Friction Testing Using Dynamic Friction Tester and Circular Texture Meter

MDOT, State Highway Administration

Office of Materials Technology, Soil and Aggregate Division

Intikhab Haider (TL, SATD) On Behalf of Dan Sajedi (DC)

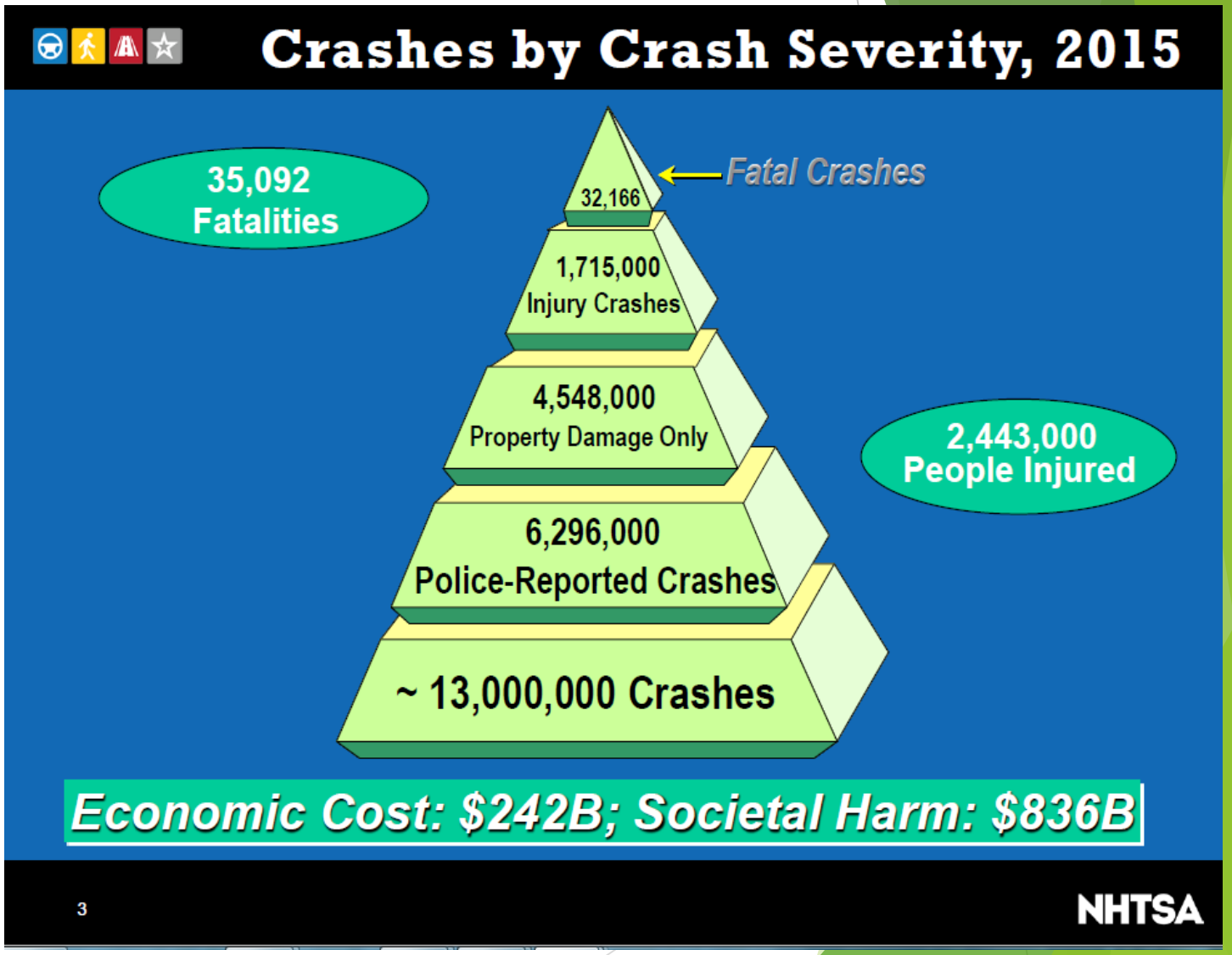
02/08/17

Why Road Friction is Important

- **15 to 18 percent of crashes occur on wet pavements**
  (Smith, 1976; Davis et al., 2002; (FHWA, 1990).

- **Relationship between wet weather accidents and pavement friction**
  (Rizenbergs et al.,1972; Giles et al., 1962; McCullough et al., 1966; Wallman and Astron, 2001; Gandhi et al., 1991)

- **An increase in average pavement friction from 0.4 to 0.55 would result in a 63 percent decrease in wet-pavement crashes**
  (Hall et al., 2006; Miller and Johnson, 1973).

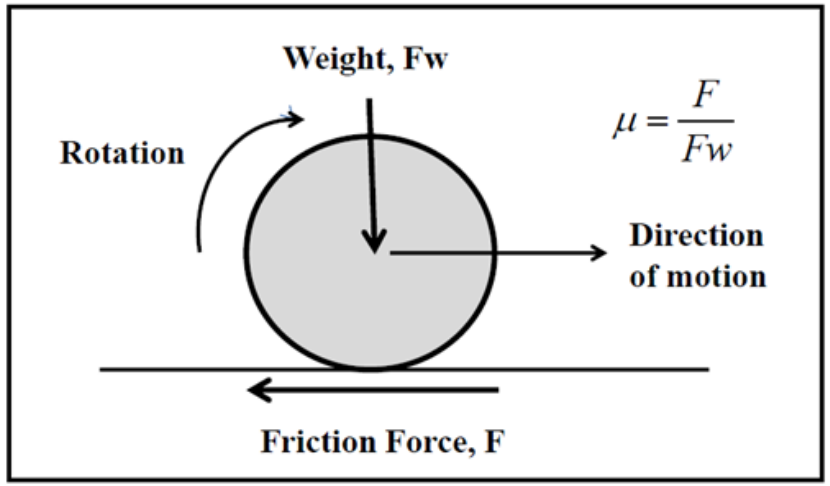


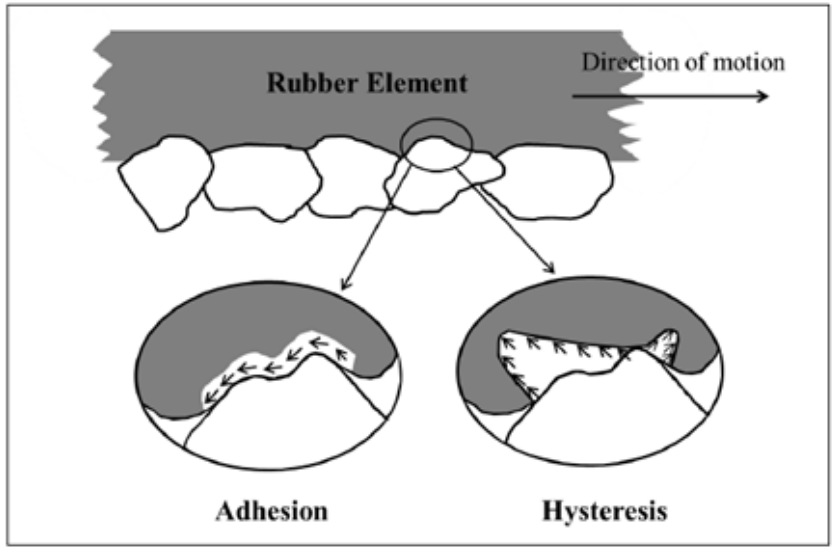
Outlines of Presentation

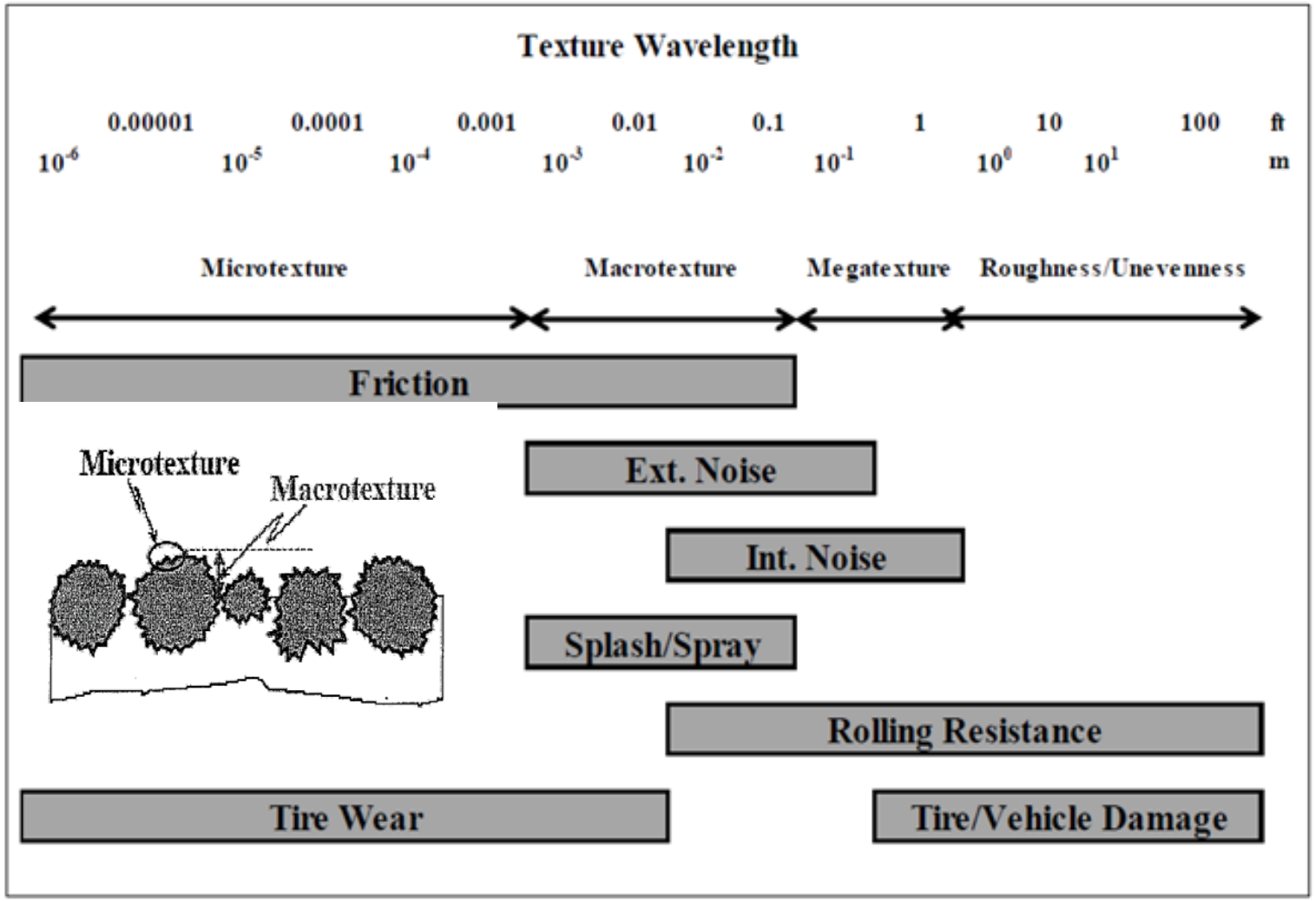
- Concept of Road Friction
- Commonly Used Equipment to Measure Road Friction
- Practice in Maryland
- Dynamic Friction Tester
- Circular Texture/Track Meter
- Summary

