High Friction Surface Treatment Aggregate Durability Study

Pavement Evaluation 2014

Blacksburg, Virginia
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U.S. Department of Transportation
Federal Highway Administration

The Transtec Group
The World's Pavement Engineering Specialists

National Center for Asphalt Technology
NCAT
at Auburn University

HighFrictionRoads.com

Overview

- What are High Friction Surface Treatments?
- SEAHC Demonstration Program
- Aggregate Durability Study Phase I
- Aggregate Durability Study Phase II

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What are High Friction Surface Treatments?

- High Friction Surface Treatments (HFST) are pavement surfacing systems with exceptional skid-resistant properties that are not typically acquired by conventional materials
- Generally proprietary polymeric resin-based products and processes
- Guidelines Document from the British Board of Agrément (BBA)

  "…defined as having a minimum skid resistance value (SRV) of 65 measured using the portable Skid-Resistance Tester as defined in TRL Report 176: Appendix E."

HFST Materials

- Binder system (proprietary blends)
  - Bitumen-extended epoxy resins
  - Epoxy-resin
  - Polyester-resin
  - Polyurethane-resin
  - Acrylic-resin
  - MMA

HFST Materials

- Aggregates
  - *Generally calcined bauxite*, but flint/chert, slags, granite, and other materials with *high abrasion and polish resistance* have also been used
  - Generally 3-4 mm maximum size
  - AASHTO Spec:

    No. 4 Sieve: 100% passing

    No. 6 Sieve: 95% min. passing

    No. 16 Sieve: 5% max. passing

HFST Finished Product

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FHWA Surface Enhancements At Horizontal Curves (SEAHC) Program

- Goals of SEAHC:
  - Demonstrate the effectiveness of HFST in enhancing/restoring friction to reduce lane departure crashes at horizontal curves (and ramps).
  - Measure the properties of HFST and monitor changes and performance over first year
  - Monitor crashes before and after HFST application
- Utilize currently available HFST products
- 3+ year study for each site
- Generally 1-5 sites per State
- Additional demos funded through EDC2

FHWA Surface Enhancements At Horizontal Curves (SEAHC) Program

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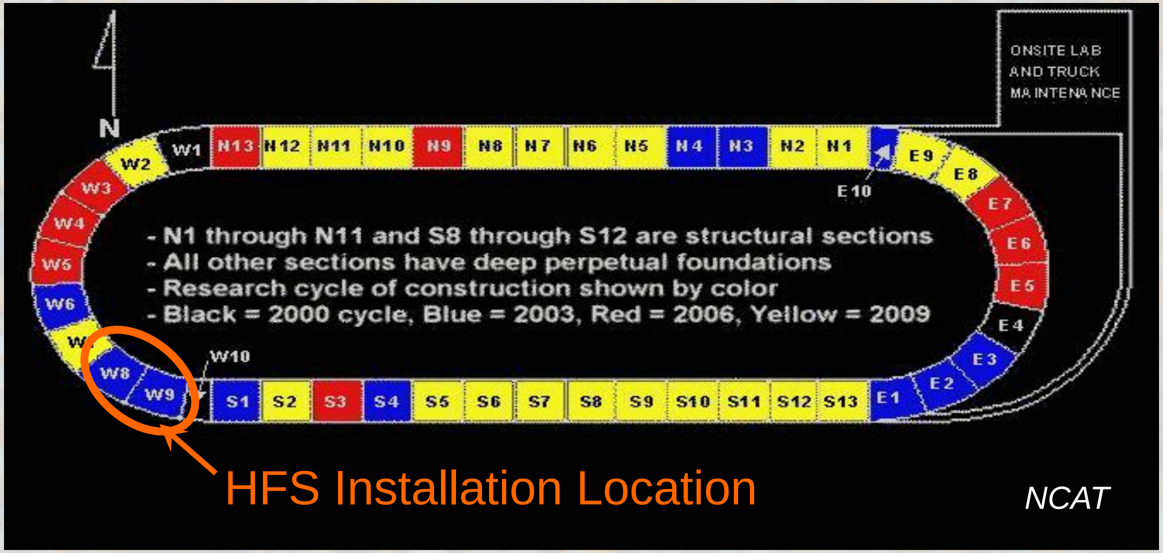
NCAT Aggregate Durability Study Phase I

- Purpose: Test the durability of various aggregate types under the same conditions
  - Installed on similar sections NCAT Test Track on a curve
  - Installed by same HFS supplier using the same resin, crew, and equipment
  - Exposed to the same traffic and climatic conditions
- 2.6 Million ESAL applications (April-October 2011)
- Aggregates Tested:
  - Granite, Calcined Bauxite, Flint (100’ each)
  - Basalt, Silica, Steel Slag, Emery, Taconite (15’ each)

