EAF STEEL SLAG DURABILITY STUDY

NSA Annual Meeting

September 18th – 21st

Champions

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Introduction

1. Initiated by member request seeking data on slag durability.
2. Industry has no recent data on the topic.
3. Getting positive information published on EAF slag
4. Provide marketing an additional tool to promote utilization in place of natural aggregates.

Key factors considered

- Adequate sampling according to ASTM.
- Determination of tests methods to be used.
- Obtaining nation wide representation.
- Testing repeatability.
- Sample confidentiality.
- Comparative data.
- Budget allocation.
- Time frame.

Key Factors resolution

Using samples from the Risk Assessment project

Key Factor	Mitigation	
Getting adequate sampling	The protocol incorporated a sampling guideline and training to key members for samples to be taken according to ASTM D75. A chain of custody record was also submitted with the samples.	✓
Obtaining nationwide representation	Samples came from members based all over the country.	✓
Sample confidentiality	Confidentiality protocol was already in place to protect sample origin and processor / producer.	✓
Testing repeatability	Using a unique lab would assure a certain repeatability.	✓

Test methods to be used

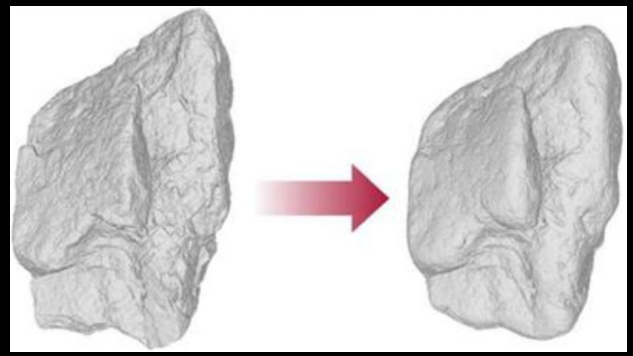
- Micro Deval for fine aggregates: ASTM D7428
- Micro Deval for Coarse aggregates: ASTM D6928
- L.A Abrasion: ASTM C131 / AASHTO T96
- Mohs Hardness: ASTM C1895 MOD

Test method determination is a critical process to ensure study credibility and allow comparison to other materials

Micro Deval

ASTM D7428 & D6928

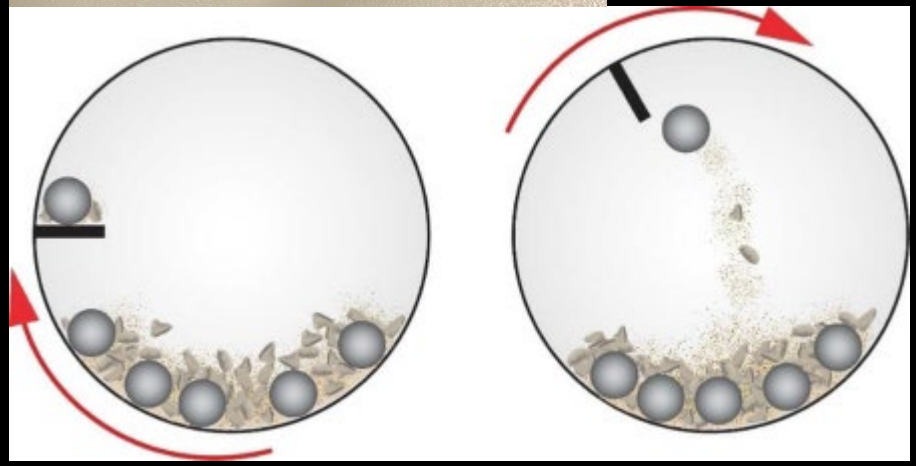
In recent years, the Micro-Deval Test has gained acceptance and popularity as an economical and accurate procedure for aggregate abrasion testing. The basis for this method was developed in France during the 1960s and provides a measure of toughness, abrasion resistance, and durability of mineral aggregates as they are ground with steel balls in the presence of water.



L.A. Abrasion

ASTM C131 / AASHTO T96

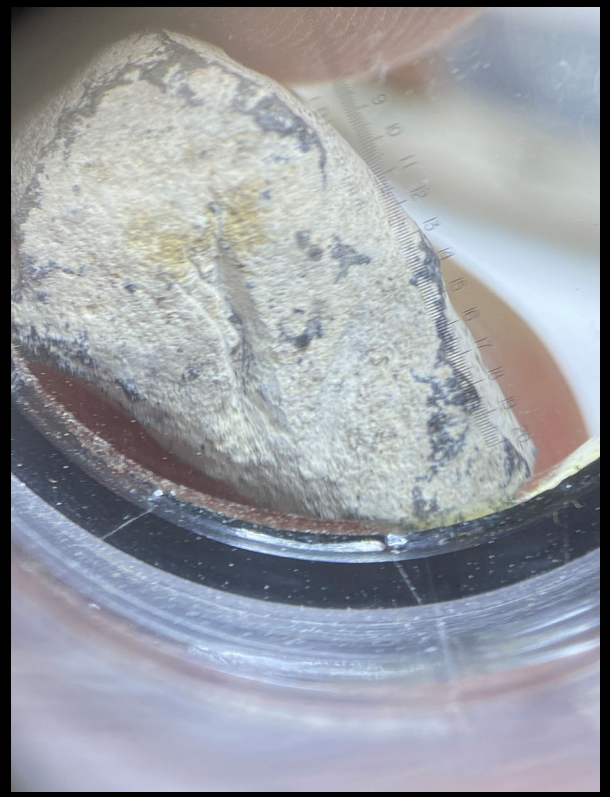
This test is used to determine aggregate toughness and abrasion qualities, primarily in asphalt applications. Poor strength aggregate can lead to HMA structural failures and reduced skid resistance. LA Abrasion test is empirical and not necessarily directly related to field performance..