Concept of Road Friction

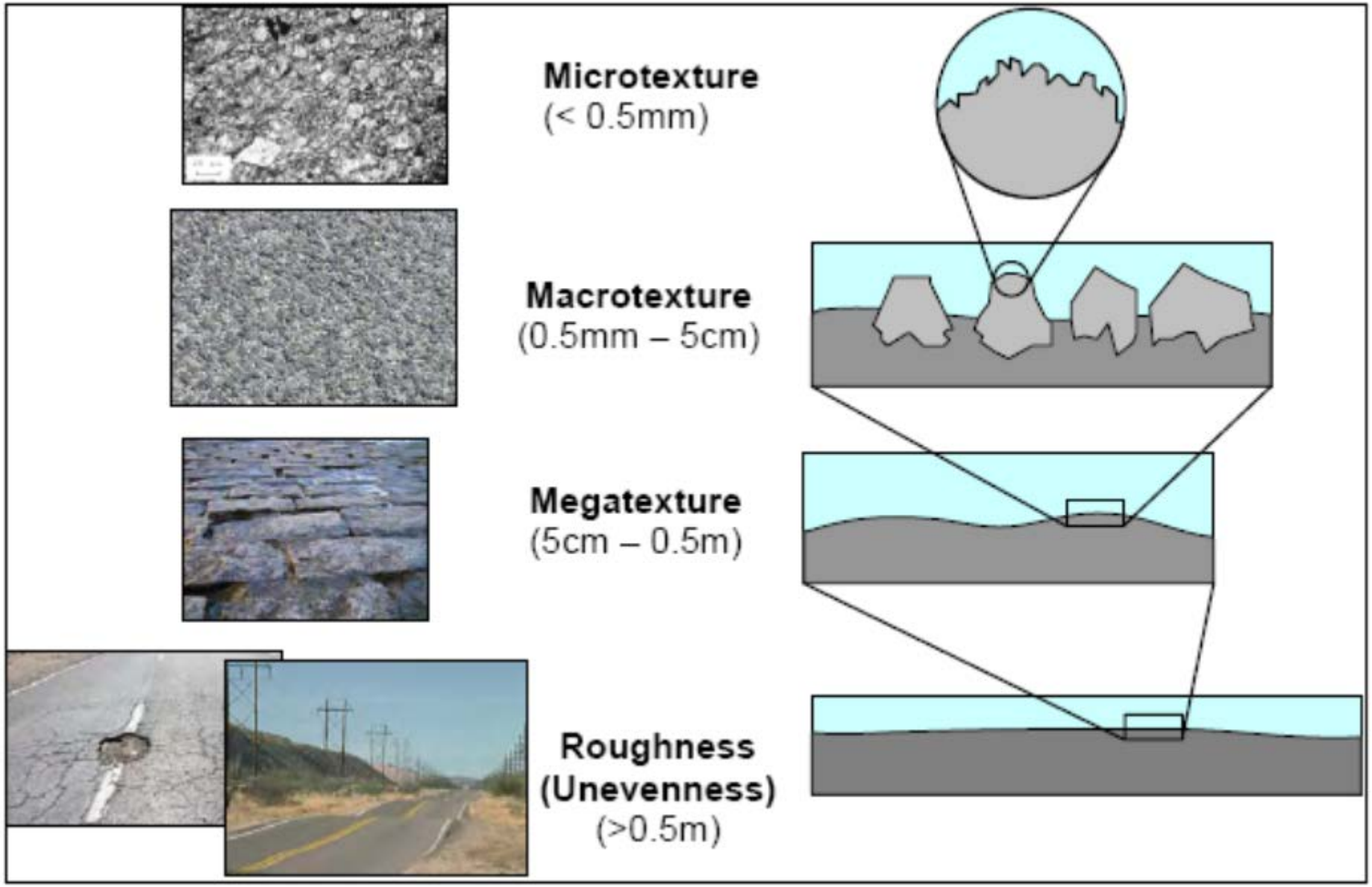
Concept of Friction on Road Surface



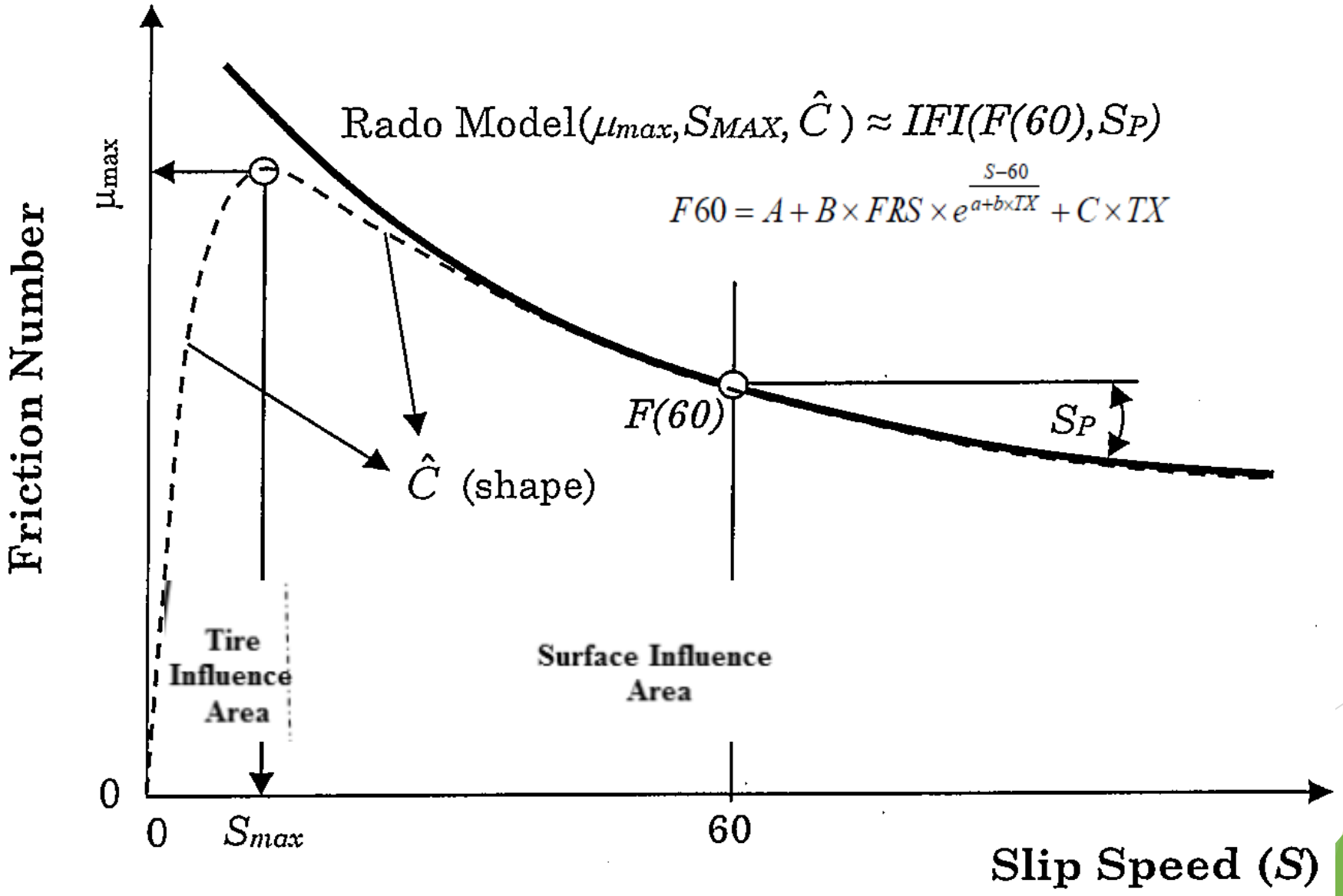




Concept of Friction on Road Surface by FHWA



Calculation of International Friction Index (IFI)



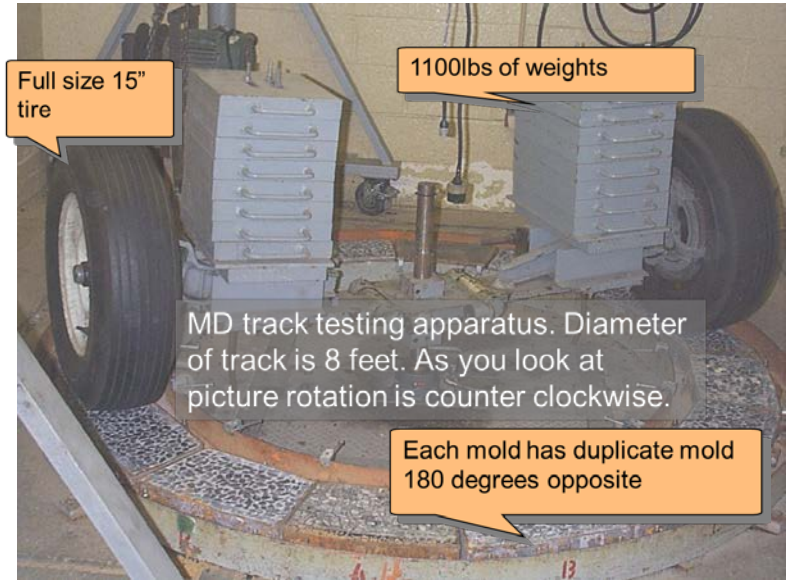
Commonly Used Equipment to Measure Road Friction

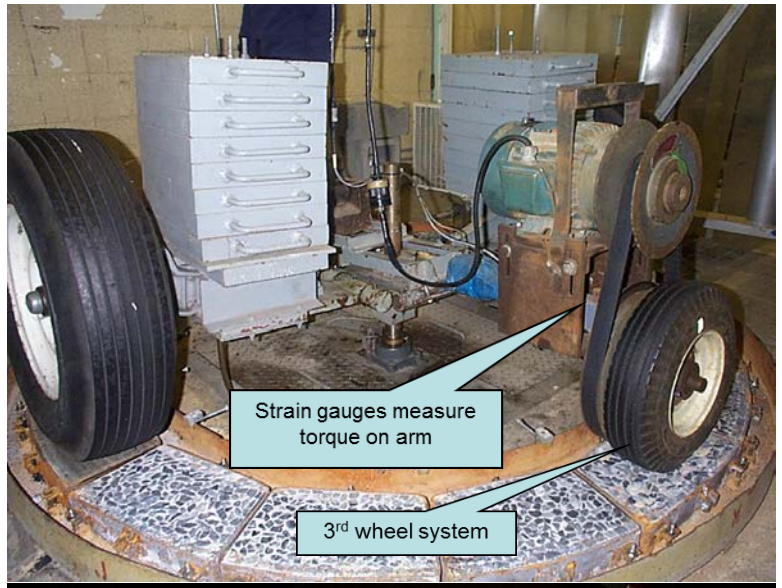
Commonly Used Equipment to Measure Road Friction

- Locked Wheel Skid Resistance(ASTM E274)
(Rib Tire (ASTM E501) and Smooth Tire (ASTM E524))
- Dynamic Friction Tester (ASTM E1911)
- Circular Texture/Track Meter (ASTM E2157)
- Volumetric Sand Patch Test (ASTM E 965)
- British Pendulum Tester (ASTM E303, ASTM D3319)
- Mu-Meter/Cont. FT (ASTM E670)

Practice in Maryland

Practice in Maryland (Up to 2005) (Old Method, Polish Value, MSMT 411)





A 3rd wheel is added to the track for periodic measurements @ 2k, 10k, 25k, 50k, 100k, 250k, 500k, 750k, 1000k, 1250k & 1500k revs. This wheel rotates @ 30mph in the clockwise direction

Time required to complete PV testing for one aggregate quarry was almost 3 months.

