

### Cantabro Testing for Mixture Durability

Southeastern Asphalt User / Producer Group (SEAUPG)  
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### Acknowledgements



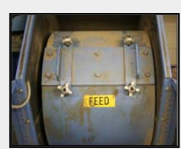
### Presentation Overview

- All data presented is for dense graded asphalt (DGA)
  - MSU has performed 1500(+) Cantabro tests on DGA to date
  - PFC/OGFC use documented by others for several years
- **Objective:** Generate discussion about Cantabro test for DGA to provide a mixture durability index
- Outline of Presentation
  1. Cantabro test method description
  2. Reference data set for traditional low RAP (mostly HMA)
  3. Testing RAP and WMA-RAP mixes
  4. Other recent and potential users of Cantabro test on DGA
  5. Summary-where does Cantabro test fit into bigger picture?

### Peer Reviewed Papers with DGA Cantabro Data

1. Doyle, J.D., Howard, I.L. (2011). "Evaluation of the Cantabro Durability Test for Dense Graded Asphalt," *Proc. of Geo-Frontiers 2011 (GSP 211)*, Mar 13-16, Dallas, TX, pp. 4563-4572.
2. Doyle, J.D., Mejias-Santiago, M., Brown, E.R., Howard, I.L. (2011). "Performance of High RAP-WMA Surface Mixtures," *Journal of the Association of Asphalt Paving Technologists*, 80, 419-457.
3. Baumgardner, G.L., Hemsley, J.M., Jordan, W., Howard, I.L. (2012). "Laboratory Evaluation of Asphalt Mixtures Containing Dry Added Ground Tire Rubber and a Processing Aid," *Journal of the Association of Asphalt Paving Technologists*, 81, 507-539.
4. Howard, I.L., Doyle, J.D., Cox, B.C. (2013). "Merits of Reclaimed Asphalt Pavement-Dominated Warm Mixed Flexible Pavement Base Layers," *Road Materials and Pavement Design*, Special Issue from 88<sup>th</sup> Association of Asphalt Paving Technologists' Annual Meeting, 14(S2), 106-128.
5. Howard, I.L., Doyle, J.D. (2015). "Durability Indices via Cantabro Testing for Unaged, Laboratory Conditioned, and One Year Outdoor Aged Asphalt Concrete," *Transportation Research Board 94<sup>th</sup> Annual Meeting*, Paper 15-1366, Accepted for Session 715.
6. Doyle, J.D., Howard, I.L. (2016). "Characterization of Dense-Graded Asphalt With the Cantabro Test," *Journal of Testing and Evaluation*, doi: 10.1520/JTE20140212.

### 1. Overview of Cantabro Test

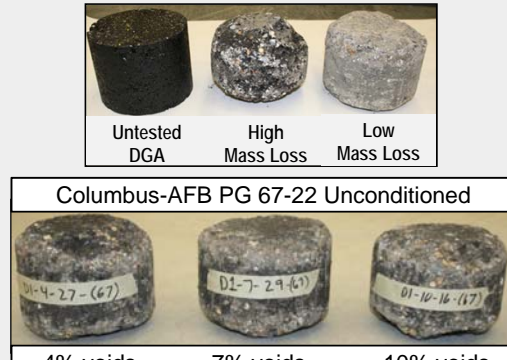


Three keys to Cantabro test

1. Cheap and easy
2. Cheap and easy
3. Cheap and easy

- Compacted specimen evaluated at 25 °C in an LA Abrasion drum for 300 revolutions without steel spheres
- Mass Loss (ML) = % mass change wrt original mass
- Some type of conditioning can be performed prior to testing (approaches vary)
  - 64 °C for 7 d (MT-85), 85 °C for 5 d (R30), 60 °C for 28 d,.....