NCAT Aggregate Durability Study Phase I

NCAT Aggregate Durability Study Phase I



NCAT Aggregate Durability Study Phase I

NCAT Aggregate Durability Study


Granite


Basalt

Pre-Traffic


Bauxite


Silica


Emery


Flint

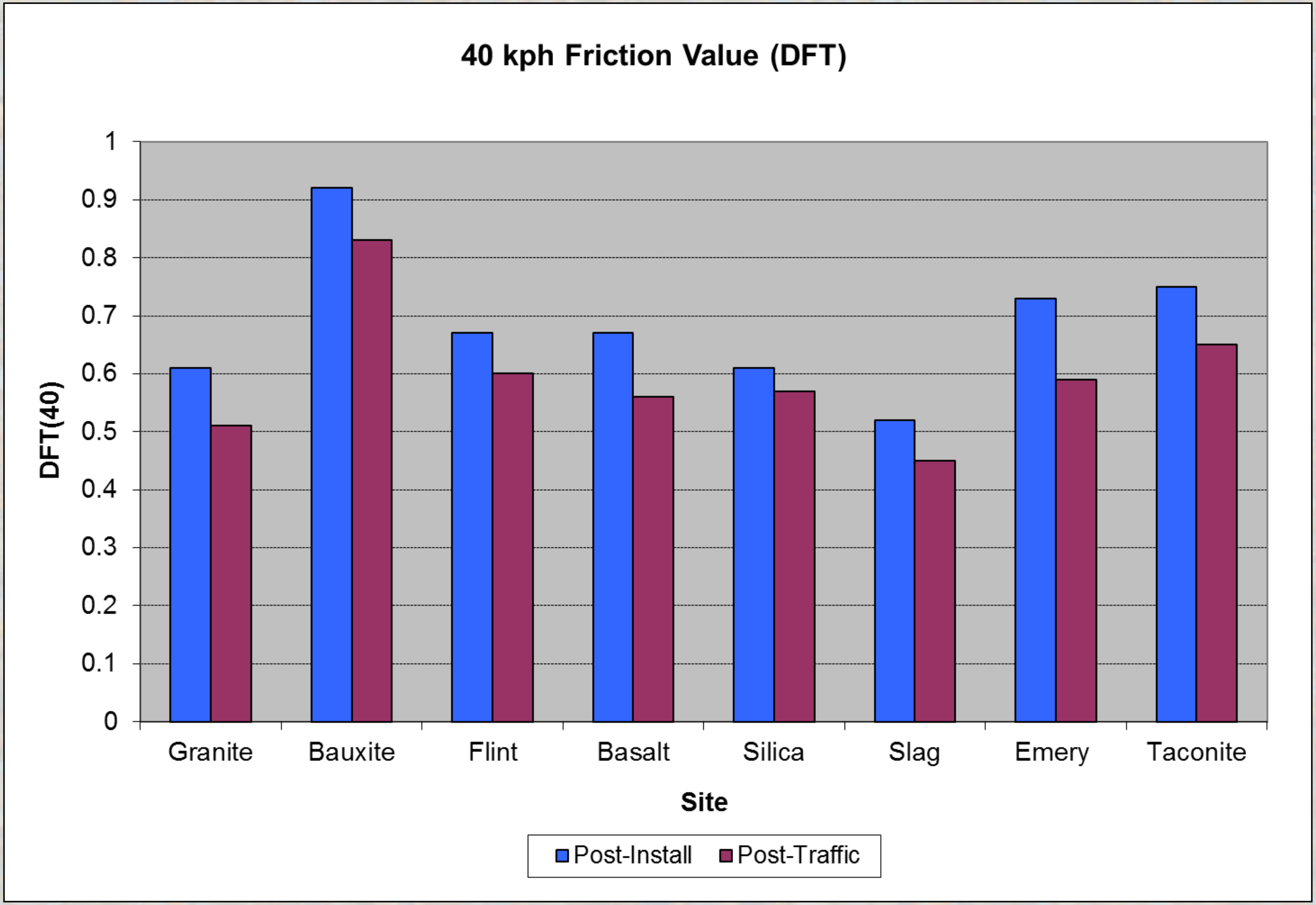

Steel Slag


Taconite

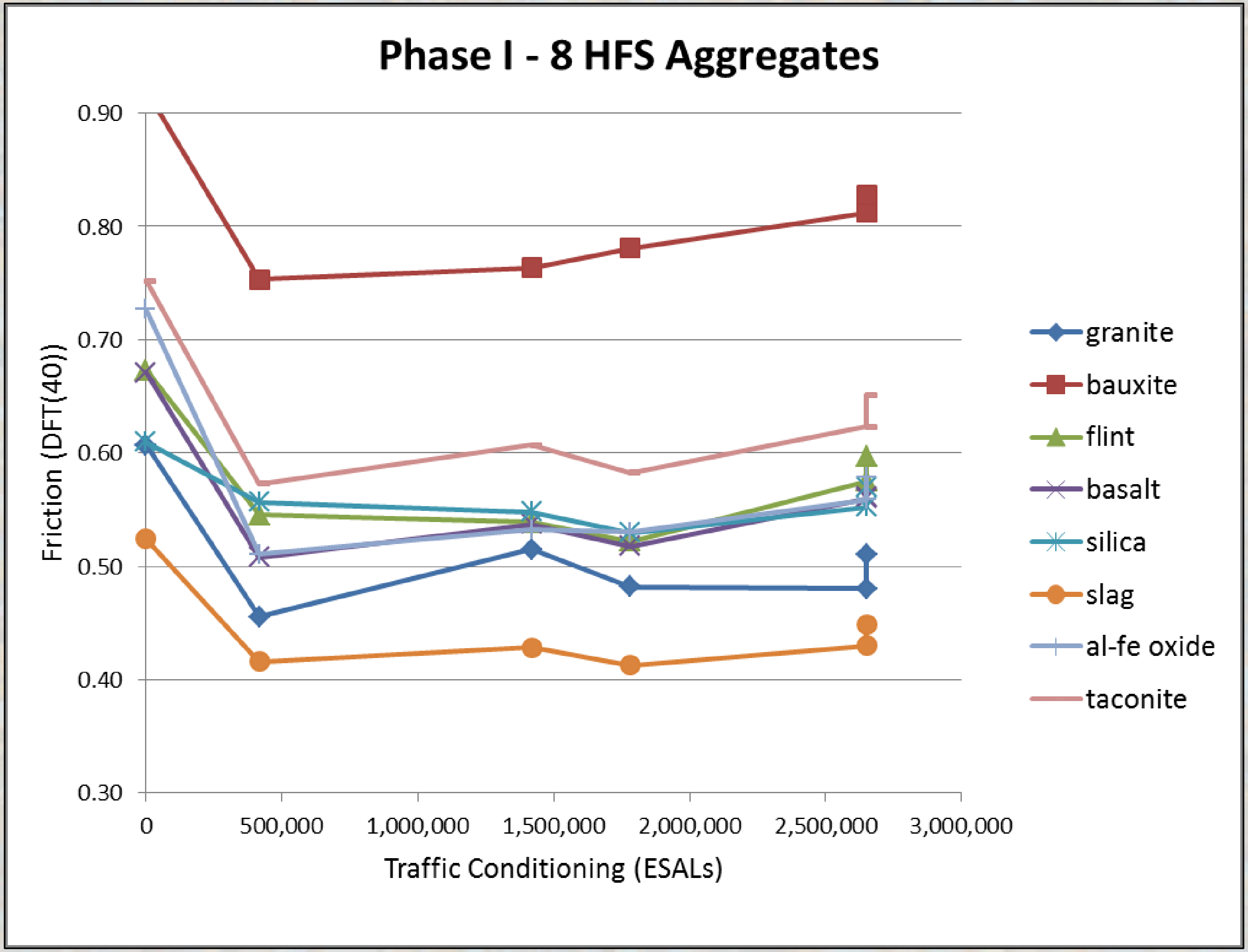
NCAT Aggregate Durability Study Phase I

- Laboratory Testing
- Three Wheel Polishing Device
  - Friction (DFT) & Texture (CTM) tested at 70k & 140k cycles
  - 2 replicates for each aggregate type

NCAT Aggregate Durability Study Phase I – Test Track Sections



NCAT Aggregate Durability Study
Phase I – Test Track Sections



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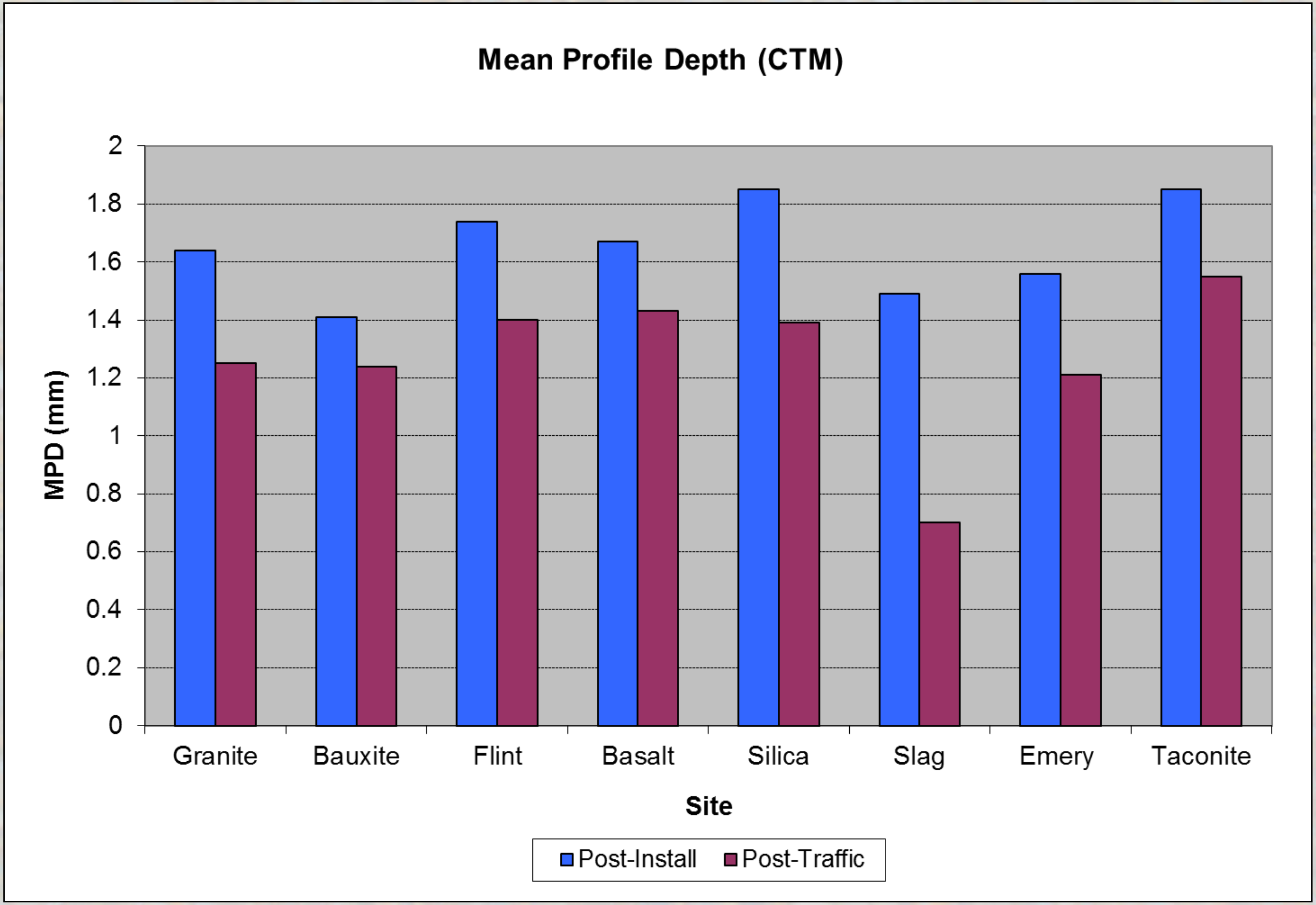
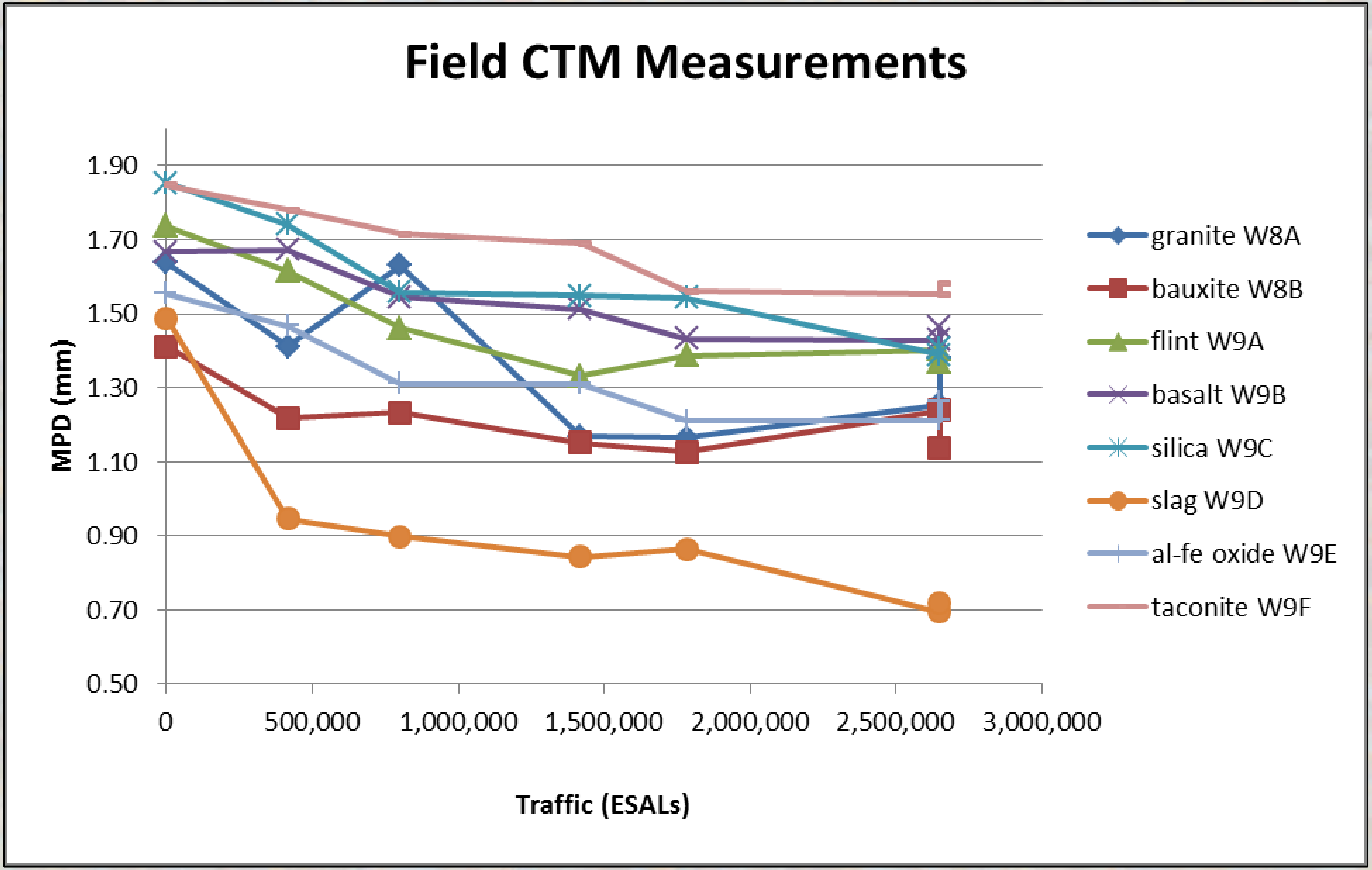