British Pendulum Testing

Quality Assurance Testing

Test	Freq. Year	Standard
Wash - #200 Gradation	1	AASHTO T-11 & 27
Specific Gravity and Absorption	1	AASHTO T-84 & 85
L A Test	2	AASHTO T-96
Soundness Test	3	AASHTO T-104
ASR Test	3	ASTM C 1260
DFT/ PV	2	ASTM E1911
BPN	2	ASTM E303, E660
AIR or Petro	2	ASTM D3042, C295

Maryland State Highway Adminstration: Coarse and Fine Aggregate Test Data

Producer	Aggregate Category	Aggregate Type	Specific Gravity (SSD)	ABS (%)	LA (%)	BPN	Friction Rating[1]	ASR (%)	Soundness (%)	Material Tested For			
			T-84 & 85		T-96	ASTM D3319 & E303	MSMT 215 & 216	ASTM C1260	T-104	General (HMA Base, GAB, Backfill, etc.)	HMA Surface	High Friction Materials	PCC
Aggregate Industries, Inc. Accokeek Sand & Gravel Brandywine, MD													
	Coarse	#57	2.602	1.2	36			0.04(R1)**	4.0	☑	☐	☐	☑
	Fine	Concrete Sand	2.571	0.8				0.02(R1)**	1.1	☑	☐	☐	☑
Aggregate Industries, Inc. Charles City Sand & Gravel Charles City, VA													
	Coarse	#57	2.582	1.2	35			0.29	2.1	☑	☐	☐	☑
	Fine	Concrete Sand	2.590	0.8				0.23	2.5	☑	☐	☐	☑
Aggregate Industries, Inc. Fulks Sand & Gravel Fredericksburg, VA													
	Coarse	#57	2.641	0.5	33			0.12	0.7	☑	☐	☐	☑
	Fine	Concrete Sand	2.577	1.1				0.12	4.0	☑	☐	☐	☑
Aggregate Industries, Inc. Kirby Road Sand & Gravel Clinton, MD													
	Coarse	#57	2.596	1.1	33			0.03(R1)**	0.9	☑	☐	☐	☑
	Fine	Concrete Sand	2.586	0.9				0.02(R1)**	0.6	☑	☐	☐	☑
Aggregate Industries, Inc. La Plata Sand & Gravel La Plata , MD													
	Coarse	#57	2.579	1.4	36			0.02(R1)**	2.2	☑	☐	☐	☑
	Fine	Concrete Sand	2.592	1.2				0.02(R1)**	1.7	☑	☐	☐	☑
Aggregate Industries, Inc. Mataponi Sand & Gravel Aylett, VA													
	Fine	Concrete Sand	2.589	0.4				0.02	0.6	☑	☐	☐	☑

Aggregate Evaluation by Polish Value using Maryland Track Testing

Polish Value

- PV ≥ 8 – High polish value (HPV)
- 5 ≤ PV < 8 -Standard polish value (SPV)
- 4 ≤ PV < 5 – Low polish value (LPV)

Carbonate/None-Carbonate Rock

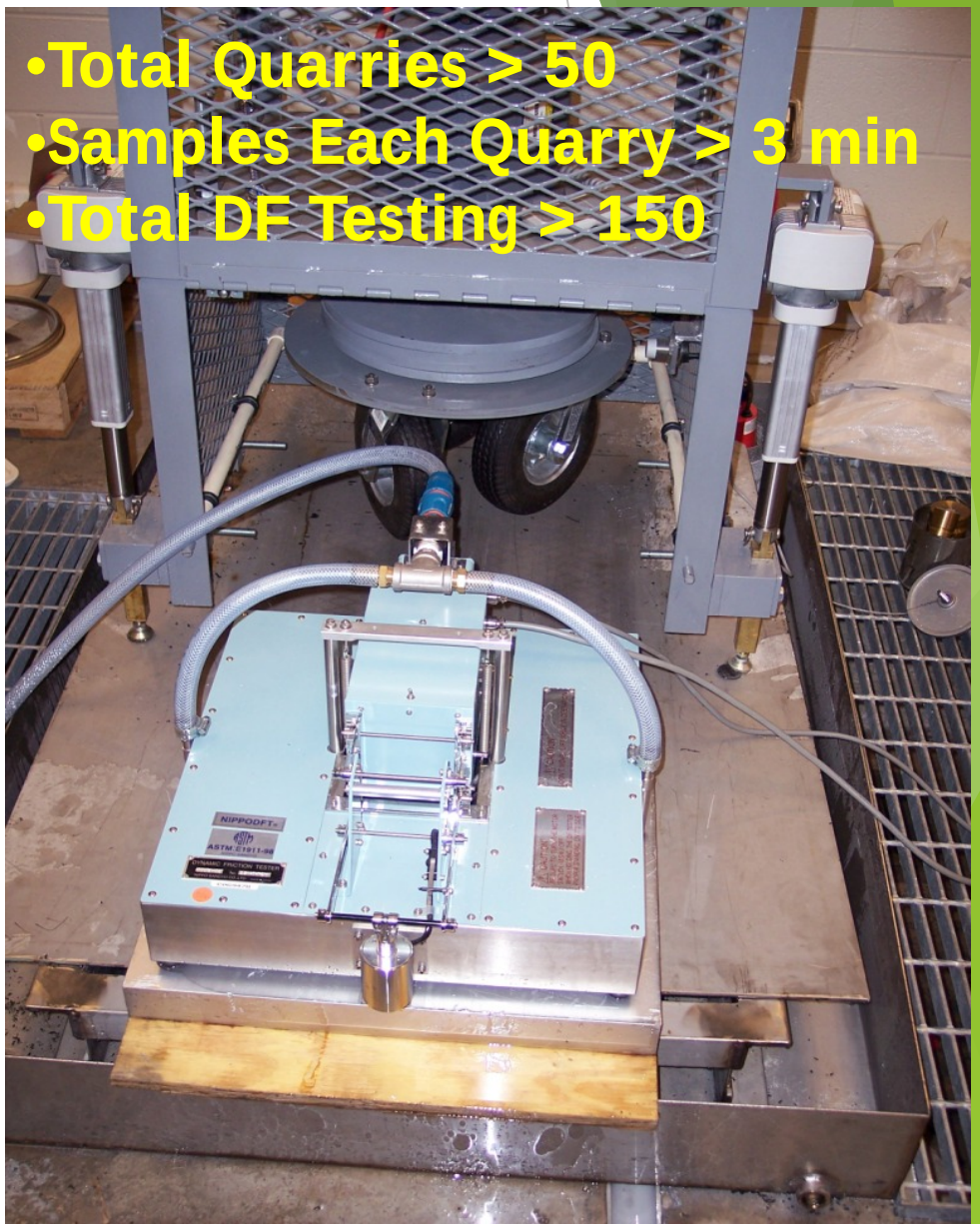
- Carbonate Rock: AIR Test
- Non-carbonate Rock: Petrographic Analysis

Dynamic Friction Tester

Moving From PV to DFV

Reasons:

- Expediting Testing Program
- Labor and Cost
- Repeatability
- Production / year



Research Studies Performed

- Evaluation Of Laboratory Tests To Quantify Frictional Properties of Aggregates (July 2010)

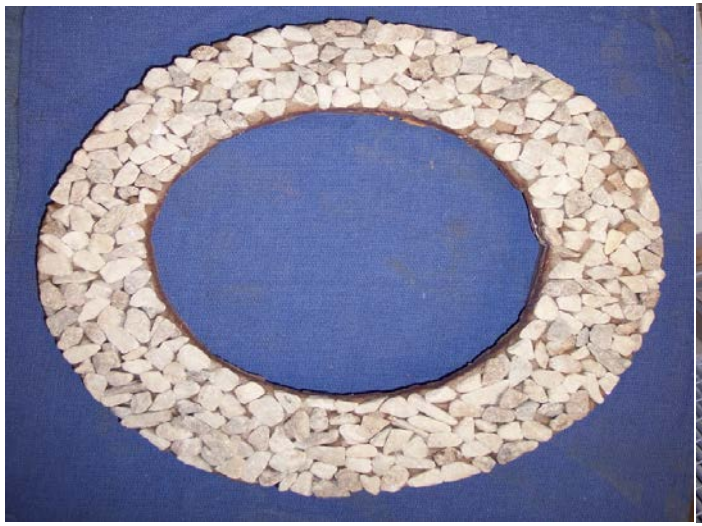
- Aggregate Friction Variability Study (January 2010)

- The Standard Method MSMT-216 ,” Measuring Frictional Properties of Aggregates Using The Dynamic Friction Tester

Major References:

ASTM E1911, FHWA’s Measuring Instrument Guide, AASHTO “Guide to Pavement Friction”, NCHRP Report 108.