### 1. Overview-Photos of Tested DGA Specimens (MSU Work to Date is Either SGC or Cores)



Columbus-AFB PG 67-22 Unconditioned

Untested DGA	High Mass Loss	Low Mass Loss
4% voids	7% voids	10% voids

## 2. Reference Data Set

- A wide assortment of mixes used by MDOT in the 2008 to 2010 time frame was tested (mostly low RAP HMA)

### MDOT Central Lab QA Specimens

NMAS	Mixes	Specimens	Avg RAP (%)	Avg ML (%)	St Dev ML
9.5	22	56	12	7.6	2.2%
12.5	16	54	16	9.8	3.0%
19.0	17	42	18	10.6	2.6%

## 2. Reference Data Set-Results of Testing 30 QC Replicates (9.5 mm) (APAC Mississippi, Inc.)

Mix	Conditioning	Ndes	Total AC	RAP	ML Avg	ML COV	Va Avg	Va COV
1	None	50	6.2	15	7.3	10.8	3.3	15.8
1	R 30	50	6.2	15	10.6	12.3	3.6	16.5
2	None	65	6.0	15	7.6	15.8	4.2	26.0

--Mix 1 to Mix 2 (no conditioning) was not statistically different

--Mix 1 (no conditioning) to Mix 1 (R 30) was statistically different

## 2. Reference Data Sets-Aging

(Needed for Comprehensive Durability Assessment)

### A. Complete-Outdoor Aging Experiment 1

No protective sleeves-1 yr-Su 2011 to 12

### B. Ongoing-Outdoor Aging Experiment 2

Protective sleeves & compacted test strips-3 of 5 yrs to date - Fa 11 to Fa 16 (planned)-Braden Smith's PhD Work

### C. Ongoing-Laboratory Aging Experiment 1

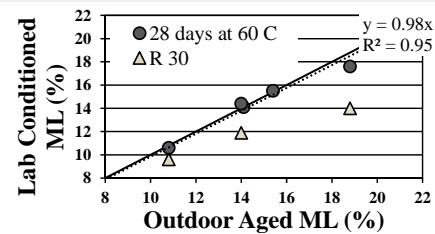
Evaluate existing conditioning protocols and as needed develop new ones to predict effects of outdoor aging on Cantabro ML-Robert James completed PhD work and Braden Smith's ongoing and anticipated PhD work

## 2. Reference Data Sets-Aging

(Outdoor Experiment 1 Results Were Promising)



Outdoor Aging Experiment 1



## 2. Reference Data Sets-Aging

(Outdoor Aging Experiment 2)

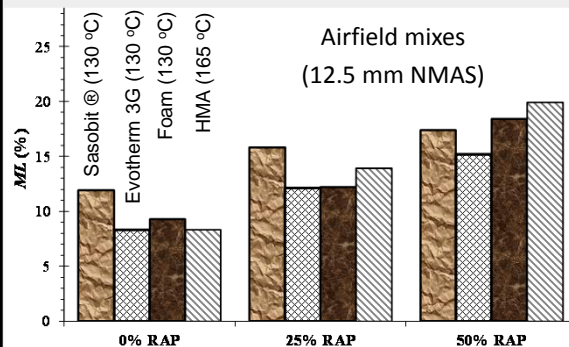


--Cores taken periodically from parking lot (12 test strips)

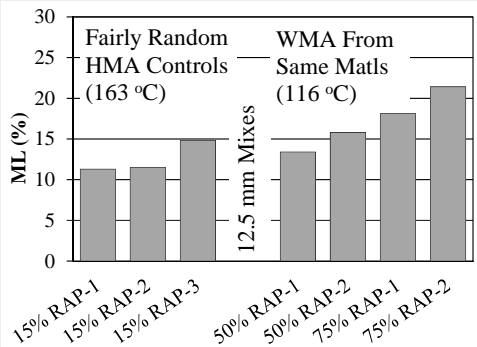
--Gyratory pills taken periodically that have been aging in the lot in PVC sleeves (USACE-ERDC & AFB's)



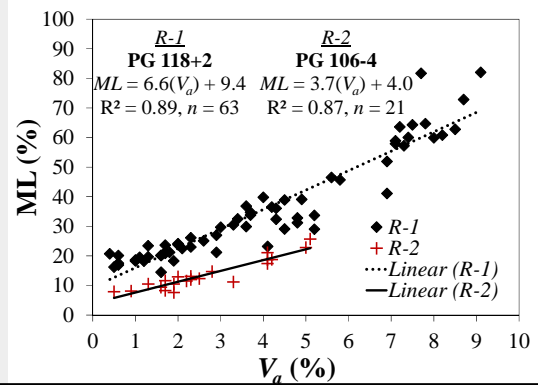
## 3. RAP Content Effects (Constant Raw Materials-Gravel Aggregates & PG 67-22)