NCAT Aggregate Durability Study Phase I – Test Track Sections

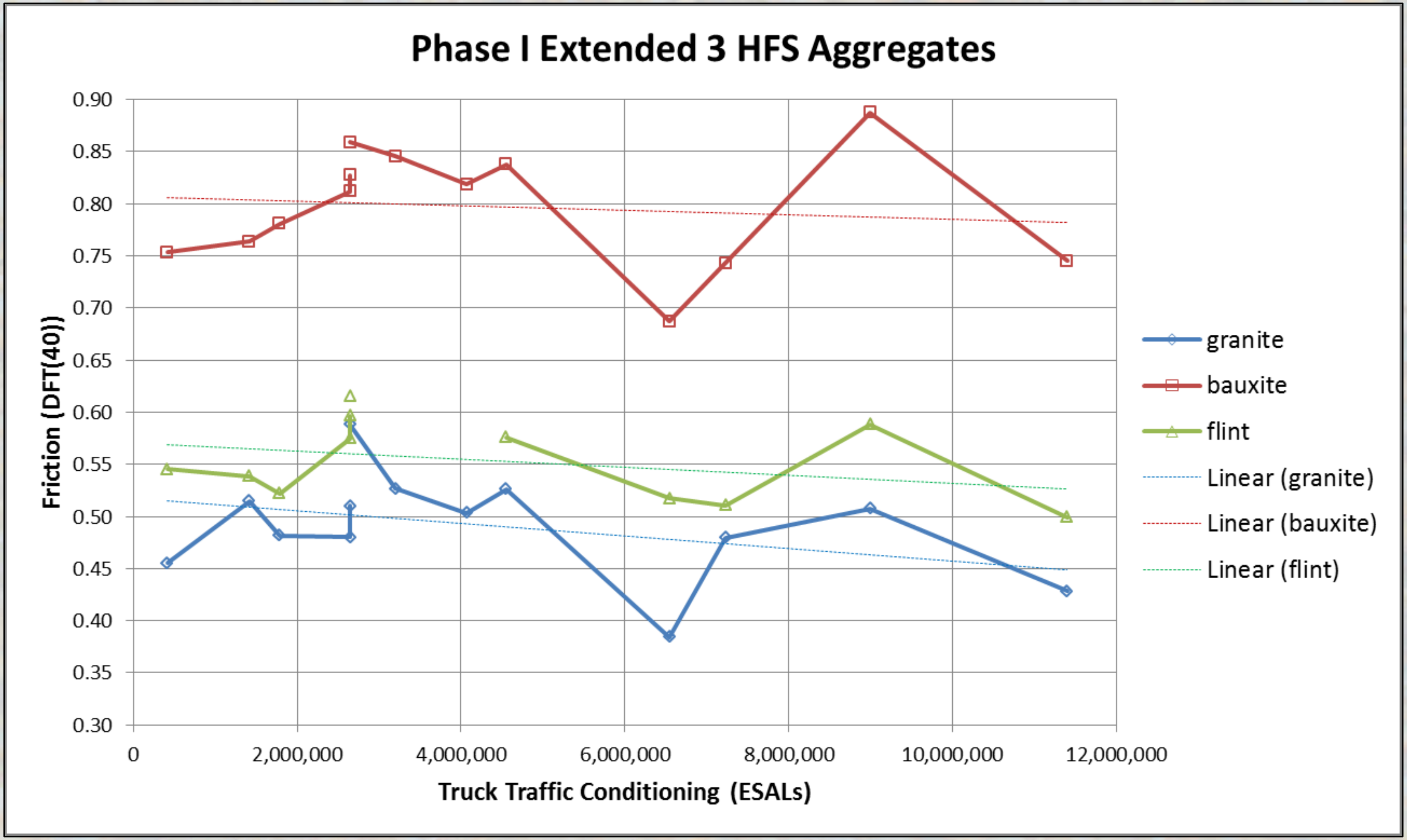


NCAT Aggregate Durability Study

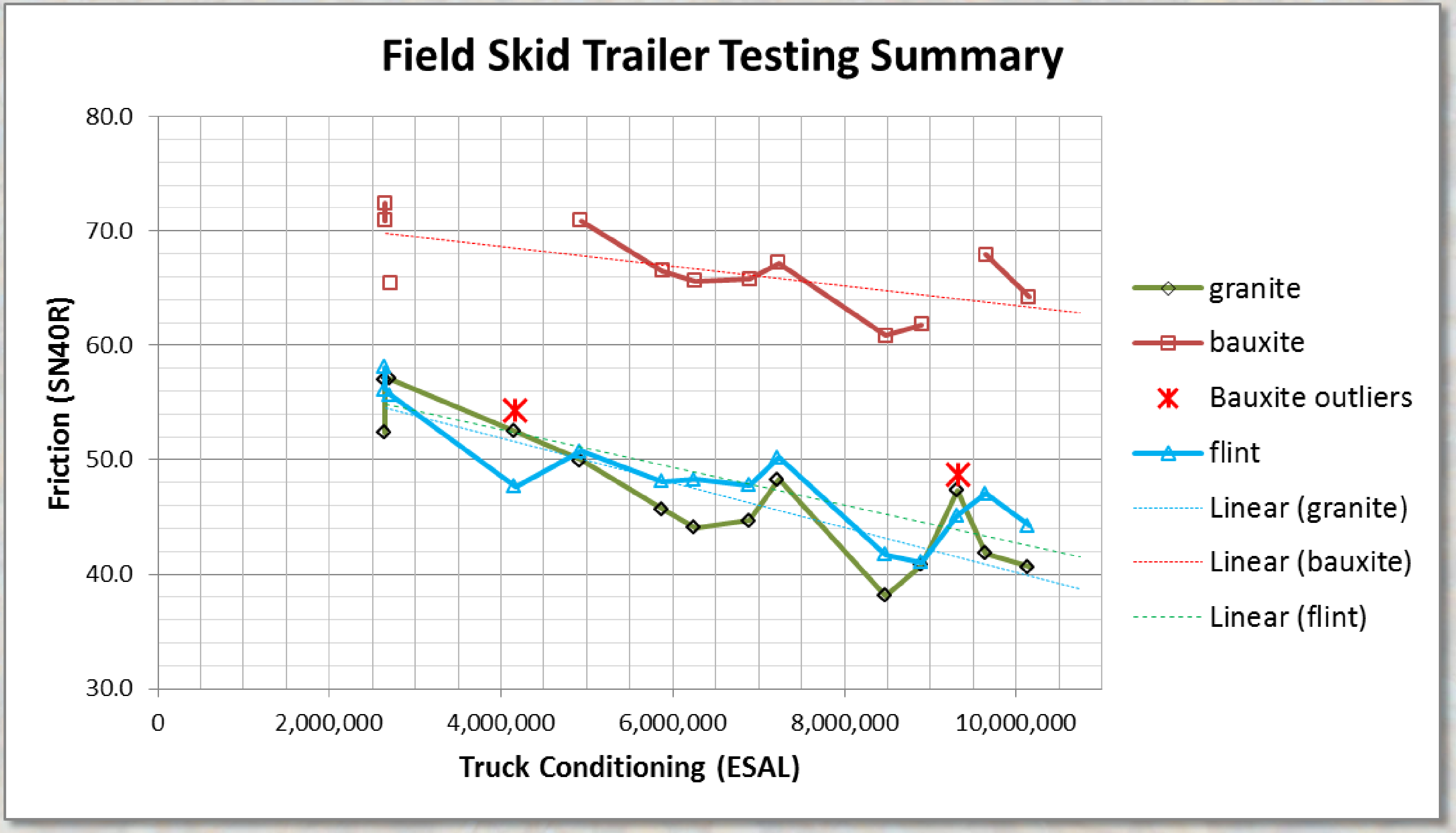
Post-Traffic

(2.6 million ESALs)