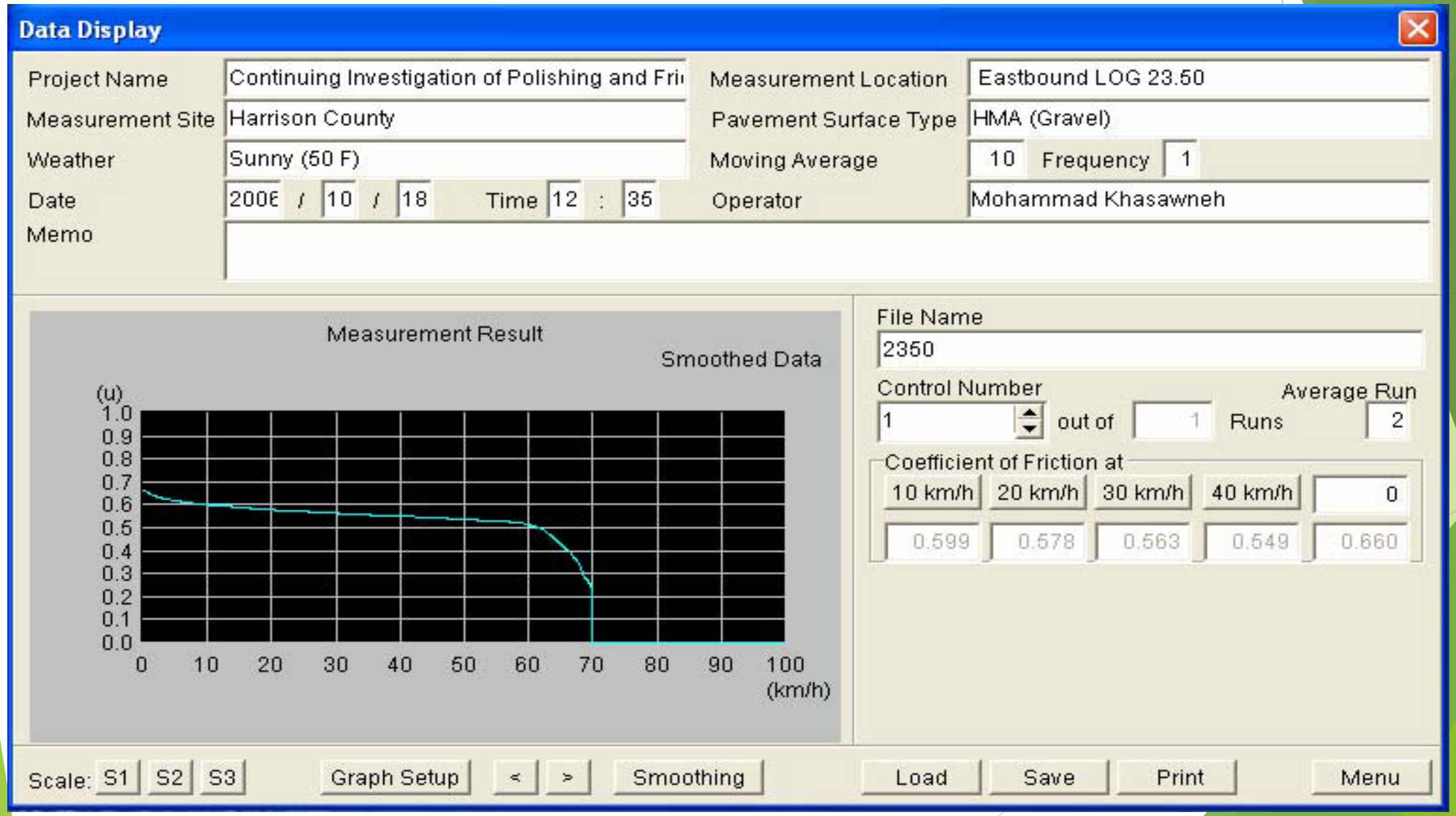
Stepwise Procedure of Dynamic Friction Testing



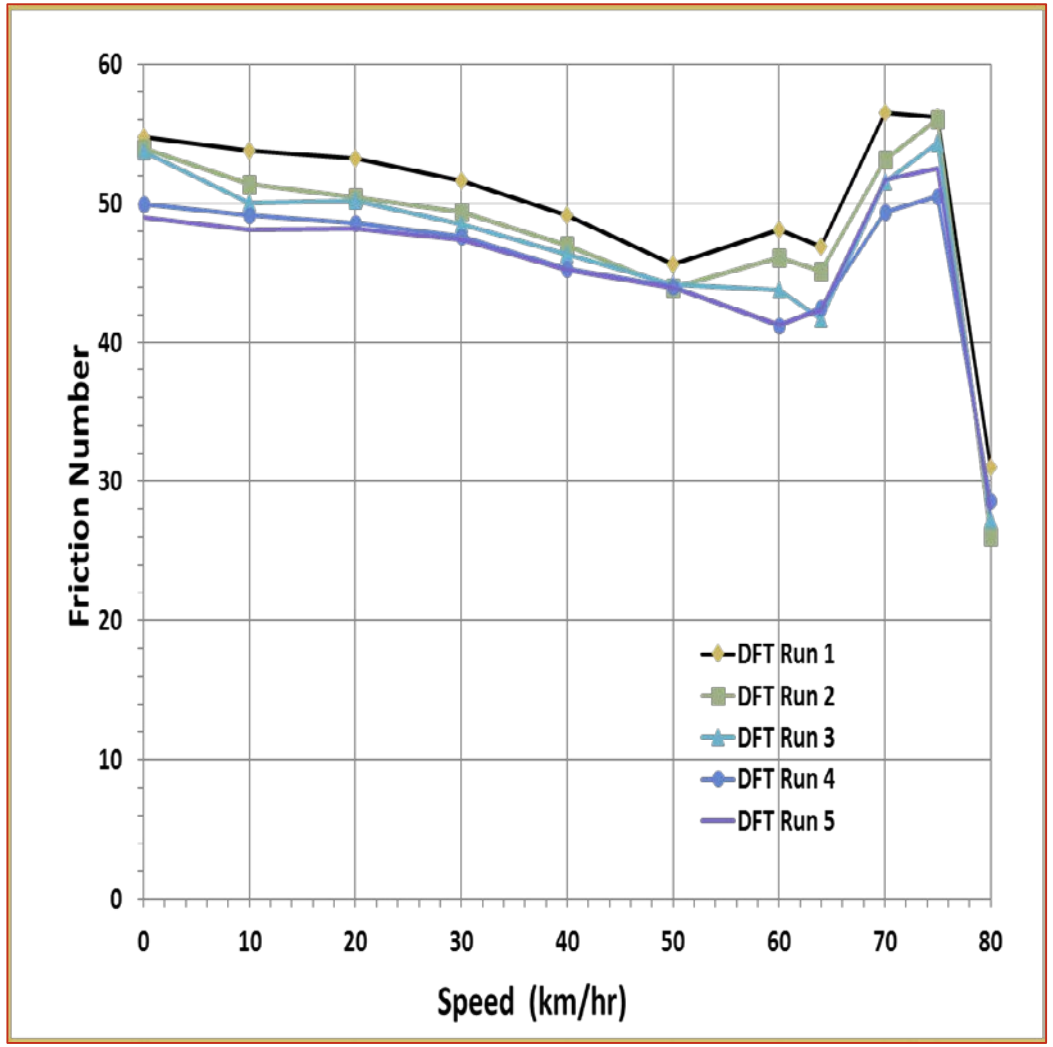
Rubber Slider as per ASTM tire standard for skid resistance
Load: 3.6kg
400X505x430mm
Gross Wt: 32kg

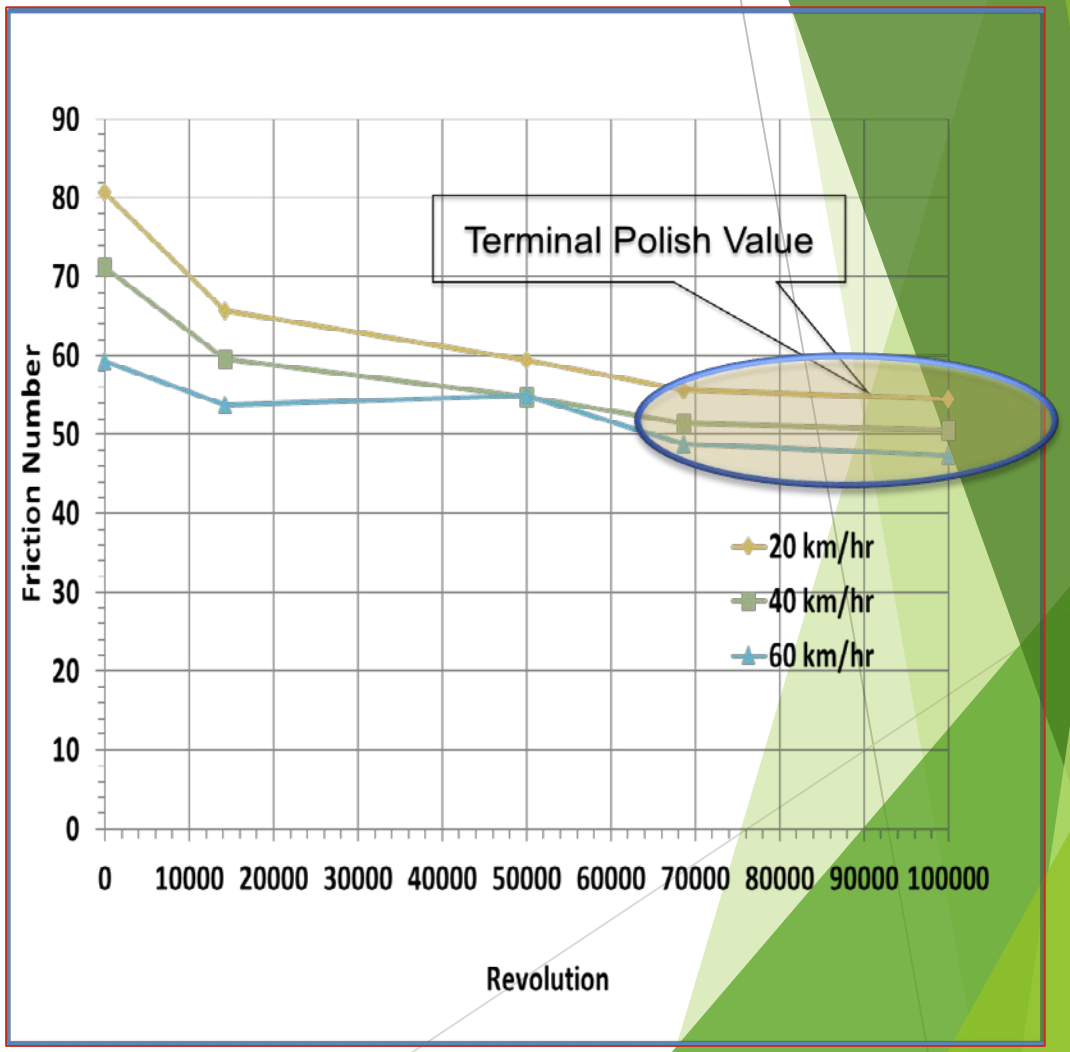
1) Virgin Aggregates, 2) Asphalt Surface, 3) HFST Material, 4) Pavement Marking