**3. HMA (15% RAP) vs. WMA (50 to 75% RAP)  
(RAP Content Isn't Only Factor at Play for ML)**



**3. 100% RAP and Virgin Binder**



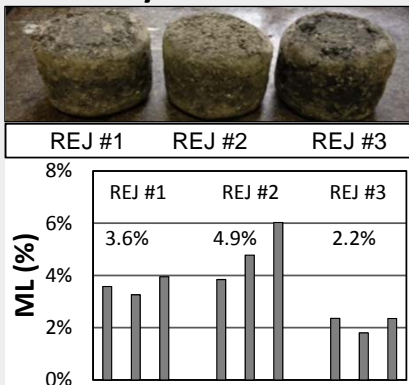
**4. DGA Cantabro Use by Others**

- A. Bob Frank, Brian Prowell have used Cantabro test for 100% RAP paving with rejuvenators (Discussed Further)
- B. Brian Prowell has used Cantabro test to evaluate 25% RAP mixes in South Carolina (Discussed Further)
- C. Mike Sullivan, Griffin Sullivan, et al. at MDOT Central Materials Laboratory have used for change requests during paving w/ SMA (Discussed Further)
- D. Tim Aschenbrener at FHWA Resource Center in Lakewood, CO is examining Cantabro test to understand excessive raveling (Not Discussed Further)

**4.A. Use by Others-100% RAP**

- Mix produced in New York City by Green Asphalt
- 100% RAP (no virgin AC)-designed via Marshall-3 rejuvenators (REJ) included in the experiment
- For Cantabro, SGC compacted ( $\approx 4.8$  kg specimens) to 3.5 to 4.0% voids at 121 °C, tested at 25 °C and 300 revolutions
- Mix was reported to do very well

**4.A. Use by Others-100% RAP**



**4.B. Use by Others 25% RAP**

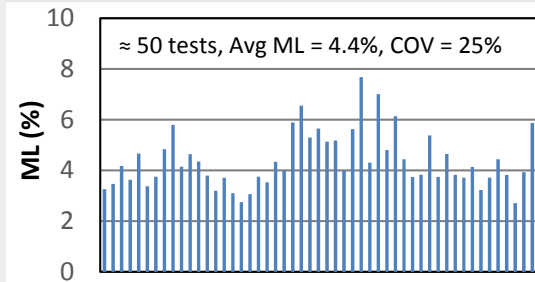
- South Carolina surface Mix ( $N_{des}$  compacted-typical test parameters discussed previously)
- Plant Mixed-Lab Compacted (4.8% binder 3.2% avg voids, 13.1% avg ML)
- Lab Mixed-Lab Compacted (4.7% binder 2.5% avg voids, 10.0% avg ML)

### 4.C. Use by Others-SMA

- 9.5 mm SMA on I-55 in Yalobusha County, MS
  - 4 mix designs used (0% RAP, 0 to 64% crushed gravel, 0.3% fiber, 6.1 to 6.5% PG 76-22 from single source)
- There were questions about exceeding 171 °C mixing temperature
- Baseline testing was performed and 10% ML was determined as an acceptance upper limit
- 150 by 115 mm SGC specimens were produced during QC and tested for ML at 25 °C with 300 drum revolutions
  - minimum 2 specimens per 2 production days

### 4.C. Use by Others-SMA

- Cantabro test results weren't tracked by mix design, but composite result is below. Well below 10% over time, result was mutually agreeable.



### Cantabro Test Applications

- Applications Being Discussed or Considered (None are proven over time at present)
  - Quality control tool-simultaneously evaluate combinations (e.g. what is the combined effect of, for example, RAP content being a little high, AC content being a little low, dust content being a little high...)
  - Detect RAP content, shingles....
  - Detect effects of design to production changes
  - Mix selection tool (thin lift joints)
  - Can be used during project for substitutions

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### Where Does Cantabro Fit Into Bigger Picture?

- Asphalt concrete options keep expanding (WMT, WMA, RAP, GTR, Sulfur additives, Shingles....) Who knows what is next?
- Durability and non-load associated cracking resistance are often very pressing questions (especially with many sustainability and recycled materials driven mixes).
- Bottom Line: Industry needs an uncomplicated mixture test such as Cantabro to help evaluate durability of all mixes, especially those with tendencies toward brittleness and cracking!!!

### Questions?



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