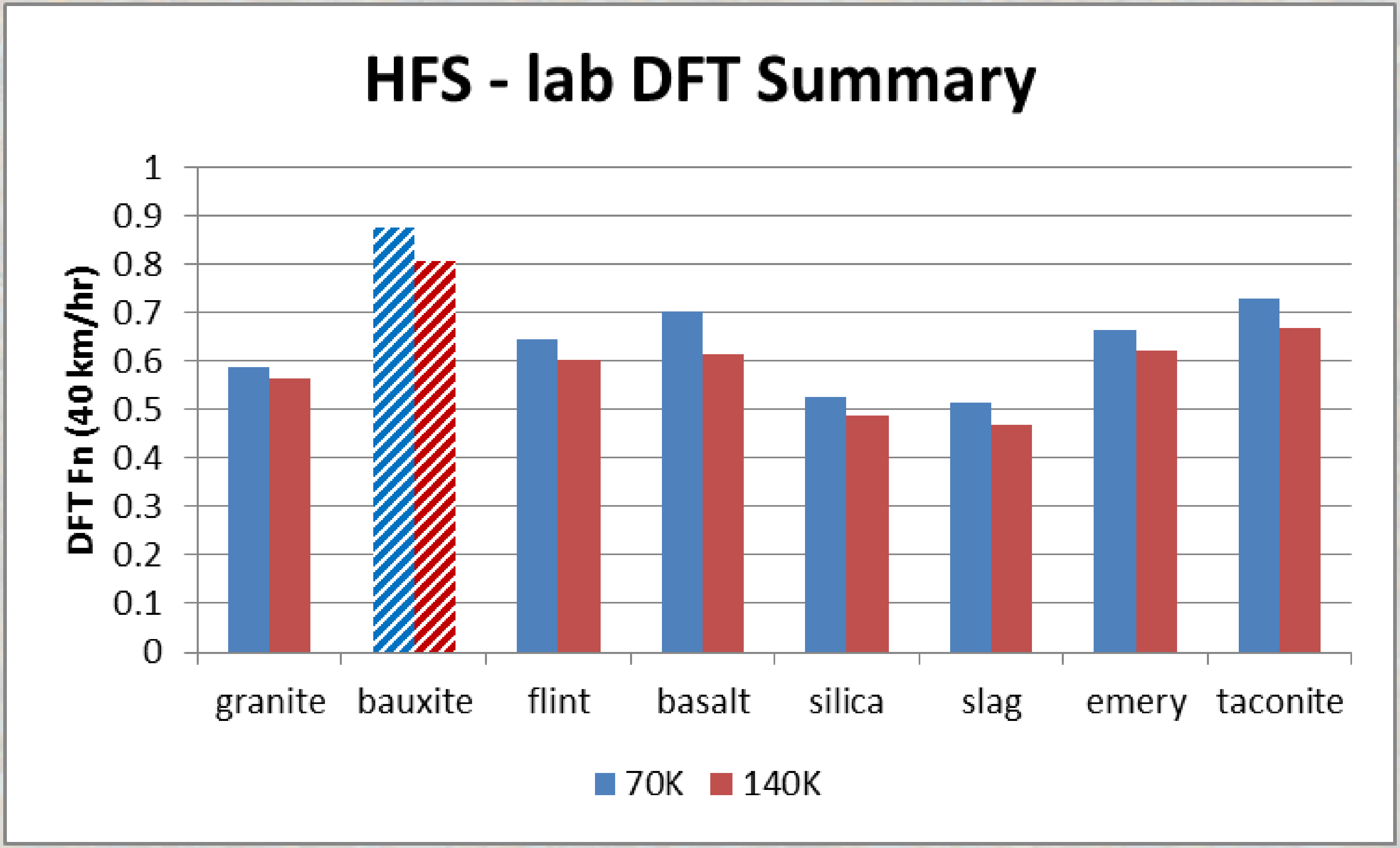
NCAT Aggregate Durability Study Phase I – Test Track Sections



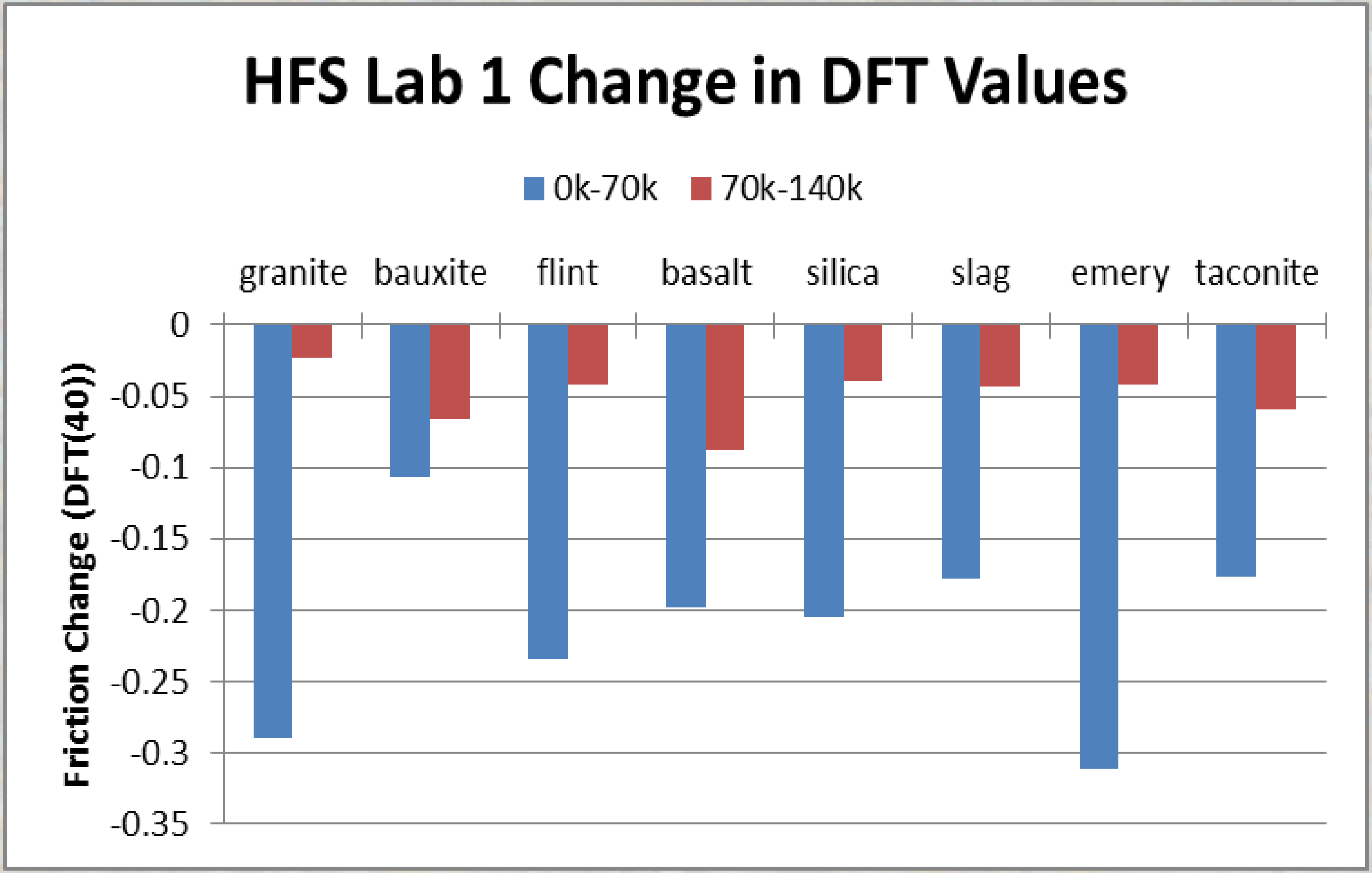
NCAT Aggregate Durability Study
Phase I – Test Track Sections



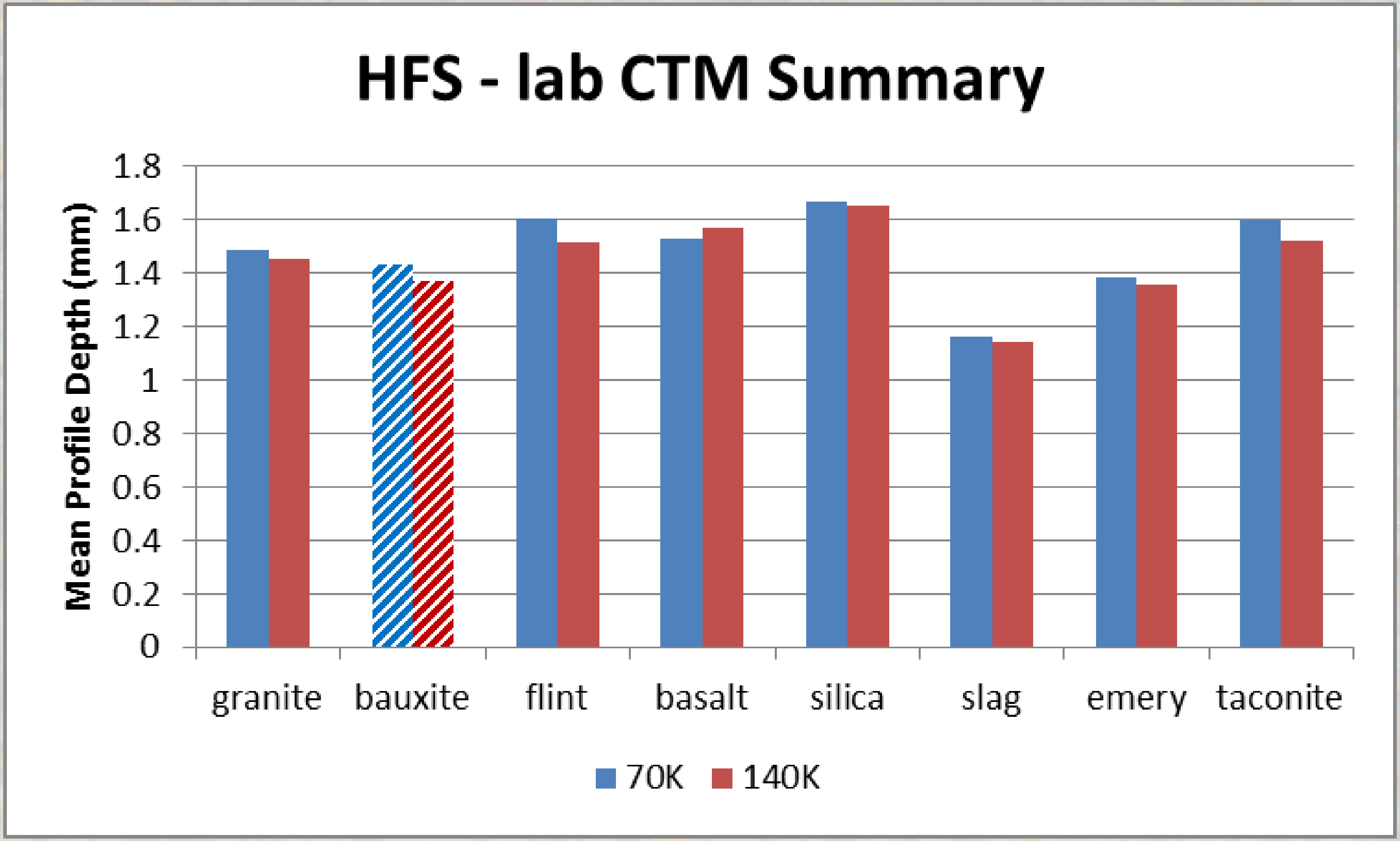
NCAT Aggregate Durability Study Phase I – Laboratory Samples