Output File of DF Testing

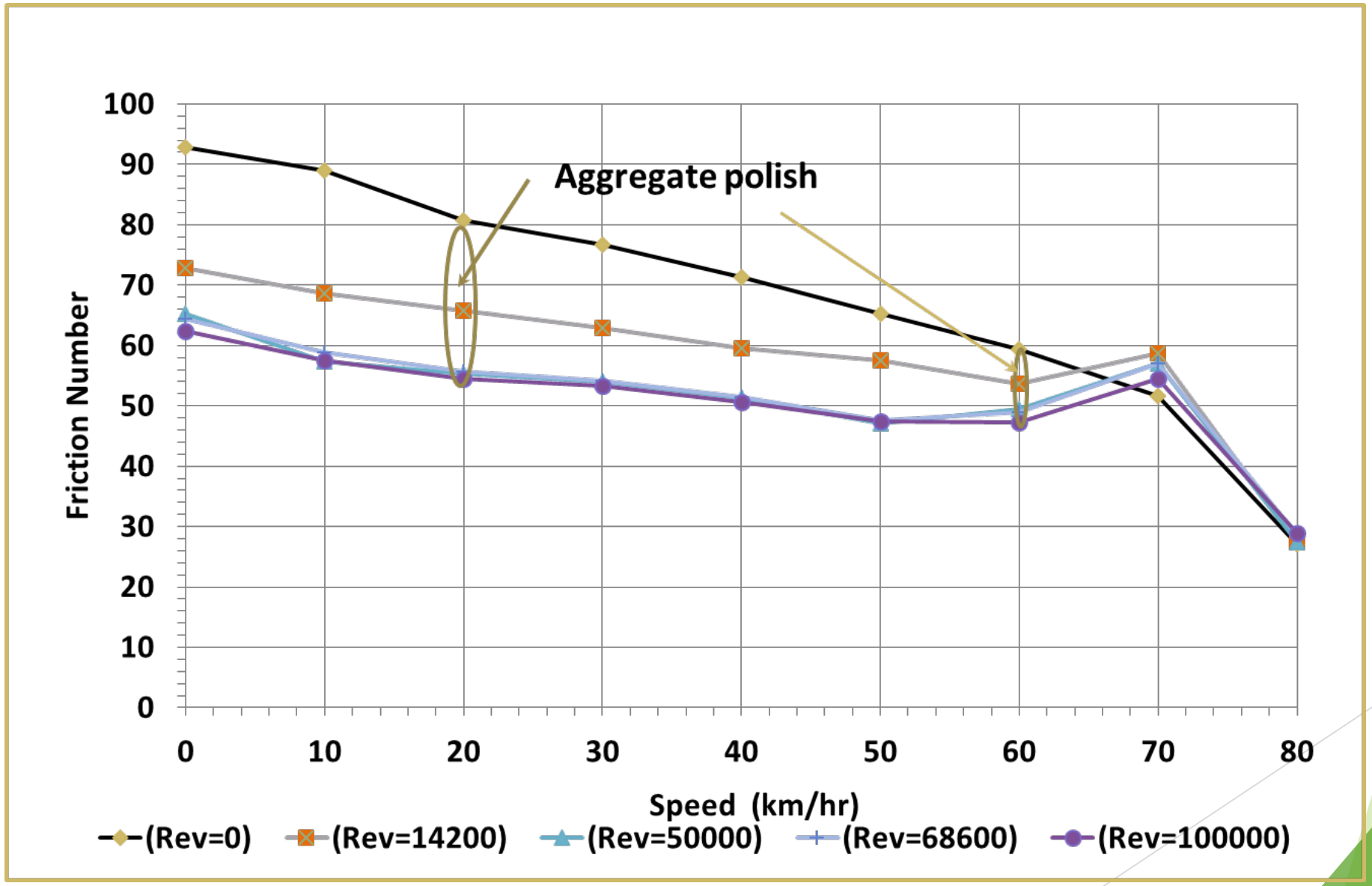


Typical DF Test Results

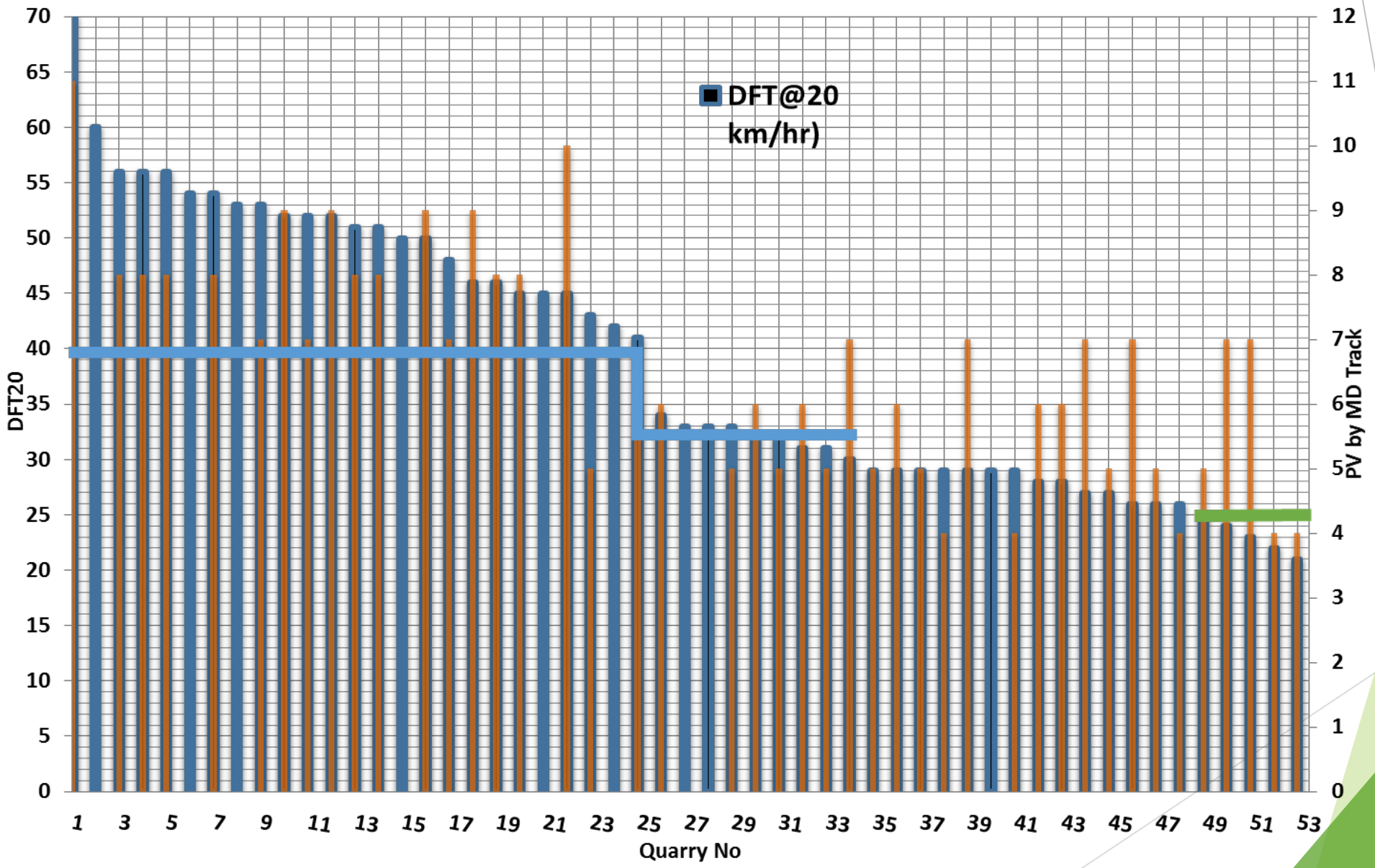




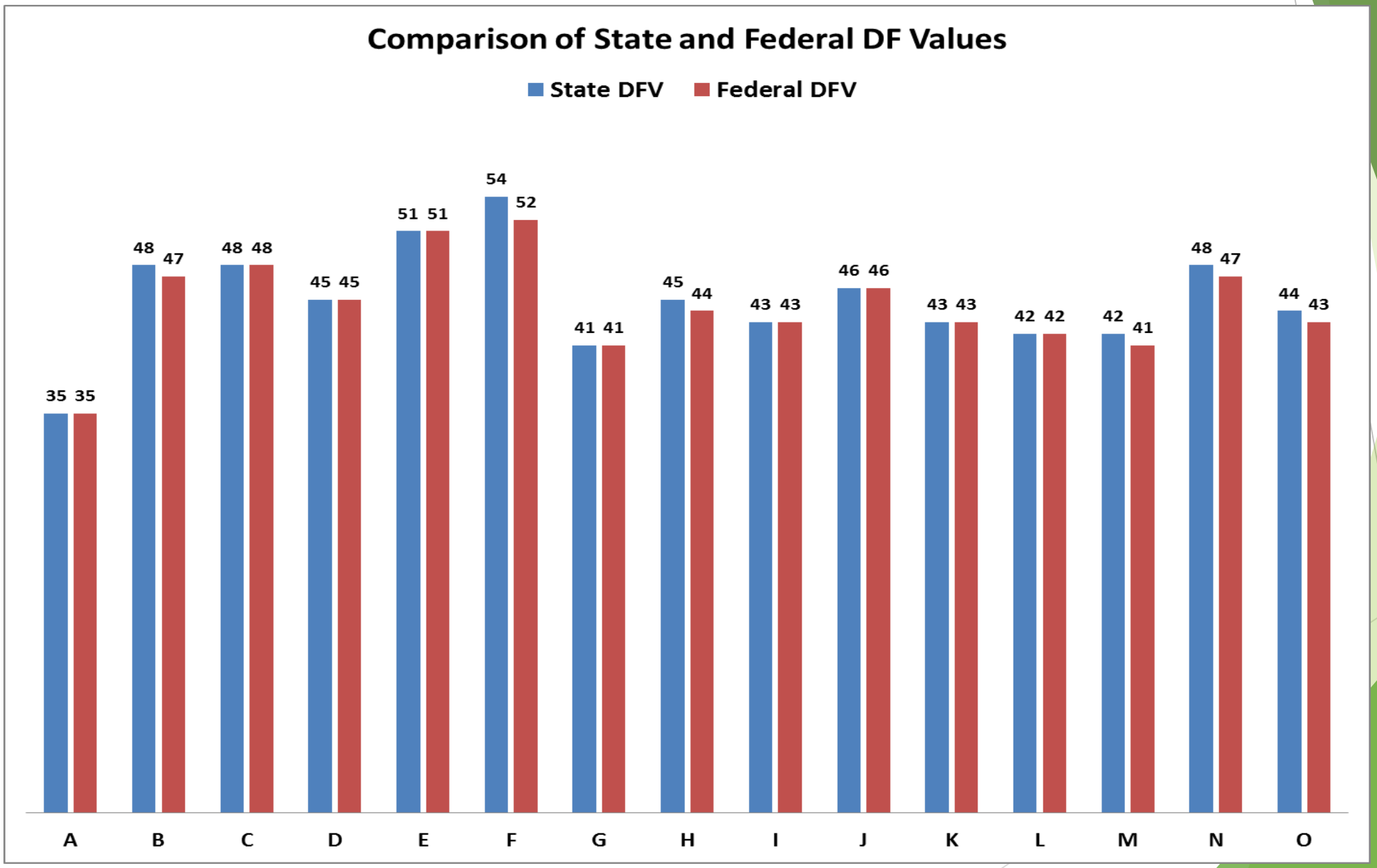
Polishing Effect On Aggregate Friction



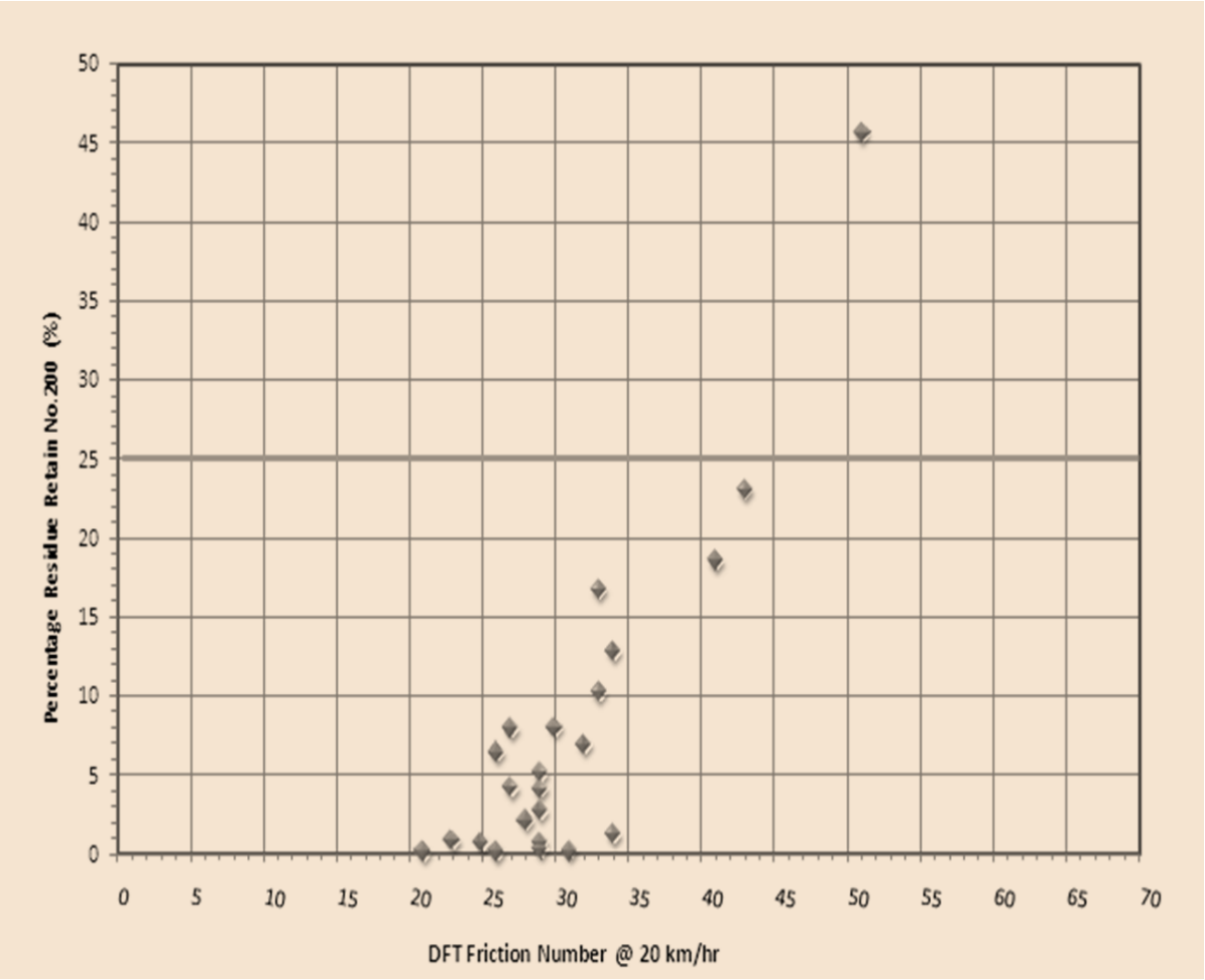
Polish Values Vs DF Values

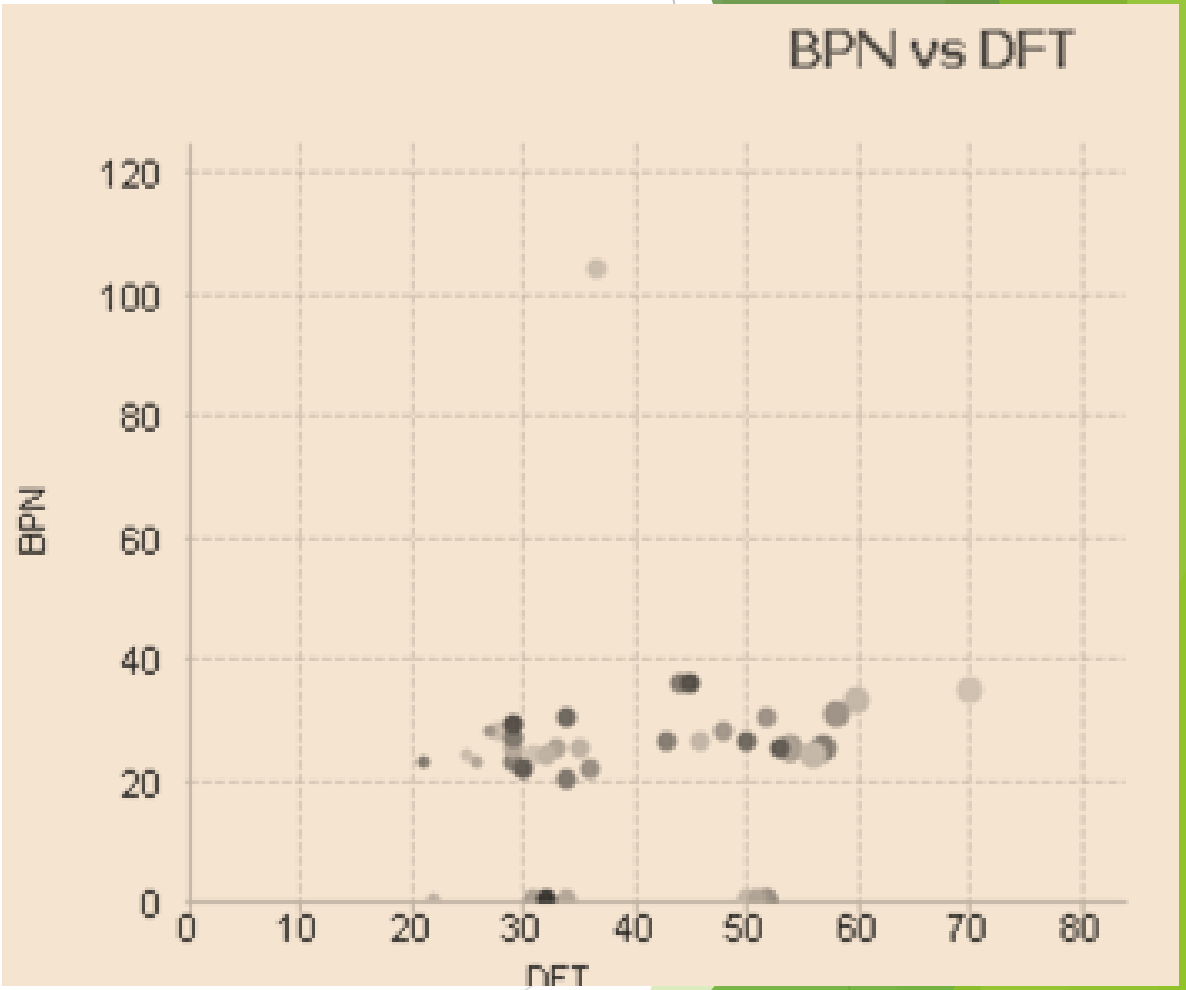


DFT Verification Testing



