

- Adopt “the Polisher” in ODOT labs to evaluate friction and polishing behavior of gyratory compacted sample surfaces;
- Adopt the proposed supplemental notes for screening/acceptance purpose of any new JMF;
- Use the predictive friction degradation model to forecast friction behavior of in-service asphalt pavement surfaces

Recommendations for Future Study

- Continue to systematically collect skid number and texture of interstate highway pavements, and conduct the accompanied lab test using “the Polisher” for future validation of predictive models for SN and F60.

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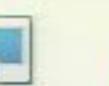
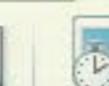
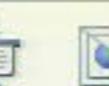
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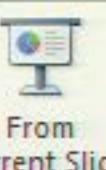
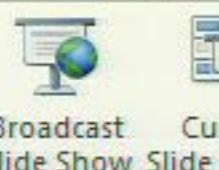
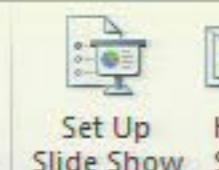
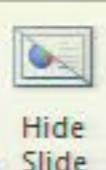


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Show

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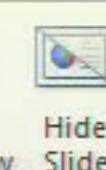
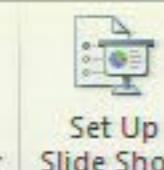
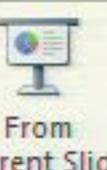
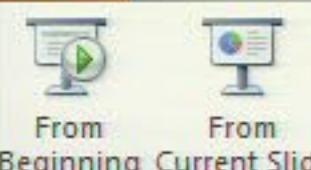
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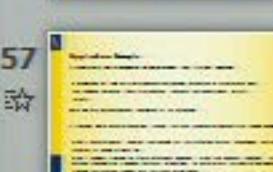
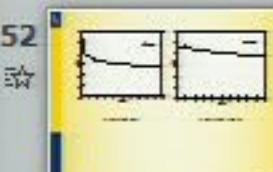
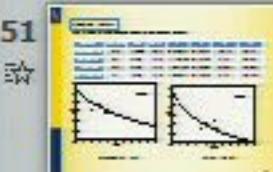
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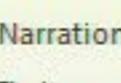
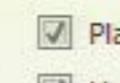


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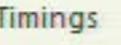
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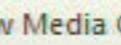
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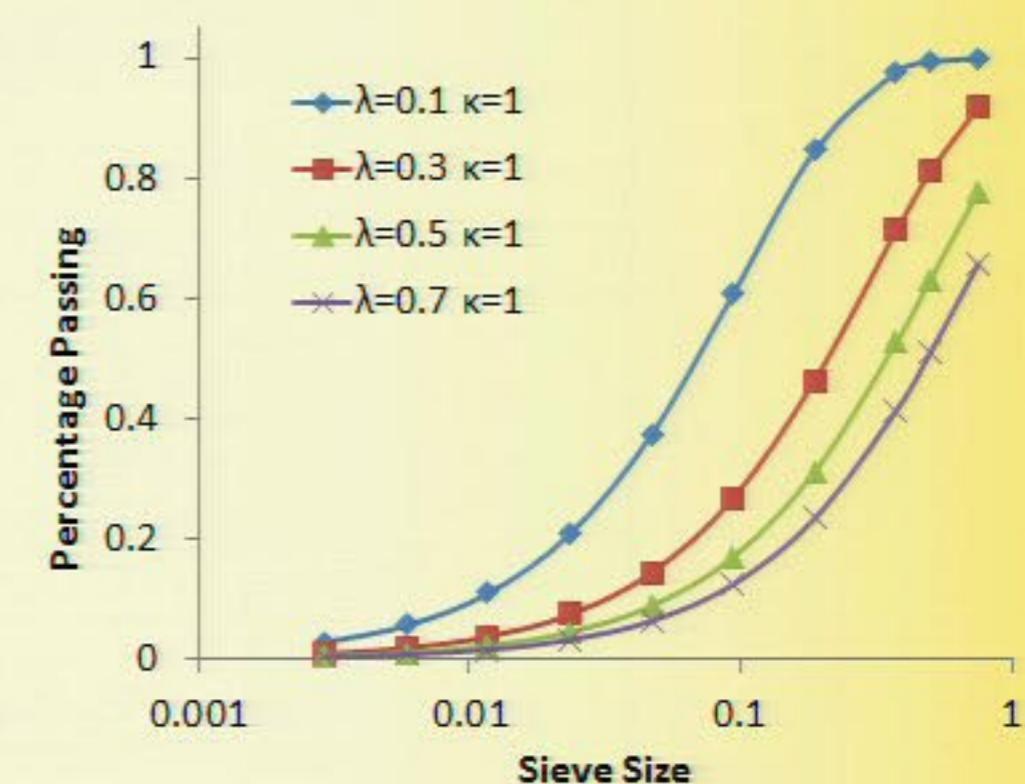
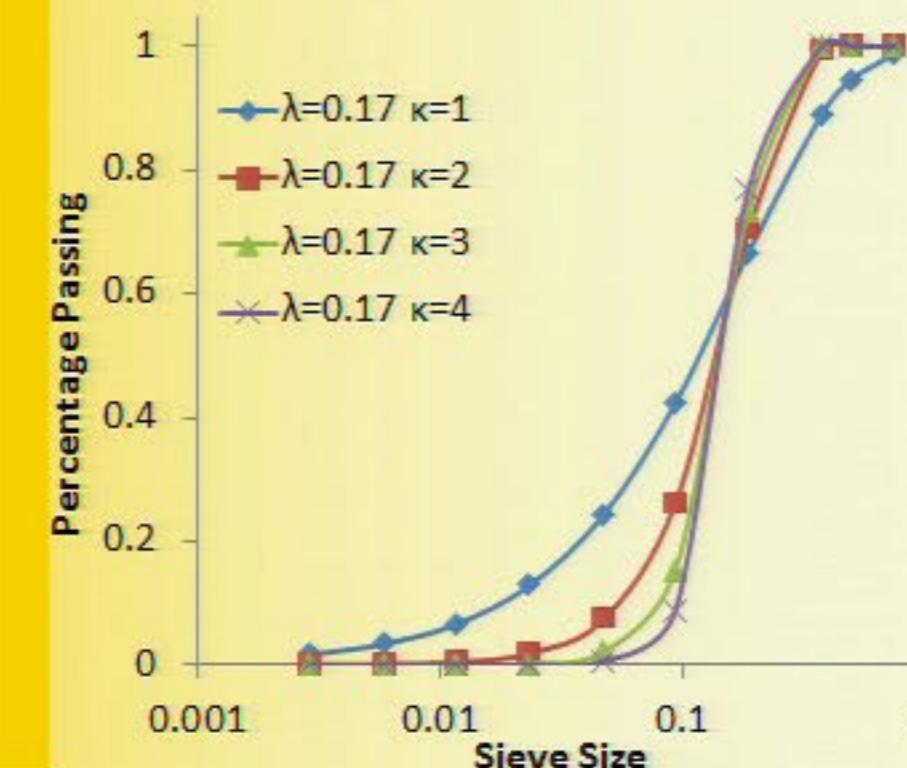
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From Beginning
Slide ShowFrom Current Slide
Slide ShowSet Up
Slide ShowHide
SlideRehearse
TimingsRecord Slide
Show

Set Up



λ : scale parameter of Gradation Curve.
 κ : shape parameter of Gradation Curve



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