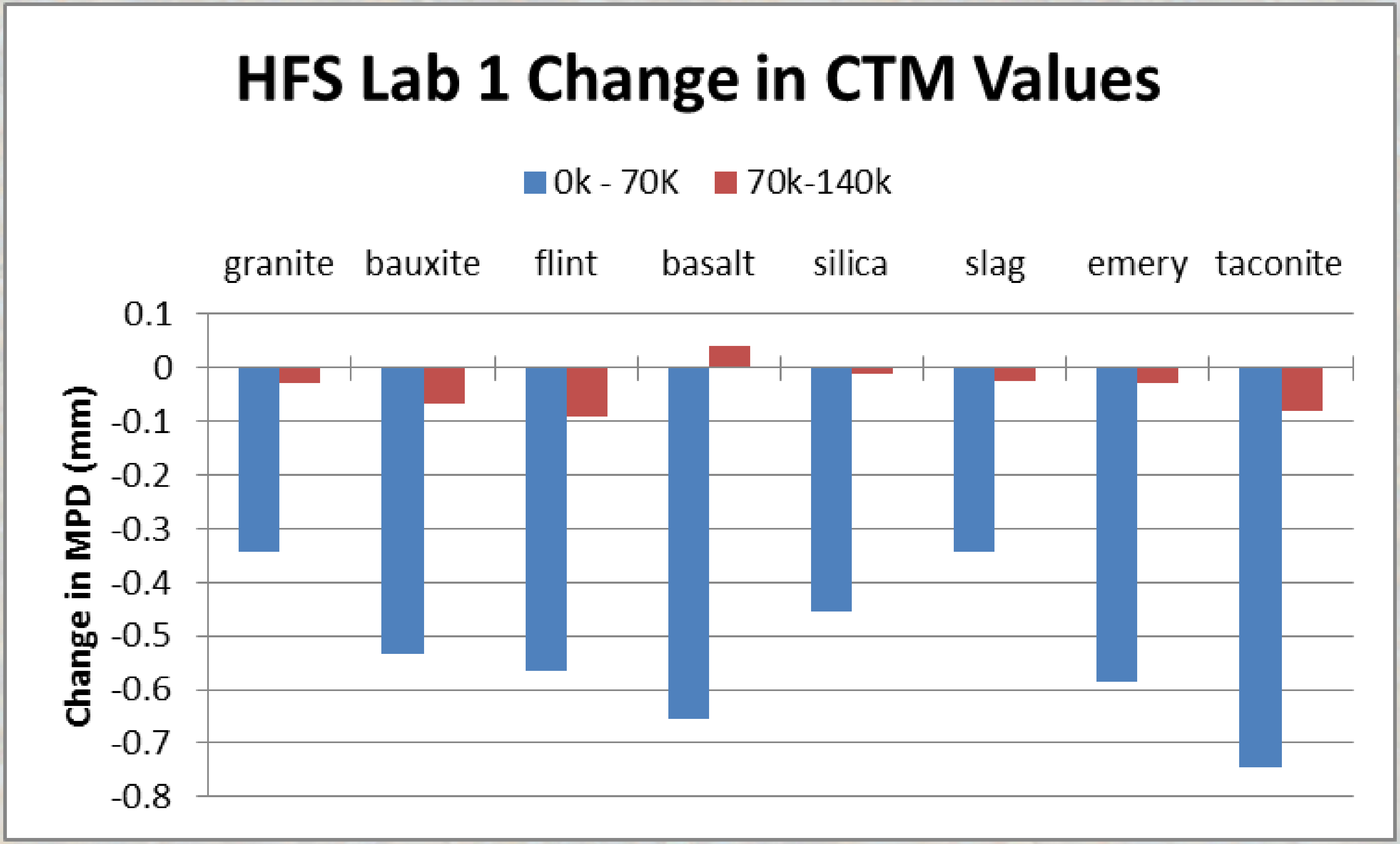
NCAT Aggregate Durability Study
Phase I – Laboratory Samples



NCAT Aggregate Durability Study
Phase I – Laboratory Samples



NCAT Aggregate Durability Study
Phase I – Laboratory Samples



Phase I Observations

- For TWPD tests…
  - Macrotexture *and* friction decreased substantially between 0 and 70k cycles
  - Macrotxture changed little between 70k and 140k cycles, but friction decreased for all aggregates, with the degree varing by aggregate
- For Test Track sections…
  - Macrotexture decreased steadily for all aggregates over 2.6M ESALs
  - Friction decreased significantly initially, then stabilized for all aggregates
- There was no correlation between DFT and CTM values.
- Overall, calcined bauxite showed the best friction performance (highest friction) in both the laboratory and on the track.

Overview

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NCAT Aggregate Durability Study Phase II

- Two Components:

  1) Separation of aggregates into size factions to compare performance of different sizes

  2) Laboratory testing of the polishing and abrasion resistance of various HFST aggregate types

- Aggregates Tested
  - Calcined Bauxite,Taconite, Flint, Steel Slag (*different source from Phase I for Flint and Slag*)
- Aggregate Size Separation
  - Sieves Retaining Aggregate: #6, #8, #12, #16
  - Less than 8% passing #16

NCAT Aggregate Durability Study Phase II

- Laboratory Tests
  - Micro-Deval: #8 size faction only
  - Aggregate Imaging System (AIMS): #8 size faction only
    - Used in conjunction with Micro-Deval
    - Only captures particle shape and angularity for fine aggregate

NCAT Aggregate Durability Study Phase II

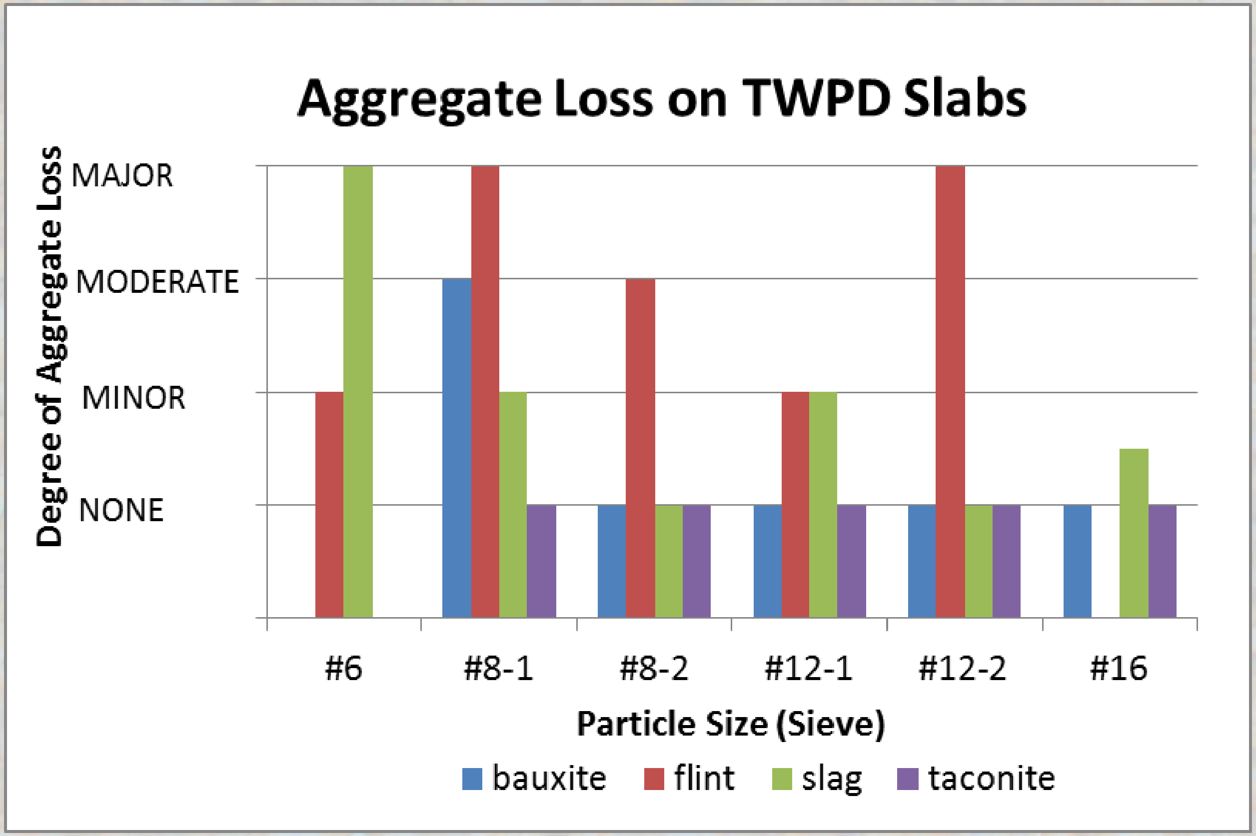
- Laboratory Tests
  - Three Wheel Polishing Device