Correlation of DFV With Other Properties of Aggregates





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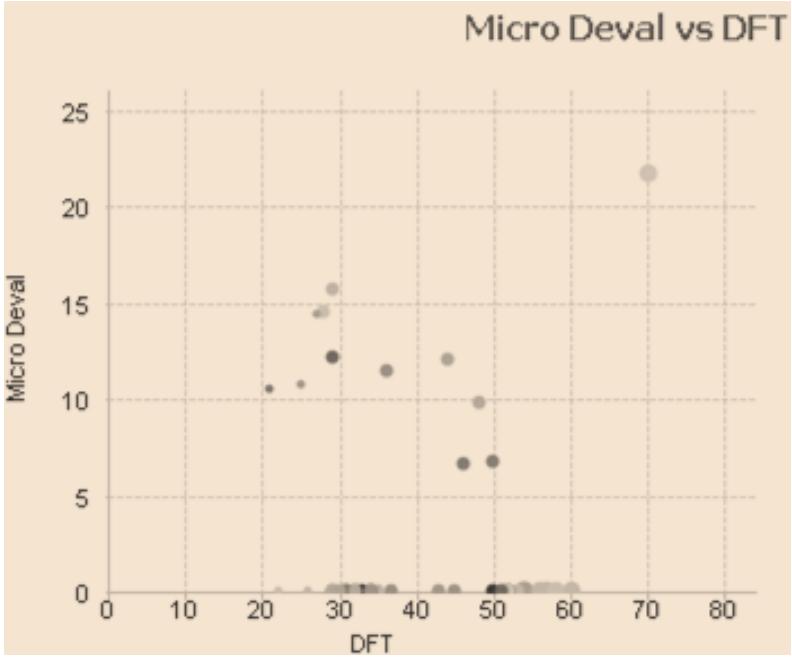
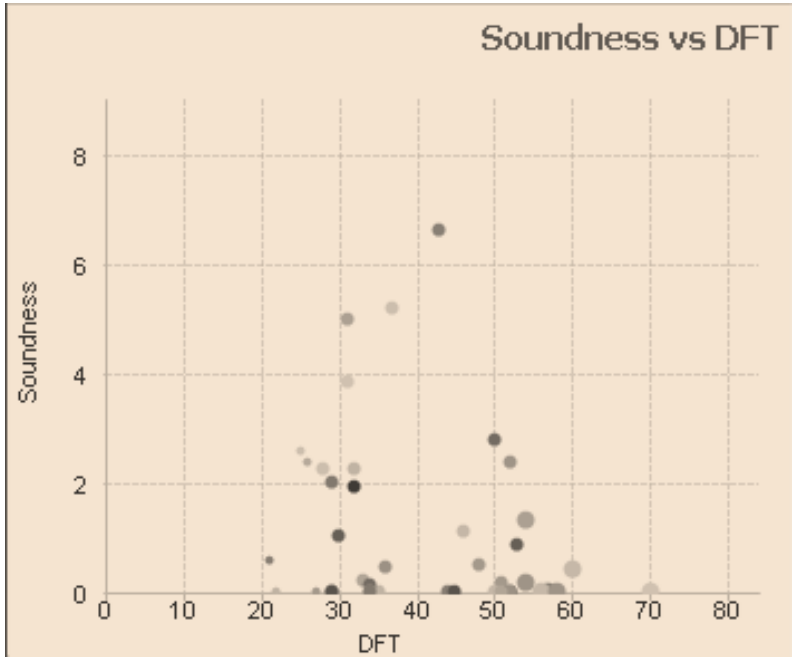
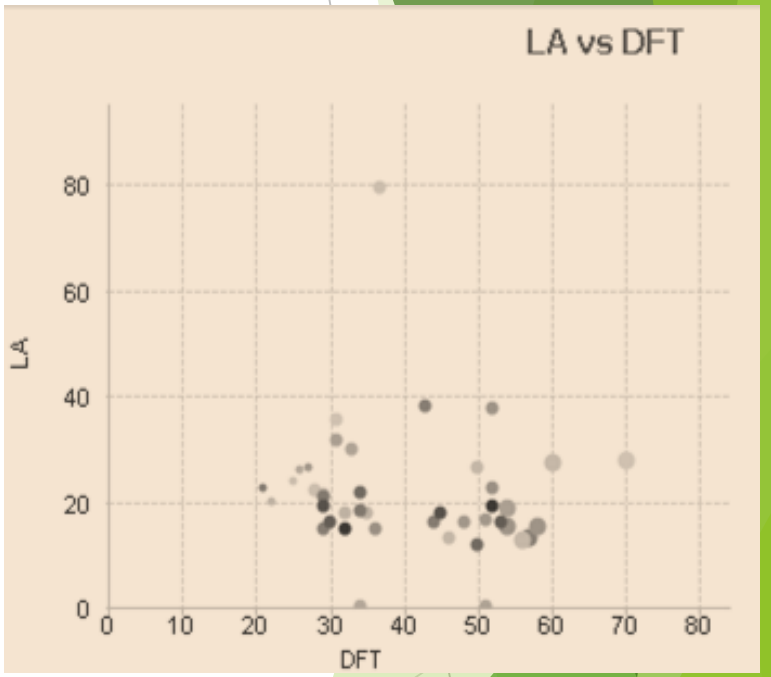
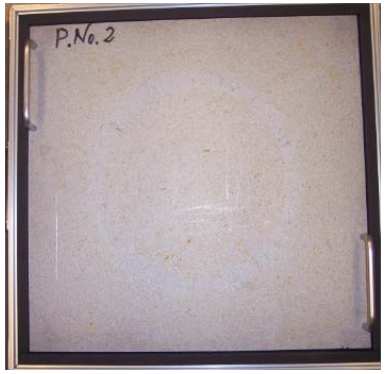






Factors That Influence Test Results

- **Material**: Change in Physical Properties and Petrography of materials.