Mohs Hardness

ASTM C1895-mod

The Mohs hardness test is one of the earliest attempts at defining and comparing the hardness of mineral materials. The Mohs scale consists of values from **1 to 10**, which correlate with the ability of the test material to withstand scratching by progressively harder minerals. It is typically used for geological purposes.



Test range results & Comparisons

Roc Type	Micro Deval	L.A Abrasion	Mohs Hardness scale range
EAF-C range (tested)	**4-12**	**15-23**	**5-6**
Hard, Igneous rock	4.4	10	N/A
Soft limestones and sandstones	19	60	N/A
Basalt (range)	12.7-21.7	10-17	6-7
Dolomite (range)	8.9-14	18-30	3.5-4
Gneiss (range)	10.1	33-57	6-7
Granite (range)	2-23	27-49	6-7
Limestone (range)	8-30	19-30	3-4
Quartzite (range)	20-35	5.7	7-8

- https://pavementinteractive.org/reference-desk/testing/aggregate-tests/los-angeles-abrasion
- Wu, Y.; Parker, F. and Kandhal, K. (1998). *Aggregate Toughness/Abrasion Resistance and Durability/Soundness Tests Related to Asphalt Concrete Performance in Pavements*. NCAT Report 98-4. National Center for Asphalt Technology. Auburn, AL. http://www.eng.auburn.edu/center/ncat/reports/rep98-4.pdf.

Cooley Jr, L: Huner, M.: James, R.: *Micro-Deval Testing of Aggregates in the Southeast.* NCAT Report 02-09. National Center for Asphalt Technology. Auburn, AL.

Test results (avg)

# of samples originally tested	Test Method	North East	North West	South East	South west
19	Micro Deval	7.33*	9.9	7.41	18**
11	L.A. Abrasion	16.33*	19	18.6	22**
19	Mohs scale	5.33*	5.4	5.53	5.26**

- *These results are not considering samples identified as comingled (4) after testing, Combined averages including discarded samples would be**, MD 15.41, LA 17.75, Mohs 5.1**

- ** Sampes from the southwest region were mostly composed of finer materials which limits data on the coarse MD & LA abrasion test, giving different results than other regions. Additional ¾" material should be tested.

XRD versus durability

At this point, we investigated the available XRD data and were unable to draw any conclusions.

XRD analysis is still novel, this procedure is currently being refined to procure more reliable and repeatable results.

Preliminary results did support that some samples we identified as probably comingled (EAF-LMF) may actually be comingled based on periclase data and hardness results. This data is currently being refined to confirm or update based on new approaches to XRD analysis.

Federal Highway specifications for L.A. Abrasion

TEST METHOD	RESULTS AVG.
MICRO DEVAL	8.66
L.A. ABRASION	18.30
COMBINED	26.96
MOHS HARDNESS	5-6 (range)

a. Coarse agg for concrete max 40%

b. Subbase, base and surface course agg max 50%

c. Asphalt concrete agg max 35%

d. Open graded asphalt friction course agg max 35%

e. Chip seal agg max 40%

f. Slurry seal max 35%

g. Micro surfacing agg max 30%

h. Coarse agg max 40%

Indiana State

TEST METHOD	RESULTS AVG.
MICRO DEVAL	8.66
L.A. ABRASION	18.30
COMBINED	26.96
MOHS HARDNESS	5-6 (range)

Micro-Deval

Total Micro-Deval abrasion loss value for an acceptable coarse aggregate or blend of coarse aggregate **shall be 18% or less**

L.A. Abrasion

a) Classes AP, A, B Max 40%

b) Class AS Max 30%

c) Classes C, D max 45%

d) Class E max 50%

Ohio State

TEST METHOD	RESULTS AVG.
MICRO DEVAL	8.66
L.A. ABRASION	18.30
COMBINED	26.96
MOHS HARDNESS	5-6 (range)

Micro-Deval

Micro-Deval Abrasion loss test for coarse aggregate gravel only – **22% max**

L.A. Abrasion

50% max

Performance appreciation

In summary this data is going to be used on a formal paper that will be available for industry and public use once the XRD revision is completed.

Pure EAF slag aggregates, when handled properly meets or exceeds specification requirements.

When compared to natural stone, results show that durability is as good or better in most cases when handled properly.

Possible future studies

- CBR (load bearing)
- Friction angle
- Skid resistance for HMA
- ???

Question?

- Thank you for listening!