	Retained Sieve Size			
	#6	#8	#12	#16
Bauxite	n/a	3 slabs	3 slabs	1 slab
Slag	1 slab	3 slabs	3 slabs	1 slab
Taconite	n/a	3 slabs	3 slabs	1 slab
Flint	1 slab	3 slabs	3 slabs	n/a

– British Wheel/British Pendulum: *test abandoned due to issues with test coupon preparation*

NCAT Aggregate Durability Study Phase II

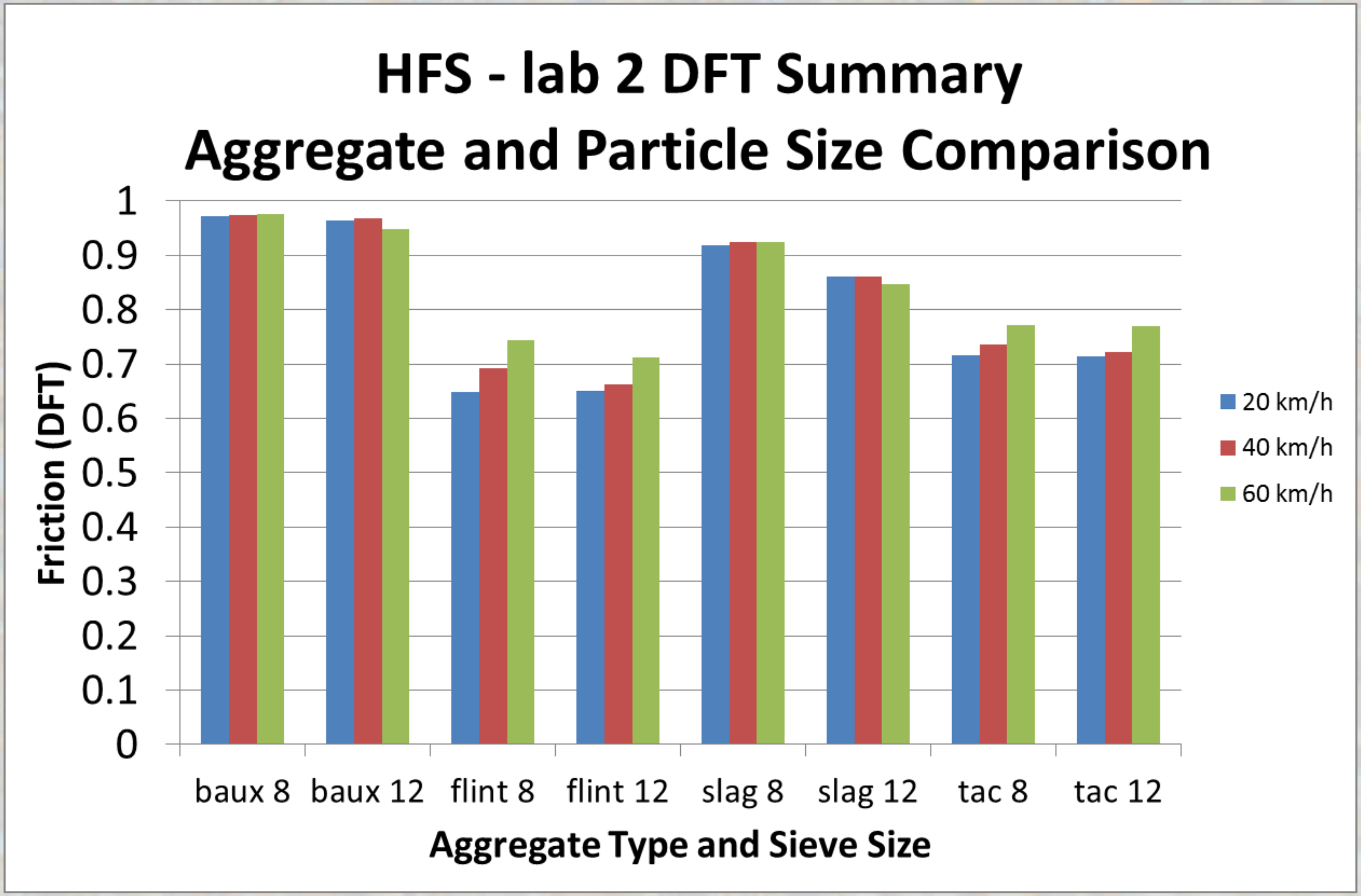
- TWPD Aggregate Loss



Note: No aggregate loss observed during Phase I

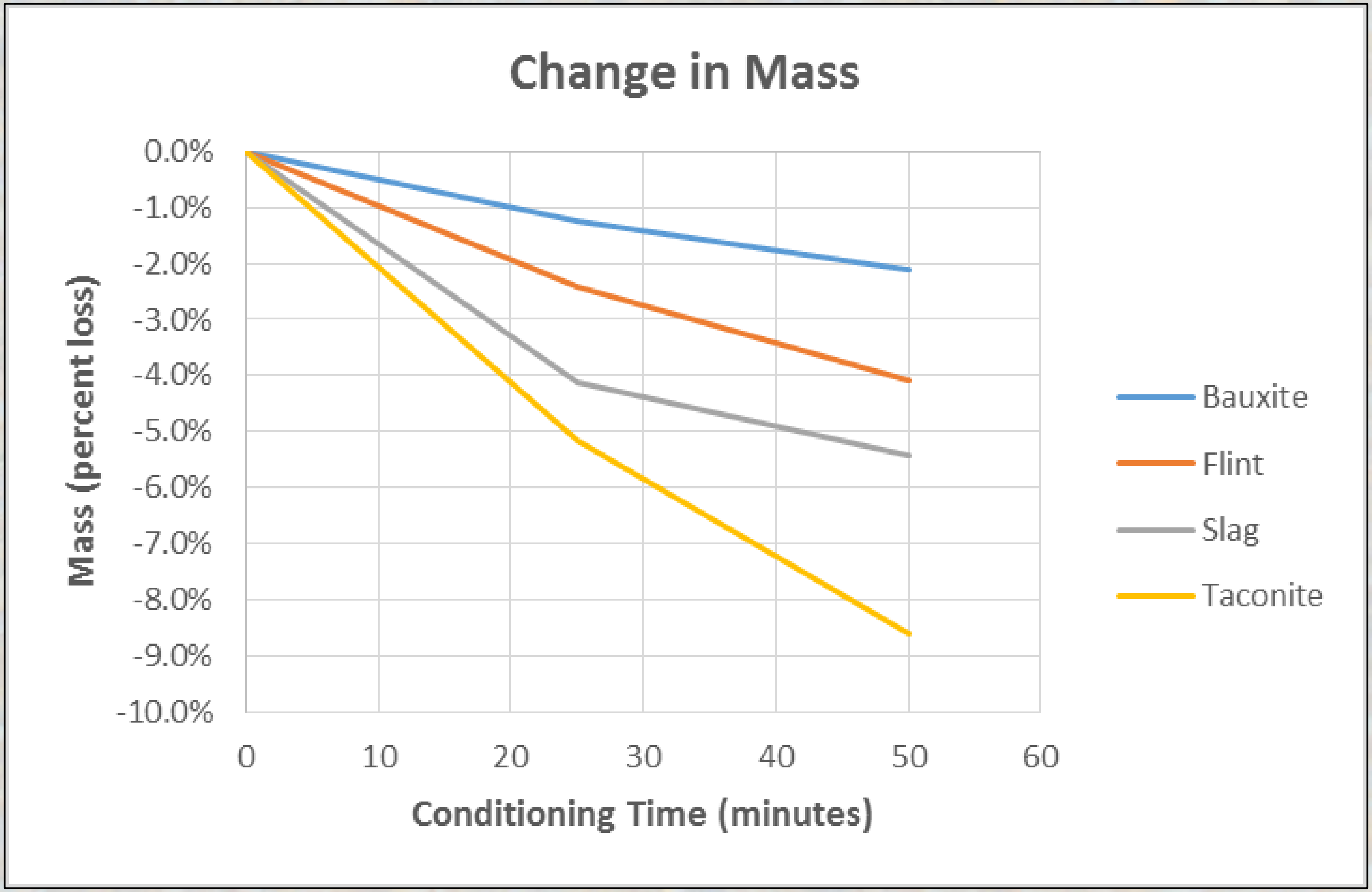
NCAT Aggregate Durability Study Phase II