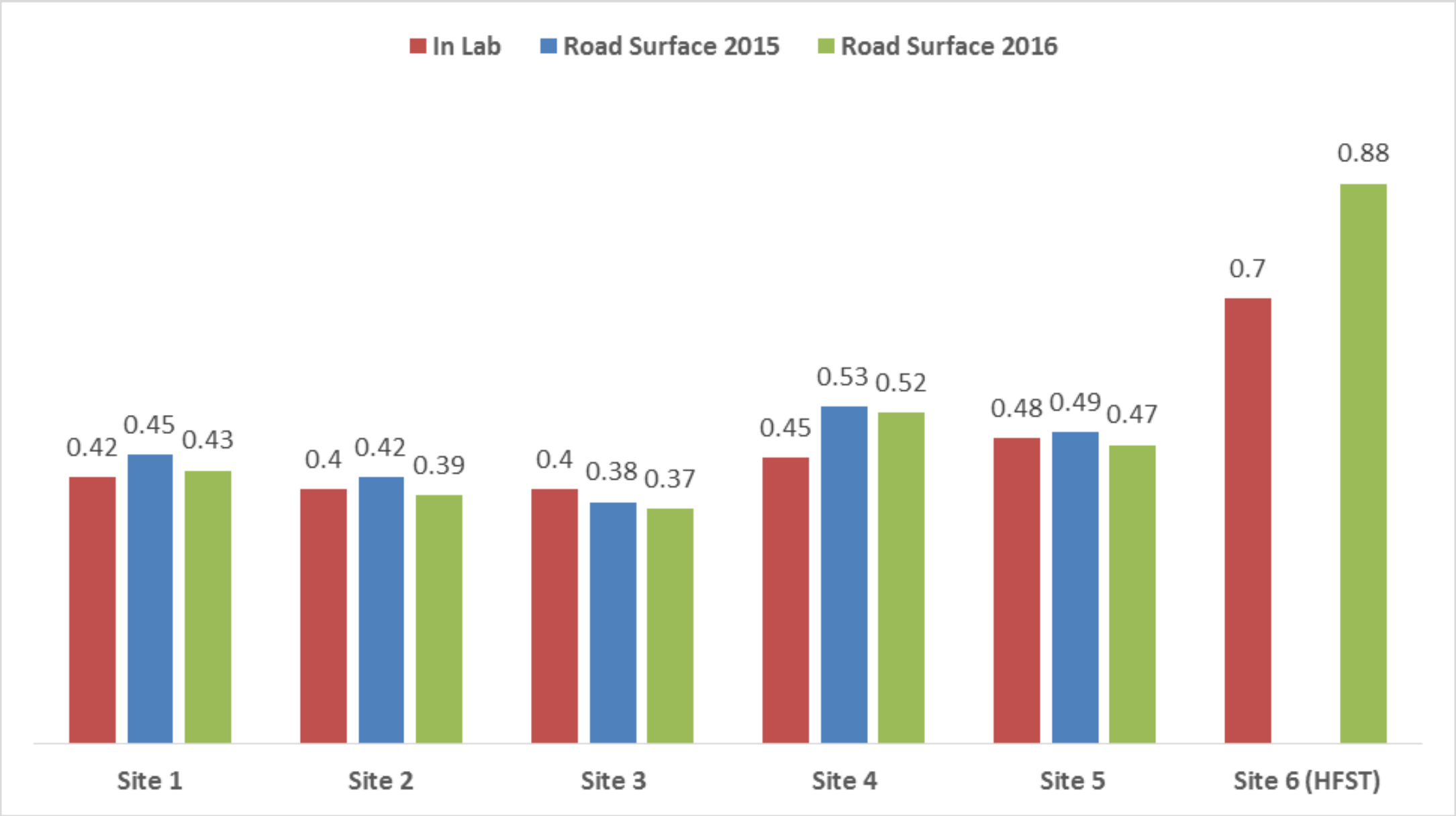
- **Equipment**: Calibration and Verification
- **Testing Procedure**: Uniform- No Change. Replicate samples (2 rings /sample)
- **Operator**: Technicians.

Current Criteria of Friction Rating in Maryland

- **DFT_{20} is an indicator of aggregate friction property**
- **Preliminary threshold values for aggregate friction property**
  - HDFV Aggregate: $DFT_{20} \geq 40$
  - SDFV Aggregate: $25 \leq DFT_{20} < 40$
  - LDFV Aggregate: $DFT_{20} < 25$
  - No use for HMA surface: $DFT_{20} < 25$
- **Aggregate for use in HMA surface**
  - Petrographic test (ASTM C-295) for non-carbonate rock
  - Acid insoluble residue (AIR) Test (ASTM D3042) for carbonate rock