- TWPD Test – Terminal Friction Values



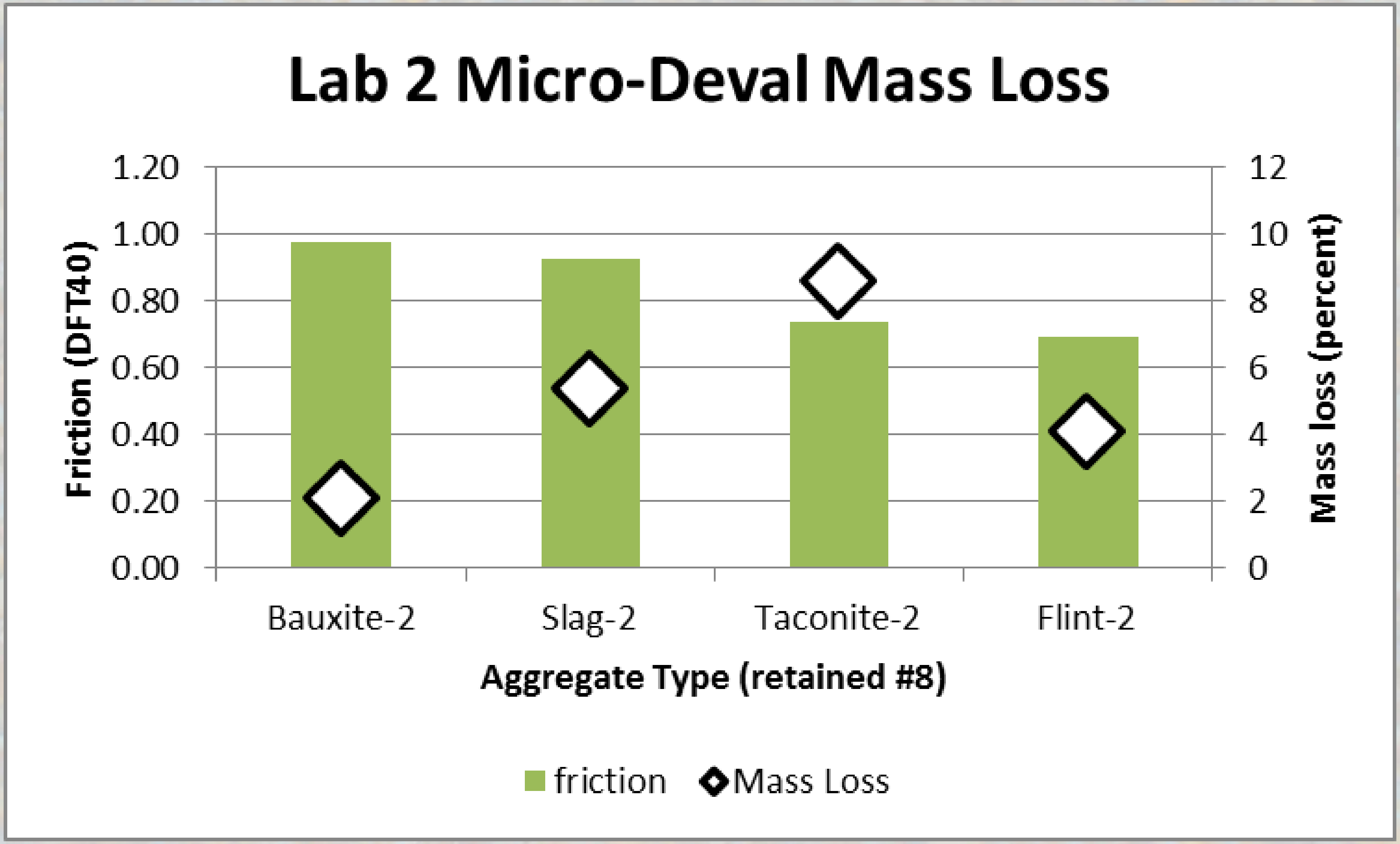
NCAT Aggregate Durability Study Phase II

- Micro-Deval Results – Mass Loss



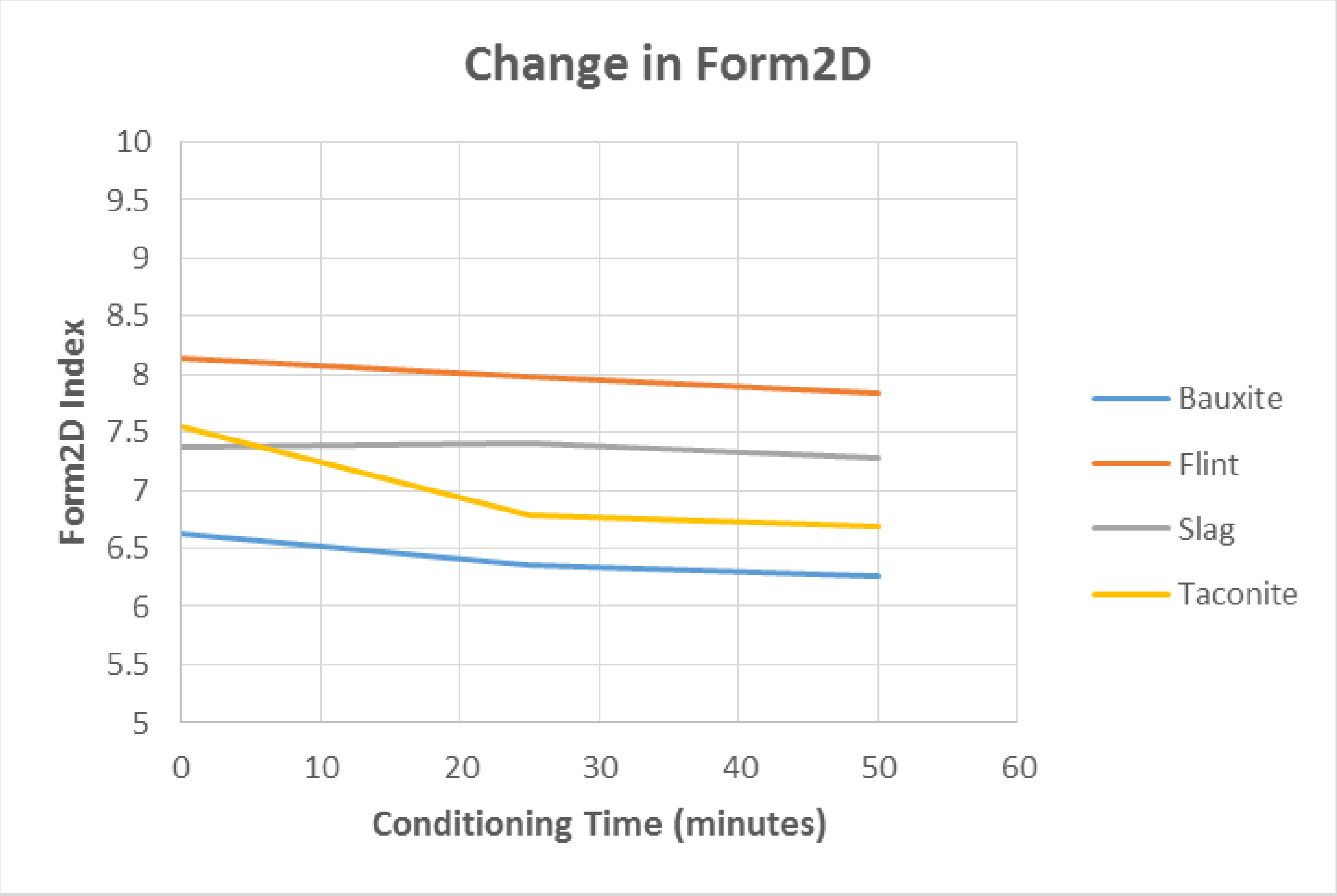
NCAT Aggregate Durability Study Phase II

- Micro-Deval Results – Mass Loss vs. Friction



NCAT Aggregate Durability Study Phase II

- AIMS Results – Change in Shape

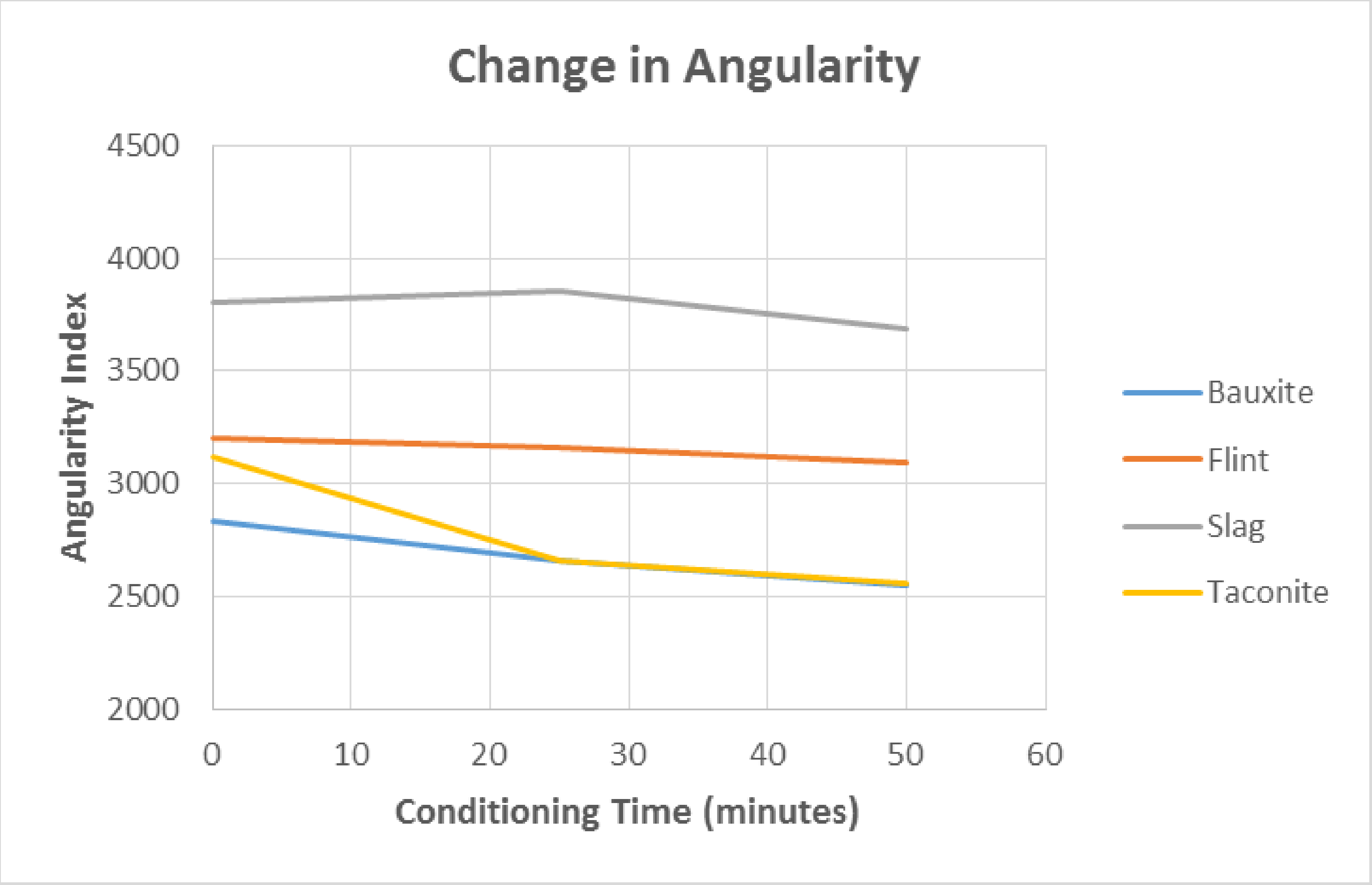


Form2D Range:
0 = sphere
20 = extremely elongated

Note: No correlation observed between change in shape and friction ranking.

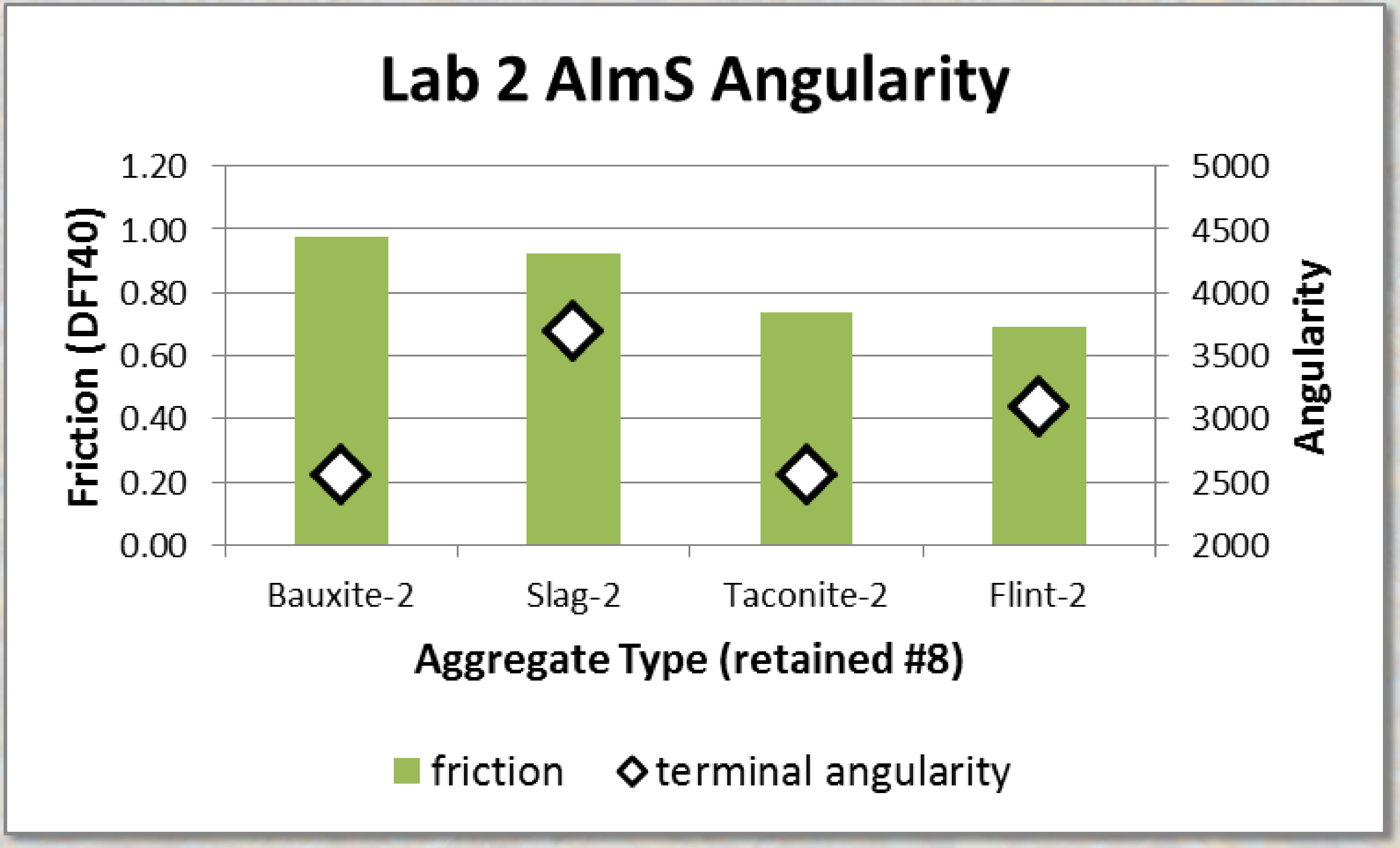
NCAT Aggregate Durability Study Phase II

- AIMS Results – Change in Angularity



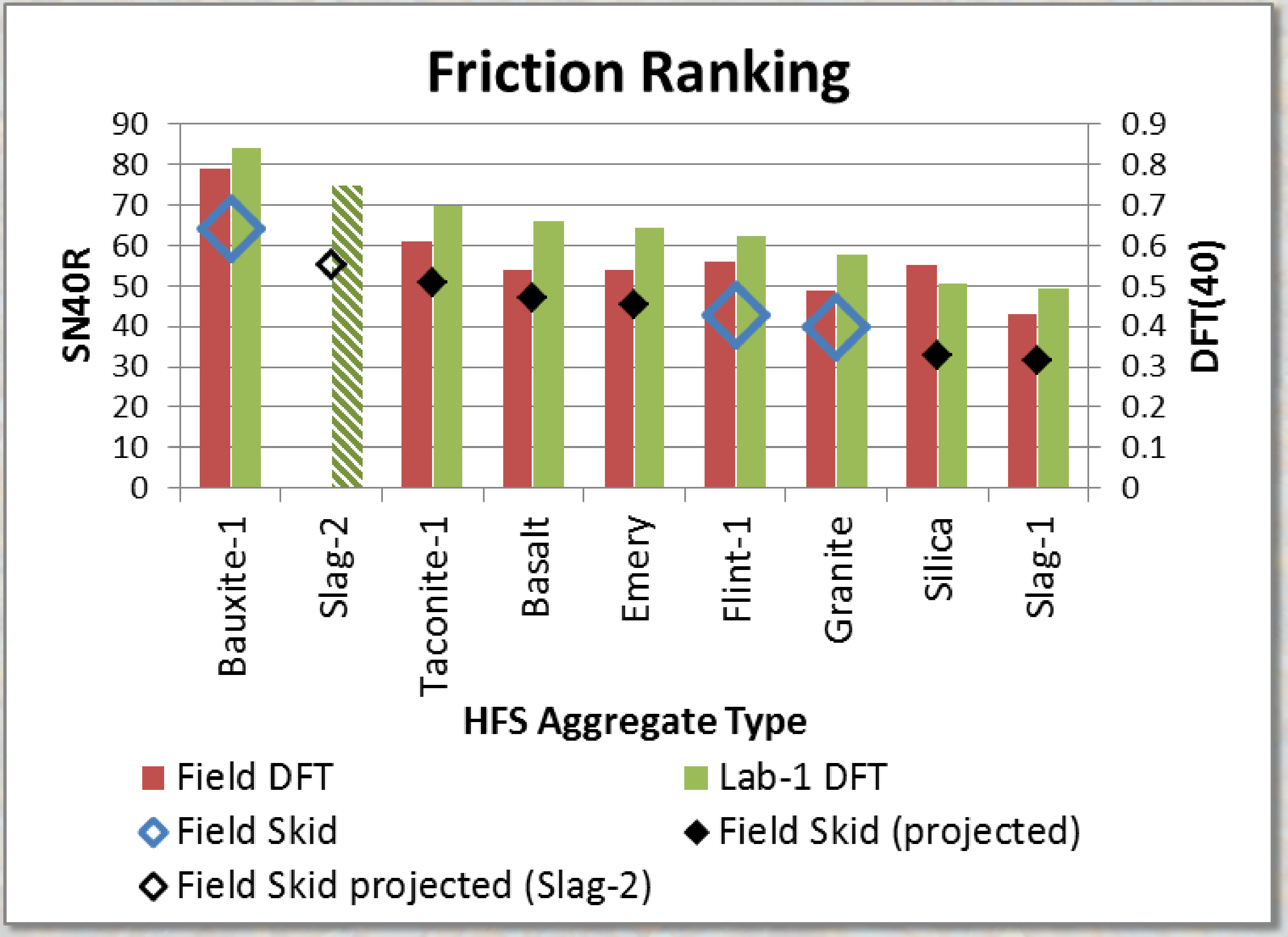
NCAT Aggregate Durability Study Phase II

- AIMS Results – Angularity



Note: No correlation between angularity and friction ranking.

Phase II Observations



Phase II Observations

- Aggregate Size Effects
  - Very little difference in friction after wear between #8 and #12 size particles, regardless of aggregate type.
  - Larger particle size contributed to more particle loss under accelerated testing
    - Importance of interlock with smaller aggregate
    - Depth of embedment of aggregate increased as particle size decreased - resulted in less loss of particles for smaller particle size.
  - Aggregate loss (lab samples) did not have a substantial impact on friction

Phase II Observations

- Aggregate Shape and Angularity Effects
  - More elongated particles (flint, taconite) show slight increase in friction with speed vs. little to no trend for bauxite, slag.
  - No correlation between *particle shape and friction or angularity and friction.*
- Aggregate Wear/Abrasion Results
  - All aggregates continued to lose mass after 50 minutes of Micro-Deval conditioning.
  - Rate of mass loss did not change over 50 minutes, but diminished slightly for slag.
  - Mass loss correlated with friction ranking for 3 aggregates, with flint being the exception.

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