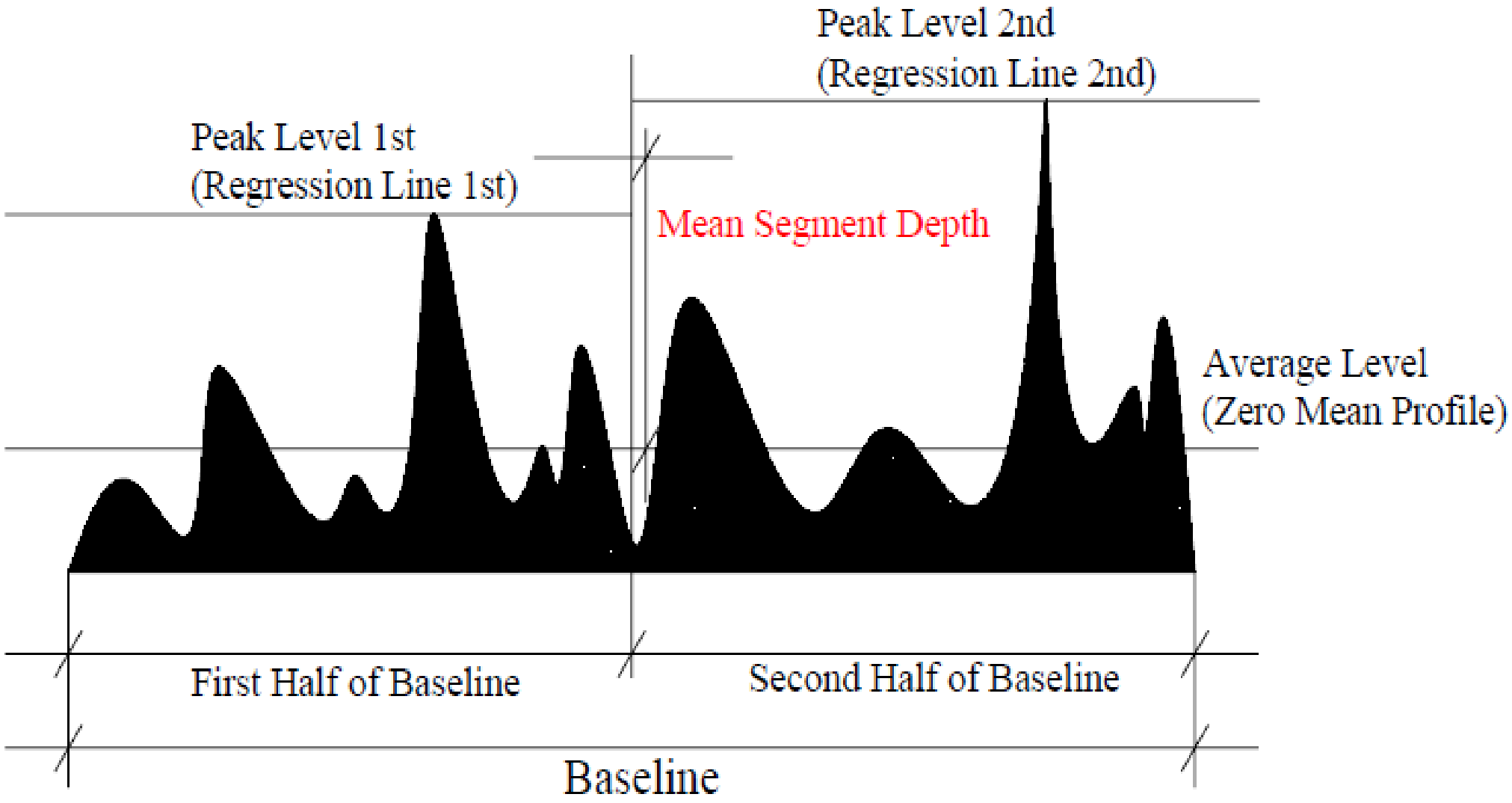
DFT and BPN Field Testing

Comparison of Lab and Field DF Testing

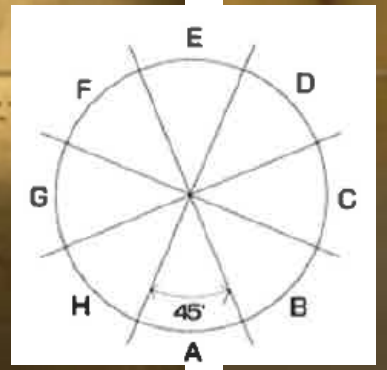


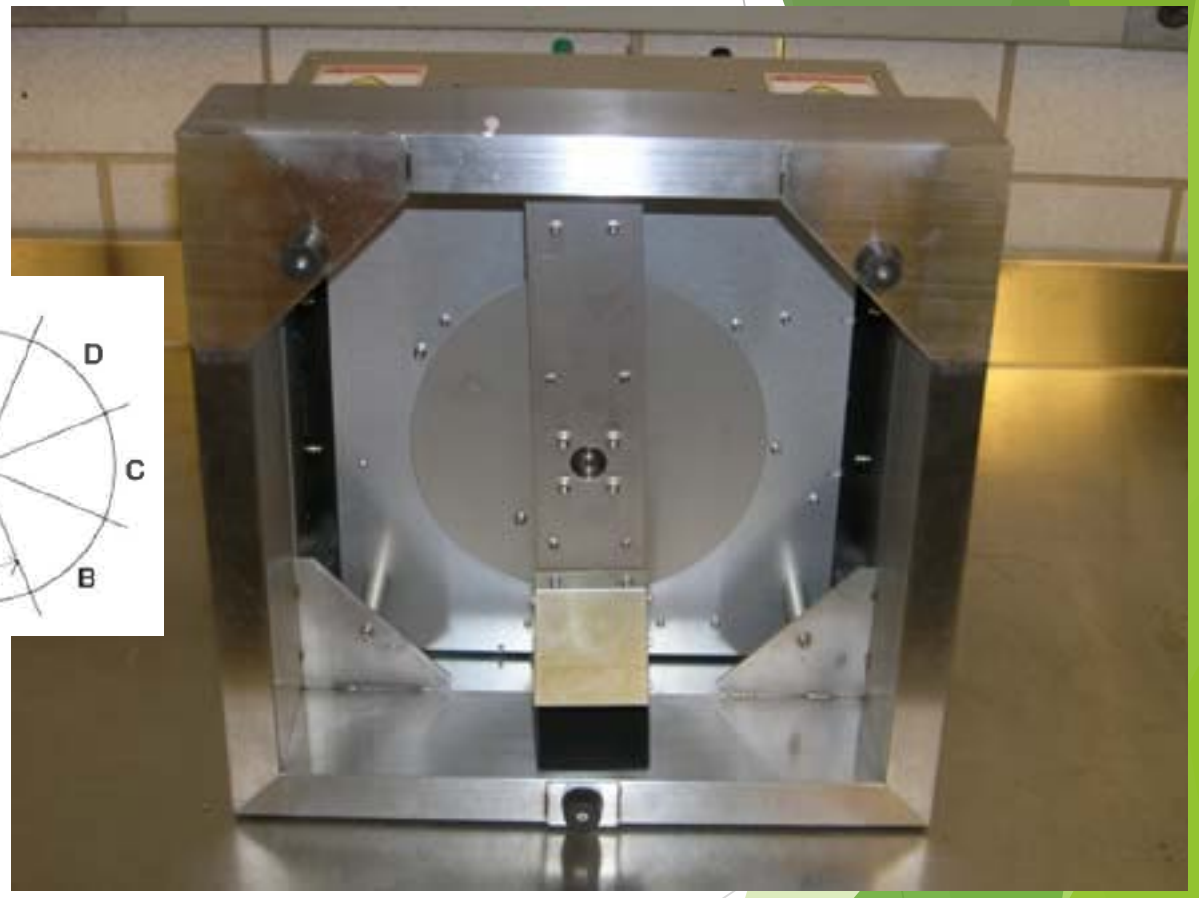
Circular Texture/Track Meter

Mean Profile Depth



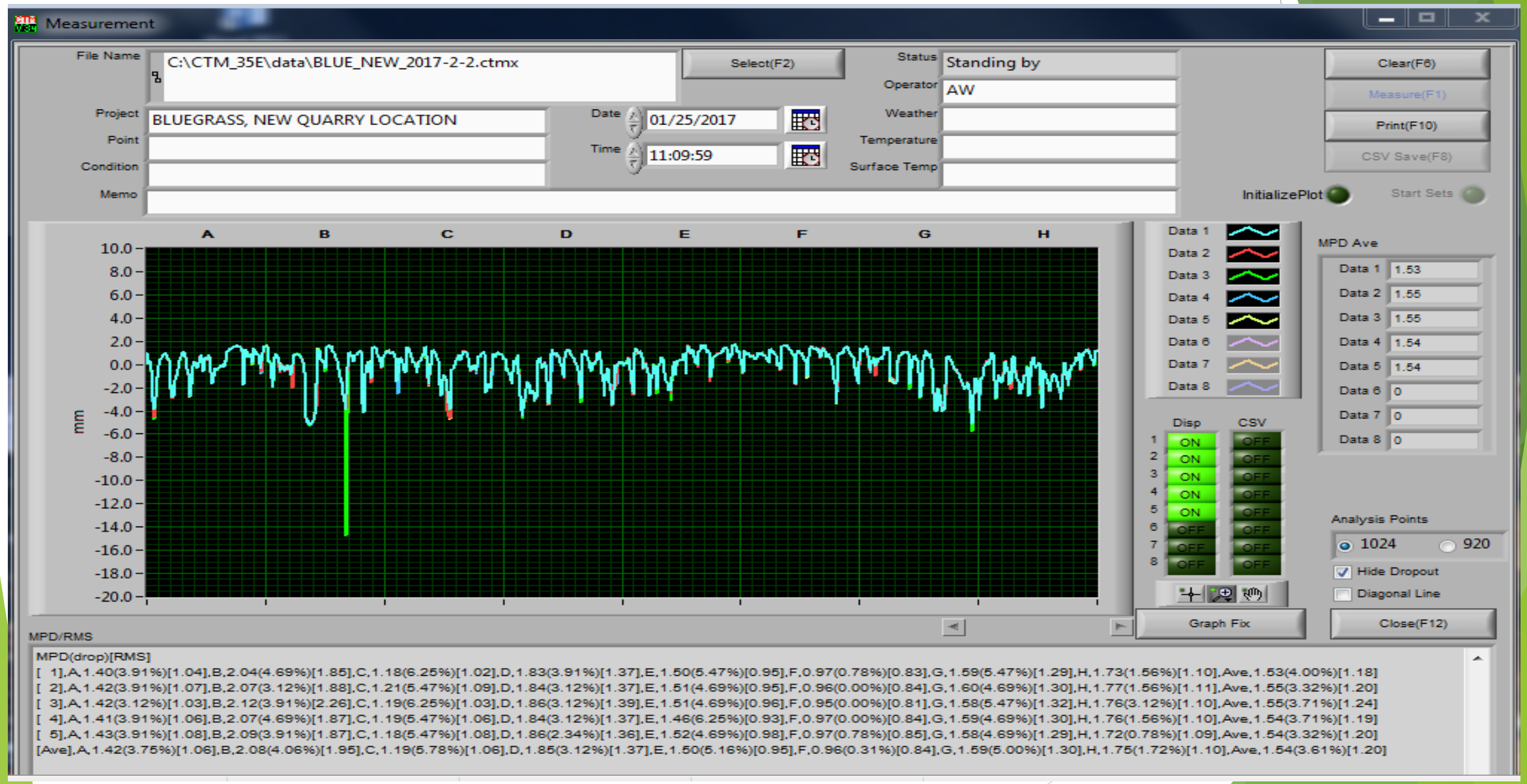
Circular Texture Meter





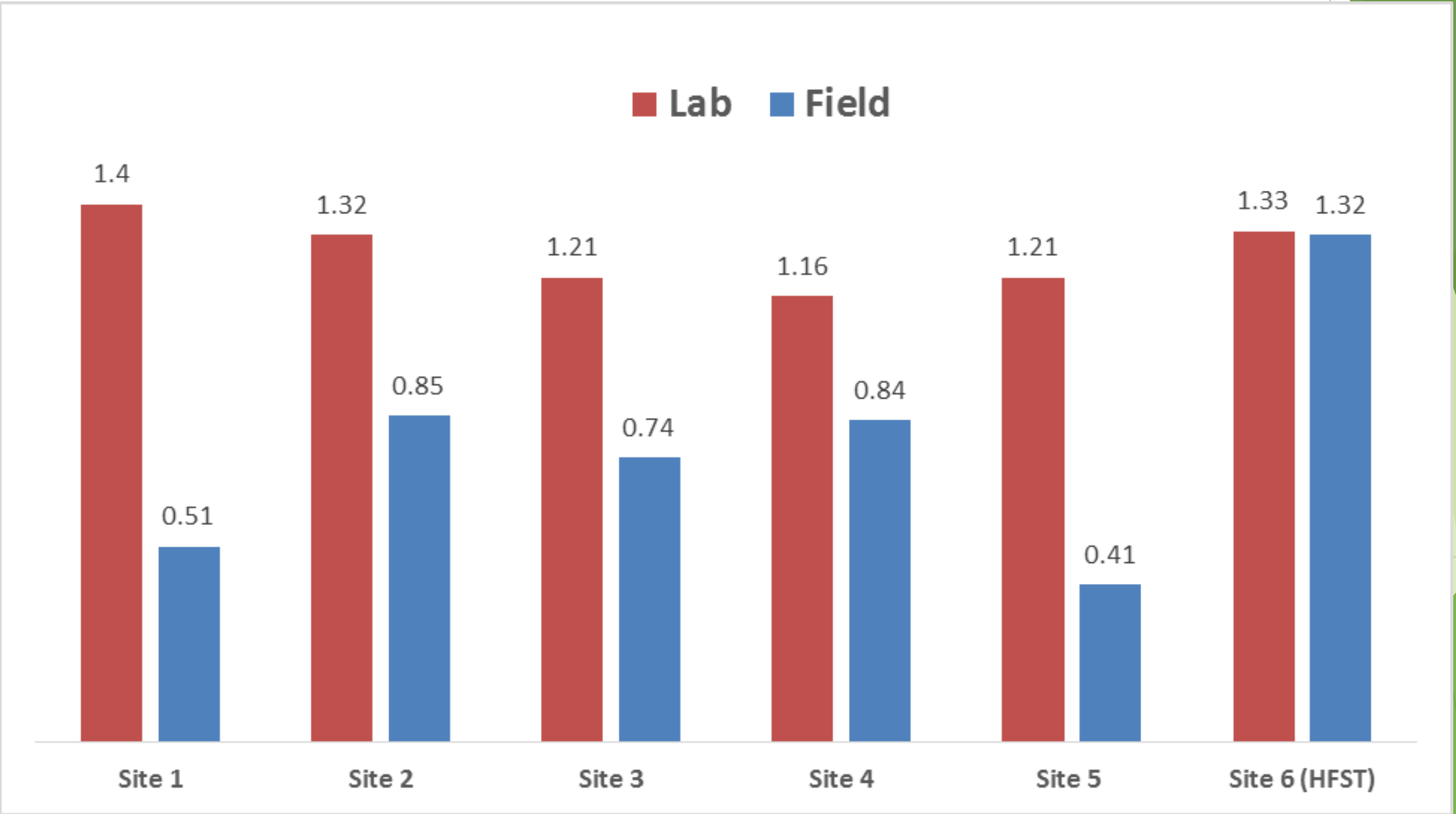
It measures macrotexture of surface in terms of MPD

Output file of CTM Test



CTM and Sand Patch Field Testing

Comparison of CTM Lab and Field Test Results



Summary

1. DFT and CTM are reliable, user friendly, less operator dependent testing to measure friction of road surface
2. DFT Lab and Field data is comparable with each other.
3. CTM Lab and Field data is not comparable with each other
4. The index properties, petrography or AIR test should be reviewed along with DFT and CTM results to rate friction quality of aggregate quarries
5. Friction properties of one quarry can be measured in one week using DFT and CTM testing.

Thanks!!!!!
and
Question?????